

ISSN 1174-0043; 116 (Print)  
ISSN 2463-638X; 116 (Online)

**NIWA**

*Taihoru Nukurangi*



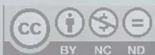
The Marine Fauna of New Zealand:

## **Echinodermata : Asteroidea (Sea-stars)**

**Order Paxillosida** H.E.S. Clark, D.G. McKnight

**Order Notomyotida** D.G. McKnight

*NIWA Biodiversity Memoir 116*



NATIONAL INSTITUTE OF  
WATER AND ATMOSPHERIC RESEARCH (NIWA)

# **The Marine Fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars)**

## **Order Paxillosida**

H.E.S. CLARK and D.G. McKNIGHT

## **Order Notomyotida**

D.G. McKNIGHT

National Institute of Water and Atmospheric Research Ltd  
(NIWA)  
P.O. Box 14-901, Kilbirnie, Wellington  
New Zealand

NIWA Biodiversity Memoir 116

2000



Cataloguing in Publication

CLARK, H.E.S.; McKNIGHT, D.G.

The marine fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars) Order Paxillosida by H.E.S. Clark and D.G. McKnight; Order Notomyotida by D.G. McKnight — Wellington : NIWA (National Institute of Water and Atmospheric Research), 2000  
(NIWA Biodiversity Memoir, ISSN 1174-0043; 116)

ISBN 0-478-23223-3

I. Title            II. Series

UDC

Series Editor: Dennis P. Gordon  
Typeset by: Rose-Marie C. Thompson  
National Institute of Water and Atmospheric Research (NIWA)  
(incorporating N.Z. Oceanographic Institute)  
Wellington

Received for publication - July 1997

© NIWA Copyright 2000

# CONTENTS

	Page
ABSTRACT .....	5
INTRODUCTION .....	7
CHECKLIST OF SPECIES .....	13
SYSTEMATICS .....	14
Order Paxillosida	
Family Luidiidae .....	14
Family Astropectinidae .....	30
Family Radiasteridae .....	108
Family Porcellanasteridae .....	114
Order Notomyotida	
Family Benthoplectinidae .....	136
ACKNOWLEDGMENTS .....	157
REFERENCES .....	158
APPENDICES	
Appendix 1 – List of Stations .....	169
Appendix 2 – List of Stomach Contents of Dissected Species .....	191
INDEX .....	195





**Frontispiece:** *Luidia maculata* Müller & Troschel, from Great Barrier Island, Hauraki Gulf. **Top:** An individual in the process of righting itself after having been overturned. **Bottom:** The same individual, having righted itself, crawling away. Photos: Roger V. Grace



# The Marine Fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars)

## Order Paxillosida

H.E.S. CLARK and D.G. McKNIGHT

## Order Notomyotida

D.G. McKNIGHT

National Institute of Water and Atmospheric Research Ltd  
(NIWA)  
P.O. Box 14-901, Kilbirnie, Wellington  
New Zealand

### ABSTRACT

In the course of this work over 3000 specimens were examined and recorded. These came from the two largest collections in New Zealand, NIWA (incorporating the New Zealand Oceanographic Institute) and the Museum of New Zealand. Collections at the Auckland Museum were also reviewed.

The order Paxillosida is represented by four families — Luidiidae (1 genus, 5 species), Astropectinidae (8 genera, 24 species), Radiasteridae (1 genus, 2 species), and Porcellanasteridae (5 genera, 7 species). There are eight new species. The order Notomyotida is represented by one family – Benthoplectinidae (3 genera, 12 species, none new).

Specimens were collected from very shallow tidal areas to nearly 5000 m. A typical specimen is described in detail for each species, and geographic distribution and variations in depth are also discussed. Photographs and drawings of relevant parts are included. In three very common species with many individuals (*Astromesites primigenius*, *Astropecten polyacanthus*, and *Psilaster acuminatus*), a number of specimens were dissected and stomach contents listed. No parasites were observed. Dissected specimens appeared to be in good condition with generally well-developed gonads. Notes on internal anatomy and other features of interest are included where applicable.

**Keywords:** Asteroidea, Paxillosida, Notomyotida, Luidiidae, Astropectinidae, Radiasteridae, Porcellanasteridae, Benthoplectinidae, New Zealand, sea-stars, taxonomy, distribution, new species, stomach contents



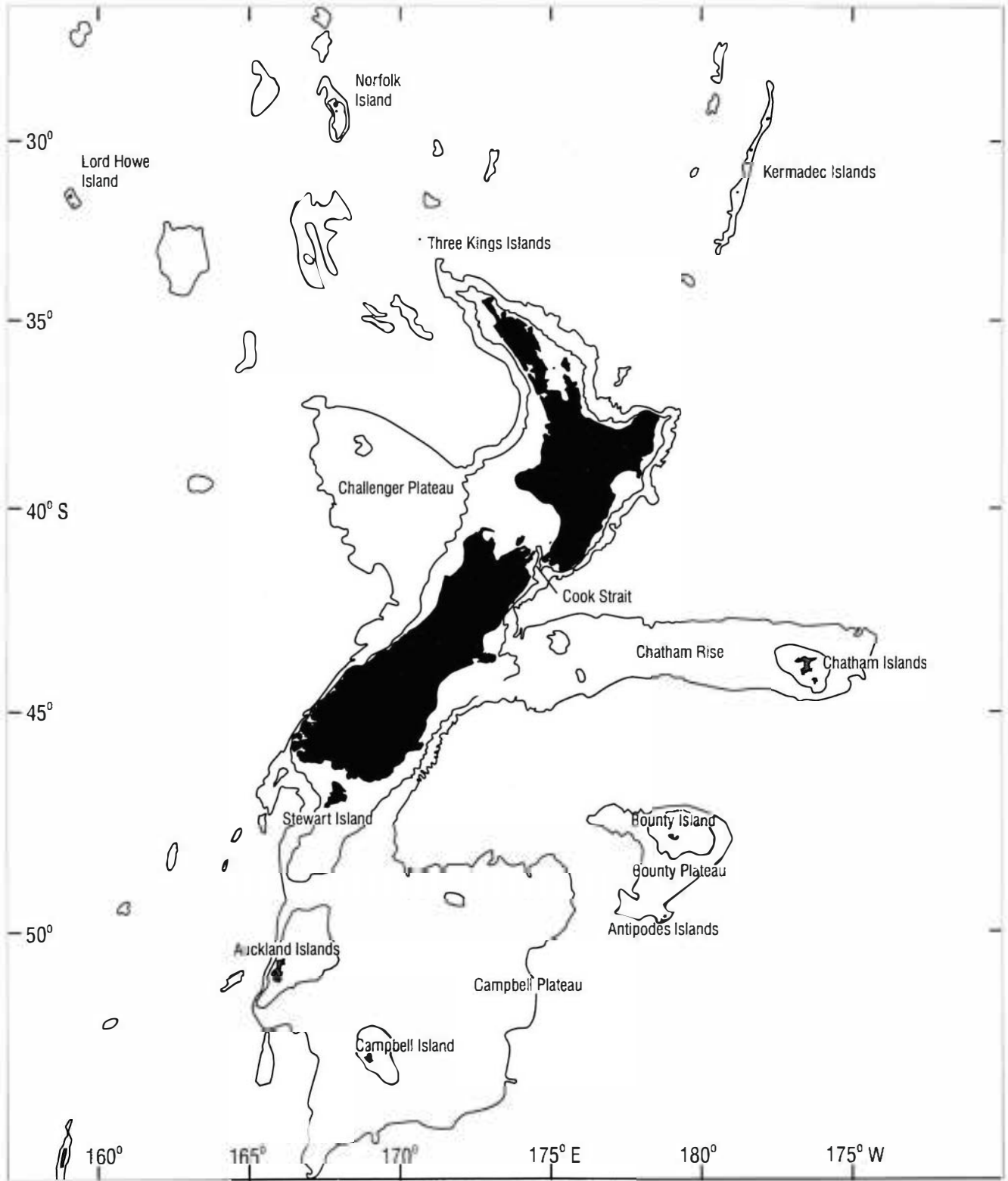


Fig. 1. Map of the New Zealand region which covers the study area.

## INTRODUCTION

The asteroids (starfish, sea-stars) belong in the Echinodermata which is one of the few exclusively marine phyla. Other members of this phylum are the ophiuroids (brittle stars), echinoids (sea-urchins, sea-eggs), crinoids (sea lilies), holothuroids (sea cucumbers), and concentricyloids (sea-daisies). In echinoderms the skeleton is of porous calcite plates, mesodermal in origin, and there is usually pentamerous (5-rayed) symmetry. (In some fossil groups, some living echinoids, and the holothuroids a bilateral symmetry is superimposed on the radial plan.) The water vascular system is also a unique feature of echinoderms. It is largely internal and is complex, comprising fluid-filled canals and bladders (*ampullae*), extensions of which emerge as *podia* or *tubefeet* which are present in the ambulacral grooves on the lower (actinal) surface of sea-stars. Tubefeet are important in movement and in respiration and they are also used (by asteroids) to open bivalve molluscs for food.

Starfish are free-living echinoderms; they are abundant on rocky shores and they are also recorded from very deep water. They were familiar to the ancient Greeks who called them asteroids. Sea-stars and ophiuroids have a long fossil history dating back to the Ordovician. Some echinoderms, including some primitive crinoids, are recorded from the earlier Cambrian epoch. The Ordovician with its warmer climate and seas saw a tremendous rise in marine invertebrates and, to judge from fossil evidence, sea-stars and brittle stars flourished.

Asteroids often have five arms, although there are many exceptions to this. There is a central *disc* and five (or more) *arms* (*rays*), the *mouth* is on the lower, oral, *actinal* surface and there is an *anus* on the upper, dorsal, *abactinal* surface generally near the disc centre.

On the abactinal surface, along the arms there is often a central row of enlarged, conspicuous *carinal plates*, on either side of which are the *dorsolateral* and *marginal* plates; the latter consist of upper *superomarginals* and lower *inferomarginals*. These plates may be more or less naked or they may bear tufts of spines, small spines, large spines, and *pedicellariae*. *Papulae*, skin gills, are generally present in the membranous spaces between the abactinal plates. The *madreporite*, or sieve plate, is the entrance to the water vascular system. It is interradial and generally lies nearer the marginal plates.

On the *actinal* lower surface there is a central mouth with *oral plates*; it is from these that the *ambulacral grooves* or *furrows* project. These furrows are lined by

*ambulacral plates* and the *tubefeet* (*podia*), connect between the plates with the bladder-like *ampullae* of the water vascular system. The ambulacral grooves are edged by *adambulacral plates* which generally bear an assortment of spines, *adambulacral furrow spines*, and *subambulacral spines* (often in surprisingly regular rows) behind the furrow spines, and sometimes *pedicellariae*.

The *actinal areas* may be limited to a few plates, or sometimes actinal plates extend almost to the arm tips and are present and conspicuous between adambulacral and marginal plates. Actinal plates may be naked or they may be paxillate, bearing tufts of spines and/or pedicellariae. *Tubefeet*, in the ambulacral grooves, occur in staggered pairs, appearing to form rows of four; the tubefeet may end in a distinct *sucker* or are long, slender, and almost pointed. Each *arm tip* is protected by a *terminal plate* which often bears enlarged and conspicuous spines. *Pedicellariae* are often present. In their simplest form these often consist of only 2 (sometimes 3, 4, or more) spines, the tips of which meet to form a pincer-like organ. Pedicellariae are believed to be important in removing foreign particles from the surface of the starfish. Pedicellariae can be quite spectacular and the spines which form them may be greatly modified and changed; the types of pedicellariae and their location on the sea-star can be important in systematics.

In the deepwater family Porcellanasteridae *cribriform organs* are present, often interradially, between the marginal plates. In *Porcellanaster*, one cribriform organ only is present, interradially; in other genera they are often more numerous. A cribriform organ is a vertical depression between two adjacent marginal plates, extending the whole width of the two marginal series of plates. The organ is lined by thin vertical plates (rather like the pages, leaves of a book) or sometimes by vertical rows of slender papillae; these vertical plates or papillae are supported by calcareous deposits and are covered by ciliated epithelium; they seem to have a respiratory function. Papulae (skin gills) are few in the Porcellanasteridae. There is also often an *epiproctal cone* or apical appendage (a blind, conical eminence of, really, unknown function) in the centre of the disc. A similar cone or appendage is also seen in some astropectinids, and cribriform organs are present in some members of the family Gonioplectinidae.

Many classifications of asteroids have been proposed. We follow that of A.M. Clark and Downey (1992) as listed in the Checklist of Species (p. 13).



The family Gonioplectinidae, also included in the order Paxillosida, has no representatives in either the NZOI/NIWA collections or those of the Museum of New Zealand and does not appear to occur in New Zealand waters.

## HISTORY OF NEW ZEALAND ASTEROID STUDIES

Müller and Troschel (1842 : 55) described *Astrogonium pulchellum* (*Pentagonaster pulchellus*) from a New Zealand specimen in the Paris Museum; there is no record of the New Zealand locality or how the specimen came to be in the Paris Museum. Five years later, Gray (1847b : 200) gave a brief description of *Astrogonium miliare* (*Diplodontias miliaris*) which "inhabited New Zealand". Gray also (1847a : 339) believed that the specimens of *Pentagonaster pulchellus* which Müller and Troschel described as coming from New Zealand, were probably from China or Japan. Four years later, Ayres (1851) described a new sea-star from "Patangaroa", New Zealand, and called it *Stephanaster elegans* — it displayed (p. 119) "much beauty of form and structure", and is a synonym of *Pentagonaster pulchellus*. Ayres believed that it was "allied" to *Pentagonaster* Gray. Verrill (1867) described four new sea-stars from the "Auckland" area; these were collected by Mr Henry Edwards — one of these, *Astropecten edwardsii* is probably the first record of a paxillosid sea-star from New Zealand waters (*A. edwardsii* is a synonym of *A. polyacanthus*).

Between 1872 and 1878, Captain F.W. Hutton described several new species of New Zealand sea-stars and some brittle-stars; his was the first catalogue (1872b) of the echinoderms of New Zealand. He described 12 species including *Astropecten armatus* which does not seem to have been collected again in the New Zealand region.

Later, Sladen (1889) in the *Challenger* Reports described asteroids from three stations near Cook Strait. One species was *Psilaster acuminatus*, one of New Zealand's commonest sea-stars. He noted that it ranged to Australia and South Africa.

Between 1898 and 1930, Farquhar described a number of new echinoderms from New Zealand waters. He remarked (1898 : 300) on the similarities of the New Zealand echinoderm fauna with that of Australia and recorded in the same publication (p. 301) 28 species of asteroids from New Zealand.

In 1909, Benham described several new sea-stars

collected by the N.Z. Government Trawling Expedition of 1907 and Mortensen (1925 : 267) (with consideration of synonymies and possibly incorrect records) believed that only 18 species of sea-stars were present. (He also omitted the Kermadec Island sea-stars and some deep-water ones.)

In the next twenty years there were very few publications on New Zealand sea-stars apart from Bennett's (1927) paper on some species and on autotomous reproduction and his very brief 1929 paper on rare New Zealand echinoderms. Young (1929) published a paper on the marine fauna of the Chatham Islands and recorded (p. 158) 12 species of asteroids. Fell (1960) also published an account of the archibenthal and littoral echinoderms of the Chatham Islands. He listed 18 species of sea-stars (16 genera). Pawson (1961) discussed the distribution of echinoderms around the Chatham Islands, and McKnight (1967) added to the list. A later paper by McKnight (1993b) recorded 21 genera and 22 species in 8 families.

From 1947 on, and especially between 1952 and 1963, H.B. Fell published a number of papers on New Zealand echinoderms. These included a useful key to the littoral asteroids (1947) and a much larger and more comprehensive account and illustrated key, "Starfishes of New Zealand", in 1959. In "Echinoderms from southern New Zealand" Fell (1952) discussed 50 species of echinoderms including 11 species of asteroids. Collections for this paper were from the *New Golden Hind* Expedition which visited the southwestern fiords early in 1946, and from collections made by the *Alert* from the fiords in 1950 and 1951. Some collections were also from the Chatham Rise area, small collections from eastern Canterbury and the Otago coasts were also included.

In "Deep-sea echinoderms of New Zealand" Fell (1958) described and illustrated 25 genera and species of starfishes and in 1962a published a small but popular account of sea-stars — "Native Sea-stars. Nature in New Zealand". Between 1952 and 1956, Fell also published several small papers on fossil asteroids.

The Kermadec Islands north of New Zealand have an interesting but still rather poorly known echinoderm fauna. Early reports include those of Sladen (1889), Farquhar (1907), and Benham (1911). More recently, McKnight (1968a) listed species from the Kermadecs and in 1978 he recorded *Acanthaster planci* from the northern Kermadec Islands. H.E.S. Clark (1970) published a review of the New Zealand asteroid fauna, based in part on collections made by the U.S. research vessel *Eltanin*.

To the south of New Zealand the echinoderm fauna of the subantarctic islands is not very well known, although McKnight has added a number of records as have Pawson (1965) and, more recently, Fenwick and

\*"Patangaroa": we are unable to find any place, town, or feature, of this name.

Horning (1980). Fenwick and Horning's paper involved, particularly, the echinoderms of the Snares Islands and they provided a very useful table (Table 2, p. 443) on species present in the various subantarctic islands.

This memoir is the first of a series of three describing the entire New Zealand asteroid fauna.

## AREA OF STUDY

Asteroid specimens in the present monograph are from collections made by the then New Zealand Oceanographic Institute (now incorporated into NIWA) and the National Museum of New Zealand. The area covered is from 24° to 57°30'S and 157°E to 167°W (CANZ 1997; Fig. 1). This is essentially the area covered by most New Zealand scientific charts. It extends from the Lord Howe Rise, South Fiji Basin, and northern edge of the Louisville Seamount Chain in the north to the Hjort Trench, Southwest Pacific Basin, and Subantarctic Slope in the south. Depths range from 0 to nearly 5000 m (4868 m, *Eltanin* Stn 1837). The area includes Norfolk, Lord Howe, and Kermadec Islands in the north and Snares, Auckland, Campbell, Antipodes, and Bounty Islands to the south of New Zealand.

## TERMINOLOGY

The general morphology of a sea-star is given in Figures 2a and 2b.

**abactinal (aboral)** – upper surface opposite mouth above marginals.

**aciculate** – slender, pointed, needle-like — refers to spines

**actinal (adoral)** – lower ventral oral surface, between marginal and adambulacral plates

**adambulacral plates** – plates lining furrow

**ambulacral groove, ambulacrum** – midradial groove or furrow on actinal surface of arms and disc; it contains the tube feet

**ambulacral plate** – plate (or plates) within or lining the ambulacrum

**anus, anal pore** – excretory opening, abactinal, often near disc centre

**apical spine** – most anterior oral spine

**arm (ray)** – radial extension of body beyond disc; often 5 arms, rays, present

**bivalved pedicellaria** – pedicellariae with 2 valves

**body** – disc and rays

**carina** – midradial, central line or ridge on arms abactinally (aborally), sometimes marked by conspicuous spines or plates

**carinate** – adambulacral plate very often with conspicuous projecting ridge

**coelom** – body cavity

**column** – pedicel, trunk, stalk of paxillar plate bearing a cluster of spinelets

**cribiform organ** – narrow, vertical passage lined by ciliated epithelium, and supported by slender platelets or papillae, characteristic of porcellanasterids

**cruciform plate** – plate, usually abactinal, with 4 basal lobes, cross-like

**diplocanthid** – with 2 spines

**disc** – central part of body of sea-star; arms (rays) project outwards from disc

**distal** – > ½R from disc centre to arm (ray) tip

**dorsolateral** – area between midradial (carina) of arms, and superomarginal plates, on abactinal surface

**epiproctal cone** – projection, cone (generally blind, no opening) near disc centre; present in many burrowing asteroids

**fascicle** – group of slender spinelets

**fascioles** – channels, grooves, between rows of plates, especially between marginal plates, generally lined with slender fasciolar spinelets

**furrow** – see ambulacral groove, furrow

**furrow spines** – adambulacral spines on furrow margin

**granules** – small round or irregularly shaped inclusions on plates

**hyaline** – glass-like, often descriptive of spines

**inferomarginal plate** – lower (nearest actinal areas) plates of two marginal series; inferomarginals may be naked, bare, or may bear granules, small and/or large spines, and sometimes pedicellariae

**interbrachial, interrarial** – between 2 arms

**interbrachial, interrarial arcs** – between 2 arms, often rounded, sometimes angular

**madreporite** – sieve plate, a specialised, generally obvious (sometimes obscured by paxillae) organ often round, interrarial and abactinal; it is the entrance to the water vascular system

**major radius** – see R

**marginal plates** – plates form a generally distinct edge to disc and arms; inferomarginals generally correspond in number to (upper) superomarginals, inferomarginals fringe lower (actinal) surface of disc and arms

**median suture** – suture line between 2 oral (mouth) plates of a pair

**minor radius** – see r

**monacanthid** – with one spine

**mouth, peristome** – digestive system opening, centrally, on lower (actinal) surface

**oral** – see actinal

**ossicle** – see plate

**papula, papulae** – soft, extensible, retractable finger-like extensions between, most often, abactinal plates; they are respiratory in function, their arrangement often important in systematics

**papular area** – area, often restricted, obvious, with papulae  
**paxilla, paxillae** – a more or less columnar plate with the base usually expanded and the top crowned with a cluster of spinelets or granules

**pedicel** – see column

**peristome** – see mouth

**pedicellaria, pedicellariae** – in the simplest form, tips of 2 spines meet forming a pincer-like organ; many spines (variously modified) may be involved; pedicellariae are



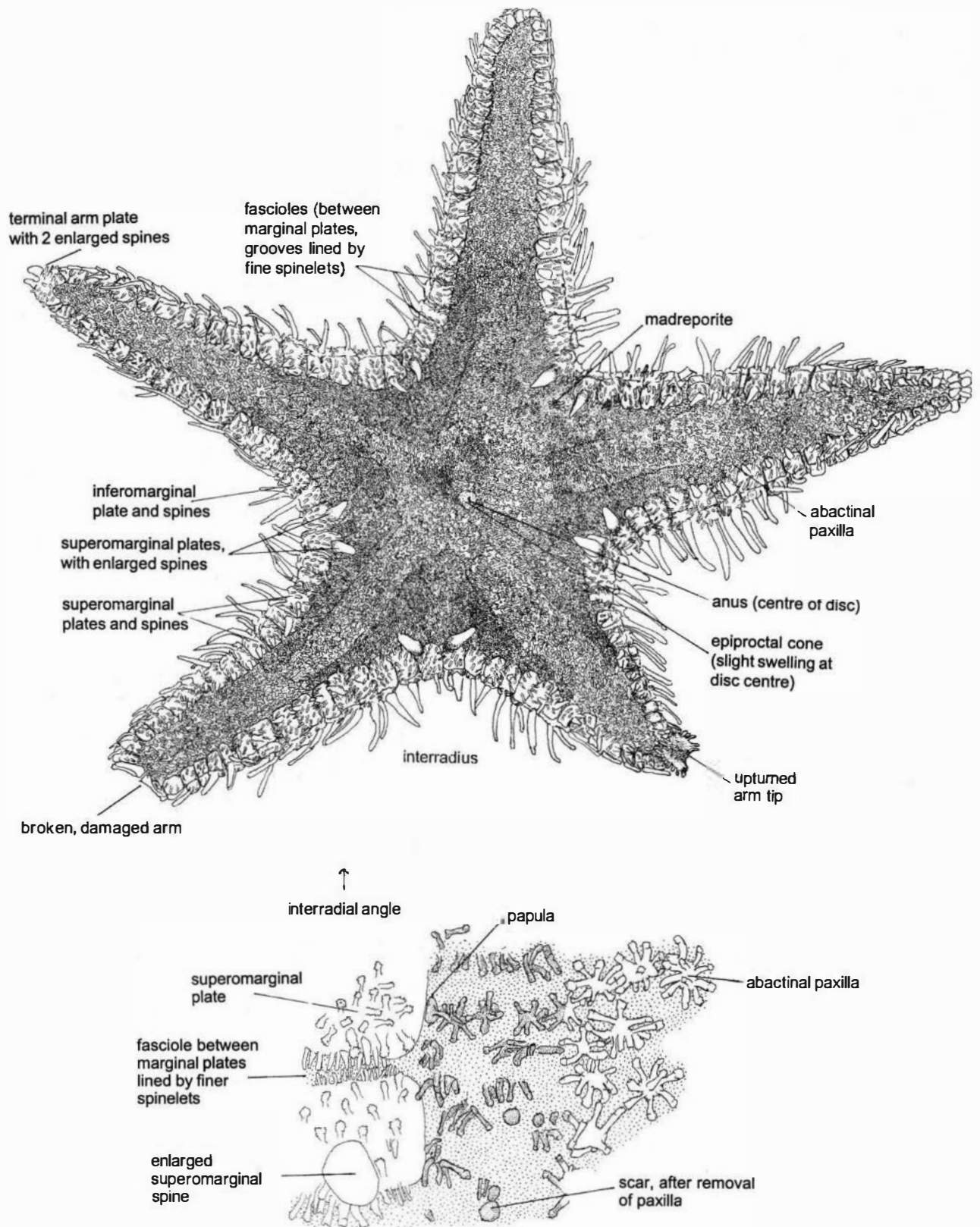
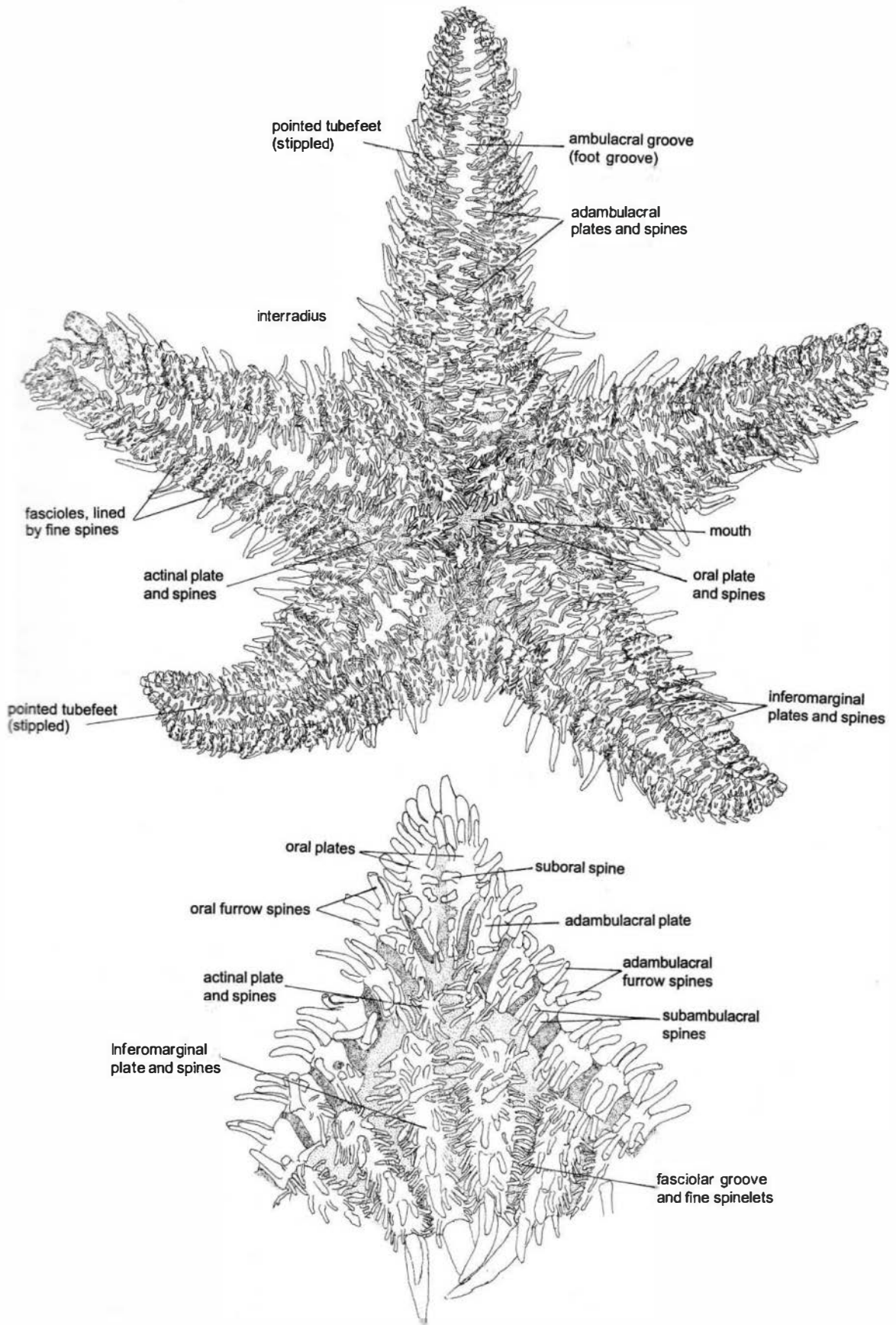


Fig. 2. Diagnostic features of a paxillosid sea-star. Example is *Astropecten polyacanthus* Müller & Troschel. Specimen taken from NZOI Stn 156. **Above**, abactinal (dorsal) view of small specimen (R/r = 21/5 mm) and highly magnified detail of abactinal surface near interradial angle. **Opposite**, actinal (ventral) view of same specimen, and of interradius showing oral, adambulacral, actinal, and inferomarginal plates and associated spines.





often conspicuous and may be present anywhere on the body.

**plate, ossicle** – skeletal element

**podia** – see tubefeet

**polian vesicle** – a round, elongate or sac-like organ extending from ring canal into coelom; numbers of polian vesicles seem to increase with age; they probably act as expansion chambers for the water vascular system

**proximal** –  $< \frac{1}{2}R$  from disc centre

**R** – distance from centre of disc to arm tip, major radius

**r** – distance from centre of disc to interradius, edge of disc

**reticulate** – skeletal ossicles, plates form a distinct network, enclosed meshes are often irregular in size and shape

**ring canal** – a circular vessel or canal around mouth, an important part of the water vascular system

**secondary plate** – small plate usually linking primary (first formed) plates

**segmental organ** – seen in some porcellanasterids – a specialised structure involving modified adambulacral furrow spines

**septum, septa** – partition, partitions, separating two cavities

**serrate** – finely toothed, saw-like edge; generally refers to spines

**sieve plate** – see madreporite

**spine** – sharp process, projection, of plate, often articulated

**spinelet** – small spine

**spinule** – very slender, sometimes flattened small spine, often seen in fascioles

**stone canal** – a tube with calcified walls which emerges from the ring canal and converges with the madreporite

**subambulacral spine** – spine, spines often forming several rows behind furrow spines on adambulacral plates

**suboral spine** – spine adjacent to furrow spines on oral plates

**sucker** – the often rounded and almost knob-like or sometimes flattened tip of a tubefoot – present in many sea-stars

**superambulacral plate** – internal plate which articulates with ambulacral and inferomarginal plates

**superomarginal plate** – upper plate of marginal series; superomarginals with adjoining inferomarginal plates form a distinct edge to disc and arms, they separate abactinal and actinal surfaces; superomarginal plates may bear small spines, large spines, pedicellariae, granules or they may be smooth and uncluttered

**tabulate plate** – plate with table-like top, low, broad

**terminal plate** – plate at arm tip, plate often modified, often with conspicuous spines

**trunk** – see column

**tubefeet** – podia, soft, extensible, retractable, fine finger-like extensions which form 2 (or staggered to appear to form 4 rows) in ambulacral grooves, tubefeet terminate either in a sucker or they are pointed, there is no sucker

**tubercle** – a rounded, sometimes almost conical extension of a plate

**water vascular system** – system of canals through which a watery fluid circulates in the body of an echinoderm

## ABBREVIATIONS OF INSTITUTIONS

NMNZ: Museum of New Zealand Te Papa Tongarewa (formerly National Museum of New Zealand)

NIWA: National Institute of Water and Atmospheric Research, Greta Point, Wellington

NZOI: New Zealand Oceanographic Institute, Wellington (now part of NIWA)



## CHECKLIST OF SPECIES

Class ASTEROIDEA  
Order PAXILLOSIDA  
Family LUIDIIDAE

*Luidia hardwickii* (Gray)  
*Luidia maculata* Müller & Troschel  
*Luidia moroisoana* Goto  
*Luidia neozelanica* Mortensen  
*Luidia prionota* Fisher

### Family ASTROPÈCTINIDAE

*Astromesites compactus* Fisher  
*Astromesites primigenius* (Mortensen) n. comb.  
*Astromesites regis* n.sp.  
*Astropecten celebensis* Döderlein  
*Astropecten dubiosus* Mortensen  
*Astropecten monacanthus* Sladen  
*Astropecten polyacanthus* Müller & Troschel  
*Astropecten tasmanicus* n.sp.  
*Astropecten* sp.  
*Dipsacaster magnificus* (H.L. Clark)  
*Dytaster felli* n.sp.  
*Dytaster pedicellaris* n.sp.  
*Plutonaster complexus* n.sp.  
*Plutonaster fragilis* H.E.S. Clark  
*Plutonaster hikurangi* n.sp.  
*Plutonaster jonathani* n.sp.  
*Plutonaster knoxi* Fell  
*Plutonaster* sp. A  
*Plutonaster* sp. B  
*Proserpinaster neozelanicus* (Mortensen)  
*Proserpinaster* sp.  
*Psilaster acuminatus* Sladen  
*Psilaster charcoti* (Koehler)  
*Tethyaster tangaroae* Rowe

### Family RADIASTERIDAE

*Radiaster gracilis* (H.L. Clark)  
*Radiaster rowei* n.sp.

### Family PORCELLANASTERIDAE

*Damnaster tasmani* H.E.S. Clark & McKnight  
*Eremicaster vicinus* (Ludwig)  
*Hyphalaster inermis* Sladen  
*Porcellanaster ceruleus* Wyville Thomson  
*Styracaster armatus* Sladen  
*Styracaster chumi* Ludwig  
*Styracaster horridus* Sladen

### Order NOTOMYOTIDA Family BENTHOPECTINIDAE

*Benthopecten munidae* H.E.S. Clark  
*Benthopecten pikei* H.E.S. Clark  
*Benthopecten pentacanthus* Fell  
*Cheiraster ludwigi* Fisher  
*Cheiraster monopedicellaris* McKnight  
*Cheiraster otagoensis* McKnight  
*Cheiraster richardsoni* Fell  
*Cheiraster subtuberculatus* (Sladen)  
*Cheiraster triplacanthus* Fisher  
*Cheiraster (Luidiaster) teres* (Sladen)  
*Cheiraster (Luidiaster)* sp.  
*Pectinaster mimicus* (Sladen)

## SYSTEMATICS

### Order PAXILLOSIDA

#### Family LUIDIIDAE Sladen, 1889

Astropectinidae: Luidiinae Sladen, 1889: 244; Süßbach & Breckner 1911: 198.

Luidiidae: Verrill 1899: 201; Fisher 1911a: 105; Bernasconi 1943: 2; Fell 1963b: 433; Spencer & Wright 1966: U42; Blake 1973: 22; A.M. Clark & Courtman-Stock 1976: 43; Downey 1973: 21; McKnight 1977: 116; Blake 1982: 186; A.M. Clark 1982: 157; A.M. Clark & Downey 1992: 4; Moyse & Tyler 1995: 665; Rowe & Gates 1995: 73.

#### *Luidia* Forbes, 1839

Arms 5 or more, long, generally slender, flattened and sometimes, aptly, described as "strap-like"; arms taper gradually, disc rather small. Abactinal plates distinctly paxilliform, these form well-ordered rows laterally along arms; centrally, both on disc and arms, paxillae often smaller, irregularly arranged, crowded. Supermarginal plates generally small, similar to adjacent abactinal plates; inferomarginal plates large, prominent, band-like, well separated laterally by distinct fasciolar grooves, grooves with slender spines. Papulae small, with even distribution except along midline of arms where they are few or sometimes absent; papulae often compound with branching tips; papulae and their distribution are best appreciated from the coelomic side. Madreporite often obscured by paxillae. Actinal interradial areas small, generally a single row of small actinal plates extends to, or near, arm tips; actinal plates may or may not bear spines and/or pedicellariae. Actinal plates with adambulacral and inferomarginals form a definite and very obvious transverse series along arm edges, plates present almost to arm tips. Bi- or sometimes trivalved straight pedicellariae present, conspicuous on adambulacral and sometimes actinal plates; pedicellariae of a more simple type also occur on abactinal paxillae; some actinal pedicellariae are stalked. Adambulacral plates band-like, well defined, separated laterally from each other by distinct muscular areas; furrow spine, often deep in furrow, is sometimes curved and often slightly flattened. Tubefeet in 2 rows, feet taper to small, often knob-like tip; there is no distinct disc. Superambulacral plates well developed, conspicuous; gonads present as distinct "tufts" along rays; no anus, no intestinal caecae and ampullae of tubefeet double and large.

TYPE SPECIES: *Luidia fragilissima* Forbes, 1839.

REMARKS: The Luidiidae is a widespread family; it includes only one genus, *Luidia*, with many species.

The genus is well represented in New Zealand waters, with at least six species present. There was one specimen of *Luidia australasiae* Döderlein in the NZOI collections (I82) from Norfolk Island. Unfortunately the specimen is not now present; it may have been retained at the Australian Museum. *Luidia hardwicki* (Gray) (with synonym *L. forficifer*) from the Kermadec Islands is a new addition to the New Zealand fauna, as are *L. maculata* (new synonym *L. varia*) with a wide distribution, *L. moroisoana* from the Capel Seamount and Norfolk Island, and *L. prionota* also from northern areas. *Luidia neozelanica* Mortensen is probably the commonest and most widespread species of *Luidia* in New Zealand waters.

The genus *Luidia* has a wide distribution in mainly shallow water; it is generally regarded as coming from tropical and subtropical seas. It is interesting that in the New Zealand collections, specimens of *L. maculata* are recorded from near the Bounty Islands, well south-east of New Zealand and almost subantarctic. It is also obvious that not all species are restricted to shallow waters as the Bounty Island specimens, among others, also show.

Little is known of the biology of luidiid species in New Zealand waters; Sewell (1990: 102) recorded *Luidia varia* (now *L. maculata*) as feeding on the common New Zealand holothurian *Stichopus mollis*.

There are no known New Zealand fossil luidiids.

#### TABULAR CHECKLIST TO SPECIES OF *LUIDIA*

Note: *Luidia australasiae* Döderlein is not included in this checklist as the single specimen in the historic NZOI collections was not seen.

- 1 Number of arms
- 2 Colour, abactinal surface
  - c – conspicuous darker bars and patches, sometimes abactinal paxillar spines also conspicuously darker
  - u – uniform, occasional darker areas along arm centre and near superomarginals
- 3 Inferomarginal spines, either:
  - a – alternating, i.e., one up, one down
  - m – matching; forming even rows



- 4 Abactinal pedicellariae, either:  
p – present and obvious  
a – absent, or very inconspicuous
- 5 Abactinal paxillae with enlarged central spines:  
p – present  
a – absent
- 6 Straight pedicellariae, either:  
s – conspicuously stalked  
u – unstalked  
a – pedicellariae not seen
- 7 Superomarginal plates, either:  
i – inconspicuous and difficult to distinguish from neighbouring abactinal plates or
- d – distinct, well-developed, obvious, with enlarged spines
- 8 Actinal plates, with  
s – spines only or with  
s.p. – spines and pedicellariae
- 9 Number of enlarged adambulacral spines
- 10 Number of oral furrow spines on each plate in angle
- 11 Oral pedicellariae, either  
p – present  
a – absent

	1	2	3	4	5	6	7	8	9	10	11
<i>Luidia</i>											
<i>hardwickii</i>	5	c	m	a	a	u	i	s	3, 4	6 + 3	p
<i>maculata</i>	7	c	m	p(a)	a	s	i	s.p.	3	6, 7	a
<i>moroisoana</i>	10	u	m	p(a)	p	u	d	s.p.	4, 5	4, 5	p
<i>neozelanica</i>	5(4)	u	a	a	p	u	i	s.p.	3, 4	5, 6	a
<i>prionota</i>	5	u	m	a	a	a	i	s	5, 6	4–6	p

***Luidia hardwickii*** (Gray, 1840) (Pl. 1, Fig. 3)

*Petalaster Hardwickii* Gray, 1840: 183; 1866: 4.  
*Luidia hardwickii*: Perrier 1875: 251; Bell 1904: 143.  
*Luidia hardwickii*: Sluiter 1895: 55; A.M. Clark 1953: 391, pl. 39, figs 2, 3; A.M. Clark & Rowe 1971: 30, pl. 4(2), 44; Chiu *et al.* 1985: 365; McKnight 1993a: 168; Rowe & Gates 1995: 74.  
*Luidia forficifer* Sladen, 1889: 258, pl. 44, figs 5, 6, pl. 45, figs 5, 6; H.L. Clark 1916: 29; Fisher 1919: 5.  
*Luidia forficifera*: Fisher 1919: 18, 164–166; Döderlein 1920: 278, text-fig. 3, pl. 20, figs 28, 29; H.L. Clark 1921: 28; Livingstone 1932: 243; H.L. Clark 1946: 71.  
*Luidia* sp. (aff. *L. forficifer*): Fisher 1906: 1036.

MATERIAL EXAMINED: NZOIS<sub>tn</sub> K857 (1).

SIZE: The type specimen is small, R/r = 32/5 mm (A.M. Clark 1953: 391), larger specimens with R 80 mm or more are reported from Australian waters.

DISTRIBUTION: Indo-West Pacific Ocean, widespread in Australia and from (this report) the Kermadec Islands, north of New Zealand.

DEPTH: 8–220 m (the present specimen is from 165 m).

DESCRIPTION: The single specimen in the present collections is described, R/r = 40/6 mm, and there are 2 arms still attached to disc.

*Disc* more or less flat, slightly sunken and irregular centrally, arms 5, gently rounded; 2 arms entire and still attached to disc. Arms not markedly distinct from disc; interradial angles acute. No terminal arm plates present in this specimen; in the one attached arm, the last, sharply distinct quarter is regenerating.

*Abactinal paxilliform plates* irregularly arranged along centre of arms; laterally, 4 or 5 rows of regular plates; centrally, paxillae with a short, broad trunk that expands into a round, oval, square or almost rectangular head; this bearing a number of similar short, spaced, thorny marginal spines surrounding thicker, well-spaced, still thorny, upright blunt-tipped spines. In most paxillae central spines and plates dark in colour, spines often barred, marginal spines pale by comparison, not always obvious. Marginal rows of plates well ordered, regular, rectangular or almost square with central area distinctly brown; spine tips surrounding lateral spines are pale in colour and not always obvious.

Neither *papulae*, *abactinal pedicellariae*, nor *madreporite* were seen.

*Superomarginal plates* not obvious, however immediately above the conspicuous inferomarginals is a row of more or less regularly arranged plates with long-stalked paxillae, these irregular in arrangement in last half of arm. Plates with finely thorny, blunt-tipped spines similar to those on abactinal plates; these spines pale coloured and less obvious than adjacent

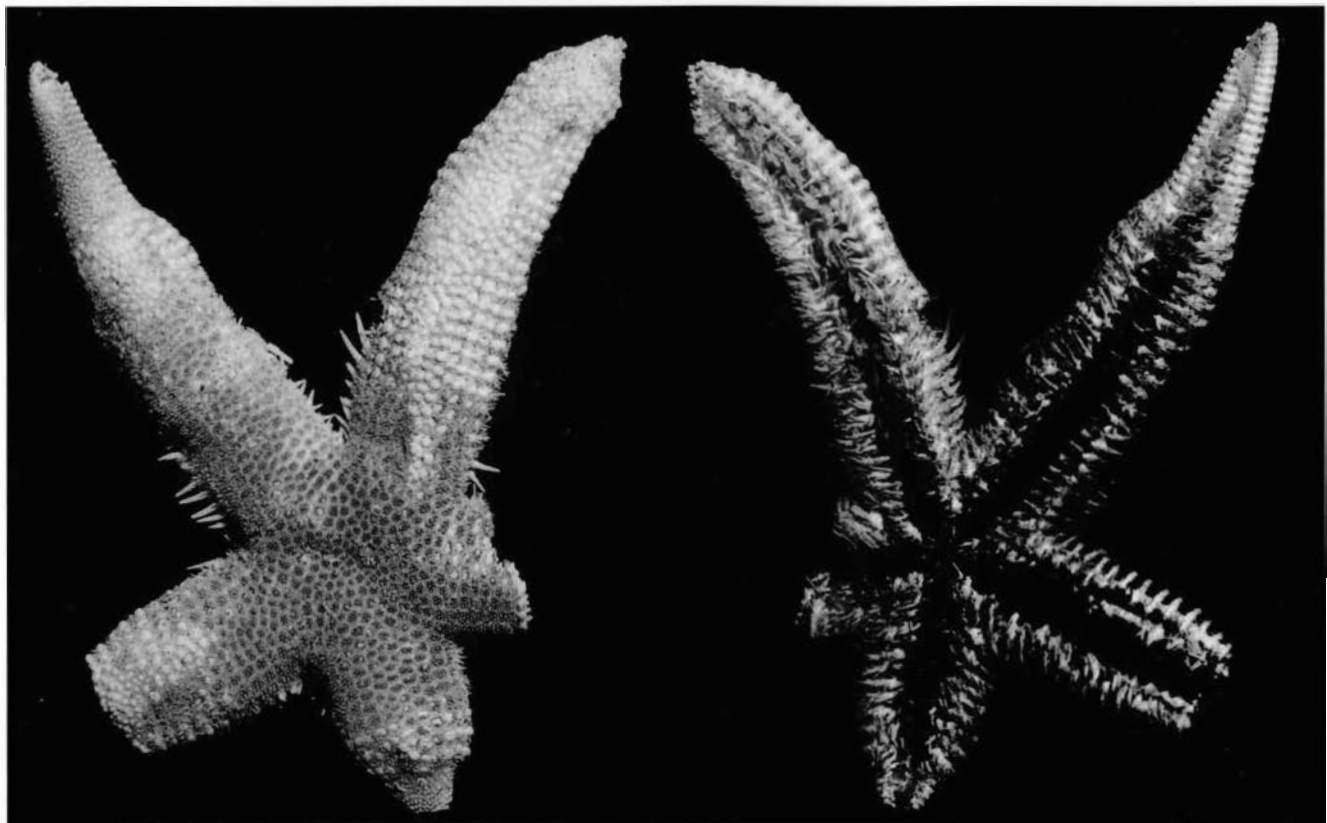


Plate 1. *Luidia hardwickii* (Gray). NZOI Stn K857. R/r = 32/5 mm. Abactinal and actinal surfaces.

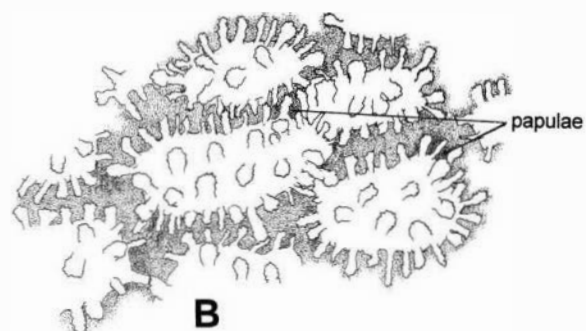
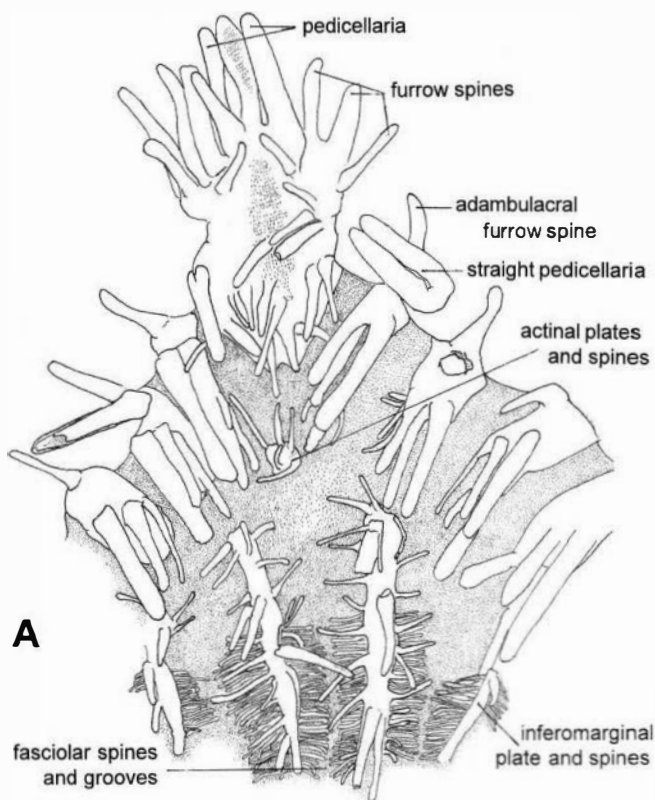


Fig. 3. *Luidia hardwickii* (Gray). NZOI Stn K857. (left) Oral, adambulacral, and actinal plates. (above) Abactinal plates and spinelets. Note darker papulae.

abactinal spines.

*Inferomarginal plates* forming a conspicuous edge to lower part of arms and actinal surface. Plates narrow, raised, band-like, well separated from each other by broad, regular membranous areas. Plates bearing at least 1 (very occasionally 2) large, tapering, slender, perhaps slightly flattened spines; these forming a conspicuous row along arm edge. First 2 inferomarginal plates, interradially, not bearing enlarged



spines. As well as the conspicuously enlarged spines a row of smaller, less conspicuous spines traverse the median longitudinal line of the plate; plates fringed by small, very slender spines continuing between plates as fasciolar spines. Plates and spines pale in colour, not conspicuous. In 1 interradial angle several small, white, straight, round-tipped, slender pedicellariae present; these on plates either at base of large spine or (in one case) on most proximal interradial plate.

*Actinal areas* very small; immediately adjacent to oral plates a single, conspicuous, irregularly oval actinal plate surrounded by membrane. This distinct plate raised centrally, with a "clump" of 7 or 8 slender, slightly tapering, blunt-tipped spines; in 2 angles spines surrounding a larger, central, sturdy, upright, blunt-tipped spine. Small, oval or rectangular actinal plates present between adambulacral and inferomarginal plates; sometimes with a single spine proximally, plates spineless near arm tips.

*Adambulacral plates* bar- or strap-like, more or less corresponding with inferomarginal plates from which they are separated by a single row of actinal plates; actinal plates most obvious in last half of arms. Adambulacral plates also separated laterally by distinct broad membranous areas, and bearing a number of enlarged, slender, blunt-tipped spines; 1 spine, recurved and conspicuous, present in the furrow. A further row of 2 or 3, occasionally 4, larger spines which form either a transverse row on the plate, or a clump of spines; 2 of these spines often forming a straight, conspicuous pedicellaria; generally, the first spines, nearest the margin, form the pedicellaria which overhangs the furrow; on some plates a small group of 2 or 3 spines may be present near plate edge.

*Oral plates* conspicuous, raised, narrow with well-developed furrow spines and pedicellariae. Six furrow spines, 3 on either side, deep in mouth; at least 2 of these forming a long, slender pedicellaria, the valves excavate; above these a row of 5 or 6 similar unmodified spines; also smaller suboral spines, the 2 plates in an angle separated by a membranous area.

*Ambulacral grooves* wide and conspicuous.

*Tubefeet* present in 2 well-ordered rows; a tubefoot between 2 curved adambulacral furrow spines. Tubefeet long, slender, tapering and pale golden-brown. No distinct sucker.

**COLOUR:** There are no colour notes of living material. The dried, ex-preservative, abactinal surface has dark-brown regular rows of paxillae, separated by distinct white or pale lemon-coloured areas.

**REMARKS:** *Luidia hardwickii* (Gray) was first described as *Petalaster Hardwickii* by Gray (1840) from the "Indian Ocean". Sladen (1889: 258) described *Luidia forficifer*

(now a synonym of *L. hardwickii*) from Torres Strait, northern Australia. Rowe and Gates (1995) list *L. hardwickii* as widespread around Australia. A conspicuous feature of this species is the large straight, bivalved pedicellariae, which are generally most obvious on proximal adambulacral plates.

Part of an arm, separate from the disc, was dissected. The superambulacral plates are slender and bar-like, passing steeply to the inferomarginal plates; ampullae of the tubefeet are double, conspicuous and ambulacral plates distinct. Near the arm margins, abactinal plates (when viewed from the coelomic side) form very obvious rows and papulae between the plates are conspicuous and regular. Along the midline of the arms, however, abactinal plates are irregular in shape and outline and papulae are small, inconspicuous and present between plate lobes. A very narrow area along the midline of the arm lacks papulae; plate outlines here are almost obscured by a thick skin. Near the inferomarginal plates there is a very regular row of small brown tufts, presumably representing small and immature gonads.

#### *Luidia maculata* Müller & Troschel, 1842

(Pl. 2, Fig. 4)

*Luidia maculata* Müller & Troschel, 1842: 77; Peters 1852: 178; Dujardin & Hupé 1862: 433; von Martens 1865: 352; 1866: 84; Perrier 1875: 258; Walter 1885: 368; Bell 1888: 384, 388; Sladen 1889: 327; Sluiter 1889: 313; de Loriol 1893: 379; Sluiter 1895: 55; Bedford 1900: 293; Bell 1904: 143; Koehler 1910a: 267, pl. 15, figs 1, 2, pl. 16, figs 8, 9, pl. 17, fig. 8; 1910b: 10; 1915: 86; H.L. Clark 1916: 29, pl. 5; Fisher 1919: 163, 168; Döderlein 1920: 262, pl. 18(4, 13), pl. 19(16), pl. 20(23, 24); H.L. Clark 1921: 28; 1923: 252; Döderlein 1926: 7; Mortensen 1933: 238; 1934: 5, pl. 5; H.L. Clark 1938: 72; Domantay & Roxas 1938: 208, pl. 4, fig. 19; Mortensen 1940: 63; H.L. Clark 1946: 71; Habe 1952: 75; B.I. Balinsky 1958: 99; Domantay & Conclu 1968: 161; Hoque 1969: 29; A.M. Clark & Rowe 1971: 43, pl. 4, fig. 3; Hayashi 1973: 48, pl. 7, fig. 4, text-figs 4, 5; Jangoux 1973: 7, fig. 1; Marsh 1974: 68; Imaoka *et al.* 1990: 40; Komatsu & Kawai 1994: 327; Flammang 1995: 125; Rowe & Gates 1995: 75.

*Luidia maculata* var. *ceylonica* Döderlein, 1920: 265.

*Luidia maculata* var. *herdmani* A.M. Clark, 1953: 389.

*Luidia varia* Mortensen 1925: 275, pl. 13, figs 13, 14, text-fig. 4a-d; Bennett 1927: 129; Fell 1959: 132; H.E.S. Clark 1970: 2; Sewell 1990: 102; Rowe & Gates 1995: 75 [new synonymy].

#### MATERIAL EXAMINED:

NZOI Stns: F936(1), I1(1), I50(3), I52(4), I56(7), T260(1).  
NMNZ: Bay of Islands: Ech. 2141(1), 4391(1), 6578(1); Bay of Plenty: Ech. 4394(1), 4395(1), 4396(1), 4398(4); near Bounty Islands: Ech. 1859(7); off East Cape: Ech. 4392(1), 4393(1), 4397(1); Hauraki Gulf: Ech. 4390(1); Kermadec Islands: 6292(1).

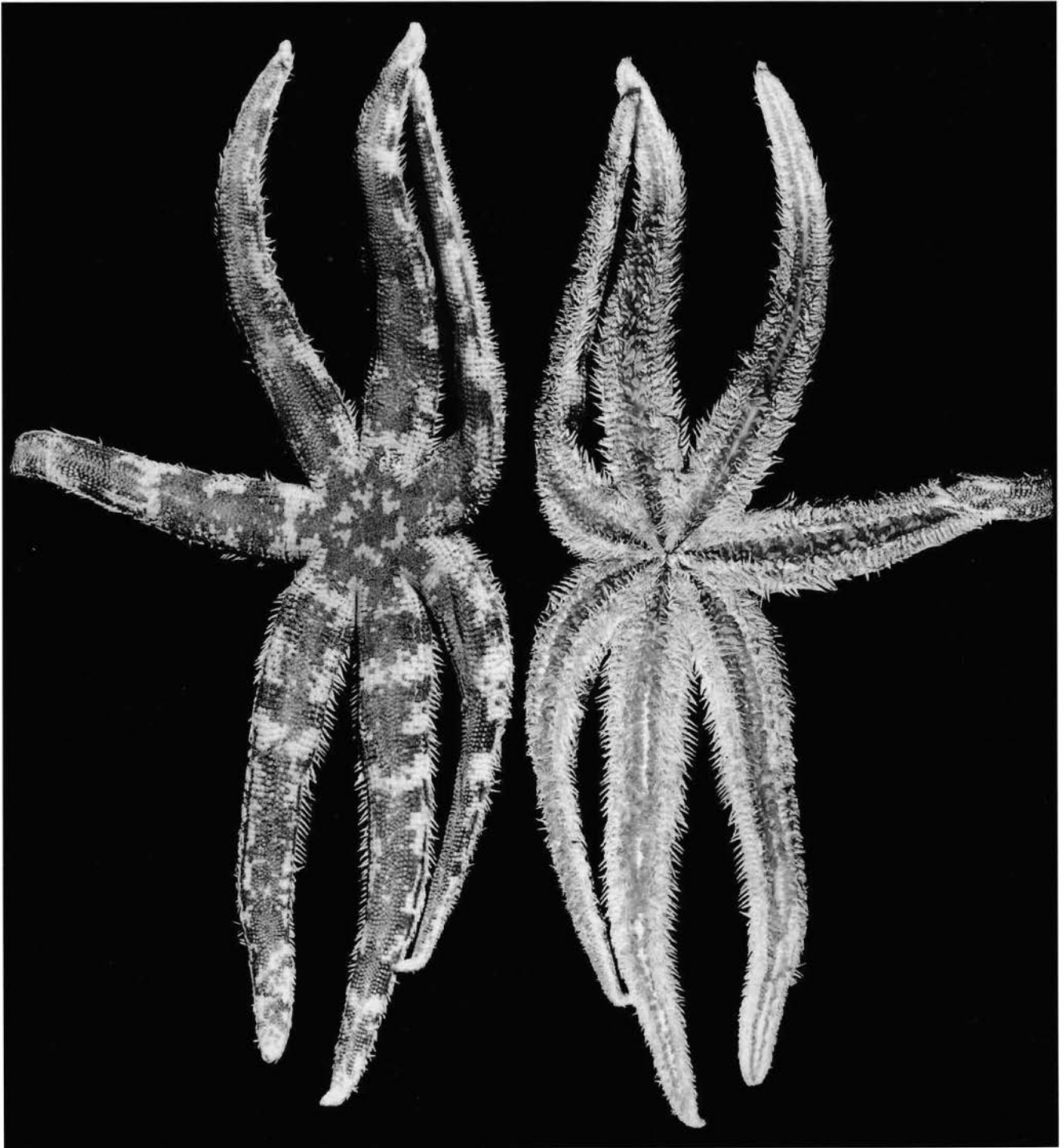


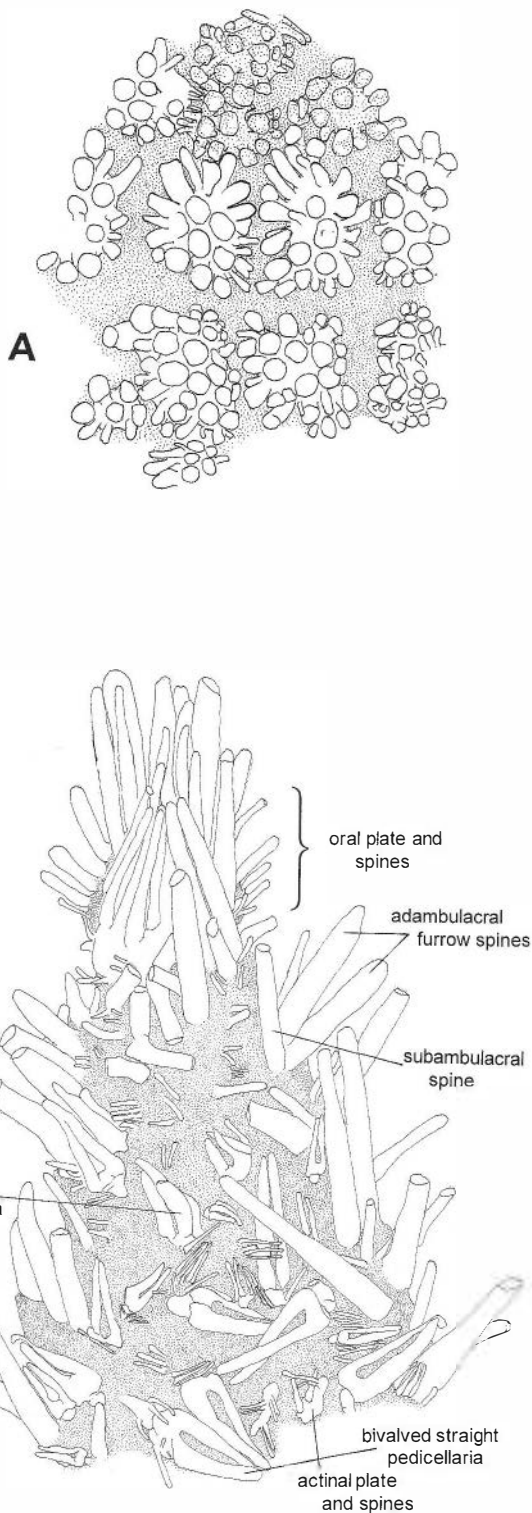
Plate 2. *Luidia maculata* Müller & Troschel. NZOI Stn T260. Abactinal and actinal surfaces.

Size: Thirty-nine specimens were examined, of which measurements were possible for 19: R/r averaged 87/11 mm. Sizes ranged from R/r = 180/19 mm to very small specimens with R/r 9/4 mm.

DISTRIBUTION: In New Zealand waters this species ranges

from the Kermadec and Lord Howe Islands in the north, to near the Bounty Islands. In the North Island it is most common from the Bay of Islands to East Cape; it has not been recorded from South Island inshore waters. Elsewhere it is widespread in the Indian Ocean and in Southwest Pacific waters.





**Fig. 4.** *Luidia maculata* Müller & Troschel. NZOI Stn T260. **A.** Abactinal paxillae at base of arm. Note the three dark paxillae at top. **B.** Oral, adambulacral, and actinal plates.

DEPTH: 0–512 m. Five large specimens in the present collections come from surprisingly deep waters near the Bounty Islands. Label details with the specimens are correct. Interestingly, A.M. Clark (1982: 163) recorded considerable depths for some Atlantic species of *Luidia*, for example, *L. sarsi* from 1300 m.

DESCRIPTION: The specimen from near the Kermadec Islands (NZOI Stn T260), R/r = 120/16 mm (arms vary in length from 105 to 217 mm) is described.

Disc flat, *arms* 7, strap-like, flat, tapering especially obvious in last half of arms, margins slightly raised, with well-ordered and distinct rows of paxillae. Interbranchial arcs acute; terminal arm plate oval with small, thick-headed, very finely thorny spinelets that form almost regular rows.

*Abactinal plates* forming very distinct paxillae, in regular transverse rows of 5 or 6 plates along arm edges, centrally on arms; disc arrangement confused. Abactinal plates generally trilobed, with a slender trunk or stem that supports a round, oval, rectangular or almost square head. Proximally on arms paxillae spaced, generally rectangular or square; near arm tip paxillae often more rounded, more closely packed. On disc, paxillae close-packed, generally round or oval, their outline often difficult to determine; each disc paxilla with 8–12 or more short, round-headed, very finely thorny spines (or, perhaps round granules), these generally well spaced and of similar size, 1 granule is often central; peripheral, shorter, slender spines also present, these forming a fringe but not always easily visible. Spines or granules finely thorny under high magnification and hyaline (glassy). At proximal base of and along arms, paxillae less crowded, central granules generally fewer, peripheral granules or slender spines more obvious and more spaced, and spinelets definitely with longer and more thorny trunks. Paxillar head flat or gently raised; peripheral spinelets on a paxilla often of 2 sizes, with thicker, shorter spine flanked by more slender and considerably longer spines or spinelets. Towards arm tips marginal spines of paxillae very distinct; spines fewer centrally.

*Papulae* very obvious, especially on arms, compound with tips divided into numerous papillae; papular pores heart-shaped or round. Papulae apparently absent from midline of arms and from disc; if present on disc, are well hidden by paxillae.

*Pedicellariae* most obvious and conspicuous actinally (discussed later). Very occasionally on abactinal paxillae, 2 marginal spines, almost triangular, somewhat larger than surrounding spines, forming an incipient pedicellaria.

*Madreporite* small, only just interradiial; more or less round, smoothly lobed and very finely, deeply and

intricately dissected; almost concealed by neighbouring paxillae.

Anus lacking.

*Superomarginal plates* not obvious, although immediately adjacent to inferomarginals a distinct row of larger, almost square, paxillae most conspicuous distally.

*Inferomarginal plates* forming a distinct edge to arms, band-like, narrow, distinct; plates separated from each other by deep fasciolar grooves lined by numerous, very slender spinelets that interlock and cross with spinelets from neighbouring plates. Inferomarginal plates separated from adambulacrals by at least 1 series of actinal plates; plates — adambulacrals, actinals, inferomarginals — forming very regular transverse rows on arm edges. Inferomarginal plates generally with 2, sometimes 3, enlarged, tapering, often slightly flattened spines; these roughened along their length by tiny, very slender spinelets. Slender, shorter spines between large spines and sometimes a large, sturdy bivalved pedicellaria present between 2 large upper spines.

*Actinal plates* not very distinct except near oral angle; small, raised, skin-covered, each plate with a slender, blunt-tipped stalk that is crowned by a large, generally trivalved pedicellaria; occasional small, bivalved pedicellariae also present; both types of pedicellariae fringed basally by short, slender spines. Actinal plates not obvious further along arms.

*Adambulacral plates* band-like, separated laterally by conspicuous wide membranous areas; a projection in the furrow with a single rather flattened recurved furrow spine. Two further large spines on the plate; all 3 forming a prominent transverse row. At base of inner spine (i.e., nearest actinal and inferomarginal plates) often a conspicuous, stalked, straight 2- or 3-valved pedicellaria. Sometimes also several slender spines.

*Oral plates* well raised, long, narrow, 2 plates in angle generally close together with little obvious membranous area between. Plates with 6, 7 furrow spines long, slender, round tipped, tapering, somewhat flattened; suboral spines of similar number and size to furrow spines. Distal part of plate near actinal plates with a jumble of small, spaced, slender spines. Proximally, deep in furrow, a row of 3, 4, 5 spines curving down into mouth; these slender, slightly flattened, with bases united by shallow membrane forming a distinctly curved line deep down on plate. No pedicellariae on oral plates, although in 1 angle, near actinal plates, 2 stalked, bivalved straight pedicellariae present, based on first and second adambulacral plates.

COLOUR: The colour, retained in preserved and dried

specimens, is very distinct, with creamy-white bars and blotches interspersed with grey bands. Colouration of type material was aptly described by Müller and Troschel (1842: 78). V. Hoggard, for a specimen from the Bay of Islands, records the living colour as "black and mauvish gray above, white below." In specimens from near the Bounty Islands, the abactinal paxillar spines are barred with black and white.

REMARKS: Mortensen (1925: 278) in his description of *L. varia* remarked that it "bears some resemblance" to *L. maculata*; he remarked on the absence of pedicellariae in *L. varia*. However, the presence or absence and number of pedicellariae varies considerably as the present material shows; pedicellariae are considerably fewer or absent in small specimens. We herein commit *L. varia* to the synonymy of *L. maculata*.

This is a very variable species; many of the present specimens have very distinctively stalked straight, often tri- sometimes bivalved pedicellariae; these are especially obvious on actinal plates near the mouth and on the most proximal adambulacral plates. Pedicellariae with distinct stalks were not mentioned in the type description (Müller & Troschel 1842). Döderlein (1920: 215) discussed the pedicellariae in this species and referred to "pedestals" (bases). He illustrated (Pl. 18, fig. 13) an adambulacral plate, and the straight pedicellariae seem to have a definite short stalk; it is considerably longer in the present material. Döderlein included *maculata* in the alternate group of specimens in section b (p. 241) with other specimens lacking paxillar spines — in the present material the fringing spines of paxillae could only be called spines.

Arms in this species (and in other species of *Luidia*) are easily lost; regeneration is probably quick as there is often an abrupt end to an arm. The terminal plate (in these arms) is slender, small, almost "beak-like"; it sometimes bears small spines.

Dissection of two large specimens (NZOI I56) showed some interesting features. Ampullae of the tubefeet are distinctly double; superambulacral plates are very distinctive, bar-like, strong; they pass from the lower end of the adambulacral ossicles onto the inferomarginals and form regular, conspicuous rows on either side of the ambulacral ridge. There is also a small, taut, membranous septum at the lower end of the ambulacral plates. It arises at the junction of two plates and passes across between the superambulacral plates and joins with the inferomarginal plates; these small septa are very constant and continue almost to the arm tips in many specimens, also a slender "ridge" of membrane passes from the septa, up the arm sides and onto the abactinal plates. The form of the ambulacral plates is interesting; the plates are almost strap-like, and broaden at the lower, furrow end, to form three flanges;



plates are sharply truncated on top of the ambulacral ridge and separated laterally and at the ridge top by distinct muscular areas. Between the ambulacral plates at the ridge top a distinct oval pore is present. These are very regular and always at the anterior edge of the plates; they are present but smaller near the arm tips. Seen from the coelomic side the abactinal plates along the arm sides are amazingly regular in their arrangement; papulae between plates are most conspicuous and form very regular rows. However, along the arm centre, seen from the coelomic side, plates are irregularly arranged, with fewer, smaller papulae haphazard in distribution and generally overlain and partly obscured by thick skin. A small central area on the disc appears devoid of papulae. In both specimens (NZOI I56) gonads were inconspicuous and appeared as very small, pale-coloured tufts along the arm margins dorsal to the inferomarginals. In contrast, dissection of a specimen from near the Bounty Islands (NMNZ Ech. 1859) showed well-developed gonads, long, branching, inflated and forming a very definite tract along arm sides. The curious holes or pores present between the ambulacral plates were also present and conspicuous in these specimens; these pores are most obvious in dry specimens. In all dissected specimens the stomachs appeared full of fine sand and shell particles.

Bay of Plenty residents (pers. comm.) report that large numbers, 100 or more, of *Luidia maculata* (identification from dry specimens) are washed ashore after storms, suggesting that they are particularly numerous in that part of New Zealand.

*Luidia moroisoana* Goto, 1914 (Pl. 3, Fig. 5)

*Luidia moroisoana* Goto, 1914: 301, pl. vi, figs 95-103; Fisher 1919: 18, 172, pl. 44, fig. 3; Hayashi 1973: 51, pl. 7, figs 5, 6; Imaoka *et al.* 1990: 40; Rowe & Gates 1995: 74 (? part).  
*Luidia avicularia*: [non Fisher 1913] Döderlein, 1920: 273, pls 18(3), 19(18, 19), 20(33); McKnight 1989a: 8.

MATERIAL EXAMINED: NZOI Stns I94(1), I735(1).

SIZE: The two present specimens, both with ten arms have the following measurements: I94, R/r = 140–159/9 mm, the arms have dried as a tight swirl above the disc; in I735 with all arms broken close to disc, disc diameter is 22, 23 mm. The type material also with disc diameter of 23 mm had arms 194 mm long. Hayashi (1973) examined five specimens with R varying from 90 to 17 mm, and r from 21 to 5 mm.

DISTRIBUTION: Sagami Bay, Japan; Capel Seamount; Norfolk Island, and possibly New South Wales and Western Australia.

DEPTH: 91–308 m.

DESCRIPTION: Of the 2 specimens, the larger and more complete (NZOI I94) from near Norfolk Island is described; of the 10 arms at least 3 show regeneration for three-quarters of their length. The specimen is dry with arms upright; unfortunately it was necessary to remove 4 arms in order to see the disc. R/r = approx. 140–150/9 mm.

*Disc* rather flat, irregularly raised near arm bases, arms lifting steeply from disc and not well differentiated from it. *Arms* long, flat, tapering very gradually in last half to tip; arm tip protected by horseshoe-shaped plate with small, finely thorny spinelets, often present in 2s; terminal plates especially obvious on regenerating arms.

*Abactinal paxillae* of disc with well-developed trunk supporting a round, oval, or almost rectangular head with outer fringe of 20–25 (sometimes more) finely thorny, slender spinelets. On many paxillae, almost every second marginal spine inset slightly on plate forming an irregular edge. Paxillar marginal spines well spaced from one another, sometimes gently tapering; central paxillar spines 2–8 (occasionally more) short, sturdy, thorny, blunt-tipped, untapering, well spaced, separated from fringing paxillar spines by broad, naked, flat area. Occasionally, centrally on paxilla, 2 spines bend towards each other with tips almost meeting to form a simple pedicellaria. Along arms, paxillar surface flat or sometimes slightly raised and number of central granules fewer. Sometimes, especially near superomarginal plates, paxillae with an enlarged central spine, similar to, but shorter than, superomarginal spines. Paxillae irregular in arrangement along arm centre — generally crowded with contours indistinct, close together towards arm tips and on newly regenerating arms, forming regular rows near superomarginals.

*Papulae* most obvious along arm margins; generally 4 present singly between lobes of abactinal plates; papulae indistinct centrally on arms, very few or absent. Papulae also indistinct on disc, perhaps hidden by close covering of paxillae.

*Pedicellariae* few, also present on disc, along arms, and on inferomarginal plates (see below).

*Madreporite* not obvious.

*Superomarginal plates* distinct; each generally with only 1 enlarged, slender, tapering spine, this usually less than half length of neighbouring inferomarginal spines. Nevertheless, spines distinct and present along arm edges almost to arm tip, smaller in last half of arms. Slender spines present at base of enlarged spines; generally 1 or 2, occasionally 3, even 4 slender, bivalved, straight pedicellariae also, especially near inferomarginals.



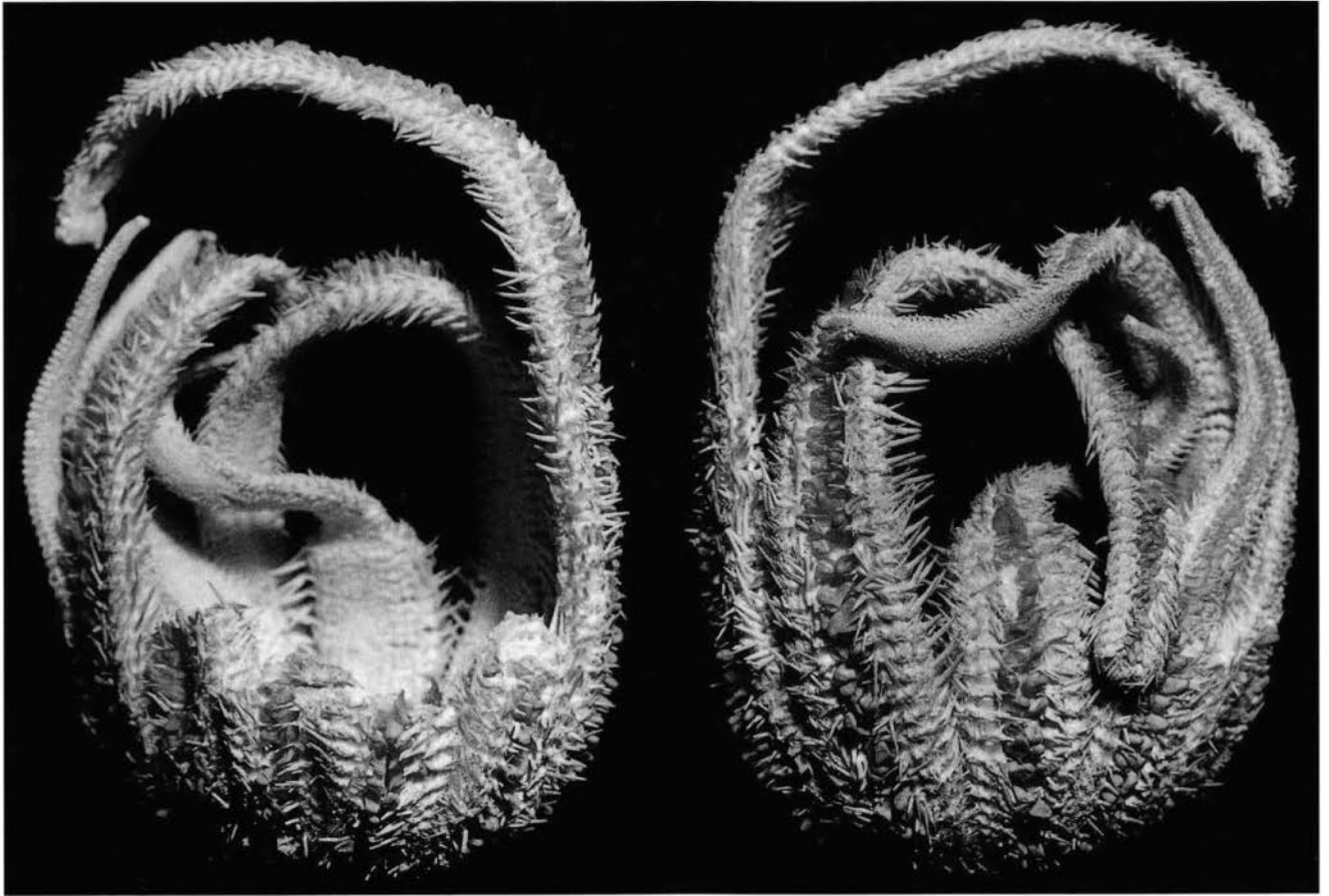


Plate 3. *Luidia moroisoana* Goto. NZOI Stn I94. R/r = 140–159/9 mm. Abactinal and actinal surfaces.

*Pedicellariae* generally on plate edges, occasionally at base of large spines. Surrounding slender, short spines generally forming a fringe around plate on margin or sometimes standing more upright at base of large spine. Some adjacent abactinal paxillae with 1 (sometimes 2) enlarged spines centrally; these may form a simple pedicellaria.

*Inferomarginal plates* large, distinct, band-like, forming a very conspicuous edge to disc and arms, well separated laterally by distinct rather shallow fasciolar grooves lined by fine, long, slender spinelets that meet with those from neighbouring plates. Enlarged inferomarginal spines 5, sometimes 4, largest spines near upper (superomarginal) edge of plate; these sturdy, tapering to sharp tip, finely thorny. Fine, small, slender spines also present, sometimes upright, sometimes horizontal. *Pedicellariae* of 2 types on plates, often at edge near fasciolar spines; *pedicellariae* small, straight, bivalved, upright with tip of one blade curved over second blade. The second type of *pedicellaria* stalked with very slender, long, thin, blades and generally marginal on plates, the 2 blades convoluted, strangely twisted and marked, blades flat-tipped.

*Actinal plates* small; interradially, adjacent to oral plates is a large, slightly raised, unpaired oval or round plate bearing a tuft of slender, radiating spinelets and often 1 or 2 long, sturdy, conspicuous straight *pedicellariae*. Three or 4 more actinal plates on either side of unpaired plate, each with tuft of slender spines; these also often bearing large sturdy, straight, bivalved *pedicellaria* similar to those already described. Distally along arms actinal plates small, rectangular, inconspicuous with 2 or 3 slender tapering spines; near arm tips, plates difficult to see or absent; no spines.

*Adambulacral plates* separated laterally from each other by distinct, wide, shallow, membranous areas; corresponding with similar areas between actinal (proximally) and inferomarginal plates — a very regular feature of the genus. *Adambulacral plates* bearing a conspicuous, long, slender-valved, blunt-tipped bivalved *pedicellaria* deep in furrow, projecting across furrow between conspicuous tubefeet, and borne on distinct angle of plate. *Adambulacral plates*, although band-like, with a distinct aboral flange, an extension of the plate in the furrow connecting with and overlying adjoining plate. Besides the large,

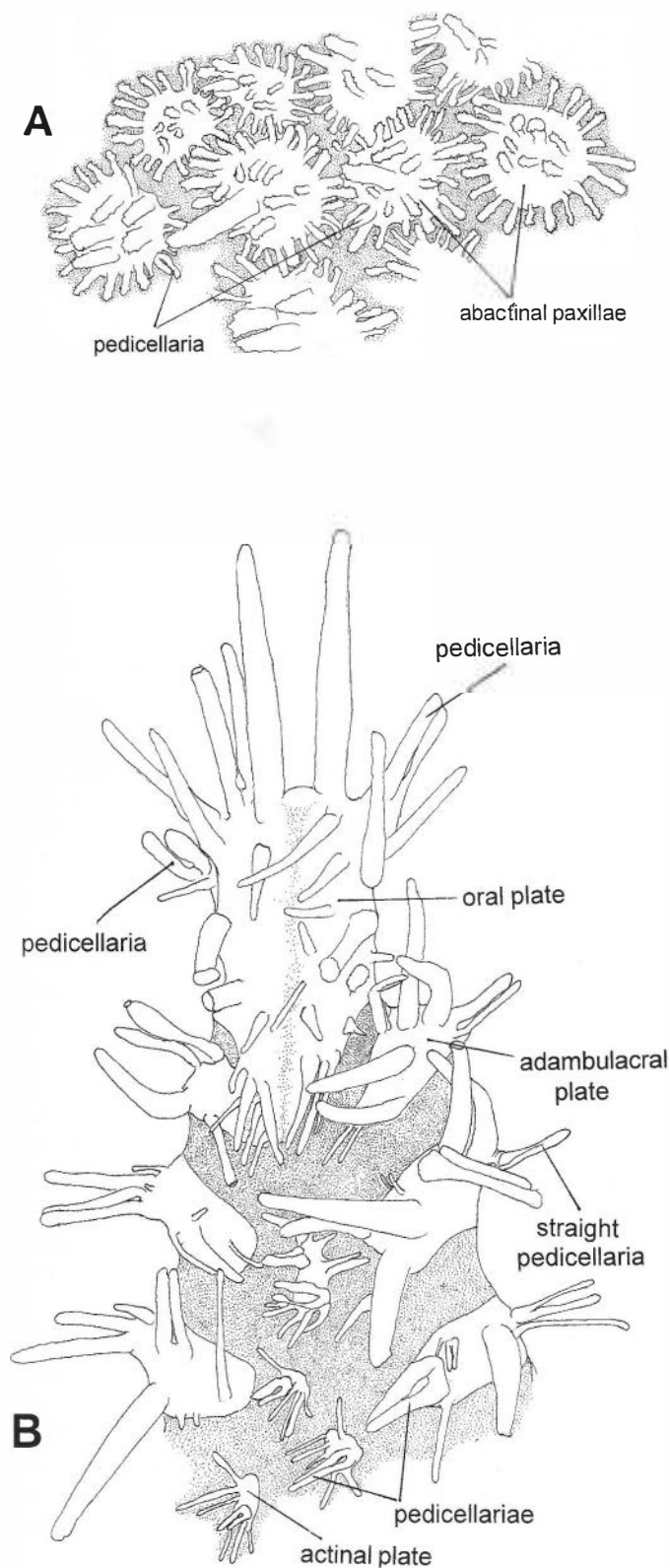


Fig. 5. *Luidia moroisoana* Goto. NZOI Stn I94. A. Abactinal paxillae. Note the small straight pedicellaria. B. Oral, adambulacral, and actinal plates.

slender straight pedicellaria deep in the furrow, there are a further 2 large recurved somewhat flattened spines which, with other spines and pedicellariae, form a conspicuous transverse row on plate. As many as 4 or 5 enlarged spines may be present on a plate and 1 or 2 large, straight pedicellariae; occasional very slender spinelets at base of large spines.

*Oral plates* conspicuous, well raised, rectangular; 2 plates in an angle separated by a broad, flat, membranous area. Deep in mouth, most anteriorly, generally a single, large bivalved pedicellaria, long, slender, round-tipped and flanked by a generally slender spine of similar length, and by 1 or 2 distinctly smaller bivalved pedicellariae; blades of these pedicellariae hollow and finely spiny. Furrow spines 4 or 5; the most anterior overhanging the mouth long, slender, tapering, blunt-tipped. A fringe of shorter suboral spines present on plate crests near membranous areas.

*Ambulacral grooves* obvious, broad, with tubefeet forming 2 very regular rows.

*Tubefeet* large, tapering, hollow and without definite suckers.

**COLOUR:** The present two dry specimens are white or pale cream with gold-brown tubefeet. Goto (1914: 301) recorded the colour of the type as abactinally "reddish brown... the other side being colourless." Hayashi (1973: 53) recorded the colour of his specimens in life as "light ochreous salmon".

**REMARKS:** The second specimen from the Capel Seamount (24°41' S, 159°37' E) in 291 m, comprises a disc (diameter 25 mm) and short remains of ten arms, there are also two small separate arm fragments; it is very similar to the specimen just described. However, on many of the abactinal plates, distinct bivalved straight pedicellariae are present, either centrally or marginally on the plates; these pedicellariae are short, squat, distinctive, generally only the tip of the two blades meet. Similar pedicellariae are present but fewer and less obvious in the specimen described. Hayashi (1973: 51) remarked on the small pedicellariae of the abactinal paxillae; Goto (1914: 305) did not record abactinal pedicellariae in the type material. The madreporite in the Capel Seamount specimen is interesting — it shows only because there is a crack or break in the disc — it is round, slightly raised and finely and deeply dissected; surrounding paxillae are considerably taller and extend well above it.

The type material is from Moroiso (Misaki), Sagami Bay, Japan and Hayashi's (1973) specimens are also from Sagami Bay. Rowe and Gates (1995) included the specimen described here (I94) as *Luidia avicularia*, following the synonymy by Jangoux (1981) (see also A.M. Clark 1989: 239, 244). The two species are



obviously very close and while both the present New Zealand specimens have superomarginal spines and Fisher (1919: 175) listed this as a major difference between the species, he also remarked on the presence of granuliform central spinelets in paxillae of *L. moroisoana*. In the present material (both specimens) central spines are not granuliform; pedicellariae of the ambulacral furrow definitely have straight jaws, and are not hooked over as Fisher recorded for *avicularia*. Following Fisher (1919) we consider *moroisoana* a valid species and herein resurrect it from its synonymy with *avicularia*.

Döderlein (1920) did not mention *Luidia moroisoana* but recorded and described *L. avicularia* from Sagami Bay; Hayashi (1973: 54) believed the specimens Döderlein identified as *L. avicularia* from Sagami Bay were probably *L. moroisoana*.

One arm (NZOI194) was dissected: abactinal plates, seen from the coelomic side, vary in shape; the marginal plates, however, are distinctly cross-like and fairly regularly arranged, forming a distinct series along the arm sides, with the aboral lobe covered by the adoral lobe of the following plate. Papulae show a very regular arrangement along the arm margins, with four papulae surrounding each cross-shaped marginal plate. Along the midline of the arms, plates are smaller and irregular in shape, size, and distribution; papulae here are very few and are probably absent from quite a wide area along the midline of the arms. The gonads are present as a rather irregular row of very tiny tufts on the marginal plates. Along the midline of the arms ambulacral plates form a conspicuous ridge; at the top of the crest (or ridge) the pair of plates are separated by a rectangular (almost shield-shaped) taut membranous area. Ampullae of tubefeet double and conspicuous and ambulacral plates near inferomarginals are divided into three distinct lobes. Superambulacral plates are strong and bar-like and pass from the lower end of the ambulacral plate, fairly steeply to the inferomarginals. At the lower end of the ambulacral plates, between the lobes, another plate is present. Perhaps this is part of the adambulacral plate.

*Luidia neozelanica* Mortensen, 1925 (Pl. 4, Fig. 6)

*Luidia neozelanica* Mortensen, 1925: 278, pl. 12(5), figs 5, 6; Fell 1952: 7; 1958: 2, 6; 1959: 132, fig. 7; 1962a: 19, fig.; 1962b: fig. 8c; 1963b: fig. 2B; McKnight 1967: 292, 297; H.E.S. Clark 1970: 10, fig. 1a, b; Rowe & Gates 1995: 75.

*Luidia* sp. Benham 1909: 6, pl. 10, figs 4, 5.

#### MATERIAL EXAMINED:

NZOI Stns: B480(1), B489(1)\*, B644(1), B666(2), B669(2), B672(2), B673(2), B687\*(7), C183(1), C184(2), C602(1), C640(1), C753(6), C851(1), D220(1), D267(1), E710(1), E746(2), F741(2),

F870(3), F887(1), F916(1), I2(1), I3(1)\*, I4(1), I6(4), I7(1)\*, I17(1), I64(1), I355(2), I356(1), P59(7), P61(2), P65(1), P122(1), P658(1), Q3B(1), S123(1)\*, S398(11), Z1928(1), Z2364(1)\*, Z2368(2)\*, Z2697(1)\*, Z2698(1)\*.

NMNZ: Ahipara Bay: Ech. 4384(6); near Aldermen Islands: Ech. 4370(2), 4373(3), 4379(1), 5218(1); Bay of Islands: Ech. 6255(1); Bay of Plenty: Ech. 1557(1), 1558(1), 4327(1), 4337(1), 4339(3), 4340(5), 4371(1), 4372(1), 4378(3), 4383(3), 4385(1), 7390(1); Cape Farewell: Ech. 951(1); Cape Turnagain: Ech. 5246(1); off Castlepoint: Ech. 4321(1), ?4322(1); near Cavalli Islands: Ech. 4382(1); Cook Strait: Ech. 4323(1), 5639(1), 6254(1); off East Cape: Ech. 1011(1), 4341(1); Hicks Bay: Ech. 4335(1); Hokianga Harbour: Ech. 1479(6); Kawhia Harbour: Ech. 4374(5); Kermadec Islands: Ech. 5219(1); near Mahia Peninsula: Ech. 4334(1); 4338(2); near New Plymouth: Ech. 4336(1); Norfolk Ridge: Ech. 4377(1); Poor Knights Islands: Ech. 4389(1); off Rangitikei River: Ech. 5640(1); Three Kings Islands: Ech. 5642(1); Tolaga Bay: Ech. 4376(1), 5245(1).

**SIZE:** Specimens of *Luidia neozelanica* are fragile and easily broken, making measurements difficult. Of the 153 specimens examined only 13 were entire; the average size for these was R/r = 53/16 mm. R varied from 12 to 124 mm, and r from 4 to 11 mm. One very long arm (no disc) 125 mm is recorded from just north of Puysegur Point, southern South Island.

**DISTRIBUTION:** The species is widespread around the North Island and especially common in the Bay of Plenty and along the east coast, extending north to the Three Kings Islands, Norfolk Ridge, and Raoul Island in the Kermadecs. It is not common around the South Island coast although there are two records from just north of Puysegur Point, southwestern South Island. It has also been collected from the Chatham Rise and it is known from New South Wales and Tasmania, Australia.

**DEPTH:** In New Zealand waters depth ranges from 58 to 898 m; Rowe and Gates (1995: 75) record depths of 5–490 m for Australian specimens.

**DESCRIPTION:** A specimen from NZOI B687 is described. R/r = 54/6 mm (measurements are approximate as the specimen with 5 intact arms has dried with arms upright).

*Arms* 5, strap-like, long, slender, tapering gently, especially in last half, to pointed tip. Arms more or less flat except near superomarginals where they are more rounded. *Arm tips* protected by distinct arch-shaped *terminal plates* with short, stumpy, finely thorny spines similar to those of neighbouring paxillae; small granules and occasional larger spines may be present.

*Abactinal paxilliform plates* oval, round, basally often distinctly 4-lobed, forming a close and even cover on disc and arms, most regularly arranged near superomarginals where they form regular transverse and



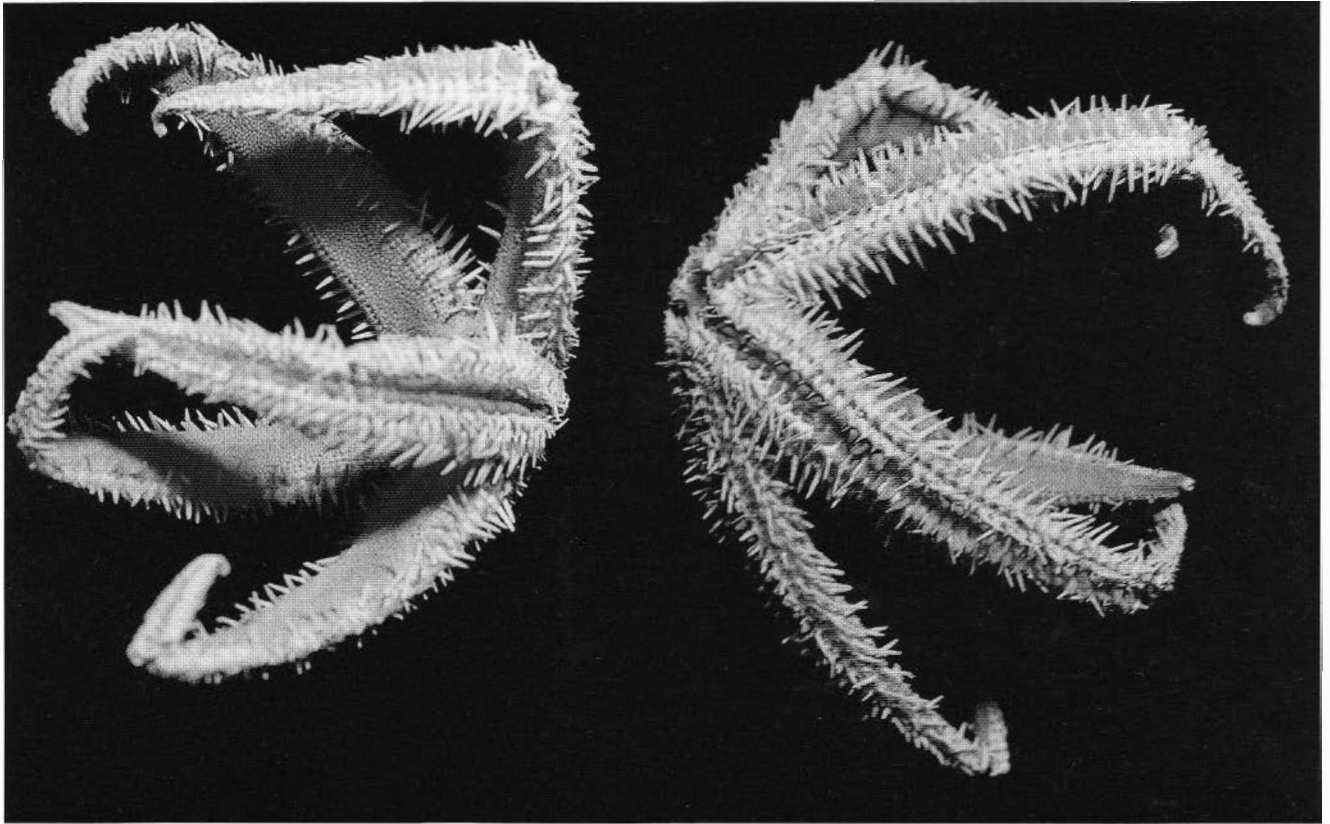


Plate 4. *Luidia neozelanica* Mortensen. NZOI Stn B687. R/r = 54/6 mm. Abactinal and actinal surfaces.

longitudinal rows. Elsewhere paxillae rather crowded, arrangement indistinct. Each paxilla with slender trunk expanding into oval (near arm edges) or more or less round (centrally) head, 10–15 or 16 well-spaced peripheral spinelets and 1–5 similar central spinelets, some distinctly taller. Paxillae are close-packed centrally on arms and disc.

*Papulae* very small, not obvious, present in membranous areas between plates along arm edges and absent from midline of arms and disc centre; apparently unbranched.

No abactinal *pedicellariae* or *madreporite* seen.

*Superomarginal plates* not obvious and easily confused with neighbouring abactinal plates. Inferomarginals form the ray edge; however, distally there are distinctly larger plates adjacent to inferomarginals; these are often almost crescent-shaped with 16 or 17 peripheral and 4 or 5 central spinelets and are presumably the superomarginal plates.

*Inferomarginal plates* distinct, band-like, well separated laterally from each other, forming arm edges. Plate centres more or less naked but fringed by slender spines that meet with neighbouring spines to form distinct fascioles; often 2, even 3 rows of slender spinelets along lateral face of each plate, and at least 2 large

conspicuous, sturdy, tapering, blunt-tipped spines alternating in position and either near to or away from abactinal surface (superomarginal plates) —this is a very distinctive arrangement. Occasionally, a third enlarged spine present or several smaller, but still long spines.

*Actinal* areas interradially small, almost triangular — near oral plates 2 or 3 round or oval plates surrounded by membrane, each bearing a single raised row of 3–6 slender spines, these round-tipped and less thorny than neighbouring inferomarginal spines of similar size. Slender ill-defined actinal plates along arms between inferomarginals and adambulacrals to near arm tips; these plates separated laterally by conspicuous, almost square or rectangular membranous areas. Occasionally small distinct bivalved straight *pedicellariae* on actinal plates interradially and along arms.

*Adambulacral plates* forming a very regular edge to furrow. Plates band-like, separated laterally by distinct membranous areas, each plate with generally 3, occasionally 4 or 5 spines in a row at right angles to furrow; innermost spine small, recurved and projecting over furrow between the tubefeet; second spine in the series longest and similar to inferomarginal

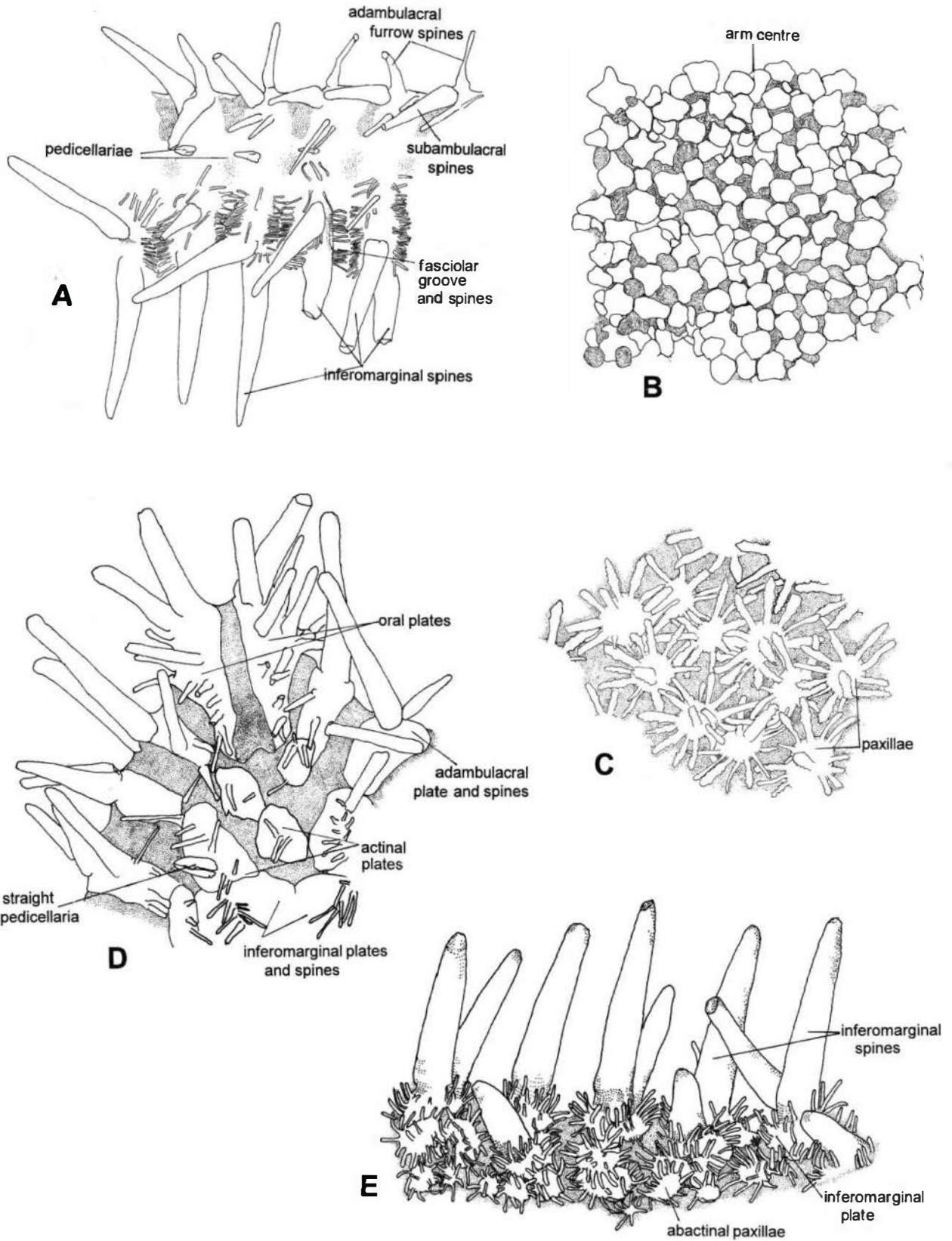


Fig. 6. *Luidia neozelanica*. NZOI Stn B867. A. Fasciolar grooves and spines. B. Abactinal plates from coelomic side. C. Abactinal paxillae near disc edge. D. Oral, adambulacral, actinal and inferomarginal plates and spines. E. Abactinal and superomarginal paxillae, inferomarginal plates, and alternate spines.



spines but less robust; between this enlarged spine and actinal edge of plate may be 1–3 further slender, but shorter, spines.

*Oral plates* broad, raised, the 2 plates widely separated by membranous area, each with 5 or 6 well-separated finely thorny furrow spines, round-tipped, sturdy, most anterior spines longest. Along plate crest, adjacent to membranous area, 5 or 6 slender suboral spines; occasional isolated spinelets elsewhere. All oral spines well-spaced from one another; no oral pedicellariae.

*Ambulacral grooves* wide, shallow, conspicuous.

*Tubefeet* biserial, no distinct discs; a wide central area between 2 rows of tubefeet. Position of first pair of tubefeet constant, each almost recessed, tucked hard against oral plate, remaining tubefeet more central forming a very regular biserial row to arm tip.

**COLOUR:** There are no colour notes of living material; dried and preserved specimens are a uniform light brown abactinally; actinally, lighter brown or white; tubefeet brown.

**REMARKS:** Probably the most obvious and constant feature of this species is the alternating position of the *upper inferomarginal spines* and the fact that all but one specimen examined had five arms; one small specimen (NZOI Stn P122) from near Cape Farewell has only four arms and four ambulacral grooves.

In the majority of specimens the *madreporite* is obscured by paxillae; occasionally, however, especially in larger specimens, the madreporite may be obvious. Thus, in a large specimen with R/r approx. 85/9 mm (NZOI Stn P59) from near East Cape, the madreporite is large, tumid, finely dissected and only partly hidden. Likewise, in larger specimens the *superomarginal plates* are often quite conspicuous and either rectangular or oval with more numerous spines than adjacent abactinal plates; these plates are often most obvious near arm tips.

*Pedicellariae*, their presence and abundance or absence, also vary greatly; they are generally present in larger specimens where they may occur on oral, actinal, and ambulacral plates. They are often present and obvious on oral plates, especially proximally and deep in the furrow, as Mortensen (1925: 280) recorded and illustrated (Mortensen 1925: fig. 6c). Occasional abactinal pedicellariae are also present as in a specimen from NZOI Stn B672 from the Aotea Seamount area.

The armature of the *actinal plates* is also very variable. Often a simple row of spines is present, sometimes a pedicellaria and occasionally, as in a specimen (NMNZ Ech. 4384) from Ahipara Bay, there are conspicuous club-shaped interradial actinal spines.

Most specimens are recorded from fine mud. Among

stomach contents were many crustacean limbs, a small ophiuroid (unidentifiable), sponge spicules, and tripterygian fish scales. Apparently the species has a very varied diet.

One specimen, R/r approx. 68/10 mm (NZOI Stn B687), was dissected. The arrangement of the *abactinal plates* seen from the coelomic side is interesting; plates are oval, gently lobed, almost square; centrally, along arms, plates form a very close pavement, near arm margins, plates are more distinctly lobed and membranous spaces between plates larger. *Papulae* are visible occasionally between plates along arm edges; they do not appear to be branched.

*Gonads*, as individual tufts, are present along the arms near the inferomarginal plates, and continue to arm tips and open individually; distally, along the arms gonadial tufts are more spaced. *Ambulacral plates* form a low keel along the arms; distinct, conspicuous bar-like superambulacral plates stretch from the lower part of the ambulacral plates to inferomarginal plates.

*Ampullae* of tubefeet are large and double, and interradial septa are *membranous*, strong, and well-developed.

*Luidia prionota* Fisher, 1914 (Pl. 5, Fig. 7)

*Luidia prionota* Fisher, 1914: 202; Marsh 1976: 216; A.M. Clark & Rowe 1971: 30, 44; Rowe & Gates 1995: 75.

**MATERIAL EXAMINED:**

NZOI Stns: K820(1), P1(1).

NMNZ: near Kermadec Islands: Ech. 4407(1), 5641(1).

**SIZE:** R/r in the present specimens varies from 27/7 mm to 70/9 mm. In the type specimen from near Antonia Island in the Philippines, R/r = 32/5 mm.

**DISTRIBUTION:** Known from the Philippine Islands, Western Australia and, this report, from the Kermadec Islands and Norfolk Ridge area. A.M. Clark and Rowe (1971: 30) also recorded it from the Red Sea, Southeast Arabia, and the Persian Gulf.

**DEPTH:** 7–451 m.

**DESCRIPTION:** Specimen described, NZOI Stn P1, from Norfolk Ridge area north of New Zealand has 5 arms, all arms separated from disc; arms and disc in good condition; R/r approx. 70/9 mm.

*Disc* small, sunken, irregular centrally. Arms not sharply distinct from disc, broad, tapering rapidly in last quarter to conspicuous round terminal plate, this covered by small, blunt-tipped, spinelets, finely thorny in last half.



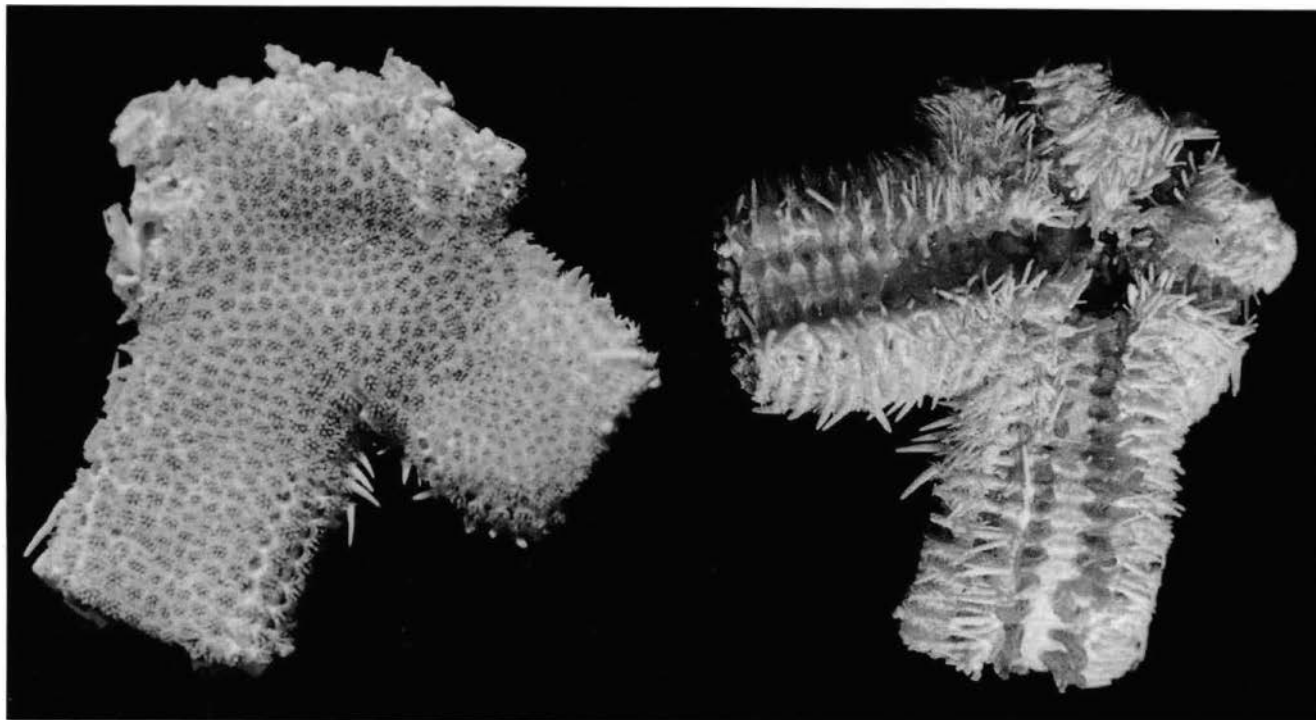


Plate 5. *Luidia prionota* Fisher. NZOI Stn P1. Abactinal and actinal surfaces.

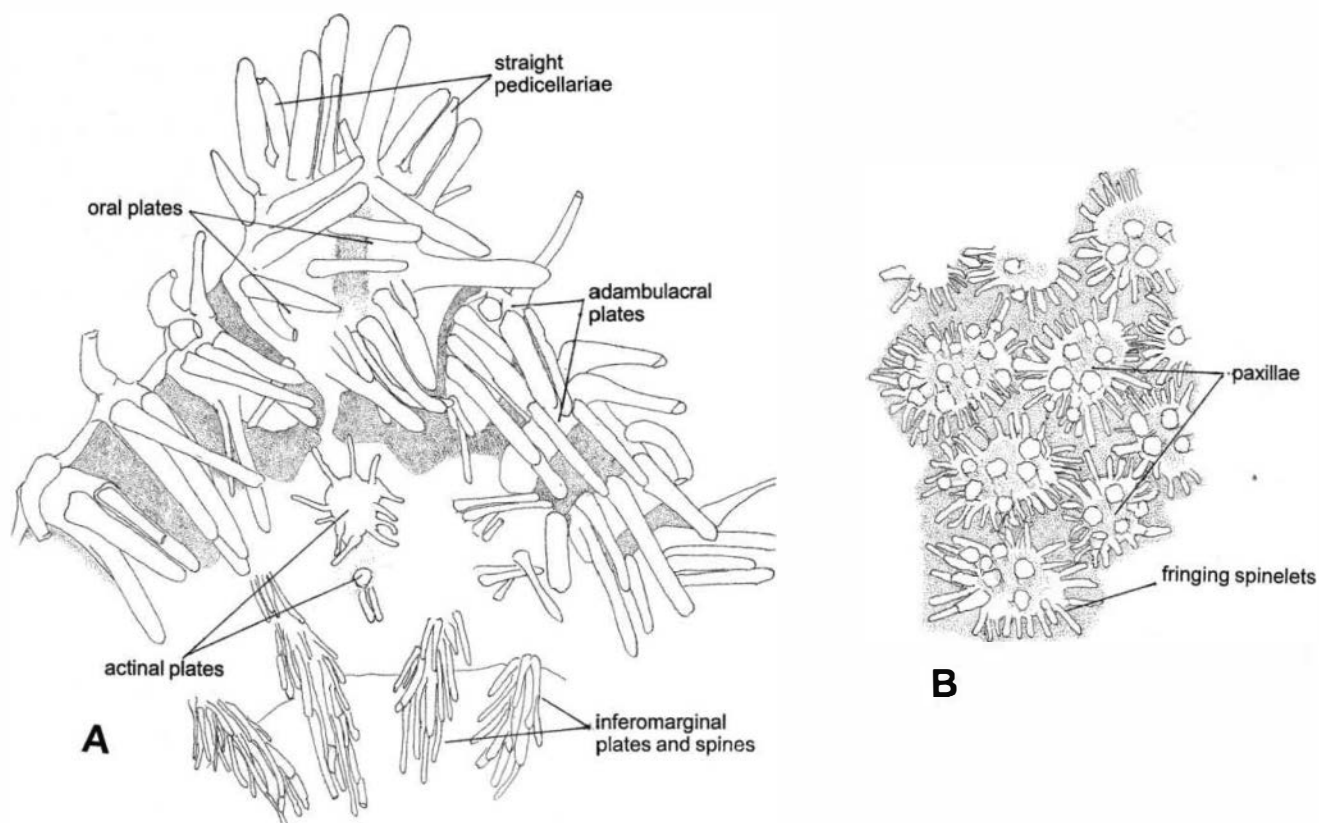


Fig. 7. *Luidia prionota* Fisher. NZOI Stn P1. A. Oral angle with oral, adambulacral, actinal, and inferomarginal plates. Note: wide membranous areas between adambulacral plates and distinctive large straight pedicellariae on oral plates. B. Abactinal paxillae, near disc edge.

*Abactinal plates* each with paxilla, forming a close cover on disc and arms; each paxilla has a distinct stem or trunk which expands into a round or oval head; this bears 14–26 (exceptionally 30) slender, thorny, blunt-tipped marginal spinelets well separated from each other and almost horizontal in position. They enclose from 6 to 7 to as many as 12 or 14 central spinelets, these small, thick-set, similar in size, well spaced, thorny, blunt-tipped, non-tapering. Along arms, paxillae smaller, spaced, oval or rectangular; most regular in arrangement along arm margins.

No *pedicellariae* (marginal, abactinal, adambulacral or actinal) seen; *madreporite* not obvious.

*Papulae* not seen on disc; however, along arms they are conspicuous, single, between plate lobes especially near arm margins.

*Superomarginal plates* not obvious, in 3 or 4 rows adjacent to inferomarginals which are regularly arranged; the row nearest inferomarginals is particularly regular and plates slightly larger than adjacent ones.

*Inferomarginal plates* long, slender, strap-like, well separated laterally from each other; they form a very regular edge to disc and arms and extend onto abactinal surface. Inferomarginal plates bear 1 enlarged, slender, blunt-tipped, slightly flattened spine; this present near abactinals. Single enlarged inferomarginal spines stand out from plates and form a regular edge to abactinal surface; spines generally incline slightly towards arm tip, as long as or slightly longer than inferomarginal plates. Near arm tips spines shorter, less distinct. Small, slender spines are also present on inferomarginal plates; at least 2 of these may be slightly enlarged. Distally along arms inferomarginal spines are shorter, thicker and plates correspondingly smaller. Distinct fascioles present, lined with fine slender spinelets.

*Actinal areas* small, unfortunately damaged in this specimen; at least 1 or 2 actinal plates present in each interradius, each plate with a tuft of slender, well-spaced spines. These plates small, rectangular, naked, continuing out along arms for at least half arm length; they form regular transverse rows with adambulacral and inferomarginal plates.

*Adambulacral plates* L-shaped, with foot of 'L' connecting along the furrows with the following plate; plates precise, well separated laterally from each other by distinct membranous areas. Each plate with a long, slender, slightly recurved furrow spine, behind this a cluster of 4 or 5 similar, straight and more sturdy blunt-tipped spines; spine adjacent to actinal and inferomarginal plates is often conspicuously more slender.

*Oral plates* distinct, swollen, short, 2 plates in an angle, separated by a wide membranous area. Anteriorly low down on plate, overhanging mouth, is a conspicuous long, straight, bivalved pedicellaria; near

this is a small, blunt, fast-tapering spine. Four to 6 spaced furrow spines proper present with a row of 3 or 4 shorter suboral spines on either side of raised membranous area.

*Ambulacral grooves* broad, shallow with tubefeet in 2 very distinct, regular rows.

*Tubefeet* long, slender, tapering, transparent, no obvious sucker; most anterior pair of tubefeet more widely separate; each tubefoot occupies a distinct niche at base of oral and first adambulacral plate (a similar misalignment is seen in *L. neozelanica*).

**COLOUR:** No colour notes of living material; dried and in preservative, central area and spines of abactinal paxillae golden-brown, with fringing spines white or pale cream. Tubefeet golden-brown.

**REMARKS:** Two arms of the specimen described (NZOI P1) were dissected; in both the ambulacral ridge is almost flat. Although the plates are well developed, there is very little elevation where plates meet from either side, and the membranous area between plates is small. Ampullae of tubefeet are conspicuous and double. Superambulacral plates are present and well developed. They reach up to a surprisingly steep angle to meet the inferomarginal plates (in other asteroids and in other species in the genus *Luidia* the superambulacral plates pass from the ambulacral ridge steeply down to the inferomarginal plates). Possibly this curious lack of height results from the preservative used, although the specimen and the ambulacral plates appear to be normal, in no way deformed or altered. Gonads appear as regular tufts along arm edges. Possibly the extreme flatness of the ambulacral plates is connected with the burrowing ability of these sea-stars.

The smaller specimen (NZOI K820, R/r = 29/30 mm), from the Kermadec Islands, is very similar to that described with the single inferomarginal spine present at the abactinal edge of the plate; the distinctive colour of the abactinal paxillae is also similar. There are no pedicellariae present apart from those of the oral plates; the slender, recurved adambulacral furrow spines often meet with neighbouring spines from across the groove. One actinal plate in this smaller specimen is present in each interradius. It is raised and round, with a radiating bunch of 7 or 8 well-spaced slender spinelets. Surprisingly, dissection of one arm showed a well developed high ambulacral ridge, with superambulacral plates reaching down to the inferomarginals and an ill-defined membranous area between ambulacral plates dorsally.

*Luidia prionota* is sometimes regarded as a synonym of *L. hardwickii*; Rowe and Gates (1995: 75) retain *prionota* but remark that L.M. Marsh considers it to be a synonym of *L. hardwickii*. The present authors prefer



to retain the two species as the absence of adambulacral pedicellariae and differences in the inferomarginal plates are regarded as important; neither do we have other material for comparison.

### Family **ASTROPECTINIDAE** Gray, 1840

Astropectinidae Gray, 1840: 180; Norman 1865: 115; Gray 1866: 2; Perrier 1875: 249; Viguier 1878a: 225; 1878b: 683; Perrier 1883: 266; Sladen 1889: 174; Bell 1892: 850; 1894: 193; Verrill 1899: 201, 218; Fisher 1911a: 37; Verrill 1914: 314; 1915: 151; Döderlein 1917: 1; Fisher 1919: 59; Koehler 1921: 44; 1924: 186; Mortensen 1927: 54; Tortonese 1936a: 15; H.L. Clark 1946: 72; D'yakonov 1950: 17 (English translation, 1968); Tortonese 1965: 129; Spencer & Wright 1966: U45; Tommasi 1970: 5; Downey 1973: 26; A.M. Clark & Courtman-Stock 1976: 47; Walenkamp 1976: 14; McKnight 1977: 114; A.M. Clark 1989: 248; A.M. Clark & Downey 1992: 22; Rowe & Gates 1995: 46.

Arms generally 5, disc and arms well defined by marginal plates; supero- and inferomarginal plates form a distinct and generally vertical edge to disc and arms. Marginal plates, especially inferomarginals, often with conspicuous spines. Marginal plates separated by distinct channels, fascioles, which are lined with slender, rather flattened spinelets. Central epiproctal cone often present, especially in small specimens. Abactinal paxillae well developed; papulae generally also restricted to interradial areas. Adambulacral plates well separated from each other with often an angular projection into furrow; both furrow and subambulacral spines well developed. Biserial tubefeet long, slender and either tapering to pointed tip or with small terminal button. Pedicellariae of a simple fasciolar type sometimes present on some or all plates, even the adambulacrals. Internally, ampullae of tubefeet large and double and superambulacral plates well developed.

The family Astropectinidae has a long fossil history and is known from the Lower Jurassic; no New Zealand fossil astropectinids are recorded. This large family has a worldwide distribution and is known from the shallow subtidal to great depths. Three subfamilies are sometimes recognised; of these, two — the Astropectininae, shallow in distribution, and the Plutonasterinae from deep water — have New Zealand representatives.

Members of this family are renowned for their carnivorous habits; certainly the present specimens fed on gastropod and bivalve molluscs and occasional small crustaceans; stomach contents, where identified, are discussed under the species concerned.

### TABULAR CHECKLIST FOR NEW ZEALAND GENERA OF ASTROPECTINIDAE

- 1 Interradii  
r – rounded  
a – angular
- 2 Madreporite either naked and obvious or hidden, covered by paxillae  
n – naked  
c – covered, hidden
- 3 Paxillae – arrangement  
i – irregular  
r – regular, forming straight rows
- 4 Marginal plates of similar height, or inferomarginals considerably larger  
s – of similar height  
l – inferomarginals longer than superomarginals
- 5 Superomarginals with enlarged, generally conspicuous spines, or no enlarged spines present  
p – enlarged spines present  
a – enlarged spines absent
- 6 Inferomarginal plates with enlarged spines, or plates lack obviously enlarged spines  
p – present  
a – absent
- 7 Actinal areas large, moderate, or small, restricted  
l – large, extensive  
m – moderate  
s – small, restricted
- 8 Number of adambulacral furrow spines
- 9 Free edge of adambulacral plate  
r – rounded  
a – angular
- 10 Pedicellariae (generally straight)  
p – present  
a – absent

### *Astromesites* Fisher, 1913

*Bollonaster* McKnight 1977: 115.

Disc well defined, arms 5, arms tapering evenly to sharp tips. Marginal plates large, conspicuous, tumid, forming an obvious and often vertical edge to disc and arms and separated laterally by distinct, well-defined fascioles. Superomarginals with regularly arranged granules, no enlarged spines; inferomarginals with an oblique comb of enlarged spines which lie flat against the plates. Actinal plates distinct, well developed; actinal plates present (generally a single series) between adambulacrals and inferomarginals for some distance along arms. Actinal plates with spinelets and



	1	2	3	4	5	6	7	8	9	10
<i>Astromesites</i>	r	n	r	s	a	p	m/s	3-9	r/a	a
<i>Astropecten</i>	a	n	r	s	p/a	p	l	3	r/a	p/a
<i>Dipsacaster</i>	r	c	r	l	a	p	m/s	8-10	r	a
<i>Dytaster</i>	r	c	r	s	p	p	l	5-10	r/a	p
<i>Plutonaster</i>	r	c	r	s	p/a	p	l	5-10	r/a	p/a
<i>Proserpinaster</i>	a	n	r	s	p/a	p	m	6-8	r/a	p/a
<i>Psilaster</i>	a	n	r	s	p/a	p	l	6-10	r/a	a
<i>Tethyaster</i>	r	n	r	s	a	p	s	3-5	a	p/a

often also an enlarged, flattened, recumbent spine. Adambulacral plates with angular furrow margin, furrow spines distinct, subambulacral spines numerous. Oral plates large, convex, with many sub-oral spines and enlarged apical spines.

TYPE SPECIES: *Astromesites compactus* Fisher, 1913

REMARKS: The type species is from southern Luzon in the Philippines. Rowe and Gates (1995) recorded specimens from southeastern Australia and it is now also known from northern New Zealand. The discovery of a second local species, *A. regis* n. sp., described here, suggests that the presence of unpaired interradial actinal plates is of specific importance only. *Bollonaster*, with *B. primigenius* as type, was erected by McKnight (1977); we now include the genus in *Astromesites*.

*Astromesites* is similar to *Psilaster* in general appearance but lacks the distinct, long, narrow, and well-ordered oral plates. *Proserpinaster* Fell is also closely related but has enlarged superomarginal spines.

Both *A. compactus* and *A. primigenius* have internal intermarginal pores, and in both species pores lie opposite every second superambulacral plate; as the single specimen of *A. regis* was not dissected, the position and occurrence of these pores is not known. Rowe and Gates (1995) included *Astropecten pectinatus* (with synonyms *A. schayeri* and *A. syntomus*) in *Bollonaster*; unfortunately we have no material for comparison.

#### TABULAR CHECKLIST TO SPECIES OF *ASTROMESITES*

	1	2	3	4	5
<i>Astromesites</i>					
<i>compactus</i>	p	y	t	s	n
<i>primigenius</i>	p	n (y)	t	n	f
<i>regis</i> n. sp.	a	y	s	n	n

- 1 An unpaired row of actinal plates is  
p - present  
a - absent

- 2 Arms long, slender, rather rigid, rapidly and evenly tapering  
y - yes  
n - no
- 3 Paxillae of abactinal plates,  
t - very trim, with short spines  
s - "shaggy" spines long, slender
- 4 Hyaline granules present and obvious on some distal superomarginal plates  
s - seen  
u - unseen
- 5 Adambulacral furrow spines  
f - few, 3, 4  
n - more numerous, 7, 8, 9

#### *Astromesites compactus* Fisher, 1913 (Pl. 6, Fig. 8)

*Astromesites compactus* Fisher, 1913: 611; 1919: 107, pls 19(1), 24(3), 25(2), 26(2), 31(4), 35(2, 2a-d); Jangoux *et al.* 1989: 167; A.M. Clark & Downey 1992: 23; Rowe & Gates 1995: 46.

#### MATERIAL EXAMINED:

NZOI Stns: I11(1), I346(1), I35 (1), I359(1), Z8255(1).

SIZE: In the five specimens in the present collections, R varies between 42 and 100 mm, and r between 10 and 18 mm; the R/r average for these five specimen is 65/14 mm.

DISTRIBUTION: This is the first record of *Astromesites compactus* in New Zealand waters, found along the east coast from North Cape (NZOI Stn I346, 34°42'S) to east of Great Barrier Island (NZOI Stn Z8255, 36°06'S). The type specimen is from Verde Island Passage, north of Mindoro in the Philippines, and the species is also known from New South Wales, Victoria, and Bass Strait in Australia in 183-540 m. Jangoux *et al.* (1989) recorded it from near Sumba in Indonesian waters.

DEPTH: 3-540 m.

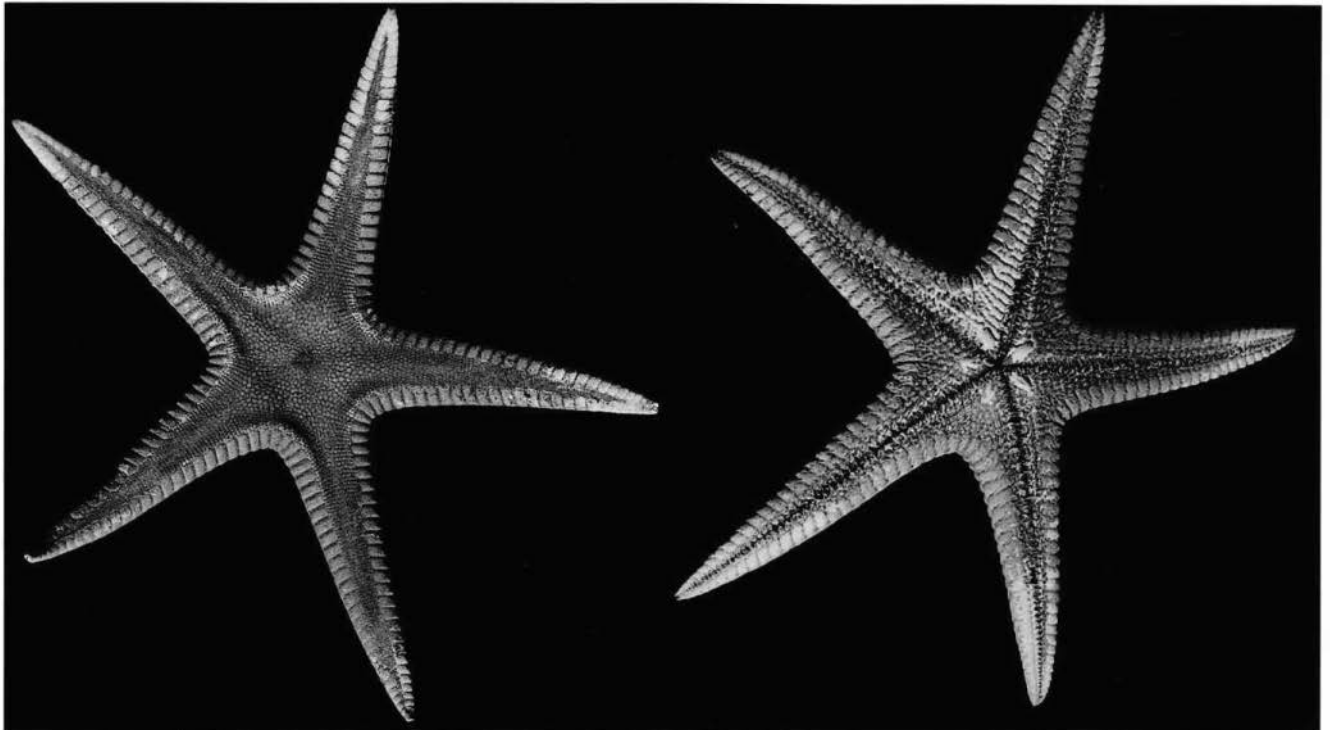


Plate 6. *Astromesites compactus* Fisher. NZOI Stn I11, R/r 64/16 mm. Abactinal and actinal surfaces.

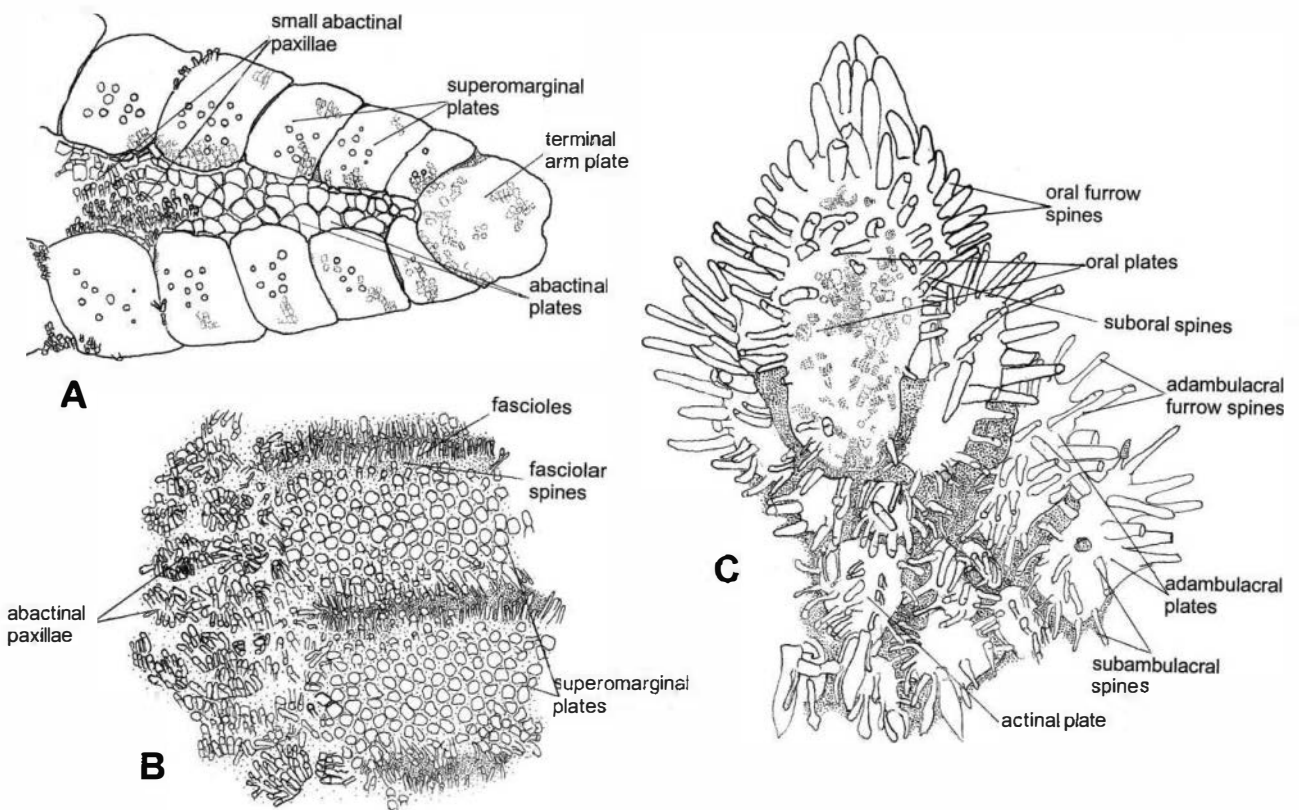


Fig. 8. *Astromesites compactus* Fisher. NZOI Stn I11. A. Arm tip and associated superomarginal plates. Abactinal plates largely without spines. B. Superomarginal plates, abactinal paxillae, and fascioles. C. Oral, adambulacral, and actinal plates.



DESCRIPTION: A specimen from NZOI Stn I11 north of Great Barrier Island with R/r = 64/16 mm is described.

*Disc* large with slight, central localised swelling; arms long, slender, tapering, *terminal plate* almost pentagonal; terminal plates may have born small spinelets or granules as faint, raised scars remain; no enlarged spines.

*Abactinal paxillae* form fairly regular rows laterally along arms; generally 3 rows of paxillae correspond to 1 superomarginal plate. Paxillae round, oblong, sometimes almost square, with very short trunk that expands into flat or gently raised head; this bears a close cover of short, upright non-tapering spinelets. Along edges of disc and arms paxillae consist of 20–35 short, similar, close-set, generally flat-tipped spinelets; difference between marginal and central spinelets slight. At disc centre paxillae small, with 17–20 spinelets; further out on disc, paxillae larger, with about 40 spinelets and outline less distinct; paxillae closely crowded; paxillar spinelets very finely spinulose.

*Papulae* not obvious.

*Pedicellariae* not seen.

*Madreporite* interradial, nearer marginal plates, coarsely dissected with high narrow ridges, and pores just visible between ridges.

*Anus* central, on slight mound at disc centre.

*Superomarginal plates* not confined to arm margins, almost three-quarters of superomarginal plate visible near arm tip; superomarginals from opposite sides of arm do not meet. Plates very regularly arranged, gently tumid, separated laterally by deep *fasciolar grooves* which are less obvious distally; plates have close regular rows of very finely spinulose flat-topped granules; near plate edges and in grooves definite long, slender, well-spaced fasciolar spinelets are present. No enlarged spines on superomarginal plates; however, in the last quarter of the arm distinct, well separated, round *hyaline granules* are present, especially obvious where covering granules have been removed; from 3 to as many as 8 or 9 are present.

*Inferomarginal plates* corresponding with superomarginals and just visible from abactinal surface; they form a very regular edge to actinal plates. Plates bear small round-headed or flat-topped regularly arranged granules (or very short spinelets) similar to those of superomarginal plates although more spaced, longer, and finely fluted around edges. Bordering spinelets and those in marginal fascioles considerably longer and more slender, forming very regular rows. Inferomarginal plates with 6–8, enlarged, flattened, long and conspicuous *spines*; these not generally present near actinal plates but often form a distinctly curved row adjacent to superomarginals. In interradial angle on first 2 or 3 plates a row of these enlarged spines is often present on either side of the plate. Further out along arms only 1 row of enlarged spines; each, of more or

less similar length, lies flat across distal edge of plates and projects against the rather rounded edge of the superomarginals; these spines often broken. Often a distinct gap between uppermost curved and regular series of spines and the 2 or 3 enlarged spines nearest the actinal and adambulacral plates. Hyaline granules also obvious, after clearance of covering granules, on inferomarginal plates in last quarter of the arm.

*Actinal areas* well defined, quite large; plates continue along arms between adambulacral and inferomarginals for at least half arm length. Interradially, actinal plates gently tumid and fairly regularly arranged; a pair of plates at base of oral plates and below this a single row of rather irregularly shaped plates that extends to the inferomarginals. Actinal plates fringed by very well-spaced long, slender, slightly flattened and round or flat-tipped spinelets; these surround a number of similar, well-spaced, perhaps slightly thicker central spinelets; actinal spinelets lean towards marginal plates. Most plates, especially centrally, also bear a conspicuous, enlarged long, slender tapering spine; generally only 1 of these enlarged spines to a plate; very occasionally a second spine present. Enlarged spines generally absent from plates adjacent to adambulacrals and inferomarginals. The enlarged spines also lean towards marginal plates. Ill-defined fascioles present between some actinal plates which lie adjacent to inferomarginals.

*Adambulacral plates* forming a conspicuous edge to narrow furrow rectangular, short edge to furrow; furrow edge gently round or distally more angular; plates separated laterally by distinct band-like membranous intervals, these less obvious and very narrow towards arm tips. Furrow spines 6–8, slightly flattened, round-tipped, untapering, narrow edge to plate and furrow, most distal furrow spine on plate slightly larger, more conspicuous, also flattened but with broad side to furrow and plate. Subambulacral spines spaced and essentially similar to, but shorter than furrow spines; they form 3, 4, even 5 irregular rows, and spines shortest near actinal plates. *Adambulacral furrow spines* meet with opposite spines across deep furrow.

*Oral plates* tumid, especially near actinal plates where there is a steep pronounced rise. Posteriorly, plates rather long, narrow, then broadening in a sweeping curve to large anterior furrow spines; most anterior furrow spines sturdy, strong, almost triangular, conspicuous; 10 or 12 smaller, shorter furrow spines flattened, thin edge to plate and mouth, spaced, quite conspicuous, becoming shorter near curve of plate. Also shorter, suboral spines in rather irregular rows on rest of plate; the 2 plates in an angle are separated for the first half by a regular muscular interval, then meet; an irregular small, triangular, muscular area between plates, near actinal areas. Most anterior adambulacral

plates on either side of oral plates larger than adjacent adambulacrals and slightly curved; plates project well into furrow.

*Ambulacral grooves* well-defined, narrow, with tapering *tubefeet* in 2 regular rows.

**COLOUR:** There are no colour notes of living specimens; dried specimens are a uniform grey-brown or (NZOI Stn Z8255) creamy-white.

**REMARKS:** The other four specimens are very similar to the specimen described; all have 5 arms. In the two smallest specimens in the present collection it is very difficult to see hyaline granules on the distal marginal plates; in the smallest specimen (NZOI Stn I356) with  $R/r = 42/10$  mm they are just noticeable and very small.

One specimen (NZOI Stn I359,  $R/r = 76/17$  mm) was dissected. Ampullae of tubefeet are double and superambulacral plates are present and conspicuous; superambulacral plates are not present on the two most proximal ambulacral plates; beyond these they are distinct and really constitute the proximal flange of the ambulacral plate, passing across to the inferomarginal plates. Distinct internal intermarginal pores are present. These are well spaced, proximally quite large, and present between the marginal plates at the tip of every second superambulacral plate; this is very characteristic. Distally, near arm tips, the pores are indistinct. Interradial septa are membranous, strong and tall and apparently reach the abactinal plates. Partial septa are also present on either side of the interradial septum, and do not extend into the arms. The stone canal is obvious and strong, and strengthened by a mosaic of calcareous plates. There seems to be only one polian vesicle in each interradius, although it is difficult to see whether a second vesicle is present in the interradius with the stone canal. Large conspicuous interradial pores are present on either side of the odontophore and at the base of the first ambulacral plate. Small finely branching gonads are attached to the abactinal plates on either side of the interradial septum and probably open abactinally.

Centrally on the disc there is a heavy membrane which obscures plate outlines; along the arms plate outlines are more distinct, especially marginally. Along arm margins abactinal plates are more or less oval and show a regular arrangement in slanting rows; these plates often have a small central swelling and are generally surrounded by 6 papular pores. Centrally along arms abactinal plates are similar in shape but form a close network; no papulae are present. The oral spines, seen from the coelomic side, are broad, flat, and numerous. An interesting feature, after dissection and when examining the abactinal plates from the coelomic side, is the presence of 2 additional septa, 1 on either

side of the interradial septum in each interradius; these seem to be attached to the abactinal plates and are somewhat fragmented.

*Astromesites primigenius* (Mortensen, 1925) n. comb.  
(Pl. 7, Fig. 9)

*Astropecten primigenius* Mortensen, 1925: 272, pl. 12 (1, 2), text-figs 2a-c, 3; Fell 1958: 4; 1959: 131; 1960: 59; McKnight 1967: 297; H.E.S. Clark 1970: 3; Fenwick & Horning 1980: 438, 443; A.M. Clark 1989: 286.

*Bollonaster primigenius* McKnight 1977: 115; Rowe & Gates 1995: 50.

**MATERIAL EXAMINED:**

NZOI Stns : A704(11), A82(1)\*, A843(1), A844(2), A866(1)\*, A870(1)\*, A898(1)\*, A900(1)\*, B196(1), B197(1), B487(6), B488(1), B515(6), B567(1), B577(3), B578(1), B581(1), B588(1), B589(1), B590(8), B591(8), B592(3), B594(1), B609(1), B615(1), B616(1), B638(1)\*, B675(1)\*, C601(2), D78(4)\*, D81(1)\*, D100(1)\*, D131(1)\*, D133(5), D139(1), D144(1), D151(5), D152(3), D154(9), D170(1)\*, D172(1)\*, D173(3), D203(1)\*, D876(1), E124(1), E127(2), E139(1)\*, E140(1), E407(1), E820(1), E821(1), E832(25), F77(1), F93(2), F97(10), G680(1)\*, G690(2), G881(7), G882(1), G883(16), G884(20), G89(4), I708(2), I711(4), I714(2), I718(8), I719(1), J54(1), J55(1), J686(1), Q16(1), Q19A(1), S134(6), T58(1), T47(1), V381(2)\*, W434(6), Y39(1).

NMNZ: near Auckland Islands: Ech. 4433(1), 4439(1), 4440(1); Cook Strait: Ech. 4441(1); Doubtful Sound: Ech. 5649(2); Mernoo Bank and slope: Ech. 642(1), 4434(1), 4436(2), 4437(1), 5510(1); near Nugget Point: Ech. 2390(14), 2649(4), 3099(1); off Oamaru: Ech. 508(1); Otago: Ech. 4302(3), 4310(1), 4312(1), 4318(1), 4431(2), 5226(2), 5227(2), 5258(1); Papanui Canyon: 5224(1), 5227(2), 5258(1); Bay of Plenty: Ech. 4435(2); Puysegur Point: Ech. 2650(2), 6332(1); Snares Island area: Ech. 2012(8), 2014(8), 2015(2), 2169(1), 5650(5); Solander Trough: Ech. 4438(1).

**SIZE:** Size ranges from  $R/r = 70/17$  mm (NMNZ specimen, Ech. 5224, from Papanui Canyon) to  $R/r = 7/3$  mm (NZOI B591, from near Snares Island). The average  $R/r$  for 70 specimens was  $34/9$  mm. In the type material  $R/r = 28/9$  and  $16/6$  mm.

**DISTRIBUTION:** The type material (Mortensen, 1925) is from near Cuvier Island off the Coromandel Peninsula in 55 m. There are two further records from the Bay of Plenty, both from near Mayor Island. The first (NMNZ Ech. 4435) is from 616–666 m and the second (NZOI Stn J686) from 194 m. A further specimen from NZOI Stn B675 north of Auckland is recorded but cannot be checked as the specimen is missing. Two further North Island records are from the Cook Strait area, NMNZ Ech. 4441 from 119–132 m, and NZOI Stn T478 (one specimen) from 93 m. The species is common from the Christchurch area south to the Snares and Auckland Islands and there are also NZOI records from near



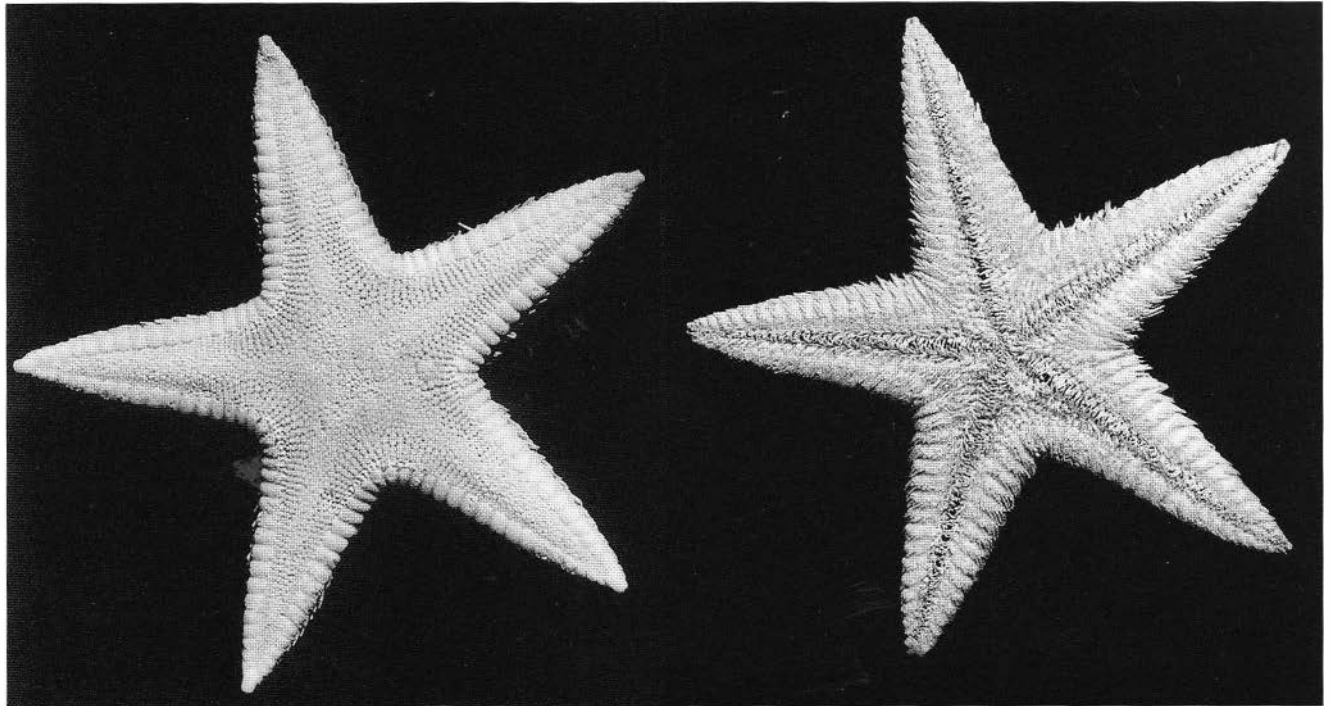


Plate 7. *Astromesites primigenius* Mortensen. NZOI Stn F97, R/r = 37/10 mm. Abactinal and actinal surfaces.

Campbell Island — unfortunately these specimens are not present and cannot be checked. The species is also known from east of New Zealand, from Chatham Rise, and Chatham and Bounty Islands.

DEPTH: Most specimens are from depths between 100 and 200 m, however a specimen (NMNZ Ech. 3099), from south of Dunedin (near Nugget Point) is recorded from 770 m. The depth ranges from 55 to 770 m.

DESCRIPTION: A specimen from near the Snares Islands, NZOI Stn F97, in 134 m, with R/r = 37/10 mm, is described.

*Disc* large, flat, well defined by marginal plates. Arms 5, also flat, broad basally, tapering evenly to sharp tips which are protected by irregularly rectangular, conspicuous, robust *terminal plates*; all 5 plates in this specimen naked but faint scars remaining in fairly regular rows; near abactinal plates a few, small, spaced, round-headed, finely thorny spinelets present; no enlarged spines but faint, larger scars suggest these may have been present at free tip of plate.

*Abactinal plates* form conspicuous regular rows along arm and disc edges; 5 or 6 plates and paxillae present; near arm tips rows are short with seldom more than 2 paxillae. Abactinal plates lobed, paxillar trunk short, round-headed, with 9–18 short, finely thorny, granules or spinelets surrounding similar short, spaced, thicker and more sturdy spinelets; sometimes only 1 central

thickened spinelet. On disc centre paxillar trunks are shorter, broader and often plates are irregular in size and shape.

*Papulae*, small, rounded, regular and conspicuous between dorsolateral rows of plates on disc and arms; 4–6, occasionally 7, present at plate bases. Papulae absent from disc and midline of arms.

No abactinal *pedicellariae* or *epiproctal* cone.

*Madreporite* interradial, conspicuously and distinctly raised, separated from superomarginal plates by 2 or 3 rows of paxillae, round, finely and narrowly dissected, with ridges meeting centrally; fringed by paxillae.

*Anus* a small opening centrally on disc, almost hidden by surrounding paxillae.

*Superomarginal plates* form a well-ordered, slanting and very regular edge to disc and arms and are very obvious abactinally; 18 or 19 plates present from interradial angle to arm tip. Interradial superomarginal plates paired, rectangular, distinct and well separated by *fasciolar grooves* which are lined by fine, slender spinelets. Plates bear small round-headed well-spaced spinelets; no enlarged spines; near junction with inferomarginals, granules slightly larger, more conspicuously rounded.

*Inferomarginal plates* correspond with superomarginals, most obvious actinally, well separated laterally by deep, distinct fasciolar grooves. Plates bear 6–8 rather flattened tapering enlarged spines in a vertical row, more or less along the plate midline.

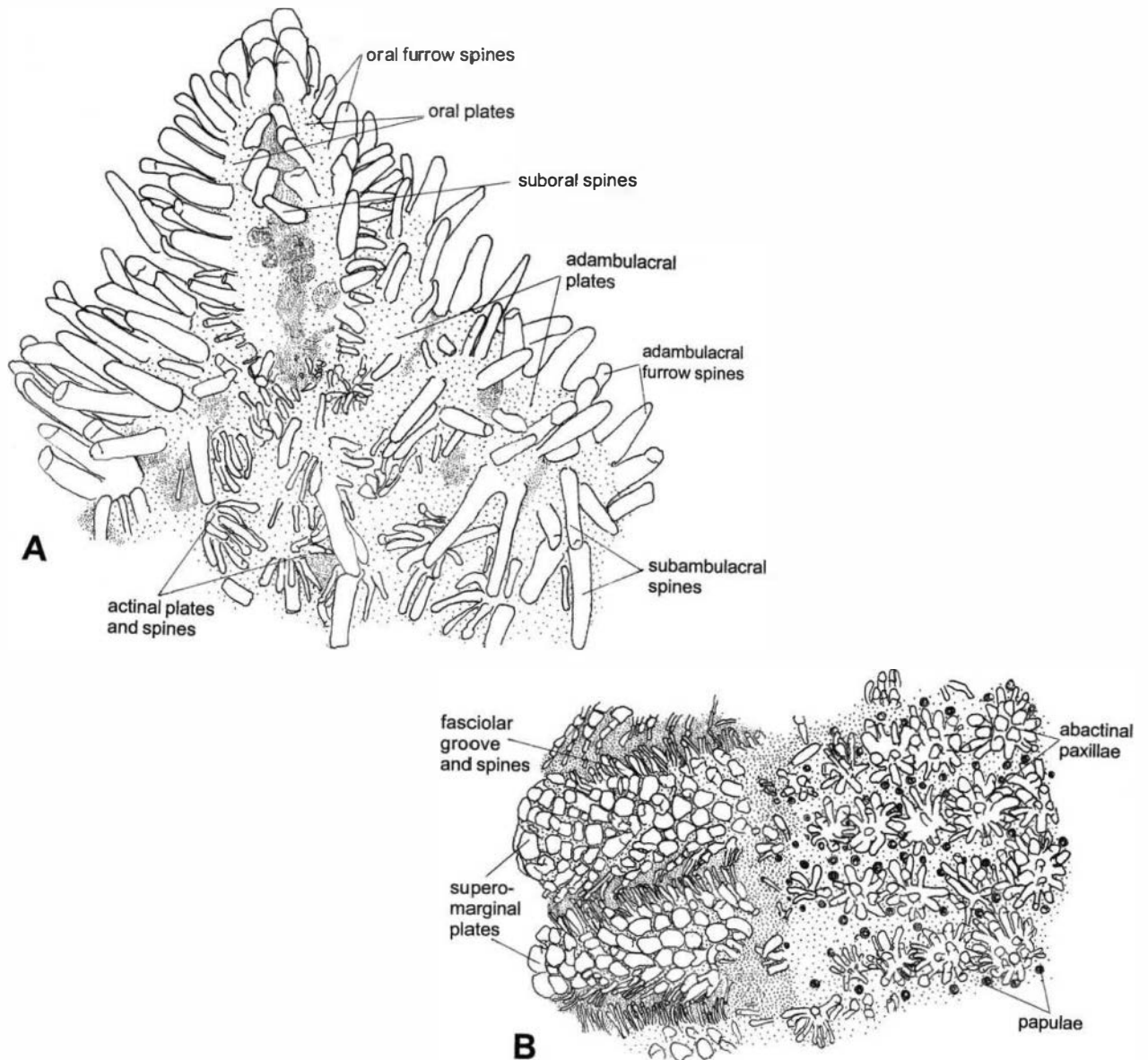


Fig. 9. *Astromesites primigenius* Mortensen. NZOI Stn F97. A. Oral, adambulacral, and actinal plates and spines. B. Superomarginal plates, fascioles and fasciolar spines, abactinal paxillae, and papulae.

Spines lie flat on plate and form a slightly oblique row pointing towards arm tips; slender, spaced spines between enlarged spines, these latter spines distinctly longer and more slender in the fasciolar grooves.

*Actinal areas* distinct, well developed; plates interradially in fairly regular rows, gently raised, with well-spaced, round-tipped, finely spiny spinelets and generally 1 (occasionally 2) enlarged, tapering, flattened, conspicuous spines pointing towards margin. Actinal plates and spines continue between adambulacrals and inferomarginals for some distance along arms. Distal actinal plates small, ill-defined, often overlooked, with few spines and no enlarged spines;

in this specimen, small plates are present to level of 12th inferomarginal plate (from interradial angle) and the 24th, 25th adambulacral plate. On first 2, occasionally 3, plates adjacent to oral and first adambulacral plates, tips of slender spines meeting together, forming incipient *spiniform pedicellaria*.

*Adambulacral plates* form regular edge to furrow; plates rather narrow, short, with angular projection into furrow, separated laterally by distinct membranous areas. Each plate with 3 furrow spines; central and longest spine somewhat angular, almost triangular in cross section. Behind furrow spines are 2 transverse rows of subambulacral spines, the first row has 3 (some-



times 2) spines, very similar to furrow spines and of similar height; behind these another row of 3 or 4 shorter spaced spines. Distally along arms, where adambulacral plates meet inferomarginals, there may be several considerably shorter and smaller spines present on plate edge.

*Oral plates* raised, conspicuous, quite broad, with numerous spines, the most anterior overhanging the mouth largest. Area between 2 oral plates in an angle rather ill-defined, bordered on each side by a row of 7 or 8 large, tapering, round-tipped, finely thorny, rather flattened spines, these tending to meet with opposite spines. Towards the distal end of the oral plates the spines are irregularly arranged, with larger spines forming a fringe around plate edge; between enlarged spines, small, short, slender well-spaced spines present.

*Ambulacral grooves* narrow, *tubefeet* slender, pointed, in 2 rows.

**COLOUR:** Colour notes of fresh material accompany specimens from NZOI B197; these notes presumably refer to the one specimen of "*Bollonaster*" *primigenius* present. They record "orange-red streak on either side of carinal series aboral surface of arms. Oral surface creamy white." Note — there is no "carinal series" in this species, but the dense midradial row of abactinal paxillae might resemble such a series. NMNZ specimen Ech. 5224 from Papanui Canyon has the colour recorded as "light orange aborally", and another from the Portobello Marine Biological Station (Ech. 4318) is recorded as "orange" when caught and "apricot" after ten days in captivity. Dried preserved specimens are white or pale brown. In wet specimens (either in preservative and probably also in specimens fresh from the sea) the abactinal paxillar spines are very obvious, generally light coloured against a dark background; this gives an almost "spotted" appearance.

**REMARKS:** Seventy-six specimens, all seen, are recorded in the Museum of New Zealand collections; in the NZOI collections there are 243 specimens from 78 stations. Only 223 of these were seen; the rest are missing or were wrongly identified.

Mortensen (1925: 274) was doubtful whether his new species, *primigenius*, should be included with *Astropecten* or be the type of a new genus; he finally decided it should remain in *Astropecten*. However, McKnight (1977: 115) created a new genus *Bollonaster* with type species *Astropecten primigenius*. We believe *primigenius* is congeneric with *Astromesites compactus* and now include it in that genus. Rowe and Gates (1995: 50) recorded a second species of *Bollonaster*, *B. pectinatus* (*Astropecten schayeri* and *A. syntomus* are synonyms according to Shepherd (1968: 733)) which may also be referable to *Astromesites*. There are other species of

*Astropecten* with numerous actinal plates but these are not available to us for comparison.

All specimens seen had five arms and there were none with epiproctal cones. There are two distinct forms of this species: the first and commonest described here (NZOI Stn F97) has short, fast-tapering rather broad arms; the second, a long-rayed form with very slender arms, is comparatively rare. In the NZOI collections two of these slender-rayed specimens are from NZOI Stn I708, near the Bounty Islands, in 155 m, with R/r = 37/9 mm, and a smaller specimen with slightly shorter rays, R/r = 21/6 mm. Apart from differences in ray length and breadth, the only other difference seems to be in the uniform nature of the granules of the superomarginal plates; enlarged superomarginal granules near the free edges of the plates are not present. Other slender-rayed specimens are also from near the Bounty Islands (NZOI Stn I711) in 139 m. The commoner short-armed specimens do not vary greatly. In small specimens, with R = 20 mm or less, enlarged actinal spines are generally present only on plates near the inferomarginals and if pedicellariae are present they generally involve 3 or 4 spines only and are not conspicuous. Terminal arm plates in small specimens are almost heart-shaped and large, distinct, enlarged spines may be present at the tip, with a uniform cover of tiny, very regularly arranged granules present also. In larger specimens, superomarginal granules are distinctly bigger near the free edge of the plate as in a specimen (NZOI Stn E407) with R/r = 50/15 mm in which there is often a distinct circle of 6–8 round-headed conspicuously enlarged finely thorny granules. These surround an even larger granule giving a "rosette"-like appearance. In one specimen (NZOI Stn G881) from near Christchurch in 140 m (R/r = 53/12 mm), there is a distinct superomarginal spine present on the 7th superomarginal plate from the interradial angle, just visible to the naked eye. Also of interest are the distinct, small rectangular pits present regularly on the actinal plates adjacent to the oral and first adambulacral plates; they are conspicuous when the brush-like pedicellariae are removed. Madreporite is often difficult to see in small specimens, and may be present only as several crests or ridges among the paxillae; in larger specimens it is large, conspicuous, almost round, very near the inferomarginal plates and finely dissected.

Actinal plates well developed. At least one series of plates present between inferomarginals and adambulacral plates for almost half the arm length; also an unpaired series of 2 or 3 actinal plates which extends from the oral plates to the inferomarginals. Regeneration of arm tips also often seen in this species.

A number of specimens were dissected. Distinct strong *superambulacral plates* are present, being generally absent from the first (most proximal) one or

two ambulacral ossicles and continuing out along the arms as strong bar-like structures which cross from the ambulacral ossicles to the inferomarginals, generally near the junction with the superomarginals. Near the arm tip, superambulacral plates are present but very small and difficult to see; they may be absent from the last few distal ambulacral plates. *Internal intermarginal pores* are present at the junction of the supero- and inferomarginal plates; these are distinct and obvious proximally and may be absent or very small and inconspicuous near the arm tips. These pores are similar to those seen in *Psilaster acuminatus*. They are well spaced and every second superambulacral plate has a pore where it abuts onto the inferomarginal plate. *Gonads* are interradial, bunch-like and compact, and there is generally only one gonad present on either side of the interradial septum; in some specimens gonads are present in some interradia and not in others. *Polian vesicles* are five, with one in each interradius

Stomach contents in this species were varied and voluminous with bryozoans and molluscs predominant. We are grateful to Dr D.P. Gordon (NIWA) and B.A. Marshall (NMNZ) for identification of bryozoans and molluscs respectively (Appendix 2).

Other animals included a small unidentified and rather battered holothurian, crushed echinoids, and from NZOI Stn E832 a juvenile *Pseudechinus* sp., a very small sea-star, possibly *Peribolaster* sp., (Stn F93), an ophiuroid (*Amphiura magellanica*) Ljungman, crustacean remains including a hermit crab (Stn D133), worm tubes (NMNZ Ech. 5650; NZOI Stns B577, E832, I718), and foraminiferans, etc.

*Astromesites regis* n.sp. (Pl. 8, Fig. 10)

MATERIAL EXAMINED:

NMNZ: Ech. 4547(1) holotype, J06/042/81, 34°51.7–34°51.6'S, 174°42.0–174°40.6'E, near the Three Kings Islands, north of New Zealand.

SIZE: R/r = approx. 82, 83/17 mm (arm tips and parts of arms are missing).

DISTRIBUTION: Known only from the type locality, near the Three Kings Islands, north of New Zealand.

DEPTH: 944–946 m.

DESCRIPTION: The type and only specimen (measurements above) is described.

*Disc* flat, arms 5, broken, long, narrow, rapidly tapering; 4 arm tips and last part of arms missing; fifth

arm more or less intact except for tip.

*Abactinal paxillae* form almost regular rows interradially and dorsolaterally along arms for a short distance on either side of radial midline. Paxillae central on disc and on first part of arms have a very short thick trunk and an enlarged gently tumid, oval, round or some-times almost heart-shaped head, crowned by a number of slender, untapering flat-tipped spinelets all of more or less similar length. Further out along arms paxillar heads are distinctly more oval, often elongate; paxillar spines are similar to those already described, but shorter. Abactinal plates bordering superomarginals especially long, slender, narrow, almost rectangular; many have a small, central rectangular or oval depression or pit. In some asteroid species these are associated with pedicellariae; however, no pedicellariae are apparent here.

Three or 4 *papulae* present basally around each paxilla, absent from midline of arms, and not obvious centrally on disc.

No *pedicellariae* seen.

*Madreporite* interradial, distinctly nearer marginal plates, 8 or 9 paxillae between madreporite and superomarginal plates. Madreporite angular in outline, almost square and coarsely and deeply dissected; surrounding paxillae not particularly obvious or larger.

*Anus* small, central on disc, surrounded by a distinct ring of 8 small plates, at least 2 of these, opposite each other, are larger.

*Superomarginal plates* conspicuous, raised, forming a very definite edge to disc and arms. Plates regularly rectangular with narrow edge to abactinal surface and inferomarginals, and more or less flat, sometimes slightly raised along midline, separated laterally by deep, fasciolar grooves with fine, very slender spinelets. Centrally, on superomarginal plates a vertical band of small, rather close-packed thick, angular or round-headed granules or very short spines; these flanked by short, upright slender spinelets which become longer and more slender near the fasciolar grooves. No enlarged superomarginal spines present.

Only a small part of the *inferomarginal plate* is obvious from the abactinal surface; plates are most obvious actinally. They are similar to but larger than the superomarginal plates, forming a well-marked edge to actinal surface, and also have a central band of short, broad, almost square or rectangular spinelets or granules; these (like those of superomarginal plates) become longer and more slender near fasciolar grooves. Each plate with 3–5, often 4, enlarged, tapering, flattened finely spinulose spines that lie flat against plates; they arise from a distinct stump and may in life have stood out from plate. These enlarged spines form a row on distal edge of plate; sometimes interradially a second row of generally 2 enlarged spines on opposite edge.



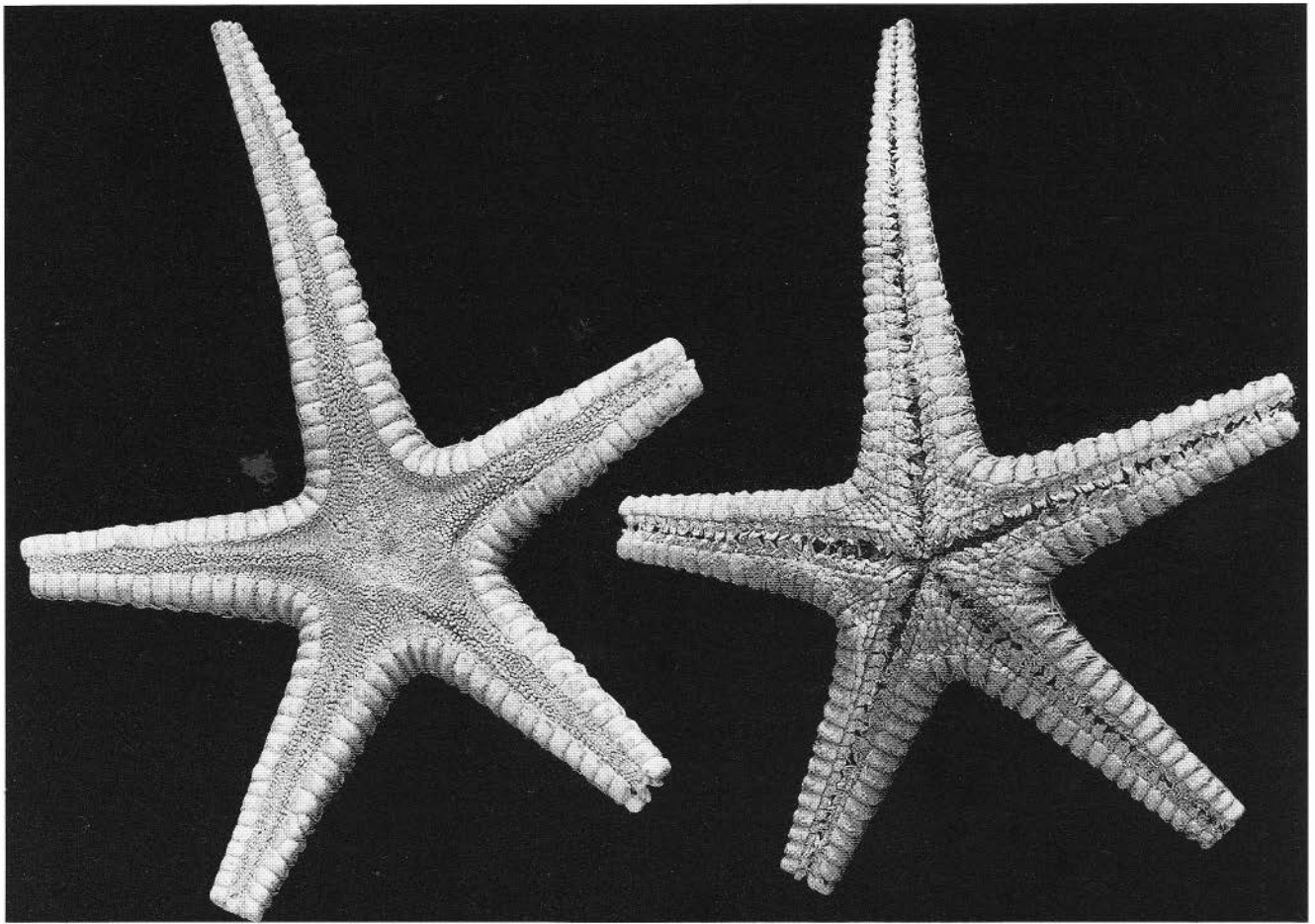


Plate 8. *Astromesites regis* n.sp. Holotype. NMNZ Ech. 4547. R/r = 82, 83/17 mm. Abactinal and actinal surfaces.

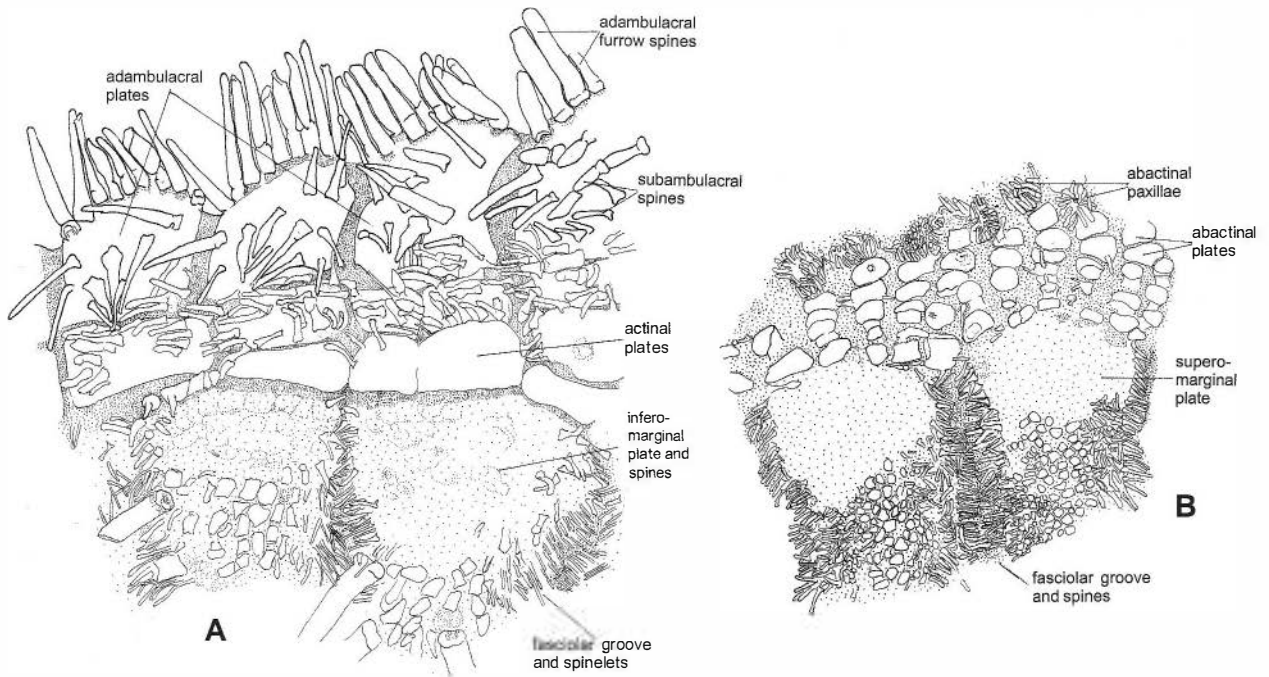


Fig. 10. *Astromesites regis* n.sp. Holotype. NMNZ Ech. 4547. A. Adambulacral, actinal, and inferomarginal plates and spines. B. Superomarginal plates separated laterally by fasciolar grooves and spines and abactinal plates, many with spines removed.

*Actinal plates* tumid, oval to round, sometimes almost rectangular, no unpaired row of plates present. Actinal plates continue as a single series between adambulacral and inferomarginal plates for about one-quarter arm length, to level of 11th, 12th most proximal adambulacral plates. Plates bear small, slender, blunt-tipped spinelets similar to those of neighbouring inferomarginal plates. Enlarged spines were certainly present on most actinal plates; round stumps or bosses, usually central on plates, remain.

*Adambulacral plates* rectangular with curved furrow margin, separated laterally by distinct, conspicuous, clear membranous channels. Plates with generally 8 or 9 somewhat flattened furrow spines, with narrow edge to plate and furrow, spines finely spinulose, tapering slightly to rounded tip; of similar size except the first and last which are markedly smaller. Several rows of smaller subambulacral spines, similar to small marginal spines, these set further back on plate, giving a conspicuous naked crescent-shaped area over the furrow; no enlarged spines between furrow and subambulacral spines. Adambulacral plates on either side of oral plates rather long and narrow with spines in regular rows.

*Oral plates* long, slender, distinctly raised, unfortunately damaged, with a fringe of 9 or 10 small slender spines similar to those of neighbouring adambulacral plates; on 4 plates large apical oral spines appear fused together; on the 5th are the remains of 2 separate spines.

*Ambulacral grooves* deep, narrow; if adambulacral furrow spines extend outward they meet with spines from plate on opposite side of furrow.

*Tube feet* hard to see; they form 2 regular rows which are well separated medially.

The specimen was not dissected.

**COLOUR:** There are no colour notes of the living animal. Dried: dull brown on disc and centrally along arms, marginal and actinal plates and spines pale creamy-white.

**ETYMOLOGY:** The specific name is derived from Latin, *rex, regis* (king) referring to the location of the type and only specimen from near the Three Kings group of islands, north of Cape Reinga, North Island.

**REMARKS:** The most notable difference between *A. compactus* and *A. regis* is the presence in *A. compactus* of a distinct unpaired row of actinal plates. Also in *A. compactus* hyaline granules are distinct and obvious on distal marginal plates; in *A. regis* none are present. There are also marked differences in the abactinal paxillae; in *A. compactus* the paxillae are compact with short erect swollen-headed very finely spinulose spinelets. In *A. regis* the abactinal paxillae are different, with long, slender spinelets which give a rather shaggy

appearance to disc and arms. In both species the arrangement of the adambulacral furrow spines is similar; there are generally more furrow spines in *A. regis* than in *A. compactus*, which may be attributed to the larger size of *A. regis*; the adambulacral plates are similar in both species and separated by distinct, narrow membranous channels. *Astromesites primigenius* differs in general body form and in abactinal paxillae which are distinctly more similar to *A. compactus*; *A. primigenius* also has more angular adambulacral plates and a furrow series of three spines only; this is very distinct from the other two species. *Astromesites primigenius*, like *A. compactus*, has an unpaired partial row of actinal plates.

### *Astropecten* Gray, 1840

Arms generally 5, arms and disc well defined by marginal plates. Both supero- and inferomarginal plates well developed, often one or both with conspicuously enlarged spines, inferomarginal plates often larger and more obvious. Abactinal paxillae present, sometimes also pedicellariae. Often an epiproctal cone centrally on disc. Papulae restricted to disc and dorsosolateral parts of arm. Simple pedicellariae also often present; generally actinal plates few, restricted. Madreporite often hidden by encroaching paxillae. Internally, ampullae of tube feet large and double and strong superambulacral plates are present.

**TYPE SPECIES:** *Asterias aurantiacus* Linnaeus, 1758 (see Fisher 1908a: 93; 1908b: 357; A.M. Clark 1989: 250, Rowe & Gates 1995: 46).

#### TABULAR CHECKLIST TO NEW ZEALAND SPECIES OF *ASTROPECTEN*

	1	2	3	4	5
<i>Astropecten</i>					
<i>celebensis</i>	a	n.a.	p	n.a.	a
<i>dubiosus</i>	p	r	p	n.a.	a
<i>monacanthus</i>	a	n.a.	p	n.a.	b
<i>polyacanthus</i>	p	p.m	p	n.a.	b/a
<i>tasmanicus</i>	a	n.a.	p	a	a
sp.	p	p	p	a	a

- 1 Enlarged superomarginal spines either  
p – present  
a – absent
- 2 If superomarginal spines are present, are they  
p – present on most plates  
r – restricted to proximal marginal plates  
m – missing from plates on either side of most proximal enlarged spine



- n.a. – not applicable (i.e., no superomarginal spines present)
- 3 Enlarged inferomarginal spines either
    - p - present
    - a - absent
  - 4 Pedicellariae (of simple type) if present are
    - a – on abactinal plates
    - b – on marginal plates
    - c – on actinal plates
    - d – on adambulacral plates
    - n.a. – no pedicellariae seen
  - 5 Adambulacral furrow margin
    - a – distinctly angular
    - b – not angular, rounded

*Astropecten celebensis* Döderlein, 1917 (Pl. 9, Fig. 11)

*Astropecten celebensis* Döderlein, 1917: 118, pl. 1(7), 10 (3, 3a, b, c); A.M. Clark 1989: 255; Rowe 1989: 288; Rowe & Gates 1995: 47.

MATERIAL EXAMINED:  
NZOI Stn P40(2).

SIZE: Size is approximate as arms are bent, broken: R/r = 24, 25/7 mm, 16/4 mm. These two specimens were identified by Dr F.W.E. Rowe, at the Australian Museum.

DISTRIBUTION: Indo-Malayan region (Celebes — now Sulawesi) and Norfolk Island, Tasman Sea.

DEPTH: 394–472 m.

DESCRIPTION: The larger specimen with R/r = 24, 25/7 mm is described; it has 26–28 superomarginal plates from near arm tip to interradial angle; arms broken, one intact although the terminal arm plate is missing.

*Disc* irregularly inflated, interbrachial arcs gently rounded; arms, 5, taper rapidly and smoothly to tip, *terminal arm plates* not seen.

*Abactinal plates* small, round-oval or faintly lobed; along arm and disc edges in fairly regular rows and paxilliform; elsewhere paxillae closely and irregularly packed. Abactinal plates with a short, thick, rather ill-defined trunk crowned, proximally, by 8–10 peripheral spinelets, these well separated from each other; each has a slightly enlarged and finely thorny head; near arm tips paxillae spaced with more oval or almost rectangular heads. Central paxillar spinelets 1, occasionally 2; often, near arm tips, spines from opposite sides of paxilla touch, no central spines. On the disc, at least marginally, paxillae form fairly regular rows of 6 or 7; centrally, paxillae crowded, with outlines

difficult to distinguish.

*Papulae* indistinct, present dorsolaterally along arms.

Neither *pedicellariae*, *madreporite* nor *anus* were seen.

*Superomarginal plates* form a regular edge to disc and arms; plates slightly raised, rectangular (wider than long) for first half of arm, becoming distinctly more square distally. Plates separated laterally by grooves; superomarginal granules (very short spines), longer and more slender near and within grooves. No enlarged spines on superomarginal plates, rather there are more or less regular rows of well-separated, very short, round-tipped, finely thorny spinelets.

*Inferomarginal plates* correspond with superomarginals although they are considerably wider than long; they generally bear 2 enlarged, conspicuous spines on a slight swelling, 1 below the other, on the lower (adambulacral) edge of the plate, the spines extend at an angle, towards the arm tips. Spines of 2 sizes; upper spine, rapidly tapering, sturdy and obvious; lower spine, proximally, often as long as or longer than upper; distally along arms lower spines are shorter. Short spinelets, similar to those of superomarginals, present basally on plates.

*Actinal areas* small, with 3 plates on either side of interradial midline; in 1 interradius actinal plates still bear several (2, 3) slender, blunt-tipped spinelets; otherwise, plates naked. Actinal plates small, oval to almost rectangular, raised, well separated from each other.

*Adambulacral plates* rectangular, with distinct angular projection into furrow; plates well separated laterally by broad sunken muscular areas. Generally, further along arms 1 inferomarginal plate corresponds to 1, or even 2 adambulacral plates. Adambulacral plates with 3 distinct furrow spines; central spine on angular part of plate projects over furrow, this spine almost triangular in cross section, tapering rapidly to a sharp tip; lateral spines, 1 on either side, slightly flattened and distinctly shorter than median spine. Actually on the plate there may be 5 or 6 short, slender spaced spines, generally arranged in 2 rows.

*Oral plates* long, slender, distinctly raised; 2 plates well separated distally by a broad membranous area. Plates well-raised medially; basally, at least for anterior half of plate, distinctly lower, flattened, verandah-like area guarded by a fringe of 6 or 7 short, tapering spines; on upper raised part of plate, along the median suture, is a row of 8–10 larger, distinct, often slightly curved spines which form a fringe along the plate crest; many oral spines are broken.

*Ambulacral grooves* broad, with tapering tubefeet in 2 very regular, well-ordered rows well separated medially.

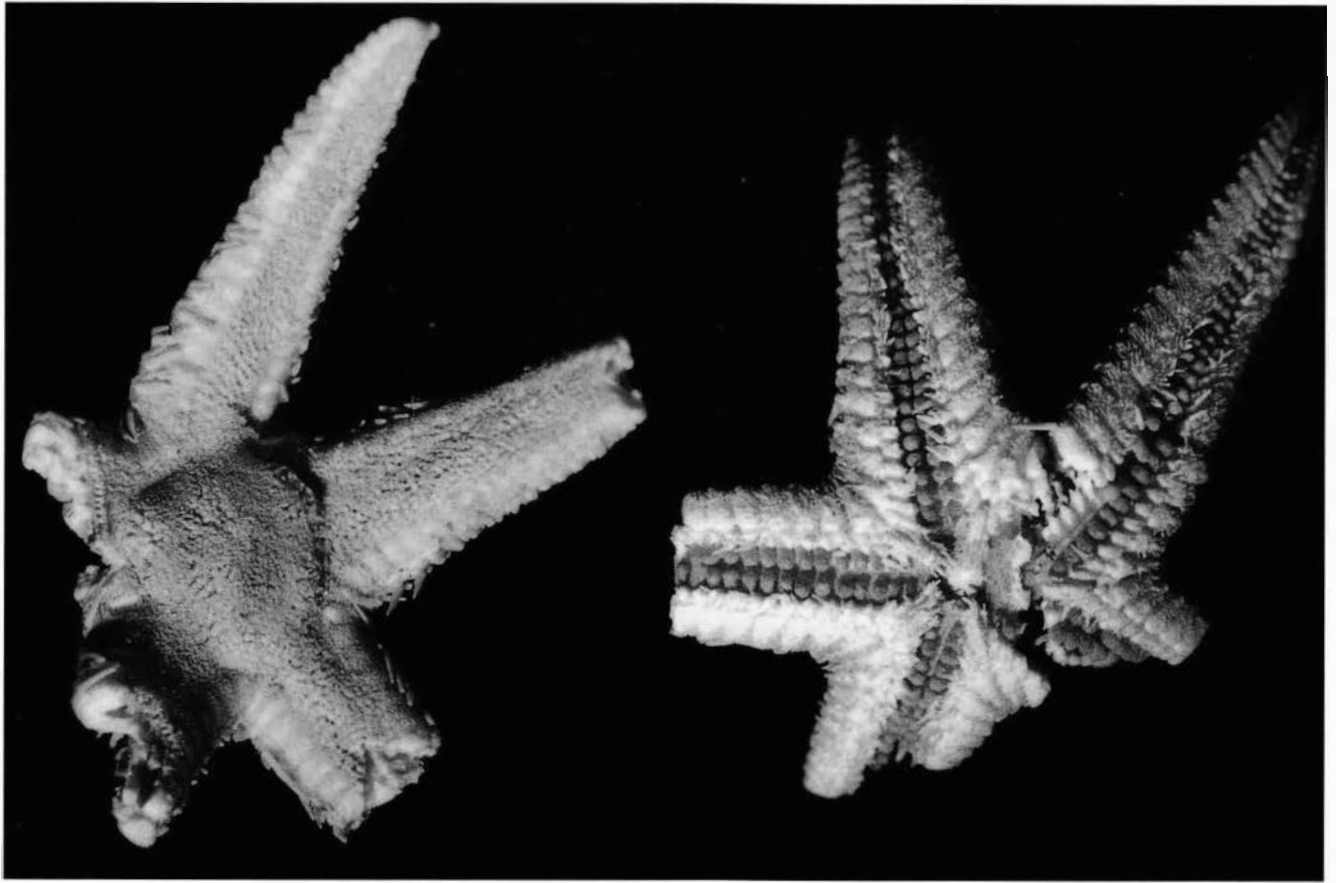


Plate 9. *Astropecten celebensis* Döderlein. NZOI Stn P40, R/r approx. 24, 25/7 mm. Abactinal and Actinal surfaces.

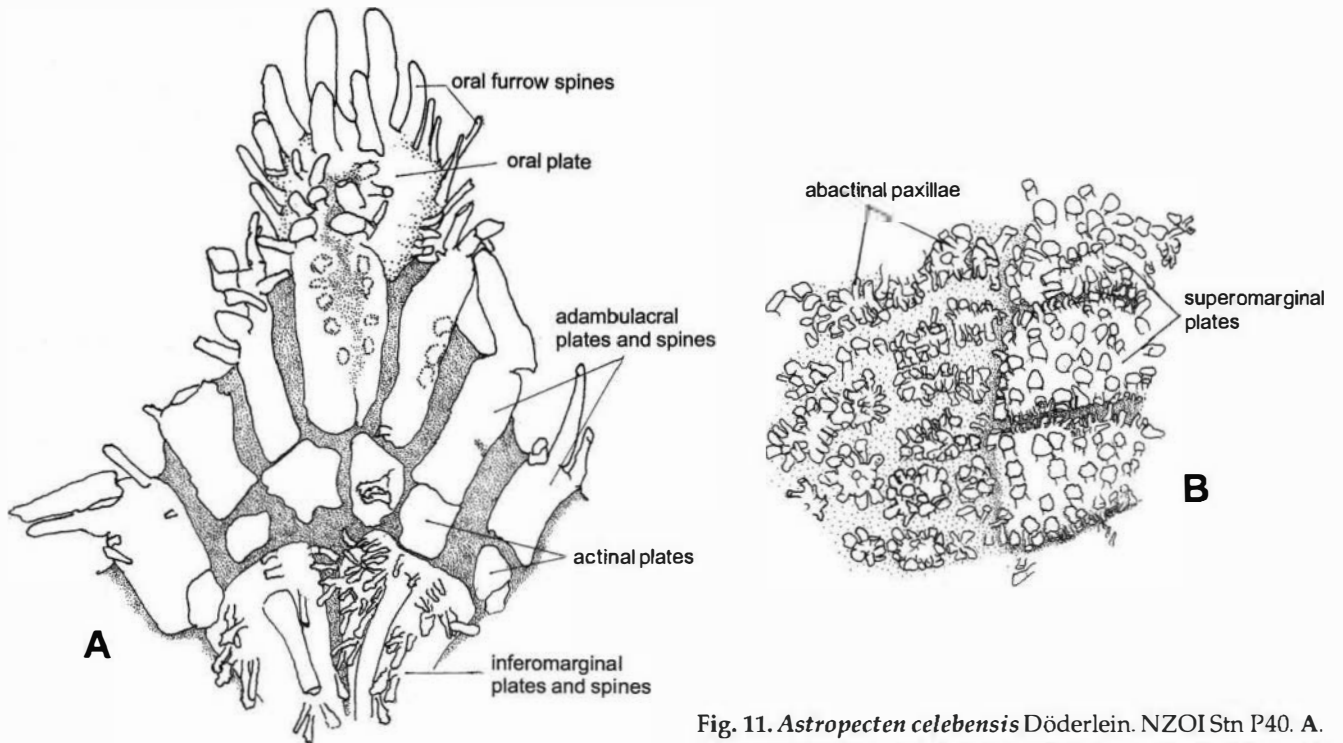


Fig. 11. *Astropecten celebensis* Döderlein. NZOI Stn P40. A. Oral, adambulacral, actinal, and inferomarginal plates and spines. B. Abactinal and supermarginal plates and spines.



**COLOUR:** There are no colour notes of living material. Dried-preserved specimens are uniformly pale brown with lighter actinal surface and darker gold-brown tubefeet.

**REMARKS:** The smaller specimen ( $R/r = 16/4$  mm) has a distinct epiproctal cone centrally on disc; it is essentially similar to the larger specimen described above. The present specimens are recorded from "gritty fine sandy mud".

Döderlein (1917) recorded the type specimen from Sulawesi (south Celebes) and the species does not seem to have been recorded again until the two present specimens listed by Rowe (1989) which are from near Norfolk Island.

In one partially dissected arm (of the larger specimen), distinct, sturdy superambulacral ossicles are present.

*Astropecten dubiosus* Mortensen, 1925  
(Pl. 10, Fig. 12)

*Astropecten dubiosus* Mortensen, 1925: 269, pl. 12(3, 4), fig. 1; Fell 1958: 2, 4; 1959: 131; H.E.S. Clark 1970: 2; A.M. Clark 1989: 256.

**MATERIAL EXAMINED:**

NZOI Stns: F904(1)\*, F936(2)\*, I5(1), I345(4), I359(7), I363(1).

NMNZ: Bay of Plenty: Ech. 4424(1).

**SIZE:** In the present specimens  $R$  varies between 50 mm (I359) and 32 mm (I5) and  $r$  between 8 and 4 mm; the average  $R/r$  for these specimens is  $43/6$  mm. In the type material, from off North Cape,  $R/r = 28/6$  mm and  $18/5$  mm.

**DISTRIBUTION:** Known from off North Cape and along the east coast as far as Mayor Island, Bay of Plenty; it has not been recorded from south of Mayor Island.

**DEPTH:** 53–260 m (555 m listed by H.E.S. Clark, 1970: 2, is incorrect).

**DESCRIPTION:** A specimen,  $R/r = 46/7$  mm, from Stn I359 is described; 5 arms, 2 regenerating.

*Disc* small, slightly and evenly raised with small epiproctal cone; arms long, slender, flat, evenly tapering to sharp tips. Two arms regenerating, these taper markedly and there is a definite line of demarcation and an obvious new "tip" to the arm; the regenerating arm tips acute, conspicuous. *Interbrachial arcs* gently rounded; marginal plates form a vertical edge to disc and arms.

*Terminal plates* of 2 entire arms broken, on third arm terminal plate present, small, quite conspicuous, broadly arch-shaped. Scars only remain of small spines which apparently formed well-ordered regular rows. The ambulacral groove almost visible from the abactinal surface; there are also 3 obvious short stumpy spines present, possibly adambulacral spines.

*Abactinal plates* small, oval, close-fitting especially centrally on disc where plate outlines are indistinct and paxilliform plates crowded. On first half of arms, along edges, paxillae spaced, fairly regularly arranged with generally 2, occasionally 3, paxillae corresponding to 1 superomarginal plate. Paxillae with sturdy trunk which expands into a round or slightly oval head, this fringed with 8–15 slender, well-separated, thorny, round-tipped spines which enclose 2–6, or even 8, similar spines. Near arm tips paxillae similar, smaller, more oval and with often only 1 central spine and fewer fringing spines. Base of plates protected by a thick wrinkled skin most obvious along arm centre.

*Papulae* restricted to edges of disc and arms; on arms 5 or 6 papulae surround each plate.

No *pedicellariae*, either abactinal, marginal, or actinal, were seen.

*Madreporite* interradial, tumid, separated by 2 or 3 paxillae from superomarginal plates; only a small part of the madreporite visible in this specimen; it is heavily and deeply fissured.

*Superomarginal plates* 33, from interradial angle to arm tip on the one complete arm. Plates form a well-defined and quite conspicuous edge to disc and arms; plates rectangular, i.e., longer than wide when viewed from above, and plates well separated laterally from each other by deep *fascioles*. These plates with more or less regular rows of slender, thorny-tipped spinelets similar to those of abactinal plates. The single, enlarged, superomarginal spines upright, conspicuous, very finely thorny, round-tipped, slightly compressed; they are considerably shorter distally and seem to be absent from plates in distal quarter of arm.

*Inferomarginal plates* band-like, wider than long, well separated laterally by shallow clefts. Plates with a shaggy covering of small spinelets; these slightly flattened, broad-headed and less thorny than neighbouring superomarginal spines. Slender rather flattened fasciolar spines present between most plates and are most obvious distally along arms. Each plate with generally 3, occasionally as many as 5, large, similar-sized, round-tipped, very finely thorny spines, these present on or near free (upper) edge of plate and visible from abactinal surface. Several considerably smaller almost scale-like spines, either pointed or rounded also sometimes present at base of enlarged spines.

*Actinal* areas membranous, small, covered with 2

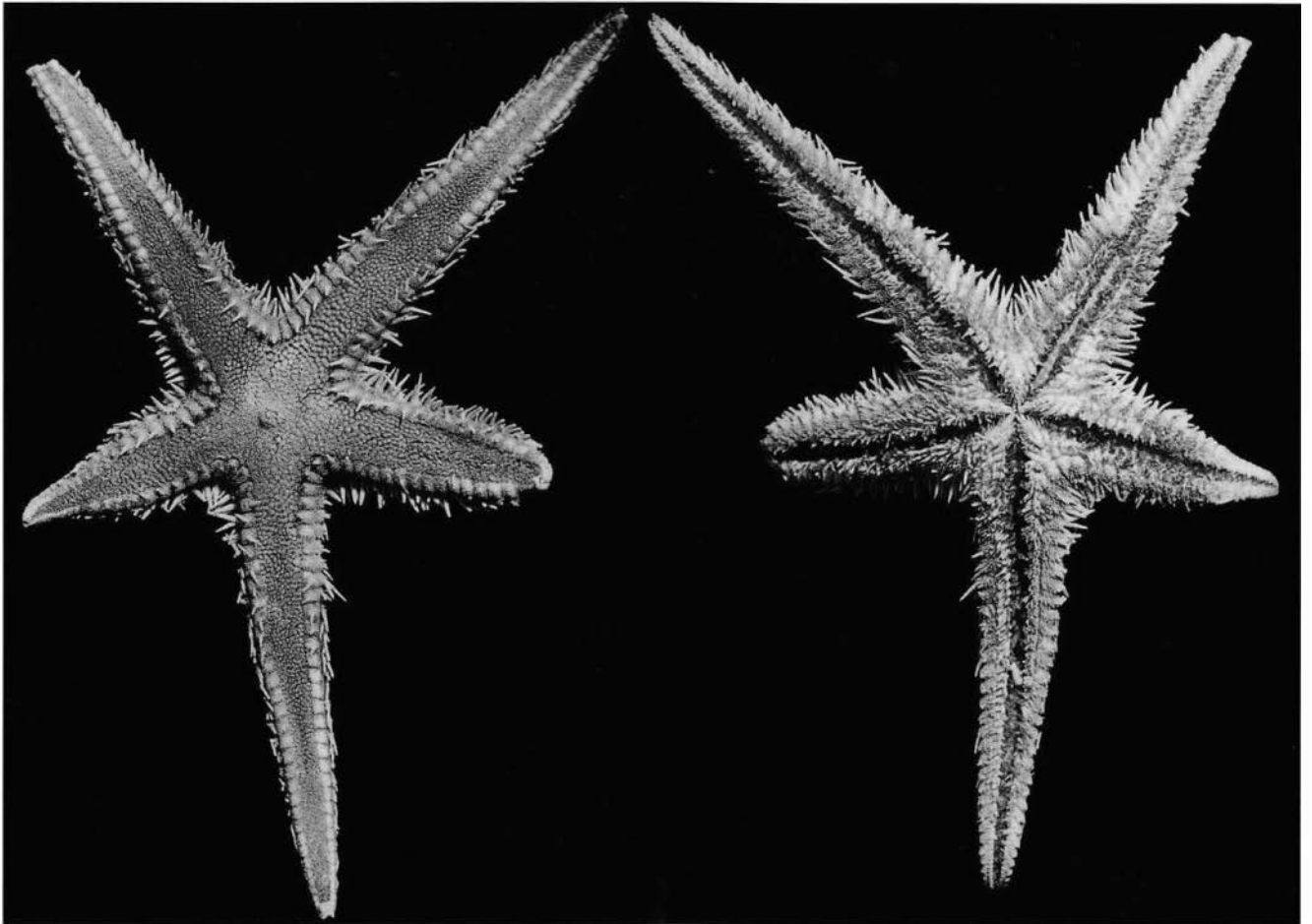


Plate 10. *Astropecten dubiosus* Mortensen. NZOI Stn I359, R/r = 46/7 mm. Abactinal and actinal surfaces.

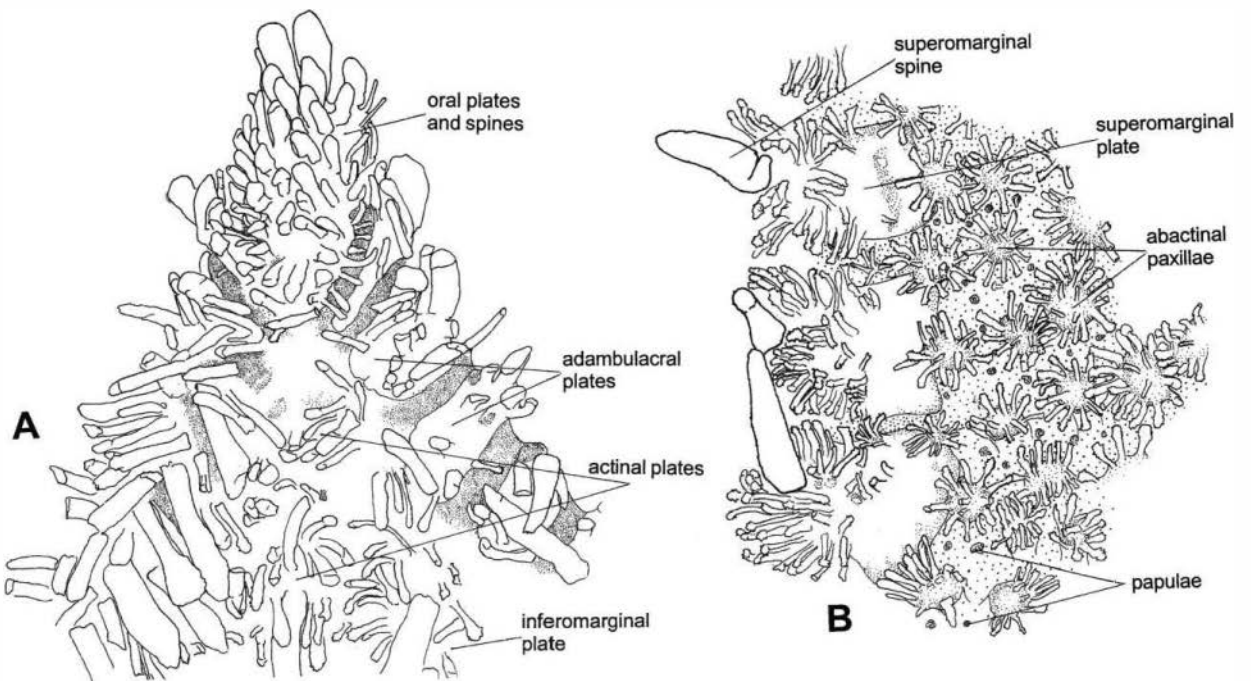


Fig. 12. *Astropecten dubiosus* Mortensen. NZOI Stn I359. A. Oral, adambulacral, actinal, and inferomarginal plates and spines. B. Superomarginal, abactinal plates and spines and papulae near interradiial angle.



or 3 tumid, oval or almost triangular plates on either side of oral plate. These plates bear a clump of 5–8 or 9 spines, these slender, long and similar to those of neighbouring inferomarginal plates, borne on an irregularly raised central area of plate.

*Adambulacral plates* narrow, band-like, well separated laterally by conspicuous, shallow membranous areas. There is an angular projection of plate into furrow; 3, often 4 furrow spines present. The central spine, triangular basally, somewhat flattened, with narrow edge to furrow, tapering gradually to a round tip, the 3 furrow spines very finely thorny. Behind furrow spines generally 2 rows of 3 spines; in the first row distal subambulacral spine conspicuously larger and considerably taller than other spines. Unfortunately, most spines are broken in the present specimen.

*Oral plates* long, slender, well raised, with conspicuous rows of enlarged spines; the first of these spines, directly over the mouth, very large. A further row of 5 or 6 small spines above these and the suture between the 2 plates also guarded by 2 rows of spines; the most anterior of the upper spines short, fat, very sturdy.

*Ambulacral grooves* wide and conspicuous with tubefeet in 2 rows; *tubefeet* long, slender, tapering, well-separated medially.

**COLOUR:** There are no colour notes of freshly caught or living material. Dried, ex-preservative, specimens brown with noticeably paler fawn or very light brown marginal plates and spines. Tubefeet dark brown.

**REMARKS:** Most specimens are similar to that described. Variation occurs, however, in the number and extent of the superomarginal spines. In several specimens, the most proximal (interradial) one or two superomarginal plates bear two similar-sized or sometimes unequally enlarged spines. Similarly, the madreporite is not always partially or completely hidden by neighbouring paxillae. In a specimen from Stn I359 (R/r = 42/7 mm) the madreporite is interradial and exposed except for one large paxilla protruding from the centre; this madreporite is finely and evenly dissected with clefts meeting centrally; fine conspicuous pores are also present in regular rows in the clefts. In all present specimens, the madreporite is solid, high, large, more or less round and generally partly hidden by encroaching paxillae. In most specimens also, there is at least one regenerating arm, the tip always conspicuous. Also, in all specimens there is a large or small central epiproctal cone present. The enlarged, distal subambulacral spine in larger specimens is always flattened with a conspicuous almost triangular tip; it is obvious and very distinctive. In one larger specimen (Stn I359, R/r = 50/7 mm) the actinal

plates' spine tips meet, forming almost a simple sort of pedicellaria. There is also often a pore or shallow depression, sometime with a membranous lining; these may be present on all actinal plates in an angle and they are also sometimes present on the first one or two adambulacral plates. The pore is surrounded by tall spines and is similar to pores associated with pedicellariae, although pedicellariae were not seen.

One specimen (Stn I363, R/r = 45/7 mm) was dissected: ampullae of tubefeet were large, double, there were conspicuous solid superambulacral plates present, and polian vesicles, one to an interradius, were long and very slender. Gonads were not seen. The ambulacral ossicles were interesting, not meeting centrally; rather there was a conspicuous muscular band holding the two plates together, the plates well separated from each other; near the arm tip, the plates were still separate but the muscular areas were less conspicuous. This condition is present in all five arms.

*Astropecten monacanthus* Sladen, 1883

(Pl. 11, Fig. 13)

*Astropecten monacanthus* Sladen, 1883: 263, 1889: 216, pl. 33 (7,8), pl. 37 (10,12); Koehler 1910b: 37, pl. 3 (9–11), pl. 5 (11); Döderlein 1917: 150, pl. 14 (5, 5b), pl. 17 (9); Fisher 1919: 74; Russo 1929: 5; H.L. Clark 1938: 63; Macan 1938: 336; H.L. Clark 1946: 76; John 1948: 491; McKnight 1968b: 712; A.M. Clark & Rowe 1971: 46, pl. 5 (1, 2); A.M. Clark 1989: 263; McKnight 1989b: 23; Rowe & Gates 1995: 47. *Astropecten notograptus* Sladen, 1888: 325, pl. 28 (5–8); A.M. Clark 1989: 263.

*Astropecten squamosus* Sluiter, 1889: 309; A.M. Clark, 1989: 263.

**MATERIAL EXAMINED:** NZOI Stn I737(1).

**SIZE:** R/r = 10/4.5 mm.

**DISTRIBUTION:** Tropical areas of the Indian and Pacific Oceans; one record from southern China. Also known from northern Australia, Tonga, and (this report) the Kelso Bank north of Lord Howe Island.

**DEPTH:** 0–94 m.

**DESCRIPTION:** The single specimen, recorded above, R/r = 10/4.5 mm, is described.

*Arms* 5, *disc* and *arms* large, flat with *interbrachial arcs* evenly rounded; arms broad basally, tapering evenly to tip. One *terminal arm plate* intact, broadly arch-shaped with no obvious spines.

*Abactinal plates* small, gently lobed, each paxilliform; the head is fringed by 6 (occasionally 5 near disc and arm edges) to 8 or 9 well-separated, generally large-headed spinelets which are finely thorny; often 1 cen-

tral spinelet. Occasionally, peripheral spinelets are slender, with no enlarged head, and often slightly flattened. Along arm and disc margins abactinal plates form reasonably regular rows of 3–5 paxillae.

*Madreporite, anus, and pedicellariae* not seen.

5–7 *Papulae* present between abactinal plate lobes along arm edges.

*Superomarginal plates* distinctly rectangular interradially and almost square near arm tips, well rounded. forming a raised and regular edge to disc and arms; they are separated laterally by distinct, smooth apparently naked channels in which there do not seem to be slender spines. Superomarginal plates with small, well-spaced, thorny-headed spinelets; no enlarged spines; near free edge of plate some spines become longer, often flat, blunt-tipped. There is a distinctly naked area (a pathway) between superomarginal and abactinal plates, this conspicuous along arms.

*Inferomarginal plates* band-like, corresponding to superomarginals and most conspicuous actinally; plates convex especially near junction with superomarginals. 2 enlarged inferomarginal spines; uppermost (nearest superomarginal plates) longest, conspicuous, tapering, and although their base is round, somewhat flattened along their length. The second smaller, shorter spine conspicuously flattened, immediately below the large spine. Upper (abactinal) part of inferomarginal plate has small, fine, slender, thorny-headed, well-spaced spinelets similar to those of abactinal plates; on actinal surface of plates, below the enlarged spines, spines are distinctly flattened, broad, scale-like. These scale-like spines arranged in more or less regular rows; laterally, on inferomarginals, spines long, slender, slightly flattened and not scale-like; these spines also present in distinct lateral grooves which separate the plates.

*Actinal plates* 2, 1 on either side of most proximal inferomarginal; in 1 interradius a third pair of very small actinal plates present. Actinal plates conspicuous, narrowly oval, raised; each plate fringed by 7–9 slender, slightly flattened well-spaced spines. No central spines.

*Adambulacral plates* forming a regular edge to furrow; free margin distinctly rounded and projecting over furrow; 3 slender, spaced furrow spines, central spine slightly longer. Subambulacral spines 3 (very occasionally 4), well spaced and similar to, but slightly shorter than, furrow spines; of the 3 (or 4) subambulacral spines, that on distalmost edge of plate distinctly larger, more obviously flattened, more conspicuous.

*Oral plates* long, narrow and raised centrally; furrow spines 6 or 7 fringing lower part of plate; these spines well spaced, tapering gently to a round tip and slightly flattened. Generally 7 suboral spines border

the median suture, well spaced and similar to furrow spines but shorter. Median suture between the 2 oral plates well defined, quite broad, and distinctly raised.

*Ambulacral grooves* broad, obvious; *tubefeet* in 2 distinct rows and occupying most of furrow. Tubefeet lacking suckers.

**COLOUR:** There are no colour notes of fresh material. Dried (from alcohol) specimen white with very pale brown tubefeet.

**REMARKS:** This species resembles *A. celebensis* as they both lack enlarged superomarginal spines; they differ from each other, however, in the body form (short, rather thick arms in *A. monacanthus*, long and very slender in *A. celebensis*). There are also differences in the adambulacral plates; in *A. celebensis* these are distinctly angular at the furrow margin and in *A. monacanthus* they are rounded.

The specimen from Tonga (McKnight 1968b) is not present in the collections.

There were two gastropod molluscs and two bivalves in the mouth of this animal.

### *Astropecten polyacanthus* Müller & Troschel, 1842

(Pl. 12, Fig. 14)

*Astropecten polyacanthus* Müller & Troschel 1842: 69, pl. 5 (3a, b); Dujardin & Hupé 1862: 417; Lütken 1865: 125; Gray 1866: 4; von Martens 1869: 133; \*Perrier 1869: 183; Gray 1872: 119; Hutton 1872a: 6; Perrier 1875: 275; Sladen 1878: 428; 1883, 251; Bell 1884: 133 (and in Coppinger 1884: 509); Studer 1884: 43, 59; Bell 1885: 499; de Lorient 1885: 76; Bell 1887: 648; 1888: 388; Döderlein 1888: 830; Sladen 1889: 201; Sluiter 1889: 310; de Lorient 1893: 379; Bell 1894: 394, 395, 396; Koehler 1895: 387; Leipoldt 1895: 645; Sluiter 1895: 53; Pfeffer 1896: 47; Farquhar 1898: 309; Döderlein 1902: 327, 329; Herdman & Herdman 1904: 143; Hutton 1904: 291; Koehler 1905: 185; Ludwig 1905: 76; Fisher 1906: 1004, pl. 1(1), pl. 2 (1, 1a, 1b); Bell 1909: 19; H.L. Clark 1909: 109; Koehler 1910a: 266; 1910b: 41; Benham 1911: 140, 141; Fisher 1911a: 61; Goto 1914: 143, pl. 3 (42–51); Bell 1917: 6; Döderlein 1917: 51, 134, pl. 4 (4, 5), pl. 12 (4, 5); Fisher 1919: 63; H.L. Clark 1923: 249; Fisher 1925: 66, 69; Mortensen 1925: 268, 396, 405; H.L. Clark 1926a: 184; Russo 1929: 5; Livingstone 1932: 242; Mortensen 1933: 219, 224; 1934: 4, 5; Tortonese 1936a: 5, 23; 1936b: 210; H.L. Clark 1938: 64; Domantay & Roxas 1938: 207, pl. 1 (1–4), pl. 2 (7,8); Hayashi 1938: 271, 272; Macan 1938: 325, 335; Mortensen 1940: 60; Ely 1942: 4, 11; H.L. Clark 1946: 73, 74; Fell 1947: 21; Tortonese 1947: 836; John 1948: 485; A.H. Clark & Bowen 1949: 3; A.M. Clark 1952c: 203; Tortonese 1953: 27; Endean 1953: 53; 1957: 237; Fell 1959: 131; Powell 1959: 9, fig. 19; Tortonese 1960: 17; Pawson 1961: 10; A.M. Clark 1962: 38, 54; Fell 1962a: 20, fig.; \*Chang *et al.* 1964: 53; A.M. Clark & Davies 1965: 598; Tortonese 1965: 131; A.M. Clark 1967: 38, 54; McKnight



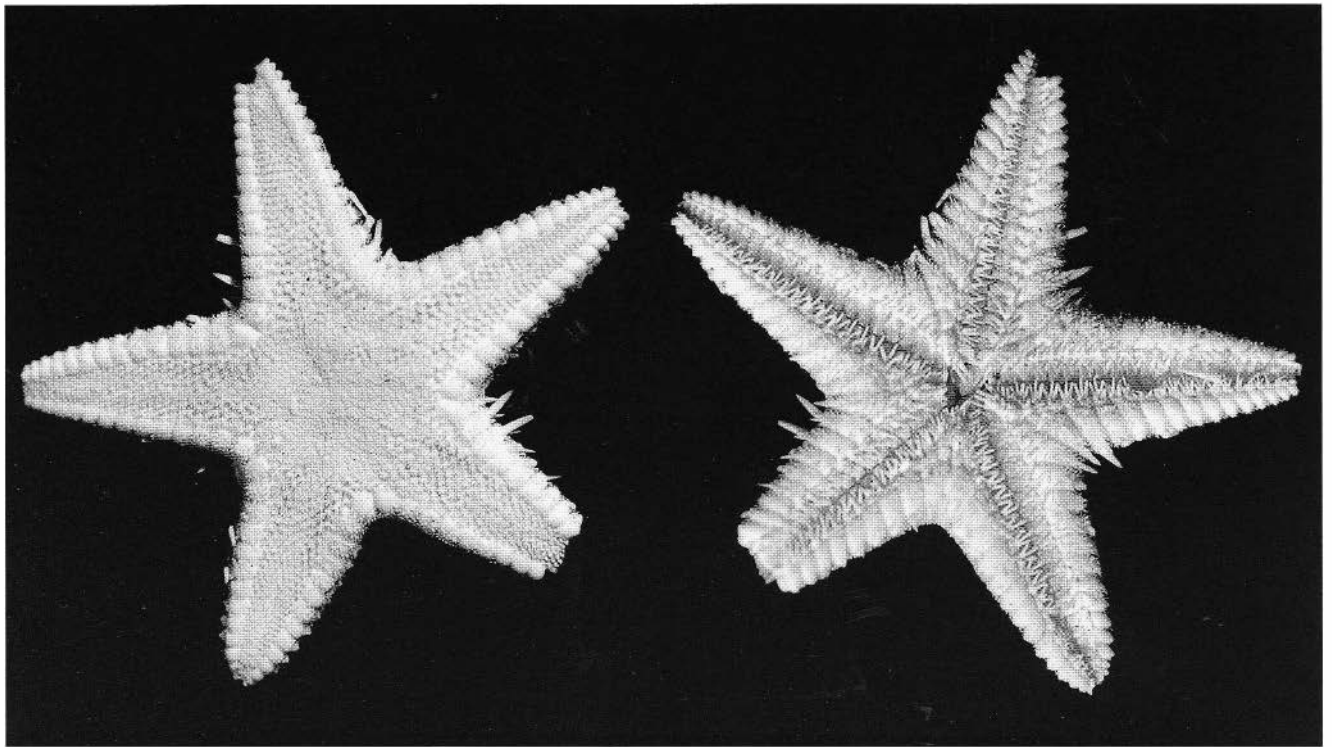


Plate 11. *Astropecten monacanthus* Sladen. NZOI Stn I737. R/r = 10/4.5 mm. Abactinal and actinal surfaces.

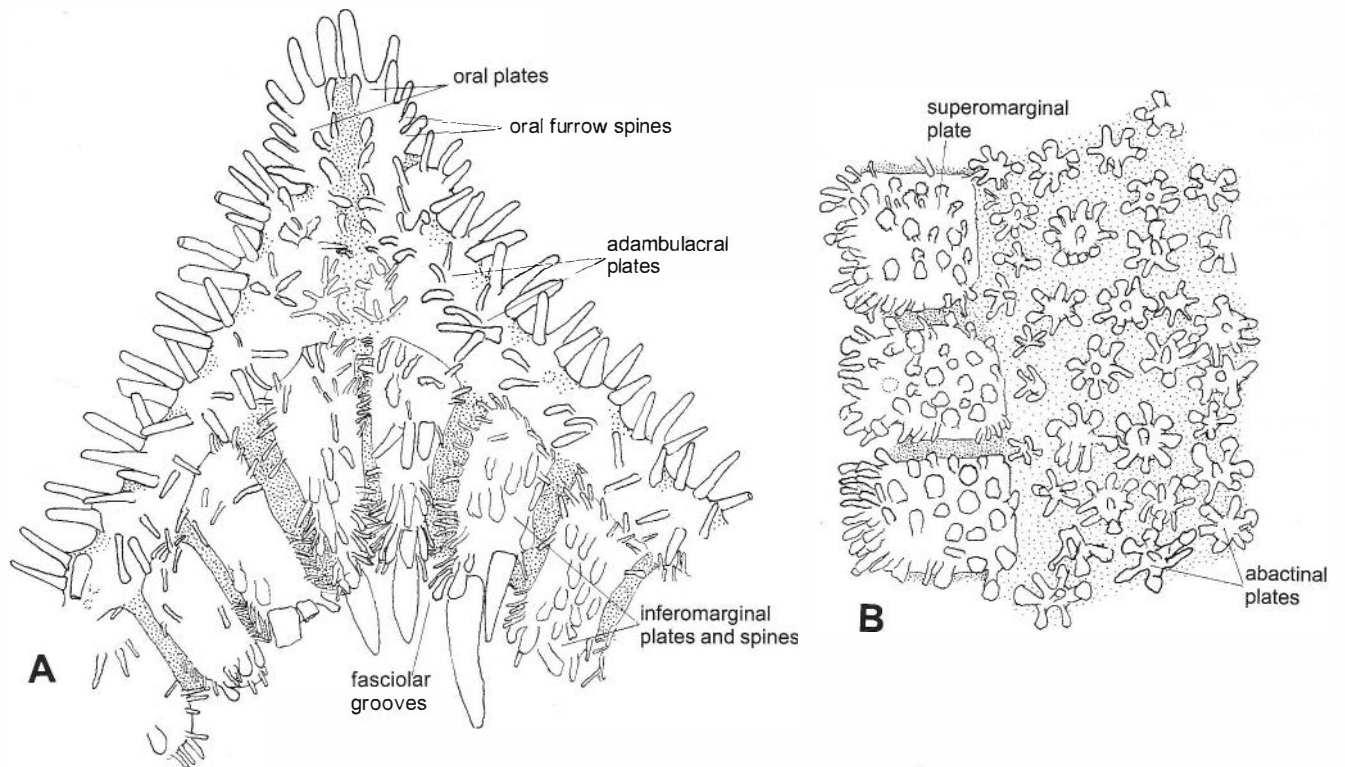


Fig. 13. *Astropecten monacanthus* Sladen. NZOI Stn I737. A. Oral plates, adambulacral and inferomarginal plates and spines and fasciolar grooves and spinelets. B. Supermarginal and abactinal plates and spines.

1968a: 506, 510; James 1969: 51; James & Pearse 1969: 82, fig. 3; H.E.S. Clark 1970: 2; A.M. Clark & Rowe 1971: 30, 44, pl. 5(3); Domantay 1972: 58, 61, pl.15(c), 18(c); McKnight 1972: 38, 42; Devaney 1973: 360; Hayashi 1973: 30, pl. 4(5); A.M. Clark 1974: 433, pl. 2(2); Marsh 1974: 68; Rowe 1974: 187; Doi 1976: 3; Marsh 1976: 216; Guille & Jangoux 1978: 49, 50; Sloan *et al.* 1979: 95; de Celis 1980: 31, 32; Willan 1981: 230; Okada & Ugida 1981: 49; Jangoux 1982: 22, 154; Price 1982: 6; Chaffee & Weitbrecht 1984: 11; Jangoux 1984: 279; Jangoux & Aziz, 1984: 863, tables 1, 2; Guille *et al.* 1986: 120, 121, photo; Jangoux *et al.* 1989: 168; table 6; A.M. Clark 1989: 266; McKnight 1989b: 23; Imaoka *et al.* 1991: 45, fig.; Pawson 1995: 179; Rowe & Gates 1995: 48; \* Liao & Clark 1995; Gosliner *et al.* 1996: 252, fig.; Chao 1999: 259, figs 5–8.

\* reference has not been seen or checked

Note: This is by no means a complete list of authors who have referred to *Astropecten polyacanthus*; many references concerned with physiology, reproduction, anatomy, etc., have been omitted.

In 1826 Savigny included illustrations of *Astropecten polyacanthus* in his volume on the Egyptian fauna. According to Sherborn (1897: 287) these appeared in Volume 1(4), pp. 203–212; this is the earliest record of the species.

A.M. Clark (1989: 266) listed as synonyms *A. hystrix* Müller & Troschel, 1842, *A. chinensis* Grube, 1866 and *A. edwardsi* Verrill, 1867; she also listed a subspecies *phragmorus* Fisher, 1913 (Jangoux & Aziz, 1984: 862 regard *phragmorus* as a distinct species). A.M. Clark (1989) also included varieties — (“of uncertain validity”) *ensifer* Grube (from Fiji), *samoensis* Perrier, 1869 and *burbonica* Döderlein, 1917. Possibly *Astropecten umbrinus* Grube should be added to this list; von Martens (1866: 87) listed it from Hong Kong.

#### MATERIAL EXAMINED:

NZOI Stns: B663(1), B664(2), B667 (arm fragments) B668(14), B671(1)\*, B672(2), B673(5)\*, C182(3), C321(1), C344(1), C748(1), C751(1), C754 (arm fragments), C756(1), F936(4)\*, I42(3), I54(1), I56(2), I57(2), I69(1), I88(2), I339(21), I349(1), I350(6), J339(1), J672(2), J697(2), J951(2), J958(1), K816(1), K817(1), K996 (field notes)\*, O59(1), O63(5), O70(3), O71(1), O72(2), O73(1), O74(2), O79(3), O80(1), O81(1), O84(1), O105(1), P28(2), P58(39), P59(1), P63 (12, field notes)\*, P82(1)\*, P109(1)\*, P622 (arm fragments), P625(1)\*, P631(5)\*, P632(2), P633(2), P645(2), P650(2), P651(5), R471D (arm fragment), U1005(1), Z1925(1), Z1930(1), Z2696(2), Z8510(6), Z8511(5), Z8642(5), Z8643(1), Z8644(3), Z8651(1), Z8659(2), Z8660(1), Z8661(2), Z8663(2), Z8664(2), Z8665(5), Z8675(3), Z8823(2), Z8833(2), Z8835(3), Z8841(1), Z8842(2), Z8843(7), Z8844(1), Z8845(3), Z8847(3), Z8850(8), Z8851(8), Z8853(2), Z8854(2), Z8943(7), Z8951(3), Z8952(4), Z8953(2), Z8954(4), Z8955(10), Z8956(2), Z8957(2), Z8958(2), Z8959(1), Z8960(2), Z8961(2), Z8962(3), Z8963(1), Z8964(3), Z8966(5).

NMNZ: Bay of Islands: Ech. 1560(1); 4415(1); 4420(1);

5247(2); 7075(1); Bay of Plenty: Ech. 674(1), 747(5), 864(1); 1561(1); 1562(2), 1564(1), 2140(1), 2411(6); 4410(1), 4412(1), 4414(7), 4417(1), 4418(2), 5220(2), 5222(4), 5223(22), 5248(2), 5249(21); off Cuvier Island: Ech. 594(1); near Kawhia Harbour: Ech. 4416(5); Kermadec Islands: Ech. 598(1), 1559(1); Manukau Harbour, Auckland: Ech. 192(1), 1560(1), 7086(1); Northland: Ech. 1565(1), 4315(1), 4411(2), 4413(1), 4421(4), 4422(7), 5228(1); off Otaki Beach: Ech. 1563(1); Takapuna, near Auckland: Ech. 191(3), 679(2); Whangarei Harbour: Ech. 5250(2).

\* specimens not seen

SIZE: In the present specimens R/r varies between 119/20 mm (NZOI Stn Z8957, from the east coast North Island, near Little Barrier Island in 26 m) to a very small specimen (NMNZ 5223 collected at Slipper Island, Coromandel Peninsula) with R/r = 3/1.5 mm. Average R/r measurements for 56 specimens chosen at random, was R/r = 57/11 mm. Other records of this very common species show a similar range in size.

DISTRIBUTION: Widespread in the Indo-West Pacific with specimens recorded from the Red Sea (type locality), Zanzibar, Mozambique, Mauritius, Seychelles, Ceylon, Andaman Islands, and Mergui Archipelago (Myeik Kyunzu), Hong Kong, China, Taiwan, East Indies, Australia (widespread), Japan, Samoa, and Hawaii. In New Zealand waters it is known from Norfolk Island and the Kermadecs; it is prolific in the northern part of North Island, especially in Bay of Islands and Bay of Plenty. One specimen is recorded from Otaki Beach, near Wellington, and there are two further reports of southern specimens — one from Calm Bay, Fiordland and another from Paterson Inlet, Stewart Island (Willan 1981: 230); specimens from Stewart Island were not collected. Mortensen (1925: 396) recorded *A. polyacanthus* from Cook Strait.

DEPTH: Most specimens are from shallow water, 0–185 m (Rowe & Gates, 1995: 48); one small specimen (NMNZ Ech. 674) collected from near Mayor Island, Bay of Plenty and identified by H.B. Fell (1957) is recorded from over 400 fathoms (732 m) — the specimen is damaged but seems definitely to be *A. polyacanthus*. A further small specimen (NMNZ Ech. 5228, Northland) is recorded from 207 to 222 m.

DESCRIPTION: Specimen described (NZOI Stn C344) is from the west coast of the North Island, north of Raglan Harbour, 55 m, R/r = 56/10 mm.

Disc well defined, slightly depressed centrally; arms raised along midline, this swelling continuing for half to three-quarters of arm length; last part of arms more or less flat. Interradial arcs acute; arms and disc well defined by superomarginal plates and spines.

Terminal arm plates large, bilobed; distinct depression



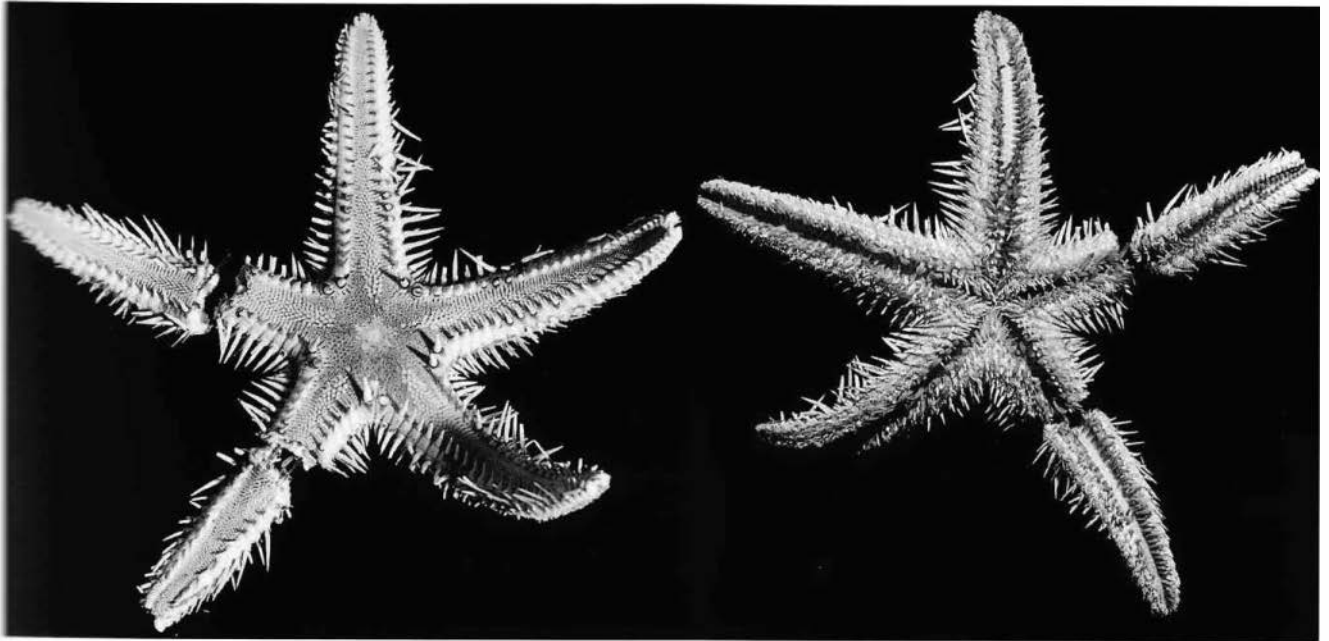


Plate 12. *Astropecten polyacanthus* Müller & Troschel. NZOI Stn C344, R/r = 56/10 mm. Abactinal and actinal surfaces.

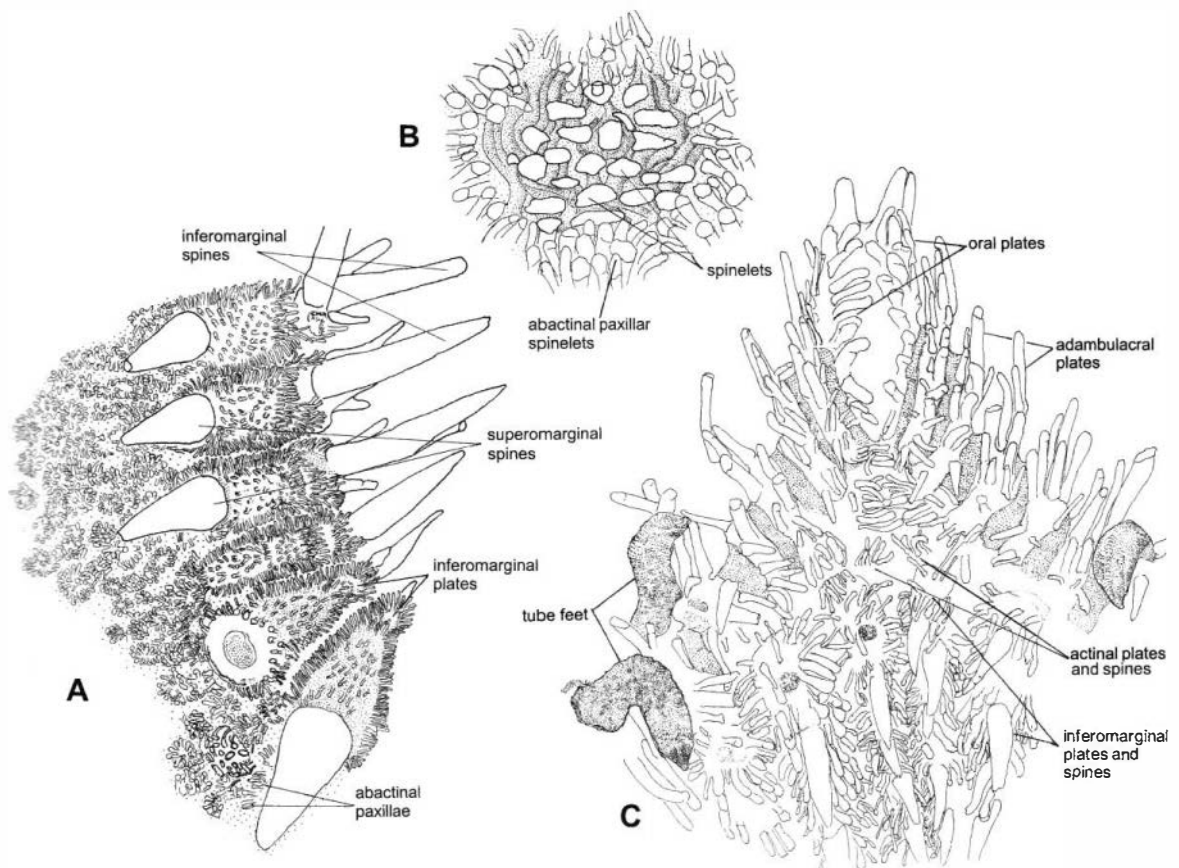


Fig. 14. *Astropecten polyacanthus* Müller & Troschel. NZOI Stn C344. A. Superomarginal and inferomarginal plates and spines, and abactinal paxillae (at interradius). B. Madreporite — note covering of large-headed spinelets. C. Oral, adambulacral, and inferomarginal plates and spines.

present between lobes. Terminal plates with conspicuous, well-separated, regularly arranged rows of very short, rather flattened, round-tipped, finely thorny stocky spines; these conspicuously shorter and more slender near ambulacral groove. Distally, the ambulacral groove curves up between terminal plate lobes and is visible from abactinal surface; 3 or 4 rapidly tapering, rather short almost conical spines are present on either side of ambulacral groove at arm tip, whether these are terminal arm spines or enlarged subambulacral spines, is difficult to decide. On 1 plate an aberrant spine — enlarged, short, stocky, similar to, but shorter than, neighbouring superomarginal spines.

*Abactinal plates* irregularly arranged near disc centre and interradially where plates form a close network and outlines of paxillate surfaces are indistinct. Along arm edges abactinal plates forming regular transverse rows of 5 or 6 plates; at arm centre arrangement of plates and paxillae irregular but paxillae distinct and well spaced. Abactinal paxillae with slender trunk that expands into a round or oval head crowned by short, very finely thorny well-separated spines; the outer fringing short spines have an expanded, sometimes almost triangular head that projects towards centre of paxilla; outer spines, from 9 to 15, encircle from 5 to 10 or 11, often 9, central spines. Central paxillar spines sometimes of several sizes, spines round-headed, finely thorny, well separated. Central disc paxillae closely crowded with fewer marginal and central spinelets. Near arm tips, paxillae smaller with a distinctly oval head, often central spines absent.

*Papulae* obvious along arm edges, generally 6 around each plate; papulae difficult to distinguish near arm tips and absent from disc centre and along midline of arms.

*Pedicellariae* and *anus* absent.

*Madreporite* interradial, occurring between 2 enlarged superomarginal spines; several rows of abactinal paxillae present between madreporite and superomarginal plates. Madreporite curious — more or less rectangular, slightly raised centrally, composed of deep strong ridges, solid struts, and trunks which terminate in an enlarged oval, sometimes almost round, granule-like, smooth head. In one instance a small paxilla-like spine seems to have grown through a granule in the madreporite.

*Superomarginal* and *inferomarginal* plates forming a distinct, trim, vertical edge to disc and arms.

*Superomarginal plates* strip-like, elevated, with distinct clefts between plates; plates bearing small, slender, swollen-headed, flat-topped, often slightly flattened spinelets in more or less regular rows. At plate margins spines longer, slender, slightly flattened and without enlarged heads. Each superomarginal plate also bearing a single, large, conical, upright sturdy

fast-tapering spine — these forming a conspicuous palisade along arms; the enlarged spines stand immediately next to abactinal paxillae. In each interradial angle 2 slightly larger, more conspicuous plates each with an enlarged, very sturdy, well-articulated spine; plates immediately next to these enlarged spines with no enlarged spines; this is a conspicuous feature. The 2 large, interradial plates taper at junction with inferomarginals.

*Inferomarginals* also conspicuous, band-like, with only a small upper part visible from abactinal surface; at least three-quarters of plate present on actinal surface. Each inferomarginal plate, including interradial plates bearing at least 3 large sturdy spines in a vertical central row; longest spine adjacent to superomarginal plates. These inferomarginal spines long, slender, slightly flattened, sharp-tipped, conspicuous; each spine articulates with a short, sturdy stalk or pedicel. Enlarged spines bordered basally by rows of short, very slender spines similar to those of superomarginal plates. Several spines, shorter than enlarged inferomarginal spines but larger than covering of small spines, often also present. Inferomarginal plates separated from adambulacral plates by distinct membranous area.

*Actinal plates* 4, confined to interradial areas with 2 on either side of interradial midline. Actinal plates rectangular to almost oval, raised, each bearing a group of 9–11 or 12 slender, blunt-tipped, spaced spines; tips of these spines often meet and spines of 2 most anterior plates also often meet to form, almost, an incipient pedicellaria.

*Adambulacral plates* rectangular, narrow, band-like, protruding furrow edge round or gently angular. Furrow spines 3, most anterior — slender, flattened, with prominent rounded base, narrow edge to furrow; another more slender spine may also be present between 3 anteriormost spines; 3 or 4 smaller, shorter subambulacral spines near inferomarginals. Plates separated laterally by conspicuous broad, regular, membranous areas.

*Oral plates* long, slender, raised centrally, well defined, 2 plates in an angle separated by a broad muscular area. Furrow spines 9 or 10, proximalmost long and slender, blunt-tipped; near adambulacral plates last 4 or 5 spines very slender, small, well separated, angular. Suboral spines 10–12, broad, rounded and forming a regular row on either side of raised, membranous area; distal spines smaller.

*Ambulacral grooves* well defined, broad, deep; *tube-feet* in 2 very regular, well-separated rows, each long and slender, tapering to a sharp tip.

COLOUR: Very varied in this common and widespread sea-star and has been reported in a number of papers.



Powell (1959: 9) recorded the colour of New Zealand specimens as "buff or yellowish brown" while Fell (1962b: 20) described it as "brownish fawn ... somewhat darker on the disc". In most of the present preserved and dried specimens the colour is very distinctive. Generally centrally on the disc and at the arm bases there is a conspicuous, dark 5-armed cross of St John, the rays of which have distinct often sharp fishtail-like endings. There is often also 1 (sometimes 2, even 3) bands of dark brown or black plates in the proximal half of the arm; these may be confined to marginal plates or continue across the arms. The bases of some (occasionally all) of the enlarged marginal spines may also be dark in colour, the marginal spines are generally white; the actinal surface is pale brown with darker tubefeet. One of us (H.E.S.C.) recently examined many specimens of *Astropecten polyacanthus* both at the Smithsonian Institution in Washington D.C., and at the British Museum in London. These specimens, from localities other than New Zealand, lacked the dark, cross-like distinctive markings, most were an almost uniform brown or grey-green-brown colour.

In other accounts of the colour of this species, among the earliest is that of Dujardin and Hupé (1862: 417) who recorded the colour as "dark yellowish" and Pfeffer (1896: 47) noted it as bright grey with grey-violet flecks. Fisher (1906: 1005), for a specimen from Bird Island, Hawaii recorded "the distal half of arms (as) vinaceous cinnamon: remainder of arms and disk, fawn colour", the "dorsal integument ... is bright vermilion" and the superomarginal spines "orange buff", while the marginal plates, inferomarginal spines and entire actinal surface are "light buff pink". H.L. Clark (1938: 64) wrote of Australian specimens as rather bright brown with whitish marginal spines, while in 1946 he recorded the live colour in a specimen, again from Port Jackson, as "deep purple" dorsally, while the oral surface was "more or less red-orange with pale yellow margins". De Celis (1980: 32) recorded "crimson spots" abactinally. In "Coral Reef Animals of the Indo-Pacific" (Gosliner *et al.* 1996: 252), the inferomarginal spines are conspicuously white while the small superomarginal spines are green; there is a central area on disc and arms which is rust-brown, almost red, and this is edged by grey-green. There is no evidence of the characteristic dark pattern seen in New Zealand specimens.

REMARKS: Four hundred and thirty specimens are recorded, including 31 NZOI specimens that were not seen; some curious features are noted.

A very interesting feature, apparently not recorded before, is the presence in some larger specimens of sturdy solid bars or struts which are attached in a vertical position to the inside (coelomic side) of the superomarginal plates. These bars are round in cross

section and extend for about three-quarters the height of each superomarginal plate; they end well clear of the abactinal plates and terminate abruptly near the junction with the inferomarginals; with some (but not all) of these bars is an accessory bar that proceeds at an angle from the vertical bar and either meets with or stops just short of the abactinal plates. In some specimens these vertical bars are attached near the plate centre, in others they are closer to one end. The place of attachment is fairly constant in the one animal and similar bars are also generally present on the opposite superomarginal plates in an arm. F.H.C. Hotchkiss (pers. comm.) suggested that the bars or struts were strengthening structures and that they might indicate breakage of the arm and regeneration at an early age. As we found no evidence of deformity or irregularity of the arms, which would suggest recovery from damage, or the presence of these internal bars in young animals, we tend to agree with the hypothesis that the bars may act as strengthening structures developed with age and size.

This species is very variable, a fact remarked on by most authors. All but one of the specimens examined, both here and overseas, had five arms; one specimen (NMNZ Ech. 2411) from near Motuhora Island, Bay of Plenty, New Zealand, 24 m, has 6 arms and 6 ambulacral grooves; the specimen is quite small  $R/r = 37/8$  mm, and it has a small, central epiproctal comb. Several other specimens had regenerating arms; one specimen in particular from the Macclesfield Bank area (British Museum (Natural History) collections) collected in 1893 had 1 long arm and 4 very short, sharp-pointed and rapidly tapering regenerating arms.

Variation also occurs in the body form, some specimens having distinctly longer and more slender arms; likewise an epiproctal cone is generally distinct in small specimens, with  $R = 20$  mm or less; occasionally, as in the 6-armed specimen mentioned above, epiproctal cones are present in larger specimens.

*Terminal arm plates* are interesting and variable. In many specimens, irrespective of size, 2 distinct plates seem to be present; these appear to be separated by a furrow or groove or perhaps the 2 plates are really one, and simply raised up on either side. Generally, the abactinal paxillae are fairly constant in their arrangement, although in small specimens there is a distinct, heavily calcified abactinal tract of plates which extends along the midline of the arms. Central abactinal paxillar spines may be numerous or few irrespective of specimen size; the heads of these central spines may be normal or they may be conspicuous and enlarged.

Differences also occur in the armature of the superomarginal plates; generally there are no spines on the 2 slender plates which are present on either side of the most proximal interradial plates; however, spines may

be present on these plates in one or 2 angles and absent from other angles in the same specimen. Sometimes, superomarginal spines are absent from 2, 3, even 4 plates on either side of the large interradial spine and, in the same specimen, the condition is normal in other interradia.

In large specimens the madreporite is conspicuous, almost cushion-like, often eroded, and appears as a series of small raised nodules or trunks with distinct channels between them. The madreporite is always interradial and lies close to the superomarginal plates; in some very large specimens, with  $R = 80$  mm, fine but distinct pores are present at the centre of the madreporite. In one large specimen,  $R/r = 117/24$  mm (NZOI Stn I54), the madreporite measured  $3 \times 5$  mm, and in another rather dilapidated specimen from near Fiordland, South Island, New Zealand the madreporite is extremely large and appears almost double. In small specimens with  $R$  less than 20 mm, the madreporite lies very close to the superomarginal plates, sometimes it is not visible.

In most specimens both supero- and inferomarginal spines are obvious, generally white, and often with dark bases; however, in the specimen pictured in "Coral Reef Animals of the Indo-Pacific", the superomarginal spines are dark green and not obvious at all.

Generally, there is relatively little variation in aspects of the actinal surface, although in larger specimens actinal spines on some plates do seem to form incipient pedicellariae and this is also true, occasionally, for adambulacral plates. Also there does not seem to be much variation in the number and arrangement of the adambulacral spines and characters of the tubefeet.

During examination of this species a number of New Zealand specimens were dissected and stomach contents noted. We are indebted to Dr Steve O'Shea (NIWA) for his help in identifying the molluscs and crustaceans (Appendix 2).

A number of workers have recorded the stomach contents of *Astropecten polyacanthus*. As far as the authors are aware only R.B. Martin (1970: M.Sc. thesis, University of Auckland, N.Z., unfortunately not available for reference) has recorded stomach contents of New Zealand specimens. He recorded gastropods, bivalves, echinoderms, and Crustacea, listing 57 prey species. Overseas, Tortonese (1947: 836) recorded molluscs and Doi (1976) listed mostly gastropods and some bivalves. Jangoux (1982) recorded these results in his interesting article on food and feeding in asteroids.

Dissections show conspicuous, very regular and strong bar-like superambulacral plates which continue to the arm tips. The stomach is thick-walled and massive and generally replete as the list above indicates. Centrally, around the mouth, the Tiedemann's bodies

are well developed and conspicuous and polian vesicles long-stemmed and obvious; ampullae of tubefeet are double. The gonads, many-branched structures, are attached on either side of the interradial septum, and extend well along the arms.

*Astropecten tasmanicus* n.sp. (Pl. 13, Fig. 15)

*Astropecten eremicus*: [non *A. eremicus* Fisher, 1913] McKnight, 1975: 54; 1993a: 167, 184.

MATERIAL EXAMINED:

NZOI Stns: G820(1), G821(1)\*, G823(1)\*, G824(1)\*, G825(1), P86(2), Q83(6), Q84(3), U582(2).

TYPES:

Holotype: from NZOI Stn Q84,  $R/r = 35/5$  mm, deposited in the NIWA collection, Wellington, H-735.

Paratypes: from NZOI Stn Q84,  $R/r =$  approx. 45, 46/7 mm, deposited in NIWA collection at Wellington, designated numbers P-1202 and P-1203.

TYPE LOCALITY: NZOI Stn Q84,  $32^{\circ}59.40$ ,  $163^{\circ}08.70'E$ , 830 m, on Lord Howe Rise.

SIZE:  $R$  varies between 50 mm and 21 mm,  $r$  between 7 mm and 5 mm. The average  $R/r$  for 12 specimens is  $35/6$  mm.

DISTRIBUTION: Known from east of Lord Howe Island, between  $32^{\circ}$  and  $33^{\circ}$  S and  $159^{\circ}$  and  $163^{\circ}$  E; there is one record (NZOI Stn U582) from further east,  $31^{\circ}51'S$ ,  $172^{\circ}26'E$ .

DEPTH: 610–830 m.

DESCRIPTION: A specimen,  $R/r = 35/5$  mm from NZOI Stn Q84 is described.

*Disc* and *arms* flat, arms long, slender, tapering evenly to sharp tip, one arm intact in present specimen. Interbranchial arcs almost acute. *Terminal plate* on intact arm broadly arch-shaped, with rows of small plates and spines.

*Abactinal plates* small, oval to round, or sometimes interradially almost square, each with a short, sturdy trunk crowned by 5–10 or 12 spaced, slender spines; these surround 1, occasionally 2, similar spaced spines. Paxillar spinelets as long as or longer than paxillar trunk, spinelets slender, thorny, round-tipped. Intermittently on plates near disc edge and for proximal half of arms a simple type of *pedicellaria* present, these not very obvious or distinct, consisting of 5–7 short, thick-set, round-tipped, tapering spines, the tips of which meet to form a simple fasciculate or perhaps spiniform



pedicellaria. These pedicellariae borne on a distinctly raised, very solid, generally round plate.

*Papulae*, 4, 5 at plate base, obvious along proximal half of arms and on disc margin.

*Pedicellariae* present on disc and arms (discussed above).

*Madreporite* high, small, round and partly obscured by paxillae; it lies very near the superomarginal plates.

*Anus* not seen, no *epiproctal cone*.

*Superomarginal plates* do not encroach on abactinal surface but form, with inferomarginals, a fairly vertical edge to arms. Superomarginals oval or rectangular, longer than wide when viewed from above, plates covered by spines similar to, but slightly longer than those of abactinal paxillae. Plates separated laterally by broad, shallow, rounded grooves, the spinelets here slender and few. Neither enlarged spines nor distinct pedicellariae on superomarginal plates. Distally along arms plates change in shape, with long edge of plate to abactinal surface, slender spaced spines present.

*Inferomarginal plates* corresponding with superomarginals but slightly longer, meeting actinally with adambulacral plates; they also have a cover of slender spines essentially similar to those of superomarginals. These plates with 2 (very occasionally 3) enlarged spines that almost reach to abactinal surface; the lower of the 2 spines generally distinctly longer; enlarged inferomarginal spines less obvious in last half of arm.

*Actinal areas* very small, with generally only 2 plates on either side of midline, each plate with a small group of slender spines; plates somewhat raised.

*Adambulacral plates* band-like, well separated laterally by muscular areas, a slight angular projection into furrow. Furrow spines 3; median spine long, sturdy, somewhat flattened, narrow edge to furrow, flanked on either side by a single, slender considerably shorter spine which is almost half the length of the large spine; behind this on the plate are 2–4 slender and shorter spines; these subambulacral spines mostly missing in the present specimen. Distally along arms angular parts of adambulacral plates almost meet with projection from opposite side of furrow, thus enclosing pairs of tubefeet in “pockets”. Adambulacral plates, near arm tips, very small, only the 3 furrow spines obvious. Some adambulacral spines skin-covered but not very obviously.

*Oral plates* conspicuous, broad, well raised centrally; 9 or 10 well-spaced furrow spines, the most proximal 1 or 2 of these on either side enlarged, sturdy, blunt-tipped and very obvious, the remaining spines slender and small. High suture between the 2 plates flanked by 7 or 8 sturdy spines, the tips sometimes meeting.

*Ambulacral grooves* broad proximally, narrow distally, *tubefeet* biserially arranged, rather small, very regular, pointed, without sucking discs.

*Mouth* large, well rounded and obvious.

**COLOUR:** There are no colour notes of living or freshly caught specimens. Dried specimens are pale fawn or white both abactinally and actinally, the tubefeet pale golden brown. Two specimens (NZOI Stn U582) are darker in colour — brown on both surfaces.

**ETYMOLOGY:** This new species was collected from the Tasman Sea, hence the specific name.

**REMARKS:** These specimens were originally identified as *Astropecten eremicus* Fisher, however they differ from *A. eremicus* as they have only three adambulacral furrow spines. Fisher (1919: 81) in his description (of *A. eremicus*) noted four or five adambulacral furrow spines as “long, slender, tapering, pointed, membrane-invested spines, that on the apex of the angle the longest and a trifle flattened.” In the present specimens there are only three furrow spines, not particularly membrane-invested, and the central spine is flattened, almost sabre-like and conspicuously different from adjoining spines. Adambulacral pedicellariae have not been seen in the present specimens although Fisher (1919: 81) described them in his Philippine specimens of *A. eremicus*. Also, spines in the present specimens are not noticeably membrane-invested as Fisher describes for his specimens and inferomarginal spines are decidedly shorter in the present specimens. *Astropecten pusillulus* Fisher, 1906 from Hawaii is distinct as it has adambulacral and actinal pedicellariae. It is however, similar in that it lacks superomarginal spines. Another species, *A. eucnemis* Fisher, 1919 lacks superomarginal spines, has three furrow spines, and no abactinal pedicellariae. Jangoux (1981: 459) reported restricted superomarginal spines for *A. eucnemis* from the Philippines where it is found in shallow water.

One specimen (Q84, a paratype, with R/r approx. 45, 46/7 mm) was dissected. The ambulacral plates are low, sturdy, almost rectangular, forming a distinct broad ridge along the arms; they are well separated dorsally by a broad muscular area. Proximally distinct pipe-like superambulacral plates are present, and are less conspicuous further out along arms. Ampullae of tubefeet are double and very distinct and there is a strong interradiial membranous septum present. Abactinal plates seen from the coelomic side are very distinct; they are often round, oval, triangular, almost rectangular, and do not overlap.

The stomach was packed with foraminiferans.

*Astropecten* sp.

(Pl. 14, Fig. 16)

**MATERIAL EXAMINED:**

NMNZ: Herald Island, Kermadec Group : Ech. 4432(1).

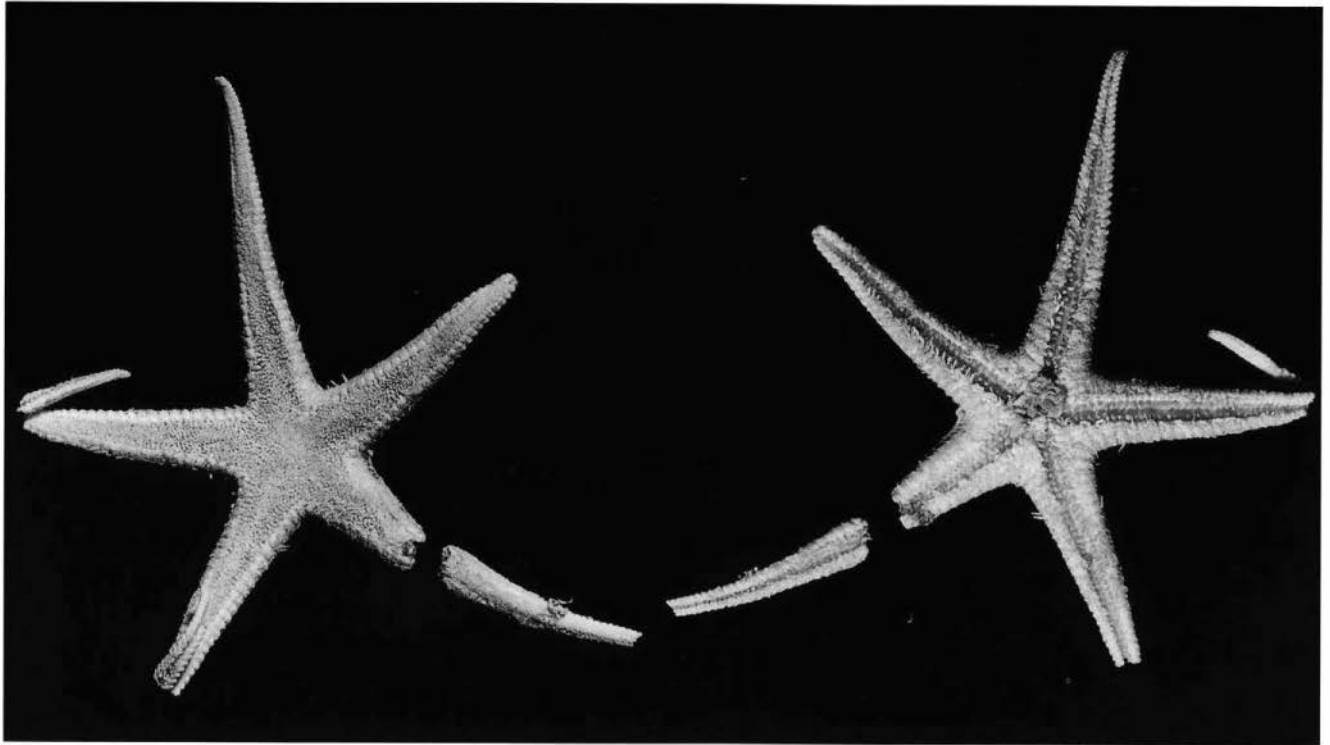


Plate 13. *Astropecten tasmanicus* n.sp. Holotype. NZOI Stn Q84. R/r = 35/5 mm. Abactinal and actinal surfaces.

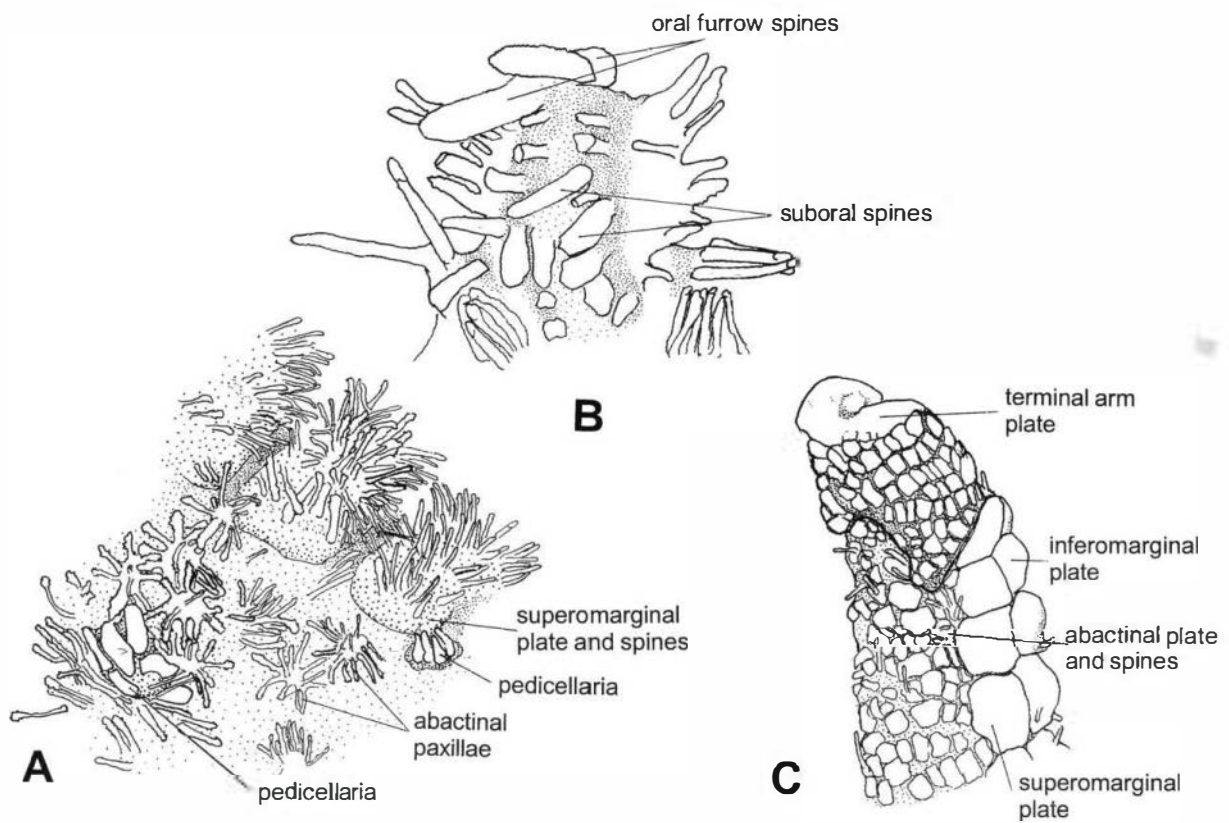


Fig. 15. *Astropecten tasmanicus* n.sp. Holotype. NZOI Stn Q84. A. Abactinal paxillae and superomarginal plates and spines. Note pedicellariae. B. Oral plates. Note large anterior oral furrow spines. C. Terminal arm plate. Note rows of small plates.



SIZE: R/r = (approx.) 23/6 mm (all arm tips broken).

DEPTH: 1,189–1,226 m.

DISTRIBUTION: Known only from northeast of Herald Island, near Raoul Island, Kermadec Group.

DESCRIPTION: The single specimen is described.

*Arms* 5, disc distinctly raised with swelling continuing centrally along arms, all arm tips missing. Arms broad basally, tapering evenly to tips. A small, shallow depression present centrally on disc.

*Terminal arm plates* missing on all 5 arms.

*Abactinal paxillar plates* oval, faintly lobed, almost round, forming very conspicuous and regular rows along edges of arms and disc; rows are of 3–5 plates. Plates raised centrally to almost a trunk, crowned by 8–16 peripheral spinelets, these finely thorny and round tipped; they surround 1–6 similar spines. Distally along arms, paxillae fewer with 3 or even 2 in a row, these paxillae smaller with fewer spines. Along midline of arms and on disc centre, abactinal plates more or less flat or very gently raised, and spinelets small, short, crowded; plates form a very irregular, close and conspicuous cover; true paxillae not present. Further out, centrally along arms, spines small, short, well spaced, not numerous.

*Papulae* obvious along arms and disc edges; generally 4–6 at base of each plate; they are absent from disc centre and midline of arms. Membranous areas proximally between abactinal plates are distinct and large.

*Pedicellariae* not obvious abactinally; however, occasionally near superomarginal plates, very small paxillae with 2 or 3 spines present, the tips of these spines sometimes meeting, almost forming a simple pedicellaria.

*Madreporite* interradial, small, almost round, raised and separated from superomarginals by a single row of plates; it is finely and deeply dissected with rifts meeting centrally.

*Anus* absent.

*Superomarginal plates* forming a very regular, raised and distinct edge to abactinal surface; plates rectangular, longer than wide when viewed from above, and distinctly tumid, well separated laterally from each other by deep channels that do not seem to be lined by fine spines. Superomarginal plates large, almost half plate length on abactinal surface; plates bearing rows of well-spaced, finely thorny spinelets that resemble those of abactinal paxillae. On upper (abactinal) part of each plate a distinct round scar where a large spine must once have been attached; no spines remaining. There seems to have been only 1 enlarged superomarginal spine; spines appear to have been present on

all plates presumably as far as arm tips.

*Inferomarginal plates* corresponding with superomarginals; only a small part of each plate visible from abactinal surface. Actinally, inferomarginal plates very conspicuous, bearing a close cover of small spinelets similar to those of superomarginals as well as an oblique row of 3–5 quite conspicuous enlarged spines, these tapering, very finely thorny and slightly flattened. These occupying a slightly raised area and were probably present on all plates. Occasional small, flattened scale- or leaf-like spines also often present at base of enlarged spines; these commoner interradially, occurring as fascicular spines between inferomarginal plates. No obvious pedicellariae, although occasionally tips of 2 or 3 spines meet.

*Actinal areas* small, ill-defined, with distinct raised, oval unpaired plate at base of oral plates; on either side of this 2 or 3 smaller plates may be present, these bearing groups of 5–8 or 9 slender spinelets where tips may meet but whether they constitute a pedicellaria is doubtful. On some actinal plates an enlarged spine present, usually central on plate. Where arms are broken, very small plates visible intermittently, sometimes with a very small spine; presumably these are actinal plates, although they are not obvious abactinally.

*Adambulacral plates* forming a very regular edge to furrow, rectangular, well separated laterally by deep membranous furrows, the free edge overhanging the grooves distinctly angular and jutting well into furrow. Two, sometimes 3, round-tipped, flattened furrow spines on either side of unpaired central spine. The latter large, triangular basally, round-tipped and very slightly taller than adjacent furrow spines; centrally on plate several other round-tipped, similarly flattened spines present. Near inferomarginals there may be 3–5 slender, round-tipped subambulacral spines; no obvious adambulacral pedicellariae.

*Oral plates*, unfortunately damaged, more or less oval and raised centrally with 6–8 fringing furrow spines; these largest anteriorly, very finely thorny, gently tapering, round-tipped. Central raised area of plate is fringed at base by 9–10 or 11 spines, some slender, untapering and blunt-tipped, others sturdier, thicker, and at a very slightly higher level. A third row of spines occupies crest of plate, these sturdy, round-tipped, slightly tapering and very finely thorny.

*Ambulacral grooves* narrow, deep; *tubefeet* distinctly tapering to fine tips, in 2 well-ordered rows.

COLOUR: There are no colour notes of fresh material; dried, ex-alcohol, the colour is pale cream to white or almost grey with conspicuously white marginal plates and, actinally, brown tubefeet.

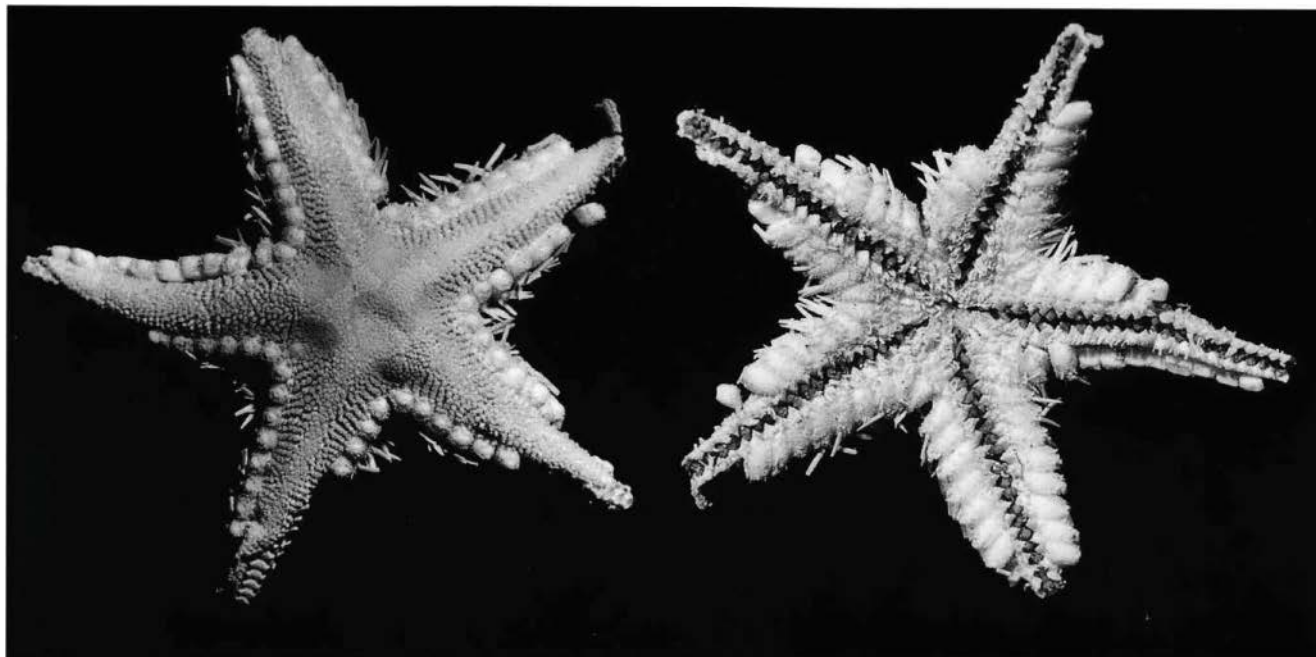


Plate 14. *Astropecten* sp. NMNZ Ech. 4432, R/r = approx. 23/6 mm. Abactinal and actinal surfaces.

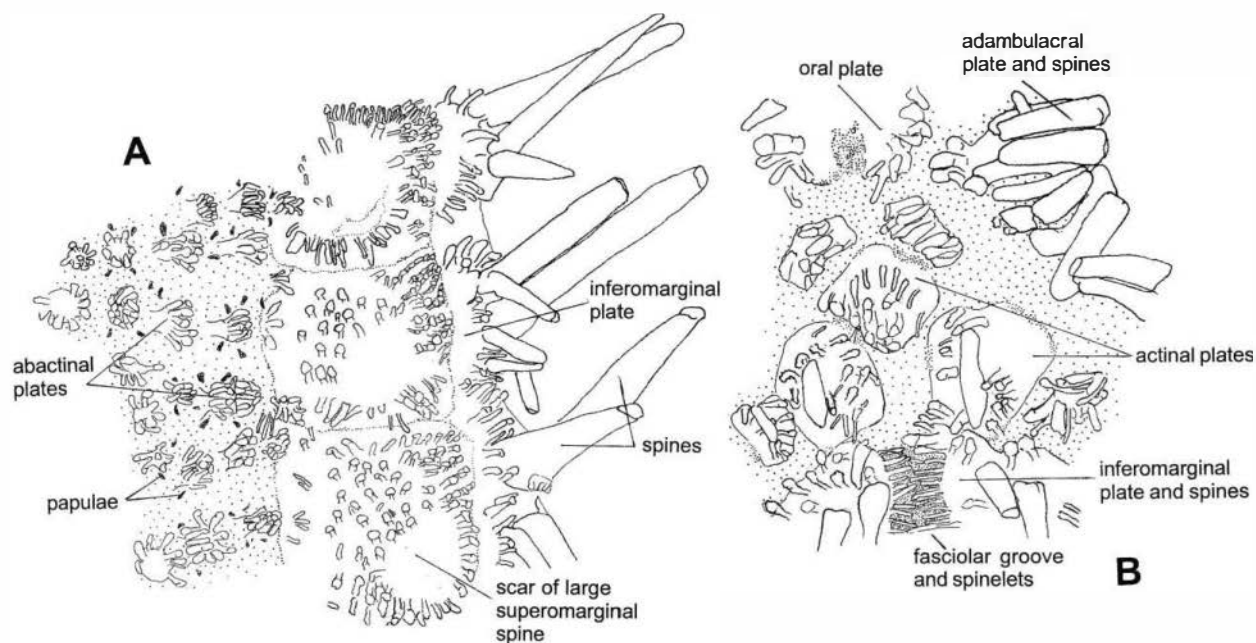


Fig. 16. *Astropecten* sp. NMNZ Ech. 4432. A. Abactinal plates and papulae, and superomarginal and inferomarginal plates and spines. B. Adambulacral plate and part of oral plates, and actinal and inferomarginal plates and spines.

REMARKS: As seen from the broken arms, ampullae of the tubefeet are well developed and double; very strong bar-like superambulacral plates are also present; the specimen was not dissected further.

This single damaged specimen belongs in Döderlein's (1917) deep-water "Griegi" group. It is perhaps

one of the deepest species of *Astropecten* ever recorded.

Armature of the abactinal plates is interesting; marginally, on arms and disc short-stalked paxillae are present; along midline of arms and on the disc centre, plates may be slightly raised but there are no true paxillae. Also of interest are the scars on the supero-



marginal plates, which suggest that spines were present on all superomarginal plates.

This small rather battered specimen bears some resemblance to *Astropecten tenellus* Fisher from the Philippine Islands in 267–366 m; however, it differs in lacking abactinal and proximal adambulacral pedicellariae. It is similar in having flattened and sharp inferomarginal spines and in the armature of the adambulacral plates.

*Astropecten* sp. is similar in many respects to *A. dubiosus*, differing however, in lacking a conspicuously enlarged and obvious subambulacral spine.

### *Dipsacaster* Alcock, 1893

Disc large, broad, depressed; inferomarginals project beyond superomarginals forming a very distinct edge to disc and arms, inferomarginals often with conspicuous tufts of small spines. Abactinal plates basally lobed, distinctly paxilliform with slender upright spinelets. Papulae widespread; sometimes fewer, smaller, along midline of arms and on disc centre. Madreporite large, hidden, covered by paxillae. Actinal areas large, conspicuous, with distinct grooves that are continuations of fasciolar grooves between marginal plates; actinal plates paxilliform with spinelets. Pedicellariae generally not present. Adambulacral plates conspicuous, furrow spines well defined, quite numerous. Oral plates broad, conspicuous with numerous spinelets. Tubefeet pointed.

TYPE SPECIES: *Dipsacaster sladeni* Alcock, 1873.

REMARKS: The genus is widespread. Halpern (1968: 236) included 13 species of *Dipsacaster* and described a new species, *D. antillensis*, from near the Little Bahama Bank, western Atlantic. A.M. Clark and Downey (1992: 49) included only two species, *D. antillensis* Halpern and *D. sladeni capensis* A.M. Clark. Fell (1958: 6) recorded *D. magnificus* from Cook Strait, New Zealand in 100–115 m and the present report extends the range very considerably; it is also widespread (Rowe & Gates 1995: 51) in Australian waters.

According to Halpern (1968: 231), gonads in species of *Dipsacaster* extend far along the arms. In the present specimens, especially larger dissected individuals, gonads are quite conspicuous but restricted to inter-radial regions. They do not extend along the arms. In his definition of the genus, Alcock (1893: 87) recorded inferomarginals “with enlarged spines” — this is certainly not so in *D. magnificus*. Likewise, A.M. Clark and Downey (1992: 50) stated in their definition of the genus that “pedicellariae (are) usually present” and they recorded “massive” actinal pedicellariae in juve-

nile *D. antillensis*; we found no pedicellariae in New Zealand specimens of *Dipsacaster magnificus*.

### *Dipsacaster magnificus* (H.L. Clark, 1916)

(Pl. 15, Fig. 17)

*Lonchotaster magnificus* H.L. Clark, 1916: 30, pl. 6(1, 2); Fisher 1917: 169; Cotton & Godfrey 1942: 195.

*Dipsacaster magnificus*: Fisher 1917: 169; Fisher 1919: 150; H.L. Clark 1946: 78; Fell 1958: 6; 1959: 132, pl. 1, fig. 3(A, B); McKnight 1967: 298; Halpern 1968: 236; H.E.S. Clark 1970: 3; A.M. Clark 1989: 276; Rowe & Gates 1995: 51.

#### MATERIAL EXAMINED:

NZOI Stns: A910(1), C605(1)\*, C607(1), D180(1)\*, D211(1), D876(1)\*, E408(1)\*, G153(1)\*, G876(1)\*, G890(1), G896(1)\*, G900(1), G901(1)\*, G903(1)\*, G905(1)\*, G908(4)\*, G918(1)\*, G927(2)\*, G928(1), G929(1)\*, G931(2)\*, G933(3)\*, G934(2)\*, G935(1)\*, G936(1)\*, G938(1)\*, I667(1)\*, I680(1)\*, J26(2), J36(1)\*, J550(1)\*, S121(1), S123(2), S124(1)\*, S125(2), S126(1), S127(2), S130(1), S159(1), S174(1), S179(4)\*, S190(1)\*, S199(1), W259(1), Z6482(1), Z8566(1), Z9209/024(1).

NMNZ: Auckland Islands: Ech. 1244(1); Bounty Plateau and Islands: Ech. 4448(1); Canterbury Bight and Banks Peninsula: Ech. 4452(1); off Cape Campbell: Ech. 569(3), 585(4); near Castlepoint: Ech. 1176(1); Challenger Plateau: Ech. 4451(1), 4453(2), 5229(1); Chatham Rise: Ech. 1242(1); near Christchurch: Ech. 4198(1), 7441(3); Cook Strait: Ech. 5231(1); off Kahurangi Point: Ech. 4454(1); Mernoo Bank and Slope: Ech. 1243(1), 2399(5); Papanui Canyon: Ech. 5230(1); near Stewart Island: Ech. 1241(1), 3101(4), 6511(1); off Westland: Ech. 4449(2), 4450(1), 4456(1); near Westport: Ech. 4455(1).

SIZE: R/r varies from 180/59 mm (NMNZ Ech. 4456, from off Westland) to R/r = 40/14 mm (NZOI Stn S125, from the Chatham Rise area). The average R/r for 46 specimens in the present collections is 97/33 mm, in the type material from the Great Australian Bight R/r = 155/50 mm.

DISTRIBUTION: There is only one coastal North Island record of this species, from off Castlepoint on the east coast (NMNZ Ech. 1176). Specimens are recorded, however from the Challenger Plateau, Lord Howe Rise area. It is commoner from Cook Strait south, from off Cape Campbell to Christchurch, from the Chatham Rise, and from near Bounty and Antipodes Islands. On the west coast of South Island it is well represented in deeper waters, especially off Westland and from around Stewart Island. It extends to near Auckland and Campbell Islands, although many of the NZOI specimens historically recorded from near Campbell Island have not been seen during this study. Fell (1958: 6) recorded 25 specimens from the Cook Strait area in 101–115 m; there is only one record from this area in the present collections (NMNZ Ech. 5231), and this is

probably one of Fell's specimens. One specimen (NMNZ Ech. 7446) is recorded from the Louisville Ridge, 40°52' S, 165°02' W, outside the range of the present work. The species is also known from the Great Australian Bight and from Victoria, New South Wales, and western Australia.

**DEPTH:** The depth range for *Dipsacaster magnificus* in New Zealand waters was previously 101–555 m (H.E.S. Clark 1970: 3); the 102 specimens recorded here range in depth from 101 to 1090 m, with the deepest specimen (NMNZ Ech. 4198) from near Christchurch. Australian specimens (Rowe & Gates 1995: 51) are from depths between 128 and 979 m.

**DESCRIPTION:** The specimen described from NZOI Stn D211, R/r 95/36 mm, from near the Snares Islands in 519 m.

*Disc* and *arms* flat, arms broadening basally and tapering rapidly and evenly to a sharp tip that is protected (on the one entire arm) by a sturdy, strong, irregularly rectangular *terminal plate*; faint scars suggest small granules or short spinelets may once have been present; *interbrachial arcs* sweepingly and evenly rounded.

*Abactinal plates* in very regular rows, especially along arm edges and interradially; generally 3 or, more distally, 2 rows of abactinal plates corresponding to 1 superomarginal; paxilliform plates crowded along arm midline and on disc centre. Abactinal plates lobed, surface somewhat obscured by membrane; each plate with short, sturdy trunk expanding into a round or oval, often conspicuously domed, head with a large number of very slender hyaline sharp-tipped spines, these often finely spinulose. Up to 50–60 or more spines in a paxilliform plate, tending to lean towards paxilla centre and forming a very characteristic "tuft" or cluster. Sometimes outer paxillar spinelets united basally by a fine membrane.

*Papulae* 4–6, obvious between plate lobes, but few and very small along midline of arms and on disc centre.

*Pedicellariae* absent.

*Madreporite* large, obscured by paxillae, ca. 8 mm from superomarginal plates, the covering paxillae distinctly larger and more prominent; the area slightly depressed.

*Superomarginal plates* forming a very obvious and regular edge to disc and arms; between 66 and 75 plates from arm tip to arm tip, rectangular, band-like and smaller, shorter near arm tips; plates covered by short, fine, small angular spinelets. Along plate margins spinelets longer, more slender, more numerous, forming a distinct edge along fine, deep fascioles between plates. Superomarginal spinelets often sharply serrate, angular in cross-section; no enlarged spines or granules

present.

*Inferomarginal plates* corresponding with and projecting beyond superomarginals, with only a small part of the inferomarginal plate obvious from abactinal surface; most obvious actinally instead. The plates rectangular, perhaps almost tapering interradially, where they meet superomarginals; with a shaggy covering of short, fine spinelets, slightly thicker and more regularly arranged than those of superomarginals; spinelets more slender and longer near edges and in the deep, bordering fasciolar grooves. No enlarged inferomarginal spines, the fine, covering spines more obvious, almost "tufted" near superomarginals. The conspicuous projecting edge of inferomarginals is illustrated by Fell (1959: pl. 1, 3B).

*Actinal areas* large, conspicuous, with very regular rows aligned longitudinally along arm, but also conspicuously between adambulacrals and inferomarginals (cf. "columns" of Clark & Downey 1992: 69 for *Plutonaster*). Interradially, actinal plates rectangular; shorter near adambulacrals, almost oval, and near oral plates often distinctly round.

*Actinal plates* with short-stalked, rather flattened sometimes almost scale-like triangular spines that form more or less regular rows on plates and give the actinal surface a distinctly "shaggy" appearance; spines tend to fall and lean across plates towards inferomarginals. A conspicuous short single (unpaired) row of 2, 3, or 4 plates which runs from between oral plates in an angle. Actinal plates separated by distinct fasciolar grooves that continue from between inferomarginal plates to adambulacrals; no enlarged spines or pedicellariae. Actinal plates continue as a single row of plates between adambulacrals and inferomarginals almost to arm tip.

*Adambulacrals plates* conspicuous, large, rectangular, with gently rounded free edge projecting into furrow; plates raised especially in first part of arms. Plates well separated laterally by membranous grooves, which are more or less continuations of fasciolar grooves between actinal and inferomarginal plates. Furrow spines strong, sturdy, compressed, sometimes triangular, flat-tipped with narrow edge to plate and furrow; 8–10 present, most anterior and posterior smallest, forming an impressive edge to furrow. Furrow spines project across groove, almost meeting spines from opposite plates. 3 rows of subambulacrals spines; the row adjacent to furrow spines has generally 4, sometimes 5 short, almost triangular flattened spines that generally stand against furrow spines and are less than half their height. Second row of spines 4–6 or 7, also forming a row parallel to furrow spines and of similar size and shape; the plates fringed by spaced spines; adambulacrals spines very similar to those of actinal plates.



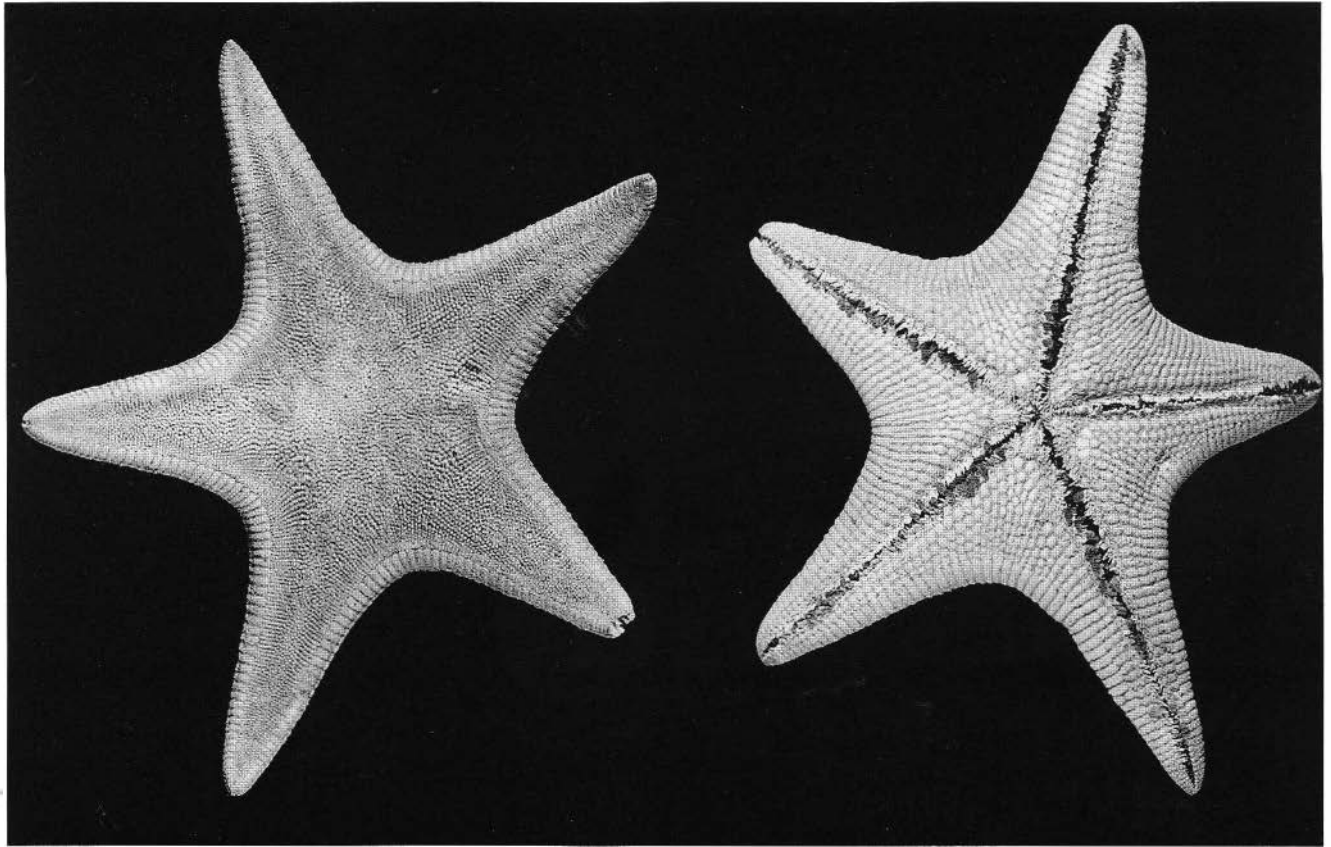


Plate 15. *Dipsacaster magnificus* (H.L. Clark). NZOI Stn D211. R/r = 95/36 mm. Abactinal and actinal surfaces.

spines; adambulacral spines very similar to those of actinal plates.

*Oral plates* large, tumid, especially posteriorly, where there is a steep rise to plate crest. Furrow spines strong, well spaced, compressed, narrow edge to furrow and plate; these spines similar to adambulacral furrow spines. There are 10 or 11 furrow spines, the largest overhanging mouth, the most posterior spine small, inconspicuous, and round the "curve" of the plate other suboral spines considerably shorter, often almost triangular, sometimes stalked, forming 3 or 4 irregular crowded rows on either side of median suture; they are similar to spines of actinal plates; when removed, spines leave distinct round scars. On steep, posterior part of the plates adjacent to actinals, spines thick, heavy-headed, often stalked, irregular and crowded. The membranous area between 2 plates in an angle is broad near actinal plates, narrowing and irregularly broad at crest of plates. An interesting feature is the presence of unpaired oral marginal furrow spines in at least 2 interradial angles; a central furrow spine with 10 or 11 spines on either side; there seem to be no other reports of unpaired oral furrows spines in other species of *Dipsacaster*.

*Tube feet* biserial, crowded, large, long, tapering with

small "button" at tip.

*Ambulacral grooves* generally narrow.

**COLOUR:** There are colour notes with only one specimen in the present collections, viz. NMNZ Ech. 5230 from Papanui Canyon, and the notes state "orange". H.L. Clark (1916:32) recorded the colour of the type material as "light dirty grayish, more or less yellow on various irregular areas" — whether this was for a living or dead specimen was not stated. Fell (1958: 6) recorded the colour as "salmon-pink above, marginals paler salmon, underside cream" and in 1959 (p. 132) he recorded the colour as "salmon-pink". Dried and in preservative specimens are either uniform dull brown or white.

**REMARKS:** In the NZOI collections 62 specimens (from 47 stations) are listed; of these, 38 specimens (27 stations) bear an asterisk, i.e., specimens are recorded but are not present in the collections.

There are 40 specimens from 15 localities in the NMNZ collections.

All specimens but one had 5 arms; this one specimen (NZOI Stn S127, from off Banks Peninsula in 322 m) had 6 arms; it is folded and battered. Regenerating arms are quite common in this species and many

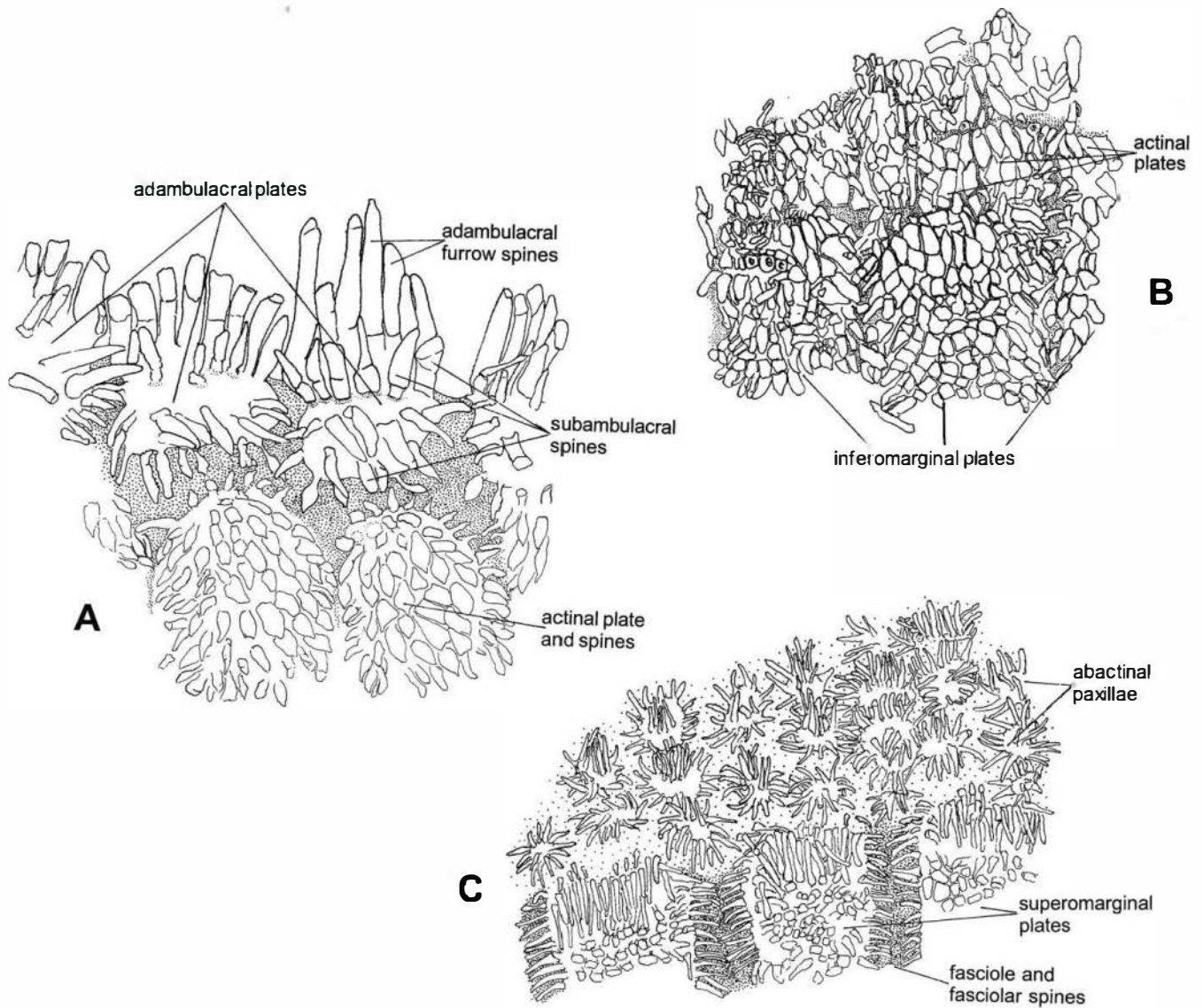


Fig. 17. *Dipsacaster magnificentus* (H.L. Clark). NZOI Stn D211. A. adambulacral and actinal plates, near interradial angle. B. inferomarginal plates and adjacent actinal plates. C. abactinal and superomarginal plates. Note fasciolar grooves and spines.

specimens lack terminal arm plates or new ones are obviously growing; likewise it is not at all unusual for specimens to have arms of different lengths; this is sometimes quite obvious, but generally does not involve more than a few millimetres difference.

A number of specimens were dissected. In a large specimen (NZOI S199, from near Christchurch, R/r = 120/43 mm), *abactinal plates* along arm edge, seen from the coelomic side, have a distinctly tumid centre and there are 4–6 rather small, ill-defined lobes. These plates overlap along arm edges, where they form conspicuous longitudinal rows. Along midline of arms and on disc centre plates are more round or oval and lobes are not obvious. Papulae are most obvious from the coelomic side, 4–6 even sometimes 7 being present around plates

along arm edges; along midline of arms and on disc centre papulae are few and small.

An interesting feature in all specimens dissected is the *partial membranous septa*. These are very regular and present for at least three-quarters the length of each arm. Interradially, the septa extend from the abactinal plates down between the superomarginals and across the actinal plates (to which the membrane is attached) in a sweeping curve, terminating between the *superambulacral plates*. The septa are very obvious and very regular, with only one in the space between two *superambulacral plates*. There is also a large and typical membranous *interradial septum*, which is more conspicuous and thicker; this extends right across the interradius to the odontophore. On either side of this, the



first and sometimes also the second partial septa in a series begin as a single septum which then divides evenly into two and these continue separately across the actinal plates to the ambulacral ridge. In the inter-radius with the *madreporite* and *stone canal* the inter-radial septum separates to encircle the stone canal and the curious and very obvious and large cup or egg-like swelling which is capped by the madreporite; the septum becomes single again near the odontophore. Both superambulacral plates and partial septa continue along the arms but they become increasingly less obvious near arm tips. The *stone canal*, somewhat flattened in dry specimens, is long and very strong; it is composed of a number of close-fitting rectangular, oblong, square, almost oval ossicles (small plates) and is enveloped in a strong membrane from the interradial septum. When the canal is dissected and opened it is obvious how well protected it is — by a thick, tough outer membrane and then an armour of small plates. It curves upward and expands into a large cup or egg-shaped mass which is crowned by the madreporite; this cup-shaped organ is packed with thin, folded, convoluted ossicles. There is a definite outer edge below the outer protective enveloping membrane.

The *madreporite*, interradial and very large, is covered and hidden by paxillae, the paxillae often forming regular, longitudinal rows; the madreporite is very finely dissected and is not raised above the surface, appearing surprisingly thin marginally with a convoluted and wavy outline. The abactinal paxillae actually seem to grow through the madreporite; the paxillar heads are large, conspicuous, and often oval in shape.

*Ampullae* of the tubefeet are large and double. *Polian vesicles*, one to an interradius, are large and very long stalked. Tiedmanns bodies are present as a pair of dark, more or less oval, rather membranous structures at the base of the first pair of ambulacral plates on the ring canal.

*Ambulacral plates* form a strong high ridge along the midline of arms, and at the crest of the ridge there is a wide membranous gap between plates, which only meet with neighbouring plates at edges. There is a conspicuous and definite pore or opening present between oral plates and the odontophore, divided by the long slender stalk of the polian vesicle. Below this, on either side of the proximal ambulacral ossicles and at the base of the T-shaped odontophore, another very small pore occurs; these pores are most obvious in larger specimens.

On many *oral plates* there is an *unpaired median furrow spine*, most obvious from the coelomic side after dissection and clearing away of oral membranes; in a large dissected specimen (NZOI Stn S199) there is an unpaired spine on at least two oral angles; this unpaired

spine is present in the membranous area between two oral plates.

*Gonads* are conspicuous, well developed, and especially obvious in larger specimens, occurring as irregular strands which adhere to the abactinal plates interradially. There are no obvious gonopores or genital stolon. The gonads do not extend into the arms for any distance.

In two small specimens (NZOI Stn S125, R/r = 40/13 and 40/12 mm), partial interradial septa are present but do not reach the *superambulacral plates* which are small, bar-like and more obvious distally along arms. In these small specimens, ampullae of the tubefeet are large and conspicuous and polian vesicles are also very obvious and long stalked, with one to each interradius. The two sets of pores near the odontophore are also obvious but small. Actinal plates appear more rounded; in large specimens actinal plates seen from the coelomic side are elongate and similar in shape when seen from the outside.

One further specimen (NMNZ Ech. 4451, from the Challenger Plateau, 520–528 m, with five arms and R/r = 63/22 mm), is interesting. In this specimen, abactinal paxillae in general are widely spaced from each other and the abactinal covering of paxillae is surprisingly sparse. The very finely dissected madreporite is large, thin, crenulated and a large number of regularly arranged paxillae are present in straight rows across its surface. Dissection showed how isolated the abactinal plates are and how very few papulae are present. Gonads are quite well developed and are interradial. The stomach was packed with fine mud and foraminiferans. The madreporite seen from the coelomic side lies very close to superomarginal plates.

Few specimens of this starfish had stomach contents — in a large specimen (NZOI Stn C607, from the Chatham Rise area, with R/r = 120/44 mm) the stomach was full of an echinoid, *Spatangus*, and the two smaller specimens (NZOI Stn S125) mentioned above had unidentified remains of ophiuroids, echinoids, and holothurians in their stomachs. *Brisopsis oldhami* Alcock, an echinoid, was present among other echinoderm remnants from a large specimen (NZOI Stn S199, near Christchurch, 685 m). As these specimens grow to a very large size, they probably take many echinoderms as food.

### *Dytaster* Sladen, 1885

Disc rather small, arms long, narrow, sometimes carinate. Interbrachial arcs rounded, abactinal paxillae generally very small and irregular in arrangement, occasionally quite regular rows of paxillae are present

interradially. Marginal plates distinct, regular, often with one enlarged spine; actinal interradial areas quite small, plates often imbricating. Adambulacral plates with numerous furrow and subambulacral spines, these often forming distinct rows. Madreporite large, covered by paxillae; simple pedicellariae often present.

TYPE SPECIES: *Dytaster nobilis* Sladen, 1885.

This is the first record of the genus from the New Zealand Exclusive Economic Zone. The two new species can be distinguished from each other by the points given in the following tabular key.

TABULAR CHECKLIST TO NEW ZEALAND SPECIES OF *DYTASTER*

	1	2	3	4
<i>Dytaster</i>				
<i>felli</i> n.sp.	s	p	e	7–9
<i>pedicellaris</i> n.sp.	b	a	a	5–7

- 1 Pedicellariae  
b – broad-headed, large, many  
s – with slender spines, generally few
- 2 Abactinal paxillae are  
p – present, distinct on disc  
a – ill-defined, absent from disc
- 3 Abactinal plates with  
e – enlarged spines  
a – no enlarged spines
- 4 Adambulacral furrow spines

*Dytaster felli* n.sp. (Pl. 16, Fig. 18)

*Dytaster insignis* [non Perrier, 1884]: McKnight 1993a: 167.

MATERIAL EXAMINED:

NZOI Stns P969(1), U195(1), U196(3).

TYPES: Holotype from Stn U196, R/r = 55/10 mm, registered number H-737 is deposited in the NIWA collection, Wellington.

Paratypes (2 specimens) from Stn U196, registered number P-1204, deposited in the NIWA collection, Wellington.

TYPE LOCALITY: NZOI Stn U196, 33°03.00' S, 165°22.4' E, 3118 m, eastern side of Lord Howe Rise.

Size: In specimens from NZOI Stns P969 and U196, R

varies between 60 and 34 mm, and r between 12 and 8 mm; a folded and damaged specimen (U195) is considerably larger but no arms are intact. R/r is approximately 90/12, 13 mm.

DISTRIBUTION: From west of New Zealand, near the Lord Howe Rise and from near East Cape, North Island.

DEPTH: 2250–3118 m.

DESCRIPTION: The holotype from NZOI Stn U196, R/r = 55/10 mm is described; there is one entire arm.

*Disc* small, irregular, arms long, very slender, rather flattened, tapering, especially in last half, interbranchial arcs rounded. *Terminal arm plate* high, arch-shaped, with straight free edge and distinctly v-shaped near abactinal plates. Small irregularities on the terminal plate suggest fine granules or spinelets were present, probably in quite regular rows; enlarged spines may not have been present.

*Abactinal paxillae* of disc and for a short distance along arms are rectangular, square, lobed — the latter near superomarginals. These plates have a short thick, distinct trunk which occupies most of plate and ends in an oval, round, and often flat head which is crowned by 5–7, sometimes as many as 12, slender, tapering, finely thorny spinelets. Often an outer fringe of small, short spinelets, which may be united basally by a slender web of tissue. Paxillae near marginal plates tend to have shorter spinelets than those centrally on disc and arms. Generally, paxillae show no very regular arrangement, although when spinelets are removed there is a faint suggestion of longitudinal and transverse rows along arms; elsewhere arrangement is irregular; paxillae distinctly shorter near arm base; half way along arms plates bear short spines, true paxillae not present. Spinelets on these distal plates are fewer, the plates often gently raised centrally but with no paxillar trunk. Also a quite distinct and shallow naked channel path bordering superomarginal and abactinal plates for some distance along arms.

*Papulae* small, often indistinct, extending interradially to superomarginal plates.

*Pedicellariae* simple, few, not very obvious, present interradially and often near superomarginals; they are formed of 2, sometimes 3, 4, thicker spinelets, the tips meeting. Pedicellariae present intermittently to arm tips, most obvious near superomarginals, with some more centrally, especially further out along arms.

*Madreporite* not particularly large, almost oval, lying nearer superomarginal plates than disc centre; it is finely dissected, with 5 or 6 enlarged, thick-headed, paxillae that hide it, and separated from superomarginal plates by 2 or 3 rather irregular rows of plates, the central row with conspicuously enlarged paxillae



almost forming a ridge along disc edge and for a short distance along arms.

*Anus* absent.

*Superomarginal plates* 36 or 37, forming a well-ordered edge to disc and arms, from interradial angle to arm tip. Superomarginal plates more or less longer than wide when viewed from above with, generally, an almost straight edge bordering both abactinal and inferomarginal plates. Plates evenly raised, almost rounded, and separated laterally from each other by broad (at least interradially), shallow *fasciolar grooves*. Superomarginal plates bear small, spaced, slender, slightly flattened, round-tipped spinelets, these forming quite regular well-spaced rows which are most obvious abactinally. Generally 1 large superomarginal spine, very occasionally 2; these sturdy, slightly tapering and generally blunt-tipped; spinelets at base of enlarged spines are slightly longer and sturdier. Occasional simple pedicellariae on superomarginals adjacent to abactinal plates, present interradially only. Laterally along plate edges spinelets become longer, more slender, and merge with and sometimes touch similar fasciolar spinelets from across the groove; fasciolar spinelets also present, also between plates of inferomarginal series.

*Inferomarginal plates* corresponding with superomarginals but taller, with a straight or gently curved margin actinally. Plates carry slender spinelets similar to those of superomarginals, forming quite regular rows as stumps show when spines are lost. Each plate bears an enlarged spine similar to, but longer and perhaps sturdier than those of superomarginals. Occasionally 2, even 3 enlarged spines present, especially interradially and for short distance along arms. Plates (of both series) separated by *fasciolar grooves*, naked grooves continuing between actinal plates.

*Actinal areas* quite large, distinct; plates present along arms to 4th or 5th inferomarginal; each with a close cover of small irregularly shaped and arranged, gently tumid plates, these with slender, well-spaced spinelets similar to those of marginal plates; generally spinelets forming a spaced fringe around plate edge; there may be central spinelets also and sometimes 1 or 2 are enlarged. It is difficult to tell whether pedicellariae are present or not; in 1 interradial angle, however, there is a distinct 2-bladed pedicellaria quite unlike any other seen on these specimens; it seems to be attached to a plate and to belong to the specimen.

*Adambulacral plates* rectangular, i.e., longer than broad when viewed from above and actinal plates; plates separated laterally by shallow naked grooves; these continue between actinal plates to inferomarginals. Adambulacral plates with a distinct series of often 8, occasionally 7 or 9 furrow spines, the free edge of plate (overhanging the furrow) gently curved.

Furrow spines short, round-tipped, finely thorny and compressed laterally, forming a very regular edge to furrow; most proximal and distal spines often conspicuously smaller. 1 or 2 longitudinal rows behind furrow spines of similar but generally shorter subambulacral spines; these well spaced, not crowded; edge of adambulacral plate next to actinal or marginal plates fringed by small, well-spaced slender spinelets, these smaller and fewer near arm tips. No enlarged subambulacral spines or pedicellariae seen. In last half of arms adambulacral plates are rounded proximally, the plate surface flat. Many furrow and subambulacral spines missing in the present specimen; adambulacral plates on either side of oral plate in an angle almost triangular, with 8 furrow spines.

*Oral plates* well raised, conspicuous, with 10 or 11 long, slender furrow spines; suboral spines form 3 or 4 regularly spaced rows to crest of plate; oral plates in the present specimen are rather damaged and only scars of suboral spines present; plates in an angle separated medially by a rather ill-defined, irregular membranous area.

*Ambulacral grooves* obvious and especially broad medially; *tubefeet* large, pointed with no disc, forming 2 distinct well-separated rows. Ambulacral grooves narrow near oral plates and in last quarter of arms.

**COLOUR:** There is no colour recorded for living or freshly preserved specimens. Dried and in preservative, specimens are a light pale brown with tubefeet decidedly more golden brown.

**ETYMOLOGY:** We are happy to name this new species for the late Professor H.B. Fell whose work on the systematics of New Zealand echinoderms has been an inspiration to both of us.

**REMARKS:** It is interesting that, in the specimen described, true abactinal paxillae are not present for most of the arm length. Downey (1973: 35) remarked on a similar condition in *Dytaster insignis* (Perrier) known from the Gulf of Mexico and the Caribbean. In some respects the present specimens are similar to *D. insignis* although there are differences in the abactinal paxillae and in the armature and arrangement of superomarginal and actinal plates.

The two other specimens (from NZOI Stn U196) are similar to that described although abactinal pedicellariae are less obvious and certainly fewer and the number of adambulacral furrow spines varies considerably. In these two specimens abactinal plates form very distinct rows of 4, 5, even 6 plates interradially, these rows are most obvious when covering spinelets are removed.

The small specimen (NZOI Stn P969, R/r = 35/

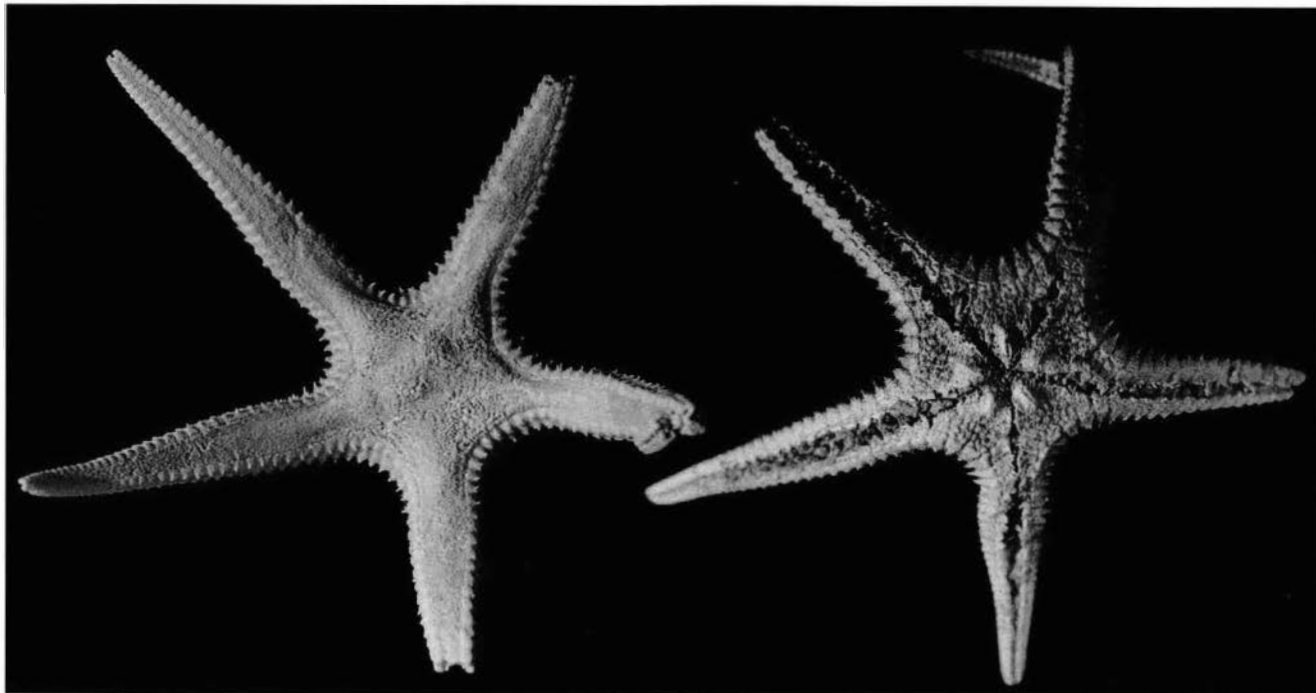


Plate 16. *Dytaster felli* n.sp. Holotype. NZO1Stn U196. R/r = 55/10 mm. Abactinal and actinal surfaces.

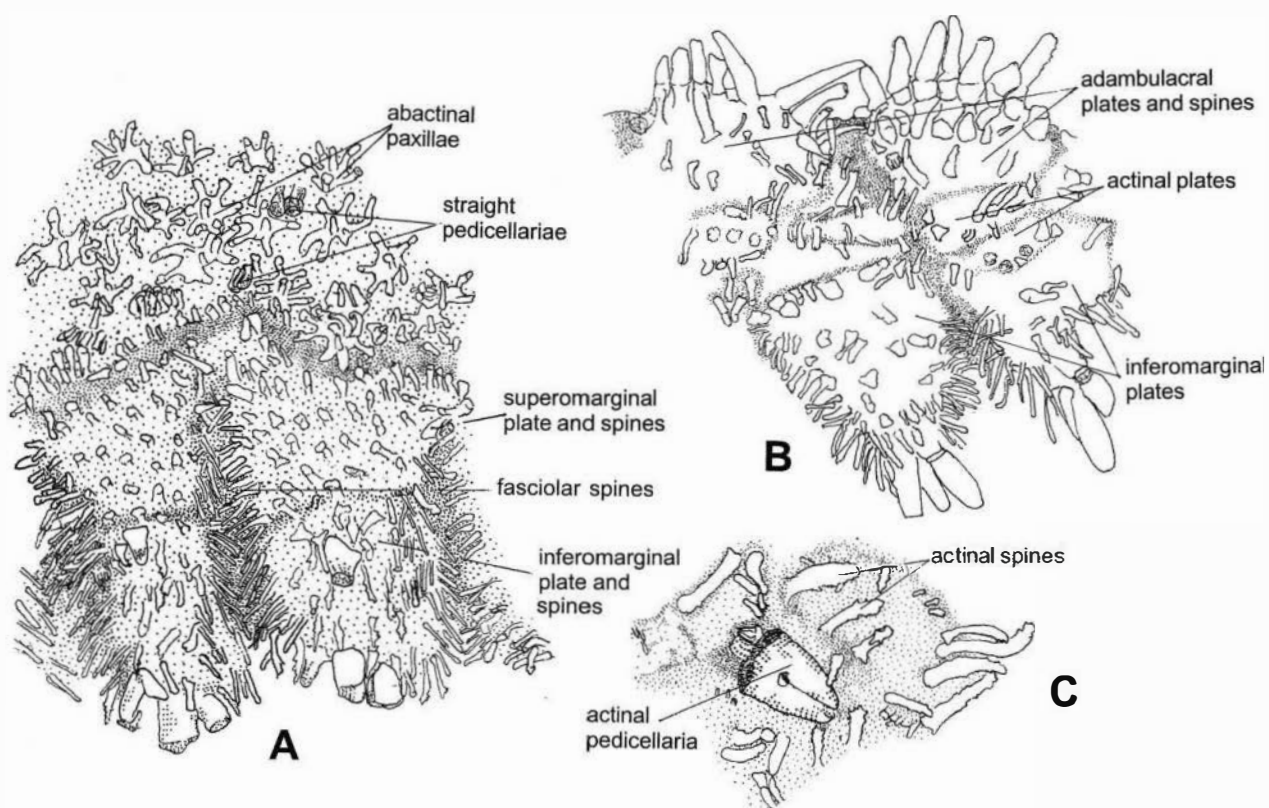


Fig. 18. *Dytaster felli* n.sp. Holotype. NZO1Stn U196. A. Marginal plates, both superomarginal and inferomarginal, abactinal paxillae and pedicellariae. B. Adambulacral plates and spines, actinal plates, and inferomarginal plates. C. Actinal plates and spines and single straight pedicellaria.



8 mm) from near East Cape in 2250 m, has one broken arm; there is one terminal arm plate intact with the remnants of three large spines. It is very similar to the specimen described although the arms are, perhaps, more rigid, more evenly tapering, and pedicellariae do not seem to be present on disc and arms. There are generally eight, sometimes nine adambulacral furrow spines, and the actinal plates are similar to those described, irregular in arrangement and slightly tumid. Oral plates are very distinct, raised and largely undamaged in this small specimen; there are 11 or 12 oral furrow spines, slender, tapering, spaced and finely thorny. Two oral plates in an angle are separated by a very shallow rather ill-defined groove. No pedicellariae were seen on this specimen.

One specimen (NZOI Stn U196, R/r = 59/11 mm) was dissected. Ambulacral plates form a conspicuous, strong and almost vertical ridge along arms; plates are separated dorsally by broad, rectangular, very regular muscular areas bordered by a small but distinct ridge. Ambulacral plates overlap slightly, and expand basally into two distinct lobes. Proximally, and for the first six or seven ambulacral plates, small, short, narrow, superambulacral plates are present; they are not obvious further out along the arms. Ampullae of tubefeet are double and large. There is a well developed membranous interradial septum and shallow partial septa are present at least to near the arm bases. Abactinal plates viewed from the coelomic side form a close, even cover; plates are oval or almost round or sometimes marginally square, rectangular, and hexagonal; there are almost regular rows of plates marginally. Plate arrangement along the midline of the arms is rather obscure. Near arm margins plates are sometimes missing, leaving a blank membranous space. No gonads were seen.

*Dytaster pedicellaris* n.sp. (Pl. 17, Fig. 19)

**MATERIAL EXAMINED:**

NZOI Stns S202(2), S204(2), ?U584(1). [The single specimen, U584, is badly damaged, folded, distorted.]

**TYPES:** Holotype, H-738, from Stn S204, deposited in the NIWA collection, Wellington.

Paratype, P-972 from same locality as holotype, deposited in the NIWA collection, Wellington.

**TYPE LOCALITY:** NZOI Stn S204, 42°10.5' S, 175°59.4' E, 2677m, Hikurangi Trough area.

**SIZE:** In specimens from Stns S202 and S204 arms are broken making accurate measurements impossible; this is also true for the single specimen, U584.

**DISTRIBUTION:** The four specimens from Stns S202 and S204 are from south of Cape Campbell in the Hikurangi Trough area; the specimen from Stn U584 is from near the Three Kings Ridge, well north of the Three Kings Islands.

**DEPTH:** 1137–2677 m.

**DESCRIPTION:** The holotype from Stn S204 is described; very approximately (all arms are broken) R/r = 43, 44/12 mm.

*Disc* quite large, gently and irregularly raised; arms long, slender, carinate (at least proximally), inter-brachial arcs rounded. No *terminal plates* present.

*Abactinal plates* with a small round swelling centrally, occupying most of plate, but whether it can be called a paxillar trunk is doubtful. Abactinal plates with 5–7 or 8 distinct slender, tapering, sharp-tipped spinelets, these finely thorny and sometimes slightly flattened. One of these spines may be enlarged; it is long, very slender, conspicuous and although often marginal in position is sometimes central on plate. Plates with enlarged spines are most numerous interradially, at arm bases. Spines on outer edges of plates sometimes seem to be united by a slender basal membrane. Abactinal paxillae do not seem to form very regular rows, although when spines are cleared there are short, more or less regular rows of plates at right angles to margins.

*Papulae* not seen.

*Pedicellariae* numerous abactinally, but not very distinct, small and most obvious near superomarginal plates, few and scattered along midline of arms and centrally on disc. Abactinal pedicellariae considerably smaller than actinal pedicellariae. Pedicellariae formed by 2, 3, even sometimes 4 very enlarged, thick rather flattened spines, the broad tips of these bent, meeting with tips of neighbouring spines; these pedicellariae could be described as “knob-like”; it is sometimes difficult to decide how many thickened enlarged spines contribute to a pedicellaria.

*Madreporite* interradial, more or less oval, close to superomarginal plates from which it is separated by 1 or 2 rows of abactinal plates; plates across madreporite partly obscure it — perhaps these could be described as short-trunked paxillae; pedicellariae present on these paxillae among the spines. These paxillae form almost regular spaced rows across the madreporite which is deeply and narrowly dissected.

*Anus* absent.

*Superomarginal plates* forming a distinct and slightly raised edge to disc and arms, obvious from abactinal surface; a distinct and gently rounded edge to each superomarginal plate before it turns to meet with the corresponding inferomarginal plate. Superomarginal

plates with a rather short, tapering, thorny, round-tipped enlarged spine, this present on abactinal surface of plate; generally only 1 enlarged spine; occasionally, especially interradially, 2 present, 1 below the other, or if 3 present they form a cluster. Also short, well-spaced, generally sturdy, sometimes rather flattened smaller spinelets at base of enlarged spine, these usually tapering to sharp tip; laterally along plates spinelets are more slender and flatter, and meet with similar spinelets from opposite plates; *fascioles* present but rather ill-defined. Fascioles more obvious along arms where they are shallow and quite wide. *Pedicellariae* present occasionally on superomarginal plates, not very distinct; sometimes incipient pedicellariae present, with tips of 2 ordinary unspecialised spines meeting or pedicellariae may be more similar to those of neighbouring abactinal plates; the distinctly thickened tips of 2 or more spines meeting. The thick-headed knob-like pedicellariae most obvious on lower surface of plate, adjacent to inferomarginals, smaller and less obvious than those of abactinal and actinal plates.

*Inferomarginal plates* corresponding with superomarginals, with a distinct uncluttered clear horizontal channel between the 2 series. Actinally, it is often difficult to decide where inferomarginal plates end and actinal plates begin. Each inferomarginal plate bears 1, sometimes 2 interradially distinct, enlarged conspicuous spines similar to, but slightly larger than, that of superomarginals; spine tapers to a blunt tip, is finely and sparsely thorny in last half, and surrounded basally by distinct spinelets larger and more numerous than elsewhere on plates. Spinelets smaller, fewer, between enlarged spines and junction with superomarginals; short, squat round-headed pedicellariae, similar to those of abactinal and actinal plates, often occur here; generally 1, sometimes 2 to a plate formed by short, thick-headed spinelets or spines.

*Actinal areas* well defined, quite large with reasonably regular rows of plates, plate outlines only really obvious when spines and the rather heavy membrane are removed. A quite conspicuous regular row of large square or rectangular plates bordering oral and adambulacral plates; actinal plates small and rather irregularly arranged along arms to level of 5th or 6th adambulacral plate. Actinal plates with a few spines, these generally very well spaced and along plate edges only; occasionally tips of 2 or 3 spinelets meet to form an incipient straight pedicellaria. Broad-headed 2- or 3-valved, rarely 4, pedicellariae very obvious and very frequent. Generally only 1 pedicellaria per plate.

*Adambulacral plates* distinct; more or less rectangular with narrow edge to furrow and actinal plates, plates separated laterally by shallow, skin-covered naked channels extending out between actinal, and further out, inferomarginal plates. Proximally, adambulacral

plates have 5 *furrow spines*; further out along arms, 6 even 7 may be present, these very distinct, curving back over adambulacral plates; furrow spines narrow and rounded basally, broadening and in the last three-quarters of their length tapering evenly to sharp or almost sharp tip; spines decidedly flattened, with very thin lateral edge; free tips are sometimes recurved. 2 or 3 sturdier, longer, upright subambulacral spines forming a distinct well-spaced row behind furrow spines. On some plates a few spaced, markedly shorter, small tapering spines also present near actinal plates. No distinct pedicellariae seen on adambulacral plates, although often present on adjacent actinal plates.

*Oral plates* well raised, broad proximally and medianly and somewhat tapering near actinal plates, 2 plates in an angle separated by a narrow, rather ill-defined membranous area; plates with a furrow series of 6 or 7 spines, most anterior and longest spines overhang mouth; spines thin-bladed, compressed with narrow edge to furrow and plates, well spaced along edge of plate; suboral spines distinctly smaller, round-tipped, tapering, forming 2 or 3 longitudinal rows, their arrangement rather erratic.

*Ambulacral grooves* broad, deep, with large tubefeet in 2 rather crowded rows, finely grooved and ridged, tapering, with no disc.

**COLOUR:** There are no colour notes of fresh material. Dried ex-alcohol specimens are white, almost light grey marginally on disc and laterally along arms. The actinal surface is white with light brown tubefeet.

**ETYMOLOGY:** The specific name *pedicellaris* refers to the obvious and very distinct actinal and smaller and less obvious abactinal pedicellariae.

**REMARKS:** The larger specimen (NZOI Stn S204), also with broken arms, was dissected. There is a conspicuous *membranous interradiial septum* and shallow membranous *partial septa* are also present for a short distance along the arms; *ampullae* of tubefeet are double and large. *Ambulacral plates* form a high ridge along arms; members of a pair of these plates are separated by a very regular rectangular membranous area; ambulacral plates are distinctly but rather irregularly rounded basally; there do not seem to be two distinct lobes present, and the rounded ends overlap the lobes of other, following plates. *Superambulacral plates* are absent or very small, and obscure on most proximal plates but they are present further along the arms. *Gonads* are present, on either side of the midline along the arms; they are finely branched (and rather damaged). When viewed from the coelomic side, abactinal plates along arms proximally are obscured by a thick skin; a short distance along the arms, plates are oval,



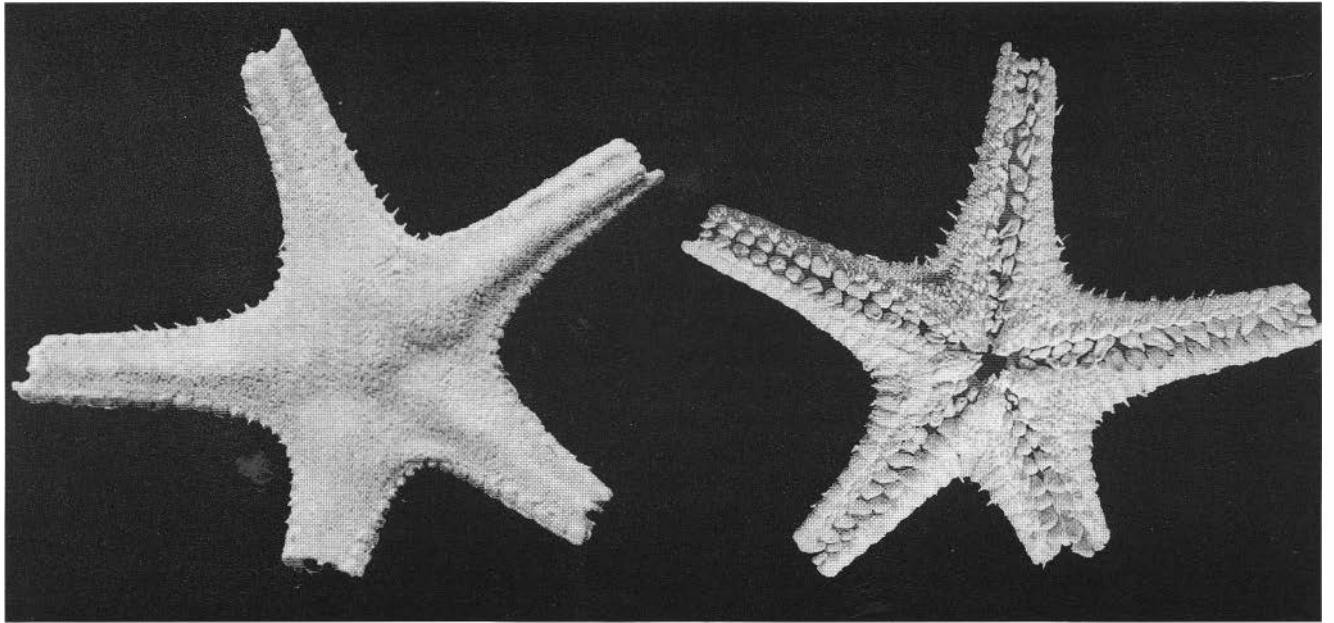


Plate 17. *Dytaster pedicellaris* n.sp. Holotype. NZOI Stn S204. R/r = approx, 43, 44/12 mm. Abactinal and actinal surfaces.

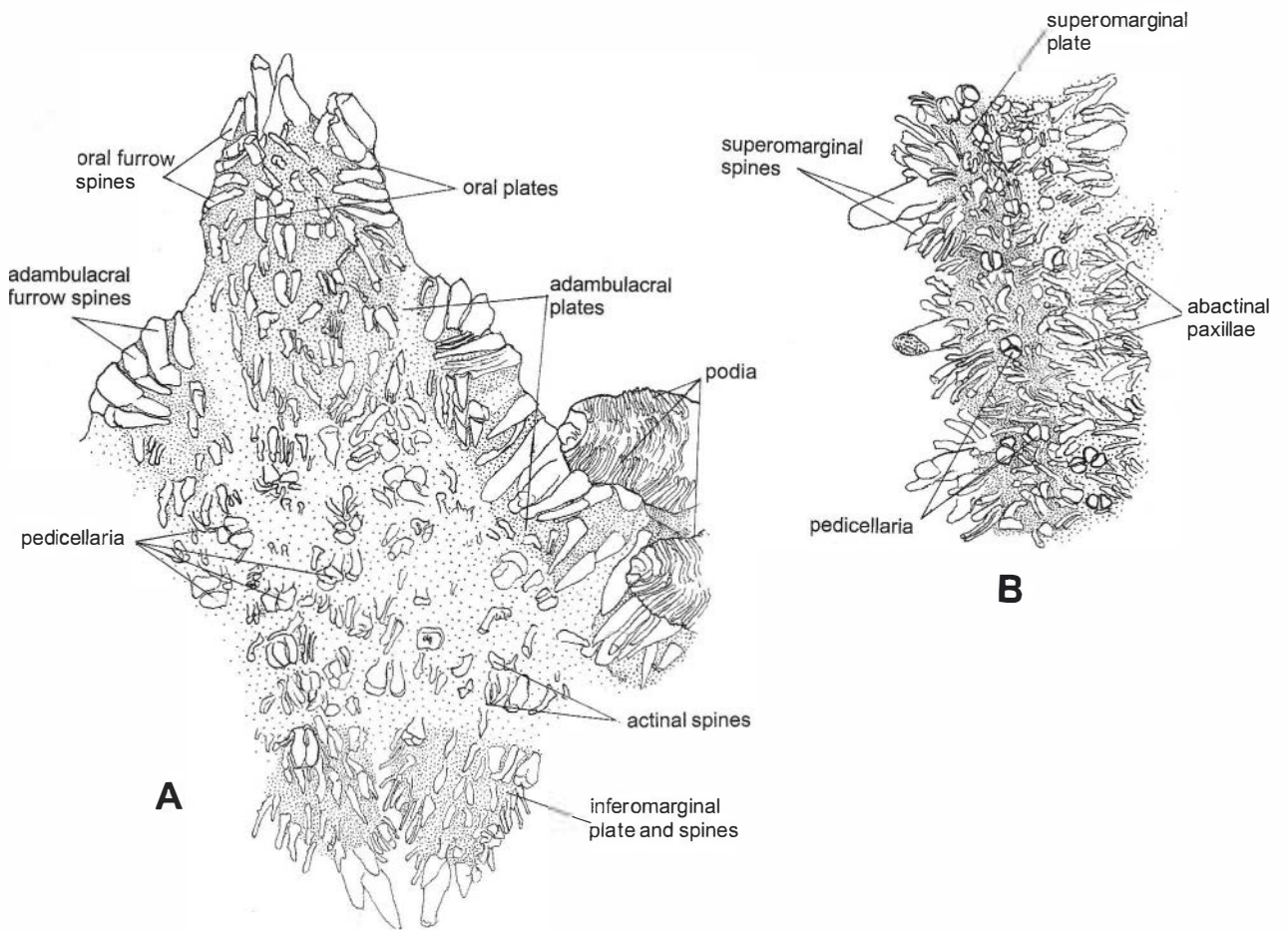


Fig. 19. *Dytaster pedicellaris* n.sp. Holotype. NZOI Stn S204. A. Interradius with oral, adambulacral, actinal, inferomarginal plates and spines and two podia. Outlines of oral and actinal plates obscured by membrane. B. Three superomarginals and adjacent abactinal plates; outlines of actinal plates obscured.

almost round, and slightly rectangular, forming a close cover; near the marginal plates they form almost regular rows and are more uniform in shape. *Papulae*, three or four around a plate, are sometimes visible near superomarginals.

Sladen (1889, p. 75) described a new species of *Dytaster*, *D. aequivocus*, from the Arafura Sea, north of Australia, in 1463 m. The specimens he described, with some misgivings because they were small ( $R = 18/4.75$  mm), seem similar to the present specimens, especially in details of abactinal paxillae and adambulacral plates. Sladen did not record abactinal pedicellariae, but in his illustration (pl. 39, fig. 10) near the bottom left-hand corner a distinct pedicellaria is shown, which is similar to that in the present specimens. *Dytaster aequivocus* has not apparently been collected again since the *Challenger* Expedition.

### *Plutonaster* Sladen, 1889

Disc large, distinct, generally rather flat; arms, always 5, often long and slender or broad based, short, and tapering rapidly. Abactinal paxillae forming a close cover; interradially and for a short distance along arms regular and distinct rather short rows of plates occur at right angles to margins. *Papulae* usually distinct, few or absent from disc centre and midline of arms. Marginal plates conspicuous; superomarginal plates with a cover of slender spinelets or distinct granules; 1 enlarged spine. Superomarginal plates may form a gently curved edge to disc and arms or there may be an abrupt drop to the inferomarginals; marginal plates form a very distinct, straight and vertical edge to disc and arms. Madreporite very large, finely and intricately dissected, interradial, often raised and obscured by enlarged "bushy" paxillae; in 1 specimen, distinct slender isolated spines were seen which appeared to be growing from the madreporite. Distinct, generally clear-cut fascioles present between marginal plates, fasciolar spinelets slender, rather flattened, blunt and finely thorny-tipped. Continuations of fascioles, as clear, distinct but naked grooves, present between actinal plates. If pedicellariae present, they may occur on abactinal, actinal, marginal, and even on adambulacral plates; they are formed by tips of spines meeting, and vary in size, number, and form. Actinal areas distinct with very regular rows of plates separated by naked grooves between the series of plates; unpaired rows of actinal plates unusual. Actinal plates carrying fine spinelets, and both enlarged spines and pedicellariae may be present; actinal pedicellariae usually short, squat, large-headed. Adambulacral plates distinct and separated laterally by clear areas which are continuations of naked actinal grooves. Adambu-

lacral plates with a gently convex margin or the edge may be more or less straight; furrow spines generally conspicuous and variable (in form, shape, number) and may be webbed basally; subambulacral armature also variable; often an enlarged and conspicuous subambulacral spine present, sometimes obvious only in last quarter of arm. Oral plates conspicuous, often "dipping" down into the mouth, with a varying number of furrow spines, longest and largest near free tip of plate.

TYPE SPECIES: *Archaster bifrons* Thomson, 1873 (see A.M. Clark & Downey 1992: 66).

REMARKS: *Plutonaster* is an interesting genus and it is often difficult to decide if New Zealand specimens are distinct species or are simply infraspecies variants.

The first *Plutonaster* recorded from New Zealand waters was *P. knoxi* Fell (1958) from near the Chatham Islands in 112–604 m; Fell (1958: 5) stated that the genus had not previously been recorded from Australian or New Zealand waters; however, Sladen (1889: 95) had recorded *P. ambiguus* from east of Sydney, New South Wales, Australia in 1737 m. The specimen was small ( $R/r = 25/6.5$  mm). As far as we are aware, no further specimens have been recorded from Australian waters. The genus *Plutonaster* is not included in the Zoological Catalogue of Australia (Rowe & Gates 1995). One other species of *Plutonaster*, *P. fragilis* H.E.S. Clark, (1970: 12) is recorded from the west coast of the South Island, in 164–1693 m. Over 500 specimens of *Plutonaster* were examined in the present report, and three new species are described.

A.M. Clark and Downey (1992: 67) stated "papulae interstitial, widely distributed except interradially and centrally". This statement caused us concern for, in New Zealand *Plutonaster*, papulae are present interradially as far as the superomarginal plates. Examination of two northern hemisphere species, *P. bifrons* Wyville Thomson (kindly lent by The Natural History Museum, London, with permission to dissect) and *P. agassizi* (Verrill) (from the U.S. National Museum, Smithsonian Institution) showed, in both species, that papulae are present right to the edge of the disc; in *P. bifrons* papulae were absent from the disc centre and a narrow central strip along the arm.

Downey (1973: 34) remarked on the differences in Atlantic *Plutonaster* and A.M. Clark and Downey (1992: 67) noted "considerable variation" in arm length and the conspicuousness of marginal plates and spines; they used details of arm tips and fascioles in their tabular key (table 10, p. 68). Of the 13 species of Atlantic *Plutonaster* reported at various times, A.M. Clark and Downey (1992) listed only three species in their tabular key. Careful examination and comparisons of arm tips and



fascioles in New Zealand specimens was **informative**. In most New Zealand specimens the fasciolar grooves are proximally well defined and deep, and the fasciolar spinelets are small, slender, often slightly flattened and with a thorny head; towards the arm tips, grooves and spinelets are smaller and, as arm tips are often rubbed bare, it is difficult to know how obvious or not fasciolar spinelets are. In most specimens, the fasciolar spinelets meet with similar spinelets from across the fasciolar groove; in *P. fragilis*, however, there is a very clear line of demarcation between fasciolar spinelets on either side which do not meet. In small specimens (R = 20 mm and less) fasciolar grooves are present and often quite conspicuous; the spines are small, very thorny, rather flattened, and generally meet with neighbours across the furrow.

In all New Zealand specimens examined, where arm tips are intact, terminal plates are arch-shaped, generally indented at the free tip, and shallowly concave adjacent to the abactinal plates. Interestingly, *P. fragilis* has a long terminal arm plate; it is convex at the free tip (not indented) and has quite a high archway at the abactinal plates. Enlarged spines on these plates are generally absent, though sometimes scars are present; in many specimens small round scars in very regular rows are present on the terminal plates, suggesting small spines or granules. In smaller specimens (R = 20 mm or less) definite spines often occur on the arm tips; there is often one on either side of the free tip of the plate and sometimes a third spine at the tip of the indentation.

A number of specimens were dissected. Anatomy is very similar in all species, with little variation. Distinct strong membranous interradial septa are present from actinal plates to abactinals; partial septa are also present, shallow, small, often inconspicuous, extending from marginal plates to actinal plates in a gentle curve; a pair of tubefeet is generally present between the septa. Ambulacral plates are separated dorsally by very regular, rectangular membranous areas. Superambulacral plates pass from the lower end of the ambulacral plates to the actinal plates; they are conspicuous and always present. Gonads are present as tufts and clumps, possibly attached to the abactinal plates or there may be a stolon present; there are no obvious openings. The pointed tubefeet have double ampullae, are generally large, and form two rows. The anatomy is very similar to that seen in species of *Dipsacaster*; in many ways there are many similarities between the two genera.

In most dissected specimens there were no stomach contents; however, in a small specimen (from Stn U226, near Bellona Trough west of the Challenger Plateau, 2417 m,) there was a fragment of squid beak, arm fragments of an ophiuroid (Ophiuridae), foraminiferans, and part of a polychaete worm tube.

#### TABULAR CHECKLIST TO SPECIES OF *PLUTONASTER*

	1	2	3	4	5	6	7
<i>Plutonaster</i>							
<i>complexus</i> n.sp.	l	g	s	a	p	8–10	p
<i>fragilis</i>	l	s	s	p	p	9–11	p
<i>hikurangi</i> n.sp.	s	g	s	a	p	9–11	a
<i>jonathani</i> n.sp.	s	g	g	a	p	8, 9	a
<i>knoxi</i>	l	s	s	p	a	7, 8	a

- Arms are:  
s – short, rapidly tapering  
l – long, slender
- Cover of superomarginal plates  
s – spines, fine  
g – granules
- Cover of inferomarginal plates  
s – spines, fine  
g – granules
- Enlarged spines on actinal plates  
p – present  
a – absent
- Adambulacral pedicellariae  
p – present  
a – absent
- Number of adambulacral furrow spines
- Adambulacral pedicellariae  
p – present  
a – absent

*Plutonaster complexus* n. sp. (Pl. 18, Fig. 20)

#### MATERIAL EXAMINED:

NZOI Stns: S102(3), U197(15), U564(2), U569(2), X568(1).

TYPE: Holotype, H-722, from NZOI Stn U564, R/r = 55/17 mm, deposited in the NIWA collection, Wellington.

Paratype from the same station, deposited in the NIWA collection, Wellington, P-1182.

TYPE LOCALITY: NZOI Stn U564, 35°17.9' S, 168°58.5' E, 1700–1890 m, on the Lord Howe Rise.

SIZE: R varies between 76 and 21 mm: r between 21 and 6 mm; the average R/r for 11 specimens is 54/15 mm.

DISTRIBUTION: The stations concerned are widely separated; specimens from Stn S102 are from near the Auckland Islands; U197 with 15 larger and 6 small specimens (the latter, discussed separately) is from the Lord

Howe Rise area, west of New Zealand, and specimens from U564 and U569 are from the West Norfolk Ridge area, northwest of North Island; X568 is east of North Cape.

**DEPTH:** The specimens are all from depths greater than 1000 m, from 1186 m (U197) to 2460 m (S102).

**DESCRIPTION:** The holotype from NZOI Stn U564 is described, R/r = 55/17 mm.

*Arms* 5, short and rapidly tapering to sharp tips; *disc* large, flat, with wide and evenly rounded interbrachial arcs. *Terminal arm plate* large, sturdy, and shallowly arch shaped; faint scars suggest that regular rows of short spines or granules were once present, with none now remaining; no large spines.

*Abactinal paxillae* forming regular rows at right angles to arm and disc edges, the rows especially obvious interradially; paxillae on midline of arms and centrally on disc show no regular arrangement. The paxillar trunk expands to form a round, oval or slightly angular head crowned by a number of slender and finely thorny round-tipped spinelets; these often surround, spaced (especially marginally on disc and for a short distance along arms), slightly larger-headed central spinelets; sometimes, especially near marginals, central enlarged spines merge to form a simple 3 or 4 bladed *pedicellaria*, most obvious along arm edges. Centrally on disc and further out along arms paxillar heads often irregular in shape, almost rectangular or long and thin. Also a clearly marked very narrow naked area present between abactinal and superomarginal plates, paved by several rows of slender, narrowly rectangular plates; these generally naked, however at base of superomarginal plates there is often a small, compact, isolated paxilla at either edge of the plate. This narrow naked area continues to the arm tip.

*Papulae* 4–6 around each plate, along disc and arm edges; less obvious along midline of arms and centrally on disc.

*Pedicellariae*, described above, of a simple type, present along arm and disc edges.

*Madreporite* large, almost circular and nearer to superomarginals than disc centre. It is slightly raised and very finely and deeply dissected; paxillae present at intervals across madreporite, some considerably larger.

*Anus* absent.

*Superomarginal plates* form a definite edge to abactinal surface; plates narrow, distinctly raised and well separated by conspicuous *fasciolar grooves*. Superomarginal plates with distinct, sturdy, generally well spaced round granules, occasionally these are angular where they meet with one another; on free edge of plate generally 1, occasionally 2 or even 3, enlarged, round,

fast-tapering short spines. These enlarged *superomarginal spines* are present almost to arm tips, absent or very small and inconspicuous on the 8–10 distal-most plates.

*Inferomarginal plates* corresponding to superomarginals but wider than long, the *fasciolar grooves* conspicuous, well defined, quite broad; *fasciolar spinelets* slender, somewhat flattened and thorny, meeting with similar spinelets from across the groove. Near arm tip, *fasciolar grooves* shallow, inconspicuous. Enlarged *inferomarginal spines* short, almost conical; a single spine may be present, or interradially 2–4 small spines may form a vertical row. The plates also with small short, thick-set, tapering very thorny spinelets in almost regularly spaced rows; it is often difficult to decide whether they should be described as granules or short spinelets. Towards arm tip, on last 9 or 10 inferomarginal plates, enlarged inferomarginal spines are often missing; on 1 arm tip, however, enlarged spines present intermittently.

*Actinal areas* large with regular well-defined rows of plates which form a close network; *actinal plates* oval, rectangular, somewhat irregular in outline and raised centrally. Plates with short, finely thorny-headed spinelets, these irregularly distributed or forming almost regular rows especially near the adambulacrals; these plates present along arms between adambulacrals and superomarginals for a short distance. No enlarged spines; occasionally, in at least 1 angle, a very simple *pedicellaria*, formed by 2 or 3 enlarged spinelets is present on a plate, but they are inconspicuous and not common.

*Adambulacral plates* conspicuous, forming a regular and slightly raised edge to furrow. Plates regular and well separated laterally from each other by broad membranous areas. Proximally, the furrow margin of the plate is distinctly rounded; in last quarter of arms it is markedly straight. Plates fringed by 7, 8–10 or 11 *adambulacral furrow spines*; these slender, well spaced, slightly tapering, round tipped and generally of similar size apart from distalmost and proximal spines which are shorter; these spines finely thorny. Behind the furrow spines are 2 or 3 rather irregular rows of spaced spines proximally, those nearest actinal plates smaller; these *subambulacral spines* similar to furrow spines but generally shorter. For almost last quarter of arm a distinct enlarged subambulacral spine on each plate; these present near distal edge of plate and separated from it by 2 or 3 *subambulacral spines*, these enlarged, quite long, slender, tapering and just visible to the naked eye, and tending to lie across the plate rather than standing upright. These spines almost meet with neighbouring spines from across the furrow. Very occasionally on adambulacral plates near arm tip, simple *pedicellariae* present, the enlarged tips of 2 or 3



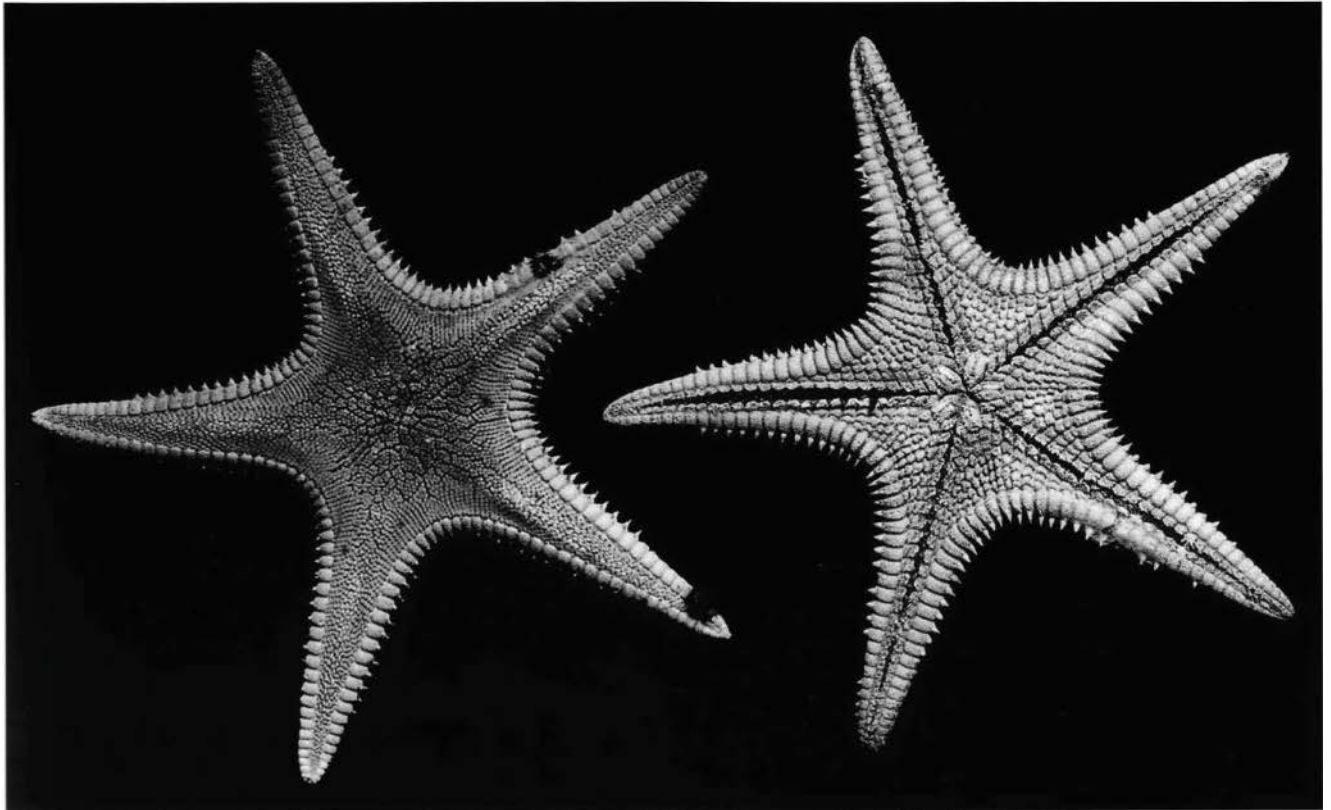


Plate 18. *Plutonaster complexus* n.sp. Holotype. NZOI Stn U564. R/r = 55/17 mm. Abactinal and actinal surfaces.

spinelets meeting.

*Oral plates* obvious, well raised, well defined; 2 plates in an angle separated by a conspicuous median muscular area; plates dip slightly into mouth. 10 or 11 *oral furrow spines*, these long, slender, tapering, round tipped, erect along plate edge. *Suboral spines* numerous, round tipped, forming several rather untidy rows. Suboral spines along and on membranous areas between the 2 plates in an angle, short with a slightly enlarged round, or sometimes almost angular, very finely thorny head.

*Ambulacral grooves* narrow, with tubefeet in 2 rows; tubefeet pointed, lacking a distinct sucking disc.

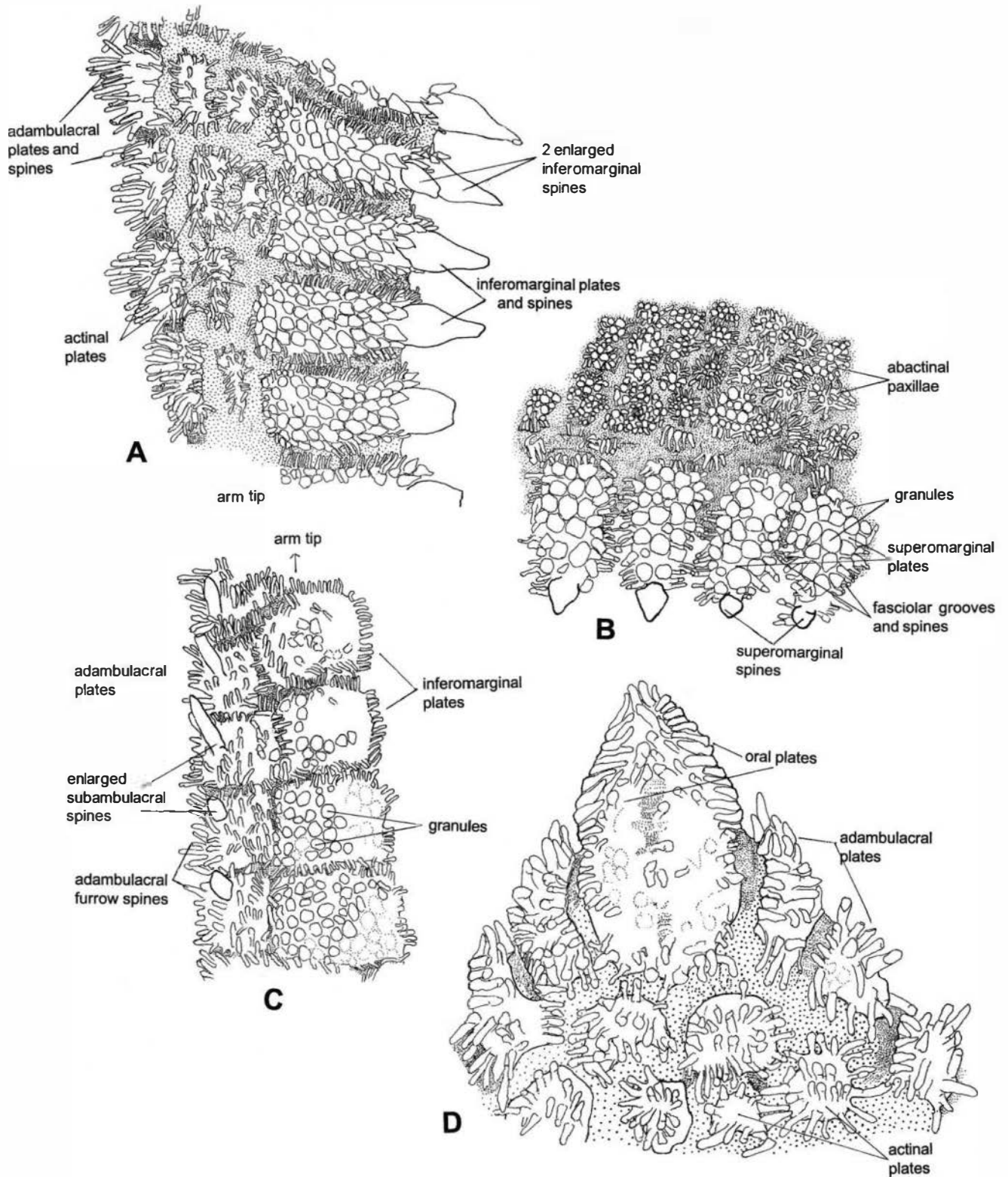
**COLOUR:** There is no colour recorded for freshly caught or living material. Dried and preserved specimens are either white or golden brown with distinctly lighter marginal plates and spines.

**ETYMOLOGY:** The specific name *complexus* refers to the complexities and difficulties of this new species.

**REMARKS:** *Plutonaster complexus* differs from *P. knoxi* Fell and *P. fragilis* H.E.S. Clark in having supermarginal plates with distinct granules instead of small spines. The supermarginal granules of *P. complexus* seem to

have a very fine dusting of small hyaline inclusions which are not present in *P. knoxi* or *P. fragilis*; they are present, however, in another new species, *P. hikurangi*, which has distinct inferomarginal pedicellariae between the inferomarginal spines and supermarginal plates; these are not present in *P. complexus*. *Plutonaster complexus* differs from *P. jonathani* n. sp. not only in the body shape (longer and more slender arms in *P. complexus*) but *P. jonathani* has enlarged subambulacral spines along the whole arm length; in *P. complexus* these spines are present only in the last quarter of the arm. Also in *P. jonathani* inferomarginal plates bear small granules, whereas *P. complexus* has short, thickset, tapering spinelets.

In *P. complexus*, variation occurs in the number and form of enlarged marginal spines. The specimen, R/r = 60/18 mm (U564, the same station as the holotype) has one shorter, narrower curious arm; probably its peculiarities are related to injury. In the last three-quarters of this shorter arm the supermarginal plates bear a distinct and enlarged spine, or sometimes two spines are present. On the other four arms (apart from two plates each with one very small, scarcely noticeable enlarged spine) no larger spines are present. Supermarginal plates on the other arms are covered by uniform granules; there are no scars or bare patches to



**Fig. 20.** *Plutonaster complexus* n.sp. Holotype. NZOI Stn U564. **A.** Adambulacral, actinal, and inferomarginal plates and spines. Note, inferomarginal with two enlarged spines. Arm tip towards bottom. **B.** Superomarginal plates and abactinal paxillae, near interradial angle. Note, no pedicellariae shown. **C.** Adambulacral plates and inferomarginals, near arm tip. **D.** Mouth plates, adambulacrals and actinal plates.



suggest that larger spines had been present. The actinal surface of the short arm seems more normal although irregularities occur in the adambulacral plates. There is one very large, long adambulacral plate, with 14 or 15 furrow spines; possibly two plates are involved although there is no obvious division. There are numerous abactinal and actinal pedicellariae in this specimen. On the "odd" smaller arm there is one strangely enlarged and tumid paxilla between adambulacral and inferomarginal plates; the marginal plates in this arm are odd shapes and sizes, some almost triangular and probably the result of injury.

Three further specimens are also of interest: two from NZOI Stn U569 and one from Stn X568. In these there are no pedicellariae, either abactinally, marginally or actinally, but in other respects they are similar to the type specimen. It is interesting also, that in these three specimens the madreporite is only partly hidden; in the large specimen (U569, R/r = 76/21 mm) the large, finely and intricately dissected madreporite is barely hidden by paxillae and on the surface of the madreporite there are isolated spines, apparently attached to it, standing more or less upright. These spines are slender, somewhat flattened, broad medially and tapering at either end; they seem similar to the outer, rather slender spines of neighbouring paxillae. In the slightly smaller specimen from the same station there are no spines on the madreporite; there is a more consistent covering of paxillae on the madreporite in this specimen.

Probably in these 23 specimens most variation occurs in the number and form of the enlarged marginal spines. Abactinal paxillae also vary in shape.

One specimen (NZOI S102, R/r = 63/22 mm) was dissected whose anatomy is very similar to that of *P. knoxi*. There are large membranous interradial septa present and the conspicuous small partial septa continue for a short distance into the arms. Small and bar-like superambulacral plates are present. There are very regular and precise rectangular membranous areas between the two ambulacral plates, continuing to the arm tips. Ampullae of the tubefeet are large, the tubefeet forming two very regular rows. Papulae, seen from the coelomic side, number 5–7, even 8 around the abactinal plates; these papulae are present right to arm edges but are few and scattered, even absent, along the arm midline and disc centre. Abactinal plates, when seen from the coelomic side, are interesting; centrally along the arms plates are almost oval, slightly irregular, and form a close cover. Sometimes the plates overlap. Centrally on many plates is a small, irregular oval swelling (similar to that seen in *P. fragilis*). Near the disc, plates are slightly smaller, often more distinctly lobed, and there are very regular rows of 5–8 plates at right angles to the marginal plates; these are especially

obvious along the arms. Gonads, in clumps, form a fringe interradially and for a short distance along arms; it is difficult to decide whether they open individually abactinally or are attached to a stolon. The stone canal, large and thick, is enveloped in the septum.

*Plutonaster fragilis* H.E.S. Clark, 1970

(Pl. 19, Fig. 21)

*Plutonaster fragilis* H.E.S. Clark, 1970: 9, 12, fig. 1c, d; pl. 1, a, b; McKnight 1977: 115.

MATERIAL EXAMINED: 129 specimens are listed, 7 of these (NZOI with an \*) were not seen.

NZOI Stns : E437(20), E758(3), F127(1)\*, F76(3)\*, P940(2)\*, P969(1)\*.

NMNZ.: Aldermen Is.: Ech. 4492(14); Chatham Rise and northern Mernoo Slope: Ech. 4473(9), 4476(3), 4489(1), 4490(2), 4491(1), 4493(22); Bay of Plenty: Ech. 4488 (4), 4492 (14).

*Eltanin* Stn 1846(43).

SIZE: Accurate measurements are difficult for this species — it is indeed fragile as the specific name suggests and very few specimens in the present collection have five intact arms. Those that do have R between 30 and 40 mm, or less. Small specimens with R = 20 mm or less are listed and described separately as *Plutonaster* sp., Several larger specimens have R = 80 to 90 mm (NZOI Stn E437) with R/r = 86/22 mm, and there is one larger specimen (NMNZ) from the Chatham Rise area (Ech. 4476) with R/r approximately 100/23 mm. Average measurements for 32 specimens is R/r 50/14 mm. In the 43 *Eltanin* specimens R varied between 98 and 66 mm (average 82 mm), and r varied between 32 and 20 mm (average 26 mm).

DISTRIBUTION: This species is commonest at the north-west end of the Chatham Rise. There are two shallow-water records from the Bay of Plenty, one (NZOI Stn P969\*) from near East Cape (the specimen was not seen), and two records, including the type material, from off the west coast of South Island. One of these (NZOI Stn P940) is listed as *Plutonaster fragilis* but the specimens were not seen. A specimen reported from near the Antipodes Islands (NZOI Stn F127) was also not seen.

DEPTH: The type material and most subsequent material is from deep-water stations over 1000 m. There is one record from near the Aldermen Islands (NMNZ Ech. 4492) of material from 803–846 m, two very shallow records (NMNZ Ech. 4488, 59–74 m) from the Bay of Plenty, and a further record from near the east coast of the South Island (NMNZ Ech. 4473, 35–41 m). Two

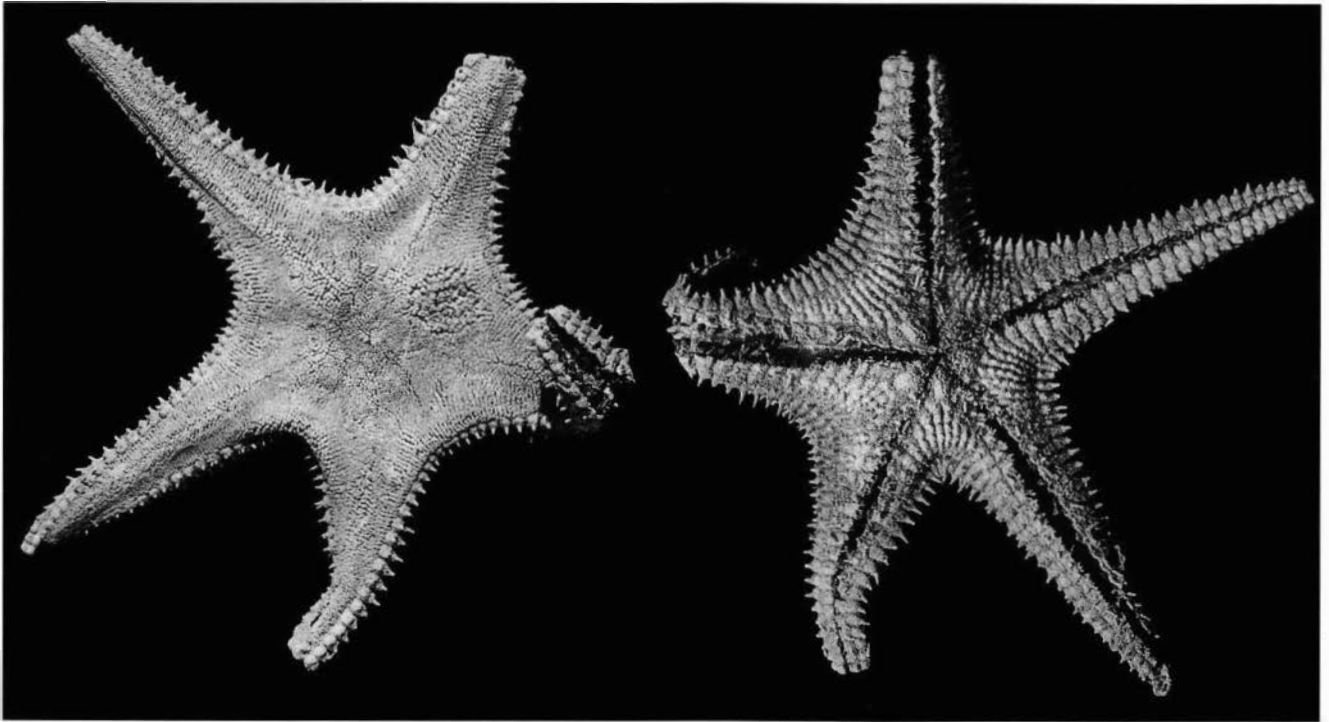


Plate 19. *Plutonaster fragilis* H.E.S. Clark. NZOI Stn E437. R/r = 82/21 mm. Abactinal and actinal surfaces.

NZWA records (Stns P940, P969) exceed 2000 m but specimens are no longer present. This is a vast depth range, from 35 m to over 2000 m.

**DESCRIPTION:** A specimen (NZOI Stn E437) from the Chatham Rise area, with R/r = 82/21 mm is described.

*Arms* 5, long, slender, tapering, *interradii* well rounded; the large *disc* more or less flat, with a very slight rather ill-defined carinal rise along arm centres, arms tapering rapidly and evenly to sharp tips. In the 1 intact arm, the *terminal plate* is high arched, with a shallow depression basally; no enlarged spines but faint scars, in very regular rows, suggest small spinelets or granules may have been present.

*Abactinal paxillae* along arm edges and interradially form very regular transverse rows of 10–12; centrally on disc and arms *paxillae* are crowded. Abactinal *paxillae* with a slender trunk that expands into an almost round or oval head, this with slender, well-spaced marginal spinelets which enclose a number of similar but broader and thicker spinelets, their tips often bending and meeting, forming a conspicuous simple *pedicellaria*; many abactinal *paxillae*, especially near superomarginals have *pedicellariae*; in other *paxillae* the central spinelets may be slightly thicker and sometimes spine tips appear swollen but do not form *pedicellariae*. All these spinelets are very finely thorny; sometimes an outer fringing spinelet contributes to the *pedicellaria*. *Pedicellariae* often with 3 spines, some-

times with 2 only, or occasionally 4 present marginally almost to arm tips. These simple *pedicellariae* uncommon on disc centre and along midline of arms.

From 4 to 6 *papulae* surround each plate, these few or absent centrally on disc and along midline of arms.

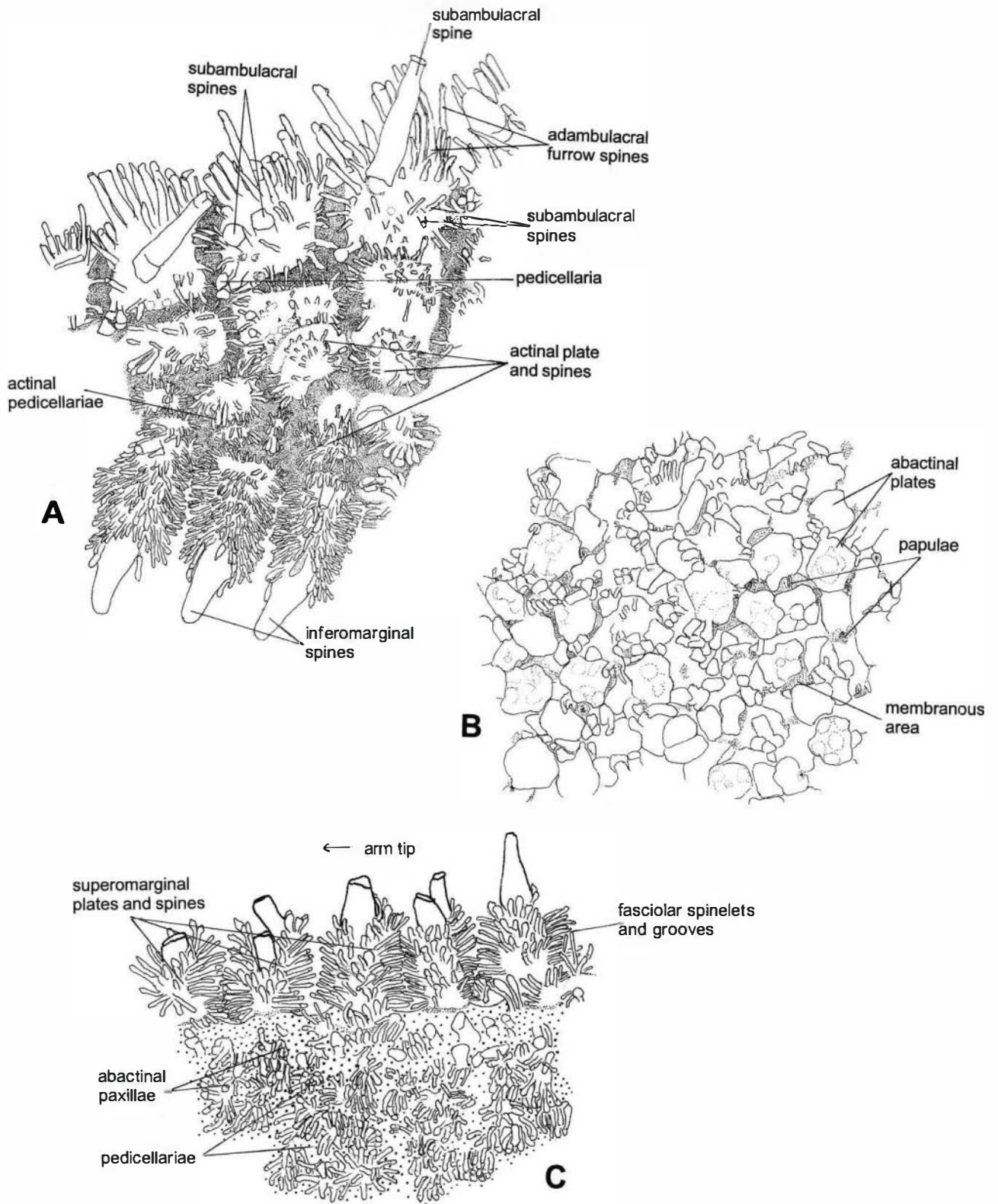
*Pedicellariae* most obvious abactinally near superomarginals.

*Madreporite* very large interradially, almost circular, about 10 mm in diameter, very finely dissected and nearer the edge than disc centre; very slightly raised, irregular in outline, and covered but not completely obscured by enlarged *paxillae*.

*Anus* indicated by a small, slightly swollen membranous area centrally on the disc.

*Superomarginal plates* forming a conspicuous edge to disc and arms, raised, wider than long when viewed from above, and separated laterally by distinct, deep and quite wide *fascioles*; distally, plates are more rectangular with long edge to furrow. *Fascioles* are lined by slender often pointed, slightly flattened spinelets which almost meet with similar spinelets from across groove; near arm tips *fascioles* are considerably more narrow. Superomarginal plates with a close cover of small, thick-headed, sometimes curved short spinelets which form quite regular rows, these replaced along lateral plate edges by slender fasciolar spines. Generally 1 (sometimes 2, either side by side or forming a vertical row) enlarged, broad-based, tapering, round-tipped





**Fig. 21.** *Plutonaster fragilis* H.E.S. Clark. NZOI Stn E437. A. Adambulacral, actinal and inferomarginal plates, near oral plates. Note stumps of two enlarged subambulacral spines. B. Abactinal plates seen from coelomic side, near midline and at base of arms. C. Superomarginal plates and spines and adjacent abactinal paxillae.

conspicuous spine on outer free edge of plate; these spines present almost to arm tips although they are shorter and easily lost in distal quarter of arm. Midradially, enlarged spines are almost central on plates; near arm tips they are on distal (arm tip) edge of plates.

*Inferomarginal plates* corresponding with superomarginals, most obvious on actinal surface where they border the actinal and, along arms, adambulacral plates. Interradially, inferomarginal plates are long, narrow, well raised, with a cover of small, slender spinelets that merge laterally with fasciolar spinelets. Each plate with 1, sometimes 2 interradially, large, round upright *spines* on free edge of plate, these pointing outwards; the second enlarged spine, often present, lies near the actinal plates; very occasionally a third enlarged spine also. Inferomarginal plates also bear, between enlarged spines and superomarginal plates, conspicuous *pedicellariae*, these formed by inward-bending, 2, 3, 4 even 5 thick-headed spinelets; these conspicuous pedicellariae present interradially only.

*Actinal areas* large, well defined, *actinal plates* extending for a short distance along arms. Actinal plates tumid, in very regular rows between inferomarginals, oral plates, and adambulacrals, separated laterally by conspicuous naked grooves; no unpaired actinal plates. Each actinal plate with a number of well-spaced, thorny-tipped spinelets, peripherally these slightly flattened and very thorny, especially at tip; centrally on plate spinelets form a closer cover and are round rather than flattened. Some actinal plates with a large central spine similar to enlarged spines of marginal plates; many spines are missing, often only the stump obvious. On some plates, especially near adambulacrals and inferomarginals is a conspicuous pedicellaria formed by the enlarged and very thorny tips of 2, 3 even 4 spinelets. Actinal plates present between inferomarginals and adambulacrals for almost half arm length; along arms, actinal plates become progressively more narrow; no enlarged spines present.

*Adambulacral plates* forming a regular edge to furrow, slightly raised and separated laterally by distinct membranous channels, the furrow edge straight or gently curved. Each plate with 10 or 11 *adambulacral furrow spines*, these long, slender, finely spinulose, tapering and webbed basally; also several rather ill-defined rows of short, well-spaced *subambulacral spines*. A large, sturdy, very obvious subambulacral spine, often taller than the furrow spines; very occasionally 2 enlarged spines present. On actinal edge of plates, in distalmost corner, especially in first quarter of arms, a distinct 3- or 4-bladed *pedicellaria* present; these are similar to actinal pedicellariae and are formed by enlarged and slightly bent heads of 3 or 4 spines. En-

larged subambulacral spines are still obvious near the arm tips, although they are often broken.

*Oral plates* large, broad, raised, with a furrow series of 10 or 11 finely thorny, broad-based slender spines; suboral spines shorter and in several rows. The 2 oral plates in an angle are separated by conspicuous and quite broad membranous area.

*Ambulacral grooves* narrow, deep, with two regular rows of *tubefeet*; these broad, pointed, no sucking discs.

COLOUR: Colour notes of fresh type material record: "Disc centre white to pale yellow with orange or yellow arms; paxillae covering madreporite lighter than those adjacent; marginal plates orange, spines white. Actinal surface pale or pale orange or yellow always darker near edge; tubefeet and actinostomial membrane orange" (H.E.S. Clark 1970: 13). Dried specimens, after preservation, are light brown, with white spines.

REMARKS: With more specimens of *Plutonaster fragilis* available the distribution and depth range of the species is considerably extended. Some NZOI specimens listed as *P. fragilis* were not seen, so whether the species occurs as far south as the Antipodes Islands (NZOI Stn F127) is uncertain. It is interesting too, that if depth records are correct, the species can no longer be regarded as only from the deep sea as the depth ranges from 35 to over 2000 m.

*Plutonaster fragilis* has numerous conspicuous abactinal, inferomarginal, actinal, and even adambulacral pedicellariae. In *P. knoxi*, pedicellariae are rare and confined to a narrow area near the superomarginals. *Plutonaster fragilis* has more numerous adambulacral furrow spines, from 9 to 12 or even occasionally 13, whereas in *P. knoxi* there are seldom more than 7 or 8. In *P. fragilis* superomarginal plates are well covered with small regularly arranged spines; in *P. knoxi* these are very small, almost qualifying as granules. They are usually well separated from one another and do not form an obvious cover on the plates. *Plutonaster knoxi* also has fewer oral furrow spines.

Another interesting difference noted between the two species is when the abactinal plates are seen from the coelomic side. In *P. fragilis* the plates, more or less oval or round, form a close network; they are distinctly lobed, and meet with and sometimes overlap with lobes of neighbouring plates. Papulae are present between lobes; these lobed plates are particularly obvious interradially. Plates immediately adjacent to superomarginals are not conspicuously lobed, forming very even and regular rows. In *P. knoxi* the plates are round, oval, or almost square, are not lobed, and do not overlap. Also, in abactinal plates of *P. fragilis* viewed from the coelomic side, there is very often a small central round or oval swelling on the plate; this



small swelling was not seen in plates of *P. knoxi*. Possibly the swelling is results from the presence of abactinal pedicellariae.

*Plutonaster hikurangi* n. sp. (Pl. 20, Fig. 22)

MATERIAL EXAMINED:

NZOI Stn F28(1). Two small damaged specimens of *Plutonaster* were with a large specimen; these are discussed separately at the beginning of Remarks.

TYPE: Holotype, H-723, from NZOI Stn F28, R/r = 63/18 mm, deposited in the NIWA collection, Wellington.

TYPE LOCALITY: NZOI Stn F28, 40°28.50' S, 177°45.00' E, 1920 m, on the landward margin of the Hikurangi Trough.

SIZE: R/r = 63/18 mm.

DISTRIBUTION: Hikurangi Trough, off southeast coast of North Island.

DEPTH: 1920 m.

DESCRIPTION: The holotype with R/r = 63/18 mm, is described.

*Disc* large, *arms* quite short, fairly broad basally and tapering rapidly to tip, no arm tips intact; *interradial arcs* sweeping, rounded.

*Abactinal plates* forming very regular rows interradially and for a short distance along arm edges; interradially, plates are narrow with 8 or 9 plates in a row; further out plates broaden and there are 5–7 in a row. Abactinal plates, gently lobed, forming a close cover; each plate has a short sturdy trunk that ends in a round or oval convex head, this crowned by slender, generally untapering flat-tipped spinelets; peripheral spinelets well spaced and form an upright fringe around the plate enclosing similar spinelets, the tips of which are sometimes expanded, larger, conspicuous and very finely thorny (fine spinelets are almost hyaline). *Paxillae* are smaller along arms, spinelets are fewer and the arrangement less regular; near arm tips paxillae often have only 1 central spinelet, surrounded by 7 or 8 slender spinelets. No enlarged spines; some paxillae bear a central *pedicellaria* (described below).

*Papulae*, 4, 5 surround each plate, most obvious on disc and proximally along arm margins, are very few or absent from disc centre and midline of arms.

*Pedicellariae* quite conspicuous centrally on many abactinal paxillae; tips of central paxillar spines meet forming a 2-, 3- even 4-bladed pedicellaria; these enlarged spines often lighter in colour, slightly raised,

tips sometimes oval or almost triangular and conspicuous; these pedicellariae most obvious on disc and along arm edges.

*Madreporite* large, interradial and well hidden by enlarged paxillae, finely and intricately dissected and slightly closer to marginal plates than disc centre. It is 6, 7 mm wide and occupies a slight depression.

*Anus* absent.

*Superomarginal plates* forming a very definite and distinct edge to disc and arms. The upper, first half of plate continues at same level as abactinal plates, then drops steeply to inferomarginals. Plates with round or slightly angular granules that form almost regular rows; 1 prominent, large, very sturdy spine stands upright (almost vertical) on plate, the base occupying almost entire width of plate; these spines tapering to a slightly flattened (almost truncated) tip. 2, even 3 enlarged spines may be present interradially, these similar, very sturdy and rapidly, evenly tapering; if 3 spines are present they form a vertical row; generally a smaller sharp-tipped spine on either side of large spine; multiple enlarged spines present interradially only. Enlarged spines are single beyond interradius.

*Inferomarginal plates* corresponding with superomarginals, most obvious on actinal surface; they are raised, narrowly rectangular and bear short, broad, thorny well-spaced spinelets in more or less regular rows. Generally only 1 enlarged spine, this similar to, but considerably longer than enlarged superomarginal spines; occasionally, a second much smaller spine also present; the base of the enlarged spine occupies almost entire width of plate. Between the enlarged spine and the edge of the adjoining superomarginal plate *pedicellariae* are obvious, usually 2 to a plate interradially, further along arms only 1 present, and in last half or quarter of arm no pedicellariae were seen. These pedicellariae consist of enlarged tips of 3 or 4 spines which bend over and meet; very often 2 pedicellariae, side by side, present on a plate often occupying almost entire width of plate.

Deep, conspicuous *fasciolar grooves* present laterally between superomarginal and inferomarginal plates; they are lined by small, slender, flattened blunt-tipped spinelets that almost meet across grooves. Actinally, grooves continue as distinct bare channels between the well-ordered rows of raised actinal plates; no fine spinelets in actinal channels.

*Actinal areas* large, well defined with very regular rows of plates, none unpaired; plates continue between adambulacrals and inferomarginals for almost half arm length. *Actinal plates* raised, rect-angular, narrow, each with slender, well-spaced spines that form almost regular rows; marginal spines more slender, central spines have enlarged and roughened heads. Many plates bear on lower (inferomarginal) edge of plate 1

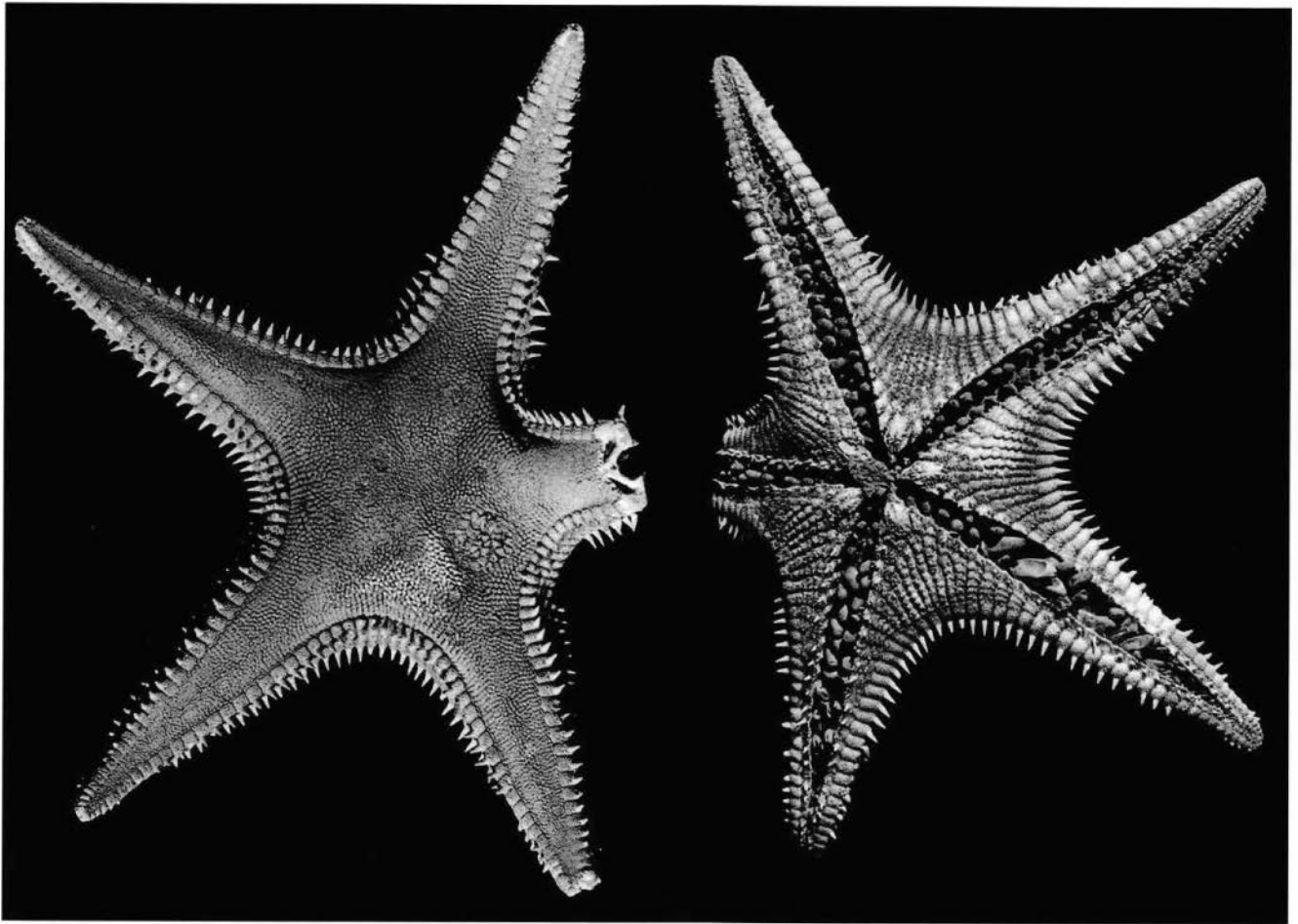


Plate 20. *Plutonaster hikurangi* n.sp. Holotype. NZOI Stn F28. R/r = 63/18 mm. Abactinal and actinal surfaces.

or 2 quite conspicuous pedicellariae, these formed by swollen tips of 2, 3, even 4 spines which meet with each other; most plates with at least 1 pedicellaria. No enlarged actinal spines present; actinal plates separated laterally by clear, naked, well-defined channels, these generally continuations of fasciolar grooves. Generally, 2 rows of actinal plates correspond to 1 inferomarginal and 2 adambulacral plates.

Proximally, *adambulacral plates* have a straight margin, in the last quarter of the arms the margin often gently rounded. *Adambulacral furrow spines* 9 or 10, spaced, round tipped, finely thorny, the most proximal and distal spines often distinctly shorter. There is 1 enlarged, conspicuous *subambulacral spine*, generally near the distal (arm tip) edge of the plate; also short, slender, well-spaced thorny, *subambulacral spinelets* on plates; these forming 2 or 3 almost regular rows, the spinelets slightly longer laterally. *Adambulacral plates* separated laterally by clear membranous areas that are continuations of fasciolar grooves between actinal plates. *Adambulacral furrow spines* stand at an angle on the plate but do not meet with spines from across

the groove.

The 2 *oral plates* in an angle separated by a narrow rather ill-defined membranous area; plates broad near actinal plates, then tapering abruptly to a blunt, narrow tip overhanging the mouth. Each plate with 11 or 12 furrow spines, those overhanging the mouth are crowded; spines slender, slightly curved, blunt-tipped and finely spiny. At least 3 rather irregular rows of *suboral spines* on each plate; many are missing but scars remain. The most proximal *adambulacral plate*, on either side of the oral plates, almost triangular, with a large and typical *subambulacral spine*, and separated from oral plates by a deep conspicuous gutter or groove.

*Ambulacral grooves* wide for most of arm length, narrowing briefly near oral plates and becoming progressively narrower in last quarter of arm.

*Tubefeet* large, pointed, in 2 rows.

The specimen was not dissected; however examination of the broken arm shows distinct *superambulacral plates*, double *tubefeet ampullae*, and large, long, pointed *tubefeet* lacking a disc.



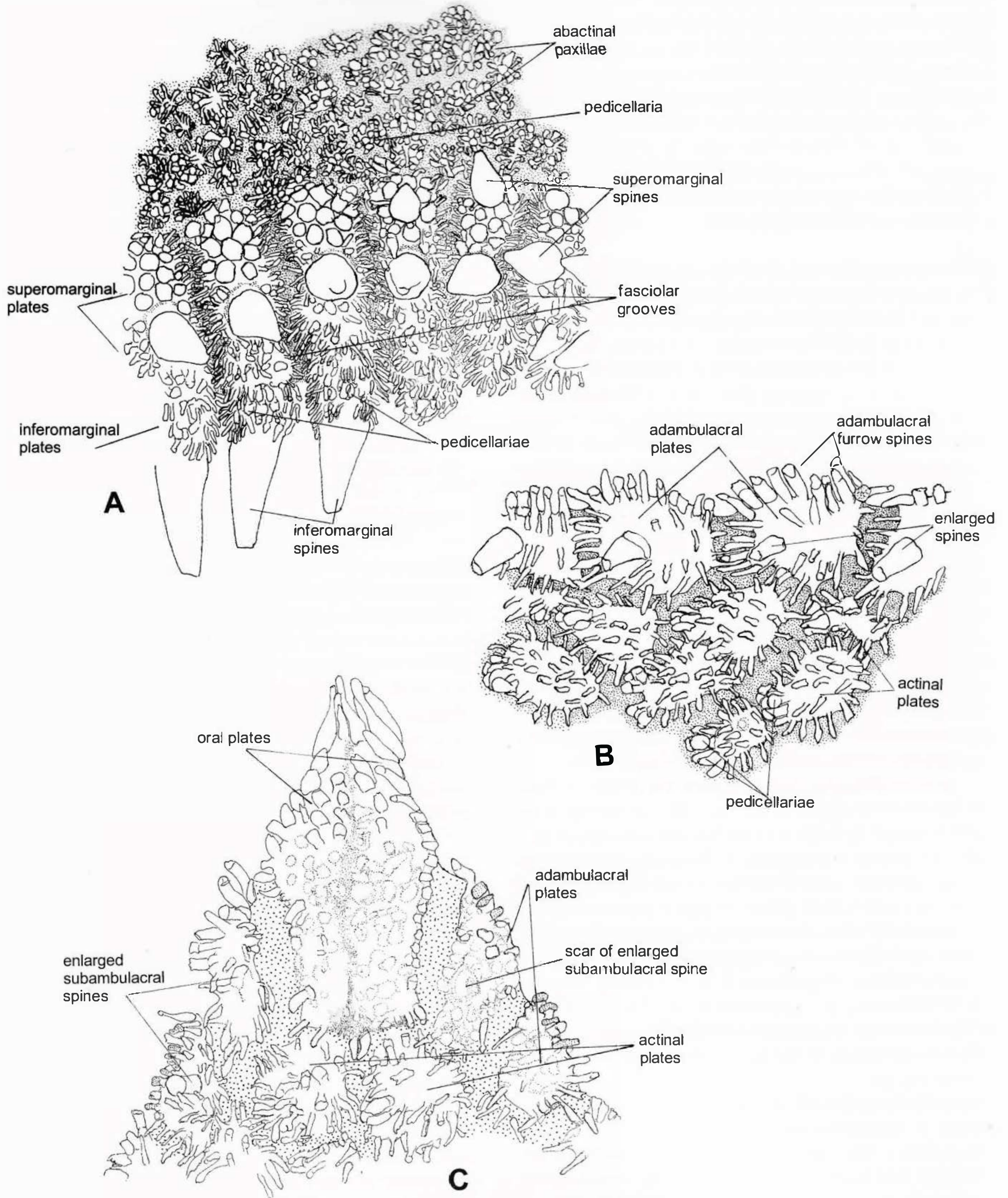


Fig. 22. *Plutonaster likurangi* n.sp. Holotype. NZOI F28. A. Abactinal, supero- and inferomarginal plates, near interradius. Note, some superomarginal plates with two spines. B. Oral, adambulacral, and actinal plates. C. Adambulacral and actinal plates. Note actinal pedicellariae.



**COLOUR:** There are no colour notes of living material. The dried holotype is faintly grey (a fine coating of blue-grey mud over much of the sea-star accounts for this), otherwise it is a faded brown colour with conspicuously lighter, often white, marginal plates and spines. The actinal surface is similarly coloured.

**ETYMOLOGY:** The single specimen comes from near the Hikurangi Trough which runs almost parallel to the southeast coast of North Island.

**REMARKS:** There are two small specimens included with *P. hikurangi*. Both are white, with very long slender arms, and both are quite badly damaged. In the smaller, less damaged specimen R/r = 37/10 m. The other specimen (folded, distorted, and broken) is slightly larger. In both specimens there is a prominent ridge (keel) along the arms and superomarginals with small spinelets, not distinct granules. The form of the marginal plates, however, bears a distinct resemblance to the large specimen, with the superomarginal plates on two levels and a distinctive vertical face to the marginal plates. In the small specimen abactinal pedicellariae were not seen; in the larger specimen occasionally 3-bladed pedicellariae occur. No enlarged subambulacral spines were seen in the small specimens, but they were certainly present in the larger animal. In the small specimen the adambulacral furrow spines are long, very slender, and webbed basally; in the large specimen the adambulacral furrow spines are quite short and compressed. In both specimens inferomarginal pedicellariae are present interradially.

In many respects *Plutonaster hikurangi* is very similar to *P. jonathani* n. sp., which is reported from further south; in both species the arms are short and the disc is broad. There are differences, however, in the general form of the marginal plates — in *P. jonathani* the superomarginal plates form a gently regular sloping edge to disc and arms; in *P. hikurangi* the upper part of the superomarginal plates is level with the abactinal plates. The plates then drop steeply to the inferomarginals, giving a vertical and distinct margin to disc and arms. *Plutonaster hikurangi* is unique among southern *Plutonaster* in this respect. There are also conspicuous inferomarginal pedicellariae in *P. hikurangi*, not present in *P. jonathani*. In some ways *P. hikurangi* resembles a short-rayed *P. fragilis* as both species have inferomarginal pedicellariae; however *P. fragilis* has a close cover of small spinelets on the superomarginal plates in no way resembling the very distinctive covering granules of *P. hikurangi*. It is also distinct from *P. knoxi* in having granules rather than fine spines on the superomarginal plates; there are also more numerous adambulacral furrow spines than in *P. knoxi*. *Plutonaster hikurangi* differs in body form from

*P. complexus* n.sp., which lacks inferomarginal pedicellariae and has subambulacral pedicellariae. Also, *P. complexus* has enlarged subambulacral spines only on the last adambulacral plates near the arm tips; in *P. hikurangi* enlarged subambulacral spines are continuous from oral plates to arm tips.

*Plutonaster jonathani* n sp. (Pl. 21, Fig. 23)

**MATERIAL EXAMINED:**

NZOI Stns: G665(1), T48(1).

**TYPES:** Holotype, H-736, from NZOI Stn T48, R/r = 58/23 mm, deposited in the NIWA collection, Wellington.

Paratype, P-1205, from NZOI Stn G665, R/r = 40/16 mm, deposited in the NIWA collection, Wellington.

**TYPE LOCALITY:** NZOI Stn T48, 49°18.6' S, 177°54.7' E, 990 m, west of the Antipodes Islands.

**SIZE:** R/r = 40/16 mm (G665); R/r = 58/23 mm (T48).

**DISTRIBUTION:** This new species is recorded from Canterbury Bight (G665) and from further south near the Antipodes Islands (T48).

**DEPTH:** 934–990 m.

**DESCRIPTION:** The holotype, R/r = 58/23 mm (T48) from near the Antipodes Islands is described.

*Disc* large, flat; *arms* rather flat and short, broad basally, tapering swiftly and evenly, arm tips slightly reflexed.

*Terminal plate* broad, almost rectangular, slightly raised at tip; 2 or 3 enlarged spines may have been present and very faint small circular scars suggest that round granules, similar to those of neighbouring superomarginal plates, were also present.

*Abactinal paxillae* form very regular rows interradially and along arm edges for at least half, almost three-quarters length of each arm; plates oval, each with a short, thick trunk expanding to form a similarly shaped, gently raised, head with 12–24 or 25 slender, well-separated, finely thorny, blunt-tipped marginal spinelets; these enclosing a number of slightly shorter, very round headed, finely thorny well-spaced spinelets. Paxillae forming a very even and close cover on abactinal surface.

*Papulae* 4–6, distinct around plates, fewer and less obvious centrally on disc, but extending interradially to superomarginal plates.

No *abactinal pedicellariae* seen; on actinal surface, however, 3, 4, even 5 enlarged actinal granules, especially near inferomarginals, form incipient straight



pedicellariae interradially.

*Madreporite* quite large, nearer inferomarginal plates than disc centre, finely dissected, with a close cover of larger paxillae in fairly regular rows.

*Anus* small, brown, membranous, central on disc.

*Superomarginal plates* well-defined, conspicuous; 18–21 plates present from interradial angle to arm tip. These regularly rectangular and form a very distinct edge to abactinal surface; they are well separated from each other laterally by *fasciolar grooves*, these lined by slender, slightly flattened, thorny spinelets. Superomarginal plates covered by round or slightly angular well-spaced granules. Most plates bear 1 round-tipped, short, sturdy tapering enlarged spine with, generally, a rounded tip. At edges of superomarginal plates and adjacent to inferomarginals, granules elongate to form very short, thorny spinelets. Enlarged spines become progressively smaller distally and are absent from the last 7 or 8 plates near arm tips.

*Inferomarginal plates* corresponding with superomarginals and not very obvious from the abactinal surface; actinally, they form a conspicuous and regular edge to actinal plates. Small, rounded, generally well-separated granules similar to those of superomarginal plates present on inferomarginals. Generally 1 enlarged conspicuous spine, similar to, but larger than enlarged spines of superomarginal plates. In 3 interradial angles another very small enlarged spine is present behind and on actinal side of larger spines. Both enlarged inferomarginal and superomarginal spines absent from most distal marginal plates.

*Actinal areas* well defined, obvious; *actinal plates* present between adambulacrals and marginals for a short distance along each arm. Actinal plates forming regular rows from adambulacrals to inferomarginals; plates slightly raised with rows of well-spaced thorny-headed granules; these similar to but slightly longer than those of inferomarginal plates. Near inferomarginals, actinal plates often bear 3 conspicuously enlarged granules, the tips of which sometimes meet to form an incipient pedicellariae. No conspicuously enlarged spines; plates forming regular rows; no unpaired row present.

*Adambulacral plates* forming a regular edge to furrow; plates separated laterally by grooves which continue out between actinal plates. Each adambulacral plate with a furrow series of 8 or 9 slender, well-spaced, very finely thorny, round-tipped spines, their bases enveloped in a thick, opaque membrane. Adambulacral plates rectangular, conspicuous, with 1 enlarged, sturdy conspicuous subambulacral spine on distal (arm tip) edge of plate and several shorter, well-spaced spines form an actinal fringe. Near arm tips adambulacral plates smaller with fewer spines; enlarged spines absent from distalmost plates.

*Oral plates* large, raised, with a furrow series on the anterior, free edge of plates, of 8, 9 slender, spaced spines, these similar to those of adambulacral plates; suboral spines and granules present in ill-defined rows on either side of plates; suboral spines longer and better defined where they overhang the mouth.

*Ambulacral grooves* wide medially and narrow proximally and distally.

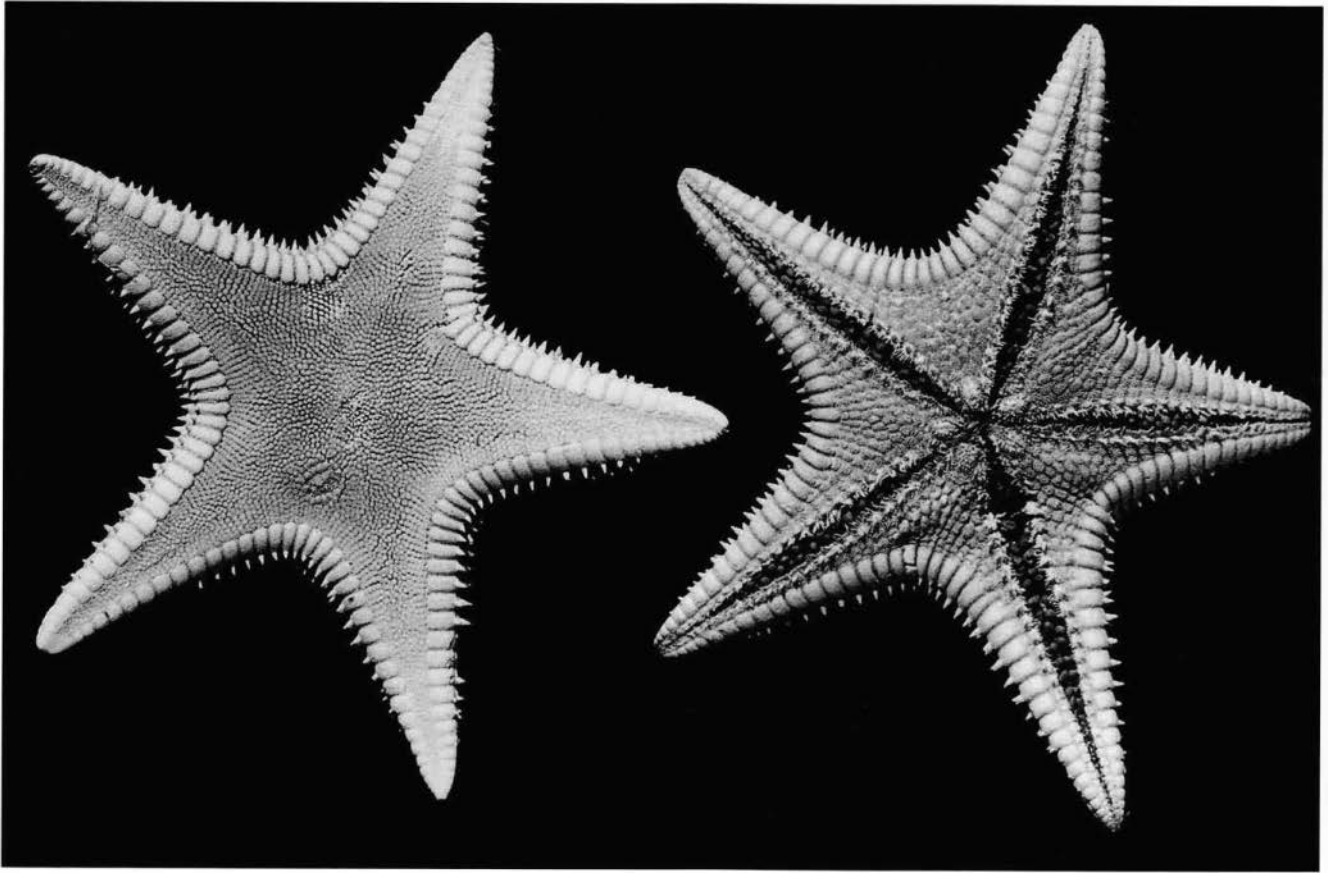
*Tubefeet* in 2 close rows within the groove; quite large, conspicuous, broad, flattened, tapering, no disc.

COLOUR: There are no colour notes of the living animal. In preservative and when dried, specimens are light brown or fawn with conspicuously paler, almost white marginal plates and spines. Actinally the colour is similar although tubefeet are a distinct golden-brown. All spines are white.

ETYMOLOGY: The specific name is for Jonathan Stephen Rotman, son of H.E.S.C. We wish him a long, successful, and rewarding life.

REMARKS: The paratype (NZOI Stn G665) with R/r = 40/16 mm, from Canterbury Bight in 934 m, also has five arms; these have upturned tips. Abactinally, this small specimen is very similar to that described, although the superomarginal spines are considerably smaller, more round and sturdier. *Papulae* are present and distinct in this small specimen, extending interradially to the superomarginal plates and are absent from a very small area centrally on the disc surrounding the anus and from a thin line, 2 or 3 abactinal plates in width, along the arm midline. The *madreporite*, well covered by paxillae, is considerably smaller and less easy to see, and nearer the margin than the disc centre. There are 7 or 8 *adambulacral furrow spines*. The most proximal and distal are smaller and a conspicuously enlarged subambulacral spine is also present. *Actinal plates* are similar to those described except that there is often an enlarged, conspicuous and globose central granule present. There are no pedicellariae. The *oral plates* are more obvious with 10 or 11 furrow spines, the most anterior, those overhanging the mouth, being longest otherwise the armature is much as described for the larger specimen.

This small specimen (NZOI G665) was dissected. The stomach was full of fine grey-white mud, among which were sponge spicules and other unidentified calcareous plates. The ambulacral plates are separated from each other dorsally by distinct, very regular rectangular membranous areas; sturdy, short superambulacral plates are present and a conspicuous flange or lobe of the ambulacral plate occurs on either side of the superambulacral plate. This lobe is most obvious on the distal (arm tip) edge of the plate. Ampullae of



**Plate 21.** *Plutonaster jonathani* n.sp. Holotype. NZOI Stn T48. R/r = 58/23 mm. Abactinal and actinal surfaces.

the tubefeet are double and large. Slender tubular gonads are present in a fringe interradially, where they seem to be attached to the abactinal plates. The abactinal plates from the coelomic side are interesting, being covered by a heavy membrane, are irregularly round or oval, and form a very close cover. Interradially and marginally they form almost regular rows of 3–5 plates and occasionally overlap. Papulae 4–6, surrounding each plate, and there is a very narrow region along the arm midline where they are very few or absent; on the disc centre, it is difficult to determine whether papulae are present or not. The stone canal is large with very regular rib-like plates.

*Plutonaster jonathani* is distinct because of its large disc and very short, broad-based, fast-tapering arms. In general appearance it is similar to *P. hikurangi* n.sp. although there are differences in the superomarginal plates. In *P. jonathani* the superomarginals form a distinctly sloping, almost rounded edge to disc and arms, whereas in *P. hikurangi* superomarginals project out and then bend sharply to inferomarginals. In both species granules are present on superomarginals, but are larger and more conspicuous in *P. hikurangi* than in *P. jonathani*. *Plutonaster jonathani* has small

granules on inferomarginal plates; in *P. hikurangi* small, broad, thorny spines are present. *Plutonaster hikurangi* also has inferomarginal pedicellariae which were not seen in *P. jonathani*; also the number of adambulacral and oral furrow spines is distinctly fewer in *P. jonathani*. *Plutonaster jonathani* differs from *P. knoxi* and *P. fragilis* in having granules rather than small spines on the marginal plates; it also differs from the more slender and longer-armed *P. complexus* n.sp. in the nature of the marginal plates; in *P. jonathani* the inferomarginals have a covering of small granules whereas in *P. complexus* there are short, thick tapering thorny spinelets. Adambulacral pedicellariae were not seen in *P. jonathani* but they are present in *P. complexus*.

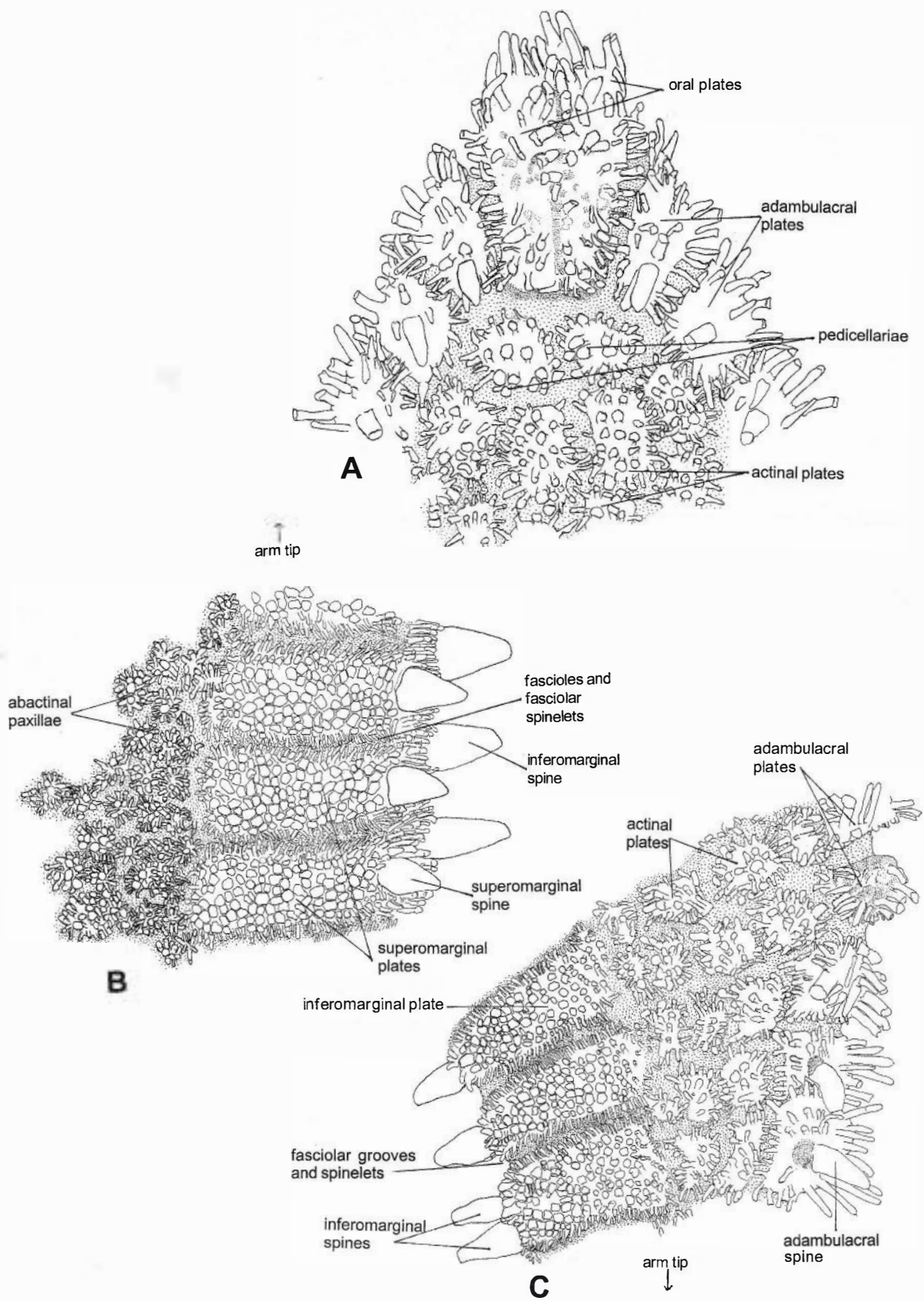
***Plutonaster knoxi* Fell, 1958** (Pl. 22, Fig. 24)

*Plutonaster knoxi* Fell, 1958: 5, pl. 1(c); 1959: 132; 1960: 60, pl. 1; 1962a: 21 (illustr); 1963b: 390, fig. 5 G; McKnight 1967: 298; H.E.S. Clark 1970: 3.

**MATERIAL EXAMINED:**

NZOI Stns: A908(1), A913(5), C606(5), C608(39), C609(1),





**Fig. 23.** *Plutonaster jonathani* n.sp. Holotype. NZOI Stn T48. **A.** Oral, adambulacral and actinal plates. **B.** Abactinal and superomarginal plates, near entrance to arm. **C.** Actinal surface showing inferomarginal, actinal, and adambulacral plates and spines. Note two enlarged inferomarginal spines on plate nearest arm tip.

C693(2), D90(14), D117(2), D468 (1), D869(8), D870(15)\*, D872(8), E80(1), E81(3), E146(6)\*, E423(1), E705(4)\*, E706(1)\*, E714(1), E745(8), E752(2), E756(6), E757(2)\*, F745(1), F752(1), F754(2), G42(1), G208A(4)\*, G212(8), G268(2), G34(8)\*, G369A(1), G374(1)\*, G403(1), G666(1)\*, I657(22), I658(2), I660(2), I664(2), Q4A(1), Q12B(1), Q33(1)\*, S200(3), V366(13)\*, V370(1), W249(5), W259(2), W261(1), W273(1), X500(2), X508(1), X514(1), X519(1), Z8539(1), Z8976(2), Z8977(1), Z8978(28), Z8979(1).

NMNZ: Aldermen Islands: Ech. 4486(3); Cape Campbell: Ech. 4470(3), 4472(1), 4473(1); Chatham Rise and northern Mernoo Slope: Ech. 1245(2), 3909(1), 4308 (7), Ech 4474(3), 4479(5); Hikurangi Trough: Ech. 4178(2), 6574(2), 6594(3); Lower Kaikoura Canyon: Ech. 4477(3), 4487(13), 4490(2); off Cape Kidnappers: Ech. 5651(1); Bay of Plenty near Mayor Island: Ech. 4478(7); Palliser Slope: Ech. 4475(1).

Size: Specimens with R 20 mm (or less) are recorded separately, and are not included here; 322 larger specimens are listed, 56 of which (NZOI specimens) were not seen. The average size for 85 specimens, chosen at random, is  $R/r = 79/20$  mm. The largest specimen in the present collections, with  $R/r = 131/32$  mm (NMNZ Ech. 4470) is from near Cape Campbell, South Island; several further specimens, from the Chatham Islands and Chatham Rise, have  $R = 130$  mm and, in these,  $r$  varies from 30 to 34 mm; in one specimen (NZOI Stn E80) the disc is very large, with  $R/r = 130/44$  mm.

DISTRIBUTION: *Plutonaster knoxi* is commonest in the Chatham Islands and Chatham Rise; it is also recorded from between Cape Campbell and Kaikoura in South Island; there are two specimens (NZOI I664) from near the Bounty Islands, the most southern recorded. It is rare north of 40°S, the most northerly records being from near the Aldermen Islands (NMNZ Ech. 4486) and Mayor Island in the Bay of Plenty; one specimen is recorded from off East Cape and there are two from near Mahia Peninsula (North Island). There are no records of this species from the west coast of either island.

The holotype is from near Pitt Island in the Chatham group, 604 m.

DEPTH: This species has a wide depth range from 59 m in Bay of Plenty (NMNZ Ech. 4478) to 1149–1915 m on Chatham Rise (NZOI Stn W273).

DESCRIPTION: A specimen, with  $R/r = 83/21$  mm, NZOI Stn I657, from the Chatham Rise area is described.

Arms 5, long, slender, tapering, 1 arm tip missing. Arms of different lengths: the 4 intact arms measure (from centre of disc to arm tip) 86 mm, 78 mm, 82 mm, and 65 mm, with an average of 83 mm. Disc large, more or less flat, and rather raised around the madreporite; *interbrachial arcs* well rounded.

*Terminal arm plates* gently arched, blunt, wide at free tip. Very small scars suggest granules or small spines may have been present. On 2 arm tips, possibly due to injury, a distinct line present, running from near abactinal plates to the free end; there is a distinct drop before plate continues.

*Abactinal paxillae* in very definite rows along arm edges and interradially, each with short thick trunks and a round, oval, or rectangular base; paxillar spinelets slender, blunt-tipped, distinct; there is an outer fringe of 7–12 (sometimes more) well-spaced, more or less horizontally directed spinelets, these enclosing 4–6 or more similar spaced spinelets. The outline of the abactinal plates distinct, even on disc centre, and plates are well separated from each other.

*Papulae* present, obvious, especially intermarginally and abactinally along arms, but absent centrally on disc.

*Pedicellariae* not seen.

*Madreporite*, oval and very large is finely, deeply and intricately dissected; it is nearer superomarginal plates than disc centre and bears a number of large, conspicuous, spaced paxillae which are present in almost regular longitudinal and horizontal rows; these paxillae are similar to, but very much larger and with more numerous spinelets than, adjacent abactinal paxillae.

*Anus* not obvious.

*Superomarginal plates* forming a very regular edge to disc and arms; interradially they are somewhat obscured by a fold or up-pushing of the abactinal surface. Superomarginals are rectangular, distinct, almost flat or very slightly raised, separated laterally by distinct, deep, regular *fascioles*. Each superomarginal plate bears short, upright well-spaced round-tipped, occasionally pointed, spinelets surrounding the single enlarged sturdy spine which tapers to a rounded tip. Very occasionally 2 enlarged spines present, especially interradially; these present at free edge of plate; the bases of these spines often free of small spinelets.

*Inferomarginal plates* corresponding with superomarginals but considerably longer, forming a regular edge to actinal surface; spinelets are longer, more conspicuous, sharp-tipped, well spaced, not forming definite rows. There is 1 large round-tipped tapering spine similar to enlarged superomarginal spines and of more or less similar length. Marginal plates and spinelets form a conspicuous margin to disc and arms. Near arm tips enlarged supero- and infero-marginal spines present but very much smaller, easily damaged, often missing.

*Actinal areas* well defined, large, obvious. *Actinal plates* forming very regular rows, generally no unpaired rows of plates present; however in present specimen, in 1 interradius there is a partial unpaired row of 3



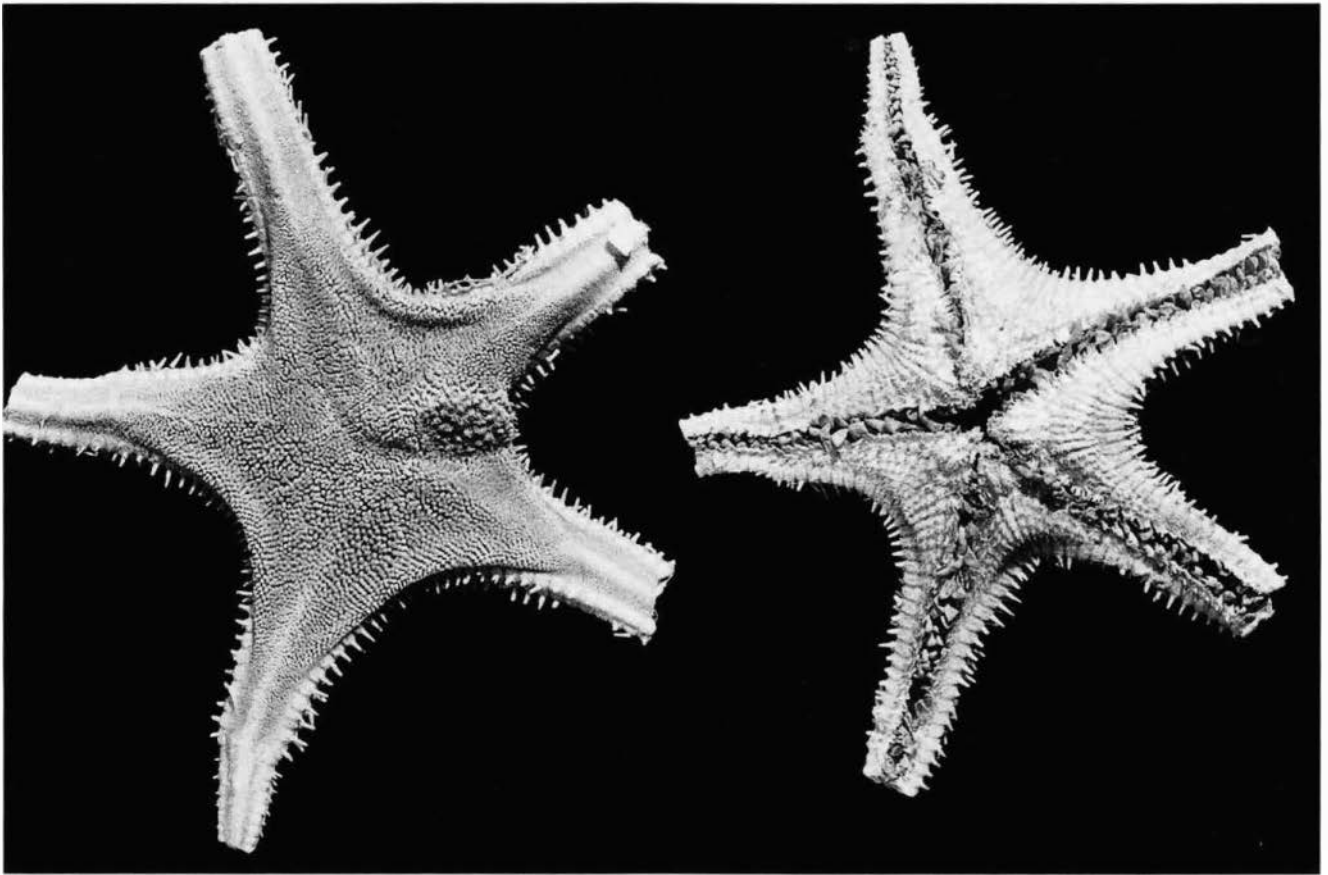


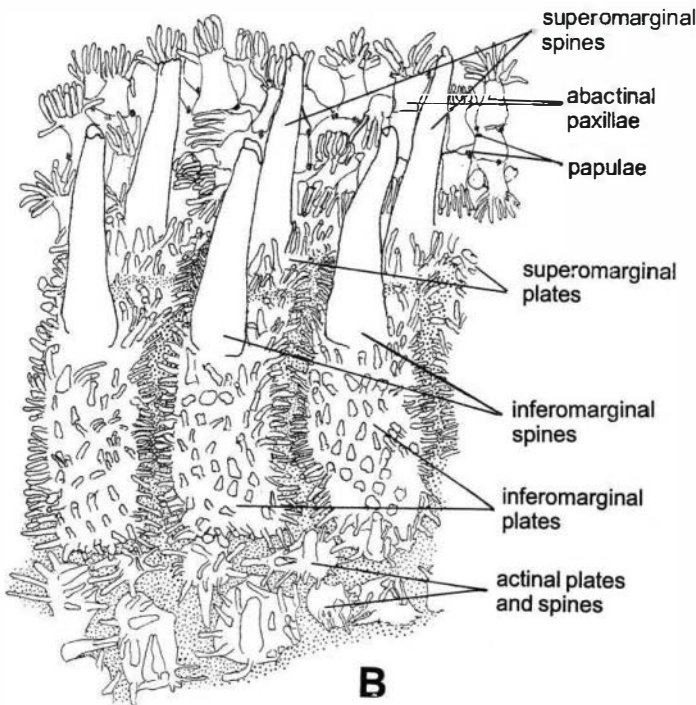
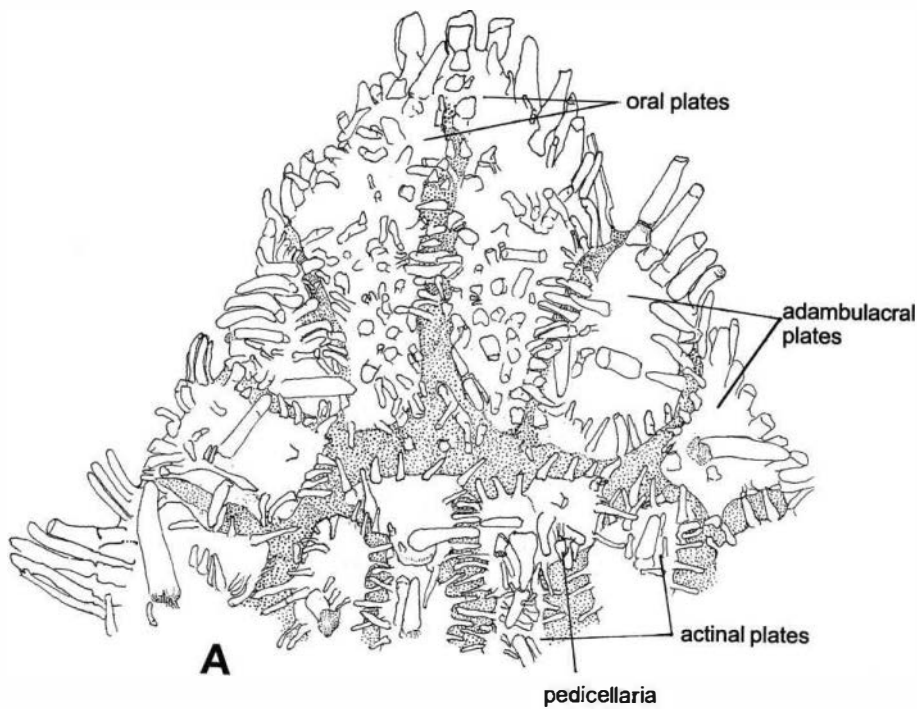
Plate 22. *Plutonaster knoxi* Fell. NZOI Stn I657. R/r = 83/21 mm. Abactinal and actinal surfaces.

plates. At actinal base of each pair of oral plates are 2 large, more or less round, slightly swollen actinal plates; from these the 2 median rows of small, less obvious actinal plates extend to inferomarginals. Rows of actinal plates are separated laterally from each other by definite channels, some of which are extensions of *fascioles* between inferomarginal plates; in general, a row of actinal plates corresponds to an adambulacral plate and 2 rows correspond to an inferomarginal. Actinal plates regularly rectangular, raised, with a number of short, spaced, fine spinelets similar to those of inferomarginal plates; along plate edges these spinelets form fairly regular rows; elsewhere their arrangement haphazard. Each actinal plate with 1 (very occasionally 2, near inferomarginals) acute, enlarged spine. Actinal plates continue along arm for a short distance; usually 8th or 9th proximal adambulacral plates are in contact with inferomarginals.

*Adambulacral plates* forming a regular edge to furrow, proximal plates rectangular, almost flat and well separated laterally by conspicuous membranous areas; towards arm tips membranous areas narrow and less obvious. Each adambulacral plate with 7 or 8

upright, round-tipped, gently tapering *furrow spines*; furrow edge of plate more or less straight. Furrow spines compressed laterally, the bases, almost the first quarter of each spine, enveloped in membrane; the most proximal and most distal spines on a plate often conspicuously smaller. Actinal surface of plate with a number of spaced, slender, pointed spinelets, these forming rather irregular longitudinal rows; also an enlarged, conspicuous subambulacral spine; these spines present to arm tips although distally often broken or missing. Generally, the enlarged subambulacral spine is nearer the distal edge of plate, particularly obvious near arm tip.

*Oral plates* raised, large conspicuous, with 9 or 10 *oral furrow spines*, these wide, round tipped, with narrow edge of spine to furrow and plate, in a regular row; the most anterior spines longest. Suboral spines short, more slender and generally round tipped, forming several rows on either side of broad membranous area between 2 plates in an angle. Along plate edges, adjacent to first adambulacrals, spinelets are short, slender, thorny and in several rather irregular rows.



*Ambulacral grooves* wide near middle of arms, generally rather narrower near oral plates and very narrow in last quarter of arm.

*Tube feet* in 2 rows; feet taper to a very narrow tip; no disc present.

**COLOR:** There are no colour notes with the present specimens. Dried, ex-preservative abactinal plates and those on the madreporite are light brown and marginal plates are lighter with darker fascioles between them. Actinally, plates and spines are light brown, shading to cream, with spines and spinelets, especially actinally, a distinctly darker brown. Fell (1959: 132; 1960: 61, 1962a: 21) recorded colour in life (according to Dr Elizabeth Batham) as "orange-red aborally" and small specimens were a "pale yellowish pink".

**REMARKS:** All specimens in the present collections had five arms; *regenerating arm tips* also occur, with plates generally markedly smaller and paler in colour, probably the result of injury. In one specimen (NZOI Stn G42) from the Chatham Rise, one arm is conspicuously forked with an ambulacral groove and tube feet present in both forks; in most specimens arms are of unequal lengths. Generally, *abactinal paxillae* are similar, with rather short undifferentiated spines; occasionally

Fig. 24. *Plutonaster knoxi* Fell. NZOI Stn 1657. A. Oral, adambulacral and actinal plates. Note simple pedicellaria on actinal plate. B. Lateral view of arm, near interradial angle.



spines are longer giving the paxilla a distinctly "shaggy" appearance. *Pedicellariae* are not generally present; occasionally, however, they are visible near the superomarginal plates, formed by the enlarged tips of paxillar spines; they are also sometimes present and similar on the actinal plates. Fell (1960: 60), in his definition of the genus, stated that there are no pedicellariae present.

The *madreporite* is always very large and conspicuous and very finely dissected, and the covering paxillae are obvious and often arranged in more or less regular rows. Pedicels of these paxillae are large, sturdy, and very obvious when deprived of spines.

There is generally only one enlarged *superomarginal spine*; occasionally two are present, especially interradially, sometimes as a result of damage to the plates. Two large spines are sometimes also present on the *inferomarginals*. Along the furrows the *adambulacral plates* are very regular with 6–8 or 9 furrow spines which are distinctly webbed basally. A specimen of *Plutonaster bifrons* Thomson (a BMNH specimen, on loan) from the North Atlantic does not have webbed adambulacral furrow spines and neither does a specimen of *Plutonaster agassizi* (Verrill) from near Massachusetts, U.S.A. The presence of *webbed adambulacral furrow spines* is interesting. They were not recorded by Fell but are certainly present in all specimens in the present collections. In many specimens webbing is present for about one-quarter the length of the spines. Enlarged *subambulacral spines* are also generally present, sometimes only near arm tips.

*Actinal plates* are distinctive and very regular. Occasionally a row of unpaired actinal plates is present in one interradius (as in the specimen from NZOI Stn I657, described here). Enlarged *actinal spines*, generally one sometimes two, are most obvious near the inferomarginal plates. The *oral plates*, large, conspicuous, and raised, have a fairly constant arrangement of spines, united in a shallow web of membrane.

Fell (1958: 5; 1960: 60) discussed the similarities and differences of *P. knoxi* with *P. bifrons* (Wyville Thomson); having examined a specimen of *P. bifrons* from the BMNH (CR 98/17), one of the most obvious differences (unmentioned by Fell) is that *P. bifrons* has rounded granules on the superomarginal plates; in *P. knoxi* superomarginal plates have a fairly uniform cover of fine distinct spinelets.

A number of specimens were dissected. Generally, stomachs were either empty or packed with fine grey mud; stomach contents included forams, echinoid spines and pieces of test, remains of Crustacea (especially claws), and very occasionally the battered remains of molluscs, perhaps ingested with the fine mud. A strong membranous *interradial septum* is present, stretching from the actinal plates to the abac-

tinals. *Partial septa* are also present at regular intervals on either side of the interradial septum; these become progressively smaller and are present for some distance along the arms. *Ampullae* of the tubefeet are double and large; the ambulacral plates rise steeply and are separated from each other by a wide conspicuous muscular area. Superambulacral plates are distinct and narrow, and arise near the centre of the lower extended part of the ambulacral plates; superambulacral plates are also present in the specimen of *P. bifrons* from the BMNH (with permission to dissect); the two species, *P. bifrons* and *P. knoxi* are very similar internally. Seen from the coelomic side, the *madreporite* forms an extensive oval mass, with neighbouring abactinal plates, large, irregular, membrane covered, and rather indistinct with occasional papulae between them. The *stone canal* is immense and very thick walled, with a mass of internal ossicles; the membranous septum splits to surround and confine it. *Polian vesicles* were not easily seen but are present, one to an interradius and possibly two in the interradius with the stone canal. *Gonads* form a conspicuous fringe interradially to a varying extent along each arm, where they seem to be attached to the abactinal plates. Possibly gonopores are present between these plates. *Abactinal plates*, seen from the coelomic side, are round, oval and sometimes very slightly angular; 4 or 5 *papulae* are present around each plate interradially to the superomarginal plates, but are absent or very few and scattered from a narrow central area along each arm and from the disc centre.

*Plutonaster* sp. A

(Pl. 23)

MATERIAL EXAMINED: NZOI Stn I722(1).

SIZE: R/r = 26/7 mm.

DISTRIBUTION: The single specimen is from near Lord Howe Island, northwest of New Zealand.

DEPTH: 1828 m.

DESCRIPTION: The single damaged and broken specimen, R/r = 26/7 mm, is described; *arms* 5, 3 are broken near the disc, the remaining 2 have terminal arm plates missing. *Disc* well defined, almost flat; *arms*, long, slender, tapering have a gently raised and heavily calcified ridge (keel) along the midline, the interbranchial arcs well rounded.

*Abactinal paxillae* form fairly regular rows along arm edges (for a short distance) and interradially; each has a short, tapering trunk which expands into a more or less round or oval head bearing 6–9 or 10 peripheral, slender, spaced, round-tipped spinelets that enclose

1–3, occasionally 4 similar-sized well-spaced spinelets; all spinelets have an enlarged and finely thorny tip or head.

*Papulae*, 4 or 5 around each plate, present interradially and for a short distance along arms, but are absent from midline of arms and disc centre.

No distinct abactinal *pedicellariae* seen; occasionally on actinal plates the tips of 2, 3 even 4 spines meet, almost forming a pedicellaria; this is probably also true for the abactinal surface.

*Madreporite* exposed, large, almost heart-shaped and separated from superomarginal plates by 3 or 4 rows of paxillae; it is quite coarsely dissected, with naked stumps of at least 4 large paxillae — the stumps oval, round, rather swollen, suggesting that the madreporite was well-hidden by paxillae.

A small central opening between paxillae on the disc centre may be the *anus*.

*Superomarginal plates* forming a very definite edge to disc and arms; plates conspicuous, raised, rounded *fasciolar grooves* between them obvious especially where plates are naked. Plates with short, thorny-headed, well-spaced spinelets, these forming almost regular rows, especially near abactinal plates. Generally 1 enlarged spine on free edge of plate, this small, sturdy, rounded, sometimes acute at tip, these enlarged spines not present in last half of arms, probably because of damage to plates; granules at base of enlarged spines often larger, more obvious, but only 1 really enlarged spine present. *Fascioles* between marginal plates distinct for at least half arm length; in last half of arm indistinct and very shallow. Fasciolar spinelets slender, perhaps slightly flattened, meeting with other spinelets from neighbouring plates.

*Inferomarginal plates* corresponding with superomarginals but considerably longer, forming an even and conspicuous edge to actinal plates interradially and adambulacral plates along arms. They bear small, fine slender spinelets which are longer and more numerous than those of superomarginal plates, merging laterally with fasciolar spinelets. One enlarged *inferomarginal spine* present, sturdier, longer, more conspicuous than enlarged superomarginal spines; basal spinelets (around the enlarged inferomarginal spines) often conspicuously longer.

*Actinal areas* large, well developed, actinal plates forming very even rows and are present between adambulacrals and superomarginals for almost half arm length. *Actinal plates* more or less hexagonal, forming a close, even, very regular cover, the centre of each plate raised to form an oval or rectangular crest, bearing a number of short, spaced, thorny and large-tipped spinelets, those around plate edges sometimes slightly longer. Occasionally tips of 2, 3 even 4 spines meet to form a simple pedicellaria.

Along furrows, *adambulacral plates* have a rounded or gently angular, free margin; they are well separated laterally from one another by clear membranous areas, most obvious proximally. Each plate bears 6–8 (occasionally 9 proximally) furrow spines, these long, slender, round-tipped and spaced from each other. Subambulacral spinelets, in 2 or 3 rather ill-defined rows present behind the furrow spines, similar to furrow spines but shorter; neither pedicellariae nor enlarged subambulacral spines present.

*Oral plates* conspicuous, raised, oval, damaged; there were probably 9–11 furrow spines, the most proximal longest; most suboral spines are missing but there are remnants of a row of spines along the median suture.

*Ambulacral grooves* narrow; towards arm tips adambulacral plates and spines almost meet across the furrow; *tubefeet* biserial, lacking distinct sucking discs.

**COLOUR:** There are no colour notes on fresh material. Dried and in preservative the specimen is white with gold-brown tubefeet.

**REMARKS:** Sladen (1889: 95) described a new species of *Plutonaster*, *P. ambiguus*, based on a single small (R/r = 25/6.5 mm) specimen taken from east of Sydney, Australia in 1737 m (950 fm); the present damaged specimen, also small and from deep water, is similar in many respects to *P. ambiguus* as it has long, narrow arms and a distinctly inflated “keel” along the midline of the arms. There are also similarities in both series of marginal plates and in the number of adambulacral furrow spines; however, enlarged subambulacral spines were not seen in the present specimen (possibly a result of damage), and Sladen (1889) did not mention actinal pedicellariae, which occur in the present specimen.

It is interesting that *Plutonaster ambiguus* does not seem to have been collected again; *Plutonaster* is not included by Rowe and Gates (1995) in the Zoological Catalogue of Australia Echinodermata.

The presence, in this specimen, of small spinelets on both series of marginal plates is similar to that seen in *P. knoxi* Fell and *P. fragilis* H.E.S. Clark; it is similar to *P. knoxi* in the number of adambulacral furrow spines and in lacking adambulacral pedicellariae; it differs from both *P. knoxi* and *P. fragilis* in having no enlarged actinal spines.

*Plutonaster* sp. B

(Pl. 24)

Small specimens of *Plutonaster* with R = 20 mm and less are listed and discussed below.



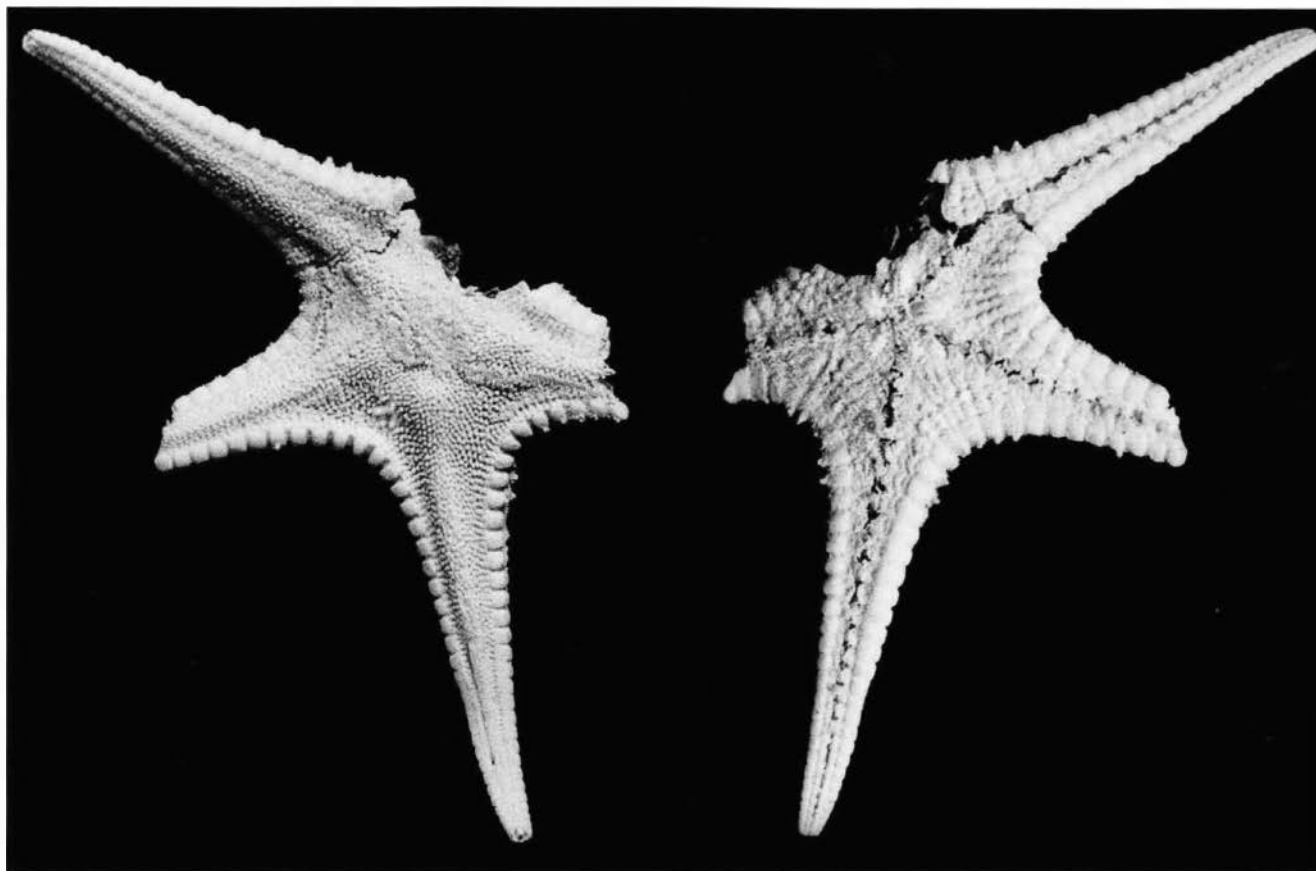


Plate 23. *Plutonaster* sp. A. NZOI Stn I722. R/r = 36/7 mm. Abactinal and actinal surfaces.

**MATERIAL EXAMINED:**

NZOI Stns : A846(1), A914(1), D117 1), D904(1), E76(1), E422(2), E714(3), F752(1), F767(3), G257(1), G282(1), G302(1), G329(1), G 373(1), I660(2), J669(1), P120(3), P971(1), Q4A(1), S202(6), U197(6), U226(2), U618(1), V365(1), V372(5), V472(1), W259(3).

NMNZ: Aldermen Islands: Ech. 4486(1); Cape Campbell: Ech. 4473(1); off Cape Kidnappers: Ech. 5233(2); Mayor Island, Bay of Plenty: Ech. 4478(12); northern Mernoo Slope: Ech. 4474(3), 4493(13); off Portland Island, Mahia Peninsula: Ech. 4485(1).

**REMARKS:** The 76 small specimens included here with R = 20 mm or less are very diverse and difficult to identify. The following NZOI and NMNZ stations included both large and small specimens of *Plutonaster*:

NZOI Stns: D117 (*P. knoxi*, 2 large), E714 (*P. knoxi*, 1 large), I660 (*P. knoxi*, 2), Q4A (*P. knoxi*, 1 large), U197 (with *P. complexus* n. sp.);

NMNZ: Mernoo Slope, Ech. 4474 and Ech. 4493 (larger specimens recorded as *P. knoxi*) and from Bay of Plenty, near Mayor Island, Ech. 4478 (*P. knoxi*, 7 large).

Distribution of these small specimens is similar to that of larger specimens of *Plutonaster*, with a concen-

tration on Chatham Rise, Mernoo slope areas. Small specimens, however, were also collected from near the Three Kings Islands, north of New Zealand and from west of Lord Howe Rise and Challenger Plateau. No small specimens were collected from near the west coasts of North and South Islands. There is one record of a small specimen, NZOI Stn A846, from near the Snares Islands south of New Zealand.

These small specimens come from a wide depth range: from 59 m (NMNZ Ech. 4478, Mayor Island, Bay of Plenty) to 2476 m (NZOI Stn S202, near Chatham Rise). Most of these small specimens are from between 300 and 500 m.

An interesting feature in small and large specimens is the R/r ratio. In some, arms are long and very slender, in others, short and broad based; both forms may occur in specimens from the one station, e.g., NMNZ Ech. 4478, Bay of Plenty. Arms in any one specimen are often of different lengths, which is also true of larger specimens. Regenerating arm tips are often also present in both large and small specimens and in a specimen (NMNZ Ech. 4493 from near Pegasus Bay) one arm is bent and crooked. Short broad arms, often with an unusually shaped terminal plate, may result from injury.

In most small specimens examined the *terminal arm plates* are typically low arched, usually with 3 large prominent spines and rows of small spines or granules; both the latter and the larger spines are often missing, with faint scars remaining.

*Abactinal paxillae* in these small specimens form regular longitudinal rows along arm edges (for at least half arm length) and on the disc have short, thorny-tipped spaced spinelets. Sometimes central spinelets appear slightly taller; plates are oval or almost angular in outline. Seen from the coelomic side (after dissection, NZOI Stn S202, R/r = 18/6 mm, from east of Cook Strait) abactinal plates are round, fitting tightly together, and are slightly opaque centrally. In one specimen (NMNZ Ech. 4485) from near Mahia Peninsula, abactinal paxillar spinelets are large and particularly broad headed.

Generally, neither *papulae* nor *pedicellariae* were seen in these small specimens. In one specimen (NZOI Stn S202, R/r = 18/6 mm), however, very small simple *pedicellariae* were present on superomarginal plates near inferomarginals; these were formed by the tips of 2 or 3 spinelets.

In large specimens of *Plutonaster* the *madreporite* is large and well hidden by paxillae; in small specimens the covering paxillae are sometimes markedly larger (NMNZ Ech. 4478, Bay of Plenty); in another specimen (also NMNZ Ech. 4493, near Pegasus Bay, South Island) the madreporite is exposed (possibly due to injury) and it lies very close, in fact almost touches, the superomarginal plates.

In most small specimens the *anus* was not obvious. In one specimen, however (NZOI U197 from near Lord Howe Rise), with R/r = 14/4 mm, a very central small opening on the disc is possibly the *anus*.

*Superomarginal plates* form with inferomarginals a distinct edge to disc and arms; the plates are separated by distinct *fascioles*. Occasionally in small specimens superomarginal plates are conspicuously narrower and raised, and the fascioles between them are very obvious. In some small specimens (NZOI Stn V365 from near the Chatham Islands, R/r = 8/3 mm) enlarged *superomarginal spines* are just obvious; in another even smaller specimen (NZOI Stn V372 from the Chatham Rise, R/r = 5/2 mm) enlarged superomarginal spines are present. Most specimens with R = 15 mm or more have enlarged superomarginal spines; sometimes two are present intermittently interradially, as in a specimen (NZOI Stn E76, Chatham Rise) with R/r 16/6 mm. Enlarged superomarginal spines are generally finely thorny. In most specimens small spinelets are present on the superomarginals. Sometimes it is difficult to decide whether short spinelets or granules are present on the plates. *Pedicellariae* were present on superomarginal plates of one small speci-

men discussed earlier under pedicellariae.

*Inferomarginal plates* are well defined in small specimens. They are generally larger than superomarginals, meeting with the adambulacrals near the entrance to the arms. The large *inferomarginal spines* are generally thorny in their last half; occasionally two enlarged spines are present on a plate, especially interradially. Sometimes simple pedicellariae are also present (NMNZ Ech. 4493, from near Pegasus Bay, South Island) with R/r = 15/4 mm. Pedicellariae are present interradially and occur near the superomarginals. In most specimens enlarged inferomarginal spines are present almost to the arm tips.

*Actinal plates* are conspicuous and regular in small specimens (this is also a very obvious feature of large specimens). The plates form very regular rows between the furrow and inferomarginal plates; occasionally there is an unpaired row of small plates which extends from between the oral plates for a short distance; such an unpaired row is often present in one interradius only (NZOI Stn D117, Chatham Rise area). *Actinal spinelets* are short, thorny tipped, well spaced; occasionally in these small specimens there is an enlarged spine present on the plate also. In one small specimen (NZOI Stn V372, Chatham Rise area) with R/r = 3/1.5 mm, only two obvious actinal plates are present in each angle. In a specimen with R/r = 10/4 mm (NZOI Stn S202, east of Cook Strait), the actinal spinelets are short, very numerous, and very thorny. No pedicellariae were seen on actinal plates in small specimens.

*Adambulacral plates* are distinctive. They are generally separated laterally by clear-cut channels, the plate margin in small specimens is well rounded, and there are from 2 to as many as 7, even 8 *adambulacral furrow spines*; *subambulacral spines*, distinct, enlarged and often surprisingly conspicuous, are sometimes also present. These are often most obvious further out along the arms (NZOI Stn E422, Chatham Rise area, with R/r = 19/6 mm, and a very much smaller specimen, R/r = 4/2 mm). In the large specimen from NZOI Stn E422, the 6 or 7 adambulacral furrow spines are webbed basally, which is not always seen in small specimens. Webbed adambulacral furrow spines were also seen in an NMNZ specimen (Ech. 4485, Portland Island R/r = 15/4 mm); enlarged subambulacral spines are present in at least the last half of the arms. In a specimen (NZOI Stn V365) from near the Chatham Islands, R/r = 8/3 mm, enlarged subambulacral spines are present for three-quarters of the arm length.

In small specimens the *oral plates* are sometimes damaged or they may be conspicuous, raised, and quite broad. *Oral furrow spines* are generally long, slender, and well spaced and range in number from 6 to as many as 10, even 11. In a specimen R/r = 19/6 mm (NZOI Stn E422, Chatham Rise) there were 9 or 10 furrow



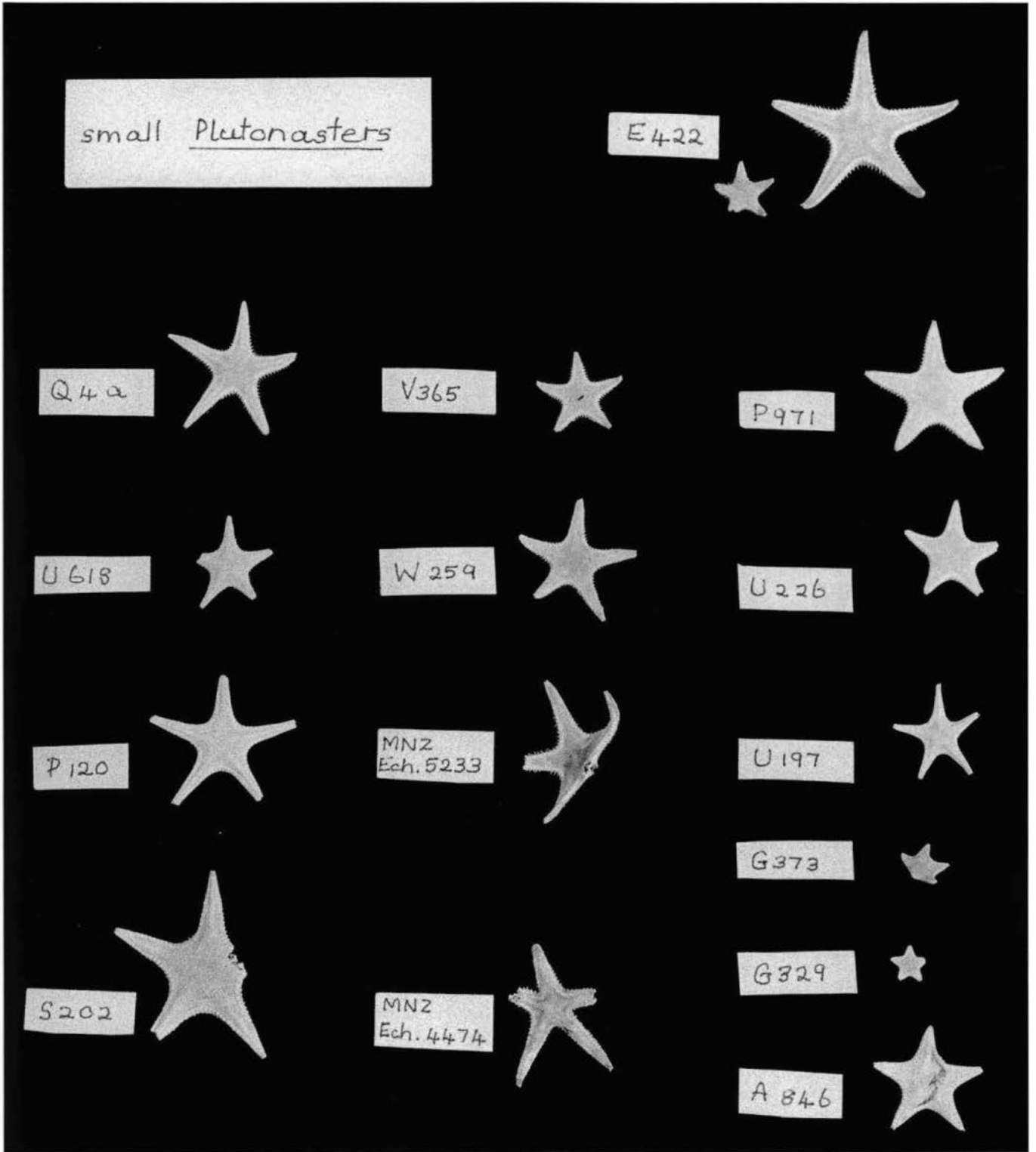


Plate 24. *Plutonaster* sp. B. Small specimens from various stations.

spines, and in a small specimen,  $R/r = 4/2$  mm, there are 9–11. The most anterior oral furrow spines are longest.

The *ambulacral grooves* are well defined and the tapering, pointed *tubefeet* form two regular rows. Generally, tubefeet are well separated and there is a broad clear central tract between the two rows. In many specimens the tubefeet are almost hidden by the adambulacral plates.

Several small specimens were dissected; in a specimen (NZOI Stn D904) with  $R/r = 19/6$  mm, *superambulacral plates* are present and well developed; the abactinal plates in this specimen, seen from the coelomic side, are large and irregular in shape — rectangular, square, almost circular, and they form interesting patterns. The *stomach* was full of closely packed mud and forams. In a very small specimen,  $R/r = 4/2$  mm (NZOI Stn G373, from near Chatham Island) there is part of a foram in the mouth and irregularities on the disc suggest other forams were present in the stomach. A specimen from NZOI Stn U226, well west of New Zealand, had a small black squid beak in its stomach, perhaps accidentally ingested with mud. And in a specimen from NZOI Stn V372, fine, slender broken echinoid spines are present in the mouth of the largest specimen,  $R/r = 5/2$  mm; in yet another specimen, NMNZ Ech. 5233, from south of Cape Kidnappers, the mouth was packed with mud and echinoid spines.

### *Proserpinaster* Fell, 1963

Disc large, more or less flat; arms rather short but distinct, tapering evenly and swiftly to pointed tips. Abactinal paxillae are very regularly arranged especially on arm and disc edges; irregular in arrangement and slightly raised along midline of arms and centrally on disc. Superomarginal plates very obvious, regular; there is a marked difference in the small covering spinelets on these plates from slender to quite broad, scale-like, rather flattened along distal (arm tip) edge of plate; superomarginal plates with 1 to sometimes 3 enlarged spines. Supero- and inferomarginal plates separated laterally by narrow, deep fascioles; fasciolar spinelets slender, short, blunt-tipped, not very obvious. Inferomarginals not easily seen from abactinal surface, but large and conspicuous actinally; plates broad in interradii, with a number of long, slender needle-like spines that give the plates a distinctly “shaggy” appearance interradially. The enlarged spines arranged in 2 rows. Actinal areas small, plates ill-defined, separated by distinct membranous areas; actinal plates with short spines and generally 1 enlarged, often rather flattened spine. Adambulacral

plates with a distinct, conspicuous angular projection into furrow proximally; distally, free edge is more rounded. Oral plates large, well raised, with conspicuous anterior furrow spines extending over mouth.

TYPE SPECIES: *Persephonaster neozelanicus* Mortensen, 1925.

REMARKS: Fell (1963a: 142) created *Proserpinaster* for *Persephonaster neozelanicus*, including in the new genus three Indonesian species, *P. euryactis*, *P. luzonicus*, and *P. anchistus*. His main criterion for the new genus was the “broadened interradiial inferomarginal plates”. A.M. Clark and Downey (1992: 23) included *Proserpinaster* in the Astropectinidae, but they did not comment further as the genus is not known from the Atlantic. The present authors follow Fell; we have not seen the Indonesian species.

A.M. Clark and Downey (1992: 60) recorded occasional actinal pedicellariae in their diagnosis of the genus. In the present collections, in a specimen from NZOI Stn Z8877, there are three quite conspicuous and large straight pedicellariae on the actinal plates, near the adambulacrals. There are also distinct but simple pedicellariae present on the superomarginal plates of the specimen described here (NZOI Stn S400), consisting of the enlarged heads of 3, 4, even 5 spines, the enlarged tips meeting to form a rather “button-like” pedicellaria.

### *Proserpinaster neozelanicus* (Mortensen, 1925)

(Pls 25, 26; Fig. 25)

*Persephonaster neozelanicus* Mortensen, 1925: 415, fig. 70; Fell 1947: 21, pl. 2, fig. J.; 1949: 210; 1952: 6; 1958: 5; 1959, 131, fig. 5; 1960: 61; 1962c: 465, fig. 6E, F.

*Proserpinaster neozelanicus*: Fell 1963a: 142; 1963b: fig. 2A, C; McKnight 1967: 298; Clark, H.E.S. 1970: 3, 11; Baker & Clark 1970: 2, 3.

#### MATERIAL EXAMINED:

NZOI Stns: A759B(1), A917(1), D871(1), D899(1), D906(1), E79(1), E117(1), E15(1)\*, E755(2), E759(2), E778(1), E781(2)\*, F765(1)\*, G153(1)\*, G155(2)\*, I6(1), I52(1)\*, I359(1)\*, I661(1), Q4C(1), Q16(1), Q27(1), Q33(3) S123(1), S179(3), S190(1), S379(1), S386(3), S400(6), S890(2), S896(1), V425(1), V426(1), V431(2), Z2371(2), Z2372(1), Z2373(1)\*, Z2374(1), Z2375(2), Z2377(2), Z826(1), Z8416(1), Z8540(1), Z8566(1), Z8877(1).

NMNZ: Bay of Plenty: Ech. 4299(1), 4469(2); off Cape Campbell: Ech. 194(2), 568(2), 1576(1); Challenger Plateau: Ech. 4461(2), 4462(4), 4548(1); Chatham Islands: Ech. 4465(1); Chatham Rise: Ech. 6330(1), 7458(3); Cook Strait: Ech. 5261(1); near Farewell Spit: Ech. 1247(2); Hikurangi Trough: Ech. 7412(1), 7420(1), 7428(1); off Kahurangi Point: Ech. 3432(1), 4458(2), 4466(1); Kapiti Island area: Ech. 4459(1); off Mahia



Peninsula: Ech. 5263(1); off Northland: Ech. 4182(1); **Palliser** and Cape Palliser: Ech. 4305(1), 6497(1); **Pegasus Bay**: Ech. 1246(2); Three Kings Islands: Ech. 5659(1); off Westland: Ech. 4460(2), 4463(9), 4464(3), 4464(3), 4467(2), 4468(1), 5653(2).

*Eltanin* Stn: 1846(1).

**SIZE:** In the present collections the largest specimen (NMNZ Ech. 568) with  $R/r = 140/37$  mm, comes from near Cape Campbell; there is a very small specimen, NZOI Stn D899, from near the Chatham Islands, with  $R/r$  approximately 19/6 mm; it is badly damaged, however. There is another small specimen, from near Chatham Rise (NZOI Stn Z8566) with  $R/r = 52/23$  mm. In the holotype, from near Cape Campbell,  $R/r = 110/33$  mm. The average size  $R/r$  for 16 specimens is 91/21 mm.

**DISTRIBUTION:** This species is commonest between 40° and 45° S and from 43°25' S, 169°17' E (NZOI Z2377) to the Chatham Rise area, 43°30' S and 176°00' W (NZOI E117). The most northerly record is a single specimen from near the Three Kings Islands (NMNZ 34°53' S, 172°19' E, Ech. 5659); there is also a specimen (NMNZ Ech. 4182) from off Northland, 35°32.1'S, 172°32.6'E; it is also known from Bay of Plenty, near Mahia Peninsula, and Hawke Bay. The type specimen is from near Cape Campbell, on the east coast of South Island.

**DEPTH:** The holotype, from 55 m off Cape Campbell, is probably the shallowest recorded. Other specimens are from 73 m to 625 m. H.E.S. Clark (1970) recorded a depth range of 92–1693 m.

**DESCRIPTION:** A specimen,  $R/r = 105/24$  mm (NZOI Stn S400, west coast, South Island) is described.

*Arms* 5; *disc*, large, flat with arms tapering evenly and swiftly to pointed tips. *Terminal arm plates* broad, indented, no enlarged spines present, although such spines may have been present at free tip of plate.

*Abactinal paxillae* forming very conspicuously regular well-spaced rows, especially along arms and on disc edges; these plates have a round or slightly lobed base and a short, thick, trunk which expands slightly into an oval and rather flattened head. Each consists of 7–12 (occasionally more) slender similar-sized round spinelets, these hyaline, tapering to a slender, round tip. The paxillar spinelets tend to bend towards the centre, giving a distinctly brush-like appearance. A narrow band, 3 or 4 plates in width, slightly raised along arm centre where paxillae do not show a regular arrangement; this also true for disc centre where paxillae are rather crowded and paxillar spinelets more numerous; paxillae centrally somewhat raised.

*Papulae* most conspicuous at plate bases along arms

and on disc edges, from 3 to 5 (occasionally 6) present; they are few and scattered from a narrow strip along arms and at disc centre.

*Pedicellariae* not seen.

*Madreporite* interradial, raised, more or less round, finely and evenly dissected, lying closer to superomarginal plates than disc centre and surrounding paxillae are spaced, slightly larger, more conspicuous.

*Anus* not obvious although there is a slight depression centrally on the disc.

*Superomarginal plates* forming an obvious and very regular edge to disc and arms; 46, 47 plates present from interradial angle to arm tip; plates broad, band-like, generally flat and separated laterally by conspicuous fasciolar grooves lined by slender spinelets. Plates with small spines or spinelets which on proximal edge of plate have a slightly expanded tip quite broad and rounded or sometimes tapering.

Along distal plate edge, spinelets tend to become enlarged, flattened, almost scale-like, this particularly obvious at base of enlarged spines. Enlarged superomarginal spines, 1, 2, occasionally 3 present on distal edge of plate near inferomarginals; these spines long, slender, tapering, finely rugose, slightly flattened. Proximally, spines extend across neighbouring plates; nearer arm tips, spines often shorter, generally more slender. Enlarged spines often differ in length and breadth on plate, there may be 1 short slender spine and 2 broader longer spines. Straight pedicellariae, of a simple type, also present on superomarginal plates; most obvious and numerous interradially along first part of arms. These pedicellariae formed by enlarged tips of 2–5 or 6 spinelets; these longer, thicker, broad-headed; 1 to 3 or 4 such pedicellariae may be present on the plates.

*Inferomarginal plates* corresponding with superomarginals, these plates obvious on actinal surface. Inferomarginals also bear numerous slender spines similar to those which cover superomarginal plates. 7–10 enlarged inferomarginal spines present, conspicuous, numerous, forming 2 rows especially interradially, spines similar to those of superomarginals but more uniform in size and shape. Towards arm tips spines fewer, generally smaller and shorter, less obvious. The enlarged inferomarginal spines most obvious from the actinal surface; interradially, spines tend to lie pointing upwards on the plate; near arm tips spines are oblique and lie across neighbouring plates. *Fasciolar grooves* also present between inferomarginal plates, these lined by slender spinelets similar to those of superomarginals.

*Actinal areas* with raised, rather ill-defined plates separated by membranous areas, these continuing from between adambulacral plates and are distinct. Each actinal plate bears a number of short, often slender,

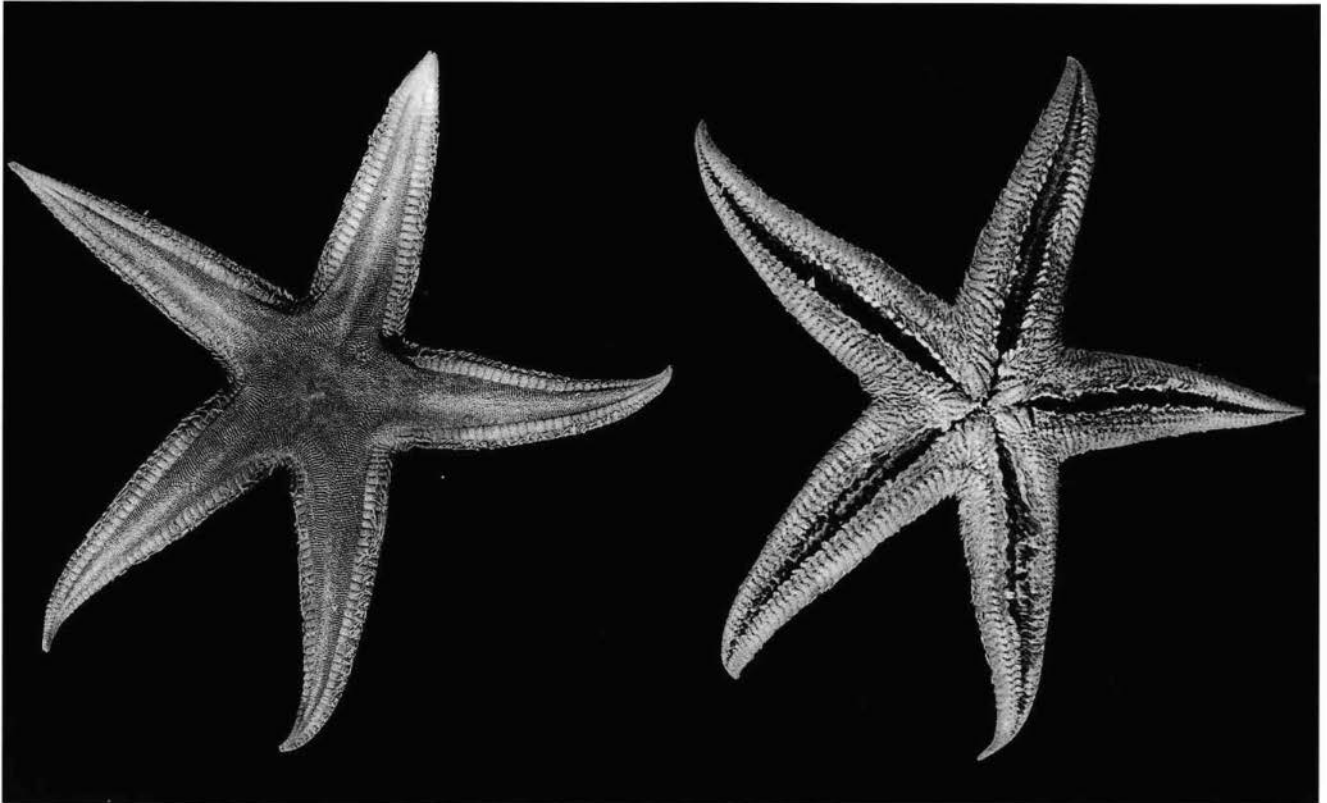


Plate 25. *Proserpinaster neozelanicus* (Mortensen). NZOI Stn S400, R/r = 105/24 mm. Abactinal and actinal surfaces.

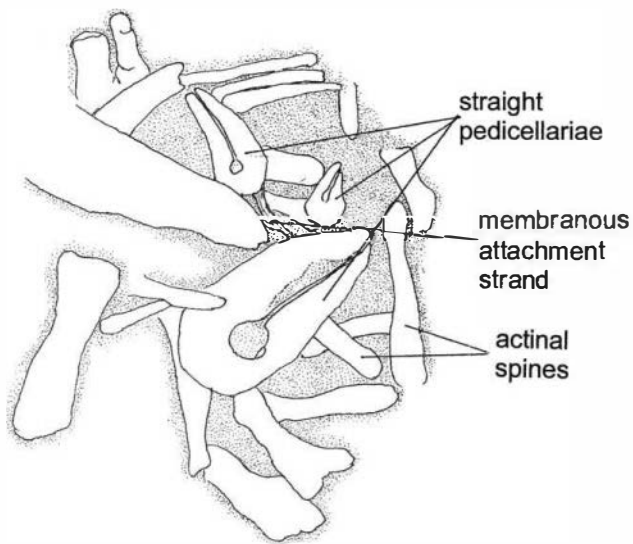


Fig. 25. *Proserpinaster neozelanicus* (Mortensen). NZOI Stn Z8877. Part of small portion of actinal surface showing three distinct and attached straight pedicellariae.

sometimes almost paddle-shaped, round-tipped spinelets; these seem to have a solid expanded base and were probably very motile; spinelets very finely thorny. Each plate also bears an enlarged flattened, conspicuous spine similar to enlarged spines of inferomarginals. Occasionally 2 enlarged spines present on a plate; these lie flat and point towards interradial angle. At least 2 rows of actinal plates continue between adambulacral and inferomarginal plates for some distance along arms.

*Adambulacral plates* project over furrow; proximally the projection is somewhat angular, distally becoming less obvious and rather more rounded; plates separated laterally by distinct flat membranous areas — these “pathways” continuing between actinal plates. Generally 6 adambulacral furrow spines, these broad, flattened, sturdy, round tipped, the central 1–3 spines on a plate generally with a narrow edge to plate and furrow, remaining spines have broad surface to furrow. Subambulacral spines conspicuous, small, generally slender, tapering, considerably shorter than furrow spines, in 3 or 4 transverse rows.

*Oral plates* somewhat damaged but large, conspicuous, long, narrow, well-raised above neighbouring plates; 2 plates in an angle separated by narrow membranous areas. At least 2 pairs of anterior furrow spines



projecting over mouth; these are large, flattened, round tipped. Suboral spines, short, stout, broad and flat tipped, these are slightly longer and well spaced nearer furrow. The first adambulacral plate on either side of oral plates is long, narrow, with 4 or 5 conspicuous furrow spines.

*Ambulacral grooves* narrow proximally and distally, broad and distinct medially.

*Tubefeet* spaced, tapering, lacking suckers; in 2 distinct rows and well separated medially.

**COLOUR:** Mortensen (1925: 417) remarked that the type specimens still showed a "fairly pronounced reddish colour" and Fell (1952: 7) alluded to the "striking" colour: "the paxillar area salmon-pink, the marginals and underside cream", and again Fell (1960: 61) recorded: "the colour in life is usually a bright salmon-pink above, the marginals paler the lower surface cream." In the present collections there seems to be only one orange specimen, from NZOI Stn E759. Dried specimens are generally cream or light brown, with darker tubefeet. Two specimens, dry (NZOI Stn S890), are exceptional as they are very dark brown, almost black.

**REMARKS:** All recorded specimens have five arms; in one specimen only (NZOI Stn S386), from off the west coast of South Island, there is one short arm with an obviously regenerating tip.

There are two distinct *forms* of this species; one with short, thick arms, the other with longer and distinctly more slender arms. In most specimens the *abactinal paxillar spines* are long and slender, giving the paxillae a paintbrush-like appearance. Sometimes these spines are considerably shorter, possibly as a result of damage. The *madreporite* in all specimens seen lies nearer the disc edge than the centre; it is always finely dissected, slightly raised, and, in larger specimens, there are often several enlarged fringing paxillae.

Generally there are no *pedicellariae*. Occasionally on the superomarginal plates the tips of 2–5 slender spines may meet to form an incipient pedicellaria. In one specimen (NZOI Stn Z8877) from the Chatham Rise area, R/r = 110/24 mm, three distinct straight pedicellariae are present on the actinal plates. Pedicellariae have not been reported previously for this species.

In general, the armature of the *marginal plates* is fairly constant, although sometimes distinct granules, rather than spines, are present. Also, enlarged superomarginal spines may be very obvious or few and scattered.

There are usually six rather flattened *adambulacral furrow spines*, sometimes only five are present; their arrangement is very characteristic as the central spine or spines have the thin edge to the groove and plate.

Dissection of specimens shows, among other

features, the very precise arrangement of abactinal plates along arm edges; here, plates are almost square or rectangular, slightly raised, and forming extremely regular longitudinal and transverse rows. Centrally along arms there is a narrow band where the plate arrangement is irregular and confused; this is also true for the disc centre. *Papulae* are few and scattered along the centre of the arms and centrally on the disc.

A *gonad* is present on either side of the interradial septum attached to the abactinal plates and probably opening abactinally, although no pores were seen.

*Interradial septa* are conspicuous, membranous, and well developed.

*Superambulacral plates* are distinct, passing from the proximal (i.e., nearest mouth) lobe of the ambulacral plate and joining with the marginal plates; a strong membranous septum is present below each superambulacral plate, extending to the actinal plates. It is the collapsed remains of these that are obvious and regularly arranged on the actinal plates after dissection. Another feature of interest is the distinct protuberance, almost a stump, internally on the inferomarginal plates to which the superambulacral plate joins or abuts, which extends along the arms. Perhaps this allows for greater flexibility. In several specimens, proximally near the oral plates, are long slender superambulacral plates surrounded and held by membrane. They lie very close to the actinal plates and seem to be developing.

There are six *polian vesicles*, with two in the inter-radius with the stone canal; ampullae of tubefeet are double and large.

*Large internal intermarginal pores* are present between superomarginal and inferomarginal plates.

The *ambulacral plates* form a steep ridge along the arm centre; there is a wide and conspicuous, often oval or almost circular muscular area dorsally between two rows of plates.

*Stomach contents* included ophiuroid arms, echinoid spines, crustacean remains, and forams.

In a large specimen (NZOI Stn Z8540, R/r 120/28 mm) from near Coromandel Peninsula, the disc appeared ridged and irregular. Dissection (Pl. 26) showed an amazing collection of quill worms (*Hyalinoecia* sp.). There were 20 almost complete tubes with remains of worms visible in at least eight of them. Tubes measured between 27 and 95 mm, and tended to lie in groups of three stretching across the body from arm to arm (see Read & Clark 1999). Two further specimens with worm tubes showing in their mouths were also dissected. A large specimen (NZOI Stn S386) from near Cape Farewell had an empty quill worm tube 80 mm long stretched from arm to opposite arm across the disc. And in a third specimen from off the Heaphy River, Westland (NMNZ Stn J15/026/76, Ech. 5653) dissection showed two small, incomplete worm tubes,

19 mm and 12 mm long, one containing part of a worm.

? *Proserpinaster* sp. (Pl. 27, Fig. 26)

MATERIAL EXAMINED: NZOI Stn I665(1).

SIZE: R/r = 26/7 mm.

DISTRIBUTION: Known only from the Bounty Plateau, 47°40.00' S, 179°14.30' W.

DEPTH: 812 m.

DESCRIPTION: The single specimen in the present collections is described.

*Disc* large; *arms* 5, broad basally, tapering evenly to tips; disc and arms well defined by superomarginal plates. One arm tip intact with *terminal plate* long, distinct, oval, almost heart-shaped; plate naked and rather irregular at free edge, probably damaged.

*Abactinal plates* round, oval, tumid, crowned by a number of short, round, thorny-headed spinelets; these well separated, surrounding 1 (occasionally 2) similar central spinelets; some peripheral spinelets more slender, shorter and less thorny than others. Proximally, and for a short distance along arms and interradially, "paxillae" form almost straight rows; centrally, on disc and arms, paxillae are small, crowded and rather indistinct. Whether abactinal plates are very tumid and crowned with short, thorny spinelets or whether paxillae are actually present is hard to decide; along midline of arms, short paxillae seem to be present.

*Papulae* interradiial and along arm edges, 6 or 7, around each plate.

*Pedicellariae* not obvious abactinally.

*Madreporite* interradiial, irregular in shape, separated from superomarginal plates by 2 or 3 rows of abactinal plates; small and coarsely and unevenly sculptured.

*Anus* not obvious.

*Superomarginal plates* distinct, tumid, forming a very regular and conspicuous edge to disc and arms; 13–15 plates present from interradiial angle to arm tip, each separated by quite deep clefts. Proximally, fine, slender fasciolar spinelets present; distally along arms they are not obvious. Superomarginal plates bear flat-headed, round and finely thorny isolated granules in reasonably regular rows; near free edge of the plate granules become quite conspicuous and considerably larger — there is a distinct "rosette" formation, with a large round-headed granule surrounded by 6 or 7 spaced and rounded granules (a similar arrangement is also sometimes seen in *Astromesites primigenius* (Mortensen);

towards arm tips enlarged granules also present, but are generally haphazard in their arrangement. No distinct superomarginal spines. Near inferomarginals, superomarginal granules very much smaller and more spaced, in more or less regular row.

*Inferomarginal plates* corresponding to superomarginals; only a small part of inferomarginal plate obvious from abactinal surface. Almost half the length of the plate present on actinal surface; plates also carry rounded granules similar to those of superomarginals in fairly regular rows. Slender, finely thorny fasciolar spinelets obvious in grooves between plates. Each

inferomarginal plate with 4 or 5 long, slender, slightly flattened spines in a very regular, gently oblique row on plate centre; the uppermost spine smallest and lies very close to the superomarginal plate. Spines lie flat against the plate borne on a slightly raised area devoid of granules. In general, the 2 or 3 central spines on a plate are longest, and may stretch right across the plate and part way across the following plate; very conspicuous near arm tips.

*Actinal areas* well developed, at least 1 row of plates extends for almost half arm length; these plates irregularly rectangular and close-fitting, a single unpaired, rather rounded, small plate at base of oral plates. Actinal plates with a number of similar, short, very slender, thorny spinelets; on the row of plates adjacent to adambulacrals distinct fasciculate *pedicellariae* present, the spinelets of these (considerably thicker than those of inferomarginal plates) bend towards each other, leaving no obvious scar or pit when plates are cleared of covering spinelets.

*Adambulacral plates* rectangular, forming a very regular edge to furrow; separated laterally by conspicuous, slanting, clear membranous areas. Adambulacral plates proximally with a gently and evenly rounded furrow margin with 6–8, even occasionally 9, furrow spines, these very similar — long, slender, well separated, non-tapering, round-tipped; basally, an enveloping membrane present for almost one-quarter of spine length, spines all of similar height. Subambulacral spines considerably smaller, short, stocky, and do not seem to form very regular rows on plates; no enlarged spines present. Near arm tips, adambulacral plates have a distinctly angular free edge which meets or almost meets with adambulacral plates from opposite side of furrow; it is difficult to distinguish the plates.

*Oral plates* raised, conspicuous, quite broad, with 2 anterior prominent apical spines; below these on plate edge is a row of 5 or 6 short, round-tipped, well-spaced spinelets. Below these again, and extending over the mouth on each side of each oral plate is a group of short sturdy, flat-tipped spines which form a conspicuous



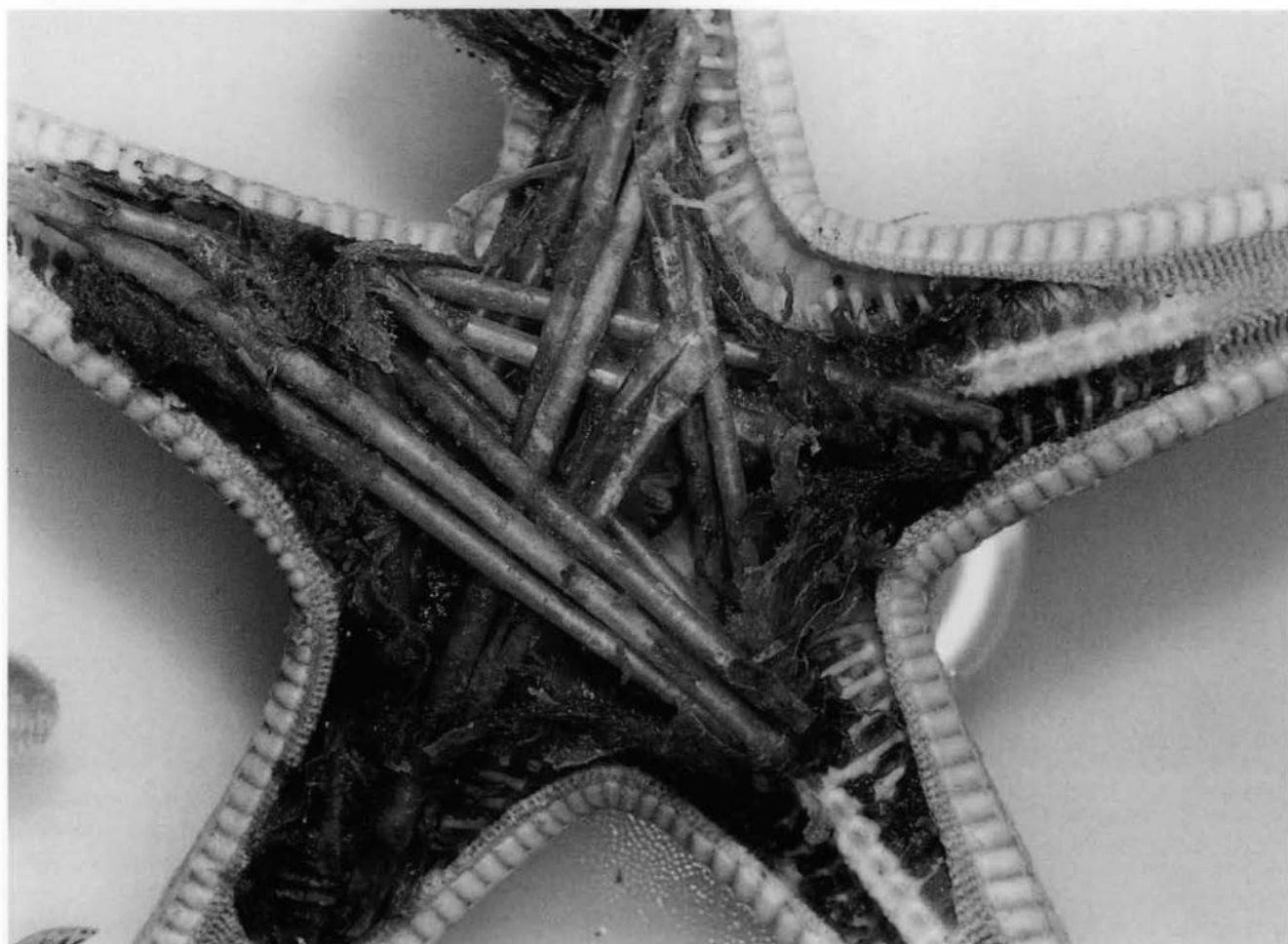


Plate 26. *Proserpinaster neozelanicus* (Mortensen). NZOISn Z8540. R/r = 120/28 mm. Dissected specimen showing collection of worm (*Hyalinoecia* sp.) tubes. Photograph : Steve O'Shea.

"pedicellaria-like" knob or clump. Bordering each oral plate is a row of short, sturdy round-tipped thorny spinelets, many of which are missing, leaving a faint round scar on plate. The membranous area between 2 plates in an angle narrow, dropping steeply and narrowly to unpaired actinal plate. Oral plates very distinct especially with the curious anterior 'clump' of spines projecting outwards either side of enlarged apical spines.

*Ambulacral grooves* narrow, deep with tubefeet in 2 very regular rows. *Tubefeet* slender, tapering, no terminal disc present.

The single specimen was not dissected.

**COLOUR:** There are no colour notes of the living specimen. Dried, it is white with very brown tubefeet.

**REMARKS:** In this specimen there are two interesting features: the unification of adambulacral furrow spines in a very even, very obvious web of membrane which

extends for almost a quarter the height of the spines, and the presence of spines on the oral plates of the curious "pedicellaria-like" clump or knob. These are low down in the mouth and posterior to the large apical spines. It is difficult to decide whether abactinal plates are tumid and crowned with spines or whether abactinal paxillae are actually present — this is possibly related to the small size of the specimen.

Using Fisher's (1911a) key to the Asteroidea of the North Pacific and adjacent waters, this specimen comes near *Persephonaster* — however, Fisher lists (for *Persephonaster* 1911a: 40) "no odd interrational actinal intermediate plates" and the present specimen certainly has an odd actinal interrational plate present. A.M. Clark and Downey (1992: 24) gave a tabular key to the Atlantic genera of the Astropectinidae; the present specimen comes, again, near to *Persephonaster* but it has marginal fascioles which, according to Clark and Downey and earlier Fell (1963a: 142), *Persephonaster* lacks. Fell (1963a: 142) created a new genus *Proserpinaster* which has mar-

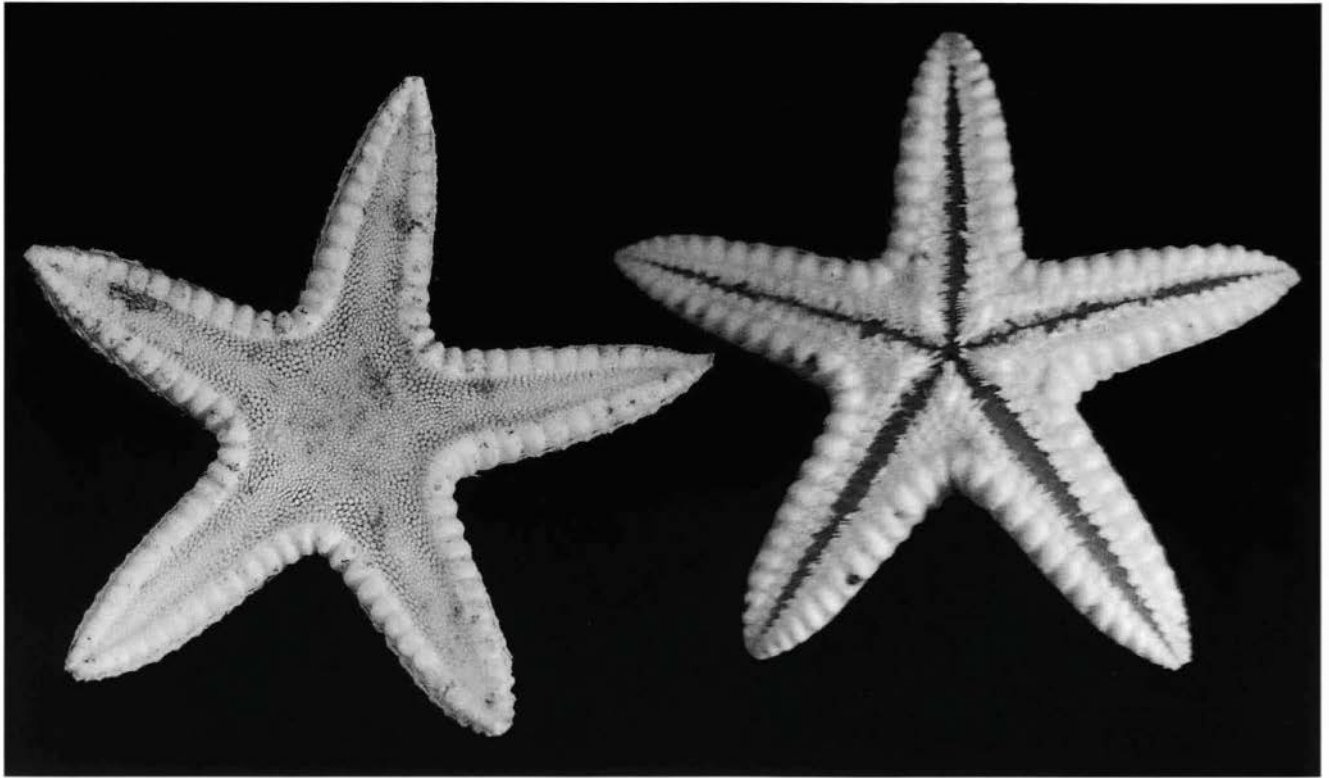


Plate 27. *Proserpinaster* sp. NZOI Stn I665. R/r = 26/7 mm. Abactinal and actinal surfaces.

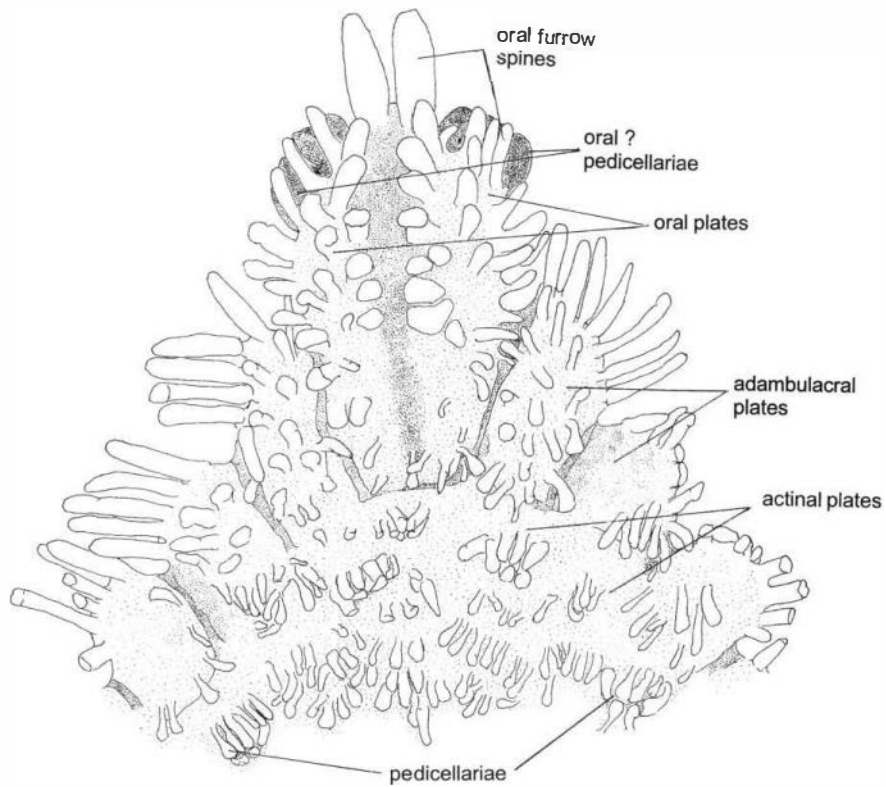


Fig. 26. *Proserpinaster* sp. NZOI Stn I665. Oral angle showing oral plates and adjacent adambulacral and actinal plates, and simple straight actinal pedicellariae. Note the curious ?pedicellariae anteriorly on each oral plate.



ginal fascioles, hence this small specimen is included in the genus. It is interesting that Fisher (1919: 114) recorded a pedicellaria-like arrangement of spines on the oral plates of *Persephonaster euryactis* — this is one of the three Indonesian species that Fell (1963a) included in *Proserpinaster*. Unfortunately, Fisher's illustration (1919, pl. 30, fig. 5) of the actinal surface of *P. euryactis* does not show the pedicellaria-like arrangement of spines deep in the mouth; however, the illustration does show the adambulacral furrow spines which certainly bear a resemblance to those described for the present specimen.

### *Psilaster* Sladen, 1885

Arms generally 5 (there are exceptions), rays either long, slender, and tapering evenly to a more or less sharp tip or rays rather short, broad at base, and fast and evenly tapering. Body thick dorsoventrally, with well-developed supero- and inferomarginal plates. Marginal plates distinct, regular and separated laterally by narrow fascioles. Abactinal plates lobed, not contiguous, each paxilliform with generally a slender trunk and short spinelets. These plates form very regular transverse rows along arm and disc edges. Papulae absent (or very few and scattered) from midline of arms and disc centre. Madreporite obvious, exposed. Inferomarginals and sometimes also superomarginals with enlarged spines, these lying flat, the plates generally with rounded granules or short spines basally. Actinal areas well developed, plates with groups of spines; sometimes a single spine (occasionally 2) conspicuously enlarged, especially near inferomarginals. Generally a single series of actinal plates present between adambulacral and inferomarginal plates for at least half arm length, plates often obscured. Adambulacral plates often with a curved furrow margin and distinct, rather slender furrow spines; subambulacral spines, well developed, in several rows. On dissection, superambulacral plates are conspicuous and there is a series of small, definite pores between the marginal plates at the end of the superambulacral plates, their function not known.

Although *Psilaster acuminatus* is common in New Zealand waters, no fossil species are recorded.

TYPE SPECIES: *Psilaster andromeda* Müller & Troschel, 1842.

### TABULAR CHECKLIST TO NEW ZEALAND SPECIES OF *PSILASTER*

	1	2	3	4	5
<i>Psilaster</i>					
<i>acuminatus</i>	0 (1-2)	2-4	s/g	5-7	3-4 rows of 2-3
<i>charcoti</i>	4	4	s/s	3-4	6 in a cluster

- 1 Superomarginal spines
- 2 Inferomarginal spines
- 3 Covering of marginals, edge/centres - spinelets  
g - granules
- 4 Adambulacral furrow spines
- 5 Subambulacral spines

### *Psilaster acuminatus* Sladen, 1889 (Pl. 28)

*Psilaster acuminatus* Sladen, 1889: 225, pls 40(1, 2), 42(7, 8); Studer 1889: 266; Farquhar 1898: 310; Bell 1905: 245; Benham, 1909: 6; H.L. Clark 1916: 32; 1923: 248; Mortensen 1925: 274; H.L. Clark 1926b: 3; Mortensen 1933: 219, 236; H.L. Clark 1946: 78, 471, 478, 494; Fell 1947: 21; 1949: 210; A.M. Clark 1952b: 194; Fell 1952: 6; 1958: 4; 1959: 131, pl. 1(13); 1962a: 22; 1962b: 15, fig. 8b; McKnight 1967: 298; Baker & Clark 1970: 4; H.E.S. Clark 1970: 3; Day *et al.* 1970: 4; A.M. Clark 1974: 434; McKnight 1975: 54; A.M. Clark & Courtman-Stock 1976: 55; Fenwick & Horning 1980: 438; A.M. Clark 1989: 289; A.M. Clark & Downey 1992: 76, pl. 22C, D; McKnight 1993b: 192; Rowe & Gates 1995: 51.

MATERIAL EXAMINED: A large number of specimens (1315) were examined in the course of this work. Of these, 741 specimens from 328 stations were from the NZOI collections, 542 specimens (122 localities) came from the NMNZ and a further 32 specimens (3 stations) were collected from the Cook Strait area by the U.S. research ship *Eltanin* in 1966. In the NZOI collections 167 specimens (from 83 stations) bear an asterisk (\*) — they were recorded but not present in the collections.

NZOI Stns: A843(1)\*, A900(1), B555(1), B556(2), B559(2), B638(1), B646(1), B669(1), B670(5), B673(5), B674(2), B675(1), B686(1), B687(2), C602(1), C605(1), C640(1), C694(1), C753(14), C930(1), D78(4), D92(1), D106(1), D170(1), D203(1), D211(2), D220(1)\*, D232(2), D233(1), D245(5), D868(1)\*, D895(1)\*, D899(4), D901(2)\*, E106(3)\*, E112(1)\*, E114(2), E120(1), E146(2)\*, E159(2)\*, E160(1), E162(1)\*, E164(1), E165(1)\*, E399(3), E403(3)\*, E405(1)\*, E406(3)\*, E415(4), E417(1)\*, E427(25), E433(1), E704(3), E710(1), E715(2), E738(1), E742(4), E753(1)\*, E757(2)\*, E772(1)\*, E775(2), E776(1), E780(3), E781(1), E782(1), E783(1)\*, E786(2), E806(14),

E811(1)\*, E812(1), E880(1)\*, E885(1), E888(1), E889(1), E901(1), F10(1)\*, F84(1)\*, F102(1), F103(1), F105(3), F107(1), F110(1), F113(1), F115(1)\*, F136(1)\*, F143(1), F752(1), F754(1), F757(2), F877(1), F887(1)\*, F898(1), F906(1)\*, F914(1), F915(2)\*, F916(4), G69(1), G155(1)\*, G156(2)\*, G157(3), G159(1), G163(1)\*, G174(1), G230(1)\*, G232B(1)\*, G292(1), G329(7)\*, G381(1), G388(1), G663(1), G666(1), G668(3), G699(2), G700(1), G820(1), G821(5), G822(2), G823(2), G824(2), G825(3)\*, G876(4), G879(1), G881(7)\*, G883(2), G895(2), G896(1)\*, G900(3), G904(1)\*, G905(1)\*, G906(4)\*, G907(2)\*, G908(2)\*, G914(1)\*, G917(7)\*, G918(3)\*, G919(2), G920(2), G928(2), G929(3)\*, G930(1)\*, G931(3)\*, G934(1)\*, G938(1)\*, H221(3), H912(1), H923(1), I6(46), I7(1)\*, I11(1)\*, I25(1), I31(3), I38(1), I60(9), I64(2), I65(3)\*, I345(2), I348(3), I355(2), I356(10), I359(2), I366(1)\*, I661(1), I663(1), I672(2), I680(1), I684(5), I685(2), I690(1), I707(1)\*, I712(2), I716(1), I721(2), J23(1)\*, J24(1), J25(1), J26(1)\*, J27(1), J30(2), J31(1)\*, J32(1), J33(1), J34(1), J539(1), J550(7)\*, K873(1), P61(1), P65(4), P66(2), P120(2), P122(1), P658(1), P662(1), P665(1), P927(1), P942(1)\*, Q2(1), Q3A(1), Q3B(2), Q11(1), Q12B(2), Q17(1), Q27(1)\*, Q33(2), Q37(1), Q40(1), Q69(2)\*, Q82(1), Q83(1)\*, Q84(1), Q136(1)\*, Q338(2), Q339(1), R435(1), S16(4), S22(1), S41(1), S42(3), S43(3), S52(2), S63(1), S66(1), S67(1), S81(1)\*, S102(1), S119(3), S120(5)\*, S121(6), S122(9)\*, S123(7)\*, S125(3), S126(1), S127(1), S138(1), S140(1), S142(1), S146(1)\*, S147(2), S148(1), S156(1), S167(1)\*, S170(1), S171(2)\*, S173(1), S174(1), S176(1), S199(1), S200(1), S364(2), S379(2), S380(5), S382(1), S383(1), S391(27), S393(2), S395(7), S398(1), S400(1), S889(1), T2(1)\*, T21(6), T22(1), T29(1)\*, T59(12)\*, T88(1), T489(1), T496(1), T577(2), U227(1), V369(1), V372(1)\*, V380(2)\*, V387(3)\*, V390(1), V393(1), V416(2), V417(1), V425(2), V426(2), V427(1), V429(1), W248(6), W251(1), W256(3), W260(1), W263(1), W265(1), W273(2), X143(1), X513(2), X521(1), X523(1), Z1921(1)\*, Z2363(1)\*, Z2364(2), Z2368(2), Z2369(4), Z2371(3), Z2372(1)\*, Z2373(1)\*, Z2374(1)\*, Z2377(2), Z8253(1), Z8259(2), Z8371(1), Z8492(5), Z8552(3), Z8553(2), Z8554(4), Z8555(1), Z8557(2), Z8558(5), Z8560(4), Z8561(4), Z8563(3), Z8566(5), Z8567(2), Z8570(1), Z8573(3), Z8574(1), Z8575(4), Z8576(1), Z8577(3), Z8578(2), Z8580(1), Z8838(1), Z8839(1), Z8840(1), Z8857(1).

NMNZ: Ahipara Bay: Ech. 1597(8), 4527(1); near Aldermen Islands: Ech. 4517(1), 6502(1); southwest of Auckland: Ech. 5660(1); Auckland Islands: Ech. 1253(1), 1254(1), 1255(1), 1495(1), 2013(2); Campbell Island and Campbell Island Rise: Ech. 2007(1), 2008(1), 2009(1), 4506(1); Canterbury Bight and Banks Peninsula: Ech. 2651(1); off Cape Campbell: Ech. 189(4), 570(6), 4525(3); near Castlepoint: Ech. 4538(5); Challenger Plateau: Ech. 3879(2), 4119(13), 4503(1), 4511(2), 4520(3), 4528(4), 4544(2), 5652(6), 5654(3), 5655(3), 6616(2); Chatham Islands: Ech. 6291(3); Chatham Rise and Mernoo Slope: Ech. 4183(2), 4185(2), 4186(2), 4498(6), 4523(1), 4534(2), 6636(1), 7410(5); near Christchurch: Ech. 7349(1); Clarence River: Ech. 4514(6); Cloudy Bay: Ech. 4518(10); Cook Strait: Ech. 5266(1); off East Cape: Ech. 1681(2), 3883(3), 3914(4); Cape Farewell and Farewell Spit: Ech. 1251(2); Great Barrier Island: Ech. 5235(1); off Greymouth: Ech. 1248(1); Hawke Bay: Ech. 6416(4), 6425(1), 6554(18), 6588(1), 7419(2); off Heaphy River: Ech. 4505(1), 4536(1), 5653(2); near Hicks Bay: Ech. 4504(2); Hokianga Harbour: Ech. 1250(17); Kahurangi Point: Ech. 4501(1), 4522(1), 4533(3), 5234(1); Kaikoura: Ech. 4524(44), 5662(4), 5663(1), 6566(1); near Mahia Peninsula: Ech. 1008(2), 4499(1), 6555(4); Marlborough Sounds: Ech. 6579(1); Ninety Mile Beach: Ech. 1249(3); near North Cape: Ech. 3885(1), 4512(4); off Oamaru: Ech. 762(2), 5237(5); Otago: Ech.

5265(4); Palliser Bay and Cape Palliser: Ech. 648(1), 871(2), 4305(9), 4495(6); Bay of Plenty: Ech. 190(1), 660(1), 661(3), 1565(28), 1578(3), 1586(22), 1588(7), 1589(2), 1590(1), 1591(4), 1592(2), 1593(2), 1594(10), 1595(9), 1596(85), 4307(1), 4500(2), 4517(1), 4519(1), 4537(2), 4545(6), 5236(9), 5656(2), 5657(2), 6498(2), 7362(11), 7411(2), 7421(5), 7427(4); Poor Knights Islands: Ech. 1678(9); Pukaki Rise: Ech. 2004(1), 2006(1); Solander Trough: 1252(1); Three Kings Islands: E5263(1); 5658(1); Turakirae Heads: Ech. 4542(1), 5661(5); off Waiau River: Ech. 4516(1); off Westland: Ech. 4546(1); off Westport: Ech. 4521(1), 4496(4).

*Eltanin* Stns: 1847(3), 1848(27), 1849(2).

SIZE: The average size for 100 of the present specimens chosen at random was  $R/r = 48/11$  mm. The largest specimen recorded is from NZOI Stn E901 west of Kawhia Harbour, with  $R/r = 121/24$  mm; it is from deep water, 1247 m. Another large specimen (NMNZ Ech. 1681) from off East Cape, with  $R/r = 103/22$  mm is also from deep water, 1518 m. One very small specimen, with  $R/r = 4/2$  mm, is known from the Chatham Rise area (NZOI Stn Q3B, 435 m); another small specimen, with  $R/r = 5/3$  mm (NZOI Stn I25) is from near the Poor Knights Islands in 675 m. Previously, the largest specimen recorded, with  $R = 100$  mm, was from the *Endeavour* collection (H.L. Clark 1916: 32) from southern Australia.

DISTRIBUTION: This species is very common in the New Zealand region. It is recorded from Lord Howe Island as a single, small ( $R/r = 29/5$  mm) clearly labelled, specimen from NZOI Stn Q82 ( $31^{\circ}31.70' S$ ,  $159^{\circ}02.80' E$ ). The depth recorded for this station is 0 m and, according to the station register, collections were by "scuba in N. Passage and snorkel under wharf". The species is also recorded from the North Cape area and there are two records (NMNZ Ech. 5263 (1) and Ech. 5658 (1)) from near the Three Kings Islands. There is no record of depth for Ech. 5263 (the specimen is quite large,  $R/r = 67/16$  mm) and the rather battered specimen Ech. 5658, with  $R/r$  approx.  $50/13$ , 14 mm, is from 985 to 1003 m. The species extends to the Chatham Islands in the East and the most southerly record is the Campbell Rise and Campbell Island area (NZOI Stn S43,  $53^{\circ}29.10' S$ ,  $170^{\circ}04.20' E$ , in 693 m). It is also known from the Snares, Bounty, Antipodes, and Auckland Islands. The species does not seem to have been collected from Foveaux Strait or Stewart Island and there are few records from the Taranaki area. *Psilaster acuminatus* is also known from southern (temperate) Australian waters and west and southwest of South Africa (A.M. Clark & Downey 1992: 76).

DEPTH: Most specimens were collected from between 200 and 600 m; it is less common in depths over 1000 m. There is one specimen from near the Auckland Islands,



(NZOI Stn S102) 2460–2519 m, the deepest record for the species. The specimen from Lord Howe Island (NZOI Stn Q82) comprises the shallowest record known. Two specimens are recorded from 31 m, one (NZOI Stn C930) from near Cape Farewell and the other from near the Auckland Islands (NZOI Stn D106). Two specimens (NZOI Stn S364) are from near Cape Foulwind in 30 m and also from the same area (NZOI Stn S383) is a specimen from 28 m. A further small specimen (NZOI Stn W265) from near the Chatham Rise is recorded from 1687 to 2039 m. The depth for *Psilaster acuminatus* given in the *Eltanin* Report (H.E.S. Clark 1970: 3), 1757 m, is incorrect; it should be 1737 m, based on Sladen's record of 950 fathoms.

**DESCRIPTION:** Specimen described, with R/r = 53/12 mm, is from NZOI Stn P658, northwest of Karamea Bight in 128 m.

*Arms* 5, *disc* more or less flat, slightly raised near arm bases and with a very slight depression centrally; *interbrachial arcs* rounded. Arms taper evenly to tip which is protected by an irregularly rectangular almost arched plate covered by more or less regular rows of granules similar to those of neighbouring marginal plates; no enlarged spines present.

*Abactinal paxillae* gently lobed with outlines more or less obscured by membrane. Along arm edges and interradially they form very regular, spaced, slanting rows; centrally on disc and arm, paxilliform plates are larger, much closer together and regularity of rows is lost. Each consists of a short trunk which expands into a round or slightly oval and gently raised head, this fringed by short, spaced, very finely thorny, untapering blunt-tipped spinelets. These surround 3–12 similar, conspicuous well-spaced spinelets; central spinelets often form a circle, with 1–3 centrally. Towards arm tips paxillae very much smaller and central spinelets either absent or only 1 or 2 are present.

*Papulae*, 5 or 6 around each plate, obvious between paxillae along arm edges and interradially on disc. Absent or very few and widely scattered centrally on arms and disc.

*Pedicellariae* not seen.

*Madreporite* conspicuous, interradial, more or less oval, nearer marginal plates than disc centre. It is separated from disc margin by 6–8 rows of paxillae; surrounding paxillae, especially those on upper side (nearest disc centre) are larger, often irregular in shape. Madreporite with high, narrow, sometimes branching ridges that converge; between ridges, in deep clefts, distinct and conspicuous round *pores* form regular rows.

*Anus* central on disc in a slight hollow, surrounded by rather densely packed, indistinct paxillae.

*Superomarginal plates* forming a very definite and distinct edge to disc and arms, only a very small part of the superomarginal plate present on abactinal surface. Plates slightly raised and well separated from each other laterally by deep fasciolar grooves; fine spinelets present along plate edges, elsewhere a cover of spaced, rather indeterminately rounded flattened granules. These may merge and touch one another or remain separate; they are most obvious on upper part of plate, near inferomarginals granules few and very scattered leaving plate surface almost bare, even polished. No enlarged superomarginal spines; superomarginal plates form almost the entire vertical depth of the arms.

*Inferomarginal plates* corresponding with superomarginals, visible from abactinal surface interradially and for a short distance along arms; at least three-quarters of each inferomarginal plate present actinally. Inferomarginals similar to superomarginals, with a central area on plate more or less bare of granules. Laterally, on both series of plates, elongate granules present, replaced by slender, blunt-tipped untapering spines which fringe plate edges. Enlarged inferomarginal spines 2, 3 even 4 to a plate, in a spaced, longitudinal row on the distal (arm tip) edge. Enlarged spines broad basally and long, slender, tapering to a sharp tip, somewhat flattened against plates and very regularly arranged. These spines present on plates almost to arm tips, distally shorter, single, and decidedly more squat. Distinct deep, narrow and very regular *fascioles* present between marginal plates lined by very slender, long blunt-tipped slightly flattened spinelets.

*Actinal areas* distinct, triangular, with plate outlines obscured by heavy membrane. Small, slightly tumid plates present in fairly regular rows from adambulacral plates to inferomarginals. These more or less rectangular and largest near inferomarginals; they bear 5–10 or 11 small, sturdy, round-headed short, spaced spinelets; occasionally 1 or 2 spinelets may be central; these sometimes rather flattened. Actinal plates, with outlines obscured by membrane, continue along arms mostly as a single series between adambulacral and inferomarginal plates for at least half, often three-quarters of arm length. Enlarged actinal spines present interradially on actinal plates; generally only 1 enlarged spine to a plate, these spines almost paddle-shaped, flattened, round tipped or tapering, bending towards inferomarginal plates.

*Adambulacral plates* forming a very regular edge to furrow with angular projection of plate over groove. 5–7 furrow spines present; these webbed basally and somewhat flattened — the most proximal on a plate have the narrow edge to furrow and plate, the most distal 1 or 2 spines have the broad edge to furrow and

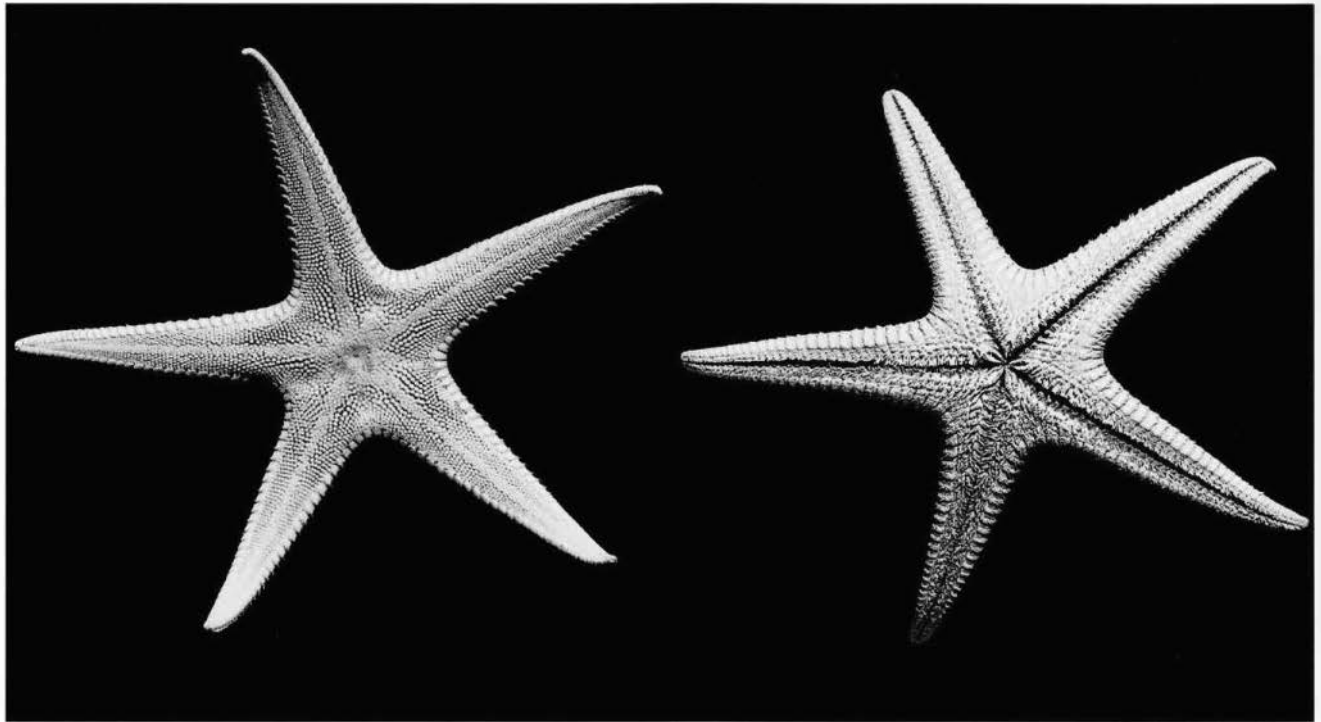


Plate 28. *Psilaster acuminatus* Sladen. NZOI Stn P658. R/r = 53/12 mm. Abactinal and actinal surfaces.

plate, this very distinctive. Towards arm tips furrow spines shorter. Subambulacral spines few, especially distally along arms where only 1 or 2 are present; proximally there may be 3, even 4 rows with 2 or 3 subambulacral spines in each. Subambulacral spines very similar to actinal spines — short, blunt-headed, untapering, spaced. The first adambulacral plate in a series, on either side of the oral plate, very distinct, long, very narrow, curved, conspicuously raised. It bears 2 marginal rows of finely thorny, rather flat, generally blunt-tipped distinctive spinelets.

*Oral plates* distinct, also raised, long, narrow; plates project well over and into mouth. Most proximal 4 oral spines, deep in mouth, long, somewhat flattened, round tipped. Oral plates edged by 14–16 small, very regular, rather squat sharp-tipped spines; at actinal end of plates these short spines or granules smaller and irregular in arrangement. Marginal spines flanked by an equally regular row of taller, short squat, round-tipped spinelets. The membranous area between plates is naked, smooth and widest near actinal plates.

*Ambulacral grooves* wide, deep with tubefeet in 2 regular rows; a distinct and clear-cut central passage between the 2 rows.

*Tubefeet* broad, squat, pointed, no suckers.

**COLOUR:** In preservative and when dried specimens are light brown, cream, or white with darker tubefeet. In life, the colour is variously recorded: in specimens

collected by the *Eltanin* (H.E.S. Clark 1970: 12) colour notes of living specimens from near Cook Strait are recorded as “Dark pink to orange-pink abactinally, regenerating arm tips white; marginal plates yellow pinkish white, actinal surface creamy yellow and tube feet delicate pink.” A colour record for NZOI Stn Z8573 is “Abactinally, uniformly orange, marginal plate and actinal surface, conspicuously white”. Fell (1959: 131) noted the colour of New Zealand specimens as “bright salmon”. A.M. Clark and Downey (1992: 76) recorded the colour of Atlantic specimens as “light pink” and the same is true for South African specimens (A.M. Clark & Courtman-Stock 1976: 55).

**REMARKS:** *Psilaster acuminatus* is one of New Zealand’s commonest and most interesting sea-stars. The type material is presumably from *Challenger* Stn 167 (Sladen 1889: 227), northwest of Port Hardy, 39°32’ S, 171°48’ E, in 150 fathoms (274 m). Port Hardy is at D’Urville Island, Nelson, South Island; the latitude and longitude given by Sladen are considerably further north, almost in the Challenger Plateau area.

Of the large number of 1315 specimens examined, only three, all from NZOI collections, had more or fewer arms than the five generally present. A specimen from south of Banks Peninsula in 100 m (NZOI Stn G879) has only 4 arms, 4 ambulacral grooves, and 4 sets of oral plates. Interestingly, in this 4-armed specimen, with R/r = 58/17 mm, there are often two



enlarged superomarginal spines, and these are continuous from the interradial angle to the arm tip; the specimen has short, broad arms. Two other specimens have 6 arms: one, from NZOI Stn J34 near the Challenger Plateau in 525 m, with  $R/r = 23/7$  mm, and the other NZOI Stn S391 from Karamea Bight area, off South Island in 133 m. In both these specimens there are six ambulacral grooves and six oral areas. These three unusual specimens do not appear to have been damaged in any way.

There are two distinct forms of *Psilaster acuminatus*: in one, the arms are long, slender, and rapidly and evenly tapering; in the second form the arms are short and broad basally and the animal is "thick" dorso-ventrally. It does not seem to be a geographical variation as short- and long-armed specimens are often found in the same area; and while, generally, short-armed specimens are smaller this is not always so. There is a possibility that these are male and female animals; in general, sexes in asteroids are separate although animals are identical but relatively little is known about this. Sectioning of the gonads and careful microscopical examination would settle the question; this has not been done.

In general, there is not much variation in the abactinal *paxillae*, although the number of central granules (very short spinelets) varies considerably; the short spinelets or granules are very finely thorny and this is particularly obvious in small specimens. However, a conspicuous feature of *Psilaster acuminatus* (both large and small specimens) is the very regular longitudinal, generally slanting rows of abactinal paxillae along arm edges and disc margins. On the centre of the arms and centrally on the disc, paxillae are close-packed and irregular; this is a characteristic and conspicuous feature.

The *madreporite*, its form, and its location are fairly constant; it is always interradial and lies near to but does not touch the inferomarginal plates. It is tumid with deep narrow striations and sometimes pores are visible at the bottom of the clefts. It is often yellow or brown and while surrounding paxillae are not particularly conspicuous, there is often one enlarged, generally rather rectangular paxilla present on the side nearest the disc centre. The madreporite is often difficult to distinguish in very small specimens where it is present as one or 2 raised bars amid the surrounding paxillae. An *epiproctal cone*, a distinct, localised appendage centrally on the disc, is often also seen in *Psilaster acuminatus*, particularly in small specimens (NZOI Stn Q33: 2 small specimens), although it is also sometimes present in larger ones. The function and significance of an *epiproctal cone* is somewhat obscure; it is also found in deep-water porcellanasterids and is often present in sea-stars from muddy areas.

*Marginal plates* are more variable; superomarginal plates are often restricted to the margins but in some specimens they intrude onto the abactinal surface and are obvious. Superomarginal plates often bear enlarged spines, generally absent interradially. Enlarged spines are often present on the 3rd or 4th plate from the interradius, sometimes on the 8th, even the 9th plate. The starting point for enlarged superomarginal spines is generally constant on all arms in any one specimen. It is unusual to have enlarged superomarginal spines on all the plates. It is interesting that the only 4-armed specimen (NZOI Stn G879), described earlier, has enlarged spines on all its superomarginals. Generally, enlarged superomarginal spines are single, sometimes erratically; two are present, lying one below the other. The enlarged spines are generally rather flattened, fast-tapering and flat against the plates; occasionally, they are very much longer and more rounded and stretch across the plate. Enlarged superomarginal spines are generally absent from near the arm tip, sometimes for almost the last quarter of the arm; they are also easily destroyed.

*Inferomarginal plates* also have a conspicuous row of enlarged spines; there may be 1, 2, or as many as 5 or 6. The number of enlarged spines seems to increase with size of the specimen; in very small specimens spines are often finely spinulose; in larger specimens they are smooth, flattened, tapering and lie flat against the plates. Generally, enlarged spines form a distinct row, one below the other, on the distal margins of the plate. The inferomarginal plates are generally more or less restricted to the actinal surface. Only a small part of the plate contributes to the margin and is visible from the abactinal surface. Marginal plates also bear small flattened generally rounded granules; these may form a close cover on the plates or plates may be almost naked, even somewhat "polished". Superomarginal plates are often almost free of granules centrally and this is very noticeable near the inferomarginals. Similarly, inferomarginal plates may lack granules and this is often most noticeable near the superomarginals. *Fascioles*, lined by fine, hair-like, blunt-tipped spinelets are present between the marginal plates in all specimens examined; they are easily lost, however, if the specimen is damaged.

*Actinal interradial areas* are very distinct, with the actinal plates regularly arranged and the plates carrying clumps of short spines; generally a single series of plates is present between adambulacrals and inferomarginals for at least half the arm length. Enlarged actinal spines may be present, often almost paddle-shaped, and most obvious near the inferomarginals. Enlarged actinal spines are generally absent in small specimens, with  $R$  less than 25 mm.

*Adambulacral plates* are generally distinctly angular

with a projection into the furrow; an exception to this is a specimen from NZOISn Q33 in which the adambulacral plates are more rounded than angular. The furrow spines, 6–8 or 4 and 5 in small specimens, form a good edge to the furrow; sometimes these spines are all more or less similar in size and shape, rather flattened, and round tipped with the narrow edge to the furrow. Occasionally, the 2nd and 3rd spines from either end of the plate are larger and more conspicuously flattened. The pointed tubefeet are always obvious, in two very distinct and regular rows clearly separated centrally.

*Oral plates* are conspicuous, long and slender, and generally rise above the neighbouring plates; the first adambulacral plate on either side is also long, narrow, often curved and very obvious.

Dissection of a number of specimens showed some interesting features. One of these is the obvious pores, which are present at the marginal end of the superambulacral plates, at the junction of supero- and inferomarginal plates. These *internal intermarginal pores* form a very regular longitudinal row along the arms, and do not seem to open to the exterior, i.e., they are "blind". Fisher (1919: 95) described similar pores in *Ctenopleura astropectinides* and remarked that such pores were also present in *Persephonaster* and (p.116) *Psilaster*. In *Psilaster acuminatus* these pores are present almost to the arm tips, but they are less obvious in the last quarter of the arm. Initially, the pores lie near the end of the superambulacral plates, i.e., where they meet the marginal plates, but nearer the arm tips pores lie almost between two superambulacral plates.

*Interradial septa* are membranous and distinct and there are also *partial septa* present at the base of the plates. These are obvious at the junction of supero- and inferomarginal plates, passing between the superambulacral ossicles and are present almost to the arm tips; these septa occur on the proximal (mouth) side of the superambulacral plates, are distinct but low, and do not seem to have been described previously. Stout, broad, bar-like *superambulacral plates* are obvious originating above the extended flange of the ambulacral ossicles, passing across and attached to supero- and inferomarginal plates. *Gonads* are interradial and attached to the abactinal plates, one on either side of the interradial septum, with no obvious opening. The arrangement of the *abactinal plates* from the coelomic side is distinctive. In some specimens a thick enveloping membrane is present which obscures the outlines, but in others, especially dry specimens, the arrangement of the plates is very obvious. Along the arm edges plates are more or less oval, sometimes almost rectangular, in very regular transverse and longitudinal rows of 4–6 plates. There are generally six *papulae* around these plates and many have a very slight

central prominence. In a central strip along the midline of the arms and on the disc centre, plates are closer together, irregular in shape, forming a very close mosaic; no papulae are present.

*Stomach contents* were recorded for a number of specimens dissected. *Psilaster acuminatus* individuals are voracious feeders, with molluscs apparently a major food. A list of molluscs is given in Appendix 2. Echinoids were also abundant, with spines and test particles recognisable as belonging to members of the order Spatangoida. In a specimen (NZOI Stn I672) from near the Bounty Islands there were remains of two ophiuroids, *Amphioplus* and *Ophiura* spp. Stomachs are often packed with fine sand or mud and forams are abundant; interestingly, forams do not show signs of disintegration and most are easily recognisable. One very tiny (unidentifiable) asteroid was also found and crustacean legs and pieces of test were also present. There were also fish scales, worm tubes (*Hyalinoecia tubicola*), sponge spicules, and tusk shells. In one specimen from the west coast of South Island (NZOI Stn E806) with R/r = 42/10 mm, there were 29 molluscs in the stomach, some crab or shrimp legs and several small stones; another smaller specimen from the same station had ten bivalve molluscs in its stomach.

Two specimens of *Psilaster florae* Verrill in the NMNZ (Ech. 5272) are part of the John Graham Collection from New York, collected by the *Albatross* in 1884. They are large specimens, R/r = 82/14 mm and 62/16 mm, with long, very slender, rapidly tapering arms. After careful comparison of these specimens with our many specimens of *Psilaster acuminatus* we decided that there were no major differences and that possibly *Psilaster florae* is conspecific with *Psilaster acuminatus*. A.M. Clark and Downey (1992: 75) included *florae* as a subspecies of *andromeda*. We have no specimens of *Psilaster andromeda* for comparison.

### *Psilaster charcoti* (Koehler)

(Fig. 27)

*Ripaster charcoti* Koehler, 1906: 4–6, pl. 3(20, 21, 31, 32); 1920: 258–259, pls 51(5), 52(1), 72(1).

*Psilaster charcoti*: Fisher 1940: 93; A.M. Clark 1962: 13; H.E.S. Clark 1963: 30, pl. 3(7–8); A.M. Clark 1989: 290; O'Hara 1998: 174, pl. 1a.

MATERIAL EXAMINED: Nil.

DISTRIBUTION: *Psilaster charcoti* has a circumpolar distribution and is known from South Georgia and Bouvet Island in 30–3248 m. It has recently been recorded from



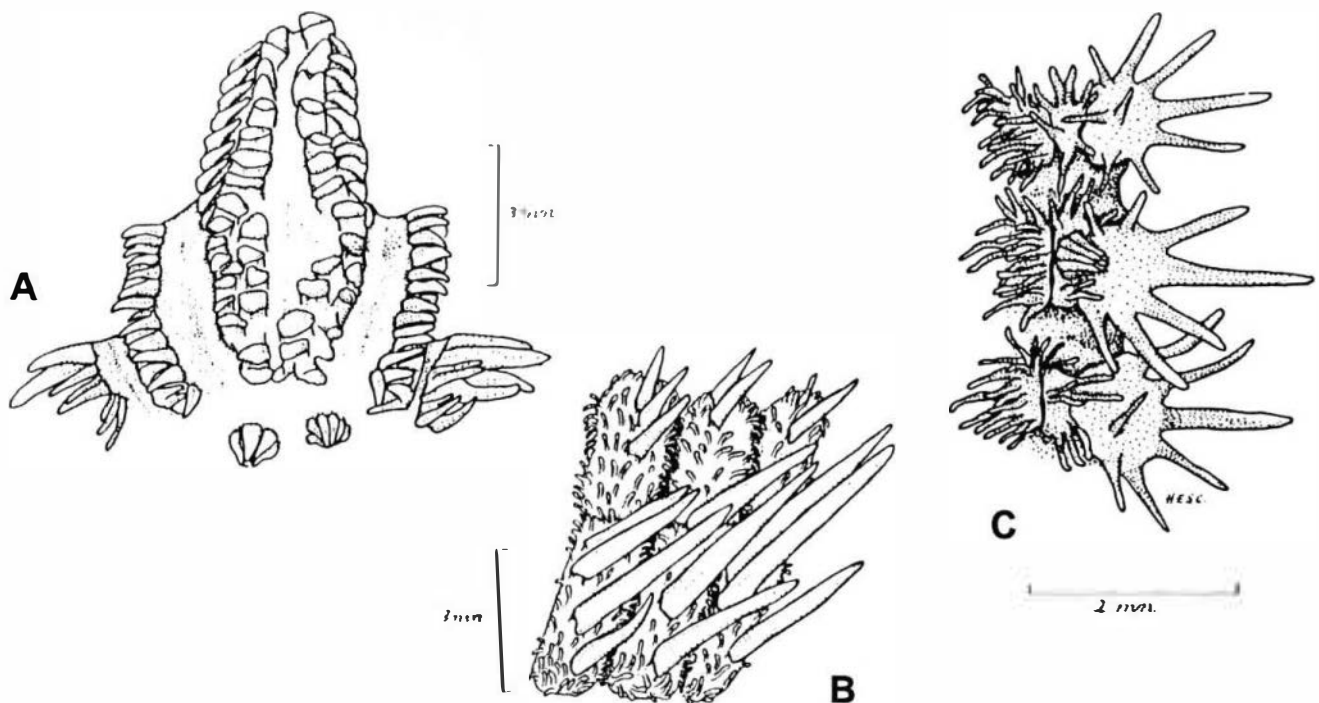


Fig. 27. *Psilaster charcoti* (Koehler). A. Oral plates and adjacent long, narrow adambulacral plates. Specimen from Stanford University Collection, Stn GLD-4. B. Superomarginal and inferomarginal plates. C. Adambulacral plates showing fan-like arrangement of furrow spines. B, C of specimen from NZOI Stn A448. Each drawing to scale shown. All images from H.E.S. Clark (1963).

Macquarie Island in 25–29 m (O'Hara 1998).

DESCRIPTION (from O'Hara 1998):

R/r = 50/11 mm. Arms 5, flat and evenly tapering, narrowly pointed.

*Abactinal plates* forming a close, uniform reticulum. Plates lobate, connected to adjacent plates by narrow bars, paxillate with a tall narrow pedicel, widened at tip; 4–9 short paxillar spinelets. Papular areas small, each with a single papula.

*Madreporite* exposed. *Epiproctal cone* present, *anus* central and inconspicuous.

*Marginal plates* conspicuous, more or less lateral in position, slightly protuberant, separated by fascioles, superomarginals slightly smaller, plates with a covering of small spinelets.

*Superomarginals* with up to 4 large flattened spines in a transverse series, extending to margin of succeeding plate. *Inferomarginals* with 4 larger spines, extending over 2 plates.

*Actinal plates* in 5 series on interradial area of disc, with only 1 extending to beyond three-quarters R. Plates small, convex, not in series with adambulacrals, each with 3–10 conical subequal spinelets.

*Adambulacral plates* with 3 or 4 long, angular and pointed furrow spines and up to 6 subambulacral spines, usually in a cluster.

*Oral plates* long, each with 2 rows of spines; 10–12 thick blunt furrow spines, the proximal 1 or 2 enlarged, and up to 6 in a suboral row.

*Ambulacral furrow* narrow, *tubefeet* lack suckers and are in 2 series.

COLOUR: Variable — reddish-brown, brown-yellow, sometimes pink on dorsal surface and centre of disc may be purple. Preserved specimens are usually light tan or fawn.

REMARKS: This specimen differs from those from the Ross Sea (H.E.S. Clark 1963) in having fewer spinelets on the abactinal paxillae and fewer furrow spines on the adambulacral plates.

*Tethyaster* Sladen, 1889

Disc generally moderate in size; arms 5, long, broad based, slender, tapering, interbrachial arcs rounded.

Abactinal paxillae lobed, plates forming regular rows and generally overlapping or meeting with one another, with a tall, slender pedicel (trunk). Papulae widespread, conspicuous on disc, continuing to arm tips and present interradially also. Madreporite interradial, sometimes hidden by paxillae, especially in small specimens. Marginal plates well developed, forming a very obvious edge to disc and arms; plate of similar size although superomarginals appear larger because inferomarginals extend onto lower surface. Marginal plates conspicuously and markedly "keeled" with deep fascioles between them; fasciolar spinelets slender, flat, blunt-tipped; fascioles continuing as shallow grooves between actinal and adambulacral plates. Superomarginal plates lacking enlarged spines, inferomarginals generally with a central vertical row of enlarged, rather flattened spines which lie against plates. Adambulacral plates with central furrow spine compressed, almost recurved, conspicuous; adambulacral plate margin angular. Actinal areas well defined, central part of actinal plates conspicuously raised, flat-topped, plates continuing between adambulacrals and inferomarginals for some distance into arms. Actinal areas with an unpaired row, or partial row of plates at base of oral plates. Pedicellariae sometimes present on actinal plates and sometimes also enlarged actinal spines.

TYPE SPECIES: *Asterias subinermis* Philippi, 1837

REMARKS: The genus is widespread; the specimen described here is from near Lord Howe Island, the most southerly known record.

Fossil species of *Tethyaster* are known. Hall and Moore (1990) reported a probable late Cretaceous *Tethyaster* from Alberta, Canada and a second species (Breton 1995) is recorded, also from Cretaceous deposits, from France. Breton (1995) discussed whether *Tethyaster* should be regarded as a "living fossil".

*Tethyaster tangaroae* Rowe, 1989 (Pl. 29, Fig. 28)

*Tethyaster tangaroae* Rowe, 1989: 268, figs 6A, B, 7A, B.

MATERIAL EXAMINED: NZOI Stn I729(1).

SIZE: In the holotype, R/r = 46.5/11.3 mm (Rowe 1989: 268); the two paratypes are smaller, with R/r = 34.6/9.2 mm and 10.3/4.2 mm, respectively.

TYPES: Holotype from NZOI Stn P35 is deposited in the collection of the Australian Museum, Sydney, AM-J2170. Two paratypes from NZOI Stn P27 are in the NIWA collection, registered number P-766.

TYPE LOCALITY: 28°57,90' S, 167°45,50' E, off Norfolk Island, 392-423 m.

DISTRIBUTION: The specimen described here is from north of Lord Howe Island. The holotype and paratypes are from near Norfolk Island.

DEPTH: 306-423 m.

DESCRIPTION: The single damaged specimen in the present collections, NZOI Stn I729, with R/r very approximately 45, 46/11 mm is described.

*Disc* large, puckered, irregularly folded, probably because of damage. *Arms*, all broken, quite broad basally, tapering rapidly and evenly, no terminal plates present.

*Abactinal paxillae* rather irregular in outline; lobed, with 4-6 lobes; plates in fairly regular marginal rows of 5-6 or 7 interradially and for a very short distance along arms. Centrally on disc and further out along arms, paxillae crowded, with no regular arrangement. Abactinal plates, on disc and first part of arms, with tall, slender, central trunk expanding into a large round or almost oval head fringed by up to 35 small, blunt-tipped, finely thorny spinelets. These enclose a number of well-spaced, thicker, round, very finely spinulose spinelets with generally well-rounded tips; spinelets adjacent to more slender marginal spines are well ordered and in quite conspicuous rows. Further along arms paxillar trunks very considerably shorter and the large, expanded, almost oval heads very obvious, especially along arm midline, almost forming a carinal series.

*Papulae* conspicuous, most obvious when paxillar spines are cleared, generally 6 around each plate; further out along arms, 4 or 5 papulae may be present.

*Madreporite* and *anus* not seen.

*Superomarginal plates* forming a precise edge to disc and arms; plates distinct, rectangular and of similar size to inferomarginals. Each plate with a well-raised, straight-sided, flat-topped keel, the plates well-separated laterally from each other by distinct deep, wide *fasciolar grooves*, these lined by slender rather flattened spinelets which do not meet with similar fasciolar spinelets from across the grooves; generally quite a sharp line of demarcation between fasciolar spinelets from opposite plates. Superomarginal plates bear, centrally, small finely spinulose short, untapering blunt-tipped, broad-headed, spinelets, not in rows; no enlarged spines seen, the rather short superomarginal spines often longer near inferomarginals.

*Inferomarginal plates* corresponding with superomarginals, with a distinct, conspicuous, raised flattened ridge and well separated laterally by continuations of deep fasciolar grooves. Interradially, and for a short



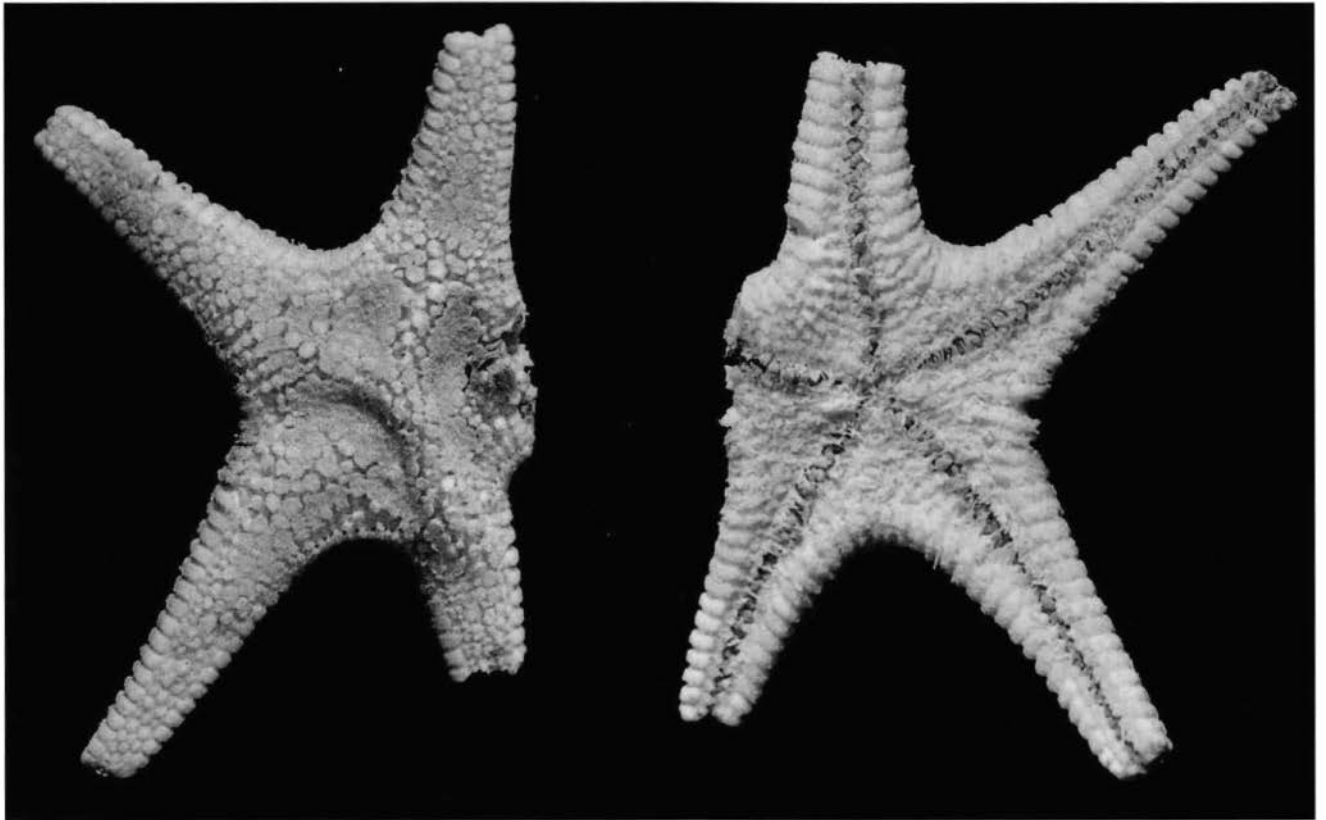


Plate 29. *Tethyaster tangaroae* Rowe. NZOI Stn I729. R/r very approximately 45, 46/11 mm. Abactinal and actinal surfaces.

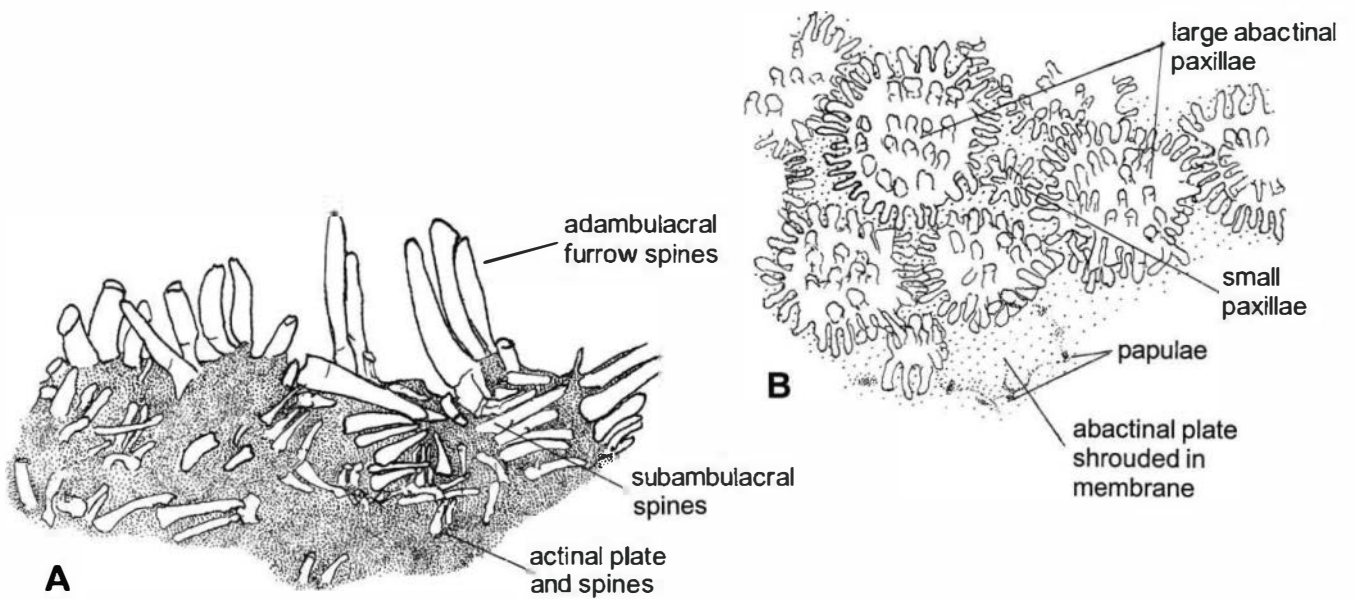


Fig. 28. *Tethyaster tangaroae* Rowe. NZOI Stn I729. **A.** Four adambulacral plates and spines, and adjacent actinals. Note the outline of the actinal plates is not distinct. **B.** Abactinal paxillae at base of arm. Note small paxillae between large ones, and papulae.

distance along arms, often 4 enlarged inferomarginal spines; the upper spine often overlaps superomarginal plates. These enlarged slightly flattened, gently tapering round-tipped spines set at a shallow angle across the plates. Further out along arms only 2 or 3, or just 1 enlarged spine.

An interesting feature is the presence, in both series of marginal plates, of a mosaic of very small, close-fitting, often angular, sometimes round or oval plates, each bearing a small, thick-based, finely spinulose round-tipped spinelet; these are presumably the "bumps" referred to by Rowe (1989: 271).

*Actinal areas* small, with a short, unpaired irregular row of plates at base of oral plates, extending to inferomarginals. Actinal plates extending between adambulacrals and inferomarginals to 15th or 16th adambulacral plate; beyond this adambulacrals and inferomarginals are in contact. Actinal plates with a distinct central swelling fringed by short spines that surround 1 to 2 or 3 longer, more conspicuous and slightly flattened spines; pedicellariae not seen, possibly because the specimen is damaged; no conspicuously enlarged spines present.

*Adambulacral plates* with an angular projection into furrow; 5, 6 occasionally 7, furrow spines present, generally the central spine longest and compressed, with narrow edge to furrow and plate; spines tending to project across furrows especially in last half of arm where they almost meet with spines from opposite plates. No definite pedicellariae seen on any plates, possibly because of damage. A number of more slender, shorter subambulacral spines present; smaller, spaced spines fringe the plates.

*Oral plates* with about 7 furrow spines; exact number and form of spines uncertain owing to specimen damage. The most anterior oral furrow spines large, crowded.

*Ambulacral grooves* deep, narrow; further out along arms angular extensions of adambulacral plates from opposite sides of the groove almost meet with spines touching.

*Tubefeet* large, pointed, in 2 rows.

**REMARKS:** The conspicuous crested flat-topped marginal plates are distinctive with deep and very well-defined fascioles. No pedicellariae apparent in the present specimen, agreeing with Rowe's (1989) description of the paratypes; in the present specimen lack of pedicellariae may be because of damage.

The specimen described (NZOI Stn I729) has damaged and broken arms, but the disc is entire, though lacking a madreporite. Rowe (1989: 268) recorded small spinelets on the madreporite of the holotype and stated (p. 270) that it is "almost hidden by the spinelets of adjacent tabulae". A.M. and A.H. Clark (1954: 6) in their

diagnosis of the genus recorded the madreporite as "large and bare", and A.M. Clark and Downey (1992: 82) noted that it is "bare" and "large" except in *T. subinermis* where it is "moderate" in size. The two paratypes of *T. tangaroae* were examined; both are well-preserved specimens, of which the larger has one intact arm and the smaller three complete arms. Again, no madreporite was seen in these two specimens.

No dissections were made of the present material so the distribution, arrangement, and extent of the gonads, the presence or absence of superambulacral plates, and other anatomical details are not known. In some species of *Tethyaster* the tubefeet are reported to contain small rods and bars, but nothing of this nature was seen in the present specimens.

*Tethyaster tangaroae* seems closest to *T. aulophora* (Fisher) from the Philippines. Perhaps the lack of pedicellariae in the present small specimens and the fact that the madreporite is apparently hidden might be attributed to age and size; in *T. aulophora* (the type and only specimen),  $R/r = 162/34$  mm.

#### Family **RADIASTERIDAE** Fisher, 1916

Mimasterinae : Pentagonasteridae Sladen, 1889: 331.

Mimasterinae : Archasteridae Perrier, 1894: 252.

Mimasteridae : Verrill, 1914: 282.

Goniasteridae : H.L. Clark, 1916: 33 (part).

Radiasteridae Fisher, 1916 : 4; 1919: 215; Mortensen 1927:

96; H.L. Clark 1946: 80; Spencer & Wright 1966: U64;

McKnight 1973b: 2; Blake 1987: 522; A.M. Clark &

Downey 1992: 88; Rowe & Gates 1995: 112; Blake & Reid

1998: 525.

#### *Radiaster* Perrier, 1881

Arms 5, generally broad basally and tapering, tips often recurved. Abactinal plates in very regular rows on either side of radial midline; plates with 4-6 lobes and a well-developed paxillar trunk with expanded head crowned by spinelets. Papulae widespread over entire abactinal surface, present between plate lobes. Marginal plates similar to abactinal paxillae, but with a larger head, each plate crowned with a tuft of spinelets. Actinal areas large with conspicuous rows of plates, these ridged or keeled and bearing a tuft or group of spinelets similar to those of abactinal and marginal paxillae, the plates separated by shallow, naked grooves, these continuations of grooves between the adambulacral plates. Oral plates longer than first adambulacrals; oral furrow and suboral spines similar to adambulacral spines. No pedicellariae. Madreporite large, generally concealed by paxillae, with an irregular, undulating edge, lying very near superomarginal



plates. Internally, interradial septa membranous, and superambulacral plates present but sometimes inconspicuous proximally. Gonads interradial, one on either side of the membranous interradial septum. Tubefeet biserial, with distinct suckers (an unusual feature for the Paxillosida).

TYPE SPECIES: *Radiaster elegans* Perrier, 1881

REMARKS: *Radiaster* (*Mimaster*) has changed families many times. *Gephyriaster* has also been included in the Radiasteridae but probably, as Blake (1987: 523) remarked, it is better in the Goniasteridae.

The family is certainly a strange and interesting one. There is probably no other family in which spines and spinelets (from abactinal, marginal, actinal, adambulacral, and oral plates) are so remarkably similar.

Recently Blake and Reid (1998: 525) described *Betelgeusia reidi* in the family Radiasteridae. It was found in Cretaceous deposits in Texas.

TABULAR CHECKLIST TO THE TWO NEW ZEALAND SPECIES OF *RADIASTER*

	1	2	3
<i>Radiaster</i>			
<i>gracilis</i>	l	f	r
<i>rowei</i>	s	r	u

- 1 Abactinal paxillae with
  - l - long, very slender penicillate spines
  - s - short, rather sturdy spines
- 2 Head of abactinal paxillae
  - f - regularly oval or round, rather flat
  - r - large, rather irregular, raised-convex
- 3 Adambulacral furrow spines
  - r - generally 3 long, slender, well-spaced, radiating spines
  - u - generally 2 short, close, upright, sturdy, finely spinulose spines

*Radiaster gracilis* (H.L. Clark, 1916) (Pl. 30, Fig. 29)

*Mimaster gracilis* H.L. Clark, 1916: 33, pl. 7, figs 1, 2; Koehler 1920: 242, pl. 49, figs 4, 18, pl. 75, fig. 5.

*Radiaster gracilis*: H.L. Clark 1946: 80; McKnight 1973b: 2; Rowe & Gates 1995: 112.

MATERIAL EXAMINED:

NZOI Stns: B685(1), E401(1), G159(1), G938(1), J34 (1),

Q342(1), Q343(3), S65(1), W265(1), Z9000(4), Z9193 (1), Z922 (1), Z9245(1).

NMNZ: Auckland Island Shelf: Ech. 2158(1); near Castlepoint: Ech. 6553(1); Challenger Plateau: Ech. 6618(1); Chatham Rise: Ech. 6471(3); off Point Gibson (near Kaitiaki): Ech. 2154(1), 2396(1), 5369(1); Mahia Peninsula: Ech. 6422(1); Milford Sound: Ech. 4515(3).

SIZE: R/r varies from 120/47 mm (NZOI Stn Z2922, western Bay of Plenty, 940 m), to R/r = 12/4 mm (NZOI Stn J34, Challenger Plateau, 525 m). Thirty-one specimens were examined, the average size for 21 of these was R/r = 63/19 mm.

DISTRIBUTION: Southeastern Australia and Tasmania; widespread around New Zealand (this report), especially the east coast from Bay of Plenty (NZOI Stn Z9222) to near Chatham and Auckland Islands (NMNZ Ech. 2158), and the west coast from the Challenger Plateau and near Milford and Doubtful Sounds, southwest South Island.

Depth: 27–2377 m. Koehler (1920: 242) recorded 1,300 fathoms (2377 m) for the specimen taken from near Maria Island, Tasmania.

DESCRIPTION: A specimen with R/r = 50/14 mm is described, NZOI Stn B685.

Disc flat; arms 5, broad proximally, tapering rapidly and evenly to sharp, recurved tips; arms flat along their length. Arm tips protected by small, slightly tumid terminal plates, these distinctly rounded at free tip and V-shaped adjacent to abactinal plates. Faint scars and several small slender spines suggest they were once covered with very fine spines similar to those of neighbouring abactinal paxillae.

Abactinal paxillae round, oval, faintly lobed, forming a close cover; each with a short, slender trunk or pedestal that expands to form a flat or sometimes gently convex top, this crowned by 8–10–12 very slender, almost hyaline, tapering, sometimes rather flattened, spaced spinelets. These enclose 1–4 or 5 similar, perhaps slightly longer and very well-spaced central spinelets. Sometimes paxillae completely closed, forming a tight upright tuft — it is often difficult with these paxillae to determine the number of spines involved. Interradially, marginally, and centrally along arms abactinal plates particularly well calcified and plate outlines often difficult to determine.

Papulae 3 or 4, between plates, often in small triangular membranous areas, widespread on disc and arms, fewer perhaps along arm midline where plates tend to be more heavily calcified.

No pedicellariae seen.

Madreporite large, interradial, more or less round,

lying very near marginal plates; it is partly obscured by a number of conspicuous paxillae which grow through it and spread out. Madreporite is finely and evenly dissected and slightly raised; the crowning paxillae slightly larger than surrounding paxillae.

A small, membranous pore centrally on disc, probably the anus.

*Superomarginal plates* with a short, thick, trunk that expands into an oval head, this crowned by a number of slender spinelets similar to those of abactinal plates; the long line of the head of these plates at right angles to the abactinal surface; superomarginal plates, when bare of spinelets, forming an extremely regular edge to disc and arms.

*Inferomarginal plates* generally directly below superomarginals and slightly larger, longer, ridge-like and more prominent; with fine spinelets similar to those of superomarginals and abactinal plates. Occasionally, inferomarginal plates tend to alternate with superomarginals interradially, but along arms pairing is more regular.

*Actinal areas* distinct, large, very regular; plate outlines indistinct but plates form very regular longitudinal rows of raised ridges, best appreciated when plates are cleared of spines. Generally, 1 actinal plate corresponds to 1 adambulacral; with distinct, naked longitudinal tracts between rows of actinal plates. Actinal plates distinctly ridged, each ridge crowned by fine, slender, hyaline spinelets similar to those of abactinal plates but perhaps longer and slightly thicker — these spinelets lying along plates and directed towards inferomarginals, giving the actinal areas an almost hair-like appearance. No enlarged spines or pedicellariae.

*Adambulacral plates* very regular, rectangular with short edge to furrow and actinal plates; plates well separated laterally by distinct, corresponding membranous areas with clear channels between. Free edges of adambulacral plates rounded, protruding slightly into furrow. *Adambulacral furrow spines* generally 3 near oral plates, occasionally 4 well-spaced spines present further out along arms. These of similar size, long, slender, round-tipped and similar to spinelets already described; where 3 are present the central spine is sometimes slightly longer; these spines sometimes meet, or almost meet, with opposite spines from across furrow. Subambulacral spines in 3 or 4 rather ill-defined crowded rows; spines similar to furrow spines, those adjacent to actinal plates sometimes rather shorter. Adambulacral plates well separated from actinal plates by a clear membranous area or tract.

*Oral plates* large, raised, almost crescent-shaped, well separated medially by an obvious membranous area. *Oral furrow spines* similar to other spines, slender, round-tipped, almost untapering; spines nearest first

adambulacral plates quite short, well spaced. Oral plates well separated from first adambulacral plates by distinct deep membranous areas.

*Ambulacral grooves* well defined, conspicuous, deep, with 2 rows of rather crowded tubefeet.

*Tubefeet* with a small, distinct sucker.

**COLOUR:** Colour in three living specimens (NMNZ Ech. 4515) from the north side of Milford Sound, South Island, in 34 m (the shallowest recorded depth for this species is 27 m, also from Fiordland) collected by M.S. Leighton in March 1986, is recorded as "brilliant orange". Dried specimens are white or cream, shading to very light brown; tubefeet and papulae are distinctly brown.

**REMARKS:** One specimen from Bay of Plenty (NZOI Z9000, R/r = 83/17 mm) has four arms; a large more or less membranous "patch" between two arms, with irregularities in the marginal plates, that may be a scar of the fifth arm. All other specimens have five arms.

One of the most interesting and striking features in the present collection is the presence of very long slender arms in some specimens while others (NZOI Stn S65) have a very large and generally flat disc, very wide arm bases and relatively short (almost triangular) and rapidly tapering arms. The difference is very noticeable. In the large specimen (NZOI Stn S65, R/r = approx. 100/40 mm) the madreporite is large, oval, and slightly raised and lies close to the inferomarginal plates. The slender radiating spines of surface paxillae almost conceal it. In slender rayed forms, the madreporite is also large, oval, and slightly raised and lies close to the inferomarginal plates. Paxillae likewise occur on it and their radiating spines almost conceal it; the paxillae growing across the madreporite are perhaps fewer in these slender-rayed specimens. A.M. Clark and Downey (1992: 90) separated northern hemisphere *R. elegans* Perrier and *R. tizardi* (Sladen) on the basis of arm length and madreporite size; *R. elegans* has "relatively long" arms and a "small" madreporite; *R. tizardi* has arms of "moderate length" and a "large" madreporite. Photographs of these two northern species (A.M. Clark & Downey 1992: pl. 25A–D) do not illustrate great differences in R/r ratios. Our southern hemisphere specimens show a very much greater variation in body form. Arms are either very long and slender or they are short, almost triangular, and with very broad bases. In other respects our southern specimens are similar, and we believe they belong to one species, *R. gracilis* (H.L. Clark).

In several smaller specimens in the present collection there is a curious arrangement of abactinal plates which may be a result of preservation. H.L. Clark (1916: 33) possibly referred to this when he remarked



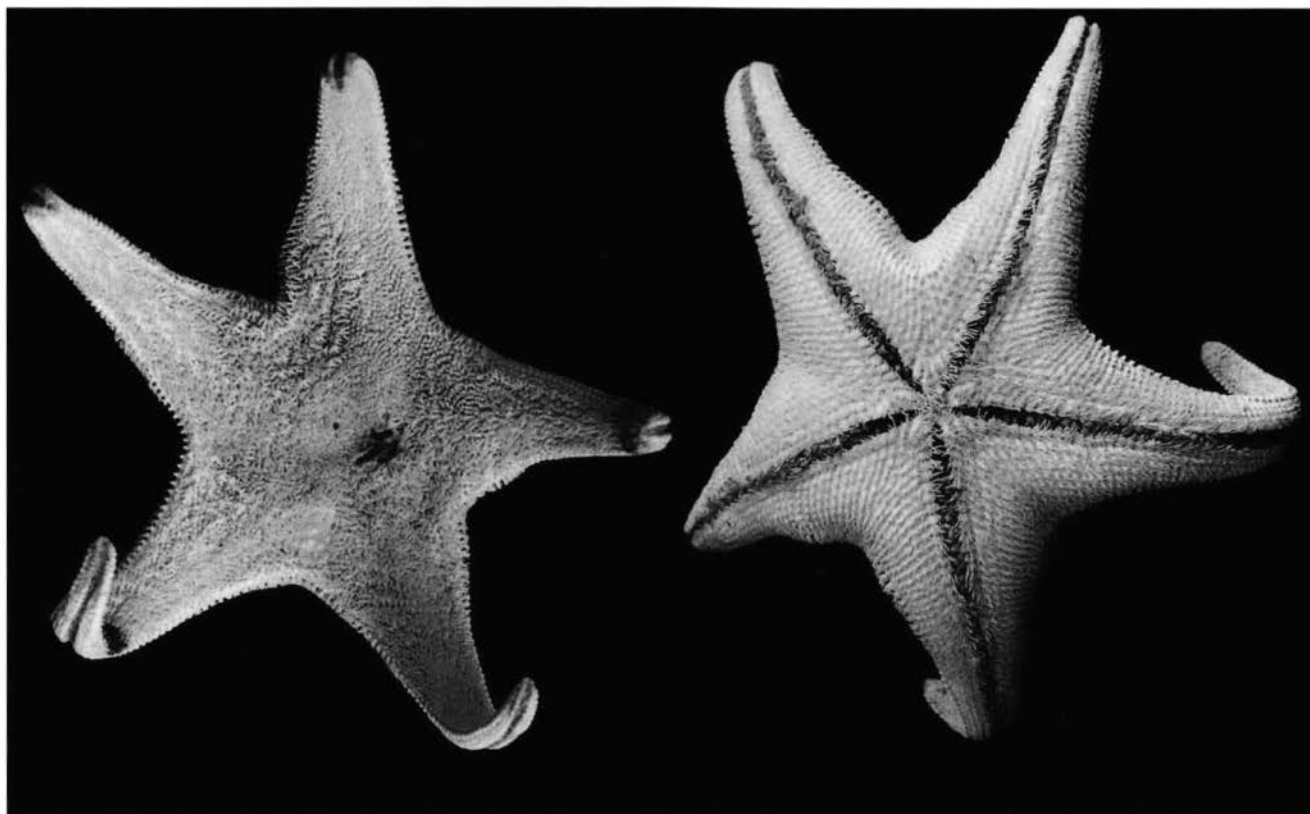


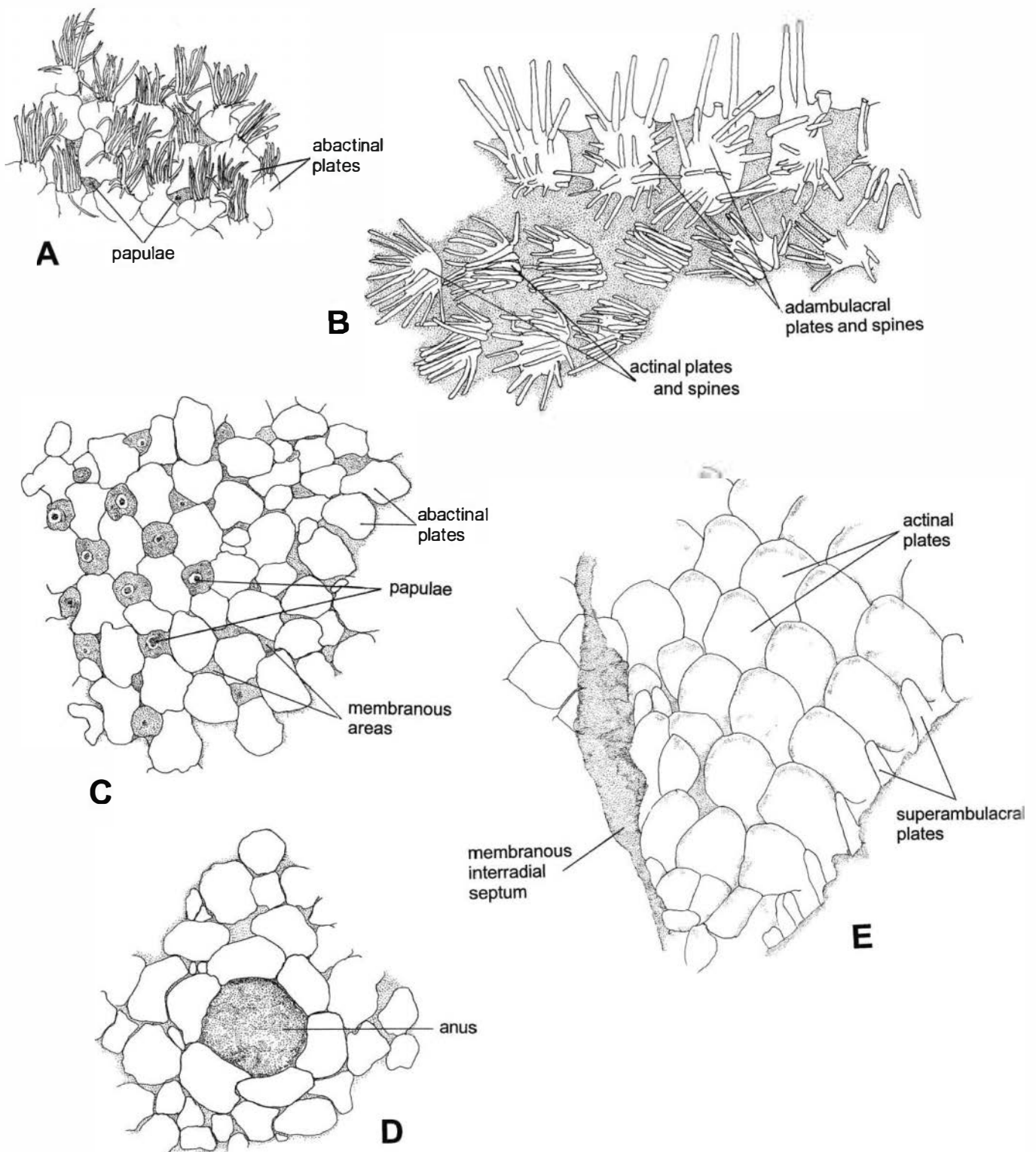
Plate 30. *Radiaster gracilis* (H.L. Clark). NZOI Stn B685. R/r = 50/14 mm. Abactinal and actinal surfaces.

that the appearance of preserved specimens, abactinally, depends on whether spinelets were drawn together into a bundle when the starfish died. In a specimen from the Challenger Plateau, R/r = 12/5 mm (NZOI Stn J34), there are definite aggregations of plates and paxillae; these groups are round, oval, rectangular, almost square or irregular in shape. They consist of 15–30 or more abactinal plates, each with its paxillar spines and trunks intact with the spines leaning towards, and converging at, the centre of the group and the whole mass forming a very definite shape and area. These distinct areas of leaning paxillae are just obvious without magnification, almost forming a patchwork or mosaic; the arrangement is less obvious along the arms. In a larger specimen from the Chatham Rise area (NZOI Stn Q342), there is also a patchwork-like arrangement of plates abactinally. In another small specimen R/r = 14/9 mm from near Dunedin (NZOI Stn E401) abactinal paxillae are small, spaced, and uniform in distribution, with no suggestion of aggregation of paxillae.

One specimen (NZOI Stn G159, R/r 63/20 mm) was dissected: the arrangement of the abactinal plates, seen from the coelomic side is interesting; plates are irregular in shape, size, and distribution, often lobed,

sometimes overlapping and with large membranous spaces and papulae between them. Interradially and along arm edges plates form quite regular rows, whereas centrally on disc and further out along arms, plates are irregularly arranged and form a very close network; papulae are few or absent centrally. There is a conspicuous ring of six crescent-shaped, distinct, strongly calcified and slightly raised plates surrounding the central anus. Ampullae of tube feet are double and the ambulacral plates form a high and regular ridge along the arms. Small, narrow, bar-like super-ambulacral plates are present, meeting with the central lobe of the ambulacral plates, but not very obvious proximally. Ambulacral plates are separated from each other by a very regular membranous rectangular area. A distinct interradiol membrane septum is present and gonads, single, large and branching, are interradiol on either side of the septum. Seen from the coelomic side, actinal plates form extremely regular, well-ordered and close rows. The stone canal is formed of small, tight-fitting rectangular plates. Stomach contents included fine sand and numerous benthic foraminiferans.

A specimen (NZOI Stn S65, R/r = 100/40 mm) with very broad arms basally was also dissected. The anatomy is essentially similar to the slender-armed



**Fig. 29. *Radiaster gracilis*** (H.L. Clark). NZOI Stn B685. **A.** Abactinal plates, paxillae, and papulae, near entrance to arms. **B.** Adambulacral and actinal plates. **C–E,** dissected specimen, NZOI Stn G159. **C.** Arrangement of abactinal plates (seen from coelomic side) near centre of arm showing papulae, spaced plates, and membranous areas. **D.** Anus with surrounding plates, from coelomic side. Note very regular ring of plates around anus. **E.** Interradial area (after dissection) showing arrangement of actinal and superambulacral plates and interradial membranous septum.



specimen already described. The superambulacral plates in this larger specimen are sturdy, rod-like, and just visible without magnification; gonads are large and single, on either side of the membranous interradial septum, and extend to the arm base. In another large broad-armed specimen (Stn Z9193 from the Campbell Plateau) with  $R/r = 94, 95/39$ , 40 mm (the specimen is unfortunately damaged), dissection showed very large and well-developed pink-orange gonads — a diffusely branched mass of small, rounded, blunt or tapering tubes, one on either side of the interradial septum attached to a single, thick, conspicuous white trunk anchored to the abactinal plates. Careful examination failed to find a definite opening between abactinal plates.

Is it possible that slender-armed specimens of *Radiaster* are one sex, males perhaps, and that large, broad-armed specimens are females? Could this also account for differences in body form between the two very closely allied European species? This could be settled by fine sectioning and microscopical examination of prepared and stained slides; unfortunately such techniques are not available to us.

This large specimen (NZOI Stn Z9193) had small, hard, oval structures in its stomach, identified as compound ascidians, *Didemnum* sp. We are grateful to Dr C.N. Battershill, formerly of NIWA, for identification.

*Radiaster rowei* n.sp. (Pl. 31, Fig. 30)

MATERIAL EXAMINED:

NMNZ: Northern Mernoo Slope: Ech. 5368(1).

SIZE:  $R/r = 63, 64/24$  mm (measurements are difficult as specimen is dry with recurved arm tips).

DISTRIBUTION: Known only from the type locality, the northern Mernoo Slope, BS648,  $42^{\circ}29.2' S$ ,  $176^{\circ}03.6' E$ , mud and boulders.

DEPTH: 1568 m.

DESCRIPTION: The holotype, the only specimen, is described,  $R/r = 63, 64/24$  mm.

*Disc* large, mostly flat, except at base of one arm where disc and first part of arm are distinctly swollen. *Arms* 5, short, broad basally and tapering rapidly to pointed recurved tips. Interradial angles more or less angular. Last 10–12 mm of arm recurved, *terminal plate* difficult to see but it is short and indented on free upper edge and near abactinal plates; faint scars suggest rows of small, fine spines may have been present.

*Paxilliform abactinal plates* in very regular longitudinal, slightly curving rows from disc edge to near disc centre, with 13 or 14 plates in a row; conspicuous rows of plates also present further out along arms; along arm midline plates are irregular in arrangement. Abactinal plates lobed basally, with a slender and quite tall trunk expanding to form a round or oval, often quite inflated and convex head with a number of small, spaced spinelets; generally also a fringe of distinct, well-separated longer, more slender marginal spines, these tapering very gradually, the tip sometimes sharp; occasionally, these spinelets serrate in their last quarter; centrally on paxillar head spinelets form quite regular spaced rows, the spinelets here generally shorter, perhaps with a more thorny tip, easily damaged.

*Papulae* quite conspicuous between lobes of abactinal plates, generally 3–5 around each plate. *Papulae* widespread on disc, extending to arm edges.

No *pedicellariae* seen.

*Madreporite* large, interradial, raised, finely dissected, distinctly lobed; paxillae grow through it, of similar size or slightly larger) than neighbouring paxillae. *Madreporite* lies nearer to superomarginal plates than disc centre.

Centrally on disc a small clear membranous area just visible between paxillae, probably the *anus*.

*Superomarginal plates* most obvious interradially, smaller, less obvious in last quarter of arms. Paxillar trunk distinct, thick, sturdy, taller than that of surrounding paxillae whose crowning spinelets are short, numerous, dense, finely serrated near tip, and essentially similar to spinelets of abactinal paxillae; they form a very close cover. Heads of superomarginal paxillae distinctly and regularly oval and convex.

*Inferomarginal plates* projecting slightly out and beyond superomarginals, this particularly obvious interradially, the cover of spinelets very dense and spinelets similar to those of superomarginals; infero- and superomarginal plates corresponding with one another for most of arm length; the arrangement particularly obvious interradially.

*Actinal areas* large, plates forming very regular and distinct rows almost to arm tips. Generally, 1 row of actinal plates corresponds to 1 inferomarginal and 1 adambulacral plate. Actinal plates with distinct ridges or knobs, these with a cluster of close spinelets similar to those of marginal and abactinal plates. Actinal plates well separated laterally by distinct, naked membranous channels continuous between adambulacrals and inferomarginals; these well defined.

*Adambulacral plates* distinct, well separated laterally by clear, deep, membranous channels; plates narrowly rectangular and distinctly raised. Generally 2 sturdier adambulacral furrow spines, sometimes 3, these slightly tapering especially proximally, round-tipped,

very finely spinulose along their length and often broken. Subambulacral spines shorter, quite crowded, in 5 or 6 rows; near actinal plates, subambulacral spines sometimes splayed out, extending over the membranous channels; generally, however, spines are upright and form a close cover on plates.

*Oral plates* large, protruding, crescent-shaped, meeting briefly proximally and distally, a distinct membranous area between. Nine or 10 oral furrow spines, these largest and most obvious overhanging mouth, very slightly flattened but similar to other spines. At least 2 or 3 rows of suboral spines, mostly broken, with stumps remaining, shorter than furrow spines; oral plates separated from neighbouring adambulacral plates by very deep, wide, distinct membranous area.

*Ambulacral grooves* deep, wide medially, narrow near oral plates and distally near arm tips.

*Tubefeet* biserial, in 2 very regular well-separated rows; tubefeet with a distinct *terminal sucker*.

**COLOUR:** There is no colour recorded of the living sea-star. Dried, the specimen is fawn, white, and pale yellow with tubefeet dull brown.

**ETYMOLOGY:** We have pleasure in naming this new species for Dr F.W.E. Rowe, who has worked on South Pacific echinoderms.

**REMARKS:** This second New Zealand species is very different from *Radiaster gracilis*, as the key shows. The rather short, sturdy abactinal and other paxillar spines and the narrow, elongate adambulacral plates, generally with only two furrow spines, are distinctive.

Fisher (1913: 624) recorded a new species of *Mimaster*, *M. notabilis*, from the Molucca Islands in 1041 m. In 1919 (p. 217) he recorded it as *Radiaster notabilis* and described it in more detail. In some respects, *R. notabilis* is similar to the present specimen as it has generally two (sometimes three) adambulacral furrow spines. However, *R. notabilis* has more slender and considerably longer arms and no recurved tips. How important body form is — long or short arms, large or small disc — seems debatable, as A.M. Clark and Downey (1992), and results of examination of the present material, show.

The single specimen was not dissected.

## Family PORCELLANASTERIDAE Sladen, 1883

Arms 5; marginal plates large, thin, porcellanous. Unique cribriform organs (1 to many) present along arm margins. A deep-water family known from 875 m (*Porcellanaster ceruleus* — this report) to over 8,000 m.

Cribriform organs were first mentioned by Thomson (1877: 379) in his description of *Porcellanaster ceruleus*, calling them ornaments and “little brushes”. These organs (respiratory in function and probably also used as a sieving device) consist of a series of very thin vertical plates (often, aptly, likened to leaves of a book), or they may consist of vertical rows of fine papillae, supported by calcareous deposits. These organs occupy shallow depressions between marginal plates, extending from the abactinal to the actinal surfaces when fully developed. They are bordered by larger more conspicuous plates.

Rowe and Gates (1995) recorded only one porcellanasterid, *Porcellanaster ceruleus*, from Australian waters. In New Zealand seas the family is represented by five genera and seven species.

### TABULAR KEY TO NEW ZEALAND GENERA OF THE PORCELLANASTERIDAE

- 1 Abactinal plates with:
  - p - distinct paxillae
  - s - isolated spines
  - g - granules
- 2 Superomarginal plates
  - j - join in midline of arms
  - a - apart, separate to arm tip
- 3 Superomarginal plates
  - c - bear conspicuous spines
  - w - are without spines
- 4 Number of cribriform organs
- 5 Cribriform organs are
  - l - lamelliform
  - p - papilliform
- 6 Oral plates in an angle
  - w - with an anterior spine
  - s - share an anterior spine
- 7 Actinal surface
  - p - paved with plates
  - n - naked, membrane covered

	1	2	3	4	5	6	7
<i>Dannaster</i> H.E.S. Clark & McKnight	g(s)	a	w	1	p	s	n (p)
<i>Eremicaster</i> Fisher	s	a	w	3	l	s	p
<i>Hyphalaster</i> Sladen	p	p	w	8, 9	p	w	p
<i>Porcellanaster</i> Wyville Thomson	s	a	c	1	l	s	p
<i>Styracaster</i> Sladen	p(s)	j	c	3–11	l, (p)	w	p



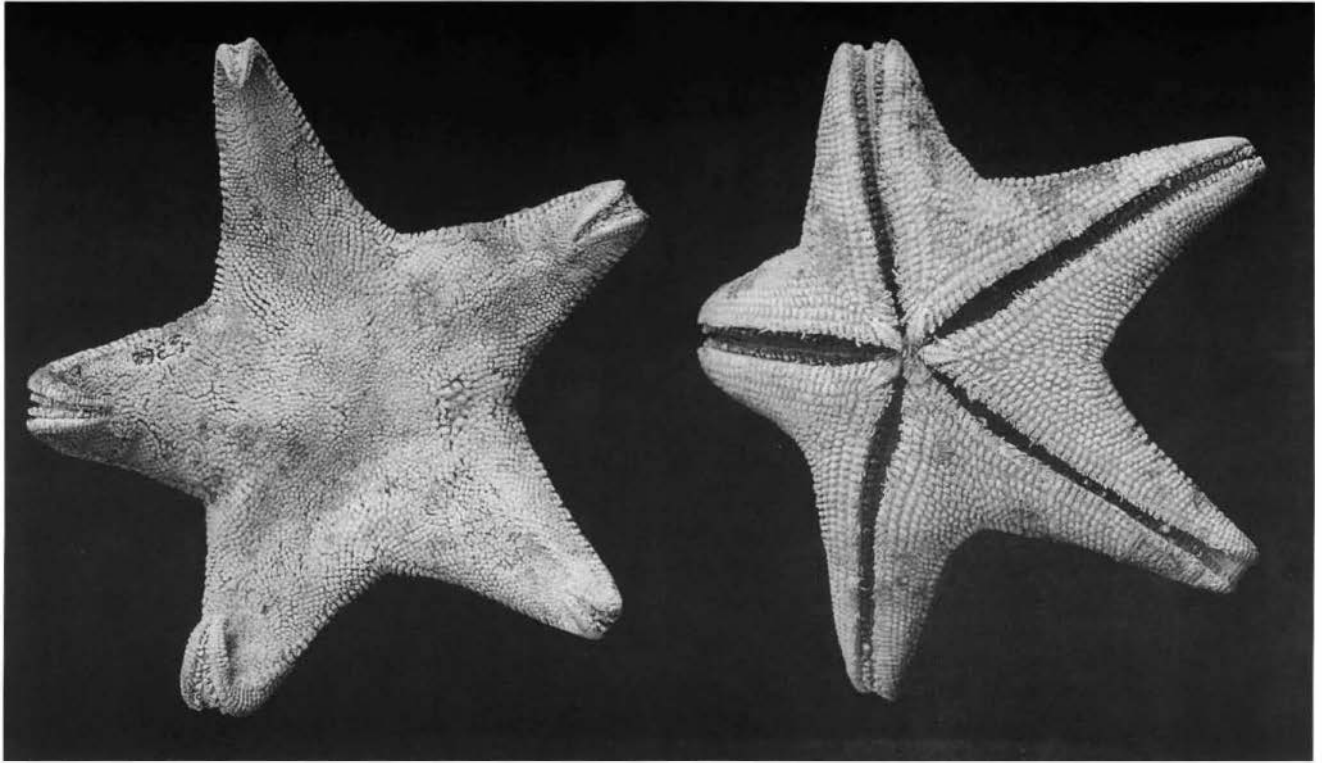


Plate 31. *Radiaster rowei* n.sp. Holotype. NMNZ Ech. 5368. R/r = approx. 63, 64/24 mm. Abactinal and actinal surfaces.

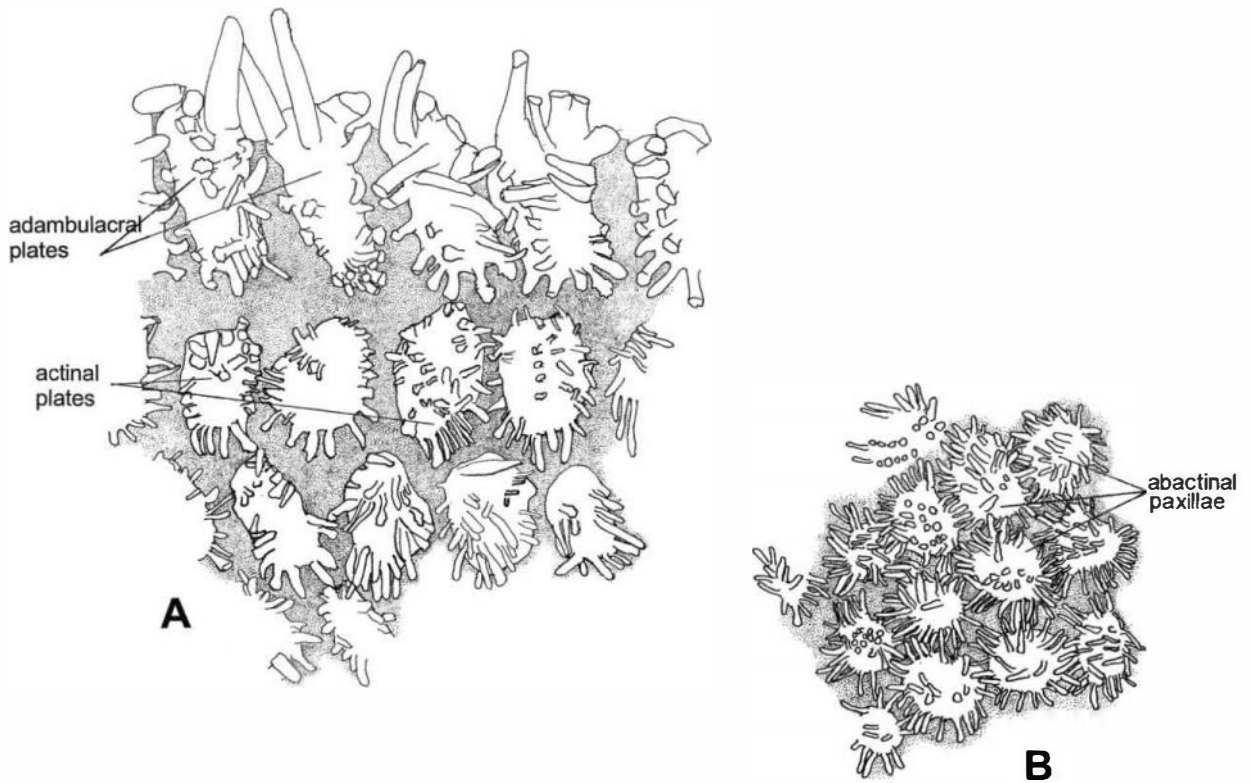


Fig. 30. *Radiaster rowei* n.sp. Holotype. NMNZ Ech. 5368. A. Adambulacral and adjacent actinal plates. B. Abactinal paxillae, from near madreporite. Note papulae are indistinct and not shown.

*Damnaster* H.E.S. Clark & McKnight, 1994

Cribriform organs single, narrow. Actinal interradial areas membrane-covered, sometimes with 1–5 small, round, isolated plates not forming a close paving. Adambulacral furrow spines broad, flattened, leaf-like, tapering to a sharp tip, occupying almost entire free margin of plate. Superomarginal plates forming most of margin; inferomarginal plates small, inconspicuous, narrow, generally alternating with superomarginals and confined almost entirely to actinal surface; inferomarginal plates not reaching terminal plate. Superomarginal and inferomarginal plates lacking spines.

TYPE SPECIES: *Damnaster tasmani* H.E.S. Clark & McKnight, 1994.

REMARKS: In his very comprehensive treatise, Madsen (1961) discussed the many variations in the genus *Porcellanaster*. Originally, the specimens included in *Damnaster* were considered to be aberrant forms of *Porcellanaster*, but careful examination showed that they all possessed the same combination of characters. Some other species attributed to *Porcellanaster ceruleus* had similar features, suggesting they also should be included in *Damnaster*.

*Damnaster tasmani* H.E.S. Clark & McKnight, 1994  
(Pl. 32, Fig. 31)

*Porcellanaster eremicus* Sladen, 1889 (part): 145, 1 fig.

*Porcellanaster caeruleus*: [non *P. ceruleus* Thomson, 1877] Madsen, 1961 (part): 142, fig. 24 l-s; Bernasconi 1967: 443, pl. 1, figs 3-6; H.E.S. Clark 1970 (part): 14, pl. 1(c-f).

*Damnaster tasmani* H.E.S. Clark & McKnight, 1994: 1367, figs 1-4.

MATERIAL EXAMINED:

NZOI Stns: U204 (4), U205 (1).

*Eltanin* Stns 1837 (2), 1844 (1), 1846 (1).

SIZE: R = 9–4 mm, r = 4–2 mm, R/r averages = 7/3 mm.

DISTRIBUTION: West of New Zealand between 35° and 46° S, and 156–167° E; in the South Atlantic (*Challenger* Stn 137, between Tristan da Cunha and Cape of Good Hope), and off Chile, South America.

DEPTH: 1647–4868 m.

DESCRIPTION: Description is of the holotype (from NZOI Stn U204, 35°29.70' S, 157°28.00' E, deposited in the NIWA collection, Wellington, holotype H-616).

*Disc* inflated radially, unevenly depressed centrally.

*Arms* short, not markedly tapering; *terminal plate* large, conspicuous, more or less oblong, longer than wide, with 3 large spines which form a triangle. Spines opaque basally then hyaline, coarsely serrated, gently-tapering, blunt-tipped. Both terminal and marginal plates roughened by tiny granules or spines.

*Abactinal plates* conspicuous, oval to round or slightly angular, plates most obvious centrally, absent from middle of arms to arm tips. This area covered by a white membrane. Large disc plates paved with small round or irregular hyaline granules, arranged in more or less concentric circles. Interradially small, round, isolated plates present; some swollen or convex plates with a single, short, tapering hyaline spine; these especially obvious near madreporite and in other interradii, near cribriform organs. Elsewhere on disc occasional small scattered plates present, each with a single, pointed spine. Pedicellariae, papulae, and gonadial papillae absent.

Centrally on disc a slender *epiproctal cone* (apical appendage) paved by numerous rough-textured plates.

*Madreporite* coarsely dissected, interradial, immediately adjacent to cribriform organ from which it is scarcely distinguishable.

*Disc* bordered by gently raised edges of superomarginal plates; 3 superomarginal plates on either side of cribriform organ.

*Superomarginal plates* very large, occupying almost entire depth of margin; no superomarginal spines; superomarginals not meeting in midline of arms.

*Inferomarginal plates* small, narrow, largely actinal in position, 3–5 on either side of cribriform organ; not corresponding with superomarginal plates, lacking spines, and not extending to terminal plate.

A single narrow *cribriform organ* in each interradial angle, that at base of madreporite considerably larger, each consisting of 5 or 6 parallel rows of slender, membrane-invested spines; similar spines present interradially on adjacent abactinal plates, but lacking the membranous surround. Cribriform organs bordered by row of enlarged, very regular spines.

*Actinal interradial areas* distinct, triangular, membrane-covered and bordered by oral, adambulacral, and inferomarginal plates. In each interradius 2–4 almost circular, naked plates may be present. Stone canal visible in 1 interradius. Each actinal area fringed by an opaque fold, a continuation of adambulacral plates.

*Adambulacral plates* conspicuous, oblong, with gently curved furrow margin, separated laterally by shallow grooves; plates with distinct depression (?segmental pit) in which the 2 flattened leaf-like furrow spines fit when folded back across plate. *Adambulacral furrow spines* 2; when folded back furrow spines occupy most of plate; spines thin, flattened leaf- or petal-like.



Oral plates rising steeply, separated along most of upper margin by an oval, muscular area; a triangular plate present basally between 2 plates in an angle. 1 large, unpaired spine common to 2 mouth plates in an angle, each plate also with 2 or 3 flattened leaf-like furrow spines similar to those of adambulacral plates.

Adambulacral furrows broad, tubefeet in 2 rows, no suckers.

COLOUR: There are no colour notes for fresh material. Dried and in alcohol, colour is grey-white with gold-brown patches on disc.

REMARKS: *Damnaster* falls in the second and last part of Madsen's (1961: 56) key; there is a single mouth spine common to the two oral plates in an angle, and the superomarginal plates from opposite sides of the arms do not meet in the midline. It can easily be distinguished from *Sidonaster* which has long, conspicuous superomarginal spines, a very large papilliform cribriform organ, up to seven spines on terminal arm plates, and slender adambulacral furrow spines.

*Damnaster* can be distinguished from *Porcellanaster* by:

- 1, the broad leaf-like adambulacral furrow spines, which occupy, at least proximally, most of the plate length;
- 2, the disc margin, which is formed almost exclusively by the superomarginal plates, the inferomarginals being small, narrow, and largely confined to the actinal surface (in *Porcellanaster* the marginals are more or less equal, and both superomarginals and inferomarginals form the disc edge); and
- 3, the distinctly naked, unpaved, and membranous actinal areas (occasional small isolated plates occur in the present material, but in several larger specimens there are none, and in similar-sized and smaller specimens of *Porcellanaster* the actinal areas are already well paved by plates).

Some previously described specimens of *Porcellanaster caeruleus* may be referable to *Damnaster*. Madsen (1961: 142) described three juvenile specimens from *Galathea* Stn 664, Kermadec Trench, north of New Zealand. These are obviously very similar to, if not conspecific with, the present specimens. Possibly the present specimens differ in having larger adambulacral furrow spines which occupy most of the plate margin, especially proximally. Bernasconi (1967: 443) recorded four young specimens from near Chile in 4116 m; these may also belong in *Damnaster* as the actinal interradial areas are membranous and the adambulacral furrow spines appear broad and leaf-like. Sladen (1889: 146) described a small porcellanasterid under the name *Porcellanaster eremicus* from the South Atlantic (*Chalenger* Stn 137), with attenuate rays, small inferomar-

ginals (one fewer than the superomarginal series), short, broad adambulacral furrow spines, and no actinal plates,  $R/r = 6.5/3.25$  mm. This specimen also appears to fall in *Damnaster*.

In contrast, Lieberkind (1935) examined 29 specimens of *Porcellanaster caeruleus* from the North Atlantic (*Ingolf* and *Godthaab* Expeditions), with  $R$  13.0–2.5 mm. In these specimens the inferomarginals, though sometimes smaller or lower than the superomarginals, are aligned with them, and are equal in number. A second species of *Porcellanaster*, *P. ivanovi* Belyaev (1969a: 19), from the hadal zone of the Pacific Ocean, lacks superomarginal spines, has small inferomarginals, but has a well-plated ventrolateral area and narrow, pointed adambulacral furrow spines.

Madsen (1961) has given an excellent summary and discussion of specimens that over the years have been included in *Porcellanaster*. While we agree with him in general, we also believe that *Porcellanaster* should be restricted and that the combination of characters in this group of specimens discussed above was ample grounds for erection of *Damnaster*. It is important to note that small specimens of *Porcellanaster caeruleus* in the NZOI/NIWA and Museum of New Zealand collections (NMNZ), of the same size as material of *Damnaster tasmani*, have well-paved actinal areas and the adambulacral and oral furrow spines are slender and not at all leaf-like.

#### *Eremicaster* Fisher, 1905

Rays 5, long, slender, tips often upturned. Superomarginal plates from opposite sides of arms separate to arm tip; superomarginals often with spines. Three cribriform organs in each interradius, these large, well separated. Actinal areas with pavement of close-fitting plates, no spines present. Two plates in oral angle share a median spine. Both oral and adambulacral spines sometimes modified as segmental papillae, which cover segmental pits.

TYPE SPECIES: *Porcellanaster (Eremicaster) tenebrarius* Fisher, 1905.

REMARKS: Fisher (1905: 293) recorded the type from some 200 miles off San Diego, California in 4016–4075 m. The presence of three cribriform organs and smaller, fewer, more distinct abactinal plates distinguishes this genus from *Porcellanaster* which it closely resembles.

Fisher (1905) proposed *Eremicaster* as a subgenus of *Porcellanaster*. We follow Madsen (1961: 143) who regarded it as a separate genus.



Plate 32. *Damnaster tasmani* H.E.S. Clark & McKnight. Holotype. NZOI Stn U204. Abactinal and actinal surfaces.



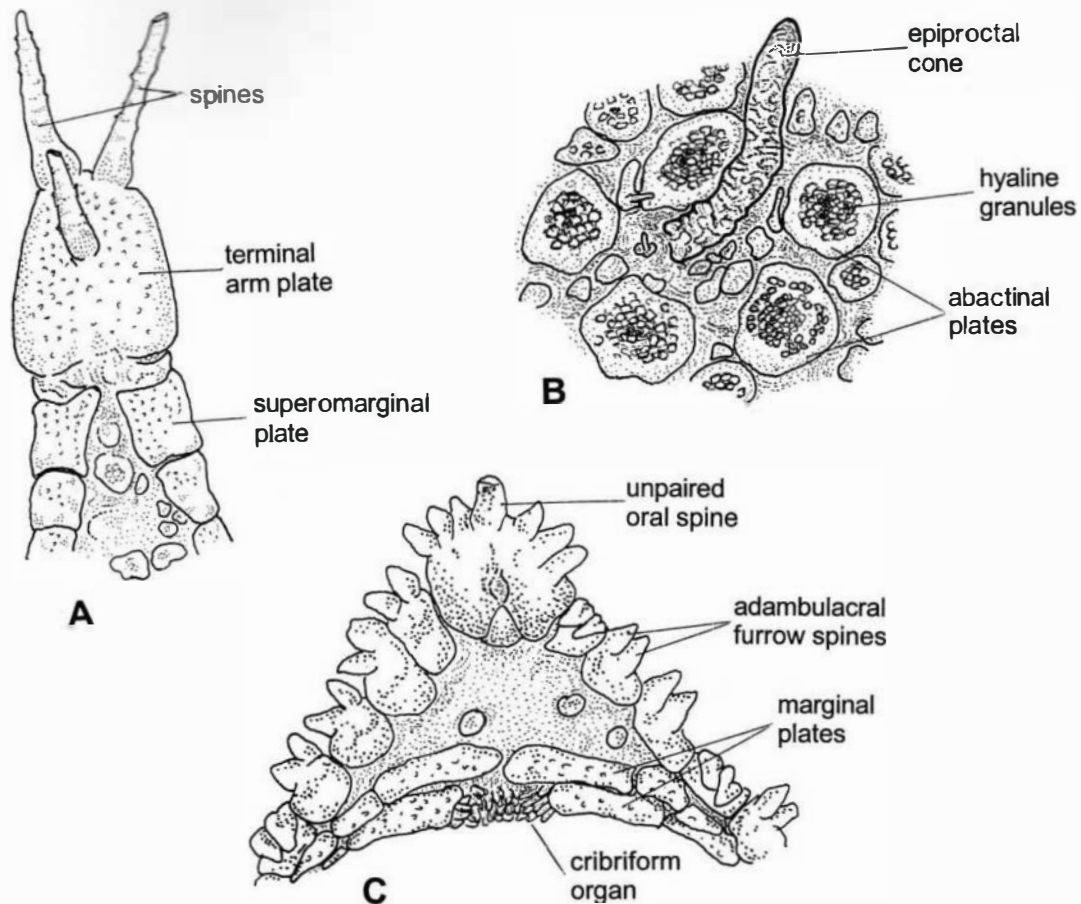


Fig. 31. *Damnaster tasmani* H.E.S. Clark & McKnight. Holotype. NZOI Stn U204. A. Terminal arm plate showing large spines. B. Epiproctal cone and hyaline granules of abactinal plates. C. Actinal interradial area showing oral plates (note unpaired spine), actinal area with scattered plates, and single cribriform organ.

*Eremicaster vicinus* (Ludwig, 1907) (Pl. 33, Fig. 32)

*Porcellanaster vicinus* Ludwig, 1907: 318.  
*Porcellanaster vicinus* var. *inermis* Ludwig, 1907: 318.  
*Eremicaster vicinus*: H.L. Clark 1920: 77, pl. 2(7, 8); Madsen 1961: 161, fig. 30; Belyaev 1969b: 110; 1985b: 871, figs 1g, 4; A.M. Clark & Downey 1992: 97, fig. 18e.  
*Eremicaster pacificus*: Madsen, 1951: 76, fig. 1; 1956a: 26 (non *E. pacificus* Ludwig, 1907).  
 ?*Eremicaster* sp. H.E.S. Clark, 1970: 14.

MATERIAL EXAMINED:  
 NZOI Stn P970(2). *Eltanin* Stn 1844(1).

SIZE: R = 20-11 mm; r = 7-4 mm; R/r (3 specimens) averages 15/6 mm.

DISTRIBUTION: Off Peru, South America (12° S), mid-Atlantic, eastern Indian Ocean, north Pacific and in the South Pacific to 46° S (165° E) in the Tasman Sea.

DEPTH: 2104-7245 m.

DESCRIPTION: Description of specimen from NZOI Stn P970, R/r = 20/7 mm.

Disc large, rather flat, arms slender with upturned tips. Disc membranous, with small, distinct, widely isolated round or oval plates, these most obvious on disc centre interradially, absent or very few and scattered and indistinct from arm base to arm tip. Some plates, especially near disc centre and interradially adjacent to superomarginals, with a single, slender, hyaline, tapering, generally sharp-tipped, spine. Small plates, sometimes visible along arms, without spines. Terminal arm plate distinct, round, inflated; with 3 (broken) spines which form a triangle.

Epiproctal cone small, rather flattened, grooved, folded, central on disc.

Madreporite, interradial, coarsely dissected, encroaching on cribriform organs.

Marginal plates forming vertical edge to disc and arms. Superomarginal plates large, rectangular, naked, raised slightly above disc level, corresponding with inferomarginals; plates separated laterally from one

another by shallow grooves.

*Inferomarginals* slightly narrower (dorsoventrally compressed) than superomarginals, sometimes more numerous (possibly resulting from injury); no spines.

Three *cribriform organs* in each interradius; each consists of 8–12 thin lamelliform sheets of membrane-covered spines. Organs bordered by broad, conspicuous spines which form a well defined palisade on either side. Cribriform organs in angle adjacent to madreporite; slightly larger, somewhat damaged, as is madreporite.

*Actinal interradiial areas* with close pavement of rectangular plates; no spines, no pedicellariae; plates larger, almost square adjacent to oral plates.

*Adambulacral plates* gently concave, i.e., with a distinct dip, well separated from each other by broad muscular areas. Free angular edge of plates with 2 slender, slightly flattened tapering spines.

*Oral plates* in an angle rising steeply, separated medianly by an elongate, oval muscular area. A distinct, well-developed, somewhat tumid triangular plate separates 2 oral plates in an angle and abuts onto actinal interradiial plates. There is a well developed (at least basally) single spine, common to 2 oral plates; unfortunately all spines are broken. 2 lateral-oral spines on each plate; these small, flattened, acute, similar to adambulacral spines.

*Epistomial membrane* distinct; mouth packed with fine, grey mud.

*Tubefeet* well developed, no suckers, in 2 rows in wide grooves.

**COLOUR:** The present material, dried from alcohol, is white or grey, with darker cribriform organs and tubefeet.

**REMARKS:** A second smaller specimen (NZOI Stn P970) has an inflated mud-filled disc. It is similar to that already described; the epiproctal cone is small, narrow, somewhat folded and grooved; the abactinal plates are scattered and isolated (partly because of disc extension); there are three cribriform organs in each interradius and no superomarginal or actinal spines present.

The smallest specimen in the present collections (*Eltanin* Stn 1844, ?*Eremicaster* sp. H.E.S. Clark 1970: 14, R/r = approx. 11/4 mm) is damaged and has only one intact arm tip with three spines. Superomarginals in this specimen, from opposite sides of an arm, are separate to the arm tip. Small characteristically isolated abactinal plates are present, of which some, especially interradially, have slender, pointed spines. There are three cribriform organs in each interradius; the outer two extend only as far as the inferomarginal plates. The epiproctal cone is short and there are no

superomarginal spines.

### *Hyphalaster* Sladen, 1883

Arms 5, slender, fast tapering to conspicuous terminal plate. Superomarginals forming complete casing to arms (i.e., contiguous midradially), generally no spines, but occasionally plates of disc bear a single small spine. Mid-interradiial suture present. Infero- and superomarginal plates of similar width; infero- marginals not conspicuously narrower. Cribriform organs 5–11, confined to disc margin.

**TYPE SPECIES:** *Hyphalaster hyalinus* Sladen, 1883

**REMARKS:** As with other members of the Porcellanasteridae, variations are numerous and specific characters are rather vague. Many and different are the species attributed to this genus. Madsen (1961: 56) discussed *Hyphalaster* in detail, giving a key to four species — *H. hyalinus* Sladen, *H. inermis* Sladen, *H. scotiae* Koehler, and *H. giganteus* Macan. Whether the large *H. giganteus* (R/r = 82/24 mm), based on a single specimen dredged by the John Murray Expedition in the Arabian Sea, should be included in *H. inermis* is debatable. Madsen included it in his key as a separate species, having “unarmed ventrolateral plates”. He suggested that this may be due to the very broken nature of the actinal surface (Madsen 1961: 72).

### *Hyphalaster inermis* Sladen, 1883 (Pl. 34, Fig. 33)

*Hyphalaster inermis* Sladen, 1883: 239; 1889: 162, pls 25(4–6), 28(5–8); Madsen, 1961 (part): 58, figs 6, 7, pls 1–3, 13(3, 4); Tommasi, 1970: 4, fig. 12; Cherbonnier & Sibuet 1973: 1342; Sibuet 1975: 285; Gage *et al.* 1983: 276; A.M. Clark & Downey 1992: 98, fig. 18(g-i), 19(a, b, j), pl. 26 A-C; Belyaev & Mironov 1993: 210, table 3, figs 3(1–2), 4, 5(3, 4).

*Hyphalaster antonii* Perrier, 1885b: 61; 1894: 232, pl. 16(1a-e); Koehler 1909b: 29.

*Hyphalaster parfaiti* Perrier, 1885b: 65; 1894: 229, pl. 16(2a-e); Lieberkind 1932: 282, fig. 9, pls 1(5, 6), 3(4–11), 6(1–4); 1935: 19, figs 6–8, pls 1(7–9), 3(1–11), 5(9, 11–14); A.H. Clark 1948: 75; Madsen 1951: 82.

*Hyphalaster moseri* Ludwig, 1905: 100, pl. 7(36, 37).

*Hyphalaster fortis* Koehler, 1907: 14; 1909b: 30, pl. 16(1, 2); 1921: 2.

*Hyphalaster gracilis* Koehler, 1907: 16; 1909b: 32, pl. 14(5, 6); 1921: 2.

*Hyphalaster giganteus* Macan, 1938: 331, pl. 1(3, 7).

**MATERIAL EXAMINED:** NZOI Stn J658(3).

**SIZE:** R = 35–12 mm, r = 10–4 mm, (average R/r = 22/7 mm).



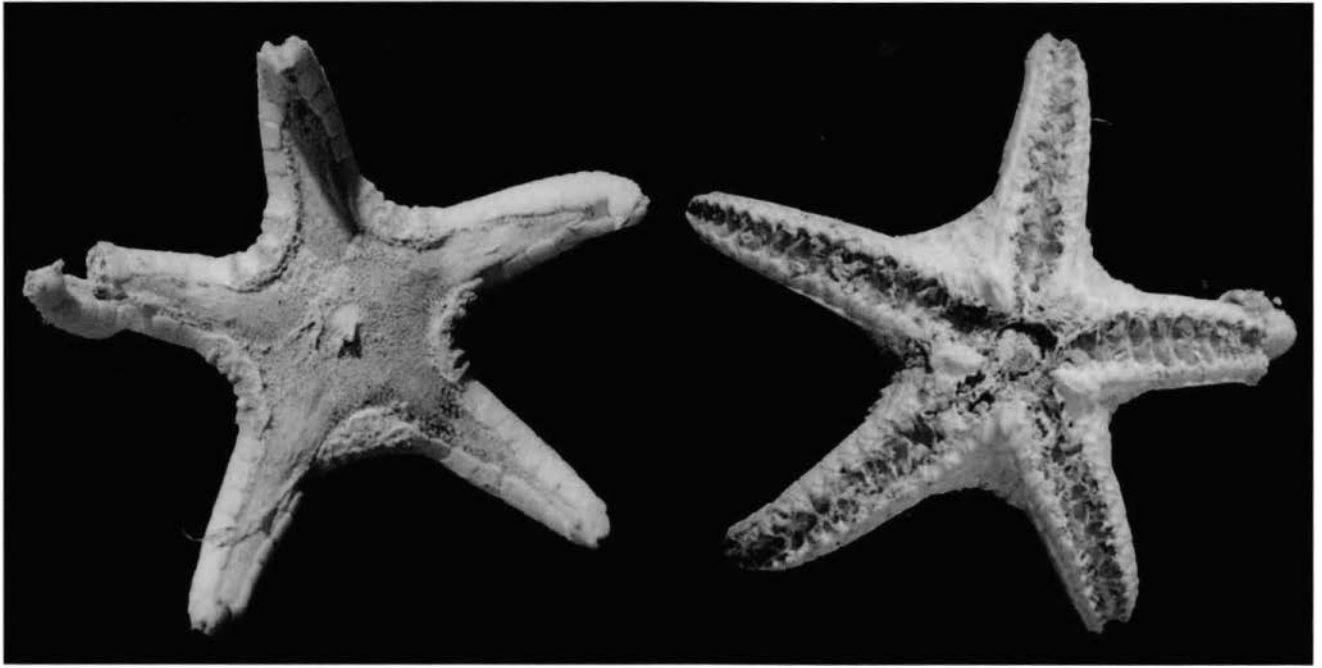


Plate 33. *Eremicaster vicinus* (Ludwig). NZOI Stn P970. R/r = 20/7 mm. Abactinal and actinal surfaces.

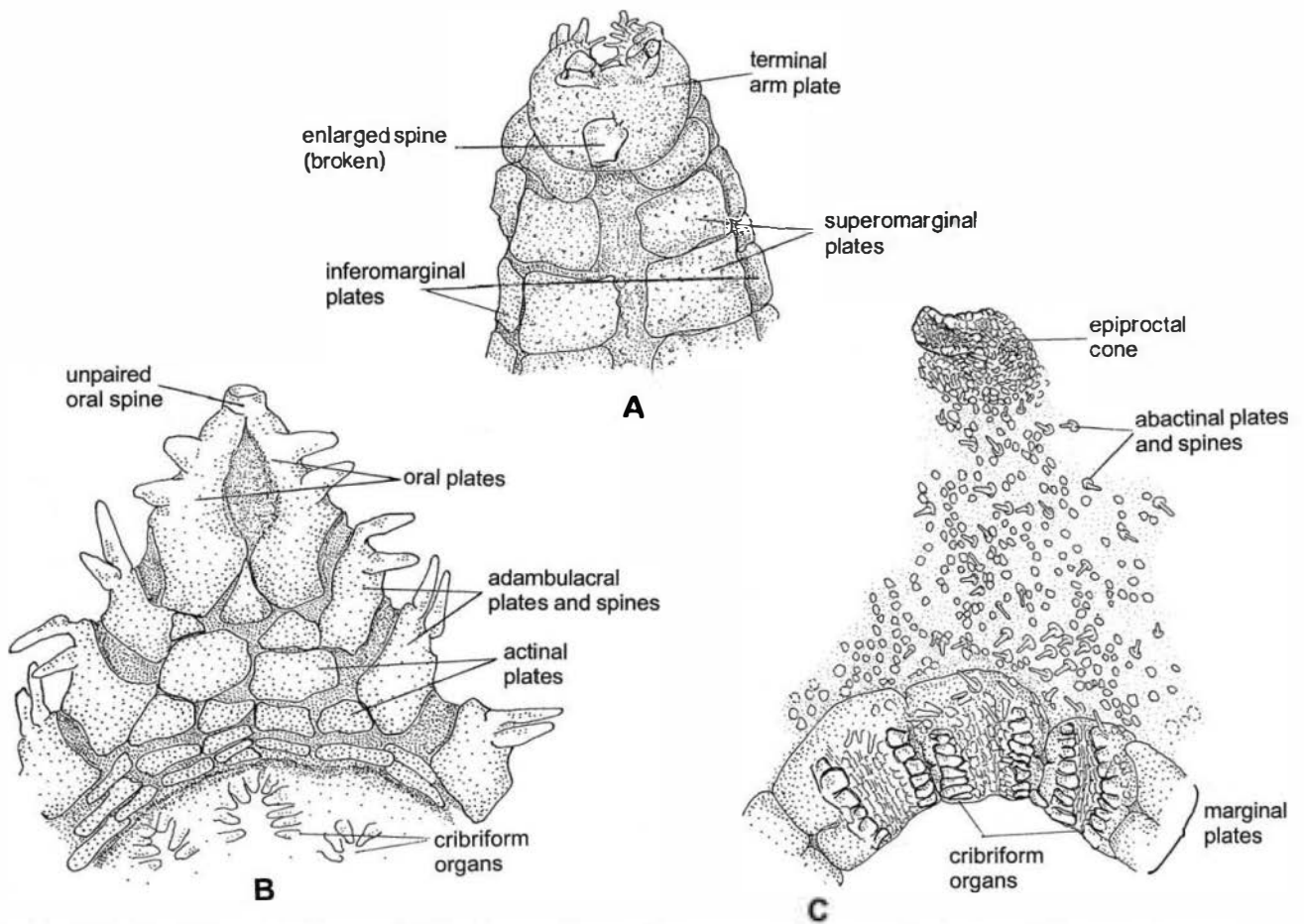


Fig. 32. *Eremicaster vicinus* (Ludwig). NZOI Stn P970. A. Terminal arm plate and adjacent abactinal and marginal plates. B. Oral, adambulacral, and actinal plates and cribriform organs. C. Interradius, with epiproctal cone, abactinal and marginal plates, and cribriform organs.

**DISTRIBUTION:** Widespread in the Atlantic from Davis Strait to the Gulf of Guinea; western Indian Ocean from Arabian Sea to South Africa, and from near Sri Lanka and the Bay of Bengal; also from near Japan, central Pacific and the Kermadec Trench, north of New Zealand.

**DEPTH:** 2278-5430 m.

**DESCRIPTION:** Description of large specimen (NZOI Stn J658, R/r = 35/10 mm).

*Disc* (1 arm intact) gently and evenly tumid, raised above level of superomarginal plates. Regular covering of small *paxillae* on disc, these in no regular arrangement except near disc edge where they form more or less regular short rows; near entrance to arms *paxillae* more widely spaced; bases of *paxillae* enveloped in membrane, making plate outlines difficult to distinguish. *Paxillar* trunks short with a very finely thorny, expanded, round or slightly angular head; 6-10 (exceptionally 5-11) small round or angular-headed spinelets or granules present; generally 1 spinelet central, but some *paxillae* with 2, or even as many as 4, centrally.

*Papulae* small, single, present at arm bases and along edges of disc and arms, absent from narrow median strip along arms and from disc centre.

Centrally on disc a small, raised *epiproctal cone* with distinctly smaller *paxillae*, these with more slender spines.

*Madreporite* hemispherical, slightly damaged, deeply and narrowly dissected, separated from marginal plates by several rows of *paxillae*.

A midinterradial *marginal suture* present. *Inferomarginal plates* slightly smaller than *superomarginals*; marginal plates directly opposite one another; no spines on any marginal plates. 13 or 14 marginal plates from interradial suture to arm tip; superomarginal plates of opposite sides of arms meet at level of fourth or fifth plate (from midline of arms). *Marginal plates* naked, porcellanous, regularly rectangular.

*Cribriform organs* 8 or 9 in any 1 interradius, with 9-13 very straight rows of small, papilliform spinelets, these flanked by larger, flatter, and slightly more conspicuous spinelets. In at least one arm a new, small cribriform organ is developing from top of superomarginal plates downwards.

*Actinal interradial areas* with close pavement of small plates; these rectangular, regularly arranged near disc margin, larger, less regular in outline near oral plates. *Actinal plates* with 5-13 or 14 small, pointed, spaced spinelets or granules; these give the actinal surface an almost "shaggy" appearance; towards disc edge spinelets considerably longer. *Actinal plates* between inferomarginals and adambulacral plates for at least three-quarters length of each arm; distally plates inter-

mittent, irregular in shape and often lacking spines.

*Adambulacral plates* rectangular, well separated from each other by a broad, conspicuous membranous area. Most proximal free margin of plate with a small, distinctly angular projection with an adambulacral furrow spine; proximally, plates bear 4 furrow spines, distally only 3 present. Furrow edge of plate raised, furrow spines united basally in membrane, spines thick, tapering, hastate, well spaced from one another; 3-7 subambulacral spines present, these small, pointed, generally confined to plate edges; towards arm tip spines distinctly longer, often almost forming a fringe which overhangs actinal plates.

*Oral plates* large, conspicuous, high, separated along their length by a broad membranous area and possibly only meeting briefly proximally. Each plate with 6, occasionally 7, furrow spines; these very similar to adambulacral furrow spines although they are less conspicuously hastate. Most anterior spines, overhanging mouth, longer, at least twice as long as adjacent oral spines. All furrow spines very finely thorny. Suboral spines broken, present along plate crest.

*Epistomial membrane* regular, mouth packed with fine, white mud.

*Ambulacral grooves*, at least in 3 arms, very distinct; *tubefeet* biserial, rounded, no suckers, in very distinct, obvious rows in wide ambulacral grooves.

**COLOUR:** No colour notes of freshly caught specimens. Sladen (1889: 164) recorded colour in alcohol as "grey". The present specimens, in preservative or dry, are white to light fawn or golden brown, the tubefeet and cribriform organs darker brown.

**REMARKS:** The smaller specimens are very similar, with eight or nine cribriform organs, six oral furrow spines and, at least initially, four adambulacral furrow spines. No papulae were seen.

Madsen (1961: 70) commented on the specimens collected in two dredgings from the Kermadec Trench by the *Galathea* Expedition. The present specimens seem similar, although actinal spinelets are more numerous and there are fewer abactinal *paxillar* spinelets.

### *Porcellanaster* Thomson, 1877

Rays 5, short, upturned. Superomarginals from opposite sides of arm separate to arm tips, sometimes with spines. Generally an elongate, conspicuous epiproctal cone (apical appendage) on disc centre. Midinterradial suture present and a single lamelliform cribriform organ. A single proximal mouth spine present, shared by a pair of oral plates. Pedicellariae sometimes present on disc, sometimes formed by furrow spines. Actinal interradial



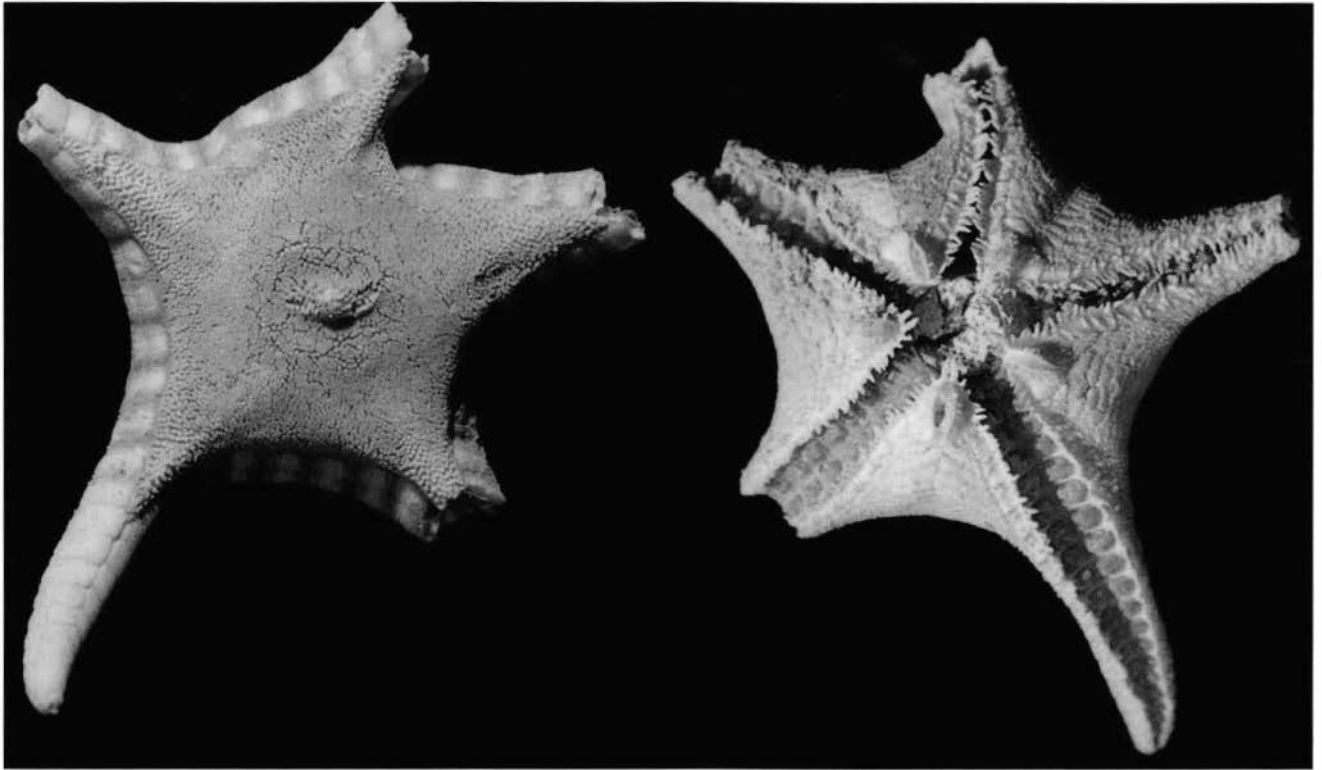


Plate 34. *Hyphalaster inermis* Sladen. NZOI Stn J658, R/r = 35/10 mm. Abactinal and actinal surfaces.

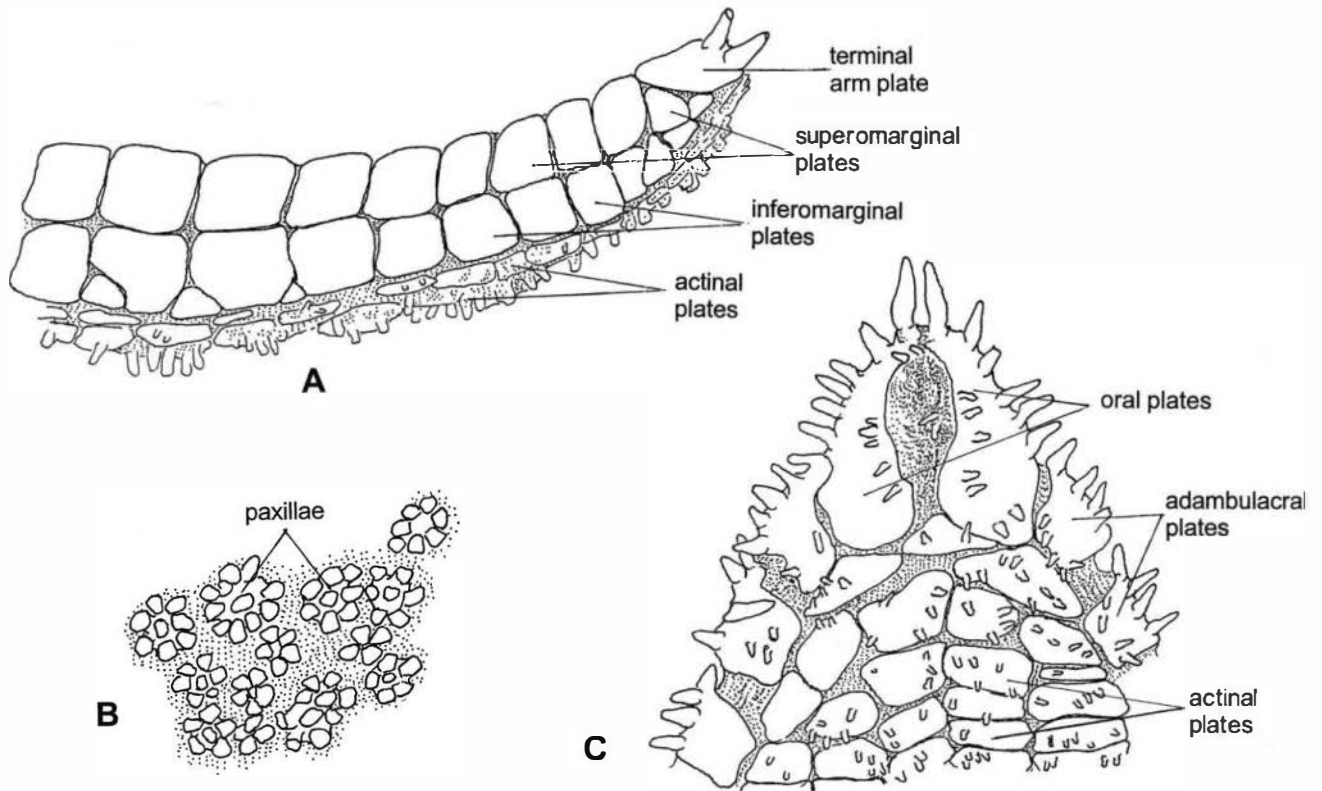


Fig. 33. *Hyphalaster inermis* Sladen. NZOI Stn J658. A. Arm tip showing supero- and inferomarginal plates and terminal plate. B. Abactinal paxillae. C. Actinal interradial area showing oral, actinal, and adambulacral plates.

areas with pavement of close-knit plates. Ambulacral grooves wide, exposed; adambulacral and oral furrow spines thin, pointed.

TYPE SPECIES: *Porcellanaster ceruleus* Thomson, 1877.

REMARKS: Thomson (1877) proposed the generic name as a reference to the porcellanous nature of the marginal plates. Madsen (1961: 124) gave a detailed discussion of the genus, under "Remarks". There is little to add to this, although as more material becomes available for study it is important to restrict and adhere to the generic diagnosis of *Porcellanaster*.

### *Porcellanaster ceruleus* Thomson, 1877

(Pl. 35, Fig. 34)

*Porcellanaster ceruleus* Thomson, 1877: 378, figs 97, 98; Gage *et al.* 1983: 275; A.M. Clark & Downey 1992: 100, fig. 18a-c, 19d, f, i, pl. 27a-c; Rowe & Gates 1995: 109; Belyaev & Mironov 1996: 887, figs 1, 2, tables 1, 2.

*Caulaster pedunculatus* Perrier, 1882: 1379; 1885b: 45; 1894: 204, pl. 15, fig. 1a-e.

*Porcellanaster caeruleus*: Sladen 1883: 218; Verrill 1885: 520, 543, pl. 14, figs 40, 41; Sladen 1889: 134, pls 20(1-7), 20A(1-10); Verrill 1895: 133; H.L. Clark 1923: 239; Madsen 1951: 74; 1961: 126, figs 22-24; Bernasconi 1967: 443, figs 3-6; H.E.S. Clark 1970 (part): 14, pl. 1, c, d; McKnight, 1973a: 220, fig. 1.

*Porcellanaster caulifer* Sladen, 1883: 222; 1889: 138, pl. 21(5-10), pl. 27(9-12); Koehler 1909b: 33, pl. 11(5), 13(1).

*Porcellanaster tuberosus* Sladen, 1883: 223; 1889: 140, pl. 23(1-4), pl. 27(13-16); A.M. Clark & Downey 1992: 99.

*Caulaster sladeni* Perrier, 1885a: 886; 1885b: 47; 1894: 208, pl. 15, figs 2b, 3a-c.

*Porcellanaster inermis* Perrier, 1885a: 886; 1885b: 50; 1894: 212, pl. 15, figs 2, 2a, c.

*Porcellanaster granulatus* Perrier, 1885a: 886; 1885b: 53; 1894: 216, pl. 17(1a-c).

*Porcellanaster eremicus* Sladen, 1889 (part): 145, text-fig.

*Albatrossia semimarginalis* Ludwig, 1905: 97.

*Albatrossaster semimarginalis*: Ludwig 1907: 319.

*Albatrossaster richardi* Koehler, 1909a: 25, pl. 19(7-9).

*Porcellanaster irregularis* Lieberkind, 1932: 272, text-figs 1-4, pls 1(1, 2), 3(1-3), 7(5, 6).

*Porcellanaster coeruleus*: Lieberkind 1935: 5, text-figs 1-5, pls 2(1-8), 3(12), 5(16, 17); Cherbonnier & Sibuet 1973: 1341; Sibuet 1975: 284.

?*Porcellanaster ivanovi* Belyaev, 1969a: 11, figs 6, 7; 1985a: 542, fig. 3; A.M. Clark & Downey 1992: 99.

#### MATERIAL EXAMINED:

NZOI Stns D591(4), E399(1)\*, E411(2), E709(1), E745(1), F744(1), F752(1)\*, G704(1), G705(2)\*, G706(1)\*, P970 (1), P971(1), S151(20), S152(1), S153(9), S154(6)\*, S202(11), S204 (9), W247b(15), W248(5), W255(1), W256(2)\*, W265(5), W273 (6), W274(1).

NMNZ: Cape Palliser: Ech. 4550(3), 4551(7), 4552(2), 4553(1), 5240(1); near Poor Knights Islands: Ech. 5516(1).

*Eltanin* Str 1846 (3).

SIZE: In 126 specimens examined, R varied between 27 and 4 mm, and r between 10 and 2 mm; average R/r for 71 specimens was 15/5 mm.

DISTRIBUTION: Widespread in the Atlantic, from southern Greenland to South Africa; in the Indian Ocean north of the equator; in the Pacific from the Philippines-Indonesian area and northern South America; wide-spread around New Zealand and in the Tasman Sea. It is also known from further south — *Eltanin* Stn 1660, 61° S, 108° E.

DEPTH: 875-6040 m.

DESCRIPTION: Description of specimen from NZOI Stn S151, R/r = 15/5 mm.

*Disc* sharply demarcated; arms almost triangular in cross section, upturned, distinct from disc. Disc gently convex, bordered by raised and distinct edges of superomarginal plates. Disc centre and broad, conspicuous interradial strips with small, isolated, round or oval plates, each with a single, sturdy, gently tapering, blunt to sharp-tipped spine; these spines arranged in almost regular rows, especially near disc margin. Plates covered by membrane; at arm base membrane obvious, extending to arm tips; below membrane, outlines of small, round, isolated spineless plates just visible especially at arm base and near margins. Arm tip protected by a well-developed, igloo-shaped *terminal plate*, this with a triangle of 3 sturdy spines; spines fast-tapering to sharp tip, markedly hyaline in distal half.

*Epiproctal cone* (apical appendage) on disc centre conspicuous, upright, paved with numerous, small, rough, sometimes spinous plates; no obvious opening.

*Madreporite* interradial, large, coarsely dissected, almost oval, encroaching on cribriform organ.

*Marginal plates* form vertical edge to disc and arms.

*Superomarginals* large, 7 or 8 from interradial angle to arm tip; plates more or less rectangular, separated laterally by shallow grooves, with a single, acute, sturdy spine; plates from opposite sides of arms more or less opposite, not meeting in midline of arms.

*Inferomarginal plates* slightly narrower, opposite superomarginals, bearing no spines; smaller and triangular near arm tips.

A single *cribriform organ* present in each interradius, large with 16-20 vertical, lamelliform rows of membrane-covered spinelets, and bordered by a fringe of larger, very regular, broad, flattened spines.

*Actinal* interradial areas with a close pavement of generally flattened, regularly arranged naked plates.

*Adambulacral plates* conspicuous, well-separated from each other by distinct membranous areas, with angular proximal margin on which 2 sharp-pointed, almost triangular (in cross section) furrow spines are borne,



rest of plate margin naked; no subambulacral spines.

*Oral plates* high, members of a pair separated by a broad muscular region. Each pair of plates in an angle with a single, sharp triangular furrow spine. Laterally each plate with 2 furrow spines similar to adambulacral furrow spines; short, triangular, acute.

*Epistomial membrane* distinct, conspicuous.

*Tubefeet* (without discs) biserial, in 2 conspicuous rows in wide ambulacral grooves.

**COLOUR:** Both the generic and specific names refer to the colour of freshly caught specimens. Thomson (1877) remarked on the clear white marginal plates "with somewhat of a porcellanous lustre", and the specific name refers to the blue mud which shows through the thin walls of the disc. Dried and in preservative, colour is white or grey with pale brown-gold cribriform organs and adambulacral grooves; tubefeet generally slightly darker in colour.

**REMARKS:** Fell (1959: 131) listed the family Porcellanasteridae and suggested that "representatives" might be present in Cook Strait Canyon although none had been recorded. Madsen (1961: 135) recorded *Porcellanaster ceruleus* from the Kermadec Trench north of New Zealand and later *Eltanin* material included specimens from off the west coast of the South Island. Belyaev and Mironov (1996), in studies of porcellanasterids from the Atlantic and Antarctic, re-established the genus *Caulaster* (*Albatrossaster* a synonym), reporting it from the Antarctic for the first time. We do not have access to their collections, and do not include their changes here.

Madsen (1961: 126) discussed at length the many variants of *Porcellanaster ceruleus*. It is obviously an extremely variable species; perhaps now with more material available for comparison, an attempt to adhere more rigidly to the generic definition should be made. Thus, the present authors recently defined a new genus *Damnaster*, from deep water off the west coast of South Island, New Zealand.

The present specimens do not show a great deal of variation although the number of adambulacral and oral furrow spines may be 1–3 (seldom more), the epiproctal cone may be completely retracted or very obvious in its extension, and superomarginal plates may or may not carry spines; generally, however, these are well developed.

### *Styracaster* Sladen, 1883

Arms 5, long, slender; superomarginal plates from opposite sides of arms meet in midline, forming complete casing to arms. Superomarginal spines erect,

conspicuous, robust, tapering; spines borne on upper edge of plates, forming a single series along median line of arms. No superomarginal spines on disc margin. Mid-interradial suture present, cribriform organs (3–11) confined to disc margin. Abactinal paxillae usually present; sometimes reduced in form.

**TYPE SPECIES:** *Styracaster horridus* Sladen, 1883.

**REMARKS:** Sladen (1883) proposed the genus *Styracaster* to accommodate two species, *horridus* and *armatus*. Since then various authors have added to the list, with Madsen (1961: 92) recording twelve species.

Of these *S. armatus* (this report), *S. chuni* (not represented in the present collections, but recorded by Madsen from the Kermadec Trench), and *S. horridus* are known from New Zealand waters.

### TABULAR KEY TO THE NEW ZEALAND SPECIES OF *STYRACASTER*

	1	2	3	4
<i>Styracaster armatus</i>	s	3	s	a
<i>chuni</i>	p	5–7	p	p
<i>horridus</i>	p	7, 8	f	a

- 1 Abactinal plates with  
p - paxillae  
s - spines or pseudo-paxillae
- 2 Number of cribriform organs in each interradius
- 3 Oral furrow spines  
f - flat, subcircular  
p - distinctly pointed, long, not flattened  
s - short, flat, rapidly tapering
- 4 Naked patch, with scattered plates, at arm base  
p - present  
a - absent

### *Styracaster armatus* Sladen, 1883 (Pl. 36, Fig. 35)

*Styracaster armatus* Sladen, 1883: 232; 1889: 154, pls 24(1–4), 28(1–4); Alcock, 1893: 86; Madsen 1961: 119, fig. 21; 1981: 318, fig. 8; A.M. Clark & Downey 1992: 102, pl. 27(G, H).

*Styracaster spinosus* Perrier, 1885a: 886; 1885b: 55; 1894: 223, pl. 17(2a–d); Koehler 1909a: 39; Madsen 1951: 80; 1961: 121; 1981: 318.

*Styracaster edwardsi* Perrier, 1885a: 886; 1885b: 59; 1894: 220, pl. 17(3a–e).

*Styracaster horridus*: McKnight 1993a: 168.

**MATERIAL EXAMINED:** NZOI Stn U196(2).

**SIZE:** R/r = 45/10 mm; 10/3 mm.

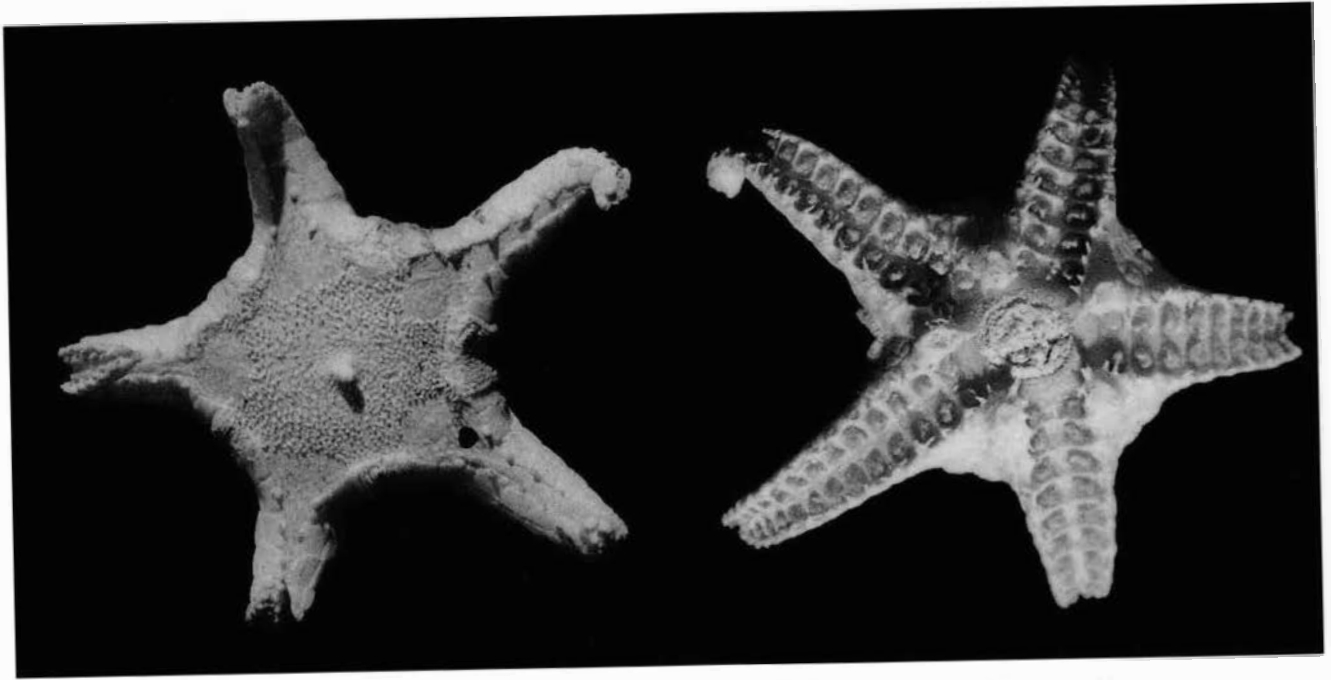


Plate 35. *Porcellanaster ceruleus* Thomson. NZOI Stn S151, R/r = 15/5 mm. Abactinal and actinal surfaces.

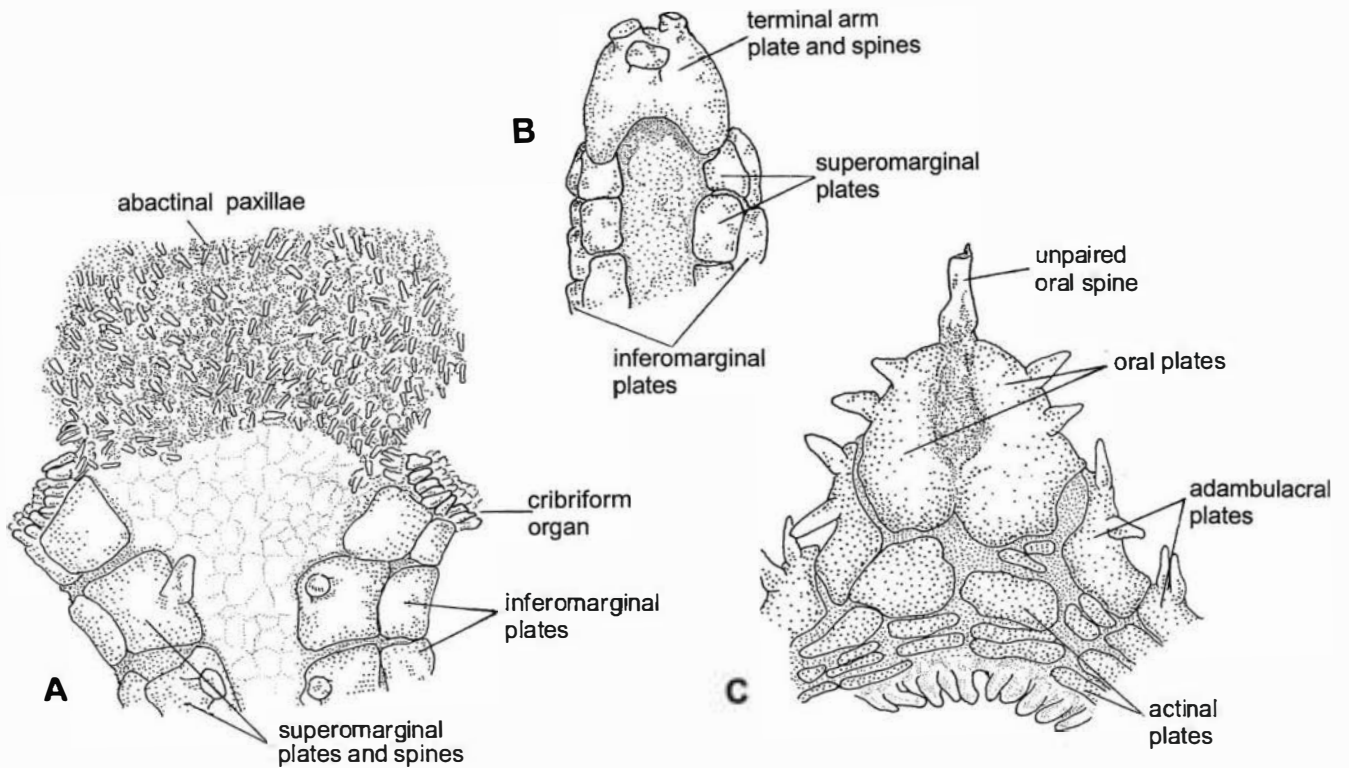


Fig. 34. *Porcellanaster ceruleus* Thomson. NZOI Stn S151. A. Abactinal surface near arm entrance. B. Arm tip. C. Actinal surface, interradially. Note unpaired oral spine.



**DISTRIBUTION:** North Atlantic (and Caribbean), Indian Ocean and western Pacific, including (this report) New Zealand.

**DEPTH:** 2995–5610 m.

**DESCRIPTION:** Large specimen from NZOI Stn U196 (R/r = approx. 45/10 mm) is described. Specimen mutilated; only 3 arms complete (1 arm separated from disc); *terminal arm plates* distorted, almost grooved, circular to irregular in shape, existing arm tips with 3 spines, none intact.

*Disc* gently and irregularly inflated, with close, almost shaggy covering of spinelets, or perhaps pseudo-paxillae; these consist of 2 or 3 short, blunt-tipped spinelets borne on a small plate; these small plates in very regular rows. At arm base an irregular, but conspicuous pavement of flat, naked plates, oval or round, embedded in membrane. These areas extend for at least the length of 1, sometimes 2, superomarginal plates. No obvious papulae. Centrally on disc a small swelling.

*Madreporite* large, interradial, more or less round, finely and deeply dissected, with ridges covering; separated from superomarginal plates by a slender row of spaced paxillae.

*Disc* bordered by *superomarginal plates*, these not raised above disc surface; 17 to about 20 plates from interradial angle to arm tip, joining with opposite plates, encasing arms. Plates oblong, very distinct with rough surface of small, scale-like excrescences or folds, every second plate in arms with a single, sturdy tapering spine on upper (dorsal) side; these alternating with similar spines from opposite sides of arm; spines long, 5–6 mm. Most anterior spine, adjacent to naked plates of disc, particularly large and sturdy (although in all instances spines broken). In 2 arms still attached to disc, plates hopelessly jumbled and distorted; it is impossible to recognise separate supero- and inferomarginal plates — possibly a result of injury in the young animal.

*Inferomarginals* in uninjured arms considerably smaller, i.e., compressed dorsoventrally, similar in texture or slightly smoother and more tumid than superomarginals, with which they more or less correspond; lacking spines; separated from actinal and adambulacral plates, at least in distal half of arm, by a conspicuous membranous “gutter” — this especially evident on the side of 1 arm.

*Cribriform organs* 4 or 5 in each interradius; quite narrow, outer ones considerably less than width of marginal plate, central cribriform organs wider. Each organ consisting of 15–20 rows of membrane-covered spines; on superomarginal plates outer edge spines of cribriform organs line edges only; on inferomarginal plates, spines curve basally, forming a partial wall

across lower end of inferomarginals. Bordering spines larger, flatter, united in membrane.

*Actinal areas* well developed; more or less triangular. Small, tightly packed plates extend in a single row almost to arm tip; these just visible between inferomarginal and adambulacral plates. Interradial actinal plates large, distinct, almost round near oral plates; near inferomarginal plates and cribriform organs plates rectangular or oval and arranged in fairly regular, closely packed rows. These plates lacking distinct spines, the surface covered with a finely folded membrane.

*Adambulacral plates* rectangular, separated laterally by distinct, shallow membranous areas; plates, especially further along arm, with an angular dish- or banana-shaped margin. 3 *adambulacral spines* present, these flattened, acute; an enveloping membrane basally. The 3 mostly broken spines (most anterior longest) in a conspicuous graduated row on free angular margin of plate. Generally a conspicuous *subambulacral spine* on extreme adoral edge of plate, these spines smaller towards arm tips. *Stone canal* visible in 1 interradius, flanked initially on either side by plates.

*Oral plates* damaged; widely separated along their length, probably only meeting proximally in life; rising very steeply and separated basally by a steep, triangular plate. *Oral furrow spines* 5 or 6 in a regular row, spines rather flat, short, acute, largely hyaline. No unpaired spine common to 2 oral plates; suboral spines 2 or 3 in a row just below crest of plate; only bases remain but appear distinctly smaller than oral furrow spines.

*Epistomial membrane* conspicuous, tight-drawn, oval; stomach packed with fine mud and foraminiferans.

*Ambulacral grooves* narrow; *tubefeet* large, squat, in 2 rows, no suckers.

**COLOUR:** The present material, dried and ex-alcohol, is largely white with pale brown cribriform organs and tubefeet.

**REMARKS:** In the smaller specimen (R/r = 10/3 mm) from the same station (U196), the *disc* is compact, with the broken surface exposing fine, packed mud. *Arms* are long, slender, and markedly distinct from the disc; *superomarginals* meet in the midline from about the fourth superomarginal plate onwards. The *terminal plate* is conspicuous, large, and almost castle-shaped, and it bears dorsally, at its tip, three spines in a row, the centre one largest, and on the lower surface there are two similar spines, broken, but which were obviously long and slender. Both terminal and superomarginal plates are rough textured.

*Abactinal plates* are small, round, oval, or rect-

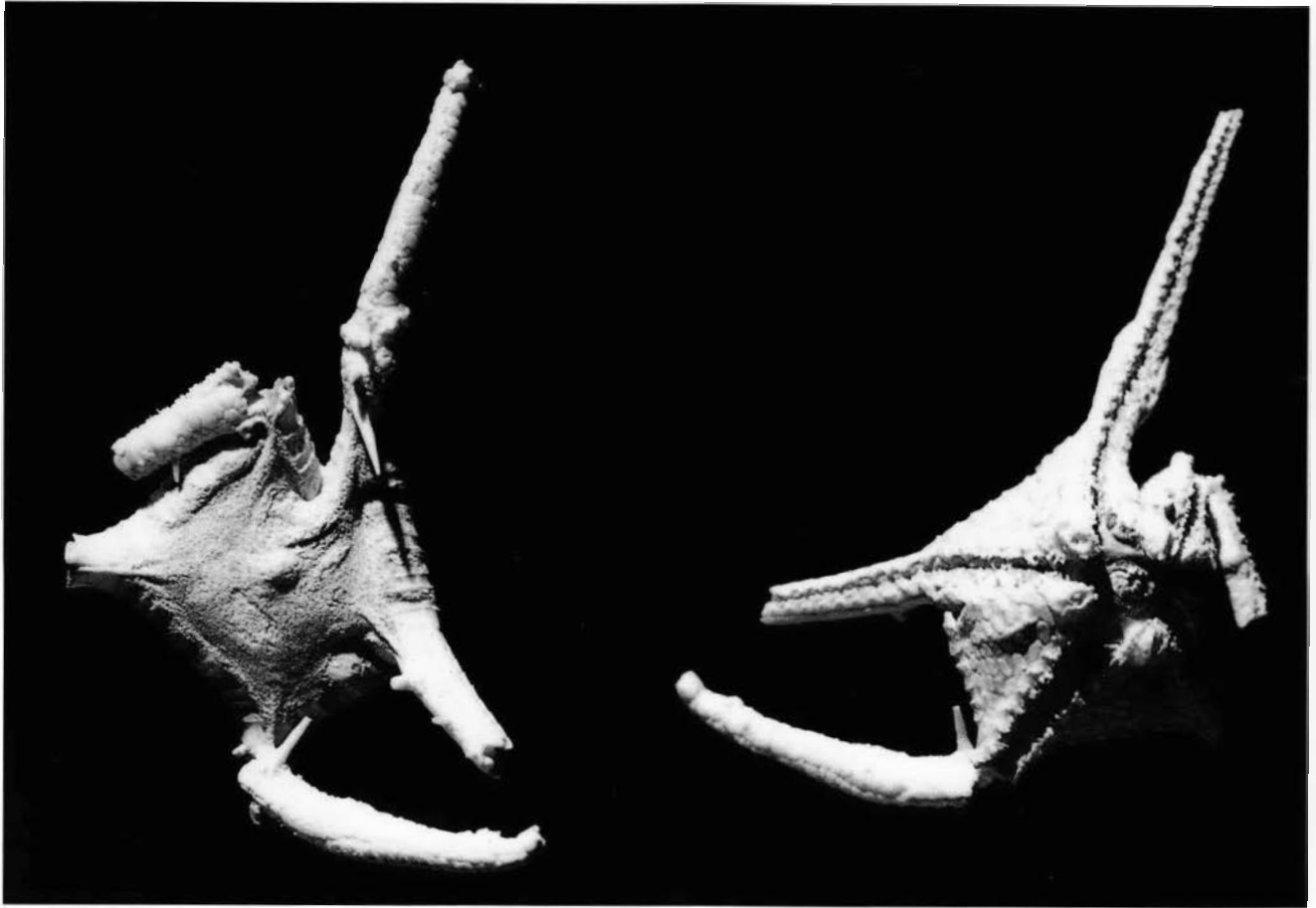


Plate 36. *Styracaster armatus* Sladen. NZOI Stn U196, R/r = approx. 43/10 mm. Abactinal and actinal surfaces.

angular, either well separated from each other or present in tracts or belts. Interradially, near superomarginals, plates bear a small simple, generally single, spine.

Centrally on the disc there appears to be a simple, flattened *epiproctal cone*. At the base of each arm is a distinct naked area closely paved with round or oblong plates.

*Superomarginals* are distinct, comprising seven from interradial angle to arm tip. Plates are sturdy, large, distinctly separated by shallow gutters, and form a complete casing to arms. Generally these plates meet with plates from opposite sides of arms, although on one arm there is a confusion of plates. In three arms there are indications of large *superomarginal spines* and, in all arms, on the last two superomarginals adjacent to terminal plates there is a small, single tapering, probably blunt-tipped spine present.

*Inferomarginals* mostly correspond with superomarginals; they are less than half the height, lack spines and are present right to the arm tip.

The three *cribriform organs* are small and narrow. In two interradia, on one side only, a fourth cribriform

organ is just seen; this is present only between superomarginal plates. Cribriform organs have 1–3 rows of lamelliform plates guarded by larger and distinct lateral spines.

*Actinal interradial areas* have a close pavement of small, irregularly shaped rough-textured plates with no spines.

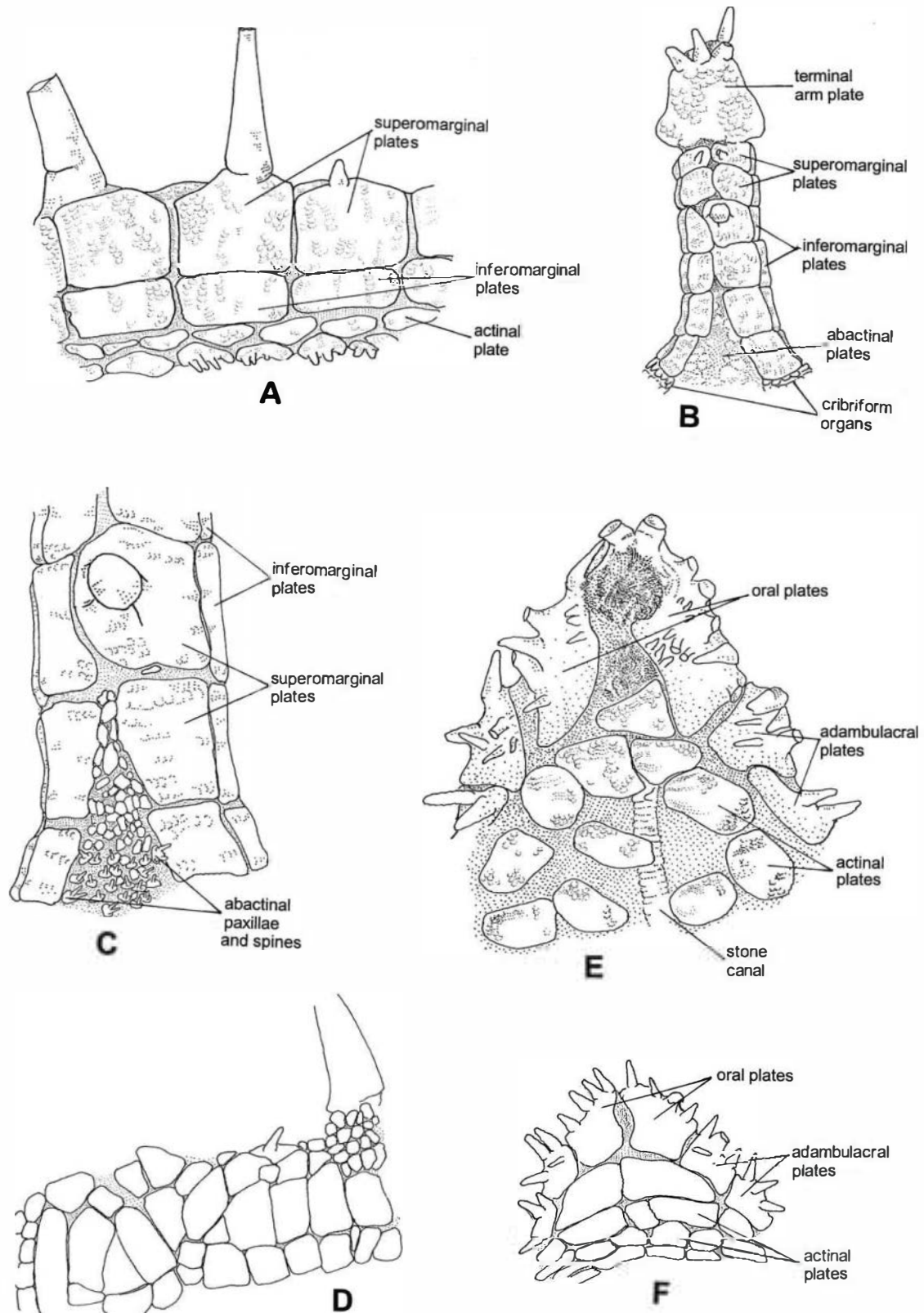
*Adambulacral plates* are oblong, well separated laterally, and separated from actinal plates by shallow, membranous gutters. The plates have an angular edge bordering the furrow. Three *adambulacral furrow spines* are present, of which the central is probably longest;

spines are hyaline, slightly flattened, and acute distally. They occupy almost the entire angular margin; only two are present near the arm tip. There are no *subambulacral spines*.

*Oral plates* meet proximally only; elsewhere they are separated by a wide membranous area. The 3 or 4 *furrow spines* are similar to those of adambulacrals. Proximally each plate bears a single, unpaired spine at its tip.

The *epistomial membrane* is constricted. *Tubefeet* are





**Fig. 35.** *Syracaster armatus* Sladen. NZOI Stn U196. **A.** Lateral view of portion of arm. **B.** Arm of smaller specimen, showing beginning of cribriform organs. Larger specimen **C**–**E**: **C.** Dorsal view of part of arm with details of abactinal plates. Note enlarged superomarginal spine. **D.** Confusion of plates on arm, probably the result of an injury. **E.** Interradial area. Note stone canal and irregular, spaced arrangement of actinal plates. **F.** actinal interradian area of smaller specimen.

biserial, somewhat obscured, short and squat, with no suckers.

This small specimen probably belongs in this species. The presence (at least in some interradial) of more than three cribriform organs, the entire superomarginal casing of the arms, and evidence of large arm spines, support this. The sparse covering of abactinal plates and spines may be a juvenile characteristic.

Madsen's (1981: 318) inclusion of *S. spinosus* in the synonymy of *S. armatus* highlights the importance of combinations of characters in this family.

### *Styracaster chuni* Ludwig, 1907

*Styracaster* sp. Ludwig in Chun, 1900: 491, fig.

*Styracaster chuni* Ludwig, 1907: 314; Lieberkind 1932: 276, figs 5–7, pls 1(3, 4), 4(2–6), 6(12–15); 1935: pl. 5(5, 5a); Madsen 1961: 113, figs 3, 20, pl. 10(3–5); Belyaev 1969b: 110; Cherbonnier & Sibuet 1973: 1341; Sibuet 1975: 284; 1980: 238, pl. 1(a); Madsen 1981: 319; A.M. Clark & Downey 1992: 103, fig. 19e.

*Styracaster chuni* var. *groenlandica* Lieberkind, 1935: 26, figs 9, 10, pls 1(1–3, 6), 3(13–16), 4(10–13), 5(6, 7).

MATERIAL EXAMINED: None.

SIZE: In seven specimens recorded by Madsen (1961: 114) from the Kermadec Trench  $R = 55\text{--}36$  mm,  $r = 17\text{--}12$  mm;  $R/r$  average = 47/15 mm.

DISTRIBUTION: Atlantic Ocean: Davis Strait (Lieberkind's var. *groenlandica*) and the Gulf of Guinea; Pacific Ocean: Kermadec Trench, northeast New Zealand.

DEPTH: 2250–4880 m.

DESCRIPTION: (Kermadec Trench material, adapted from Madsen 1961: 116).

Disc broad, rather flattened, clear cut. Arms short, completely encased by superomarginal plates. Terminal arm ossicles conspicuous with generally 3 large spines, forming a triangle.

Well-developed paxillae present on disc; paxillar spinelets generally 4–7, sometimes 8 or 9. Paxillae often crowded at disc centre; paxillar spinelets of similar height to paxillar shaft. Paxillae absent (in Kermadec Trench specimens) near entrance to arms where naked plates form a close-knit pavement.

Madsen's photograph (1961: pl. 10(3–5)) and his description do not record an epiproctal cone.

*Madreporite* circular, interradial, not very distinct.

*Marginal plates* form distinct edge to disc and encase arms. Generally, in arms superomarginal plates lie directly opposite each other; surface of plates smooth and plates join with opposite superomarginals at arm

base; 4–6 plates from interradial angle. Dorsal arm spines 2–5, long, slender, often slightly recurved towards disc. Inferomarginals with no spines, considerably smaller dorsoventrally, corresponding with superomarginals. Cribriform organs generally 5, occasionally 7, but where 7 occur, outer organs often rudimentary.

Actinal plates forming a distinct pavement, most regularly arranged near disc edge where they are closely crowded. Actinal plates generally naked, occasionally with small scattered spines or granules.

Adambulacral plates with 3 or 4 spines proximally; subambulacral spines may be present or plates may be completely naked. The presence of subambulacral spines seems typical of the species; they are sometimes absent on most proximal plates.

Oral plates with 4–6 marginal spines, often longest proximally; generally no suboral spines present.

Epistomial membrane distinct; tubefeet without suckers, in 2 rows.

COLOUR: No colour notes are recorded.

REMARKS: Madsen (1961: 117) regarded the pavement of naked plates at the entrance to the arms as an important specific character. In 1981, however, reporting on Pillsbury specimens from the Gulf of Guinea, he noted that several of his specimens have the whole abactinal surface covered by paxillae. There is no naked area at the arm base.

### *Styracaster horridus* Sladen, 1883 (Pl. 37, Fig. 36)

*Styracaster horridus* Sladen, 1883: 229; 1885: 612, fig. 203; 1889: 150, pls 23(5–7), 27(17–20); Koehler 1909a: 38; 1921: 2; Madsen 1951: 78, fig. 2; 1961: 93, figs 12–17, pls 7, 8; Belyaev 1969b: 110; H.E.S. Clark 1970: 15, fig. 1(e), pl. 1(g, h).

*Styracaster* sp. Ludwig in Chun, 1900: 228, fig.

*Chunaster scapanephorus* Ludwig, 1907: 316; Lieberkind 1932: 288, fig. 11, pls 1(7), 5(1–3), 6(16–18), 7(4); Madsen 1951: 80; A.M. Clark & Downey 1992: 104, fig. 19c, g, l.

MATERIAL EXAMINED: *Eltanin* Stn 1844 (1).

SIZE:  $R/r = 44/8$  mm.

DISTRIBUTION: Atlantic Ocean: Bay of Biscay to Gulf of Guinea; Indian Ocean: north of Madagascar, near Ceylon, and off Sumatra; Pacific Ocean: near New Zealand, the Kermadec Trench and west coast of South Island.

DEPTH: 2104–5610 m.



**DESCRIPTION:** Description of damaged specimen from *Eltanin* Stn 1844, R/r 44/8 mm; the arms are broken and the disc distorted.

*Disc* broad, rather flat, very distinct. *Arms* 5, long, slender, completely encased by marginal plates from fourth or fifth superomarginal plate, superomarginals along arms with single long, sturdy tapering spines, 9 or 10 present from beginning of arm to tip. Spines almost oval in cross section, generally borne dorsally at junction of 2 plates or sometimes on alternate plates. First spines in series largest, with a tendency to bend in direction of disc; smallest spines towards arm tips. 2 terminal arm plates remain, large, conspicuous, almost pear-shaped, with 3 large spines; the largest unpaired spine leaves a large circular scar.

*Disc* and entrance to arms with numerous small, closely packed, very even *paxillae* in very regular rows, especially near disc edge and entrance to arms; with 3–7 (often 4) very short, blunt-headed, club-shaped spines, these borne on a short trunk; spines and trunk subequal in length. No naked plates at entrance to arms. Centrally on disc a short, rather amorphous *epiproctal cone*.

*Madreporite* convex, oval, strongly and finely dissected, separated from marginal plates by 2 or 3 rows of abactinal *paxillae*. It is not very obvious, being obscured by a fold of the disc.

*Marginal plates* forming very distinct edge to disc and arm, very slightly raised above level of disc *paxillae*. Plates fairly smooth, almost porcellanous, oblong, regularly arranged, 17–19 from interradial angle to arm tip. *Superomarginal spines* large, upright, in a single row along arm centre, spines varying in size and mostly broken. Last 2 or 3 plates at arm tips lack spines.

*Inferomarginals* corresponding closely to superomarginals; along arms inferomarginals are narrow, smaller, half depth of superomarginals, smooth, lacking spines.

*Cribriform organs* 7, occasionally 8, in each interradius, consisting of 8–11 rows of small, upright, very regularly arranged spinelets; spinelets larger laterally, flattened.

*Actinal areas* with small, isolated, oval plates centrally; near disc edge plates rectangular, more closely fitting. Actinal plates present for about three-quarters length of each arm small, naked, almost triangular, often isolated, with 1, 2 or occasionally 4 or 5 very tiny round-headed spines or granules; where 2 are present they are generally at opposite ends of plate. *Stone canal* visible in 1 interradius, actinal plates here more numerous, more regularly arranged.

*Adambulacral plates* almost boat or banana-shaped, making a regular raised border along furrows, actinal margin of plates also gently raised, forming a quite

conspicuous angular edge to plate. Proximally, plates bear 5 small furrow spines, distal plates with 4; most aboral spine conspicuously longer, acute, hyaline at tip, most obvious in last half of arms. Small *furrow spines* rather flattened, broad, leaf-like, acute, occupying angular fold of plate; occasionally small, indistinct subambulacral granules or small spines on adoral edge of plate, most obvious on proximal plates. Plates separated laterally from one another by distinct membranous areas. No obvious segmental pits or papillae present.

*Oral plates* large, conspicuous, tumid, members of a pair separated along their length; conspicuous triangular plate present at base of 2 plates. *Furrow spines* 6 or 7, small, flat, leaf-like, similar to adambulacral furrow spines, very finely thorny, as is lower part of oral plate.

*Epistomial membrane* hidden.

*Ambulacral grooves* deep, *tubefeet* in 2 rows, no suckers.

**COLOUR:** There are no colour notes of living material. Dried and ex-alcohol, they are largely white with cribriform organs pale golden-brown, and actinal membrane and tube feet dark brown.

**REMARKS:** Members of the Porcellanasteridae are exceedingly variable as literature and illustrations show. In some cases (e.g., *Porcellanaster ceruleus*) variations and even combinations are not necessarily seen as constituting different species. However, in *Styracaster*, the opposite seems true and characters used in defining the species often seem very slender and nebulous. With more material, many of these characters are being recognised as merely specific variations as Madsen (1981: 318) shows by synonymising *Styracaster spinosus* with *S. armatus*. It is probable that further synonymies will arise in *Styracaster*, thus reducing the number of species.

## DISCUSSION

### ABUNDANCE

Within the study area, 24–57.5° S latitude, 159° E–167° W longitude, the order Paxillosida is represented by 4 families, 15 genera, and 38 species. The Astropectinidae has the most species (62%) and distributional records (84%), while the Radiasteridae has only 5% of the species and 2 station records.

The Luidiidae has 9% of the station records (5 species) and the Porcellanasteridae 4% of the records (7 species). Of the 38 species 26 are rare, with only <10 records; 5 species are uncommon (15–34 records); 6 are

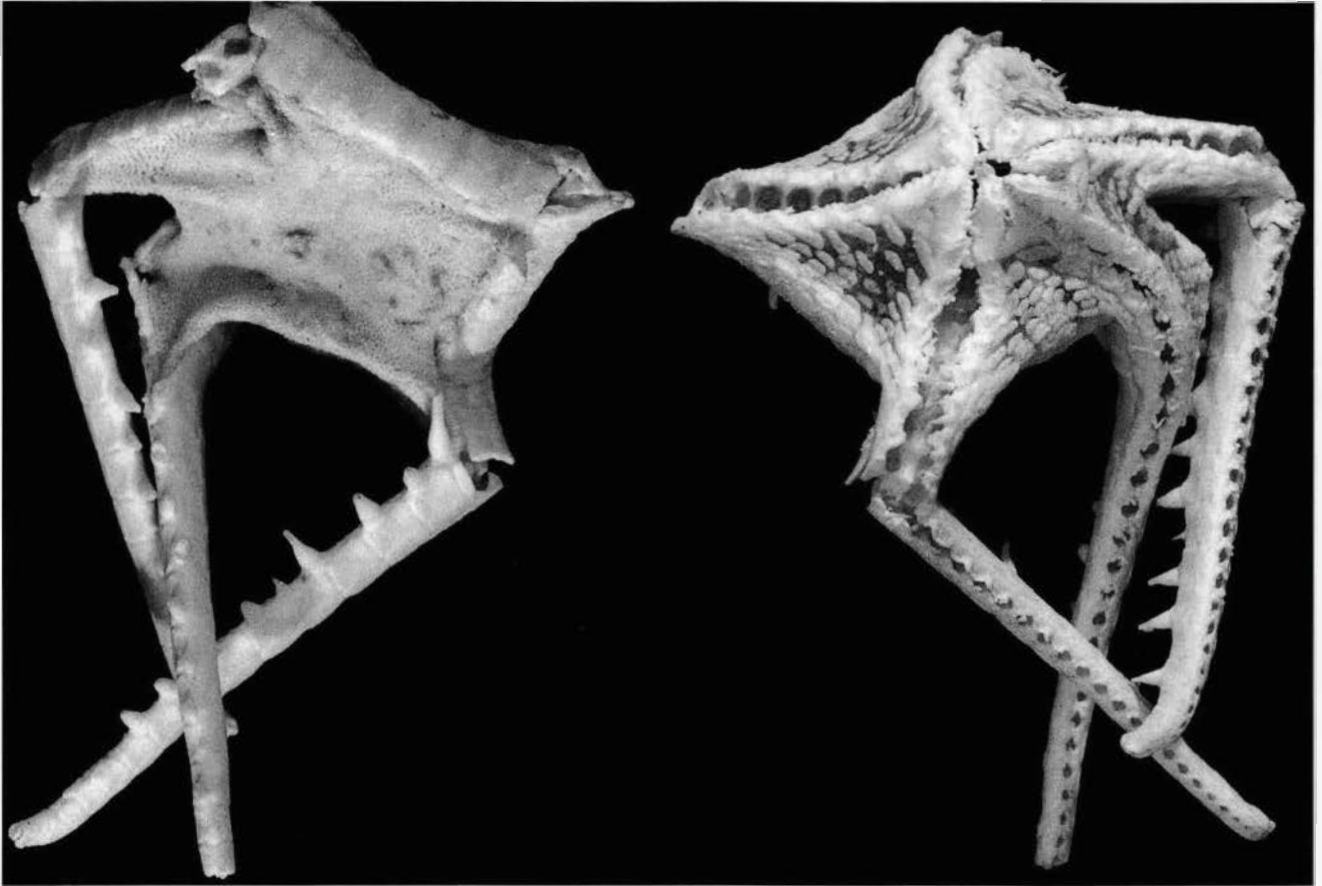


Plate 37. *Styracaster horridus* Sladen. *Eltanin* Stn 1844. R/r = 44/8 mm. Abactinal and actinal surfaces.

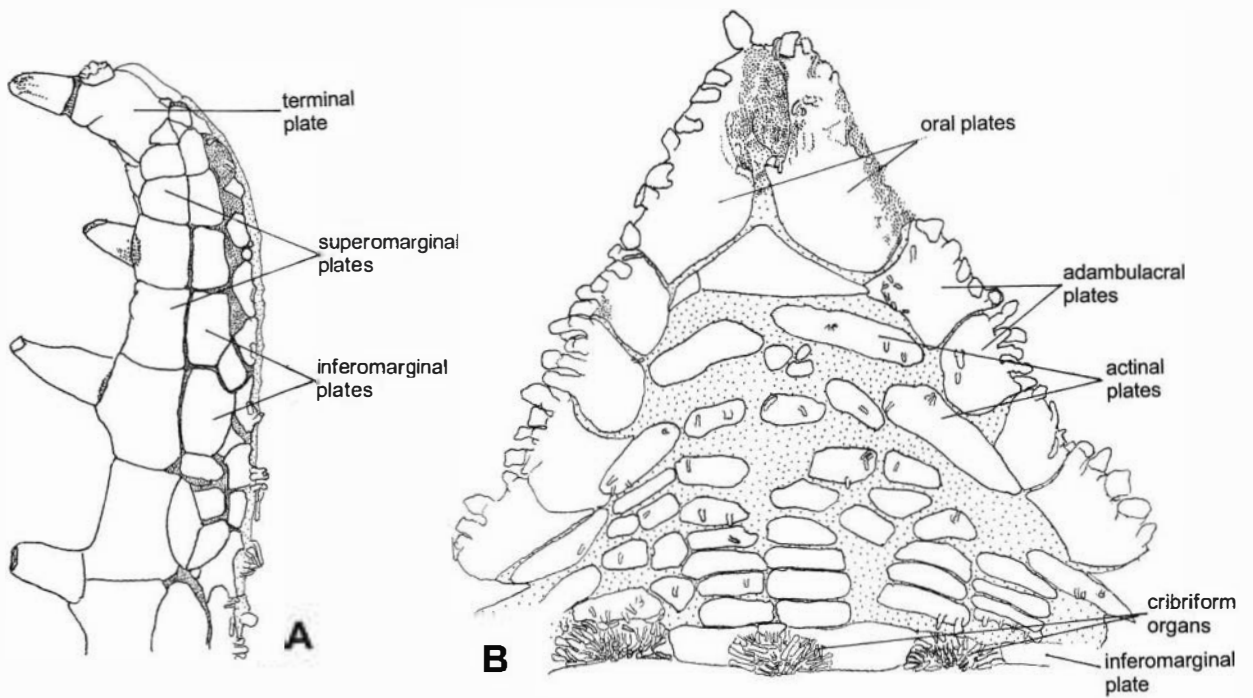


Fig. 36. *Styracaster horridus* Sladen. *Eltanin* Stn 1844. A. Lateral view of arm. Note the large unpaired spine on the terminal plate. B. Interradius with oral, adambulacral, actinal, and inferomarginal plates and cribriform organs.



relatively common (67–116 records) while only one species can be considered abundant with >400 records.

#### Rare

<i>Astropecten celebensis</i>	<i>Astropecten monacanthus</i>
<i>Astropecten</i> sp.	<i>Astropecten dubiosus</i>
<i>Astropecten tasmanicus</i>	<i>Astromesites regis</i>
<i>Astromesites compactus</i>	<i>Plutonaster</i> sp. A
<i>Plutonaster hikurangi</i>	<i>Plutonaster complexus</i>
<i>Plutonaster jonathoni</i>	<i>Dytaster felli</i>
<i>Dytaster pedicellaris</i>	<i>Tethyaster tangaroae</i>
? <i>Proserpinaster</i> sp.	<i>Luidia moroisoana</i>
<i>Luidia hardwickii</i>	<i>Luidia prionota</i>
<i>Radiaster rowei</i>	<i>Styracaster armatus</i>
<i>Styracaster chuni</i>	<i>Eremicaster vicinus</i>
<i>Hyphalaster inermis</i>	<i>Styracaster horridus</i>
<i>Damnaster tasmani</i>	<i>Psilaster charcoti</i>

#### Uncommon

<i>Plutonaster fragilis</i>	<i>Luidia maculata</i>
<i>Radiaster gracilis</i>	<i>Plutonaster</i> sp. B
<i>Porcellanaster ceruleus</i>	

#### Common

<i>Dipsacaster magnificus</i>	<i>Plutonaster knoxi</i>
<i>Proserpinaster neozelanicus</i>	<i>Luidia neozelanica</i>
<i>Astropecten polyacanthus</i>	<i>Astromesites primigenius</i>

#### Abundant

*Psilaster acuminatus*

### BATHYMETRIC DISTRIBUTION

Within the study area, specimens of the Paxillosida have been collected from depths of 0–6730 m. Three families are known from less than 200 m, the exception being the Porcellanasteridae with a minimum depth of 1222 m. The Luidiidae have the smallest total depth range, 0–898 m, followed by the Radiasteridae, 128–1568 m. The Astropectinidae range from the continental shelf to relatively deep water, 0–3118 m, while the Porcellanasteridae extend into the hadal zone, in excess of 6000 m.

Eight species are more or less restricted to the continental shelf, with at least 60% of their records from less than 200 m depth.

*Astropecten monacanthus*  
*Astropecten dubiosus*  
*Astropecten polyacanthus*  
*Astromesites primigenius*  
*Luidia hardwickii*  
*Luidia prionota*  
*Luidia maculata*  
*Luidia neozelanica*

Of the remainder, no species has more than 16% of its records on the continental shelf. Five species have at least 60% of their records in the range 200–500 m.

*Astropecten celebensis*  
*Astromesites compactus*  
*Proserpinaster neozelanicus*  
*Tethyaster tangaroae*  
*Luidia moroisoana*

A further four species are restricted to the range 500–1000 m.

*Astropecten tasmanicus*  
*Astromesites regis*  
 ? *Proserpinaster* sp.  
*Plutonaster jonathani*

Ten species have at least 60% of their records in the range 1000–3000 m.

<i>Astropecten</i> sp.	<i>Plutonaster fragilis</i>
<i>Plutonaster complexus</i>	<i>Plutonaster hikurangi</i>
<i>Plutonaster</i> sp.	<i>Dytaster felli</i>
<i>Dytaster pedicellaris</i>	<i>Radiaster rowei</i>
<i>Porcellanaster ceruleus</i>	<i>Hyphalaster inermis</i>

Five species have at least 60% of their records from depths greater than 3000 m.

*Eremicaster vicinus*  
*Styracaster horridus*  
*Damnaster tasmani*  
*Styracaster armatus*  
*Styracaster chuni*

Finally, there are a further five species with relatively extensive ranges —

*Dipsacaster magnificus*  
*Psilaster acuminatus*  
*Plutonaster knoxi*  
*Plutonaster* sp.  
*Radiaster gracilis*

### GEOGRAPHIC DISTRIBUTION

Paxillosid sea-stars are recorded from latitudes 24° to 53° South; some 12 species have a range of only 1 degree, and 20 species have a range of less than 7 degrees. Sixteen species have ranges between 11 and 18 degrees, while only one species has a greater range (*Psilaster acuminatus*, 27 degrees.)

Three zones of latitude are used in describing geographic distributions: Northern 24–36° S; Central 36–42° S; Southern 42–53° S.

#### Northern Species

Fifteen species are distinctly northern in known

distribution; all but one have at least 67% of their records north of 36° S. Six are known between 24° and 30° S latitude —

*Astropecten celebensis*  
*Astropecten monacanthus*  
*Astropecten* sp.  
*Tethyaster tangaroae*  
*Luidia moroisoana*  
*Luidia hardwickii*

Five species occur between latitudes 29° and 33° S.

*Luidia prionota*  
*Astromesites regis*  
*Styracaster armatus*  
*Plutonaster* sp.  
*Astropecten tasmanicus*

Three species occur between latitudes 34° and 37° S.

*Astromesites compactus*  
*Astropecten dubiosus*  
*Dytaster felli*

One species has a wider range, 28–38° S, with 48% of the records north of 36° S.

*Astropecten polyacanthus*

### Central Species

Eight species are thought to be more or less central; three are known only between latitudes 36° and 42° S;

*Plutonaster hikurangi*  
*Hyphalaster inermis*  
*Styracaster chuni*

and three have at least 67% of their records from this range.

*Luidia maculata*  
*Luidia neozelanica*  
*Styracaster horridus*

One species is evenly distributed throughout the sampled area;

*Eremicaster vicinus*

and one, with five records, is known only from northern and southern stations.

*Plutonaster complexus*

### Southern Species

Fourteen species appear southern in distribution, with at least 50% of their records south of 42° S, although most are quite wide ranging. Six species occur in the north and to the south.

*Plutonaster* sp. A

*Proserpinaster neozelanicus*  
*Psilaster acuminatus*  
*Damnaster tasmani*  
*Dytaster pedicellaris*  
*Porcellanaster ceruleus*

Five species are present between 36° and 42° S, but have at least 67% of their records south of 42° S.

*Plutonaster knoxi*  
*Plutonaster fragilis*  
*Radiaster gracilis*  
*Astromesites primigenius*  
*Dipsacaster magnificus*

Three species are known only from south of 42°.

? *Proserpinaster* sp.  
*Radiaster rowei*  
*Plutonaster jonathani*

### EXTERNAL RELATIONSHIPS

Some 49% of the species are not known from outside the New Zealand area. All but one are in the Astropectinidae, the exception is in the Radiasteridae; no species of Luidiidae or Porcellanasteridae are endemic. Eleven species are shared with Australia.

*Astropecten monacanthus*  
*Astropecten polyacanthus*  
*Astromesites compactus*  
*Dipsacaster magnificus*  
*Psilaster acuminatus*  
*Luidia hardwickii*  
*Luidia maculata*  
*Luidia moroisoana*  
*Luidia neozelanica*  
*Luidia prionota*  
*Radiaster gracilis*

One species is shared with Southern Africa.

*Psilaster acuminatus*

Eight species are more widely distributed in the Pacific and Indian Oceans.

*Astropecten celebensis*  
*Astropecten monacanthus*  
*Astropecten polyacanthus*  
*Astromesites compactus*  
*Luidia hardwickii*  
*Luidia maculata*  
*Luidia moroisoana*  
*Luidia prionota*

Species of the Porcellanasteridae differ, with all widespread in deep water. Four major patterns of distribution are evident.



Endemic species, 49% of the fauna —

*Astropecten dubiosus*  
*Astropecten* sp.  
*Astropecten tasmanicus*  
*Astromesites primigenius*  
*Astromesites regis*  
*Dytaster felli*  
*Dytaster pedicellaris*  
*Plutonaster* spp.  
*Plutonaster complexus*  
*Plutonaster fragilis*  
*Plutonaster hikurangi*  
*Plutonaster jonathani*  
*Plutonaster knoxi*  
*Proserpinaster neozelanicus*  
 ? *Proserpinaster* sp.  
*Tethyaster tangaroae*  
*Radiaster rowei*

Southern, partially circumpolar, species, 14% of the fauna —

*Dipsacaster magnificus*  
*Psilaster acuminatus*  
*Luidia neozelanica*  
*Radiaster gracilis*  
*Dammaster tasmani*

Widespread Indo-West Pacific species, 22% of the fauna —

*Astropecten celebensis*  
*Astropecten monacanthus*  
*Astropecten polyacanthus*  
*Astromesites compactus*  
*Luidia hardwickii*  
*Luidia maculata*  
*Luidia moroisoana*  
*Luidia prionota*

Widespread deep-water species, present in the Atlantic and Pacific Oceans, sometimes also the Indian Ocean, 16% of the fauna —

*Eremicaster vicinus*  
*Hyphalaster inermis*  
*Porcellanaster ceruleus*  
*Styracaster armatus*  
*Styracaster chuni*  
*Styracaster horridus*

Table 1  
 Abundance, depth, and geographic ranges.

	No. of records	Depth (m)	Latitude (° S)	
<b>Astropectinidae</b>				
<i>Astropecten celebensis</i>	1	394	29	
<i>Astropecten dubiosus</i>	7	53–260	34–37	
<i>Astropecten monacanthus</i>	1	52	24	
<i>Astropecten polyacanthus</i>	105	0–135	28–38	
<i>Astropecten</i> sp.	1	1189–1226	29	
<i>Astropecten tasmanicus</i>	9	610–830	31–33	
<i>Dipsacaster magnificus</i>	67	110–685	38–53	
<i>Astromesites compactus</i>	5	?–540	34–36	
<i>Astromesites primigenius</i>	116	55–770	36–51	
<i>Astromesites regis</i>	1	944–946	34	
<i>Dytaster felli</i>	3	2250–3118	33–37	
<i>Dytaster pedicellaris</i>	3	1137–2677	31–42	
<i>Plutonaster</i> sp. B	34	55–2476	33–47	
<i>Plutonaster</i> sp. A	1	1828	31	
<i>Plutonaster complexus</i>	5	1186–2460	34–51	
<i>Plutonaster fragilis</i>	15	35–2250	37–49	
<i>Plutonaster hikurangi</i>	1	1920	40	
<i>Plutonaster jonathani</i>	2	934–990	44–49	
<i>Plutonaster knoxi</i>	76	59–1915	37–47	
<i>Proserpinaster neozelanicus</i>	77	55–1693	34–44	
? <i>Proserpinaster</i> sp.	1	812	47	
<i>Psilaster acuminatus</i>	453	0–2519	27–53	
<i>Psilaster charcoti</i>	1	25–29	54	
<i>Tethyaster tangaroae</i>	3	306–423	26–28	
<b>Luidiidae</b>				
<i>Luidia hardwicki</i>	1	165	30	
<i>Luidia maculata</i>	19	0–512	31–46	
<i>Luidia moroisoana</i>	2	291–308	24–29	
<i>Luidia neozelanica</i>	85	58–898	34–46	
<i>Luidia prionota</i>	4	?95–122	?29–32	
<b>Radiasteridae</b>				
<i>Radiaster gracilis</i>	22	128–914	37–49	
<i>Radiaster rowei</i>	1	1568	42	
<b>Porcellanasteridae</b>				
<i>Dammaster tasmani</i>	4	1647–4714	35–46	
<i>Eremicaster vicinus</i>	3	2104–6730	32–46	
<i>Hyphalaster inermis</i>	3	2505–4540	36	
<i>Porcellanaster ceruleus</i>	34	1222–4670	35–46	
<i>Styracaster armatus</i>	1	3120	33	
<i>Styracaster chuni</i>	2	4410–4570	36	
<i>Styracaster horridus</i>	3	2104–4540	36–46	
Species				
<b>Astropectinidae</b>	24	987	0–3118	24–53
<b>Luidiidae</b>	5	111	0–898	24–46
<b>Radiasteridae</b>	2	23	128–1568	37–49
<b>Porcellanasteridae</b>	7	51	1222–6730	32–46

## Order NOTOMYOTIDA

### Family BENTHOPECTINIDAE Verrill, 1894

The cosmopolitan family Benthopectinidae comprises eight genera, three of which are recorded herein. This sole family in the order Notomyotida is distinguished from other asteroids by the following combination of character states: disc small, arms long and slender; tubefeet terminating in a disc; and infero- and supero-marginal plates alternating in position, not opposite; papulae confined to base of ray.

**DIAGNOSIS:** Marginal plates alternating in position along the ray. Arms long and pointed, actinal areas small to moderate in size, more or less confined to the arm base. Interradial arcs rounded or with a blunt angle. Terminal plates small and inconspicuous. Abactinal plates small and flattened, with 1 or more spinelets or spines; or low, paxilliform, with a denser armament. Papulae restricted to a small area at arm base. Marginal plates tending to alternate in position along the arm, superomarginals mainly lateral in position and inconspicuous from above. Superomarginals usually with a single prominent spine, horizontally placed, the inferomarginals with a similar spine and also with 1 or more accessory spines. Pedicellariae are fasciculate or pectinate, i.e., shared between 2 or more plates. Tubefeet with distinct sucking discs.

#### TABULAR CHECKLIST TO GENERA OF BENTHOPECTINIDAE IN NEW ZEALAND WATERS

	1	2	3	4
<i>Benthopecten</i>	yes	no	n	p
<i>Cheiraster</i>	no	yes	b	p
<i>Pectinaster</i>	no	yes	a	f

- 1 An unpaired interradian marginal plate present in both series
- 2 Papulae in a distinctly limited area at arm base
- 3 Papularium
  - a – swollen, ovate, limited in extent
  - b – flat, bilobate, limited in extent
  - n – flat, extends over disc and arm base

	1	2	3	4	5	6
<i>Benthopecten</i>						
<i>munidae</i>	7–8	21	no	1/3–5	5–7/2	10–12/5–6
<i>pikai</i>	4–5	25	yes	1/2	5–7/2	7–8/6
<i>pentacanthus*</i>	?	?	?	(1) 2/1 (3)	2(3)/2	4/2

\* From Fell (1958)

- 4 Pedicellariae
  - f – fasciculate
  - p – pectinate

### *Benthopecten* Verrill, 1884

Unpaired interradian marginal plates in both series, superomarginals usually inserted on disc; marginal plates with 1 or more erect spines, often also accessory spines or spinules; abactinal plates flat to convex, with spinelets and sometimes enlarged spines; papulae often scattered over disc and proximal part of arm, usually extending further at edge of arm; 1–3 enlarged subambulacral spines; pedicellariae when present pectinate.

TYPE SPECIES: *Benthopecten spinosus* Verrill, 1884.

#### TABULAR CHECKLIST TO SPECIES OF *BENTHOPECTEN* RECORDED FROM NEW ZEALAND

- 1 Abactinal plate flat, with
  - a – small spinelet
  - b – convex at least proximally, larger with 1+ spines and usually 1+ spinelets
- 2 Marginal plates definitely alternating: yes/no
- 3 Papulae extend to paired superomarginal number
- 4 Adambulacrals to first 10 inferomarginals
- 5 Marginals longer than wide: yes/no
- 6 Superomarginal and inferomarginal spines

### *Benthopecten munidae* H.E.S. Clark, 1969 (Pls 38, 39; Fig. 37)

*Benthopecten munidae* H.E.S. Clark, 1969: 86, pl. 1(C, D); A.M. Clark 1981: 29, table 9.

#### MATERIAL EXAMINED:

NZOI Stns: A917(1), D149(1), D175(3), D207(1), D232(1), D899(1), D906(2), E79(1), E40(2), F10(2), G259(1), G290(1), G307(3), G886(5), G895(1), I707(2), J483 (fragments), J550(3), Q16(1), Q17(1), Q342(2), S22(2), S25(2), S28(6), V373(1); U227(1).



SIZE: R/r = 93/11 mm to 18/4 mm.

DISTRIBUTION: Known from central and southern New Zealand, and to the south on the Campbell Plateau and Bounty Platform.

DEPTH: 203–622 m.

DESCRIPTION: The study specimen from NZOI Stn D899, R/r = 93/11 mm, br = 10 mm, is described.

Outline stellate, with angular interbranchial arcs, 5 slowly tapering sharply pointed rays. Abactinal and actinal surfaces flat, margin vertical. Arms may be recurved distally. Thin skin covers abactinal plates of disc and proximal part of arms, and tends to obscure plate outlines.

*Abactinal plates* tumid, in 2 sizes on disc, the larger weakly lobate and smaller, simply ovoid. On arms, larger plates present to about level of 4th paired superomarginal, all plates almost of the same size beyond. Towards arm tip plates are lower, slightly spaced apart, and membrane is much thinner, so that plate outlines are distinct. Among the larger disc plates, primaries are not readily identifiable; most disc plates have a single pointed spine, rarely 2 or 3, up to 3 mm, long, although size appears roughly correlated with size of plate. At base of each is a cirlet of small spinules. Some smaller plates lack central spine. *Plates of arms* similarly armoured, although spines and spinelets are smaller distally.

*Papulae* set around margins of abactinal plates, with up to 6 around larger plates. Papulae absent from a small area at centre of disc and extend along arms to opposite 8th paired superomarginal. Proximally, papulae extend across arm to superomarginals, but distally are absent from edges of abactinal area.

*Madrepore* tumid, rounded, 3 mm diameter, placed about one-third r from margin. Sculpture coarse and radiate.

*Anal aperture* small, more or less centrally placed.

Unpaired *superomarginal plates* conspicuous in abactinal view, slightly raised above abactinal surface. Paired superomarginals in abactinal view about as wide as long or wider, encroaching onto abactinal surface and markedly convex on outer face. In lateral view, plates are higher than long, strongly tumid. Unpaired superomarginal with an erect central spine, sometimes 2, about 5 mm long, these usually longest on specimen. Paired superomarginals with a single spine close to edge of abactinal surface, with a few spinelets encircling inner margin at base. On lateral face of plate, below major spine, are 10 or more elongate spinules in 1 or 2 rows, extending down towards lower margin. Lower part of plate with a covering of spaced small “prickles”.

*Inferomarginal plates* alternating with superomarginals, markedly tumid, wider than long in actinal view, and as high as long or higher in lateral view. Unpaired inferomarginal relatively broad in actinal view. Inferomarginals with a vertical row of 3–5 slender spines, up to 4 mm long. These noticeably more slender than major superomarginal spine. Plates with smaller spinelets at bases of spinules and “prickles” at margins.

A single series of ovoid *actinal plates*, extending to 4th adambulacral plate or first paired inferomarginal. Plates with 1 or 2 spines, often 1 comb of a pectinate pedicellaria, with up to 10 short curving spinelets; 1 or 2 such pedicellariae in each interradius.

*Adambulacral plates* as wide as long, with a curved furrow margin; 5–7 short furrow spines, with smaller proximal and distal spines. A few small spinelets also on outer margin of plate. Usually 2 larger subambulacral spines set in a longiseries, or oblique transverse series.

*Oral plates* tumid, quite conspicuous, with 10–12 furrow spines, proximal 2 or 3 which face over actinosome being much stronger. On actinal face 5 or 6 suboral spines loosely arranged in a longiseries, near median suture.

*Tube feet* biserial throughout the ray, with distinct sucking-discs.

COLOUR: Specimens in alcohol are dull brown. In life the abactinal surface is scarlet, turning to pink in the distal third of arm. Marginal and larger disc spines are white as is the actinal surface of recurved arm tips.

REMARKS: NZOI Stn S28 yielded small specimens, which show the marginal form as in the adult. The smallest is R/r = 18/4 mm. Major abactinal spines are rare, and papulae extend to the 4th paired superomarginals. There are two or three actinals at the base of each arm, lacking pedicellariae; adambulacrals have four or five furrow and two subambulacral spines; orals with seven furrow and five suboral spines; superomarginals have one spine, and inferomarginals have three. At R about 60 mm, r 9 mm, major disc spines are present, and papulae extend to paired superomarginal 6–7; 2–4 actinals have pedicellariae.

A specimen from NZOI Stn D175 has two superomarginal spines on most distal plates and occasional pedicellariae between the inferomarginal plates; in other respects it is referable to *B. mumidae*.

*Benthopecten pentacanthus* Fell, 1958

*Benthopecten pentacanthus* Fell, 1958: 6, pl 1(D, E).

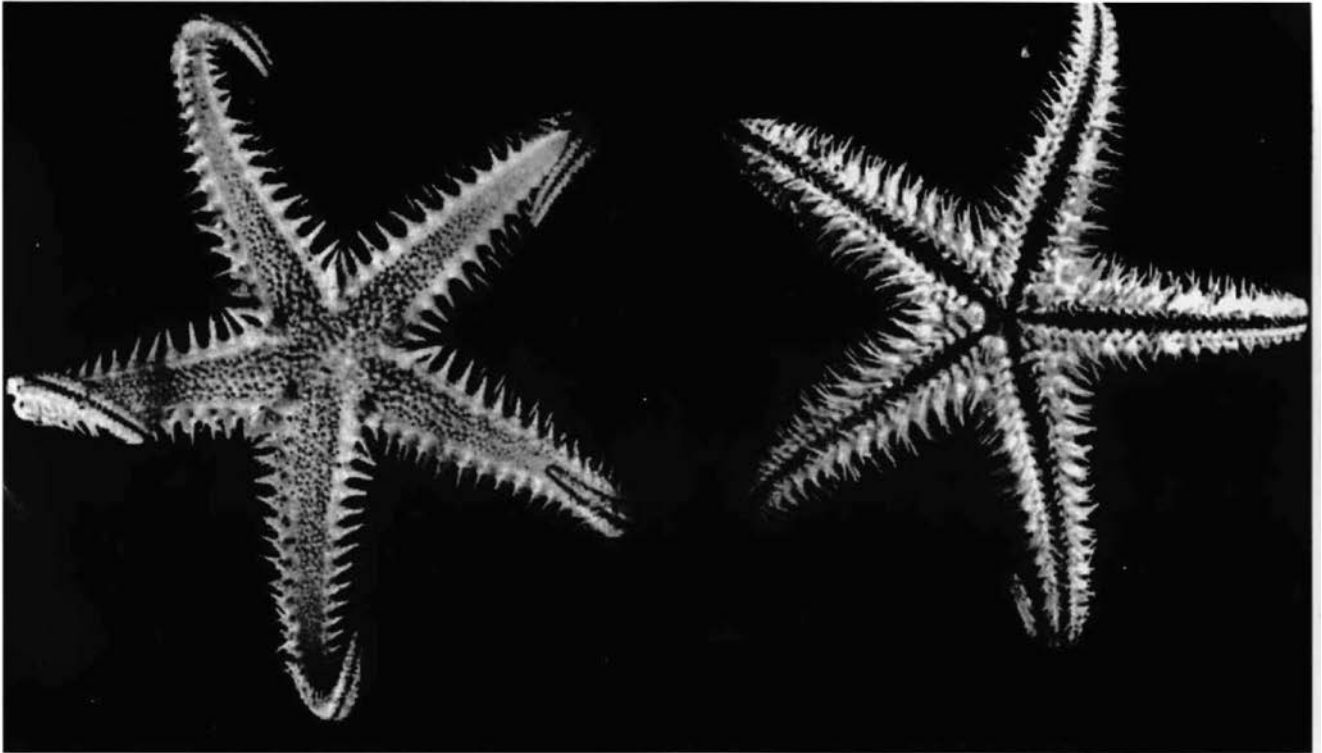


Plate 38. *Benthopecten munidae* H.E.S. Clark. Holotype. Abactinal and actinal surfaces (from H.E.S. Clark 1969).

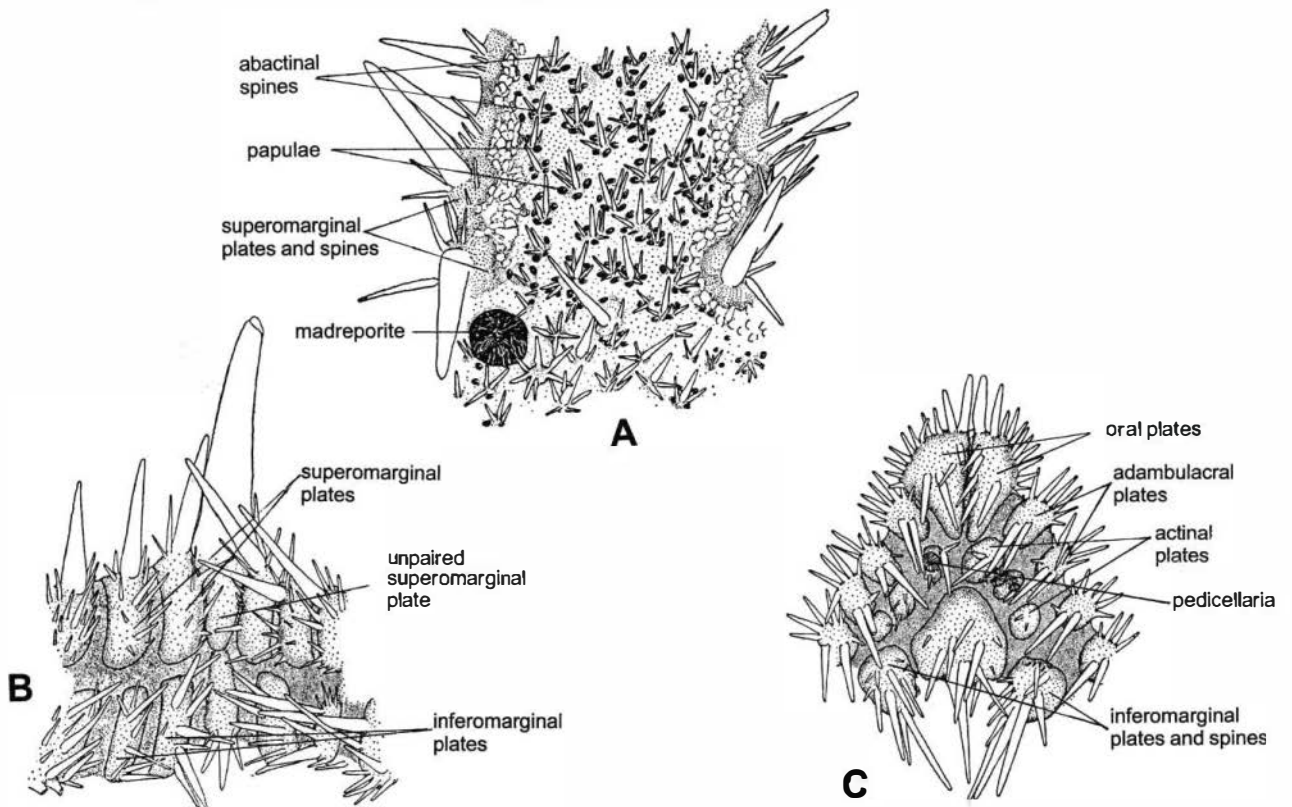


Fig. 37. *Benthopecten munidae* H.E.S. Clark. Holotype. A. Arm, near interradius, showing madreporite, superomarginal plates and spines, abactinal plates (outlines mostly hidden by membrane), and spines and papulae. B. Marginal plates, showing centrally, the unpaired row of marginal plates. C. Interradial angle showing oral, adambulacral, actinal, and inferomarginal plates; note pedicellariae (from H.E.S. Clark 1969).



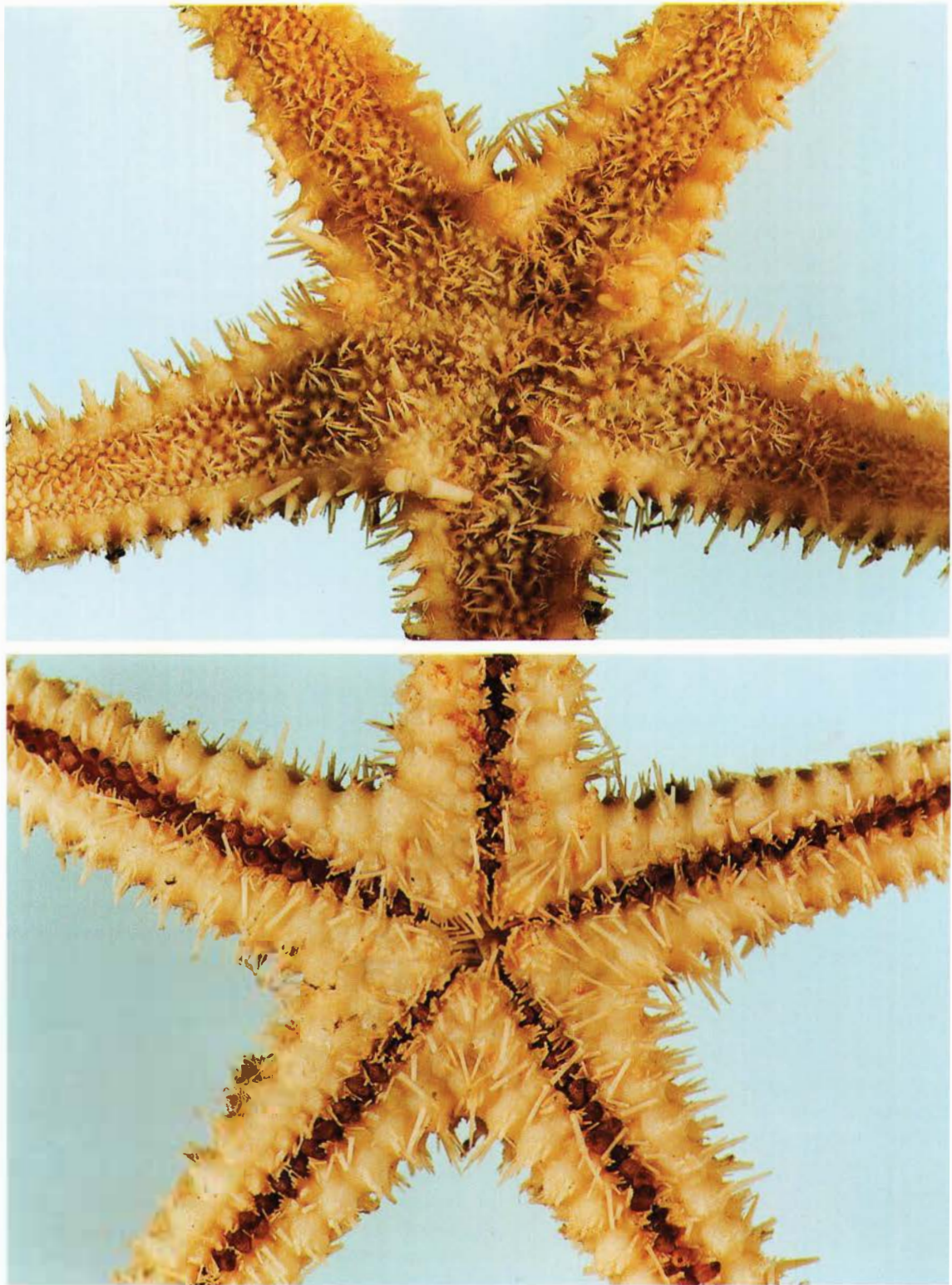


Plate 39. *Benthopecten munidae* H.E.S. Clark. NZOI Stn D899, R/r = 93/11 mm. Abactinal and actinal surfaces.

MATERIAL EXAMINED: Nil.

SIZE: Species is based on juvenile specimens, with the holotype,  $R/r = 5/2$  mm.

DISTRIBUTION: This species was recorded from one station in the Bay of Plenty, North Island, New Zealand.

DEPTH: 732 m.

REMARKS: Distinctive features are: 2 superomarginal spines, 1 inferomarginal, with 2 smaller above. Adambulacra with 3 furrow, and 2 subambulacra; orals with 4 furrow and 2 suboral. However, the figures suggest 1 superomarginal, and 2 or 3 adambulacral furrow spines. Superomarginals appear to encroach onto abactinal surface.

It is not possible to refer any of the small specimens examined to this species. One suspects they could be the juvenile form of *B. pikei* or *B. munidae*, but the descriptions and figures preclude the likelihood.

*Benthopecten pikei* H.E.S. Clark, 1969  
(Pls 40, 41; Fig. 38)

*Benthopecten pikei* H.E.S. Clark, 1969: 83, pl. i(A, B); A.M. Clark, 1981: 29, table 9.

*Benthopecten pikei* var. *australis* H.E.S. Clark, 1970: 15, pl. 1 (i, j)

MATERIAL EXAMINED:

NZOI Stns: D85(1), D211(3), E72(2), E120(2), E748(10), E776(1), E783(2), F107(2), F754(3), G700(1), G703(1), G916(1), I21(1), I25(1), I366(2), I672(1), I679(1), J550(1), P666(1), P667(1), P941(6), P942(1), S16(2), S43(4), S66(1), S130(1), S150(4), S15(10), S152(2), S153(2), S215(1), S377(2), S378(4), U194(1), U197(1), U198(5), V370(2), V376(3).

SIZE:  $R/r = 150$  (est.)/17 mm to 12/4 mm.

DISTRIBUTION: This species is the commonest species of *Benthopecten* in the New Zealand region, with records covering the area between 34° and 53° S latitude; three records are from north of New Zealand, all on the Lord Howe Rise; most records are from the New Zealand continental slope, especially the Chatham Rise; to the south, records are from the Campbell Plateau and Bounty Platform.

DEPTH RANGE: 327-1815 m.

DESCRIPTION: The study specimen from NZOI Stn E72,  $R/r = 150$  (est.)/18 mm, br = 17 mm, is described.

Outline stellate, with 5 arms, gently tapering, and sharply pointed; arm tips recurved; interradial arcs

rounded, abactinal surface flat with more or less vertical margins. Actinal surface flat, actinosome not sunken.

*Abactinal plates* of disc and proximal part of arms strongly convex and lobate, except at centre of disc where they are ovoid and abutting. Beyond proximal quarter of arm abactinal plates are smaller, lower, ovoid, and abutting. Distally, plates become slightly spaced. Larger and smaller plates occur on disc, though none of larger readily identifiable as primaries. Larger plates just extending onto arms, to about opposite 2nd superomarginal. Beyond here occasional plates may be slightly enlarged, although the general trend is decreasing size. Smaller disc plates have 3-6 pointed spinelets, in clump, or circlet. Larger plates, and a few of smaller have, in addition, a much larger erect spine, tapering, pointed, up to 8 mm long. Beyond arm base abactinal plates have 1-5 short spinelets, shorter than on disc. Occasional plates in proximal third of arm may have 1 spinelet a little enlarged. Near arm tip most plates have a single inconspicuous spinelet.

*Papulae* confined to disc and proximal part of arm, extending distally to opposite 5th paired superomarginal. Papulae absent from centre of disc, papular area more or less trilobate distally, with a few papulae in a linear series adjacent to superomarginals and a more extensive and broader streak along radial midline.

*Pedicellariae* pectinate, with 2 combs of spinelets, each on a separate plate, on proximal side of unpaired superomarginal plates, a few elsewhere on disc and arm bases. Similar pedicellariae present on a few actinal plates. Also present are pedicellariae with 1 comb absent, these occurring on disc and actinal plates.

*Madreporite* tumid and ovoid, diameter 4 mm, placed about two-thirds  $r$  from disc centre; with coarse, radiate sculpture, and surrounded by ovoid plates which abut, lacking papular pores between them. Each of these plates with a larger spine.

*Anal pore* central, small, distinct, surrounded by small, close-set plates with clusters of spinelets.

In each interradius a large and conspicuous unpaired *superomarginal plate* projecting above abactinal surface. Other superomarginals scarcely encroaching on abactinal surface, and in consequence, appearing markedly longer than wide when viewed from above. In lateral view, unpaired superomarginal is seen to be a high plate, with lateral margins converging downward, squeezed between next superomarginals of adjacent rays. First and second paired superomarginals are rectangular plates, first as long as high, second somewhat longer. Subsequent plates elongate-ovoid in outline, oriented so that distal end is higher than proximal. All superomarginals have a few spaced spinelets, unpaired plate has 2 or 3 conspicuous, sharply pointed



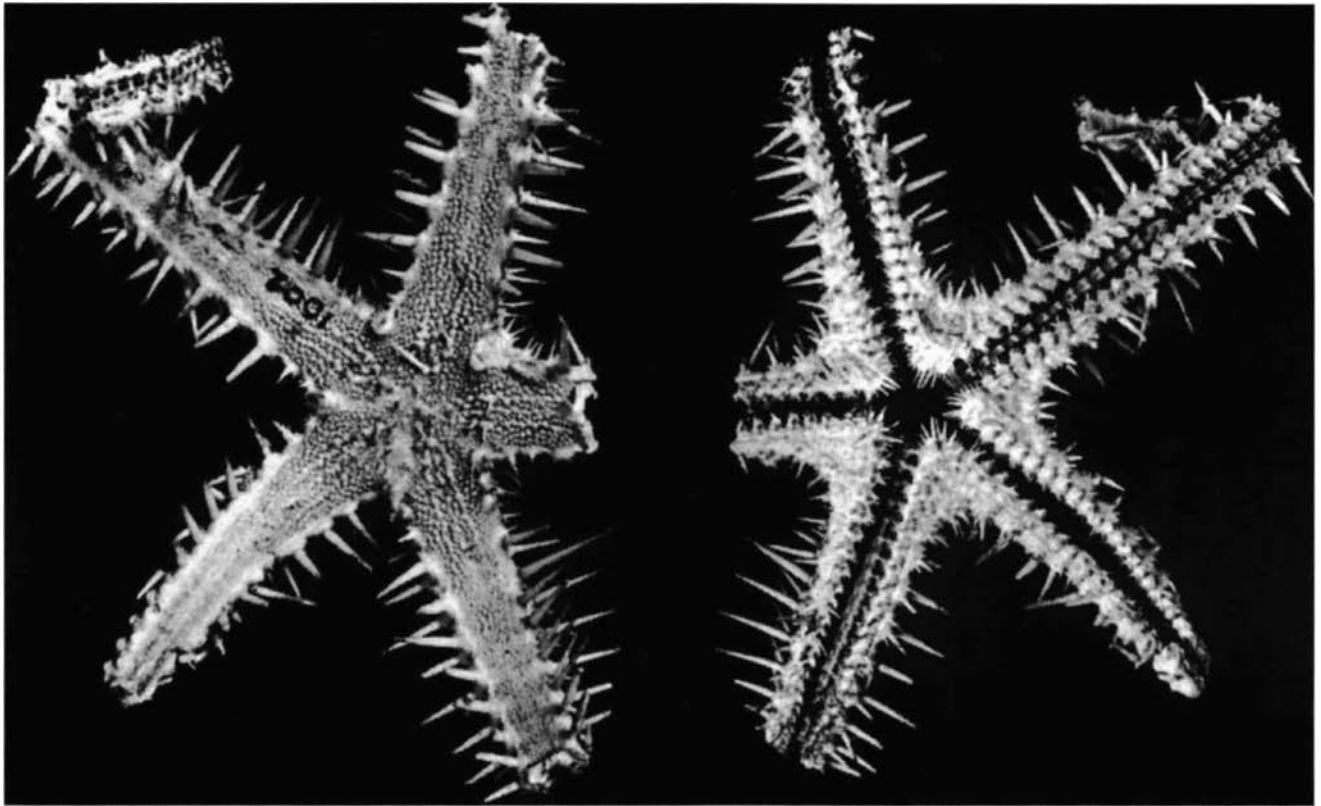


Plate 40. *Benthopecten pikei* H.E.S. Clark. Holotype. Abactinal and actinal surfaces.

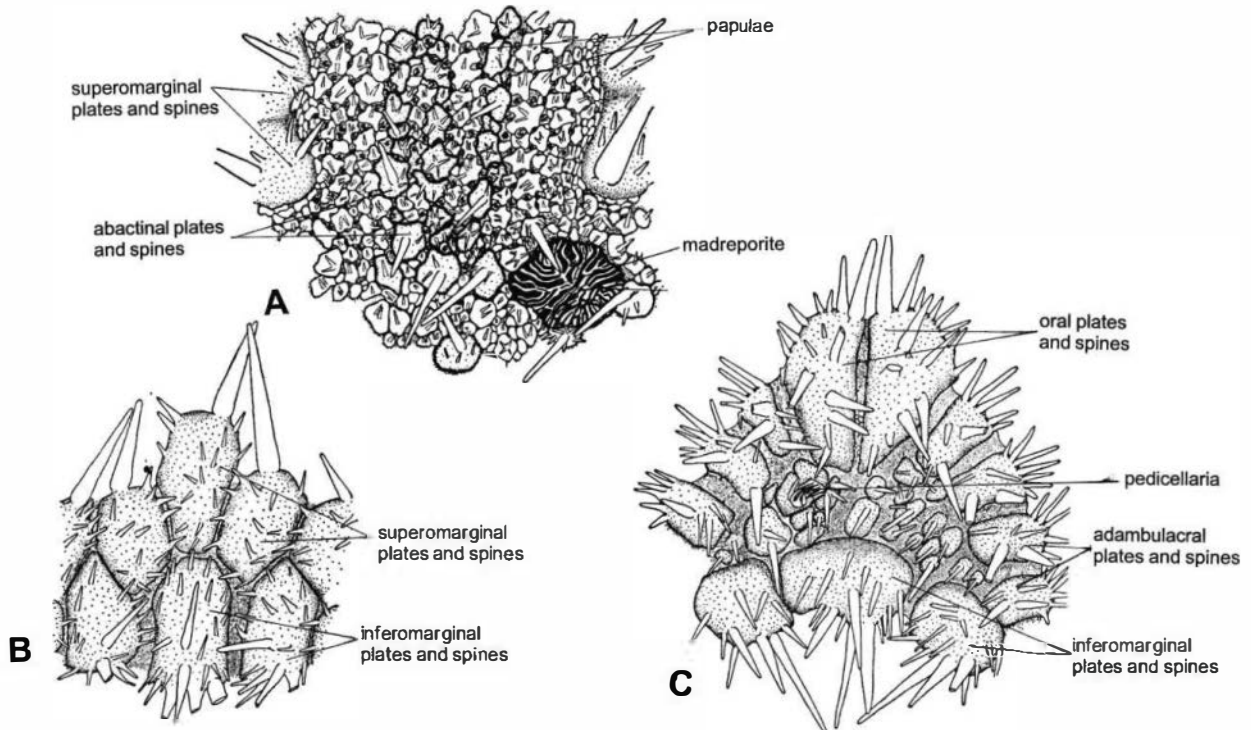


Fig. 38. *Benthopecten pikei* H.E.S. Clark. A. Part of arm near interradius. Note the three rows of larger, more conspicuous plates along midline of arm. B. Arrangement of supero- and inferomarginal plates in an interradial angle. C. Inter-radial angle showing arrangement of oral, adambulacral, actinal, and inferomarginal plates and spines and distinctive pedicellaria (from H.E.S. Clark 1969).



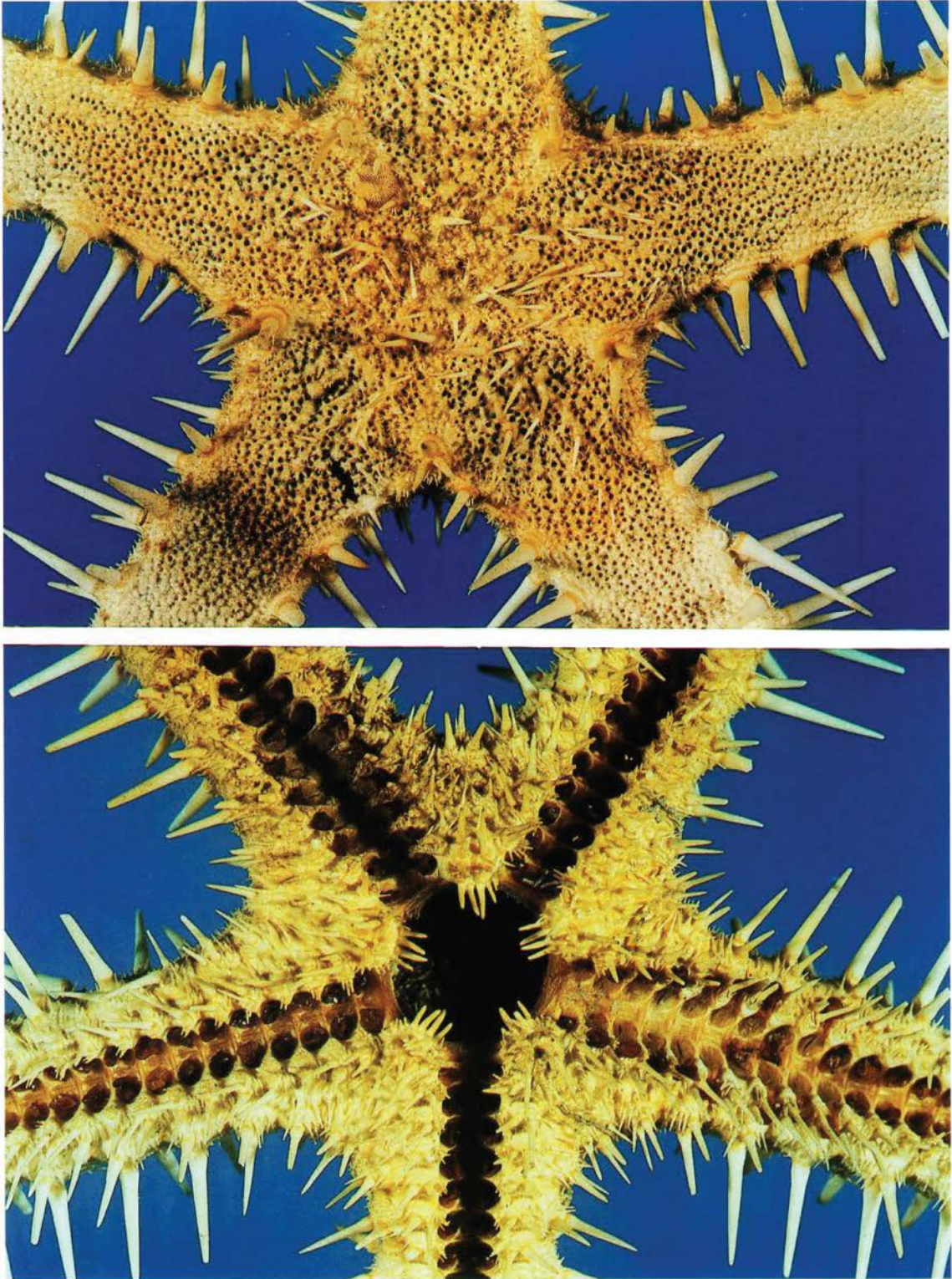


Plate 41. *Benthopecten pikei* H.E.S. Clark. NZOI Stn E72. R/r = 90+/18 mm. Abactinal and actinal surfaces.



spines; other plates have a single erect spine, up to 12 mm long. Spine on first and second paired superomarginals often smaller than those further out, or may be absent. Unpaired inferomarginal plate subtriangular in actinal view, the remainder elongate, more or less alternating with superomarginals. In lateral view unpaired plate is almost a mirror image of unpaired superomarginal, while first and second plates are rectangular. Succeeding plates elongate and more or less ovoid, with proximal end lying below distal end of preceding plate. Unpaired inferomarginal with spaced spinelets and 3 or 4 short spines, other plates with similar spaced spinelets and 2 spines, uppermost longer, as long as those on superomarginals.

A single series of *actinal plates* extends to fifth adambulacral or second paired inferomarginal. Plates small, ovoid, with 1–3 spinelets.

*Adambulacral plates* wider than long throughout arm, separated by distinct membranous bands; furrow margin with a central projection; 5–7 short, slender, blunt-tipped furrow spines. Similar spines occur around outer margin of plate, and 2 much longer subambulacral spines in a transverse series.

*Oral plates* quite conspicuous, somewhat inflated and slightly projecting above actinal plates. Each pair of plates with a broad, curving proximal margin, each tapering distally to a blunt point; with 7 or 8 furrow spines, increasing in size proximally so that 4 stout spines project across actinosome. Actinal face of each plate with 6 suboral spines, 2 or 3 in a transverse proximal row, and 3 or 4 behind them, in a longiseries, near median suture.

*Tube feet* biserial throughout ray, with distinct sucking-discs.

COLOUR (ex ethanol): Dull light brown.

REMARKS: The smaller specimen, R 32+ mm, r 5 mm, br = 4 mm, has very conspicuous spines on unpaired superomarginals, and lacks spines on the next two plates, adding to the conspicuous appearance of the first spines. The papular area ends at the proximal end of the second paired superomarginals, and is straight

across the ray, not trilobate. Most inferomarginals have a single spine, although adambulacrals are similar to those in the large specimen. On oral plates there are five furrow spines and four suboral spines in a single longiseries. Most juvenile specimens examined in NIWA collections are of this form, with superomarginals appearing elongate in abactinal view.

### *Cheiraster* Studer, 1883

Without odd interradial marginal plates; abactinal plates parapaxilliform, flat, or convex, with 1 or more spinelets, sometimes also spines. Papular pores limited to a more or less bilobed area at arm base, usually flattened in preserved specimens; superomarginal plates forming a slight to prominent edge to abactinal area; 1 or more enlarged subambulacral spines. Fasciculate pedicellariae often present.

TYPE SPECIES: *Cheiraster gazellae* Studer, 1883.

#### TABULAR CHECKLIST TO SPECIES OF *CHEIRASTER*

- 1 No. of papulae in each area
- 2 No. of proximal papulae  
e – enlarged  
se – slightly enlarged  
n – not enlarged
- 3 Spinelets on abactinal plates  
+ – no. of spines
- 4 No. of superomarginal spines  
d – distal  
oc – occasional
- 5 No. of inferomarginal spines
- 6 Adambulacral spines; furrow + Sa
- 7 Oral furrow + suboral spines

<i>Cheiraster</i>	R mm	1	2	3	4	5	6	7
<i>ludwigi</i>	32+	7–9	1, e	10–15	1	2(1)	7+1	7, 1–2
<i>monopedicellaris</i>	35	3–5	1, se	9–18+1	1	2(3)	7–9+1	7–10, 0
<i>otagoensis</i>	21	4–9	1, se	8–15 +1	1	1(2)	5–7+1	7–9
<i>richardsoni</i>	31	?	?	9–15 +1	1, oc	2(1, 3)	6–8+1	9
<i>subtuberculatus</i>	24	16–18	2, n	5–12	1	1	5–6+1	7, 1–2
<i>teres</i>	17	3–5	1, n	25–38 +1	1	2(3)	9–11 +3	7, 0
<i>triplacanthus</i>	35	19–28	1, n	5–12	2–3 d	1(2)	7–9+1(2)	8–9, 0

*Cheiraster ludwigi* Fisher, 1913 (Pl. 42)

*Cheiraster ludwigi* Fisher, 1913: 205; 1919: 203, pls 48(1), 49(2), 55(2, 2a); A.M. Clark 1981: 109.

MATERIAL EXAMINED: NZOI Stn I722(1).

SIZE: The single specimen R/r = 32+8 mm, br = 8 mm.

DISTRIBUTION: Known from the northern Tasman Sea, near Lord Howe Island. Previous records are from Indonesia.

DEPTH: Tasman Sea, 1828; Indonesia 470 m.

DESCRIPTION: The single specimen from NZOI Stn I722 (det. Dr F.W.E. Rowe) is described.

Outline stellate, interbrachial arcs rounded to angular, the 5 rays slowly tapering. Abactinal and actinal surfaces flat, margins vertical, although narrowly rounded above and more broadly below. Arms slightly recurving distally.

*Abactinal plates* slightly elevated with top slightly convex. Disc plates a little larger than those of arms; basals larger than other plates on disc. No enlarged radials at arm bases. Larger disc plates with 10–15 small, bluntly-tipped spinelets, usually in a divergent group; smaller plates of disc and those of arms with 5–8 similar spinelets. Sometimes a central spinelet may be slightly enlarged, but no abactinal spines.

*Papulae* restricted to a small area at arm base, opposite first superomarginals, with 7–9 papulae in each area. Papular area bilobed distally, largest papulae proximal, on radial midline, just distal to a larger disc plate which, although it may be a radial, is not otherwise distinguished.

*Anal aperture* near central, and inconspicuous.

*Madreporite* small, not prominent, placed close to margin; rounded, diameter about 3 mm, with coarse sculpture.

*Marginal series* alternating along ray; superomarginals laterally longer than wide from about 5th, encroaching slightly on abactinal surface. Each with a stubby spine, shortest on first 2 plates, and a general covering of small spinelets. Spine placed near upper margin of lateral face. Inferomarginal plates also laterally longer than wide from about 5th, with a general covering of small spinelets. First few plates with a small spine, most of the rest have 2 spines, uppermost longer, both on lateral face of plate. At arm base 2 or 3 small actinal plates, each with a few scattered spinelets, with pectinate pedicellariae developed between plates.

*Adambulacral plates* with a distinct angular furrow prominence, mostly wider than long; 17 adambulacrals

corresponding to first 10 inferomarginals, 7 furrow spines, and about 5 smaller spinelets on lateral and outer margins of plate. A single, slightly curving and pointed subambulacral spine, much stronger and more prominent than furrow spines.

*Oral plates* with a relatively broad proximal margin, with 7 oral furrow spines, the inner largest, and 1 or 2 suboral spines, as well as 5–7 suboral spinelets.

*Tube feet* biserial with small distinct sucking-discs.

COLOUR (dried, ex ethanol): Creamy-white, with tube-feet darker.

*Cheiraster monopedicellaris* McKnight, 1973 (Pl. 43)

*Cheiraster monopedicellaris* McKnight 1973a: 223–225, fig. 3; A.M. Clark 1981: 112.

MATERIAL EXAMINED:

NZOI Stns: E712(2), I24(1), S378(1).

HOLOTYPE: Specimen from NZOI Stn E712 deposited in the NIWA collection, Wellington, as H-152.

PARATYPE: From NZOI Stn E712 deposited in the NIWA collection, Wellington, registered as P-210, size R/r = 35/6 mm.

SIZE: R/r = 39/7 mm to 21/5 mm.

DISTRIBUTION: Known from the east coast of northern and central New Zealand.

DEPTH: 615–900 m.

DESCRIPTION: The holotype from NZOI Stn E712, with R/r = 39/7 mm, is described.

Outline stellate, with 5 arms tapering from a relatively broad base; margins more or less vertical, abactinal and actinal surfaces flat. Abactinal surface slightly sunken. In preserved specimens arms usually recurved.

*Abactinal plates* rounded and convex, varying in size, but primary disc plates not prominent, and only basals recognised. Larger plates have 9–18 spinelets in 1 or 2 circles, with 1 spine, while smaller plates have 3–5 spinelets only.

*Papular areas* small, each with 3–5 pores in V-shaped arrangement; proximal pore slightly enlarged, but not adjacent plates.

*Madreporite* placed close to margin, rounded, diameter 1.5 mm; deep, coarse sculpture almost concealed by adjacent spinelets.



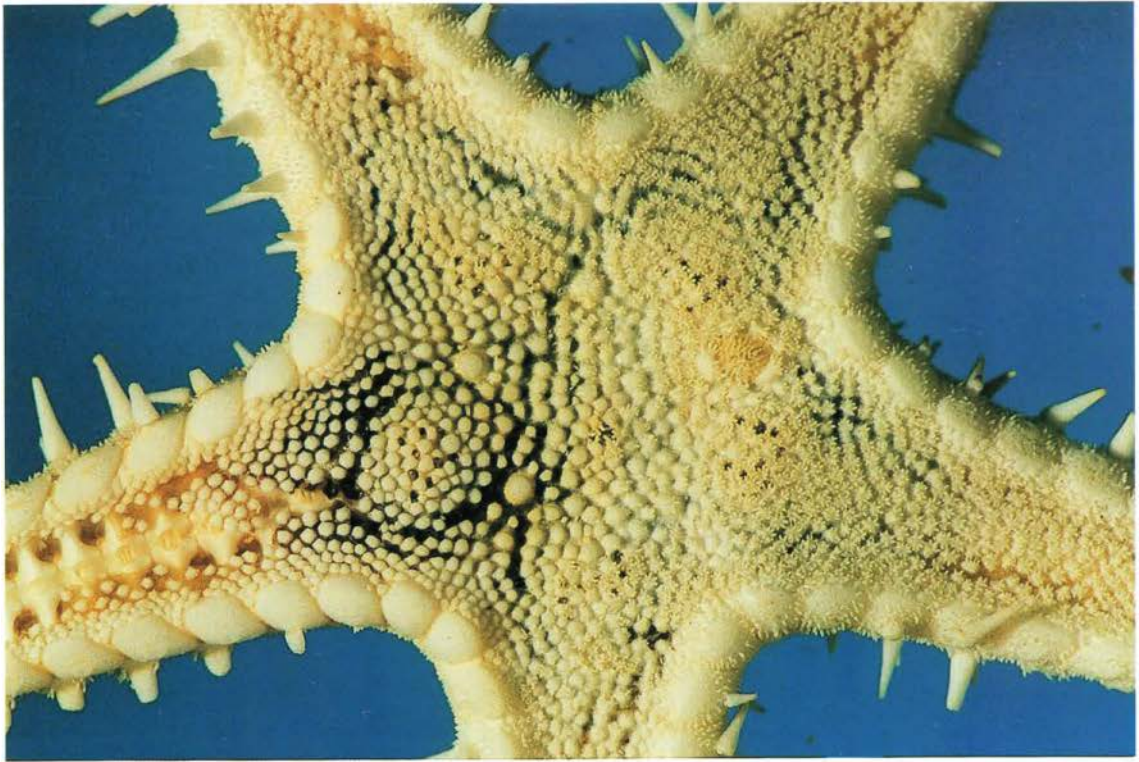
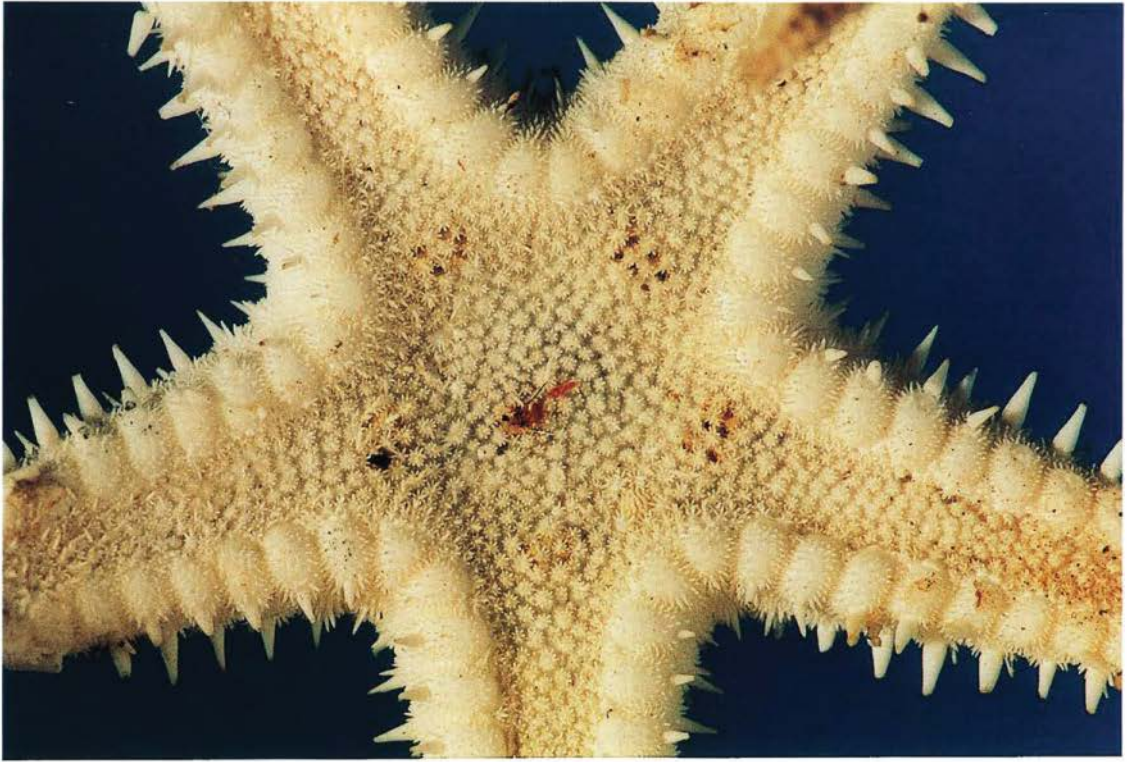


Plate 42. *Cheiraster ludwigi* Fisher. NZOI Stn I722. R/r = 32+/8 mm. Abactinal and actinal surfaces.





**Plate 43.** *Cheiraster monopedicellaris* McKnight. Holotype. NZOI Stn E712. R/r = 39/7 mm. Abactinal and actinal surfaces.



*Anal aperture* more or less central, overhung by spinelets.

*Marginal plates* subalternate, all relatively broad, with only distal inferomarginals longer than wide laterally. Plates have a close covering of small spinelets, supero-marginals have 1 erect spine, at rounded upper margin; inferomarginals have 2 spines over most of arm, uppermost longest. Proximal 2 or 3 plates usually with 3 spines, central the longest. Occasionally 1 or 2 spinelets are elongated.

*Actinal plates* confined to arm base, extending to 3rd adambulacral, or slightly beyond, in 2 series, with 4 plates in inner, and 1 or 2 in outer. Plates with 1–5 spinelets, often 1 large pectinate pedicellariae situated just distal to oral plates.

*Adambulacral plates* mostly wider than long, with 7–9 furrow spines and 2–5 spinelets on lateral and outer margins. Subambulacral spine single, placed between furrow series and spinelets of outer margin.

*Oral plates* have 7–10 furrow spines, proximal 2 largest, and 8–10 suboral spines, none enlarged.

*Tube feet* biserial, with small, distinct sucking-discs.

COLOUR (ex ethanol): Creamy-white to dull grey. Field notes record the colour as "Disc grey, arms pink, cream under".

REMARKS: This species is distinguished from *Cheiraster otagoensis* by the single large actinal pedicellaria in each interradius, the more numerous adambulacral and inferomarginal spines, and the fewer papulae. The relative dimensions of both specimens are similar but in *C. monopedicellaris* the ambital height is more than three-quarters *r* and in *C. otagoensis* it is less than half *r*. *Cheiraster richardsoni* Fell has abactinal pedicellariae and lacks the regular superomarginal spine and *C. niascus* Fisher has fewer papulae and has intermarginal fasciculate pedicellariae.

*Cheiraster otagoensis* McKnight, 1973 (Pl. 44)

*Cheiraster otagoensis* McKnight 1973a: 220–223, fig. 2; A.M. Clark 1981: 109

MATERIAL EXAMINED:

NZOI Stns E399(2), E405(2), E410(2), E414(1), F108(4), F123(1), F126(2), F752(1), F754(2), F758(3), F761(5), G700(5), G701(1), T33(1), T36(1).

HOLOTYPE: Specimen from NZOI Stn E410 deposited in the NIWA collection, Wellington, as H-151. R/r = 21/5 mm.

PARATYPES: Deposited in the NIWA collection Welling-

ton, as P-208, with R/r = 20/5 mm, from Stn E410; P-209 (2 specimens) sizes R/r = 19/5 mm, 23/6 mm, from Stn E399.

SIZE: The study specimen, holotype from NZOI Stn E410, R/r = 21/5 mm.

DISTRIBUTION: Known from central and southern New Zealand and the Bounty Platform.

DEPTH: 721–1400m.

DESCRIPTION: The holotype from NZOI Stn E410, R/r = 21/5 mm is described.

Outline stellate, interbranchial arcs rounded, 5 slowly tapering arms, with margin vertical and abactinal and actinal surfaces flat. Arm tips may be recurved.

*Abactinal plates* convex with larger and smaller plates on disc and arms. Larger plates have 8–15 small spinelets with usually a single spine, smaller plates have 1–9 spinelets.

*Papular areas* relatively small, with 4–9 papulae each. Papularium has a slightly enlarged proximal pore, bilobate distally.

*Madreporite* placed just over half *r* from disc centre, rounded, diameter 1 mm, with deep coarse sculpture. Overhanging spinelets of adjacent plates tend to obscure madreporite.

*Anal aperture* more or less central and obscured by flanking spinelets.

*Marginal plates* alternating, superomarginals wider than long laterally for about the first 3 or 4 plates with a covering numerous small spinelets; a single erect tapering spine up to 3 mm long placed on rounded margin. Inferomarginals have similar numerous small spinelets, and 1, occasionally 2 spines; if 2, usually on proximal plates, uppermost longer, slightly longer than superomarginal spine.

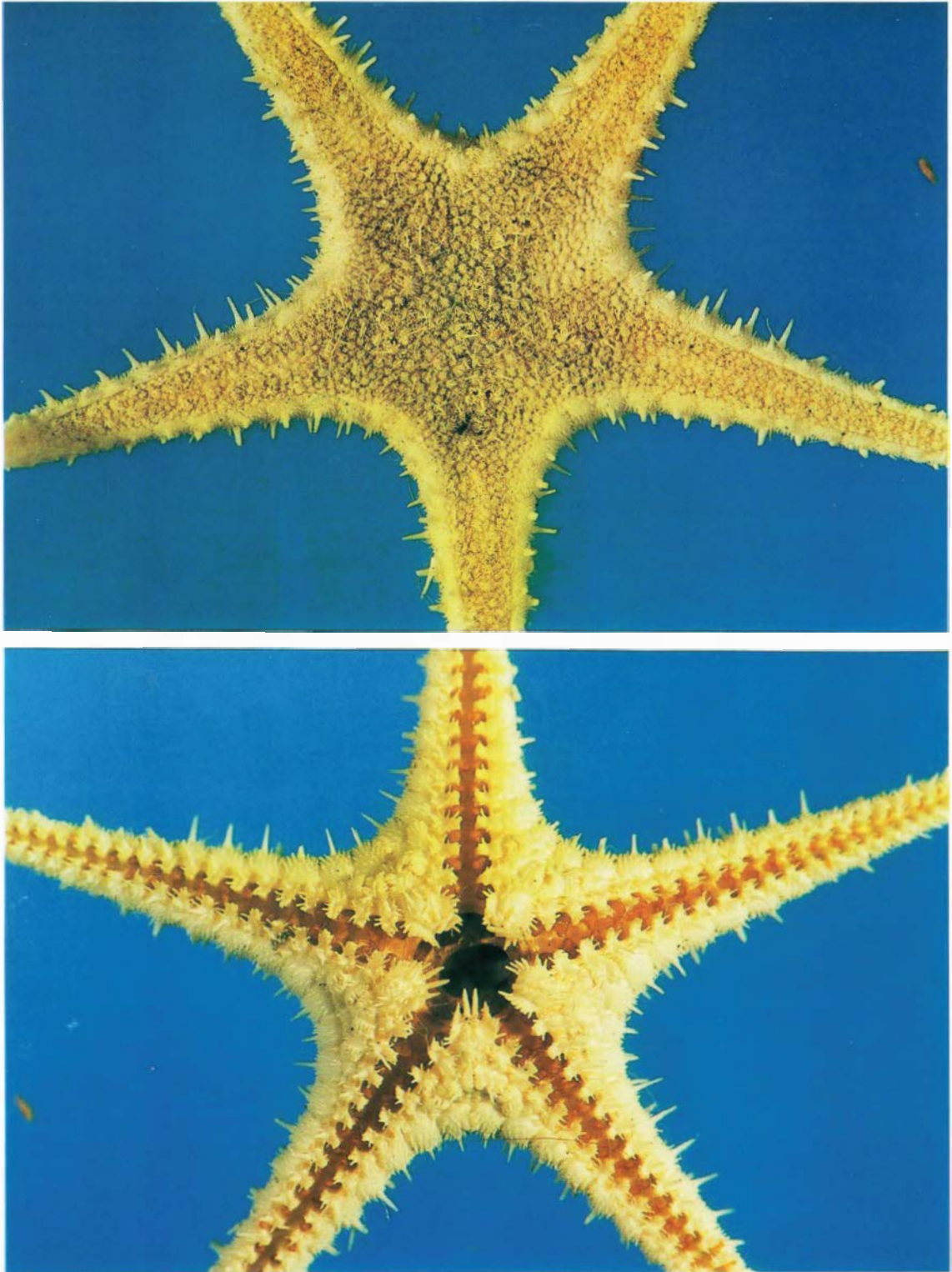
*Actinal plates* in 2 longiseries at arm base, 2 plates in outer series, 3 in inner, which extends to adambulacral 3. Plates have 1–7 spinelets, pectinate pedicellariae are developed between plates of inner series.

*Adambulacral plates* have a prominent furrow angle with 16 adambulacrals to first 10 inferomarginals. Adambulacral plates with 5–7 furrow spines, and 3–5 spinelets on lateral and outer margins. Subambulacral spine, single, erect and tapering, situated centrally between furrow spines and spinelets along outer margin.

*Oral plates* have 7–9 furrow spines, inner 2 longest, 8–11 suboral spines, of which, although they decrease in size distally, none can be considered enlarged.

*Tube feet* biserial with small, distinct sucking-discs.

COLOUR (ex ethanol): Dull brown or cream, lighter on



**Plate 44.** *Cheiraster otagoensis* McKnight. Holotype. NZOI Stn E410. R/r = 21/5 mm. Abactinal and actinal surfaces.



actinal surface. Field notes record the colour as "Disc grey with brown patches, arms light pink to red, underside cream, tubefeet yellowish".

***Cheiraster richardsoni*** Fell, 1958

*Cheiraster richardsoni* Fell, 1958: 7, pl. 1(F,H); A.M. Clark, 1981: 112.

MATERIAL EXAMINED: Nil.

DISTRIBUTION: Known only from Cook Strait.

DEPTH: 732 m.

DESCRIPTION: Taken from Fell (1958); specimen R/r = 31/9 mm.

*Abactinal plates* of disc and arms have 9–15 short spinelets, and one enlarged central spine, spinelets in 1 or 2 circles.

Pectinate *pedicellariae* on abactinal, actinal, and also in interbrachial angle.

*Superomarginals* broader than long laterally, proximal inferomarginals similar, becoming longer than broad distally. Both series with a dense coat of spinelets. Interbrachial superomarginals occasionally with an erect spine, proximal inferomarginals with 2, sometimes 1 or 3.

*Actinal plates* not extending beyond 4th adambulacral, or 2nd inferomarginal. Actinal plates with 1 erect spine and several spinelets.

*Adambulacral plates* with 6–8 furrow spines and 5 or 6 spinelets on outer margin, plus 1 larger subambulacral spine.

*Oral plates* with about 9 furrow spines, inner 3 largest, especially innermost; 4 suboral spines or spinelets, in a linear series, innermost largest.

REMARKS: Fell (1958) distinguished this species from *C. niascus* Ludwig, *C. inops* Fisher, and *C. trullipes* (Sladen), but it has not been recognised in later collections.

***Cheiraster subtuberculatus*** (Sladen, 1889) (Pl. 45)

*Pontaster subtuberculatus* Sladen, 1889: 58, pls 5(3, 4), 13(7, 8).

*Cheiraster subtuberculatus*: Fisher 1919: 207; A.M. Clark 1981: 111.

MATERIAL EXAMINED:

NZOI Stns: K861(2), Q84(1).

SIZE: R/r = 24/5 mm to 21/4 mm.

DISTRIBUTION: Known from the Kermadec Islands and Lord Howe Rise. The only previous record is from off Sydney, eastern Australia.

DEPTH: Northern Tasman Sea, 830–1739 m.

DESCRIPTION: A single specimen from NZOI Stn Q84, with R/r = 24/5 mm, br. = 5 mm, is described.

Outline stellate, with rounded to angular interbrachial arcs, and 5 gradually tapering arms. Abactinal surface slightly sunken, flat, as actinal surface. Arms not recurved near tip.

*Abactinal plates* swollen, close set, with 5–12 short, blunt-tipped and finely thorny spinelets, in a divergent group. Disc basals a little larger than other plates. Slightly enlarged plates also present at papular areas, and proximal to them, this area being a little inflated. On arms, plates smaller with up to 8 spinelets.

A small naked and slightly sunken plate, diameter about 1 mm, placed near margin may represent the *madreporite*. It has a few faint grooves on its exposed surface.

*Papular area* at arm base, with 16–18 papulae in each area, arranged in bilobed pattern; no unpaired proximal pore and no pores enlarged. As noted, papular area is part of a slightly inflated area extending proximally onto disc, and composed of larger plates; proximal of these plates is removed from first papulae by 3 plates.

*Madreporite* placed just over half r from disc centre, rounded, diameter 1 mm, with deep coarse sculpture. Overhanging spinelets of adjacent plates tend to obscure madreporite.

*Anal aperture* more or less central and obscured by flanking spinelets.

*Marginal plates* alternating, superomarginals encroaching onto abactinal area, separated by relatively broad distinct grooves, wider than long laterally to 5th plate. Plates covered by small spaced spinelets with a short stubby spine, placed at rounded edge of plate. Spine reduced or absent on first plate. Inferomarginals similarly wider than long to 5th or 6th plate, with small spaced spinelets like superomarginals, and also have 1 stubby spine up to 2 mm long placed on lateral face. Some spinelets, around base of spine, may be slightly enlarged.

*Actinal plates* confined to arm base, in 2 series, with 4 plates in inner series, and 1 or 2 in outer. Inner series extending to adambulacral 4. Plates slightly tumid with 4–9 small spinelets. 1 interradius with a small pectinate pedicellaria, developed between plates of inner series. *Adambulacral plates* have a prominent furrow projection, about as wide as long, 17 adambulacrals correspond to first 10 inferomarginals; 5 or 6 furrow spines, and usually 2 spinelets near outer edge of plate. Sub-

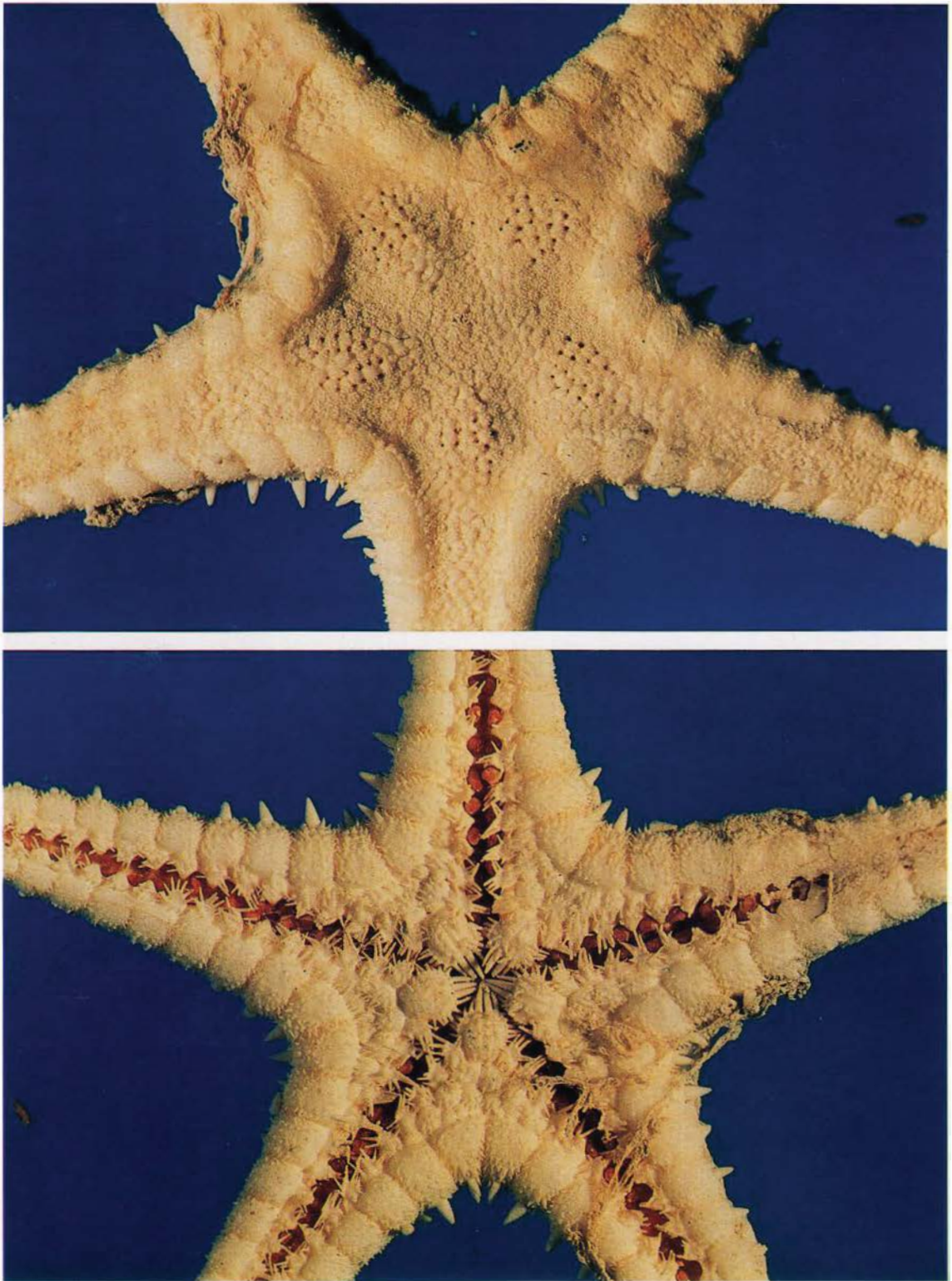


Plate 45. *Cheiraster subtuberculatus* (Sladen). NZOISn Q84. R/r = 24/5 mm. Abactinal and actinal surfaces.



ambulacral spine single, between these 2 spinelets, conical, slightly curved, and clearly largest spine on plate.

*Oral plates* have 7 furrow spines, inner 2 larger, innermost clearly largest; also 9 suboral spine, arranged in 2 longiseries, with a single larger spinelet proximally.

*Tubefeet* biserial with distinct sucking-discs.

COLOUR (ex ethanol): Dull cream, with the tubefeet light brown.

***Cheiraster triplacanthus* Fisher, 1913 (Pl. 46)**

*Cheiraster triplacanthus* Fisher, 1913: 206; 1919: 205, pls 48(3, 4), 44(1, 1a); A.M. Clark 1981: 109.

MATERIAL EXAMINED: NZOI Stn T244(1).

SIZE: R/r = 35/4.9 mm.

DISTRIBUTION: Known locally only near the Kermadec Islands. It is also recorded from the Philippines and southeast Asia.

DEPTH: 1050–1280 m, and New Zealand region 1450 m.

DESCRIPTION: The sole specimen from NZOI Stn T244, R/r = 35/4.9, br = 8 mm, is described.

Outline stellate, interbrachial arcs rounded, and 5, slowly tapering arms, recurved near tip. Margin is vertical, rounded above and below, abactinal surface is slightly sunken below level of superomarginal plates.

*Abactinal plates* swollen, slightly larger on disc. Primary plates not prominent, although in 4 interradii there is a slightly larger plate, probably the basal. Plates with 5–12, small, slightly rugose spinelets, often 1 or 2 centrally placed, although not enlarged. On outer part of arm, plates have 3–5 spinelets.

*Papular area* at arm base, each with 19–28 papulae. Proximally a central pore, the area bilobate distally. No single pore is enlarged.

*Madreporite* placed at about one-third r from margin, rounded, diameter 2–3 mm, tumid, with coarse radiate sculpture; 5 enlarged plates surround madreporite.

*Anal aperture* centrally placed, surrounding plates have slightly enlarged spinelets.

*Marginal plates* alternating in position. Superomarginals broad, encroaching onto abactinal surface, separated by distinct grooves, from about 7th plate longer than wide laterally. Plates with a sparse covering of small spinelets, no larger than those on abac-

tinal plates, and 1 stubby spine up to 3 mm long; this absent from 2 of the first superomarginals. 2, then 3, small stubby spines near arm tip, from just proximal to recurved portion.

*Inferomarginal plates* also separated by distinct grooves, with a sparse covering of spinelets, longer than those on abactinal or superomarginal plates. Inferomarginals also with a single stubby spine, up to 4 mm long. First 1 or 2 plates may have a shorter spine below major spine.

*Actinal plates* confined to arm base, in 3 series, inner with 5 or 6 plates, the median with 3 or 4, and outer with 2. Plates have 1–4 spinelets, with pectinate pedicellariae developed between plates of inner series.

*Adambulacral plates* about as wide as long, with a blunt furrow prominence; 7–9 furrow spines and 2–5 spinelets on lateral and outer margins of plate. Subambulacral spine slightly enlarged, usually aligned with outer spinelets. Infrequently there may be 2 subambulacral spines.

*Oral plates* with 8 or 9 furrow spines, the inner largest, and 10–12 suboral spinelets, roughly arranged in 2 longiseries on actinal surface.

*Tubefeet* biserial with distinct though small sucking-discs.

COLOUR (ex ethanol): Abactinal surface of disc light brown, arms and actinal surface cream, tubefeet light brown.

***Cheiraster (Luidiaster) teres* (Sladen, 1889) (Pl. 47)**

*Pontaster teres* Sladen, 1889: 41, pls 9(5, 6), 12 (11, 12).

*Cheiraster teres*: A.M. Clark 1981: 111; McKnight 1989a: 8.

MATERIAL EXAMINED:

NZOI Stns I91(1), I730(1), P27(1).

SIZE: R/r = 17/3.5 mm to 15+/5 mm.

DISTRIBUTION: Known to the north of New Zealand from Lord Howe Rise and Norfolk Ridge, also from Indonesia.

DEPTH: New Zealand region 300–390 m, Indonesia 260 m.

DESCRIPTION: A single specimen from Stn I730, with R/r = 17/3 mm, br = 4.5 mm, is described.

Outline stellate, interbrachial arcs narrowly rounded, 5 gradually tapering arms, with margins vertical, abactinal and actinal surfaces flat. Arms not recurved.

*Abactinal plates* low, slightly convex with 15–23

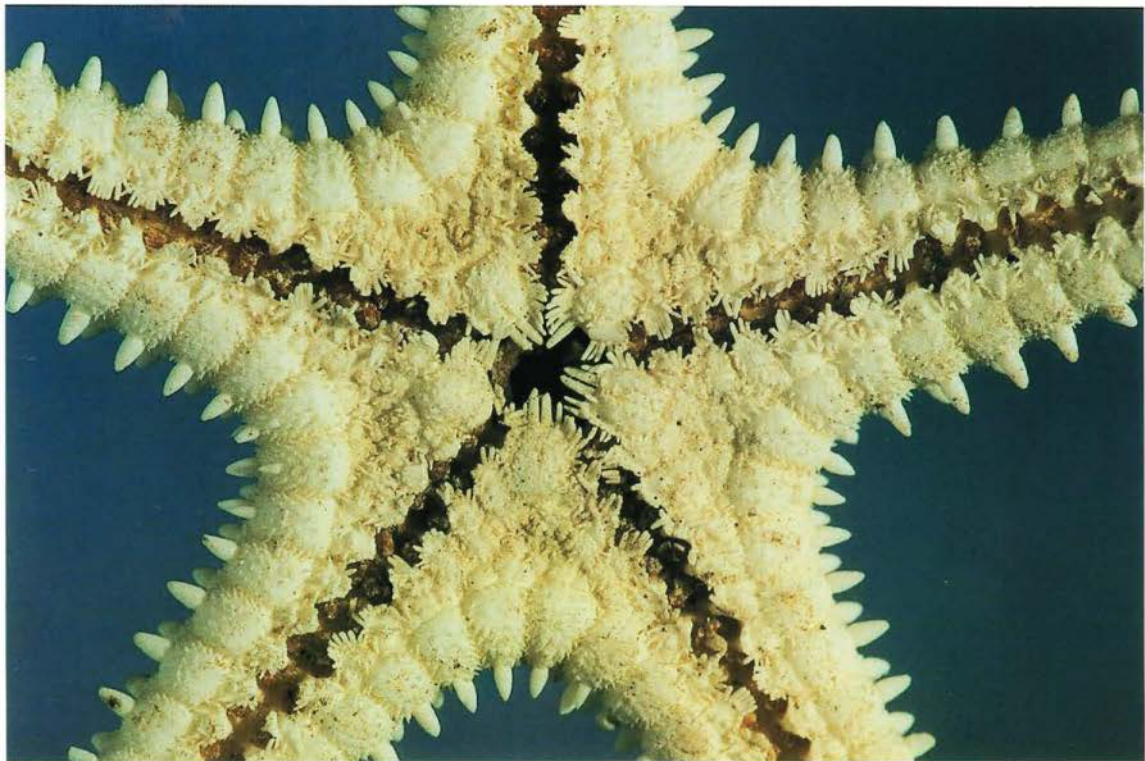
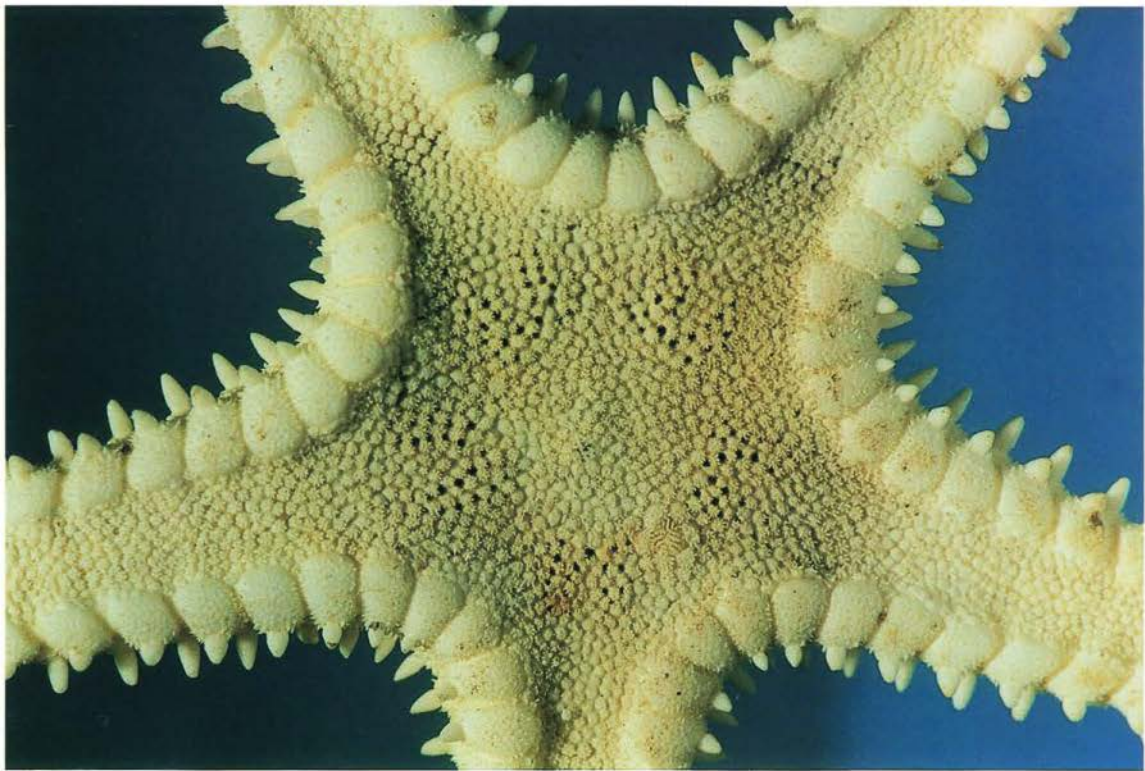


Plate 46. *Cheiraster triplacanthus* Fisher. NZOI Stn T244. R/r = 35/4.9 mm. Abactinal and actinal surfaces.



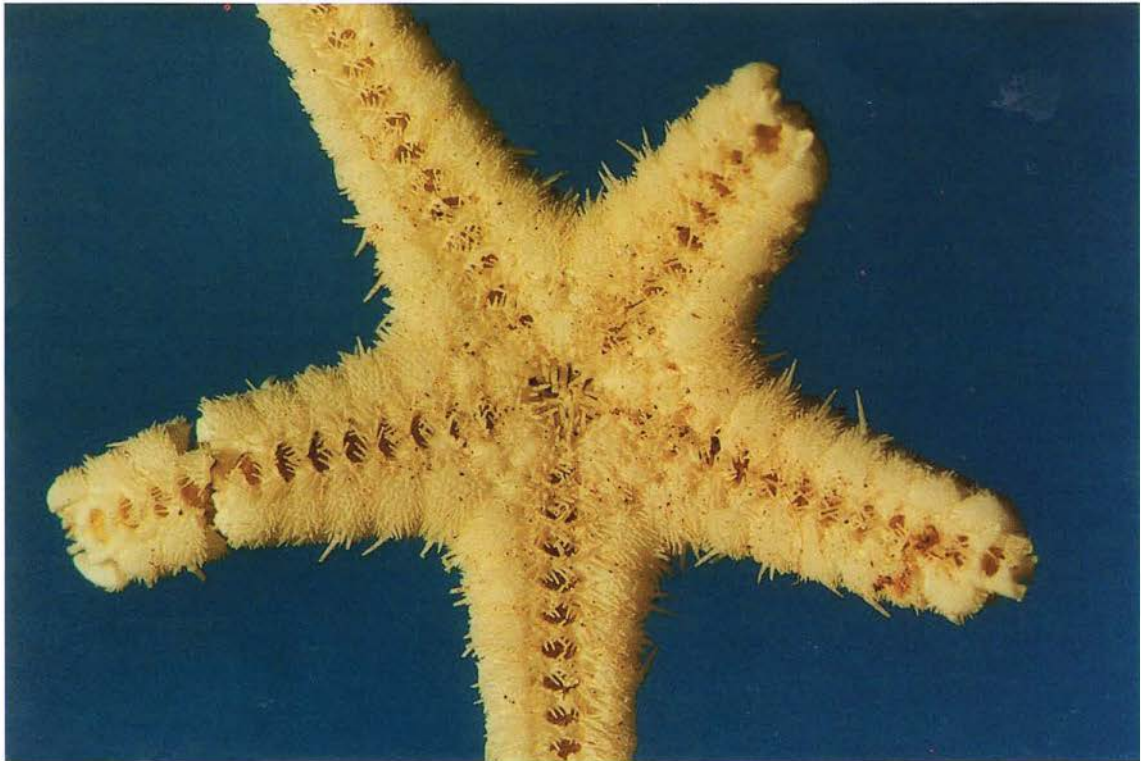
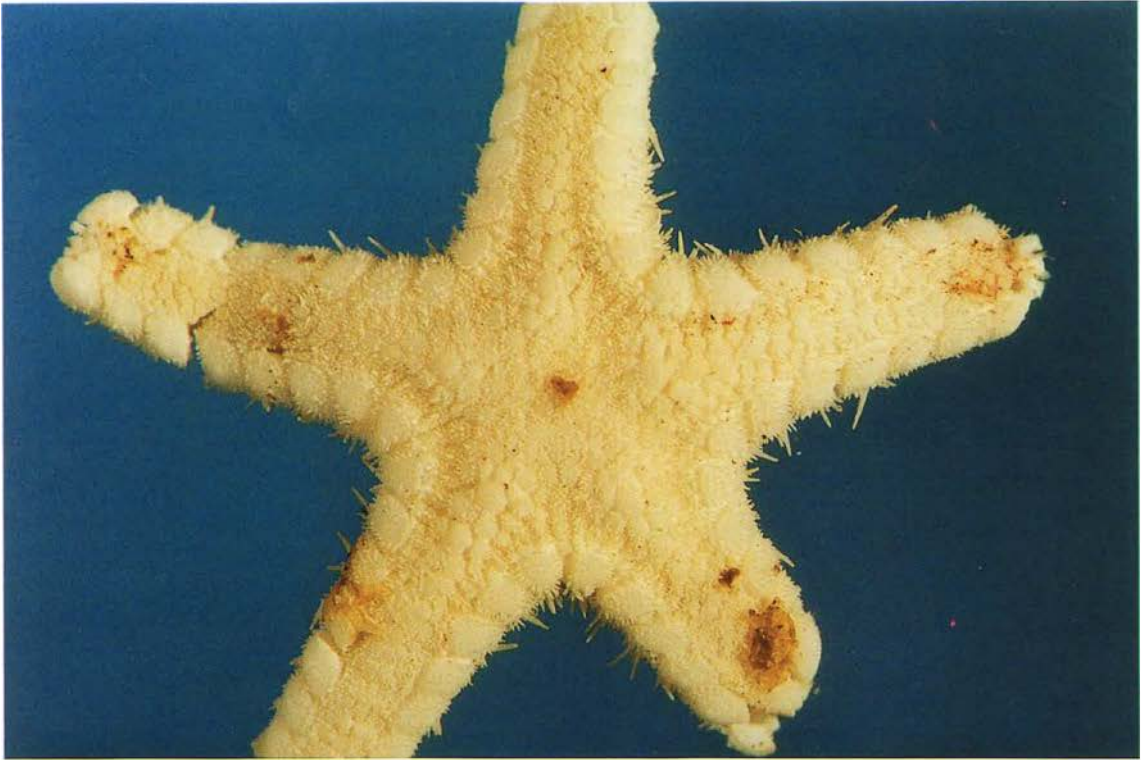


Plate 47. *Cheiraster (Luidiaster) teres* (Sladen). NZOI Stn I730. R/r = 17/3.5 mm. Abactinal and actinal surfaces.

peripheral and 10–15 inner spinelets. Peripherals tapering, finely thorny, with inner slightly longer and bluntly tipped. Often 1 inner spinelet enlarged, up to 0.7 mm long.

*Papulae* concealed, 3–5 in each area, in 2 more or less linear series on either side of radial midline, with an unpaired pore at proximal end.

*Madreporite* not apparent.

*Anal aperture* more or less concealed by overhanging spinelets of adjacent plates.

*Marginal plates* alternating, superomarginals relatively broad, with first 6 or 7 plates wider than long laterally. Plates with a covering of small spinelets and 1 slender spine up to 1.5 mm long. Inferomarginals with spinelets a little longer and also 2, rarely 3, spines, plus 1 or 2 elongate spinelets almost as long. Each interradius has 2 or 3 actinal plates in a single series extending to 3rd adambulacral.

*Actinal plates* with 3–7 spinelets, 1 of which may be a little larger.

*Adambulacral plates* with a distinct furrow prominence, 14 to first 10 inferomarginals. Plates with 9–11 furrow spines and 3 subequal subambulacral spines.

*Oral plates* with 7 furrow spines, inner 2 longest, and 8 or 9 suboral spinelets, roughly arranged in 2 longiseries.

*Tubefeet* biserial with distinct sucking-discs.

COLOUR (ex ethanol): Creamy-white.

REMARKS: A small specimen from NZOI Stn I91 has  $R/r = 15+ / 5$  mm. Primary radial plates are apparent, with 3 papulae on each side, distal to it. The madreporite is at the margin and less than 1 mm across, with a few coarse grooves.

### *Cheiraster (Luidiaster)* sp.

#### MATERIAL EXAMINED:

NZOI Stns I94 1), P16(1), P946(1), P947(3).

REMARKS: Juvenile specimens lacking papulae were taken at the above stations; material from NZOI Stns I94 and P16 from off Norfolk Island were identified by Dr F.W.E. Rowe. The other specimens are from near the Kermadec Islands.

### *Pectinaster* Perrier, 1888

No odd interradial marginal plates; abactinal plates small, paxilliform, papulae restricted to a small, ovoid papularium at each arm base; at least 3 pores developed at R 20 mm, papularium usually inflated in preserved

specimens; superomarginal plates forming an inconspicuous edge to abactinal area; a single, large, conical adambulacral spine over most of arm; fasciculate pedicellariae usually present, scattered over most plates, ovoid in outline, formed of 3 or more modified spinelets.

TYPE SPECIES: *Pectinaster filholi* Perrier, 1885b (see A.M. Clark 1989: 319).

### *Pectinaster mimicus* (Sladen, 1889) (Pl. 48)

*Pontaster mimicus* Sladen, 1889: 48, pls 6(1, 2), 7(5, 6).

*Pectinaster mimicus*: Fisher 1919: 182, pl. 49(1); H.E.S. Clark 1970: 16, pl. 2(a-d).

#### MATERIAL EXAMINED:

NZOI Stns: D591(1), E709(25), E733(1), E753(1), E758(3), E869(1), E871(6), F28(2), F744(4), F754(2), G700(4), G831(1), G955(1), I686(1), I690(2), I699(1), J38(3), J39 3), J40(1), J41(8), J42(3), J43(1), J44(1), J45(1), J47(1), J49(5), J50(1), J51(2), J52(2), K861(10), P667(2), P927(4), P928(field notes), P942(3), P969 (1), S154(1), S202(1), T29(1), U194(6), U198(1), U617(1), V370(1), V376(2).

SIZE:  $R/r = 74+ / 14$  mm to 18/6 mm.

DISTRIBUTION: Widespread in the New Zealand region, 30°–48° S latitude, occurring near the Kermadec Islands, Norfolk Ridge, Lord Howe Rise, on the New Zealand continental slope and the Bounty Platform. Known also from the Philippines and Indonesia.

DEPTH: New Zealand region, 700–2476 m; Indonesia and the Philippines 692–1693 m.

DESCRIPTION: The study specimen from Stn J42, with  $R/r = 22 / 7$  mm, br. = 5 mm, is described.

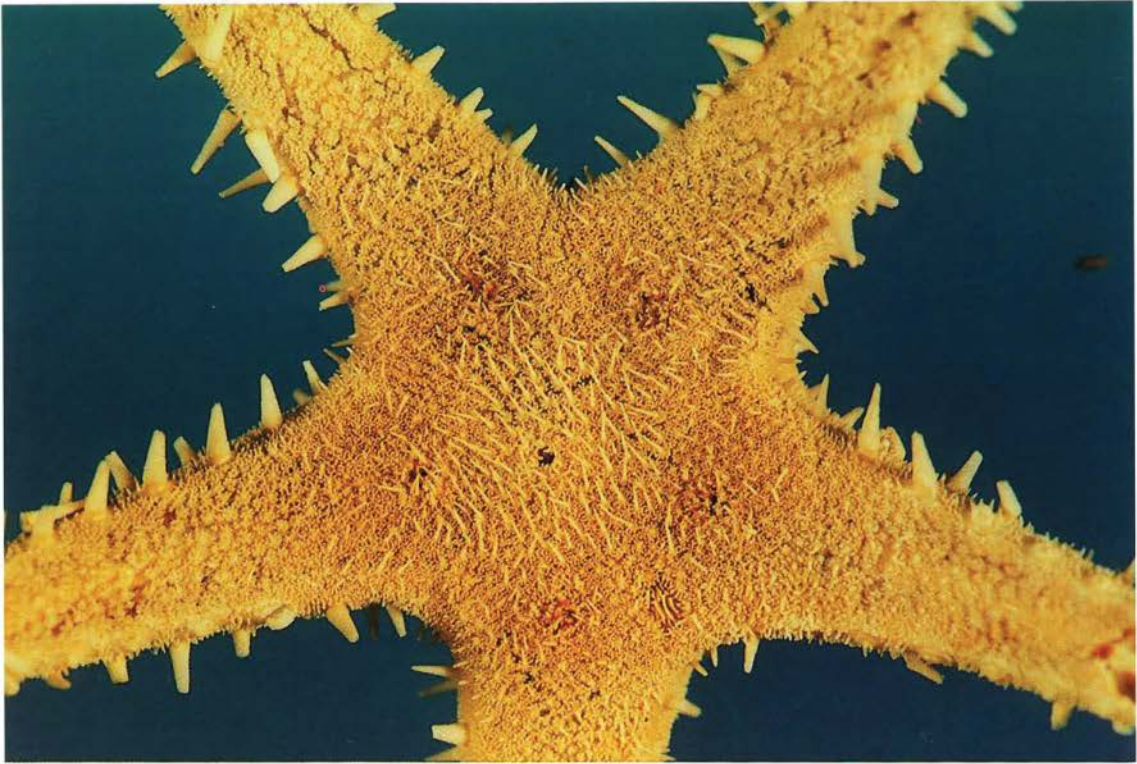
Outline stellate, with interbranchial arcs bluntly rounded, 5 gently tapering arms, abactinal and actinal l surfaces flat; margin vertical, rounded below and slightly bevelled above.

All *abactinal plates* small, slightly tabulate; disc primaries not apparent. Most disc plates with a single, slender, central, pointed spine, often finely thorny, up to 2 mm long. Around base of spine are 6–12 or more, short spinelets. On arms, plates along midline often similar, others (and also those towards margins) lacking a central spine.

*Papulae* restricted to a distinct, usually inflated ovoid area, on radial midline at arm base, with 6–10 papulae in each area.

Fasciculate *pedicellariae* present on actinal face of inferomarginal plates, each with 3–6 spinelets. Some





**Plate 48.** *Pectinaster mimicus* (Sladen). NZOI Stn J42. R/r = 22/7 mm. Abactinal and actinal surfaces.

pedicellariae appear to be developed on adjacent plates and are therefore pectinate.

*Madreporite* close to margin, small, rounded, and slightly tumid, not projecting. Sculpture coarse and radiate.

*Anal aperture* small, inconspicuous, more or less central, sometimes surrounded by spines.

*Superomarginal plates* slightly encroaching onto abactinal surface, forming a slightly bevelled edge. In abactinal view they are longer than wide; longer than high in lateral view, as inferomarginals. Most superomarginals have a single erect spine. Basal surface of the plate smooth and bare, edge of plate has scattered small spinelets. 1 or more of proximal superomarginals may have spine reduced in size or absent. Inferomarginals with 1 spine and, sometimes proximally, an elongate spinelet near its base. Like superomarginals, area around spine base is smooth, while margins of plates have scattered spinelets.

*Actinal plates* confined to arm base, with 3 or 4 plates in each series; plates have a few spinelets and sometimes a fasciculate pedicellaria, i.e., the spinelets arise from a single plate.

*Adambulacral plates* slightly spaced apart, wider than long or as wide as long over most of arm; 15–18 adambulacrals to the first 10 inferomarginals. Furrow margin angular, with 5 or 6 furrow spines, the median longest, and 2–4 spinelets on outer face of plate; the single subambulacral spine longer and more robust than furrow spines and is more or less centrally placed.

*Oral plates* slightly tumid and relatively prominent. Each has 6 or 7 furrow spines, the proximal largest, and about 8 suboral spinelets scattered over actinal surface.

*Tubefeet* biserial, with small, distinct sucking discs.

COLOUR (ex ethanol): Dull brown. "Abactinal surface ranges from pale pink (R = 25 mm, or less) to darker pink; papularia cream or white; actinal surface dark pink; tubefeet yellow-orange, actinosomal membrane grey-yellow" (H.E.S. Clark 1970: 18).

REMARKS: A large specimen from NZOI Stn P969 has R/r = 74+/14 mm, br. 14 mm. Over most of the arm there are two inferomarginal spines per plate; abactinal and marginal plate spines are stubby in comparison with those in smaller specimens. There are usually five adambulacral furrow spines, with six on oral plates.

## DISCUSSION

### ABUNDANCE

The family Benthopectinidae is not generally abundant compared with the Astropectinidae; of the 12 species listed above only three have more than 20 records. The total number of station occurrences for the family is 122. The commonest species are *Pectinaster mimicus*, *Benthopecten pikei*, and *B. munidae*; the only other species with more than ten records is *Cheiraster otagoensis*; five species are recorded once only.

### BATHYMETRIC DISTRIBUTION

None of the species was recorded from shallow shelf depths, although one was obtained from 203 m. In general, records are commonest between 300 m and 1000 m.

Species with most records between 200 and 500 m are:

*Benthopecten munidae*  
*Cheiraster teres*

Species with most records between 500 and 1000 m are:

*Benthopecten pentacanthus*  
*Benthopecten pikei*  
*Cheiraster monopedicellaris*  
*Cheiraster richardsoni*  
*Cheiraster subtuberculatus*

Species commonest below 1000 m are:

*Cheiraster ludwigi*  
*Cheiraster otagoensis*  
*Cheiraster triplacanthus*  
*Pectinaster mimicus*

### GEOGRAPHIC DISTRIBUTION

The Benthopectinidae is known over most of the area with records extending from 25° to 50° South latitude. Only three species appear to be widespread, however, with ranges over 12 degrees of latitude or more; these are:

*Benthopecten munidae*  
*Benthopecten pikei*  
*Pectinaster mimicus*

Most of the other species are known from only a few records and further collecting is necessary to clearly establish distributional patterns. Four species which appear to be more northern in distribution are:



*Cheiraster ludwigi*  
*Cheiraster teres*  
*Cheiraster subtuberculatus*  
*Cheiraster triplacanthus*

Three species are known only from the central part of the area:

*Benthopecten pentacanthus*  
*Cheiraster monopedicellaris*  
*Cheiraster richardsoni*

One species is known only from more southern waters:

*Cheiraster otagoensis*

## FAUNAL RELATIONSHIPS

A feature of the fauna is the relatively high proportion of endemic species:

*Benthopecten munidae*  
*Benthopecten pentacanthus*  
*Benthopecten pikei*  
*Cheiraster monopedicellaris*  
*Cheiraster otagoensis*  
*Cheiraster richardsoni*

Of the remaining species, four are also known from Indonesia and the Philippines, with one also recorded from southeast Africa:

*Cheiraster ludwigi*  
*Cheiraster teres*  
*Cheiraster triplacanthus*  
*Pectinaster mimicus*

One species is known only from off eastern Australia:

*Cheiraster subtuberculatus*

Table 2

Abundance, depth, and geographic ranges.

	No. of records	Depth (m)	Latitude (° S)
<b>Benthopectinidae</b>			
<i>Benthopecten munidae</i>	25	203–622	38–50
<i>Benthopecten pentacanthus</i>	1	732	37
<i>Benthopecten pikei</i>	38	327–1815	34–53
<i>Cheiraster ludwigi</i>	1	1828	31
<i>Cheiraster monopedicellaris</i>	3	615–900	35–41
<i>Cheiraster otagoensis</i>	15	721–1400	42–49
<i>Cheiraster richardsoni</i>	1	732	41
<i>Cheiraster subtuberculatus</i>	2	830–1020	30–32
<i>Cheiraster teres</i>	3	300–390	25–29
<i>Cheiraster triplacanthus</i>	1	1450	30
<i>Cheiraster</i> sp.	4	308–646	25–29
<i>Pectinaster mimicus</i>	43	532–2250	30–48
12 species	137	203–2250	25–53

## ACKNOWLEDGMENTS

We are very grateful to the many people who have helped us in the writing of this monograph. In particular we wish to thank Dr Dennis Gordon, without whose patience and encouragement the monograph might not have been completed. We are also extremely grateful to Rose-Marie Thompson who has also encouraged, supported, and assisted us. Others who have also given support and help are Drs Rob Murdoch and Steve O'Shea from NIWA. Dr John Yaldwyn and Bruce Marshall of the Museum of New Zealand have done much to help with identification of stomach contents, respectively crustaceans and molluscs. We are also grateful to other Museum staff who have made the asteroid collections available to us; these include Rick Webber and Andrew Stewart, the latter for help-

ing with station data. Brett Robertson, who is responsible for the photographs has been patient and helpful and we are very grateful. We would also like to thank Tracy Adamson for her help with typing and Mr Jan Rotman for his care and help in translation of German descriptions. NIWA also deserves thanks and praise for its excellent collections and we also thank staff from the Auckland Museum for allowing us to examine their collections. Finally Dr David L. Pawson, Smithsonian Institution has been most helpful in answering many queries and we thank him.

This research was supported by Research Contract CO 1421 with the Foundation for Research, Science and Technology.

## REFERENCES

- ALCOCK, A. 1893: Natural history notes from H.M. Indian Marine Survey Steamer "Investigator", Commander C.F. Oldham, R.N., commanding. Series II, No. 7. An account of the collection of deep-sea Asteroidea. *Annals and Magazine of Natural History, series 6, 11* : 73–121, pls 4–6.
- AYRES, W.O. 1881 (1854): *Stephanaster elegans*. *Proceedings of the Boston Society of Natural History 4* : 118.
- BAKER, A.N.; CLARK, H.E.S. 1970: Some archibenthal echinoderms from northern New Zealand. *Records of the Dominion Museum Wellington 7* : 1–11.
- BALINSKY, B.I. 1958: The Echinoderms. Pp 97–107, figs 25–28 in Macnae, W.; Kalk, N. (eds) *A Natural History of Inhaca Island, Moçambique*. Witwatersrand University Press, Johannesburg.
- BEDFORD, F.P. 1900: On echinoderms from Singapore and Malacca. *Proceedings of the Zoological Society of London 20* : 271–299, pls 21–24.
- BELL, F.J. 1884: Echinodermata. Pp 117–177, tables 1–5, pls 8–17 in *Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. "Alert" 1881–82*. [And a summary of the voyage by R.W. Copping: 509–512, pls 8–17, 45.] Trustees of the British Museum (Natural History), London.
- BELL, F.J. 1885: Notes on a collection of Echinodermata from Australia. *Proceedings of the Linnean Society of New South Wales 9 (for 1884)* : 496–509.
- BELL, F.J. 1887: The echinoderm fauna of the island of Ceylon. *Scientific Transactions of the Royal Dublin Society 3* : 643–658, pls 39, 40.
- BELL, F.J. 1888: Report on a collection of echinoderms made at Tuticorin, Madras, by Mr Edgar Thurston, C.M.Z.S., Superintendent, Government Central Museum, Madras. *Proceedings of the Zoological Society of London 27* : 383–389.
- BELL, F.J. 1892: *Catalogue of the British Echinoderms in the British Museum (Natural History)*. Trustees of the British Museum (Natural History), London. xvii + 202 p., pls 1–xvii.
- BELL, F.J. 1894: On the echinoderms collected during the voyage of H.M.S. "Penguin" and by H.M.S. "Egeria", when surveying Macclesfield Bank. *Proceedings of the Zoological Society of London 20* : 392–412, pls 23–27.
- BELL, F.J. 1904: Notes and additions. In *Report on the Echinoderma collected by Professor Herdman, at Ceylon, in 1902 by W.A. Herdman, D.Sc., F.R.S. and Jane B. Herdman, B.Sc (Lond.)*. *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, Part II, Supplementary Report 10* : 137–147.
- BELL, F.J. 1905: On the Echinoderma found off the coast of South Africa. Asteroidea. Part 2. *Marine Investigations in South Africa 3* : 241–253.
- BELL, F.J. 1909/10: Report on the Echinoderma (other than Holothurians) collected by Mr J. Stanley Gardiner in the western parts of the Indian Ocean. *Transactions of the Linnean Society of London, series 2, Zoology 13* : 17–22, pl. 3.
- BELL, F.J. 1917: Echinoderma. Part 1. Actinogonidiata. *British Antarctic Terra Nova Expedition, 1910. Natural History Report, Zoology 4(1)* : 1–10, pls 1, 2.
- BELYAEV, G.M. 1969a: New sea stars from the abyssal and ultrabyssal of the Pacific Ocean. *Byulleten Moskovskogo Obshchestva Ispytatelei Prirody. Otdel Biologii 74(3)* : 5–26, figs 1–11, tables 1–3.
- BELYAEV, G.M. 1969b: Sea stars (Asteroidea). Pp 109–115 in Zenkevich, L.A. (ed.) *Biology of the Pacific Ocean. 2. The deep-sea benthic fauna. Biology of the Pacific Ocean (1968)*. Izdatel'stvo 'Nauka', Moskva. [In Russian]
- BELAYEV, G.M. 1985a: New findings of starfishes of the family Porcellanasteridae in the ultraabyssal zone. *Zoologicheskii Zhurnal 64* : 538–548, 3 figs.
- BELYAEV, G.M. 1985b: Abyssal starfishes of the genera *Eremicaster* and *Abyssaster* (Porcellanasteridae) : Composition and distribution. *Zoologicheskii Zhurnal 64* : 865–875.
- BELYAEV, B.M.; MIRONOV, A.N. 1993: Deep sea starfishes of the genus *Hyphalaster* (Porcellanasteridae). *Trudy Instituta Okeanologii Akademii Nauk SSR 127* : 205–217.
- BELYAEV, G.M.; MIRONOV, A.N. 1996: Starfishes *Porcellanaster* and *Caulaster* (Porcellanasteridae) from the Atlantic and the Antarctic. *Zoologicheskii Zhurnal 75* : 886–899.
- BENHAM, W.B. 1909: Scientific results of the New Zealand Government Trawling Expedition, 1907. Echinoderma. *Record of the Canterbury Museum 1* : 83–116, pls vii–xi. [Also issued as a separate publication : 1–34, pls 7–11.]
- BENHAM, W.B. 1911: Stellerids and echinids from the Kermadec Islands. *Transactions of the New Zealand Institute 43* : 140–163.
- BENNETT, E.W. 1927: Notes on some New Zealand seastars and on autotomous reproduction. *Record of the Canterbury Museum 3* : 125–149.



- BENNETT, E.W. 1929: Rare New Zealand echinoderms. *New Zealand Journal of Science and Technology* 10 : 173.
- BERNASCONI, I. 1943: Los Asteroideos sudamericanos de la familia Luidiidae. Invertebradas Marinas. *Anales del Museo Argentino, Buenos Aires* 41 : 1–20, 4 pls.
- BERNASCONI, I. 1967: Algunos asteroideos abisales del Oeste de Chile. *Physis, B. Aires* 26 : 443–449, 1 pl.
- BLAKE, D.B. 1973: Ossicle morphology of some recent asteroids and descriptions of some west American fossil asteroids. *University of California Publications in Geological Sciences* 104 : 1–59, pls 1–19.
- BLAKE, D.B. 1982: Somasteroidea, Asteroidea, and the affinities of *Luidia* (*Platasterias*) *latiradiata*. *Palaeontology* 25 : 167–191.
- BLAKE, D.B. 1987: A classification and phylogeny of post-Palaeozoic sea stars (Asteroidea : Echinodermata). *Journal of Natural History* 21 : 481–528.
- BLAKE, D.B.; REID, R. 1998: Some Albian (Cretaceous) asteroids (Echinodermata) from Texas and their paleobiological implications. *Journal of Paleontology* 72 : 512–532.
- BRETON, G. 1995(1996): *Tethyaster guerangeri* sp. nov. (Astropectinidae, Asteroidea, Echinodermata) deux specimens d'astérides d'une conservation exceptionnelle du Cénomanién du Mans (Sarthe, France). *Bulletin trimestriel de la Société Géologique de Normandie et des amis du Muséum du Havre* 82,4 (4e Trimestre) : 17–29.
- CANZ, 1997: New Zealand region bathymetry, 3rd edition. 1:4,000,000. NIWA *Miscellaneous Chart No. 73*.
- CELIS, A.K. de 1980: The asteroids of Marinduque Island. *Acta Manilana, series A*, 19(29) : 20–74, pls 1–6.
- CHAFFEE, C.; WEITBRECHT, B. 1984: Catalog of the asteroid type-specimens and Fisher voucher specimens at the California Academy of Sciences. *Occasional Papers of the California Academy of Sciences* 142 : 1–22.
- CHANG, F.Y.; LIAO, Y.; WU, B.; CHENG, L. 1964: *Echinodermata. Illustrated fauna of China*. Science Press, Beijing. [In Chinese]
- CHAO, S.-M. 1999: A revision of the family Astropectinidae (Echinodermata : Asteroidea) from Taiwan, with description of five new records. *Zoological Studies* 38 : 257–267.
- CHERBONNIER, G.; SIBUET, M. 1973: Résultats scientifiques de la campagne Noratlante : Astéroïdes et Ophiurides. *Bulletin du Muséum national d'Histoire Naturelle (Zoologique)* 76 : 1333–1394.
- CHIU, S.T.; LAM, V.W.W.; SHIN, P.K.S. 1985: Mollusc pre-dation by *Luidia* spp. (Echinodermata : Asteroidea) in Tolo Harbour and Channel, Hong Kong. Pp 365–379 in Morton, B.; Dudgeon, D. (eds) *The Malacofauna of Hong Kong and Southern China. Proceedings of the Second International Workshop on the Malacofauna of Hong Kong and Southern China*, Hong Kong, 6–24 April 1983. Volume 2. Hong Kong University Press, Hong Kong. 681 p.
- CHUN, C. 1900: *Aus den Tiefen des Weltmeeres. Schilderungen von der deutschen Tiefsee-Expedition*. (Asteroidea : H. Ludgwig). Fischer, Jena, viii + 550 p., 46 pls.
- CLARK, A.H. 1948: Some interesting starfishes and brittle-stars dredged by the Atlantis in the mid-Atlantic. *Journal of the Washington Academy of Sciences* 38 : 75–78.
- CLARK, A.H.; BOWEN, R.L.E.B. 1949: Echinoderms of Tarut Bay and vicinity, Saudi Arabia, with notes on their occurrence. *American Museum Novitates* 1390 : 1–20.
- CLARK, A.M. 1952a: On some specimens of the family Porcellanasteridae (Asteroidea) in the British Museum (Natural History). *Annals and Magazine of Natural History*, 5 : 945–953, 1 pl.
- CLARK, A.M. 1952b: Some echinoderms from South Africa. *Transactions of the Royal Society of South Africa* 33 : 193–221.
- CLARK, A.M. 1952c: The Manihine Expedition to the Gulf of Aquaba, 1948–1949. Echinodermata. *Bulletin of the British Museum (Natural History), (Zoology)* 1 : 203–213, pls 31, 32.
- CLARK, A.M. 1953: Notes on asteroids in the British Museum (Natural History). 3. *Luidia*. 4. *Tosia* and *Pentagonaster*. *Bulletin of the British Museum (Natural History) (Zoology)* 1 : 379–411, pls 39–46, figs 1–15.
- CLARK, A.M. 1962: *Starfishes and their Relations*. Trustees of the British Museum (Natural History), London. 119 p., pls 1–14. [1977 edition, *Starfishes and Related Echinoderms*. TFH Publications. 10–160, additional colour plates.]
- CLARK, A.M. 1962: Asteroidea. Report B.A.N.Z. Antarctic Research Expedition 1919–1931, B : 10–104, 6 pls.
- CLARK, A.M. 1967: Echinoderms from the Red Sea. Part 2 Crinoids, ophiuroids, echinoids and more asteroids. [Israel South Red Sea Expedition 1962 Report No. 21.] *Bulletin. Sea Fisheries Research Station, Israel* 41 : 26–59.
- CLARK, A.M. 1974: Notes on some echinoderms from southern Africa. *Bulletin of the British Museum (Natural History) (Zoology)* 26 : 423–487, pls 1–3.
- CLARK, A.M. 1981: Notes on Atlantic and other Asteroidea : Family Benthoplectinidae. *Bulletin of the British Museum (Natural History) Zoology* 41 : 91–135.
- CLARK, A.M. 1982: Notes on Atlantic Asteroidea. 2. Luidiidae. *Bulletin of the British Museum (Natural History) (Zoology)* 42 : 157–184.

- CLARK, A.M. 1989: An index of names of recent Asteroidea. Part 1 : Paxillosoida and Notomyotida. *Echinoderm Studies* 3 : 225–347.
- CLARK, A.M. 1993: An index of names of recent Asteroidea. *Echinoderm Studies* 4 : 187–366.
- CLARK, A.M.; CLARK, A.H. 1954: A revision of the sea-stars of the genus *Tethyaster*. *Smithsonian Miscellaneous Collections* 122(11) : 1–27, pls 1–12.
- CLARK, A.M.; DAVIES, P.S. 1965: Echinoderms of the Maldive Islands. *Annals and Magazine of Natural History, ser. 13*, 8 : 597–612, pl. 18(a, b).
- CLARK, A.M.; COURTMAN-STOCK, J. 1976: *The Echinoderms of Southern Africa*. Trustees of the British Museum (Natural History), London. 277 p.
- CLARK, A.M.; DOWNEY, M.E. 1992: *Starfishes of the Atlantic*. Chapman and Hall, London. xxvi + 794 p.
- CLARK, A.M.; ROWE, F.W.E. 1971: *Monograph of shallow-water Indo-West Pacific Echinoderms*. Trustees of the British Museum (Natural History), London. vii + 238 p., pls 1–31.
- CLARK, H.E.S. 1963: The fauna of the Ross Sea. Part 3, Asteroidea. *Memoirs. New Zealand Oceanographic Institute* 21 : 1–84 p., 15 pls.
- CLARK, H.E.S. 1969: Two new species of *Benthopecten* (Asteroidea) from New Zealand. *Transactions of the Royal Society of New Zealand (Biology)* 11 : 83–88, 1 pl.
- CLARK, H.E.S. 1970: Sea-stars (Echinodermata : Asteroidea) from “Eltanin” Cruise 26, with a review of the New Zealand asteroid fauna. *Zoology Publications from Victoria University of Wellington* 52 : 1–34, pls 1–3.
- CLARK, H.E.S.; MCKNIGHT, D.G. 1994: *Damnaster tasmani*, a new genus and species of Asteroidea (Echinodermata) from New Zealand. *Invertebrate Taxonomy* 8 : 1367–1372.
- CLARK, H.L. 1909: Notes on some Australian and Indo-Pacific echinoderms. *Bulletin of the Museum of Comparative Zoology at Harvard College* 52 : 109–135, 1 pl.
- CLARK, H.L. 1916: I. Report on the sea-lilies, starfishes, brittle-stars and sea-urchins obtained by the F.I.S. “Endeavour” on the coasts of Queensland, New South Wales, Tasmania, Victoria, South Australia, and Western Australia. *Biological Results of the Fishing Experiments carried out by F.I.S. “Endeavour” 1909–14*, 4 : 3–123, pls 1–44.
- CLARK, H.L. 1920: Eastern tropical Pacific Asteroidea. *Memoirs of the Museum of Comparative Zoology of Harvard College* 39 : 73–113, 6 pls.
- CLARK, H.L. 1921: The echinoderm fauna of Torres Strait : its composition and its origin. *Papers from the Department of Marine Biology of the Carnegie Institution of Washington* 10 : 1–223, pls 1–38.
- CLARK, H.L. 1923: The echinoderm fauna of South Africa. *Annals of the South African Museum* 13 : 221–435, pls 8–23.
- CLARK, H.L. 1926a: Notes on a collection of echinoderms from the Australian Museum. *Record of the Australian Museum* 15 : 183–192.
- CLARK, H.L. 1926b: Echinoderms from the South African fisheries and marine biological survey. 2. Sea-stars (Asteroidea). *Report. Fisheries and Marine Biological Survey, Union of South Africa* 4 : 1–34, pls 1–7.
- CLARK, H.L. 1938: Echinoderms from Australia. An account of collections made in 1929 and 1932. *Memoirs of the Museum of Comparative Zoology of Harvard College* 55 : iii–viii, 3–596, pls 1–28.
- CLARK, H.L. 1946: The echinoderm fauna of Australia. Its composition and its origin. *Carnegie Institution of Washington Publication* 566 : iv + 567 p.
- COPPINGER, R.W. 1884: *Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. “Alert” 1881–82*. [Summary of the voyage with a list of Echinodermata by F.J. Bell.] Trustees of the British Museum (Natural History), London. Pp. 509–512.
- COTTON, B.C.; GODFREY, F.K. 1942: Echinodermata of the Flindersian region, southern Australia. *Record of the South Australian Museum* 7 : 193–234, pl. 12.
- DAY, J.H.; FIELD, J.G.; PENRITH, M.J. 1970: The benthic fauna and fishes of False Bay, South Africa. *Transactions of the Royal Society of South Africa* 39 : 1–108.
- DEVANEY, D.M. 1973: Zoogeography and faunal composition of south-eastern Polynesian asterozoan echinoderms. Pp 357–366 in Fraser, R. (comp.) *Oceanography of the South Pacific 1972*. N.Z. National Commission for UNESCO, Wellington. 524 p.
- DÖDERLEIN, L. 1888: Echinodermen von Ceylon. Bericht über die von den Herren dres sarasin gesammelten Asteroidea, Ophiuroidea und Echinoidea. *Zoologische Jahrbucher* 3 : 821–846, pls 31–33.
- DÖDERLEIN, L. 1902: Japanische Seesterne. *Zoologischer Anzeiger* 25(659–684) : 326–335.
- DÖDERLEIN, L. 1917: Die Asteriden der Siboga-Expedition. 1. Die Gattung *Astropecten* und ihre Stammesgeschichte. *Siboga-Expedition* 46a : xxv + 191 p., pls 1–17.
- DÖDERLEIN, L. 1920: Die Asteriden der Siboga-Expedition. 2. Die Gattung *Luidia* und ihre Stammesgeschichte. *Siboga-Expedition* 46b : 193–293, pls 18–20.



- DÖDERLEIN, L. 1921: Die Asteriden der Siboga-Expedition. 1. Porcellanasteridae, Astropectinidae, Benthoplectinidae. *Siboga-Expeditie* 46(1) : 1–47, pls 1–13.
- DÖDERLEIN, L. 1926: Über Asteriden aus dem Museum von Stockholm. *Kungliga Svenska Vetenskapsakademiens Handlingar, Tredje Serien*, 2(6) : 3–22, pls 1–4.
- DOI, T. 1976: Some aspects of feeding ecology of the sea stars, genus *Astropecten*. *Publications from the Amakusa Marine Biological Laboratory, Kyushu University* 4 : 1–19.
- DOMANTAY, J.S. 1972: Monographic studies and checklist of Philippine littoral echinoderms. *Acta Manila, Series A*, 9(15) : 36–159, pls 1–18.
- DOMANTAY, J.S.; CONCLU, P. 1968: The echinoderm fauna of Manila Bay. *Philippine Journal of Science* 97 : 159–176.
- DOMANTAY, J.S.; ROXAS, H.A. 1938: The littoral Asteroidea of Port Galera Bay and adjacent waters. *Philippine Journal of Science* 65 : 203–237, pls 1–17.
- DOWNEY, M.E. 1973: Starfishes from the Caribbean and the Gulf of Mexico. *Smithsonian Contributions to Zoology* 126 : 1–158, pls 1–48.
- DUJARDIN, F.; HUPÉ, M.H. 1862: *Histoire naturelle des Zoophytes. Echinodermes*. Libraire Encyclopedique de Roret, Paris. 627 p., 10 pls.
- D'YAKONOV (DJAKONOV), A.M. 1950: Sea stars (asteroids) of the USSR seas. Keys to the fauna of the USSR. *Zoological Institute of the Academy of Sciences of the USSR No. 34*. [Israel Program for Scientific Translations, Jerusalem, 1968 : 1–183.]
- ELY, C.A. 1942: Shallow-water Asteroidea and Ophiuroidea of Hawaii. *Bulletin of the Bernice P. Bishop Museum* 176 : 3–63, pls 1–13.
- ENDEAN, R. 1953: Echinodermata (excluding Crinoidea). Queensland. *Faunistic Records* 1 : 53–50.
- ENDEAN, R. 1957: The biogeography of Queensland's shallow-water echinoderm fauna (excluding Crinoidea), with a rearrangement of the faunistic provinces of tropical Australia. *Australian Journal of Marine and Freshwater Research* 8 : 233–272.
- FARQUHAR, H. 1898: On the echinoderm fauna of New Zealand. *Proceedings of the Linnean Society of New South Wales* 23 : 300–327.
- FARQUHAR, H. 1907: Notes on New Zealand echinoderms; with description of a new species. *Transactions and Proceedings of the New Zealand Institute* 39 : 123–130.
- FELL, H.B. 1947: A key to the littoral asteroids of New Zealand. *Tuatara* 1 : 20–23.
- FELL, H.B. 1949: The constitution and relations of the New Zealand echinoderm fauna. *Transactions and Proceedings of the Royal Society of New Zealand* 77 : 208–212.
- FELL, H.B. 1952: Echinoderms from southern New Zealand. *Zoology Publications from Victoria University College* 18 : 1–37.
- FELL, H.B. 1958: Deep sea echinoderms of New Zealand. *Zoology Publications from Victoria University of Wellington* 24 : 1–40.
- FELL, H.B. 1959: Starfishes of New Zealand. *Tuatara* 7 : 127–142.
- FELL, H.B. 1960: Biological results of the Chatham Islands 1954 Expedition. Part 2. Archibenthal and littoral echinoderms of the Chatham Islands. *Memoirs. New Zealand Oceanographic Institute* 5 : 55–75.
- FELL, H.B. 1962a: Native sea-stars. Pp 3–64 in *Nature in New Zealand*. A.H. & A.W. Reed, Wellington.
- FELL, H.B. 1962b: A living somasteroid, *Platasterias latiradiata* Gray. *Paleontological Contributions. University of Kansas* 6 : 1–16, pls 1–4, text-figs 1–8.
- FELL, H.B. 1962c: The evolution of the echinoderms. *Report of the Smithsonian Institution*: 457–490, pls 1–3.
- FELL, H.B. 1963a: Starfishes of New Zealand — a correction. *Tuatara* 11 : 142.
- FELL, H.B. 1963b: The phylogeny of sea-stars. *Philosophical Transactions of the Royal Society, London* 246B : 381–435, pls 50–51.
- FENWICK, G.D.; HORNING, D.S. 1980: Echinodermata of The Snares islands, southern New Zealand. *New Zealand Journal of Marine and Freshwater Research* 14 : 437–445.
- FISHER, W.K. 1905: New starfishes from deep water off California and Alaska. *Bulletin of the Bureau of Fisheries* 24 : 291–320.
- FISHER, W.K. 1906: The starfishes of the Hawaiian Islands. *Bulletin of the Bureau of Fisheries* 23 : 987–1130.
- FISHER, W.K. 1908a: Necessary changes in the nomenclature of starfishes. *Smithsonian Miscellaneous Collections* 5(1), Q52 : 87–93.
- FISHER, W.K. 1908b: Some necessary changes in the generic names of starfishes. *Zoologischer Anzeiger* 33 : 356–359.
- FISHER, W.K. 1911: Asteroidea of the North Pacific and adjacent waters. Part 1. Phanerozonia and Spinulosa. *Bulletin of the United States National Museum* 76 : ii–vi, 1–419, pls 1–122.
- FISHER, W.K. 1913: Four new genera and fifty-eight new

- species of starfishes from the Philippine Islands, Celebes and the Moluccas. [Scientific results of the Philippine cruise of the Fisheries Steamer "Albatross" 1907–1910. No. 23.] *Proceedings of the United States National Museum* 43 : 599–648.
- FISHER, W.K. 1914: New starfishes from the Philippine Islands, Celebes and the Moluccas. [Scientific Results of the Fisheries Steamer "Albatross", 1907–1910. No. 30.] *Proceedings of the United States National Museum* 46 : 201–224.
- FISHER, W.K. 1916: Notes on the systematic position of certain higher groups of starfishes. *Proceedings of the Biological Society of Washington* 29 : 1–6.
- FISHER, W.K. 1917: Notes on Asteroidea. *Annals and Magazine of Natural History ser. 8*, 20 : 166–172.
- FISHER, W.K. 1919: Starfishes of the Philippine seas and adjacent waters. *Bulletin of the United States National Museum* 3(100) : i–xi, 1–712, pls 1–156.
- FISHER, W.K. 1925: Sea stars. Sea stars of tropical central Pacific. [Tanager Expedition Publication 1.] *Bulletin of the Bernice P. Bishop Museum* 27 : 63–88.
- FISHER, W.K. 1940: Asteroidea. 'Discovery' Reports 20 : 69–305, pls 1–23.
- FLAMMANG, P. 1995: Fine structure of the podia in three species of paxilloid asteroids of the genus *Luidia* (Echinodermata). *Belgian Journal of Zoology* 125 : 125–134.
- FORBES, E. 1839: On the Asteriadae of the Irish Sea. *Memoirs of the Wernerian Natural History Society, Edinburgh* 8 : 114–129, 2 pls.
- GAGE, J.D.; PEARSON, M.; CLARK, A.M.; PATERSON, G.L.J.; TYLER, P.A. 1983: Echinoderms of the Rockall Trough and adjacent areas. I. Crinoidea, Asteroidea and Ophiuroidea. *Bulletin of the British Museum (Natural History) (Zoology)* 45 : 263–308.
- GOSLINER, T.M.; BEHRENS, D.W.; WILLIAMS, G.C. 1996: *Coral Reef Animals of the Indo-Pacific*. Sea Challengers, Monterey. vi + 314 p., figs.
- GOTO, S. 1914: A descriptive monograph of Japanese Asteroidea. 1. *Journal of the College of Science, Imperial University of Tokyo* 29 : 1–808, pls 1–19.
- GRAY, J.E. 1840: A synopsis of the genera and species of the class Hypostoma (*Asterias*, Linnaeus). *Annals and Magazine of Natural History* 6 : 175–184, 275–290.
- GRAY, J.E. 1847a: The description of some new species of starfishes, Asteriadae. Pp 339–354 in *Narrative of the surveying voyage of H.M.S. Fly, commanded by Captain F.P. Blackwood, R.N., in Torres Strait, New Guinea and other islands of the Eastern Archipelago, during the years 1842–1846: ...* T. & W. Boone, London. Vol. 2.
- GRAY, J.E. 1847b: Descriptions of some new genera and species of Asteriadae. *Proceedings of the Zoological Society of London 1847* : 72–82. [Also in *Annals and Magazine of Natural History* 20 : 193–204.]
- GRAY, J.E. 1866: *Synopsis of the Species of Starfish in the British Museum (with figures of some of the new species)*. J. van Voorst, London. iv + 17 p., pls 1–16.
- GRAY, J.E. 1872: List of echinoderms collected by Robert McAndrews, Esq., F.R.S., in the Gulf of Suez in the Red Sea. *Annals and Magazine of Natural History ser. 4*, 10 : 115–125.
- GRUBE, A.E. 1866: Einige neue Seesterne des hiesigen zoologischen Museums. *Jahresbericht der Schlesischen Gesellschaft 1865* : 35–37.
- GUILLE, A.; JANGOUX, M. 1978: Astérides et Ophiurides littorales de la région d'Amboine (Indonésie). *Annales de l'Institut Océanographique, Paris* 54 : 47–73, pls 1, 2.
- GUILLE, A.; LABOUTE, P.; MENOUE, J.-L. 1986: Guide des étoiles de mer, oursins et autres échinodermes du lagon de Nouvelle-Calédonie. [Handbook of the sea-stars, sea-urchins and related echinoderms of the New Caledonia lagoon.] *Faune Tropicale* 25 : 1–238.
- HABE, T. 1952: Parasitic gastropods found in echinoderms from Japan. *Publications of the Seto Marine Biological Laboratory* 11(2), 6 : 73–85.
- HALL, R.L.; MOORE, S. 1990: *Tethyaster albertensis*, a late Cretaceous (Turonian) sea star from the Cardium Formation, Alberta, Canada. *Journal of Paleontology* 64 : 1045–1049.
- HALPERN, J.A. 1968: Biological investigations of the deep sea. 38. A new western Atlantic *Dipsacaster* (Echinodermata, Asteroidea) with the distribution of known species. *Proceedings of the Biological Society of Washington* 81 : 231–240.
- HAYASHI, R. 1938: Sea-stars in the vicinity of the Seto Marine Biological Laboratory. *Bulletin of the Biogeographical Society of Japan* 8 : 271–292, pls 5–7.
- HAYASHI, R. 1973: *The sea-stars of Sagami Bay : Collected by His Majesty the Emperor of Japan. Described by R. Hayashi*. Imperial Household, Tokyo. viii + 114 p., pls 1–18.
- HERDMAN, W.A.; HERDMAN, J.B. 1904: Report on the echinoderma collected by Professor Herdman, at Ceylon, in 1902. With notes and additions by F.J. Bell. *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, Part II, Supplementary Report* 10 : 137–147.
- HOQUE, M.M. 1969: Echinoderms of Pakistan coasts. *Record. Zoological Survey of Pakistan* 1 : 27–38.
- HUTTON, F.W. 1872a: Descriptions of some new starfishes



- from New Zealand. *Proceedings of the Scientific Meetings of the Zoological Society of London, 1872* : 810–812.
- HUTTON, F.W. 1872b: *Catalogue of the Echinodermata of New Zealand with Diagnoses of the Species*. James Hughes, Government Printer, Wellington. vi + 17 p.
- HUTTON, F.W. 1904: Echinodermata. Pp 286–292 in *Index Faunae Novae Zealandiae*. Dulau, London. vii + 372 p.
- IMAOKA, T.; IRIMURA, S.; OKUTANI, T.; OGURO, C.; OJI, T.; SHIGEL, M.; HORIKAWA, H. 1990: Echinoderms from continental shelf and slope around Japan. In *The Intensive Research of Unexploited Fishery Resources on Continental Slopes*. Japan Fisheries Resource Conservation Association, Tokyo. Vol. 1. 1–159. [In English and Japanese]
- JAMES, B.D. 1969: Catalogue of echinoderms in the reference collections of the Central Marine Fisheries Research Institute. [In James, P.S.B.R. et al. *Catalogue of Types and of Sponges, Corals, Polychaetes, Crabs and Echinoderms in the Reference Collections of the Central Marine Fisheries Research Institute*.] *Bulletin. Central Marine Fisheries Research Institute* 7 : 51–62. [Also *Advance Abstracts of Contributions on Fisheries and Aquatic Sciences in India* 3 : 183.
- JAMES, D.B.; PEARSE, J.S. 1969: Echinoderms from the Gulf of Suez and the northern Red Sea. *Journal of the Marine Biological Association of India* 11 : 78–125.
- JANGOUX, M. 1973: Les Astéries de l'île d'Inhaca (Mozambique) (Echinodermata, Asteroidea). 1. Les espèces récoltées et leur répartition géographique. *Zoologische Wetenschappen* 208 : 1–50, pls i–vii, figs 1–13. [Annales du Musée r. de l'Afrique central, Série 8, Sciences zoologiques, 208.]
- JANGOUX, M. 1981: Echinoderms : Asteroïdes. Results of the MUSORSTOM Expeditions. 1. Philippines (18–28 Mars 1976). *Mémoires ORSTOM* 91 : 457–476, pls 1–5.
- JANGOUX, M. 1982: Food and feeding mechanisms : Asteroidea. Pp 117–159 in Jangoux, M.; Lawrence, J.M. (eds) *Echinoderms. Proceedings of an International Echinoderm Conference, Tampa Bay, 1981*. A.A. Balkema, Rotterdam.
- JANGOUX, M. 1984: Les astérides littoraux de Nouvelle-Calédonie. *Bulletin du Muséum national d'Histoire naturelle, 4e ser. A, 6* : 279–293.
- JANGOUX, M.; AZIZ, A. 1984: Les astérides (Échinodermes) du centre-ouest de l'océan Indien (Seychelles, Maldives et îles Mineures). *Bulletin du Muséum national d'Histoire naturelle, 4e ser. A, 6* : 857–883, pls 1–4.
- JANGOUX, M.; DE RIDDER, C.; MASSIN, C.; DARSONO, P. 1989: The holothuroids, echinoids and asteroids (Echinodermata) collected by the Snellius-II Expedition. *Netherlands Journal of Sea Research* 23 : 161–170.
- JOHN, D.D. 1948: Notes on asteroids in the British Museum (Natural History). 1. The species of *Astropecten*. *Novitates Zoologicae* 42 : 485–508.
- KOEHLER, R. 1895: Catalogue raisonné de Échinodermes recueillis par M. Korotnev aux îles de la Sonde. *Mémoires de la Société Zoologique de France* 8 : 374–423.
- KOEHLER, R. 1905: Echinides, Astéries et Ophiures recueillis par M. Gravier dans la Mer Rouge (Golfe de Tadjourah). *Bulletin du Muséum d'Histoire Naturelle* 3 : 184–186.
- KOEHLER, R. 1906: Echinodermes (Stellerides, Ophiures et Echinides). *Expedition Antarctique Française (1903–1905)* : 41, 4 pls.
- KOEHLER, R. 1907: Note préliminaire sur quelques Astéries et Ophiures provenant des campagnes de la "Princess Alice". *Bulletin de l'Institut Océanographique Monaco* 99 : 1–47.
- KOEHLER, R. 1909a: Échinodermes provenant des campagnes du yacht "Princess-Alice" (Astéries, Ophiures, Echinides et Crinoïdes). *Résultats des Campagnes Scientifiques accomplies sur son Yacht par Albert Ier Prince Soverain de Monaco* 34 : 3–317, pls 1–32.
- KOEHLER, R. 1909b: *Echinoderma of the Indian Museum. Asteroidea. An account of the deep sea Asteroidea collected by the Royal Indian Marine Survey Ship "Investigator". I. Les Astéries de Mer profonde*. Trustees of the Indian Museum, Calcutta. 5–143, pls 1–13.
- KOEHLER, R. 1910a: Astéries et Ophiures des îles Aru et Kei. *Abhandlungen hrsg. von der Senckenbergischen Naturforschenden Gesellschaft. Frankfurt* 33 : 265–295, pls 15–17.
- KOEHLER, R. 1910b: *An account of the shallow-water Asteroidea — Astéries du Musée de Calcutta. II. Les Astéries littorales. Echinoderma of the Indian Museum. Part 6*. Printed by Order of the Trustees of the Indian Museum, Calcutta. 5–191, pls 1–20.
- KOEHLER, R. 1920: Echinodermata Asteroidea. *Scientific Reports of the Australasian Antarctic Expedition 1911–1914. Series C, Zoology and Botany* 8(1) : 5–308, pls 1–75.
- KOEHLER, R. 1921: Échinodermes (Astéries, Ophiures, Echinides et Crinoïdes) des dernières campagnes de la "Princess Alice" et de l'Hirondelle II'. *Bulletin de l'Institut Océanographique Monaco* 396 : 1–8.
- KOEHLER, R. 1924: *Les Échinodermes des mers d'Europe. 1. Généralités, Astérides, Ophiurides*. In Doin, G. (ed.). Librairie Octave Doin, Paris. ix–xiii + 362 p., pls 1–9.
- KOMATSU, M.; KAWAI, M. 1994: Development of the multi-armed seastar, *Luidia maculata* Müller & Troschel. In David, Guille, Féral and Roux (eds) *Echinoderms through Time*. A.A. Balkema, Rotterdam. Pp. 327–333, figs 1, 2.

- LEIPOLDT, F. 1895: Asteroidea der "Vettor-Pisani" Expedition (1882–1885). Mit Anhang : Die von F. Orsini im rothen Meere gesammelten Asteroideen. *Zeitschrift Wissenschaftliche Zoologie* 59 : 545–653, pls 31, 32.
- LIEBERKIND, I. 1932: Asteridae der Deutschen Tiefsee-Expedition. I. Porcellanasteridae. *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898–1899*, 21 : 3–31, 271–299, pls 11–17.
- LIEBERKIND, I. 1935: Asteroidea. I. Porcellanasteridae. *Danish Ingotf-Expedition* 4(10) : 1–37, pls 1–5.
- LINNAEUS, C. 1758: *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. 10th ed. Laurentii Salvii, Holmiae. Vol. 1, 824 p.
- LIAO, YL.; CLARK, A.M. 1995: *The Echinoderms of Southern China*. Science Press, Beijing. iii + 613 p., map.
- LIVINGSTONE, A.A. 1932: Asteroidea. *Scientific Reports of the Great Barrier Reef Expedition (1928–29)* : 241–265, pls 1–12.
- LORIOU, P. de 1885: Catalogue raisonné des Échinodermes recueillis par M.V. de Robillard à l'île Maurice. 2. Stellerides. *Mémoires de la Société de physique et d'Histoire Naturelle de Genève* 29(4) : 3–83, pls 7–22.
- LORIOU, P. de 1893: Echinodermes de la Baie d'Amboine. *Revue Suisse de Zoologie* 1 : 359–426.
- LUDWIG, H. 1900: Asteroidea. In Chun, C. *Aus den Tiefen des Weltmeeres. Schilderungen von der deutschen Tiefsee-Expedition*. Fischer, Jena, viii + 550 p., 46 pls, 30 figs. 2 maps.
- LUDWIG, H. 1905: Reports on an exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission Steamer "Albatross", during 1891, Lieut. Commander Z.L. Tanner, U.S.N. commanding. 35. Reports on the Scientific Results of the Expedition to the Tropical Pacific, in charge of Alexander Agassiz, on the U.S. Fish Steamer "Albatross" from August 1899, to March 1900, Commander Jefferson F. Moser, U.S.N. commanding. 7. Asteroidea. *Memoirs of the Museum of Comparative Zoology of Harvard College* 32 : vi–xii, 1–292, pls 1–36.
- LUDWIG, H. 1907: Diagnosen neuer Tiefsee Seesterne aus der Familie der Porcellanasteriden. *Zoologischer Anzeiger* 31 : 312–319.
- LUTKEN, C. 1865: Kritiske Bemærkninger om forsk-jellige Soøstjerner (Asterider), med Beskrivelse af nogle nye Arter. *Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjøbenhavn* 8–12 : 123–169.
- MACAN, T.T. 1938: Asteroidea. *Scientific Reports. John Murray Expedition, 1933–1934*, 4(9) : 323–435, pls 1–6.
- MACNAE, W.; KALK, N. (eds) 1958: *A natural history of Inhaca Island, Mocambique*. Witwatersrand University Press, Johannesburg.
- McKNIGHT, D.G. 1967: Additions to the echinoderm fauna of the Chatham Rise. *New Zealand Journal of Marine and Freshwater Research* 1 : 291–313.
- McKNIGHT, D.G. 1968a: Some echinoderms from the Kermadec Islands. *New Zealand Journal of Marine and Freshwater Research* 2 : 505–526.
- McKNIGHT, D.G. 1968b: Some echinoderms from Tongatabu Island and the south Minerva Reef. *New Zealand Journal of Marine and Freshwater Research* 2 : 712–715.
- McKNIGHT, D.G. 1972: Echinoderms collected by the Cook Islands Eclipse Expedition 1965. *NZOI Records* 1(3) : 37–45.
- McKNIGHT, D.G. 1973a: Additions to the asteroid fauna of New Zealand : Families Benthoplectinidae, Odontasteridae, Asteroiidae and Brisingidae, with notes on *Porcellanaster caeruleus* Wyville Thomson (family Porcellanasteridae). *NZOI Records* 1(16) : 219–239.
- McKNIGHT, D.G. 1973b: Additions to the asteroid fauna of New Zealand : Families Radiasteridae, Solasteridae, Pterasteridae, Asterinidae, Ganeriidae and Echinasteridae. *NZOI Records* 2(1) : 1–15.
- McKNIGHT D.G. 1975: Some echinoderms from the northern Tasman Sea. *NZOI Records* 2(5) : 49–76.
- McKNIGHT, D.G. 1977: Classification of Recent paxilloid sea-stars (Asterozoa : Echinodermata). *NZOI Records* 3(12) : 113–119.
- McKNIGHT, D.G. 1978: *Acanthaster planci* (Linnaeus) (Asteroidea : Echinodermata) at the Kermadec islands. *NZOI Records* 4(3) : 17–19.
- McKNIGHT, D.G. 1989a: Further records of Tasman and Coral Sea echinoderms. *DMFS Report* 3 : 3–17.
- McKNIGHT, D.G. 1989b: Some echinoderm records from the tropical South-western Pacific Ocean. *DMFS Report* 3 : 19–30.
- McKNIGHT, D.G. 1993a: Records of echinoderms (excluding holothurians) from the Norfolk Ridge and Three Kings Rise north of New Zealand. *New Zealand Journal of Zoology* 20 : 165–190.
- McKNIGHT, D.G. 1993b: Records of echinoderms (excluding holothurians) from the Chatham Islands. *New Zealand Journal of Zoology* 20 : 191–200.
- MADSEN, F.J. 1951: Asteroidea. *Report of the Swedish Deep-Sea Expedition 1947–1948*, 2(6) : 73–92.



- MADSEN, F.J. 1956: Report of the Lund University Chile Expedition 1948–49. 24. Asteroidea, with a survey of the Asteroidea of the Chilean Shelf. *Acta Universitatis lundensis (n.s.)* 52(2) : 1–53, 6 pls.
- MADSEN, F.J. 1961: The Porcellanasteridae. A monographic revision of an abyssal group of sea-stars. *Galathea Report* 4 : 33–174, pls 1–13.
- MADSEN, F.J. 1981: Records of a porcellanasterid, *Styrcaster elongatus* (Echinodermata, Asteroidea) from the Caribbean, with remarks on growth and notes on some other species of the genus. *Steenstrupia* 7 : 309–319.
- MARSH, L.M. 1974: Shallow-water asterozoans of south-eastern Polynesia. 1. Asteroidea. *Micronesica* 10 : 65–104.
- MARSH, L.M. 1976: Western Australian Asteroidea since H.I. Clark. *Thalassia Jugoslavica* 12 : 213–225.
- MARTENS, E. von 1865: Ueber östasiatische Echinodermen. *Archiv für Naturgeschichte* 31 : 345–360.
- MARTENS, E. von 1866: Ueber östasiatische Echinodermen. 3. Seesterne des indischen Archipels. *Archiv für Naturgeschichte* 32 : 57–88.
- MORTENSEN, T. 1925: Echinoderms of New Zealand and the Auckland-Campbell Islands. 3–5: Asteroidea, Holothuroidea and Crinoidea. Zoogeographical remarks on the echinoderm fauna of New Zealand and the Auckland-Campbell Islands. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhavn* 79 : 261–420, pls 1 2–14.
- MORTENSEN, T. 1927: *Handbook of Echinoderms of the British Isles*. Oxford University Press, London. v-ix + 471 p.
- MORTENSEN, T. 1933: Papers from Dr Th. Mortensen's Pacific Expedition 1914–26. 65. Echinoderms of South Africa (Asteroidea and Ophiuroidea). *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhavn* 93 : 215–399, pls 8–19.
- MORTENSEN, T. 1934: Echinoderms of Hong Kong. *The Hong Kong Naturalist, supplement* 3 : 3–14, pls 1–8.
- MORTENSEN, T. 1940: Echinoderms from the Iranian Gulf. Asteroidea, Ophiuroidea and Echinoidea. (Crinoidea by T. Gislén.). *Danish Scientific Investigations in Iran* 2 : 55–112, 2 pls.
- MOYSE, J.; TYLER, P.A. 1995: Sea urchins, starfish, and sea cucumbers. In Hayward, P.J.; Ryland, J.S. (eds) *The Marine Fauna of the British Isles and North-west Europe*. University Press, Oxford, New York, etc. Vol. 2 : 663–686, figs 121–210.
- MÜLLER, J.; TROSCHER, F.H. 1842: *System der Asteriden*. 1. *Asteridae*. 2. *Ophiuridae*. Friedrich Vieweg & Son, Braunschweig. v-xx, 1–134, pls 1–12.
- NORMAN, A.M. 1865: On the genera and species of British Echinodermata. *Annals and Magazine of Natural History, Series 3*, 15 : 98–129.
- O'HARA, T.D. 1998: Systematics and biology of Macquarie Island echinoderms. *Memoirs of the Museum of Victoria, Melbourne* 57 : 167–223.
- OKADA, A.; UGIDA, C. 1981: *New Illustrated Encyclopedia of the Fauna of Japan*. Hokuryukan Press, Tokyo.
- PAWSON, D.L. 1961: Distribution patterns of New Zealand echinoderms. *Tuatara* 9 : 9–18.
- PAWSON, D.L. 1965: The distribution of echinoderms along the east coast of New Zealand. *Transactions of the Royal Society of New Zealand* 6 : 245–252.
- PAWSON, D.L. 1995: Echinoderms of the tropical island Pacific : Status of their systematics and notes on their ecology and biogeography. Pp 171–192 in Maragos, J.E.; Peterson, M.N.A. et al. (eds) *Marine and Coastal Biodiversity in the Tropical Island Pacific Region*. 1. *Species Systematics and Information Management Priorities*. East-West Center, Honolulu, Hawaii. xxii + 424 p.
- PERRIER, E. 1869: *Recherches sur les Pédicellaires et les Ambulacres des Astéries et des Oursins*. Masson, Paris. 1–188, 2 pls. [Also in *Annales des Sciences naturelles, Zoologie, Series 5*, 12(1869) : 5–81, 197–304, pls 17, 18; 13(1870) : 1–81 (Echinides).]
- PERRIER, E. 1875(1876): *Revision de la Collection des Stellérides du Muséum d'Histoire Naturelle de Paris*. 384 p. [Also in : *Archives de Zoologie expérimentale et générale* 4 (1875) : 265–450; 5 (1876) : 1–104, 209–304. Abstracts in *Compte rendu hebdomadaire des Séances de l'Académie des Sciences, Paris* 81 (1875) : 1271–1273 and *Annals and Magazine of Natural History, ser. 5*, 17 : 259–261 (1876).]
- PERRIER, E. 1881: Reports on the results of the dredging under the supervision of Alexander Agassiz, in the Gulf of Mexico, 1877–78, by the United States coast and geodetic steamer 'Blake' ... Description sommaire des espèces nouvelles d'Astérie. *Bulletin of the Museum of Comparative Zoology* 9, 1 : 1–31.
- PERRIER, E. 1882: Sur une astérie des grands profondeurs de l'Atlantique, pourvue d'un pédoncule dorsal. *Compte rendu hebdomadaire des Séances de l'Académie des Sciences, Paris* 95 : 1379–1381.
- PERRIER, E. 1883: Mémoire sur les Étoiles de Mer recueillies dans la Mer des Antilles et le Golfe du Mexique durant les expéditions de dragage faites sous la direction de M. Alexandre Agassiz. *Nouvelles archives du Muséum d'Histoire naturelle, Paris* 6 : 127–276, pls 1–10.
- PERRIER, E. 1885a: Sur les Stellérides recueillis durant la mission du 'Talisman'. *Compte rendu hebdomadaire des Séances de l'Académie des Sciences, Paris* 101 : 884–897.

- PERRIER, E. 1885b: Première note préliminaire sur les Echinodermes recueillis durant les campagnes de dragages sous-marins du 'Travailleur' et du 'Talisman'. *Annales des Sciences naturelles, Zoologie sér. 6, 19(8)* : 1–72.
- PERRIER, E. 1894: Echinodermes. Part I. Stellérides. *Expéditions Scientifiques du Travailleur et du Talisman pendant les années 1880, 1881, 1882, 1883* : 1–431, pls 1–26.
- PETERS, W. 1852: Übersicht der Seesterne (Asteridae) von Mossambique. *Abhandlungen der K. Preussischen Akademie der Wissenschaften zu Berlin* [1852]: 177–179.
- PFEFFER, G. 1896: Östafrikanische Echiniden, Asteriden und Ophiuriden, gesammelt von Herrn Dr F. Stuhlmann im Jahre 1888 und 1889. *Mitteilungen aus dem Naturhistorischen Museum in Hamburg* 13 : 45–48.
- PHILIPPI, A. 1837: Ueber die mit *Asterias auranciaca* verwandten und verwechselten Asterien der Sicilianschen Kuste. *Archiv für Naturgeschichte* 3 : 193–194.
- POWELL, A.W.B. 1959: *Native Animals of New Zealand*. The Unity Press Ltd, Auckland. 96 p.
- PRICE, A.R.G. 1982: Echinoderms of Saudi Arabia. *Fauna Saudi Arabia* 4 : 3–21.
- READ, G.B.; CLARK, H.E.S. 1999: Ingestion of quill-worms by the astropectinid sea-star *Proserpinaster neozelanica* Mortensen. *New Zealand Journal of Zoology* 26 : 49–54.
- ROWE, F.W.E. 1974: Catalogue of the Sladen Collection in the Royal Albert Memorial Museum, Exeter, Devon. *Biological Journal of the Linnean Society* 6 : 179–242.
- ROWE, F.W.E. 1989: Nine new deep-water species of Echinodermata from Norfolk Island and Wanganella Bank, northeastern Tasman Sea, with a checklist of the echinoderm fauna. *Proceedings of the Linnean Society of New South Wales* 111 : 257–291.
- ROWE, F.W.E.; GATES, J. 1995: Echinodermata. In Wells, A. (ed.) *Zoological Catalogue of Australia*, Vol. 33. CSIRO, Melbourne, Australia. xiii + 510 p.
- RUSSO, A. 1929: Echinodermi raccolti dal Prof. L. Sanzo nella campagna della R.N. Ammiraglio Magnaghi in Mar Rosso e zone viciniori, 1923–1924. (Memoria biologica IX della campagna.) Nota 1 — Crinoidea, Asteroidea. *Memorie. R. Comitato Talassografico Italiano* 166 : 1–9.
- SEWELL, M.A. 1990: Aspects of the ecology of *Stichopus mollis* (Echinodermata : Holothurioidea) in north-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research* 24 : 97–103.
- SHEPHERD, S.A. 1968: The shallow water echinoderm fauna of South Australia. Part 1. The Asteroids. *Record of the South Australian Museum* 15 : 729–756.
- SHERBORN, C.D. 1897: On the dates of the natural history portion of Savigny's 'Description de l'Égypte'. *Proceedings of the Zoological Society of London* [1897] : 285–288.
- SIBUET, M. 1975: Astérides abyssales de l'Atlantique sud. (Résultats de la campagne Walda, juin-juillet-àout, 1971.) *Bulletin du Muséum national d'Histoire Naturelle, Paris (Zoologie)* 289 : 281–296, 1 pl.
- SIBUET, M. 1980: Adaptation des échinodermes à la vue abyssale. Pp 233–240 in Jangoux, M. (ed.) *Echinoderms Present and Past*. A.A. Balkema, Rotterdam.
- SLADEN, W.P. 1878: On the Asteroidea and Echinoidea of the Korean seas. *Journal of the Linnean Society, Zoology* 14 : 424–445, pl. 8.
- SLADEN, W.P. 1883: The Asteroidea of H.M.S. 'Challenger' Expedition. (Preliminary notices). Part 2. Astropectinidae. *Journal of the Linnean Society, Zoology* 17 : 214–269.
- SLADEN, W.P. 1885: *Report on the Scientific Results of the Voyage of H.M.S. Challenger 1873–76, Narrative* 1(2) : 607–617.
- SLADEN, W.P. 1888: On the Asteroidea of the Mergui Archipelago, collected for the Trustees of the Indian Museum, Calcutta, by Dr John Anderson, F.R.S., Superintendent of the Museum. *Journal of the Linnean Society, Zoology* 21 : 319–331, pl. 28.
- SLADEN, W.P. 1889: Report on the Asteroidea collected by H.M.S. 'Challenger' during the years 1873–76. *Report on the Scientific Results of the Voyage of H.M.S. Challenger 1873–76, Zoology* 30 : i–xlii, 1–893, pls 1–117, 1 map.
- SLOAN, N.A.; CLARK, A.M.; TAYLOR, J.D. 1979: The echinoderms of Aldabra and their habitats. *Bulletin of the British Museum (Natural History), Zoology Series* 37 : 81–128.
- SLUITER, C.P. 1889: Die Evertebraten aus der Sammlung des Koniglichen naturwissenschaftlichen vereins in Niederländischen Indien in Batavia. Zugleich eine Skizze der Fauna des Java-Meeress, mit Beschreibung der Neuen Arten. *Tijdschrift Nederlandsch-Indie* 48 : 285–313.
- SLUITER, C.P. 1895: Die Asteriden Sammlung des Museums zu Amsterdam. *Bijdragen tot de Dierkunde* 17 : 51–64.
- SPENCER, W.K.; WRIGHT, C.W. 1966: Asterozoans. Pp U4–U107 in Moore, R.C. (ed.) *Treatise on Invertebrate Paleontology. Part U. Echinodermata 3. Asterozoa-Echinozoa*. Geological Society of America, University of Kansas Press. Vol. 1.
- STUDER, T. 1883: Über der Asteriden welche während der Reise S.M.S. *Gazelle* gesammelt. *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* 1883, 1884(3) : 1–64, 5 pls.



- STUDER, T. 1884: Verzeichniss der während der Reise S.M.S. 'Gazelle' um die Erde 1874–76 gesammelten Asteriden und Euryaliden. *Physikalische Mathematische Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, 1883–1884*, 3 : 1–64, pls 1–5.
- STUDER, T. 1889: *Die Forschungsreise S.M.S. 'Gazelle' in den Jahren 1874 bis 1876, unter Kommando des Kapitan sur See Freiherrn von Schleinitz*. 3. Zoologie und Geologie. E.S. Mittler und sohn, Berlin. i-iv + 1–322, 33 pls.
- SUSSBACH, S.; BRECKNER, A. 1911: Die Seeigel, Seesterne und Schlangensterne der Nord- und Ostsee. *Wissenschaftliche Meeresuntersuchungen der Kommission zur wissenschaftlichen Untersuchung der deutschen Meere, n.s.* 12 : 167–300, pls 1–3.
- THOMSON, C.W. 1873: *The Depths of the Sea. An account of the general results of the dredging cruises of H.M.S.S. 'Porcupine' and 'Lightning' during the summers of 1868, 1869, and 1870, under the scientific direction of Dr Carpenter, F.R.S., J. Gwyn Jeffreys, F.R.S., and Dr Wyville Thomson, F.R.S.* Macmillan & Co., London. 527 p.
- THOMSON, C.W. 1877: *The voyage of the "Challenger" : the Atlantic : a preliminary account of the general results of the exploring voyage of H.M.S. 'Challenger' during the year 1873 and the early part of the year 1876.* Macmillan, London. Vol. 1 : 1–424; Vol. 2 : 1–396.
- TOMMASI, L.R. 1970: Lista das Asteróides recentes do Brasil. *Contribuições avulsas do Instituto oceanográfico, Universidade de São Paulo, Ser. Oceanografia biológica* 18 : 1–61.
- TORTONESE, E. 1936a: Gli Echinodermi del Museo di Torino. Part III : Asteroidi. *Bollettino dei musei di zoologia e di anatomia comparata della R. Università di Torino* 45(61) : 3–108, pls 1–11.
- TORTONESE, E. 1936b: Echinodermi del Mar Rosso. *Annali del Museo civico di storia naturale Giacomo Doria* 59 : 202–245.
- TORTONESE, E. 1947: Recherche zoologiche nel Canale di Suez e dintorni. 1. Echinodermi. Nota di E. Tortonese, presentata dal Socio F. Sacco. *Atti della Accademia Nazionale dei Lincei. Rendiconti. Series 8*, 2 : 835–838.
- TORTONESE, E. 1953: Spedizione Subacquea Italiana nel mar. II. Echinodermi. *Ricercher di Zoologia* ?? : 25–49, 1 pl.
- TORTONESE, E. 1960: Echinoderms from the Red Sea. 1. Asteroidea. [Contributions to the Knowledge of the Red Sea 19] *Bulletin. Sea Fisheries Research Station, Israel* 29 : 17–23, 1 pl.
- TORTONESE, E. 1965: Echinodermata. *Fauna d'Italia* 6 : vii–xiii, 1–422.
- VERRILL, A.E. 1867: Notes on the Radiata in the Museum of Yale College, with descriptions of new genera and species. No. 1. Descriptions of new star-fishes from New Zealand. *Transactions of the Connecticut Academy of Arts and Sciences* 1, 1866–1871 : 247–292 [reprinted in *Transactions of the New Zealand Institute* 1879, 12 : 278–283.]
- VERRILL, A.E. 1870: Contributions to zoology from the Museum of Yale College — No. 5. Descriptions of echinoderms and corals from the Gulf of California. *American Journal of Science* 49 : 43–100.
- VERRILL, A.E. 1884: Notice of the remarkable marine fauna occupying the outer banks off the south coast of New England. No. 9. *American Journal of Science* 28 : 213–220.
- VERRILL, A.E. 1885: XVI — Results of the explorations made by the steamer "Albatross" off the northern coast of the United States in 1883. United States Commission of Fish and Fisheries. Part XI. Report of the Commissioner for 1883. A. Inquiry into the decrease of food-fishes. B. The propagation of food-fishes in the waters of the United States. Government Printing Office, Washington. 503–699 (1–142), pls 1–44. [Echinoderms at Pp 517–521, 538–552, and pls 10–21.]
- VERRILL, A.E. 1894: Descriptions of new species of starfishes and ophiurans, with a revision of certain species formerly described, mostly from the collections made by the United States Commission of Fish on Fisheries. *Proceedings of the United States National Museum* 17(1000) : 245–297.
- VERRILL, A.E. 1895: Distribution of the echinoderms of north-eastern America. *American Journal of Science* 49 : 127–141.
- VERRILL, A.E. 1899: Revision of certain genera and species of starfishes with descriptions of new forms. *Transactions of the Connecticut Academy of Arts and Sciences* 10 : 145–234, pls 24–30.
- VERRILL, A.E. 1914: Monograph of the shallow-water starfishes of the North Pacific coast from the Arctic Ocean to California. *Harriman Alaska Series* 14 : ix–xii, 1–408, pls 1–110.
- VERRILL, A.E. 1915: Report on the starfishes of the West Indies, Florida, and Brazil including those obtained by the Bahama Expedition from the University of Iowa in 1893. *Bulletin of the University of Iowa* 7 : 1–232, pls 1–29.
- VIGUIER, C. 1878a: Anatomie comparée du squelette des stellérides. *Archives de Zoologie expérimentale et générale* 7 : 33–250, pls 5–16.
- VIGUIER, C. 1878b: Zoologie—Classification des Stellérides. Note de M. C. Viguié présentée par M. de Quatrefages. *Compte rendu hebdomadaire des Séances de l'Académie des Sciences, Paris* 86 : 681–683.





# APPENDIX 1

## LIST OF STATIONS

### N.Z. Oceanographic Institute (NZOI/NIWA)

Paxillosida: 2077 specimens from 697 stations. Of these, 349 specimens (from 167 stations) have an \*; i.e., specimens were recorded but not now in the collections.

Notomyotida: 308 specimens from 122 stations.

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
A704	4.11.62	47 42.00'	179 27.00'E	154	<i>Astromesites primigenius</i> (11)
A759B	21.11.62	43 16'	176 11'E	348	<i>Proserpinaster neozelanicus</i> (1)
A823	25.8.63	46 35.20'	167 05.00'E	390	<i>Astromesites primigenius</i> (1)*
A843	26.8.63	47 13.50'	167 15.00'E	139	<i>Astromesites primigenius</i> (1), <i>Psilaster acuminatus</i> (1)*
A844	"	47 13.5'	167 02.2'E	386	<i>Astromesites primigenius</i> (2)
A846	27.8.63	47 19.2'	166 34.5'E	1485	<i>Plutonaster</i> sp. (1, small)
A866	29.8.63	47 15.00'	168 25.00'E	106	<i>Astromesites primigenius</i> (1)*
A870	"	47 07.5'	168 55.00'E	117	<i>Astromesites primigenius</i> (1)*
A898	8.9.63	43 22.00	177 17.00'E	231	<i>Astromesites primigenius</i> (1)*
A900	"	43 22.00'	177 03.5'E	250	<i>Astromesites primigenius</i> (1), <i>Psilaster acuminatus</i> (1)
A908	13.9.63	43 27.3'	179 03.00'W	439	<i>Plutonaster knoxi</i> (1)
A910	"	43 04.00'	178 39.00'W	549	<i>Dipsacaster magnificus</i> (1)
A913	14.9.63	43 37.00'	178 11.5'W	402	<i>Plutonaster knoxi</i> (5)
A914	15.9.63	44 04'	178 11.5'W	455	<i>Plutonaster</i> sp. (1, small)
A917	"	43 56.00'	179 15.00'W	203	<i>Proserpinaster neozelanicus</i> (1), <i>Benthopecten munidae</i> (1)
B196	18.10.59	46 20.60'	170 27.60'E	135	<i>Astromesites primigenius</i> (1)
B197	"	46 14.10'	170 32.50'E	110	<i>Astromesites primigenius</i> (1)
B480	5.6.61	45 16.8'	166 51.3' E	116	<i>Luidia neozelanicus</i> (1)
B487	6.6.61	46 16.00'	166 03.00'E	196	<i>Astromesites primigenius</i> (6)
B488	7.6.61	46 28.70'	166 14.30'E	164	<i>Astromesites primigenius</i> (1)
B489	"	46 39'	165 57.0'E	198	<i>Luidia neozelanicus</i> (1)*
B515	5.2.62	43 27.00'	175 03.00'E	165	<i>Astromesites primigenius</i> (6)
B555	6.10.62	44 00.50'	173 35.00'E	128	<i>Psilaster acuminatus</i> (1)
B556	"	44 00.00'	173 47.50'E	179	<i>Psilaster acuminatus</i> (2)
B559	7.10.62	44 40.40'	172 10.00'E	132	<i>Psilaster acuminatus</i> (2)
B567	8.10.62	46 00.00'	170 55.00'E	124	<i>Astromesites primigenius</i> (1)
B577	11.10.62	47 20.00'	168 55.00'E	130	<i>Astromesites primigenius</i> (3)
B578	"	47 20.'	169 08.00'E	143	<i>Astromesites primigenius</i> (1)
B581	"	48 00.00'	168 06.00'e	138	<i>Astromesites primigenius</i> (1)
B588	12.10.62	48 00.00'	166 53.00'E	148	<i>Astromesites primigenius</i> (1)
B589	13.10.62	48 44.00'	166 30.00'E	187	<i>Astromesites primigenius</i> (1+ fragments)
B590	"	48 46'	166 49.00'E	159	<i>Astromesites primigenius</i> (8)
B591	"	48 46.00'	167 05.00'E	143	<i>Astromesites primigenius</i> (8)
B592	"	48 46.00'	167 19.00'E	152	<i>Astromesites primigenius</i> (3)
B594	14.10.62	46 40.80'	170 04.00'E	132	<i>Astromesites primigenius</i> (1)
B609	18.10.62	46 00.00'	166 21.8'E	220	<i>Astromesites primigenius</i> (1)
B615	"	45 23.00'	166 45.40'E	79	<i>Astromesites primigenius</i> (1)
B616	"	45 20.00'	166 47.00'E	134	<i>Astromesites primigenius</i> (1)
B638	21.10.62	41 21.50'	171 32.50'E	135	<i>Astromesites primigenius</i> (1)*, <i>Psilaster acuminatus</i> (1)
B644	22.10.62	40 40.00'	171 42.70'E	205	<i>Luidia neozelanicus</i> (1)
B646	"	40 00.09'	173 00.00'E	117	<i>Psilaster acuminatus</i> (1)
B663	25.10.62	38 01.20'	174 46.40'E	22	<i>Astropecten polyacanthus</i> (1)
B664	"	38 01.8'	174 25.30'E	75	<i>Astropecten polyacanthus</i> (2)
B666	"	38 02.05'	173 55.80'E	170	<i>Luidia neozelanicus</i> (2)
B667	"	37 18.70'	174 37.20'E	17	<i>Astropecten polyacanthus</i> (1)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
B668	"	37 18.70'	174 23.00'E	75	<i>Astropecten polyacanthus</i> (14)
B669	"	37 18.70'	174 06.20'E	130	<i>Luidia neozelanica</i> (2), <i>Psilaster acuminatus</i> (1)
B670	26.10.62	37 18.70'	174 03.80'E	170	<i>Psilaster acuminatus</i> (5)
B671	26.10.62	36 40.00'	174 17.00'E	22	<i>Astropecten polyacanthus</i> (1)*
B672	26.10.62	36 40.00'	174 03.30'E	75	<i>Luidia neozelanica</i> (2), <i>Astropecten polyacanthus</i> (2)
B673	"	36 40.00'	173 56.50'E	124	<i>Luidia neozelanica</i> (2)*, <i>Astropecten polyacanthus</i> (5)*, <i>Psilaster acuminatus</i> (5)
B674	"	36 40.00'	173 53.00'	196	<i>Psilaster acuminatus</i> (2)
B675	"	36 40.00'	173 50.00'E	384	<i>Astromesites primigenius</i> (1)*, <i>Psilaster acuminatus</i> (1)
B685	28.10.62	40 00.00'	172 08.00'E	305	<i>Radiaster gracilis</i> (1)
B686	"	40 16.00'	172 32.3'E	126	<i>Psilaster acuminatus</i> (1)
B687	"	40 33.00'	173 05.40'E	59	<i>Luidia neozelanica</i> (7), <i>Psilaster acuminatus</i> (2)
C182	5.9.59	39 50.00'	173 57.00'E	55	<i>Astropecten polyacanthus</i> (3)
C183	"	39 50.00'	173 44.00'E	95	<i>Luidia neozelanica</i> (1)
C184	6.9.59	39 50.00'	173 31.00'E	95	<i>Luidia neozelanica</i> (2)
C321	25.10.59	37 18.60'	174 31.20'E	20	<i>Astropecten polyacanthus</i> (1)
C344	26.10.59	37 58.60'	174 34.40'E	55	<i>Astropecten polyacanthus</i> (1)
C601	24.4.61	44 18.00'	176 16.00'E	144	<i>Astromesites primigenius</i> (2)
C602	"	43 13.20'	176 40.30'E	287	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)
C605	"	43 40.00'	179 30.00'E	441	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (1)
C606	26.4.61	44 15.2'	179 35.4'E	990-1005	<i>Plutonaster knoxi</i> (5)
C607	27.4.61	43 48'	179 00'W	420-430	<i>Dipsacaster magnificus</i> (1)
C608	"	43 19.00'	179 00.00'W	450	<i>Plutonaster knoxi</i> (39)
C609	"	43 03'	178 58'W	570-580	<i>Plutonaster knoxi</i> (1)
C640	28.5.61	39 17.00'	171 53.00'E	364	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)
C693	18.6.61	42 32.30'	173 40.40'	878	<i>Astromesites primigenius</i> (1)*, <i>Plutonaster knoxi</i> (2)
C694	"	42 33.60'	173 41.00'E	374-540	<i>Psilaster acuminatus</i> (1)
C748	16.2.62	36 00.00'	173 32.20'E	135	<i>Astropecten polyacanthus</i> (1)
C751	17.2.62	35 19.80'	173 02.20'E	75	<i>Astropecten polyacanthus</i> (1)
C753	"	35 20.10'	172 52.00'E	174	<i>Luidia neozelanica</i> (96), <i>Psilaster acuminatus</i> (14)
C754	"	34 40.00'	172 51.30'E	24	<i>Astropecten polyacanthus</i> (1, fragments)
C756	"	34 40.00'	172 32.40'E	75	<i>Astropecten polyacanthus</i> (1)
C851	2.3.62	40 40.40'	174 43.60'E	128	<i>Luidia neozelanica</i> (1)
C930	11.2.63	40 56.9'	173 57.3'	31	<i>Psilaster acuminatus</i> (1)
D78	12.5.63	50 39.60'	166 01.80'E	132	<i>Astromesites primigenius</i> (4)*, <i>Psilaster acuminatus</i> (4)
D81	"	50 37.00'	165 53.00'E	159	<i>Astromesites primigenius</i> (1)*
D85	"	49 50.00'	170 13.00'E	611	<i>Benthopecten pikei</i> (1)
D90	"	43 50.00'	179 00.00'W	399	<i>Plutonaster knoxi</i> (14)
D92	19.5.63	37 31.00'	177 08.00'E	183	<i>Psilaster acuminatus</i> (10)
D100	26.9.63	48 02.00'	166 36.00'E	161	<i>Astromesites primigenius</i> (1)*
D106	"	50 46.3'	166 02.5'E	35	<i>Psilaster acuminatus</i> (1)
D117	10.10.63	43 15.00'	178 40.00'E	432	<i>Plutonaster knoxi</i> (2), <i>Plutonaster</i> sp. (1, small)
D131	11.1.64	48 02.00'	167 03.00'E	132	<i>Astromesites primigenius</i> (1)*
D133	12.1.64	48.11.50'	168 21.00'E	141	<i>Astromesites primigenius</i> (5)
D139	13.1.64	48 20.50'	167 46.50'E	150	<i>Astromesites primigenius</i> (1)
D144	14.1.64	48 31.00'	167 17.00'E	132	<i>Astromesites primigenius</i> (1)*
D149	"	49 10.50'	166 51.00'E	454	<i>Benthopecten munidae</i> (1)
D151	15.1.64	48 12.00'	166 38.00'E	150	<i>Astromesites primigenius</i> (5)
D152	"	48 30.00'	166 18.5'E	159	<i>Astromesites primigenius</i> (3)
D154	16.1.64	48 09.00'	166 23.00'E	159	<i>Astromesites primigenius</i> (9)
D170	20.1.64	50 54.50'	165 42.50'E	465	<i>Astromesites primigenius</i> (1)*, <i>Psilaster acuminatus</i> (1)
D172	"	51 00.00'	166 03.00'E	179	<i>Astromesites primigenius</i> (1)*
D173	21.1.64	50 53.00'	166 32.00'E	141	<i>Astromesites primigenius</i> (3)
D175	"	50 36.50'	167 41.00'E	426	<i>Benthopecten munidae</i> (3)
D180	22.1.64	51 08.50'	166 51.00'E	465	<i>Dipsacaster magnificus</i> (1)*
D203	24.1.64	51 00.00'	169 29.50'E	556	<i>Astromesites primigenius</i> (1)*, <i>Psilaster acuminatus</i> (1)
D207	25.1.64	40 04.00'	171 23.00'E	510	<i>Benthopecten munidae</i> (1)
D211	26.1.64	48 53.00'	172 17.50'E	519	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (2), <i>Benthopecten pikei</i> (3)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
D220	26.9.64	39 32.00'	171 48.00'E	344	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)*
D232	29.9.64	38 30.00'	169 09.00'E	505	<i>Psilaster acuminatus</i> (2), <i>Benthopecten munidae</i> (1)
D233	"	38 50.00'	169 20.00'E	530	<i>Psilaster acuminatus</i> (1)
D245	3.10.64	39 54.00'	172 00.00;E	466	<i>Psilaster acuminatus</i> (5)
D267	6.10.64	40 50.00'	173 43.00'E	60	<i>Luidia neozelanica</i> (1)
D468	4.11.65	37 32.0'	179 21.0'E	1280	<i>Plutonaster knoxi</i> (1)
D591	26.1.67	42 28.80'	176 51.20'E	1829	<i>Porcellanaster ceruleus</i> (4), <i>Pectinaster mimicus</i> (1)
D868	24.3.69	43 54.00'	179 44.00'W	420	<i>Psilaster acuminatus</i> (1)*
D869	"	43 30'	179 00'W	474	<i>Plutonaster knoxi</i> (8)
D870	"	43 30.00'	178 40.00'W	440	<i>Plutonaster knoxi</i> (15)*
D871	24.3.69	43 20'	178 40'W	420	<i>Proserpinaster neozelanicus</i> (1)
D872	"	43 30'	178 20'W	435	<i>Plutonaster knoxi</i> (8)
D876	25.3.69	43 20.00'	176 50.00'W	148	<i>Astromesites primigenius</i> (1), <i>Dispsacaster magnificus</i> (1)*
D895	28.3.69	43 40.00'	175 55.00'W	246	<i>Psilaster acuminatus</i> (1)*
D899	29.3.69	44 23.00'	176 49.00'W	370	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (4), <i>Benthopecten munidae</i> (1)
D901	30.3.69	43 55'	177 30'W	366	<i>Psilaster acuminatus</i> (2)*
D904	"	43 58.5'	178 40'E	459	<i>Plutonaster</i> sp. (1, small)
D906	31.3.69	43 54.00'	179 14.00'W	222	<i>Proserpinaster neozelanicus</i> (1), <i>Benthopecten munidae</i> (2)
E72	22.3.64	42 50.00'	176 22.00'E	748	<i>Benthopecten pikei</i> (2)
E76	23.3.64	44 00'	178 00'E	821	<i>Plutonaster</i> sp. (1, small)
E79	24.3.64	43 05.00'	178 00.00'E	371	<i>Proserpinaster neozelanicus</i> (1), <i>Benthopecten munidae</i> (1)
E80	25.3.64	43 23.00'	179 32.00'W	459	<i>Plutonaster knoxi</i> (2)
E81	"	43 03.00'	179 30.00'W	529	<i>Plutonaster knoxi</i> (3)
E106	11.10.64	43 55.00'	177 10.00'W	98	<i>Psilaster acuminatus</i> (3)*
E112	12.10.64	43 15.00'	176 30.00'W	393	<i>Psilaster acuminatus</i> (1)*
E114	13.10.64	43 35.00'	176 15.00'W	135	<i>Psilaster acuminatus</i> (2)
E117	"	43 30.00'	176 00.00'W	333	<i>Proserpinaster neozelanicus</i> (1)
E120	14.10.64	42 59.00'	175 29.00'W	872	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (2)
E124	"	43 50.00'	175 40.00'E	262	<i>Astromesites primigenius</i> (1)
E127	15.10.64	43 55.00'	175 50.00'W	128	<i>Astromesites primigenius</i> (2)
E139	16.10.64	44 00.00'	176 00.00'W	95	<i>Astromesites primigenius</i> (1)*
E140	17.10.64	44 30.00'	175 00.00'W	192	<i>Astromesites primigenius</i> (1)
E146	"	44 30.00'	177 00.00'W	664	<i>Plutonaster knoxi</i> (6)*, <i>Psilaster acuminatus</i> (2)*
E152	18.10.64	44 15.00'	177 00.00'W	373	<i>Proserpinaster neozelanicus</i> (1)*
E159	19.10.64	44 00.50'	176 59.00'W	165	<i>Psilaster acuminatus</i> (2)*
E160	"	43 59.50'	176 50.00'W	128	<i>Psilaster acuminatus</i> (1)
E162	"	43 44.80'	177 20.00'W	172	<i>Psilaster acuminatus</i> (1)*
E164	20.10.64	43 15.00'	177 20.00'W	380	<i>Psilaster acuminatus</i> (1)
E165	"	43 00.00'	177 20.00'W	591	<i>Psilaster acuminatus</i> (1)*
E399	6.10.65	46 00.00'	171 33.00'E	1222	<i>Psilaster acuminatus</i> (3), <i>Porcellanaster ceruleus</i> (1)*, <i>Cheiraster otagoensis</i> (2)
E400	"	46 00.00'	171 02.00'E	622	<i>Benthopecten munidae</i> (1)
E401	7.10.65	46 00.00'	171 12.00'E	914	<i>Radiaster gracilis</i> (1)
E403	9.10.65	47 20.00'	169 11.00'E	285	<i>Psilaster acuminatus</i> (3)*
E405	"	47 20.00'	169 55.00'E	1004	<i>Psilaster acuminatus</i> (1)*, <i>Cheiraster otagoensis</i> (2)
E406	"	47 20.00'	170 17.00'E	1213	<i>Psilaster acuminatus</i> (3)*
E407	10.10.65	46 40'	170 08.00'E	278–305	<i>Astromesites primigenius</i> (1)
E408	"	46 40'	170 11'E	518	<i>Dipsacaster magnificus</i> (1)*
E410	"	46 40.00'	170 44.60'E	1086	<i>Cheiraster otagoensis</i> (2)
E411	"	46 38.5'	170 59.00'E	1275	<i>Porcellanaster ceruleus</i> (2)
E414	11.10.65	45 16.00'	171 49.00'E	999	<i>Cheiraster otagoensis</i> (1)
E415	"	45 21.00'	171 57.00'E	1258	<i>Psilaster acuminatus</i> (4)
E417	13.10.65	45 12.00'	171 49.00'E	860	<i>Psilaster acuminatus</i> (1)*
E422	15.10.65	44 15'	175 00'E	615	<i>Plutonaster</i> sp. (2, small)
E423	"	44 18'	174 31'E	640	<i>Plutonaster knoxi</i> (1)
E427	16.10.65	44 54.00'	172 54.00'E	1240	<i>Psilaster acuminatus</i> (25)
E433	18.10.65	43 43.00'	174 30.00'E	571	<i>Psilaster acuminatus</i> (1)
E437	19.10.65	42 13'	174 33'E	1847	<i>Plutonaster fragilis</i> (20)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
E704	21.3.67	40 02.00'	177 08.5'E	278	<i>Psilaster acuminatus</i> (3)
E705	"	40 08'	177 10'E	497-461	<i>Plutonaster knoxi</i> (4)*
E706	"	40 10'	177 17.8'E	752-719	<i>Plutonaster knoxi</i> (1)*
E709	"	40 28.0'	177 43.0'E	1642	<i>Porcellanaster ceruleus</i> (1), <i>Pectinaster mimicus</i> (25)
E710	22.3.67	39 20.00'	178 11.3'E	258	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)
E712	"	39 20.00'	178 15.8'E	772	<i>Cheiraster monopedicellaris</i> (2)
E714	"	39 19.6'	178 21.2'E	1284-1249	<i>Plutonaster knoxi</i> (1), <i>Plutonaster</i> sp. (3, small)
E715	23.3.67	38 40.00'	178 29.3'E	322	<i>Psilaster acuminatus</i> (2)
E733	"	37 12.5'	177 18.0'E	1525	<i>Pectinaster mimicus</i> (1)
E738	27.3.67	37 35.00'	179 03.00'E	263	<i>Psilaster acuminatus</i> (1)
E742	"	38 00.00'	178 45.00'E	278	<i>Psilaster acuminatus</i> (4)
E745	28.3.67	38 04.00'	179 06.5'E	1441	<i>Plutonaster knoxi</i> (8), <i>Porcellanaster ceruleus</i> (1)
E746	29.3.67	40 41.3'	176 41.6'E	267	<i>Luidia neozelanica</i> (1)
E748	"	40 46.0'	176 55.0'E	739	<i>Benthopecten pikei</i> (10)
E752	30.3.67	41 40.7'	175 15.4'E	618-596	<i>Plutonaster knoxi</i> (2)
E753	"	41 46.2'	175 15.00'E	1074	<i>Psilaster acuminatus</i> (1)*, <i>Pectinaster mimicus</i> (1)
E755	"	42 00.5'	174 25.4'E	247-267	<i>Proserpinaster neozelanicus</i> (2)
E756	"	42 01.8'	174 26.5'E	885-969	<i>Plutonaster knoxi</i> (6)
E757	"	42 03.2'	174 27.2'E	1081	<i>Plutonaster knoxi</i> (2)*, <i>Psilaster acuminatus</i> (2)*
E758	30.3.67	42 08.5'	174 33.2'E	1917-2070	<i>Plutonaster fragilis</i> (3), <i>Pectinaster mimicus</i> (3)
E759	31.3.67	42 45'	173 40'E	195-213	<i>Proserpinaster neozelanicus</i> (2)
E772	14.10.67	42 00.00'	170 16.00'E	748	<i>Psilaster acuminatus</i> (1)*
E775	15.10.67	42 43.00'	168 42.00'E	1256	<i>Psilaster acuminatus</i> (2)
E776	"	42 43.00'	169 15.50'E	978	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (1)
E778	16.10.67	42 43'	169 52'E	469-463	<i>Proserpinaster neozelanicus</i> (1)
E780	"	43 23.50'	169 27.00'E	252	<i>Psilaster acuminatus</i> (3)
E781	"	43 22.50'	169 17.00'E	478	<i>Psilaster acuminatus</i> (1), <i>Proserpinaster neozelanicus</i> (2)*
E782	"	43 23.00'	169 03.50'E	823	<i>Psilaster acuminatus</i> (1)
E783	17.10.67	43 23.00'	168 36.50'E	966	<i>Psilaster acuminatus</i> (1)*, <i>Benthopecten pikei</i> (2)
E786	"	44 00.00'	168 15.50'E	454	<i>Psilaster acuminatus</i> (2)
E806	21.10.67	46 02.20'	166 35.00'E	238	<i>Psilaster acuminatus</i> (14)
E811	22.10.67	46 07.10'	166 41.80'E	178	<i>Psilaster acuminatus</i> (1)*
E812	"	46 02.40'	166 47.30'E	88	<i>Psilaster acuminatus</i> (1)
E820	23.10.67	46 35.00'	165 58.00'E	220	<i>Astromesites primigenius</i> (1)
E821	"	46 43.5'	165 46.5'E	549	<i>Astromesites primigenius</i> (1)
E832	25.10.67	47 21.00'	167 21.00'E	251	<i>Astromesites primigenius</i> (25)
E869	19.3.68	33 58.00'	167 45.00'E	1705	<i>Pectinaster mimicus</i> (1)
E871	20.3.68	34 09.00'	169 20.00'E	1930	<i>Pectinaster mimicus</i> (6)
E880	22.3.68	35 20.00'	172 20.00'E	1029	<i>Psilaster acuminatus</i> (1)*
E885	23.3.68	35 58.00'	173 16.00'E	449	<i>Psilaster acuminatus</i> (1)
E888	"	36 38.00'	173 46.00'E	507	<i>Psilaster acuminatus</i> (1)
E889	"	36 48.00'	173 40.00'E	727	<i>Psilaster acuminatus</i> (1)
E901	25.3.68	38 00.00'	173 19.00'E	1247	<i>Psilaster acuminatus</i> (1)
F10	30.10.64	38 43.00'	172 35.00'E	333	<i>Psilaster acuminatus</i> (1)*
F28	6.11.64	40 28.50'	177 45.00'E	1920	<i>Plutonaster hikurangi</i> (1), <i>Pectinaster mimicus</i> (2)
F77	12.1.65	47 00.00'	169 30.00'E	117	<i>Astromesites primigenius</i> (1)
F84	15.1.65	50 46.00'	167 07.00'E	417	<i>Psilaster acuminatus</i> (1)
F93	17.1.65	48 31.00'	167 30.00'E	141	<i>Astromesites primigenius</i> (2)
F97	"	48 00.00'	168 32.00'E	134	<i>Astromesites primigenius</i> (10)
F102	19.1.65	48 39.00'	169 51.00'E	810	<i>Psilaster acuminatus</i> (1)
F103	20.1.65	48 03.00'	170 38.00'E	1280	<i>Psilaster acuminatus</i> (1)
F105	"	49 34.50'	170 57.00'E	499	<i>Psilaster acuminatus</i> (3)
F106	"	49 30.00'	172 00.00'E	371	<i>Benthopecten munidae</i> (2)
F107	"	48 45.00'	172 00.00'E	658	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (2)
F108	"	48 19.00'	171 59.00'E	1108	<i>Cheiraster otagoensis</i> (4)
F110	21.1.65	48 07.00'	174 02.00'E	1167	<i>Psilaster acuminatus</i> (1)
F113	23.1.65	48 46.00'	177 02.00'E	1372	<i>Psilaster acuminatus</i> (1)
F115	"	49 18.50'	179 52.00'E	1518	<i>Psilaster acuminatus</i> (1)*
F123	27.1.65	47 38.00'	178 57.00'W	1280	<i>Cheiraster otagoensis</i> (1)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
F126	28.1.65	49 48.00'	176 01.00'E	1256	<i>Cheiraster otagoensis</i> (2)
F127	"	49 22.00'	176 16.00'E	1280	<i>Plutonaster fragilis</i> (1)*
F136	30.1.65	51 20.00'	172 42.00'E	547	<i>Psilaster acuminatus</i> (1)*
F143	1.2.65	35 05.50'	170 13.00'E	380	<i>Psilaster acuminatus</i> (1)
F741	2.4.66	40 30.00'	174 30.00'E	117	<i>Luidia neozelanica</i> (2)
F744	3.4.66	41 10.00'	177 08.00'E	1609	<i>Porcellanaster ceruleus</i> (1), <i>Pectinaster mimicus</i> (4)
F745	4.4.66	44 47'	175 22'E	1390	<i>Plutonaster knoxi</i> (1)
F752	18.8.66	45 25.00'	174 30.00'E	1233	<i>Plutonaster knoxi</i> (1), <i>Plutonaster</i> sp. (1, small), <i>Psilaster acuminatus</i> (1), <i>Porcellanaster ceruleus</i> (1)*, <i>Cheiraster otagoensis</i> (1)
F754	19.8.66	42 48.00'	174 32.00'E	1324	<i>Plutonaster knoxi</i> (2), <i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (3), <i>Pectinaster mimicus</i> (2), <i>Cheiraster otagoensis</i> (2)
F757	"	42 45.00'	175 30.00'E	911	<i>Psilaster acuminatus</i> (2)
F758	"	42 37.00'	175 30.00'E	1245	<i>Cheiraster otagoensis</i> (3)
F761	20.8.66	42 33.20'	176 23.50'E	1234	<i>Plutonaster fragilis</i> (3)*, <i>Cheiraster otagoensis</i> (5)
F765	21.8.66	41 24'	175 59'E	285–315	<i>Proserpinaster neozelanicus</i> (1)*
F767	"	41 30.8'	176 07'E	1205–1293	<i>Plutonaster</i> sp. (3, small)
F870	2.10.68	37 25.50'	178 10.80'E	263–254	<i>Luidia neozelanica</i> (3)
F877	3.10.68	37 31'	177 32'E	728–783	<i>Psilaster acuminatus</i> (1)
F887	5.10.68	37 13.60'	176 11.00'E	216	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)*
F898	8.10.68	36 13.00'	176 10.00'E	363–260	<i>Psilaster acuminatus</i> (1)
F904	10.10.68	35 28.80'	174 45.20'E	91–102	<i>Astropecten dubiosus</i> (1)*
F906	"	35 22.00'	174 51.50'E	260	<i>Psilaster acuminatus</i> (1)*
F914	11.10.68	34 52.00'	174 28.00'E	510	<i>Psilaster acuminatus</i> (1)
F915	"	34 58.70'	174 18.00'E	251	<i>Psilaster acuminatus</i> (2)*
F916	12.10.68	34 38.50'	173 28.00'E	249	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (4)
F936	17.10.68	36 09.00'	174 45.00'E	53	<i>Luidia maculata</i> (1), <i>Astropecten dubiosus</i> (2)*, <i>Astropecten polyacanthus</i> (4)*
G42	25.2.67	43 54'	178 30'W	412	<i>Plutonaster knoxi</i> (1)
G69	28.2.67	43 15.50'	177 27.00'W	357	<i>Psilaster acuminatus</i> (1)
G153	12.11.67	42 45'	173 40'E	137	<i>Dipsacaster magnificus</i> (1)*, <i>Proserpinaster neozelanicus</i> (1)*
G155	"	42 46'	173 39'E	137	<i>Proserpinaster neozelanicus</i> (2)*, <i>Psilaster acuminatus</i> (1)*
G156	13.11.67	42 38'	173 30'E	110	<i>Psilaster acuminatus</i> (2)*
G157	"	43 09'	173 38'E	143	<i>Psilaster acuminatus</i> (3)
G159	"	43 02'	173 38'E	146	<i>Psilaster acuminatus</i> (1), <i>Radiaster gracilis</i> (1)
G163	15.11.67	42 45'	173 38'E	128	<i>Psilaster acuminatus</i> (1)*
G174	17.1.68	43 41'	179 28'W	366	<i>Psilaster acuminatus</i> (1)
G208A	19.1.68	43 38'	179 56'E	413	<i>Plutonaster knoxi</i> (4)*
G212	20.1.68	43 22'	179 56'E	455	<i>Plutonaster knoxi</i> (8)
G230	21.1.68	43 33'	179 43'E	410	<i>Psilaster acuminatus</i> (1)*
G232B	"	43 31'	178 36'E	410	<i>Psilaster acuminatus</i> (1)*
G257	23.1.68	43 36'	179 22'E	424	<i>Plutonaster</i> sp. (1, small)
G259	"	43 33.00'	179 22.00'E	419	<i>Benthopecten munidae</i> (1)
G268	"	43 22'	179 22'E	424	<i>Plutonaster knoxi</i> (2)
G282	"	43 30'	179 07'E	399	<i>Plutonaster</i> sp. (1, small)
G290	24.1.68	43 40.00'	179 01.00'E	327	<i>Benthopecten munidae</i> (1)
G292	25.1.68	43 42'	179 48'E	454	<i>Psilaster acuminatus</i> (1)
G302	26.1.68	43 00'	179 20'W	294	<i>Plutonaster</i> sp. (1, small)
G307	"	44 07.00'	179 13.00'W	402	<i>Benthopecten munidae</i> (3)
G329	1.2.68	44 06.00'	179 00.00'W	417	<i>Plutonaster</i> sp. (1, small), <i>Psilaster acuminatus</i> (7)*
G348	2.2.68	43 35'	178 45'W	446	<i>Plutonaster knoxi</i> (8)*
G369A	5.2.68	43 27'	177 50'W	439	<i>Plutonaster knoxi</i> (1)
G373	"	43 13'	177 50'W	377	<i>Plutonaster</i> sp. (1, small)
G374	"	43 48'	177 50'W	373	<i>Plutonaster knoxi</i> (1)*
G381	6.2.68	43 32.00'	177 58.00'W	377	<i>Psilaster acuminatus</i> (1)
G388	"	43 35.00'	178 03.00'W	384	<i>Psilaster acuminatus</i> (1)
G403	7.2.68	43 54.00'	179 44.00'W	391	<i>Plutonaster knoxi</i> (1)
G663	18.1.70	44 24.00'	173 30.00'E	612	<i>Psilaster acuminatus</i> (1)
G665	"	44 43.00'	172 40.00'E	934	<i>Plutonaster jonathani</i> (1)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
G666	19.1.70	44 52.20'	172 20.20'E	1015	<i>Plutonaster knoxi</i> (1)*, <i>Psilaster acuminatus</i> (1)
G668	"	46 10.00'	171 00.20'E	731	<i>Psilaster acuminatus</i> (3)
G680	20.1.70	45 43.00'	171 02.40'E	113	<i>Astromesites primigenius</i> (1)*
G690	21.1.70	46 09.00'	170 36.00'E	78	<i>Astromesites primigenius</i> (2)
G699	22.1.70	46 20.2'	171 00.00'E	1116	<i>Psilaster acuminatus</i> (2)
G700	"	46 20.00'	171 15.00'E	1116	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (1), <i>Pectinaster mimicus</i> (4), <i>Cheiraster otagoensis</i> (5)
G701	"	46 20.00'	171 30.00'E	1400	<i>Cheiraster otagoensis</i> (1)
G703	"	46 20.00'	172 04.00'E	1480	<i>Benthopecten pikei</i> (1)
G704	23.1.70	46 17.00'	172 37'E	1600	<i>Porcellanaster ceruleus</i> (1)
G705	"	46 04.00'	172 28.50'E	1460	<i>Porcellanaster ceruleus</i> (2)*
G706	"	45 49'	172 30'E	1550	<i>Porcellanaster ceruleus</i> (1)*
G820	15.2.71	33 09'	162 36'E	793	<i>Astropecten tasmanicus</i> (1), <i>Psilaster acuminatus</i> (1)
G821	"	33 18.50'	162 35.50'E	791	<i>Astropecten tasmanicus</i> (1)*, <i>Psilaster acuminatus</i> (5)
G822	"	33 20.40'	162 49.20'E	875	<i>Psilaster acuminatus</i> (2)
G823	"	33 10.40'	162 59.20'E	798	<i>Astropecten tasmanicus</i> (1)*, <i>Psilaster acuminatus</i> (2)
G824	"	33 10.40'	162 59.20'E	811	<i>Astropecten tasmanicus</i> (1)*, <i>Psilaster acuminatus</i> (2)
G825	"	33 20.9'	167 59.5'E	829	<i>Astropecten tasmanicus</i> (1), <i>Psilaster acuminatus</i> (3)*
G831	20.2.71	37 45.00'	171 24.30'E	1748	<i>Pectinaster mimicus</i> (1)
G876	27.11.70	38 46.0'	168 23.2'E	510	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (4)
G879	6.12.70	44 12'	173 05'E	100	<i>Psilaster acuminatus</i> (2)
G881	7.12.70	46 06.80'	175 16.80'E	140	<i>Astromesites primigenius</i> (7), <i>Psilaster acuminatus</i> (7)*
G882	12.12.70	47 54'	179 08.8'E	150	<i>Astromesites primigenius</i> (1)
G883	"	47 54'	179 09'E	200–180	<i>Astromesites primigenius</i> (16), <i>Psilaster acuminatus</i> (2)
G884	"	47 52'	179 09'E	180	<i>Astromesites primigenius</i> (20)
G886	"	48 14.00'	179 41.00'E	335	<i>Benthopecten munidae</i> (5)
G890	15.12.70	47 59.40'	178 51.10'E	250	<i>Dipsacaster magnificus</i> (1)
G892	16.12.70	49 29.2'	178 58.9'E	165	<i>Astromesites primigenius</i> (4)
G895	18.12.70	49 41.40'	173 30.00'E	495	<i>Psilaster acuminatus</i> (2), <i>Benthopecten munidae</i> (1)
G896	"	49 22'	173 22'E	480	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (1)*
G900	20.12.70	49 04.9'	171 26.9'E	470	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (3)
G901	21.12.70	49 13.50'	171 30.10'E	260	<i>Dipsacaster magnificus</i> (1)*
G903	"	49 10.20'	170 58.00'E	550	<i>Dipsacaster magnificus</i> (1)*
G904	22.12.70	49 46.7'	171 32.2'E	460	<i>Psilaster acuminatus</i> (1)*
G905	23.12.70	50 04.3'	171 43.4'E	460	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (1)*
G906	"	49 50.2'	172 11.9'E	480	<i>Psilaster acuminatus</i> (4)*
G907	"	49 50.00'	171 49.60'E	460	<i>Psilaster acuminatus</i> (2)*
G908	24.12.70	49 46.9'	172 36.9'E	480	<i>Dipsacaster magnificus</i> (4)*, <i>Psilaster acuminatus</i> (2)*
G914	7.1.71	50 59.1'	169 49.5'E	560	<i>Psilaster acuminatus</i> (1)*
G916	"	51 35.00'	169 38.00'E	480	<i>Benthopecten pikei</i> (1)
G917	8.1.71	52 02'	169 13'E	200	<i>Psilaster acuminatus</i> (7)*
G918	"	51 53.6'	169 51.0'E	240	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (3)*
G919	"	51 56'	170 14'E	200	<i>Psilaster acuminatus</i> (2)
G920	9.1.71	52 29.20'	169 45.00'E	155	<i>Psilaster acuminatus</i> (2)
G927	12.1.71	53 32.8'	172 16.6'E	580	<i>Dipsacaster magnificus</i> (2)*
G928	13.1.71	51 59.60'	171 49.00'E	535	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (2)
G929	"	51 58.3'	171 29.6'E	520	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (3)*
G930	"	52 00.90'	171 05.00'E	500	<i>Psilaster acuminatus</i> (1)*
G931	14.1.71	51 02.00'	167 16.50'E	500	<i>Dipsacaster magnificus</i> (2)*, <i>Psilaster acuminatus</i> (3)*
G933	15.1.71	50 33.2'	167 56.5'E	445	<i>Dipsacaster magnificus</i> (3)*
G934	"	50 45.2'	167 28.5'E	460	<i>Dipsacaster magnificus</i> (2)*, <i>Psilaster acuminatus</i> (1)*
G935	"	50 32.5'	167 07.0'E	110	<i>Dipsacaster magnificus</i> (1)*
G936	16.1.71	50 26.1'	167 07.0'E	120	<i>Dipsacaster magnificus</i> (1)*
G938	17.1.71	49 33.90'	166 44.50'E	490	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (1)*, <i>Radiaster gracilis</i> (1)
G955	3.6.73	42 40.50'	174 45.50'E	1345	<i>Pectinaster mimicus</i> (1)
H221	29.1.71	44 59.95'	167 11.40'E	411	<i>Psilaster acuminatus</i> (3)
H912	11.8.75	43 32.40'	177 46.50'W	408	<i>Psilaster acuminatus</i> (1)
H923	13.8.75	43 29.00'	179 32.20'E	395	<i>Psilaster acuminatus</i> (1)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
I1	2.5.75	35 48.10'	174 40.00'E	79	<i>Luidia maculata</i> (1)
I2	"	35 47.8'	174 50.5'E	122-129	<i>Luidia neozelanica</i> (1)
I3	"	35 48.40'	175 03.70'E	134	<i>Luidia neozelanica</i> (1)*
I4	"	35 47.80'	175 13.00'E	151	<i>Luidia neozelanica</i> (1)
I5	"	35 48.10'	175 24.90'E	177	<i>Astropecten dubiosus</i> (1)
I6	3.5.75	35 47.80'	175 36.60'E	257	<i>Luidia neozelanica</i> (4), <i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (46)
I7	"	35 47.80'	175 50.10'E	367	<i>Luidia neozelanica</i> (1)*, <i>Psilaster acuminatus</i> (1)*
I11	4.5.75	35 36.00'	176 13.6'E	308	<i>Astromesites compactus</i> (1), <i>Psilaster acuminatus</i> (1)*
I17	"	35 24.70'	174 40.00'E	130	<i>Luidia neozelanica</i> (1)
I21	2.5.75	35 24.20'	175 25.80'E	633	<i>Benthopecten pikei</i> (1)
I24	5.5.75	35 22.30'	175 47.20'E	615	<i>Cheiraster monopedicellaris</i> (1)
I25	6.5.75	35 11.10'	175 06.10'E	675	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (1)
I31	7.5.75	35 11.70'	174 39.80'E	245	<i>Psilaster acuminatus</i> (3)
I38	8.5.75	34 59.5'	174 23.00'E	282	<i>Psilaster acuminatus</i> (1)
I42	"	35 12.10'	174 18.30'E	0	<i>Astropecten polyacanthus</i> (3)
I50	10.8.75	36 00.20'	175 13.15'E	92	<i>Luidia maculata</i> (3)
I52	"	36 11.20'	175 13.50'E	63	<i>Luidia maculata</i> (4), <i>Proserpinaster neozelanicus</i> (1)*
I54	"	36 11.70'	174 44.80'E	44	<i>Astropecten polyacanthus</i> (1)
I56	"	36 23.00'	175 13.10'E	50	<i>Luidia maculata</i> (7), <i>Astropecten polyacanthus</i> (2)
I57	11.5.75	36 22.60'	175 25.00'E	50	<i>Astropecten polyacanthus</i> (2)
I60	12.5.75	36 22.80'	176 01.80'E	235	<i>Psilaster acuminatus</i> (9)
I64	"	36 12.00'	176 11.80'E	335	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (2)
I65	"	36 12.00'	176 00'E	327	<i>Psilaster acuminatus</i> (3)*
I69	14.5.75	36 11.20'	175 17.70'E	23	<i>Astropecten polyacanthus</i> (1)
I88	23.5.75	29 25.00'	167 55.10'E	60	<i>Astropecten polyacanthus</i> (2)
I91	"	29 24.80'	168 10.00'E	342	<i>Cheiraster (L.) teres</i> (1)
I94	24.5.75	29 20.20'	168 10.80'E	308	<i>Luidia moroisoana</i> (1), <i>Cheiraster (L.)</i> sp. (1)
I339	16.11.77	34 53.30'	172 55.00'E	51	<i>Astropecten polyacanthus</i> (21)
I345	17.11.77	34 40.40'	173 31.00'E	182	<i>Astropecten dubiosus</i> (4), <i>Psilaster acuminatus</i> (2)
I346	"	34 42.00'	173 40.40'E	3	<i>Astromesites compactus</i> (1)
I348	"	34 32.20'	173 38.00'E	349	<i>Psilaster acuminatus</i> (3)
I349	18.11.77	34 50.90'	173 13.60'E	19	<i>Astropecten polyacanthus</i> (1)
I350	"	34 51.10'	173 12.90'E	17	<i>Astropecten polyacanthus</i> (6)
I355	19.11.77	34 50.10'	174 06.20'E	330	<i>Luidia neozelanica</i> (2), <i>Psilaster acuminatus</i> (2)
I356	"	34 52.40'	174 05.70'E	275	<i>Luidia neozelanica</i> (1), <i>Astromesites compactus</i> (1), <i>Psilaster acuminatus</i> (10)
I359	20.11.77	35 17.30'	174 50.50'E	260	<i>Astromesites compactus</i> (1), <i>Astropecten dubiosus</i> (7) <i>Proserpinaster neozelanicus</i> (1)*, <i>Psilaster acuminatus</i> (2)
I363	"	34 50.20'	174 00.20'E	227	<i>Astropecten dubiosus</i> (1)
I366	"	34 42.30'	174 17.60'E	705	<i>Psilaster acuminatus</i> (1)*, <i>Benthopecten pikei</i> (2)
I657	10.3.79	43 06.9'	178 37.00'W	525	<i>Plutonaster knoxi</i> (22)
I658	10.3.79	43 31'	179 09.5'W	455	<i>Plutonaster knoxi</i> (2)
I660	"	43 50.1'	179 00.1'W	405	<i>Plutonaster knoxi</i> (2), <i>Plutonaster</i> sp. (2, small)
I661	11.3.79	43 50.20'	179 05.80'W	375	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (1)
I663	"	43 51.60'	179 44.50'W	394	<i>Psilaster acuminatus</i> (1)
I664	12.3.79	47 39.80'	179 27.80'W	595	<i>Plutonaster knoxi</i> (2)
I665	"	47 40 00'	179 14.30'W	812	? <i>Proserpinaster</i> sp. (1)
I667	13.3.79	47 45.60'	179 17.00'W	648	<i>Dipsacaster magnificus</i> (1)*
I672	"	48 00.30'	179 44.00'W	380	<i>Psilaster acuminatus</i> (2), <i>Benthopecten pikei</i> (1)
I679	14.3.79	48 10.00'	180 00.00'	327	<i>Benthopecten pikei</i> (1)
I680	15.3.79	48 09.50'	179 47.00'E	220	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (1)
I684	"	48 20.00'	179 29.00'W	705	<i>Psilaster acuminatus</i> (5)
I685	16.3.79	48 19.50'	179 29.50'W	722	<i>Psilaster acuminatus</i> (2)
I686	"	48 30.50'	179 45.00'W	710	<i>Pectinaster mimicus</i> (1)
I690	17.3.79	48 51.00'	179 15.00'E	700	<i>Psilaster acuminatus</i> (1), <i>Pectinaster mimicus</i> (2)
I699	19.3.79	48 16.00'	179 00.00'E	532	<i>Pectinaster mimicus</i> (1)
I707	22.3.79	47 20.00'	179 30.00'E	552	<i>Psilaster acuminatus</i> (1)*, <i>Benthopecten munidae</i> (2)
I708	"	47 40.00'	179 50.00'E	155	<i>Astromesites primigenius</i> (2)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
I711	"	47 50'	179 15'E	139	<i>Astromesites primigenius</i> (4)
I712	"	48 00.10'	179 30.10'E	129	<i>Psilaster acuminatus</i> (2)
I714	23.3.79	47 49.00'	178 46.00'E	277	<i>Astromesites primigenius</i> (2)
I716	25.3.79	44 00.00'	176 13.90'E	500	<i>Psilaster acuminatus</i> (1)
I718	25.3.79	44 06.70'	175 57.10'E	140	<i>Astromesites primigenius</i> (8)
I719	"	44 07.30'	175 55.20'E	140	<i>Astromesites primigenius</i> (1)
I721	26.3.79	44 07.40'	175 46.20'E	540	<i>Psilaster acuminatus</i> (2)
I722	8.5.79	31 34.00'	159 26.50'E	1828	<i>Plutonaster</i> sp. (1), <i>Cheiraster ludwigi</i> (1)
I729	10.5.79	26 40.40'	159 27.00'E	306	<i>Tethyaster tangaroae</i> (1)
I730	"	25 32.50'	159 39.00'E	300	<i>Cheiraster</i> (L.) <i>teres</i> (1)
I735	11.5.79	24 41.20'	159 37.00'E	291	<i>Luidia moroisoana</i> (1)
I737	"	24 03.80'	159 27.70'E	82	<i>Astropecten monacanthus</i> (1)
J23	15.4.70	39 00.00'	169 13.00'E	525	<i>Psilaster acuminatus</i> (1)*
J24	"	39 00.00'	169 00.00'E	516	<i>Psilaster acuminatus</i> (1)
J25	"	38 50.00'	169 00.00'E	510	<i>Psilaster acuminatus</i> (1)
J26	"	38 50.00'	169 13.00'E	515	<i>Dipsacaster magnificus</i> (2), <i>Psilaster acuminatus</i> (1)*
J27	16.4.70	33 50.00'	169 26.00'E	528	<i>Psilaster acuminatus</i> (1)
J30	"	38 40.00'	169 26.00'E	525	<i>Psilaster acuminatus</i> (2)
J31	"	38 39.00'	168 15.00'E	525	<i>Psilaster acuminatus</i> (1)*
J32	"	38 40.00'	169 00.00'E	502	<i>Psilaster acuminatus</i> (1)
J33	17.4.70	38 25.20'	169 00.20'E	500	<i>Psilaster acuminatus</i> (1)
J34	"	38 27.00'	169 12.00'E	525	<i>Psilaster acuminatus</i> (1), <i>Radiaster gracilis</i> (1)
J36	"	38 30.00'	169 39.00'E	560	<i>Dipsacaster magnificus</i> (1)*
J38	18.4.70	37 00.00'	170 13.00'E	2042	<i>Pectinaster mimicus</i> (3)
J39	"	37 00.00'	170 00.00'E	2096	<i>Pectinaster mimicus</i> (3)
J40	"	36 50.00'	170 00.00'E	2113	<i>Pectinaster mimicus</i> (1)
J41	19.4.70	36 50.00'	170 13.00'E	2060	<i>Pectinaster mimicus</i> (8)
J42	"	36 50.00'	170 26.00'E	2008	<i>Pectinaster mimicus</i> (3)
J43	"	36 39.50'	170 27.00'E	2064	<i>Pectinaster mimicus</i> (1)
J44	"	36 40.00'	170 13.00'E	2112	<i>Pectinaster mimicus</i> (1)
J45	20.4.70	36 40.00'	170 00.00'E	2146	<i>Pectinaster mimicus</i> (1)
J47	"	36 30.00'	170 13.00'E	2162	<i>Pectinaster mimicus</i> (1)
J49	"	36 30.00'	170 34.00'E	2150	<i>Pectinaster mimicus</i> (5)
J50	21.4.70	36 40.00'	170 39.00'E	2112	<i>Pectinaster mimicus</i> (1)
J51	"	36 52.00'	170 42.00'E	2000	<i>Pectinaster mimicus</i> (2)
J52	"	37 00.00'	170 39.00'E	1919	<i>Pectinaster mimicus</i> (2)
J54	16.5.70	43 12.50'	175 26.00'E	102	<i>Astromesites primigenius</i> (1)
J55	17.5.70	44 05.50'	176 12.00'E	198	<i>Astromesites primigenius</i> (1)
J339	24.6.73	39 52.00'	174 35.00'E	20	<i>Astropecten polyacanthus</i> (1)
J483	7.12.73	50 31.60'	169 02.10'E	575	<i>Benthopecten munidae</i> (fragments)
J485	"	50 38.00'	167 38.00'E	320	<i>Benthopecten pikei</i> (1)
J539	14.12.73	52 56.90'	169 01.40'E	500	<i>Psilaster acuminatus</i> (1)
J550	17.12.73	49 04.00'	172 40.30'E	535	<i>Dipsacaster magnificus</i> (1)*, <i>Psilaster acuminatus</i> (7)*, <i>Benthopecten munidae</i> (3)
J658	4.9.74	36 00.60'	179 12.80'E	2505	<i>Hyphalaster inermis</i> (3)
J669	6.9.74	36 44.8'	176 30.0'E	1585	<i>Plutonaster</i> sp. (1, small)
J672	7.9.74	36 26.50'	175 46.05'E	25	<i>Astropecten polyacanthus</i> (2)
J686	8.9.74	37 16.2'	176 51.2'E	194-219	<i>Astromesites primigenius</i> (1)
J697	10.9.74	37 51.70'	176 57.50'E	34	<i>Astropecten polyacanthus</i> (2)
J951	18.6.81	35 02.00'	172 52.70'E	52	<i>Astropecten polyacanthus</i> (2)
J958	19.6.81	34 22'	173 55'E	78-105	<i>Astropecten polyacanthus</i> (1)
K816	24.7.74	29 13.04'	177 55.50'W	22	<i>Astropecten polyacanthus</i> (1)
K817	"	29 13.65'	177 56.30'W	21	<i>Astropecten polyacanthus</i> (1)
K820	"	29 13.30'	177 59.80'W	95	<i>Luidia prionota</i> (1)
K857	30.7.74	30 33.80'	178 30.60'W	165	<i>Luidia hardwicki</i> (1)
K861	"	30 36.50'	178 22.50'W	1030	<i>Pectinaster mimicus</i> (10), <i>Cheiraster subtuberculatus</i> (2)
K873	4.8.74	37 34.00'	179 22.00'E	1270-1280	<i>Psilaster acuminatus</i> (1)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
K996	11.2.77	46 56.80'	168 08.70'E	22	<i>Astropecten polyacanthus</i> (1)*
O59	9.4.76	37 02.92'	174 26.52'E	low tide	
		Orua Bay, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
O63	12.4.76	37 09.03'	174 42.10'E	high tide	
		Waiau Pa, Manukau Harbour			<i>Astropecten polyacanthus</i> (5)
O70	13.4.76	37 06.75'	174 41.61'E	low tide	
		West Poutawa Bank, Manukau Harbour			<i>Astropecten polyacanthus</i> (3)
O71	14.4.76	36 59.60'	174 44.26'E	high tide	
		Karore Bank, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
O72	"	36 59.60'	174 44.26'E	upper mid-tide, Karore Bank, Manukau Harbour	<i>Astropecten polyacanthus</i> (2)
O73	"	36 59.22'	174 43.66'E	lower mid-tide, Karore Bank, Manukau Harbour	<i>Astropecten polyacanthus</i> (1)
O74	"	37 00.02'	174 42.58'E	low tide	
		Karore Bank, Manukau Harbour			<i>Astropecten polyacanthus</i> (2)
O79	25.7.76	37 05.42'	174 42.20'E	6 m east of	
		Waiuku Channel, Manukau Harbour			<i>Astropecten polyacanthus</i> (3)
O80	"	37 05.83'	174 41.28'E	4 m east of	
		Waiuku Channel, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
O81	"	37 03.82'	174 40.78'E	8 m east of	
		Grahams Beach, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
O84	"	37 09.03'	174 42.10'E	high tide	
		Waiau Pa, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
O105	30.7.76	37 00.84'	174 36.42'E	low tide	
		Cornwallis Beach, Manukau Harbour			<i>Astropecten polyacanthus</i> (1)
P1	24.1.77	32 35.44'	167 32.0'E	122	<i>Luidia prionota</i> (1)
P16	26.1.77	29 36.30'	168 05.00'E	310	<i>Cheiraster</i> (L.) sp. (1)
P27	27.1.77	28 54.60'	167 44.20'E	390	<i>Cheiraster</i> (L.) <i>teres</i> (1)
P28	28.1.77	28 49.80'	167 59.60'E	53	<i>Astropecten polyacanthus</i> (2)
P40	29.1.77	29 10.2'	167 50.0'E	394-472	<i>Astropecten celebensis</i> (2)
P58	5.2.77	35 07.20'	173 05.60'E	24	<i>Astropecten polyacanthus</i> (39)
P59	"	35 05.30'	172 48.80'E	105	<i>Luidia neozelanica</i> (7), <i>Astropecten polyacanthus</i> (1)
P61	"	35 14.30'	172 42.20'E	216	<i>Luidia neozelanica</i> (2), <i>Psilaster acuminatus</i> (1)
P63	7.2.77	34 38.5'	172 47.0'E	42	<i>Astropecten polyacanthus</i> (12)
P65	"	35 05.00'	172 26.60'E	302	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (4)
P66	"	35 03.80'	172 22.60'E	435	<i>Psilaster acuminatus</i> (2)
P82	28.5.77	31 49.80'	159 19.70'E	78	<i>Astropecten polyacanthus</i> (1)*
P86	"	31 39.5'	159 09.4'E	610	<i>Astropecten tasmanicus</i> (2)
P109	31.5.77	31 30.20'	158 57.90'E	69	<i>Astropecten polyacanthus</i> (1)*
P120	3.6.77	35 45.7'	165 04.1'E	950	<i>Plutonaster</i> sp. (3, small), <i>Psilaster acuminatus</i> (2)
P122	5.6.77	40 32.50'	173 06.80'E	58	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)
P622	27.8.78	36 48.32'	173 19.17'E	28	<i>Astropecten polyacanthus</i> (1)
P625	28.8.78	34 46.3'	173 16.7'E	42	<i>Astropecten polyacanthus</i> (1)*
P631	29.8.78	34 52.10'	173 12.89'E	12	<i>Astropecten polyacanthus</i> (5)*
P632	"	34 50.19'	173 13.85'E	20	<i>Astropecten polyacanthus</i> (2)
P633	"	34 48.33'	173 15.60'E	30	<i>Astropecten polyacanthus</i> (2)
P645-2	31.8.78	34 57.30'	173 26.24'E	21	<i>Astropecten polyacanthus</i> (2)
P650	"	34 58.59'	173 28.05'E	21	<i>Astropecten polyacanthus</i> (2)
P651	"	34 58.26'	173 28.62'E	18	<i>Astropecten polyacanthus</i> (5)
P658	14.6.79	41 38.6'	171 25.6'E	128	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (1)
P662	19.6.79	41 29.7'	171 00.9'E	196	<i>Psilaster acuminatus</i> (1)
P665	23.6.79	42 47.2'	169 51.7'E	768-531	<i>Psilaster acuminatus</i> (1)
P666	24.6.79	41 41.10'	169 31.20'E	925	<i>Benthopecten pikei</i> (1)
P667	25.6.77	42 24.30'	169 25.00'E	1047	<i>Benthopecten pikei</i> (1), <i>Pectinaster mimicus</i> (2)
P927	18.4.80	40 50.10'	168 14.80'E	1009	<i>Psilaster acuminatus</i> (1), <i>Pectinaster mimicus</i> (4)
P928	"	40 46.00'	167 54.90'E	1029	<i>Pectinaster mimicus</i> (field notes)
P940	23.4.80	41 22.7'	166 44.4'E	2092-2154	<i>Plutonaster fragilis</i> (2)*

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
P941	"	41 15.20'	167 07.20'E	1463	<i>Benthopecten pikei</i> (6)
P942	24.4.80	41 00.60'	169 06.00'E	914	<i>Psilaster acuminatus</i> (1)*, <i>Benthopecten pikei</i> (1), <i>Pectinaster mimicus</i> (3)
P946	1.6.80	25 59.10'	179 18.10'W	660	<i>Cheiraster</i> (L.) sp. (1)
P947	"	25 13.7'	177 04.1'W	646	<i>Cheiraster</i> (L.) sp. (3)
P969	15.6.80	37 05.5'	178 20.9'E	2250	<i>Dytaster felli</i> (1), <i>Plutonaster fragilis</i> (1)*, <i>Pectinaster mimicus</i> (1)
P970	17.6.80	39 30.00'	178 50.00'E	3391	<i>Eremicaster vicinus</i> (2), <i>Porcellanaster ceruleus</i> (1)
P971	18.6.80	41 11.90'	177 19.60'E	2200	<i>Plutonaster</i> sp. (1, small), <i>Porcellanaster ceruleus</i> (1)
Q2	12.3.78	43 36.8'	178 43.7'W	400	<i>Psilaster acuminatus</i> (1)
Q3A	"	43 39.7'	179 27.3'W	435	<i>Psilaster acuminatus</i> (1)
Q3B	"	43 37.6'	179 28.2'W	435	<i>Luidia neozelanica</i> (1), <i>Psilaster acuminatus</i> (2)
Q4A	"	43 42.2'	179 54.7'E	398	<i>Plutonaster</i> sp. (1, small), <i>Plutonaster knoxi</i> (1)
Q4C	"	43 41.1'	179 56.5'E	385	<i>Proserpinaster neozelanicus</i> (1)
Q11	15.3.78	43 44.1'	179 31.6'W	300	<i>Psilaster acuminatus</i> (1)
Q12B	"	43 51.5'	179 51.4'W	410	<i>Plutonaster knoxi</i> (1), <i>Psilaster acuminatus</i> (2)
Q16	16.3.78	43 59.40'	179 15.60'W	215	<i>Astromesites primigenius</i> (1), <i>Proserpinaster neozelanicus</i> (1), <i>Benthopecten munidae</i> (1)
Q17	16.3.78	44 00.70'	179 08.10'W	314	<i>Psilaster acuminatus</i> (1), <i>Benthopecten munidae</i> (1)
Q19A	"	44 01.6'	179 18.0'W	285	<i>Astromesites primigenius</i> (1)
Q27	22.3.78	44 23.3'	176 47.1'W	355	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (1)*
Q33	23.3.78	44 13.5'	177 04.7'W	403	<i>Plutonaster knoxi</i> (1)*, <i>Proserpinaster neozelanicus</i> (3), <i>Psilaster acuminatus</i> (2)
Q37	"	44 23.7'	176 47.8'W	358	<i>Psilaster acuminatus</i> (1)
Q40	24.3.78	44 29.5'	176 32.5'W	345-380	<i>Psilaster acuminatus</i> (1)
Q69	2.6.78	27 00.00'	159 18.30'E	354	<i>Psilaster acuminatus</i> (2)*
Q82	6.6.78	31 31.70'	159 02.80'E	0	<i>Psilaster acuminatus</i> (1)
Q83	7.6.78	33 00.20'	163 01.20'E	816	<i>Astropecten tasmanicus</i> (6), <i>Psilaster acuminatus</i> (1)*
Q84	"	32 59.40'	163 08.70'E	830	<i>Astropecten tasmanicus</i> (3), <i>Psilaster acuminatus</i> (1), <i>Cheiraster subtuberculatus</i> (1)
Q136	15.12.78	41 31.8'	174 44.7'E	136	<i>Psilaster acuminatus</i> (1)*
Q338	13.11.79	44 00.7'	176 04.9'E	480	<i>Psilaster acuminatus</i> (2)
Q339	"	44 05.6'	176 11.4'E	455	<i>Psilaster acuminatus</i> (1)
Q342	14.11.79	44 10.10'	175 49.30'E	365	<i>Radiaster gracilis</i> (1), <i>Benthopecten munidae</i> (2)
Q343	"	44 07.80'	175 47.80'E	500	<i>Radiaster gracilis</i> (3)
R435	15.6.90	39 25.8'	178 25.3'E	985	<i>Psilaster acuminatus</i> (1)
R471D	7.8.92	39 50.27'	174 06.39'E	35-37	<i>Astropecten polyacanthus</i> (1)
S16	14.9.78	49 50.00'	170 14.00'E	593	<i>Psilaster acuminatus</i> (4), <i>Benthopecten pikei</i> (2)
S22	17.9.78	50 39.00'	167 39.60'E	400	<i>Psilaster acuminatus</i> (1), <i>Benthopecten munidae</i> (2)
S25	"	50 41.80'	167 40.60'E	339	<i>Benthopecten munidae</i> (2)
S28	18.9.78	50 41.10'	167 44.00'E	375	<i>Benthopecten munidae</i> (1)
S41	20.9.78	52 55.50'	169 32.70'E	184	<i>Psilaster acuminatus</i> (1)
S42	21.9.78	53 15.6'	169 30.5'E	480	<i>Psilaster acuminatus</i> (3)
S43	"	53 29.10'	170 04.20'E	693	<i>Psilaster acuminatus</i> (3), <i>Benthopecten munidae</i> (6), <i>B. pikei</i> (4)
S52	23.9.78	52 47.00'	172 54.00'E	494	<i>Psilaster acuminatus</i> (2)
S63	25.9.78	48 04.7'	179 49.3'E	220	<i>Psilaster acuminatus</i> (1)
S65	26.9.78	48 10.35'	179 41.3'W	490	<i>Radiaster gracilis</i> (1)
S66	"	48 03.8'	179 40.3'W	466	<i>Psilaster acuminatus</i> (1), <i>Benthopecten pikei</i> (1)
S67	"	48 05.9'	179 55.2'W	380	<i>Psilaster acuminatus</i> (1)
S81	23.11.78	47 52.8'	179 18.8'E	178	<i>Psilaster acuminatus</i> (1)*
S102	5.12.78	51 38.9'	165 24.4'E	2460-2519	<i>Plutonaster complexus</i> (3), <i>Psilaster acuminatus</i> (1)*
S119	20.10.79	43 32.00'	175 59.4'E	368	<i>Psilaster acuminatus</i> (3)
S120	"	43 33.00'	175 58.8'E	365	<i>Psilaster acuminatus</i> (5)*
S121	"	43 30.60'	175 58.10'E	335	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (6)
S122	"	43 35.5'	175 57.3'E	322	<i>Psilaster acuminatus</i> (9)*
S123	"	43 37.10'	175 56.60'E	322	<i>Luidia neozelanica</i> (1)*, <i>Dipsacaster magnificus</i> (2), <i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (7)*
S124	"	43 30.7'	175 59.9'E	363	<i>Dipsacaster magnificus</i> (1)*
S125	"	43 32.1'	175 58.5'E	365	<i>Dipsacaster magnificus</i> (2), <i>Psilaster acuminatus</i> (3)
S126	"	43 33.40'	175 58.60'E	322	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (1)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
S127	"	43 35.4'	175 57.3'E	322	<i>Dipsacaster magnificus</i> (2), <i>Psilaster acuminatus</i> (1)
S130	"	43 34.00'	175 57.70'E	335	<i>Dipsacaster magnificus</i> (1), <i>Benthopecten pikei</i> (1)
S134	23.10.79	44 09.00'	176 06.50'E	126	<i>Astromesites primigenius</i> (6)
S138	24.10.79	44 35.4'	174 49.6'E	785	<i>Psilaster acuminatus</i> (1)
S140	"	44 33.90'	174 51.20'E	750	<i>Psilaster acuminatus</i> (1)
S142	"	44 30.90'	174 52.50'E	715	<i>Psilaster acuminatus</i> (1)
S146	25.10.79	44 21.00'	174 20.7'E	663	<i>Psilaster acuminatus</i> (1)*
S147	"	44 30.1'	174 18.8'E	760	<i>Psilaster acuminatus</i> (2)
S148	"	44 41.00'	174 20.9'E	859	<i>Psilaster acuminatus</i> (1)
S150	26.10.79	45 46.00'	174 24.5'E	1640	<i>Benthopecten pikei</i> (4)
S151	"	45 45.80'	174 30.40'E	1586	<i>Porcellanaster ceruleus</i> (20), <i>Benthopecten pikei</i> (10)
S152	"	45 52.30'	174 04.90'E	1676	<i>Porcellanaster ceruleus</i> (1), <i>Benthopecten pikei</i> (2)
S153	27.10.79	45 21.10'	173 34.80'E	1386	<i>Porcellanaster ceruleus</i> (9), <i>Benthopecten pikei</i> (2)
S154	"	45 24.20	173 59.80'E	1373	<i>Porcellanaster ceruleus</i> (6)*, <i>Pectinaster mimicus</i> (1)
S156	28.10.79	44 12.3'	173 29.9'E	327	<i>Psilaster acuminatus</i> (1)
S159	"	44 19.3'	173 35.5'E	525	<i>Dipsacaster magnificus</i> (1)
S167	29.10.79	44 13.9'	174 08.00'E	608	<i>Psilaster acuminatus</i> (1)*
S170	30.10.79	43 59.8'	174 19.2'E	565	<i>Psilaster acuminatus</i> (1)
S171	"	44 05.00'	174 08.6'E	555	<i>Psilaster acuminatus</i> (2)*
S173	"	43 59.40'	174 02.00'E	486	<i>Psilaster acuminatus</i> (1)
S174	"	44 06.5'	173 54.1'E	518	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (1)
S176	30.10.79	44 00.5'	173 38.6'E	123	<i>Psilaster acuminatus</i> (1)
S179	"	43 50.30;	173 58.90'E	600	<i>Dipsacaster magnificus</i> (4)*, <i>Proserpinaster neozelanicus</i> (3)
S190	31.10.79	43 14.4'	173 34.4'E	140	<i>Dipsacaster magnificus</i> (1)*, <i>Proserpinaster neozelanicus</i> (1)
S199	1.11.79	43 04.2'	173 55.0'E	685	<i>Dipsacaster magnificus</i> (1), <i>Psilaster acuminatus</i> (1)
S200	"	43 03.00'	173 51.7'E	1400	<i>Plutonaster knoxi</i> (3), <i>Psilaster acuminatus</i> (1)
S202	2.11.79	42 14.70'	175 08.60'E	2476	<i>Dytaster pedicellaris</i> (2), <i>Plutonaster</i> sp. (6, small), <i>Porcellanaster ceruleus</i> (11), <i>Pectinaster mimicus</i> (1)
S204	3.11.79	42 10.5'	175 59.4'E	2677	<i>Dytaster pedicellaris</i> (2), <i>Porcellanaster ceruleus</i> (9)
S215	4.11.79	42 40.00'	173 44.60'E	750	<i>Benthopecten pikei</i> (1)
S364	27.1.83	43 02.4'	170 17.7'E	30	<i>Psilaster acuminatus</i> (2)
S377	30.1.83	42 37.00'	169 31.50'E	955	<i>Benthopecten pikei</i> (2)
S378	31.1.83	41 37.3'	169 56.3'E	900	<i>Benthopecten pikei</i> (4), <i>Cheiraster monopedicellaris</i> (1)
S379	1.2.83	41 59.2'	170 28.4'E	515	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (2)
S380	"	42 15.4'	170 53.3'E	191	<i>Psilaster acuminatus</i> (5)
S382	2.2.83	42 19.6'	171 01.1'E	124	<i>Psilaster acuminatus</i> (1)
S383	3.2.83	42 24.8'	171 07.3'E	28	<i>Psilaster acuminatus</i> (1)
S386	4.2.83	41 20.9'	170 40.8'E	513–507	<i>Proserpinaster neozelanicus</i> (3)
S391	6.2.83	41 33.8'	171 28.5'E	133	<i>Psilaster acuminatus</i> (27)
S393	7.2.83	41 00.2'	171 47.9'E	127	<i>Psilaster acuminatus</i> (2)
S395	8.2.83	41 26.4'	171 07.7'E	179	<i>Psilaster acuminatus</i> (7)
S398	10.2.83	40 52.4'	171 32.9'E	175	<i>Luidia neozelanica</i> (11), <i>Psilaster acuminatus</i> (1)
S400	"	41 39.7'	171 06.8'E	503	<i>Proserpinaster neozelanicus</i> (6), <i>Psilaster acuminatus</i> (1)
S889	17.7.91	41 26.1'	170 46.9'E	351–352	<i>Psilaster acuminatus</i> (1)
S890	18.7.91	42 30.1'	170 31.9'E	298–300	<i>Proserpinaster neozelanicus</i> (2)
S896	21.7.91	42 34.0'	170 20.0'E	598–625	<i>Proserpinaster neozelanicus</i> (1)
T2	6.3.81	44 09.9'	175 46.9'E	522	<i>Psilaster acuminatus</i> (1)*
T21	11.3.81	47 39.80'	179 49.90'E	211	<i>Psilaster acuminatus</i> (6)
T22	"	48 00.10'	180 00.00'	268	<i>Psilaster acuminatus</i> (1)
T29	12.3.81	48 20.3'	179 30.7'W	768	<i>Psilaster acuminatus</i> (1)*, <i>Pectinaster mimicus</i> (1)
T33	13.3.81	48 30.2'	179 43.6'E	721	<i>Cheiraster otagoensis</i> (1)
T36	"	48 43.70'	179 27.10'E	775	<i>Cheiraster otagoensis</i> (1)
T48	15.3.81	49 18.6'	177 54.7'E	990	<i>Plutonaster jonathani</i> (1)
T58	26.3.81	47 11.30'	169 21.70'E	143	<i>Astromesites primigenius</i> (1)
T59	"	47 11.9'	169 21.6'E	228	<i>Psilaster acuminatus</i> (12)*
T88	31.3.81	44 02.00'	174 46.60'E	500	<i>Psilaster acuminatus</i> (1)
T244	24.3.82	30 05.20'	178 10.20'W	1450	<i>Cheiraster triplacanthus</i> (1)
T260	28.3.82	31 20.80'	178 49.60'W	68	<i>Luidia maculata</i> (1)
T478	7.12.83	41 03.2'	174 21.5'E	93	<i>Astromesites primigenius</i> (1)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
T489	8.12.83	41 08.60'	174 16.6'E	44	<i>Psilaster acuminatus</i> (1)
T496	9.12.83	41 07.9'	174 15.3'E	45	<i>Psilaster acuminatus</i> (1)
T577	17.12.83	41 28.4'	171 00.4'E	196	<i>Psilaster acuminatus</i> (2)
U194	22.9.82	37 57.80'	165 35.10'E	1815	<i>Benthopecten pikei</i> (1), <i>Pectinaster mimicus</i> (6)
U195	23.9.82	34 31.50'	166 21.00'E	2930	<i>Dytaster felli</i> (1)
U196	24.9.82	33 03.00'	165 22.4'E	3118	<i>Dytaster felli</i> (3), <i>Styracaster armatus</i> (2)
V393	17.9.89	42 54.89'	176 12.53'E	538	<i>Psilaster acuminatus</i> (1)
U197	25.9.82	34 09.80'	163 36.70'E	1186	<i>Plutonaster</i> sp. (6, small), <i>Plutonaster complexus</i> (15), <i>Benthopecten pikei</i> (1)
U198	*	34 59.30'	162 11.21'E	1573	<i>Benthopecten pikei</i> (5), <i>Pectinaster mimicus</i> (1)
U204	30.9.82	35 29.70'	157 28.00'E	4570	<i>Damnaster tasmani</i> (4)
U205	1.10.82	35 48.6'	156 31.8'E	4714	<i>Damnaster tasmani</i> (1)
U226	16.10.82	38 37.3'	165 36.0'E	2417-2421	<i>Plutonaster</i> sp. (2, small)
U227	18.10.82	39 33.90'	169 14.70'E	604	<i>Psilaster acuminatus</i> (1), <i>Benthopecten munidae</i> (1)
U564	2.2.88	35 17.9'	168 58.5'E	1890-1700	<i>Plutonaster complexus</i> (2)
U569	3.2.88	34 55.5'	169 22.4'E	1210	<i>Plutonaster complexus</i> (2)
U582	5.2.88	31 51.7'	172 26.0'E	790	<i>Astropecten tasmanicus</i> (2)
U584	6.2.88	31 26.3'	172 35.6'E	1137-1150	? <i>Dytaster pedicellaris</i> (1, badly damaged)
U617	12.2.88	33 05.1'	173 21.4'E	1680	<i>Pectinaster mimicus</i> (1)
U618	*	33 06.9'	173 18.1'E	1690-1670	<i>Plutonaster</i> sp. (1, small)
U1005	1.4.93	39 44.97'	174 07.73'E	-	<i>Astropecten polyacanthus</i> (1)
V365	8.9.89	43 44.64'	178 59.80'W	391	<i>Plutonaster</i> sp. (1, small)
V366	*	43 29.69'	178 59.55'W	499	<i>Plutonaster knoxi</i> (13)*
V369	11.9.89	43 05.67'	178 59.94'E	399	<i>Psilaster acuminatus</i> (1)
V370	12.9.89	42 42.76'	178 59.76'W	1024	<i>Plutonaster knoxi</i> (1), <i>Benthopecten pikei</i> (2), <i>Pectinaster mimicus</i> (1)
V372	13.9.89	43 20.22'	178 58.88'E	415-	
		to 43 20.44'	178 57.24'E	415	<i>Plutonaster</i> sp. (5, small), <i>Psilaster acuminatus</i> (1)*
V373	*	43 34.85'	179 00.03'E	385	<i>Benthopecten munidae</i> (1)
V376	-9.89	44 20.29'	179 00.08'E	1239	<i>Benthopecten pikei</i> (3), <i>Pectinaster mimicus</i> (2)
V380	15.9.89	43 34.92'	176 59.98'E	335	<i>Psilaster acuminatus</i> (2)*
V381	*	43 20.46'	177 00.5'E	244	<i>Astromesites primigenius</i> (2)*
V387	16.9.89	43 49.62'	176 59.82'E	497-498	<i>Psilaster acuminatus</i> (3)*
V390	17.9.89	43 05.00'	177 00.00'E		
		to 43 04.46'	176 59.72'E	330	<i>Psilaster acuminatus</i> (1)
V416	6.9.92	42 34.25'	170 27.8'E	577	<i>Psilaster acuminatus</i> (2)
V417	*	42 34.25'	170 25.30'E	670	<i>Psilaster acuminatus</i> (1)
V425	10.9.92	41 39.63'	170 43.61'E	260-263	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (2)
V426	*	41 40.01'	170 37.8'E	327-352	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (2)
V427	*	42 35.43'	170 40.82'E	366-380	<i>Psilaster acuminatus</i> (1)
V429	11.9.92	41 35.10'	170 34.50'E	499-500	<i>Psilaster acuminatus</i> (1)
V431	12.9.92	41 27.0'	170 37.5'E	507-515	<i>Proserpinaster neozelanicus</i> (2)
V472	5.6.94	38 59.23'	178 44'E	1650	<i>Plutonaster</i> sp. (1, small)
W247B	14.9.93	44 47.4'	178 59.8'E		
		to 44 48.6'	178 57.1'E	1932-1963	<i>Porcellanaster ceruleus</i> (15)
W248	*	44 36.00'	178 55.00'E	1442-1468	<i>Psilaster acuminatus</i> (6), <i>Porcellanaster ceruleus</i> (5)
W249	*	44 18.9'	179 00.0'E	1200-1230	<i>Plutonaster knoxi</i> (5)
W251	15.9.93	43 50.50'	178 59.5'	442-	
		to 43 50.5'	178 59.4'E	469	<i>Psilaster acuminatus</i> (1)
W255	18.9.93	44 40.9'	179 01.2'	1600-	
		to 44 42.5'	179 02.8'E	1706	<i>Porcellanaster ceruleus</i> (1)
W256	*	44 41.1'	179 01.2'	1610-	
		to 44 43.2'	179 00.4'E	1688	<i>Psilaster acuminatus</i> (3), <i>Porcellanaster ceruleus</i> (2)*
W259	19.9.93	42 54.1'	179 00.2'	812-	<i>Dipsacaster magnificus</i> (1), <i>Plutonaster</i> sp. (3, small), <i>Plutonaster knoxi</i> (2)
		to 42 55.7'	178 59.5'E	725	
W260	*	42 57.00'	179 00.00'	665-	
		to 42 57.7'	178 58.6'E	625	<i>Psilaster acuminatus</i> (1)
W261	*	42 47.2'	178 59.6'	1212-	
		to 42 48.5'	178 59.9'E	1126	<i>Plutonaster knoxi</i> (1)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
W263	*	42 41'	179 00.3'E	1493-1660	<i>Psilaster acuminatus</i> (1)
W265	*	42 38.3'	178 59.9	2039-	<i>Psilaster acuminatus</i> (1), <i>Porcellanaster ceruleus</i> (5), <i>Radiaster gracilis</i> (1)
		to 42 40.6'	179 00.00'E	1687	
W273	26.9.93	42 39'	178 57.2'E	1915-1491	<i>Plutonaster knoxi</i> (1), <i>Psilaster acuminatus</i> (2), <i>Porcellanaster ceruleus</i> (6)
W274	*	42 39.2'	179 00.9'E	1844	<i>Porcellanaster caeruleus</i> (1)
W434	20.2.95	43 11.90'	175 21.72'E	89-100	<i>Astromesites primigenius</i> (6)
X143	27.11.79	37 09.04'	176 51.42'E	650-700	<i>Psilaster acuminatus</i> (1)
X500	6.7.94	43 42.33'	174 06.76'	1207-	
		to 43 40.37'	174 03.70'W	1235	<i>Plutonaster knoxi</i> (2)
X508	8.7.94	42 51.86'	174 56.90'	1163-	
		to 42 57.67'	174 52.13'W	1173	<i>Plutonaster knoxi</i> (1)
X513	10.7.94	42 52.39'	175 59.12'	937-	
		to 42 52.43'	175 55.06'W	949	<i>Psilaster acuminatus</i> (2)
X514	*	42 52.67'	175 49.52'	941-	
		to 42 52.94'	176 45.52'W	944	<i>Plutonaster knoxi</i> (1)
X519	11.7.94	42 55'	175 36.69'	905-	
		to 42 54.40'	175 35.58'W	915	<i>Plutonaster knoxi</i> (1)
X521	*	42 58.16'	175 27.91'	862-	
		to 42 59.16'	175 23.99'W	865	<i>Psilaster acuminatus</i> (1)
X523	*	42 56'	175 18'W	941-942	<i>Psilaster acuminatus</i> (1)
X568	4.2.96	34 51.058'	179 02.865	1587-	
		to 34 51.352'	179 03.453'E	1428	<i>Plutonaster complexus</i> (1)
Y39	16.3.97	46 08.128'	166 10.465'E	107	<i>Astromesites primigenius</i> (1)
Z1921	28.9.62	36 53.00'	176 10.00'E	350	<i>Psilaster acuminatus</i> (1)*
Z1925	14.11.62	36 44.00'	175 24.00'E	47	<i>Astropecten polyacanthus</i> (1)
Z1928	3.4.63	37 34.00'	177 50.00'E	119	<i>Luidia neozelanica</i> (1)
Z1930	2.7.56	29 15.00'	177 54.00'W	27	<i>Astropecten polyacanthus</i> (1)
Z2363	-.-.71	37 21.00'	176 26.00'E	311-348	<i>Psilaster acuminatus</i> (1)*
Z2364	-.-.71	37 25.00'	176 26.00'E	277	<i>Luidia neozelanica</i> (1)*, <i>Psilaster acuminatus</i> (2)
Z2368	-.-.71	37 21.00'	176 24.00'E	183	<i>Luidia neozelanica</i> (2)*, <i>Psilaster acuminatus</i> (2)
Z2369	-.-.71	36 52.50'	176 24.00'E	168	<i>Psilaster acuminatus</i> (4)
Z2371	15.4.71	41 23.00'	170 47.00'E	366	<i>Proserpinaster neozelanicus</i> (2), <i>Psilaster acuminatus</i> (3)
Z2372	*	41 33.00'	170 46.00'E	294	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (1)*
Z2373	*	41 33.00'	170 39.00'E	274	<i>Proserpinaster neozelanicus</i> (1)*, <i>Psilaster acuminatus</i> (1)*
Z2374	15.4.71	42 09.00'	170 36.00'E	366	<i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (1)*
Z2375	16.4.71	42 30.00'	170 36.00'E	348	<i>Proserpinaster neozelanicus</i> (2)
Z2377	17.4.71	43 25'	169 17'E	360	<i>Proserpinaster neozelanicus</i> (2), <i>Psilaster acuminatus</i> (2)
Z2696	22.11.77	34 24.00'	173 05.00'E	64	<i>Astropecten polyacanthus</i> (2)
Z2697	*	34 24.00'	173 05.00'E	101	<i>Luidia neozelanica</i> (1)*
Z2698	*	off North Cape		101-113	<i>Luidia neozelanica</i> (1)*
Z6482	13.12.88	43 44.7'	175 07.9'E	417-	
		to 43 45.2'	175 10.0'E	422	<i>Dipsacaster magnificus</i> (1)
Z8253	-.12.94	36 07.90'	176 07.20'E	220	<i>Psilaster acuminatus</i> (1)
Z8255	-.12.94	36 06.2'	176 17.2'E	540	<i>Astromesites compactus</i> (1)
Z8259	-.12.94	36 14.50'	176 12.10'E	360	<i>Psilaster acuminatus</i> (2)
Z8265	-.12.94	36 38.9'	176 11.2'E	310	<i>Proserpinaster neozelanicus</i> (1)
Z8371	10.8.95	39 50'	177 39'E	1000-1100	<i>Psilaster acuminatus</i> (1)
Z8416	-.10.95	43 10'	175 44'E	450	<i>Proserpinaster neozelanicus</i> (1)
Z8492	-	36 23.40'	176 04.40'E	280	<i>Psilaster acuminatus</i> (5)
Z8510	16.7.96	36 36'	174 49'E	10	<i>Astropecten polyacanthus</i> (6)
Z8511	21.7.96	36 13.4'	175 06.81	14	<i>Astropecten polyacanthus</i> (5)
Z8539	8.11.95	44 45.71'	176 37.92'	1220-	
		to 44 46.07'	176 40.71'W	1222	<i>Plutonaster knoxi</i> (1)
Z8540	8.4.96	36 55.07'	176 16.42'	349-	
		to 36 52.07'	176 16.35'E	351	<i>Proserpinaster neozelanicus</i> (1)
Z8552	24.9.96	36 55.44'	176 17.21'	400-	
		to 37 00.72'	176 16.11'E	399	<i>Psilaster acuminatus</i> (3)

Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
Z8553	"	36 59.00'	176 16.00'	382–	
		to 36 53.91'	176 16.95'E	380	<i>Psilaster acuminatus</i> (2)
Z8554	24.9.96	36 55.01'	176 16.56'	357–	
		to 36 56.57'	176 16.51'E	364	<i>Psilaster acuminatus</i> (4)
Z8555	25.9.96	36 59.85'	176 16.01'	382–	
		to 36 54.30'	176 16.98'E	385	<i>Psilaster acuminatus</i> (1)
Z8557	"	36 59.57'	176 16.03'	377–	
		to 36 54.52'	176 16.95'E	384	<i>Psilaster acuminatus</i> (2)
Z8558	"	36 56.18'	176 17.08'	400–	
		to 36 57.76'	176 87'E	402	<i>Psilaster acuminatus</i> (5)
Z8560	26.9.96	36 55.39'	176 16.73'	369–	
		to 37 01.02'	176 15.43'E	372	<i>Psilaster acuminatus</i> (4)
Z8561	"	36 58.72'	176 17.04'	420–	
		to 36 54.27'	176 17.61'E	422	<i>Psilaster acuminatus</i> (4)
Z8563	"	36 57.59'	176 16.17'	386–	
		to 36 58.59'	176 16.57'E	387	<i>Psilaster acuminatus</i> (3)
Z8566	7.10.96	43 04'	175 39'	460	<i>Dipsacaster magnificus</i> (1), <i>Proserpinaster neozelanicus</i> (1), <i>Psilaster acuminatus</i> (5)
		to 43 12'	175 53'E		
Z8567	18.10.96	36 59.05'	176 16.51'	395	
		to 36 52.90'	176 17.11'E		<i>Psilaster acuminatus</i> (2)
Z8570	19.10.96	36 55.90'	176 17.47'	421	
		to 37 00.85'	176 16.54'E		<i>Psilaster acuminatus</i> (1)
Z8573	20.10.96	37 00.23'	176 16.38'	404–	
		to 36 54.38'	176 17.30'E	405	<i>Psilaster acuminatus</i> (3)
Z8574	"	36 56.00'	176 17.30'	413–	
		to 37 65'	176.16.43'E	412	<i>Psilaster acuminatus</i> (1)
Z8575	"	37 00.38'	176 16.58'	417–	
		to 36 54.34'	176 17.58'E	421	<i>Psilaster acuminatus</i> (4)
Z8576	"	36 54.09'	176 17.40'	411–	
		to 37 01.04'	176 16.28'E	415	<i>Psilaster acuminatus</i> (1)
Z8577	21.10.96	37 00.36'	176 16.51'E	415–	
		to 36 54.25'	176 17.42'E	411	<i>Psilaster acuminatus</i> (3)
Z8578	"	36 55.06'	176 17.38'	410–	
		to 37 00.77'	176 16.32'E	412	<i>Psilaster acuminatus</i> (2)
Z8580	"	36 54.66'	176 17.40'	412–	
		to 37 00.75'	176 16.39'E	413	<i>Psilaster acuminatus</i> (1)
Z8642	24.2.97	36 00.8'	174 47.9'E	27	<i>Astropecten polyacanthus</i> (5)
Z8643	"	36 05.7'	174 39.0'E	40.4	<i>Astropecten polyacanthus</i> (1)
Z8644	"	36 10.1'	174 41.9'E	41	<i>Astropecten polyacanthus</i> (3)
Z8651	2.3.97	34 46.9'	173 12.4'E	36	<i>Astropecten polyacanthus</i> (1)
Z8659	26.2.97	34 59.7'	173 45.5'E	17.5	<i>Astropecten polyacanthus</i> (2)
Z8660	27.2.97	34 23.6'	172 53.6'E	38	<i>Astropecten polyacanthus</i> (1)
Z8661	26.2.97	34 59.4'	173 50.5'E	33	<i>Astropecten polyacanthus</i> (2)
Z8663	27.2.97	34 23.8'	172 53.3'E	37.5	<i>Astropecten polyacanthus</i> (2)
Z8664	26.2.97	34 58.1'	173 45.5'E	28.4	<i>Astropecten polyacanthus</i> (2)
Z8665	2.3.97	34 48.0'	173 12.3'E	24	<i>Astropecten polyacanthus</i> (5)
Z8675	"	34 58.3'	173 45.9'E	27.4	<i>Astropecten polyacanthus</i> (3)
Z8823	24.2.97	35 59.0'	174 36.3'e	37	<i>Astropecten polyacanthus</i> (2)
Z8833	2.3.97	34 46.7'	173 12.0'E	38	<i>Astropecten polyacanthus</i> (2)
Z8835	27.2.97	34 23.1'	172 54.8'E	51.5	<i>Astropecten polyacanthus</i> (3)
Z8838	2.3.97	41 34.04'	171 40.28'E	54–57	
		to 41 36.18'	171 37.23'E		<i>Psilaster acuminatus</i> (1)
Z8839	11.4.97	41 44.58'	171 09.82'	155	
		to 41 46.91'	171 07.24'E		<i>Psilaster acuminatus</i> (1)
Z8840	8.4.96	37 01.21'	176 19.49'	567–	
		to 37 04.10'	176 20.51'E	571	<i>Psilaster acuminatus</i> (1)
Z8841	27.2.97	34 23.7'	172 44.6'E	34	<i>Astropecten polyacanthus</i> (1)
Z8842	24.2.97	36 00.4'	174 36.3'E	33	<i>Astropecten polyacanthus</i> (2)
Z8843	"	35 54.6'	174 28.8'E	17	<i>Astropecten polyacanthus</i> (7)



Stn No.	Date	Latitude (° S)	Longitude (°)	Depth (m)	Species and number
Z8844	"	35 56.9'	174 35.3'E	38	<i>Astropecten polyacanthus</i> (1)
Z8845	25.2.97	34 05.7'	174 37.1'E	17	<i>Astropecten polyacanthus</i> (3)
Z8847	26.2.97	34 58.9'	173 50.6'E	35	<i>Astropecten polyacanthus</i> (3)
Z8850	24.2.97	35 54.6'	174 28.8'E	17	<i>Astropecten polyacanthus</i> (8)
Z8851	2.3.97	34 37.2'	173 03.2'E	30	<i>Astropecten polyacanthus</i> (1)
Z8853	26.2.97	34 58.3'	173 46.5'E	25	<i>Astropecten polyacanthus</i> (2)
Z8854	26.2.97	34 58.6'	173 46.1'E	26	<i>Astropecten polyacanthus</i> (2)
Z8857	17.6.96	42 47.15'	179 01.97'	811–	
		to 42 47.09'	178 59.93'W	827	<i>Psilaster acuminatus</i> (1)
Z8877	22.1.97	43 14.77'	178 24.68'	372–	
		to 43 16.88'	178 27.78'E	381	<i>Proserpinaster neozelanicus</i> (1)
Z8943	24.2.97	35 58.6'	174 30.7'E	17.9	<i>Astropecten polyacanthus</i> (7)
Z8951	"	36 00.0'	174 31.7'E	16	<i>Astropecten polyacanthus</i> (3)
Z8952	"	36 02.4'	174 34.7'E	16	<i>Astropecten polyacanthus</i> (4)
Z8953	"	35 56.3'	174 32.8'E	29	<i>Astropecten polyacanthus</i> (2)
Z8954	"	35 53.6'	174 33.7'E	21.6	<i>Astropecten polyacanthus</i> (4)
Z8955	25.2.97	36 06.9'	174 38.7'E	30	<i>Astropecten polyacanthus</i> (1)
Z8956	"	36 06.1'	174 37.3'E	23	<i>Astropecten polyacanthus</i> (2)
Z8957	"	36 08.1'	174 39.0'E	26	<i>Astropecten polyacanthus</i> (2)
Z8958	"	36 07.6'	174 40.6'E	46	<i>Astropecten polyacanthus</i> (2)
Z8959	"	36 12.7'	174 45.3'E	37	<i>Astropecten polyacanthus</i> (1)
Z8960	"	36 13.9'	174 44.5'E	18	<i>Astropecten polyacanthus</i> (2)
Z8961	26.2.97	34 58.8'	173 51.1'E	34	<i>Astropecten polyacanthus</i> (2)
Z8962	"	34 39.3'	173 50.0'E	29	<i>Astropecten polyacanthus</i> (3)
Z8963	27.2.97	34 21.4'	172 48.8'E	60	<i>Astropecten polyacanthus</i> (1)
Z8964	2.3.97	34 36.0'	173 03.1'E	31	<i>Astropecten polyacanthus</i> (3)
Z8966	3.3.97	34 54.1'	173 24.3'E	16	<i>Astropecten polyacanthus</i> (5)
Z8976	19.6.96	42 51.24'	178 41.73'	934–	
		to 42 51.54'	178 43.76'E	936	<i>Plutonaster knoxi</i> (2)
Z8977	18.10.95	44 39.61'	175 54.20'W	1201–1210	<i>Plutonaster knoxi</i> (1)
Z8978	13.1.97	44 08.54'	178 37.83'	483–	
		to 44 08.13'	178 41.97'W	484	<i>Plutonaster knoxi</i> (28)
Z8979	13.12.97	44 26.90'	178 02.67'	858–	
		to 44 27.89.5'	178 02.78'W	891	<i>Plutonaster knoxi</i> (1)
Z9000	--.98	37 37.11'	177 13.94'E	445–467	<i>Radiaster gracilis</i> (4)
Z9193	12.4.98	49 09.95'	167 12.41'	708–	
		to 49 07.15'	167 14.06'E	713	<i>Radiaster gracilis</i> (1)
Z9209					<i>Dipsacaster magnificus</i> (1)
Z9222	7.8.98	37 03.1'	176 30.9'E	940	<i>Radiaster gracilis</i> (1)
Z9245	23.3.95	45 17'	166 51'E	0–27	<i>Radiaster gracilis</i> (1)
Z9764	12.10.95	44 08.45'	178 47.31'	922–	
		to 44 08.38'	178 50.10'E	928	<i>Dipsacaster magnificus</i> (1, very large)
Z8945	18.12.96	44 22.44'	173 16.76'	390–	
		to 44 23.76'	173 14.66'E	399	<i>Dipsacaster magnificus</i> (1)

### Museum of New Zealand (NMNZ)

1121 specimens recorded from 73 different localities which are in alphabetical order. For location see figure on p. 169.

Location	Cat. No. (Ech.)	Depth (m)	Species and number
Ahipara Bay	4384	90	<i>Luidia neozelanica</i> (6)
	1597	270	<i>Psilaster acuminatus</i> (8)
	4527	231–234	<i>Psilaster acuminatus</i> (1)
Aldermen Islands, near	4370	178–248	<i>Luidia neozelanica</i> (2)
	4373	108–113	<i>Luidia neozelanica</i> (3)
	4379	202–207	<i>Luidia neozelanica</i> (1)

Location	Cat. No. (Ech.)	Depth (m)	Species and number	
Aldermen Islands, near	5218	516–521	<i>Luidia neozelanica</i> (1)	
	4486	803–846	<i>Plutonaster</i> sp. (1, small), <i>Plutonaster knoxi</i> (3)	
	4492	803–846	<i>Plutonaster fragilis</i> (14)	
	4517	178–248	<i>Psilaster acuminatus</i> (1)	
	6502	410–415	<i>Psilaster acuminatus</i> (1)	
Auckland, southwest of Auckland Islands	5660	500–522	<i>Psilaster acuminatus</i> (1)	
	4433	178	<i>Astromesites primigenius</i> (1)	
	4439	178	<i>Astromesites primigenius</i> (1)	
	4440	182	<i>Astromesites primigenius</i> (1)	
	1244	540	<i>Dipsacaster magnificus</i> (1)	
	1253	457	<i>Psilaster acuminatus</i> (1)	
	1254	457	<i>Psilaster acuminatus</i> (1)	
	1255	558	<i>Psilaster acuminatus</i> (1)	
	1495	540	<i>Psilaster acuminatus</i> (1)	
	2013	646–670	<i>Psilaster acuminatus</i> (2)	
Auckland Islands Shelf Bay of Islands	2158	520–562	<i>Radiaster gracilis</i> (1)	
	2141	56	<i>Luidia maculata</i> (1)	
	4391	20	<i>Luidia maculata</i> (1)	
	6578	22–31	<i>Luidia maculata</i> (1)	
	6255	99	<i>Luidia neozelanica</i> (1)	
	1560	shallow	<i>Astropecten polyacanthus</i> (1)	
	4415	–	<i>Astropecten polyacanthus</i> (1)	
	4420	18–27	<i>Astropecten polyacanthus</i> (1)	
	5247	shallow	<i>Astropecten polyacanthus</i> (2)	
	7075	–	<i>Astropecten polyacanthus</i> (1)	
	7086	–	<i>Astropecten polyacanthus</i> (1)	
	Bay of Plenty	4394	39	<i>Luidia maculata</i> (1)
		4395	64–69	<i>Luidia maculata</i> (1)
		4396	129–139	<i>Luidia maculata</i> (1)
		4398	44	<i>Luidia maculata</i> (4)
1557		293–333	<i>Luidia neozelanica</i> (1)	
1558		–	<i>Luidia neozelanica</i> (1)	
4327		–	<i>Luidia neozelanica</i> (1)	
4337		139–179	<i>Luidia neozelanica</i> (1)	
4339		203–248	<i>Luidia neozelanica</i> (3)	
4340		–	<i>Luidia neozelanica</i> (5)	
4371		139–179	<i>Luidia neozelanica</i> (1)	
4372		72–84	<i>Luidia neozelanica</i> (1)	
4378		–	<i>Luidia neozelanica</i> (3)	
4383		198–273	<i>Luidia neozelanica</i> (3)	
4385		818–898	<i>Luidia neozelanica</i> (1)	
7390		–	<i>Luidia neozelanica</i> (1)	
4435		616–666	<i>Astromesites primigenius</i> (2)	
4424		–	<i>Astropecten dubiosus</i> (1)	
674		731	<i>Astropecten polyacanthus</i> (1)	
747		–	<i>Astropecten polyacanthus</i> (5)	
864		–	<i>Astropecten polyacanthus</i> (1)	
1561		–	<i>Astropecten polyacanthus</i> (1)	
1562		38	<i>Astropecten polyacanthus</i> (2)	
1564		–	<i>Astropecten polyacanthus</i> (1)	
2140		32	<i>Astropecten polyacanthus</i> (1)	
2411		24	<i>Astropecten polyacanthus</i> (6)	
4410		72–84	<i>Astropecten polyacanthus</i> (1)	
4412	44	<i>Astropecten polyacanthus</i> (1)		
4414	37	<i>Astropecten polyacanthus</i> (7)		
4417	–	<i>Astropecten polyacanthus</i> (1)		
4418	–	<i>Astropecten polyacanthus</i> (2)		



Location	Cat. No. (Ech.)	Depth (m)	Species and number
Bay of Plenty	5220	-	<i>Astropecten polyacanthus</i> (2)
	5222	40	<i>Astropecten polyacanthus</i> (4)
	5223	-	<i>Astropecten polyacanthus</i> (22)
	5248	-	<i>Astropecten polyacanthus</i> (2)
	5249	-	<i>Astropecten polyacanthus</i> (21)
	4478	59-74	<i>Plutonaster</i> sp. (12, small)
	4488	59-74	<i>Plutonaster fragilis</i> (4)
	4478	59-74	<i>Plutonaster knoxi</i> (7)
	4299	369-410	<i>Proserpinaster neozelanicus</i> (1)
	4469	210-373	<i>Proserpinaster neozelanicus</i> (2)
	190	82	<i>Psilaster acuminatus</i> (1)
	660	494	<i>Psilaster acuminatus</i> (1)
	661	207-219	<i>Psilaster acuminatus</i> (3)
	1565	293-346	<i>Psilaster acuminatus</i> (28)
	1578	350-376	<i>Psilaster acuminatus</i> (3)
	1586	-	<i>Psilaster acuminatus</i> (22)
	1588	365-410	<i>Psilaster acuminatus</i> (7)
	1589	361-401	<i>Psilaster acuminatus</i> (2)
	1590	376-440	<i>Psilaster acuminatus</i> (1)
	1591	380-400	<i>Psilaster acuminatus</i> (4)
	1592	480-555	<i>Psilaster acuminatus</i> (2)
	1593	355-388	<i>Psilaster acuminatus</i> (2)
	1594	370-408	<i>Psilaster acuminatus</i> (10)
	1595	340-394	<i>Psilaster acuminatus</i> (9)
	1596	293-332	<i>Psilaster acuminatus</i> (85)
	4307	227	<i>Psilaster acuminatus</i> (1)
	4500	631-666	<i>Psilaster acuminatus</i> (2)
	4517	178-248	<i>Psilaster acuminatus</i> (1)
	4519	304-398	<i>Psilaster acuminatus</i> (1)
	4537	129-139	<i>Psilaster acuminatus</i> (2)
	4545	198-273	<i>Psilaster acuminatus</i> (6)
	5236	256-292	<i>Psilaster acuminatus</i> (9)
	5656	673-606	<i>Psilaster acuminatus</i> (1)
	5657	352-315	<i>Psilaster acuminatus</i> (2)
	6498	410-415	<i>Psilaster acuminatus</i> (2)
7362	226-240	<i>Psilaster acuminatus</i> (11)	
7411	228	<i>Psilaster acuminatus</i> (2)	
7421	310	<i>Psilaster acuminatus</i> (5)	
7427	326	<i>Psilaster acuminatus</i> (4)	
Bounty Plateau and Islands	1859	503-512	<i>Luidia maculata</i> (7)
	4448	547-561	<i>Dipsacaster magnificus</i> (1)
Campbell Island and Campbell Island Rise	2007	480-482	<i>Psilaster acuminatus</i> (1)
	2008	687-695	<i>Psilaster acuminatus</i> (1)
	2009	480-488	<i>Psilaster acuminatus</i> (1)
	4506	492-528	<i>Psilaster acuminatus</i> (1)
Canterbury Bight and Banks Peninsula	4452	192	<i>Dipsacaster magnificus</i> (1)
	2651	160	<i>Psilaster acuminatus</i> (1)
Cape Campbell	569	110-128	<i>Dipsacaster magnificus</i> (3)
	585	101-115	<i>Dipsacaster magnificus</i> (4)
	4470	1292-1395	<i>Plutonaster</i> sp. (1, small), <i>Plutonaster knoxi</i> (4)
	4472	454-424	<i>Plutonaster knoxi</i> (1)
	194	139	<i>Proserpinaster neozelanicus</i> (2)
	568	110-128	<i>Proserpinaster neozelanicus</i> (2)
	1576	73	<i>Proserpinaster neozelanicus</i> (1)
	189	55-73	<i>Psilaster acuminatus</i> (4)
	570	110-128	<i>Psilaster acuminatus</i> (6)
	4525	73	<i>Psilaster acuminatus</i> (3)

Location	Cat. No. (Ech.)	Depth (m)	Species and number
Cape Kidnappers	5233	-	<i>Plutonaster</i> sp. (2, small)
	5651	752-688	<i>Plutonaster knoxi</i> (1)
Cape Turnagain	5246	139	<i>Luidia neozelanica</i> (1)
	Castlepoint	4321	73-110
4322		128-182	<i>Luidia neozelanica</i> (1)
Cavalli Islands, near Challenger Plateau	1176	146	<i>Dipsacaster magnificus</i> (1)
	4538	278-283	<i>Psilaster acuminatus</i> (5)
	6553	858-843	<i>Radiaster gracilis</i> (1)
	4382	79	<i>Luidia neozelanica</i> (1)
	4451	520-528	<i>Dipsacaster magnificus</i> (1)
	4453	560-572	<i>Dipsacaster magnificus</i> (2)
	5229	612-630	<i>Dipsacaster magnificus</i> (1)
	4461	408-472	<i>Proserpinaster neozelanicus</i> (2)
	4462	492-528	<i>Proserpinaster neozelanicus</i> (4)
	4548	212-332	<i>Proserpinaster neozelanicus</i> (1)
	3879	-	<i>Psilaster acuminatus</i> (2)
	4119	612-630	<i>Psilaster acuminatus</i> (13)
	4503	712-740	<i>Psilaster acuminatus</i> (1)
	4511	520-528	<i>Psilaster acuminatus</i> (2)
	4520	-	<i>Psilaster acuminatus</i> (3)
	4528	504-526	<i>Psilaster acuminatus</i> (4)
	4544	560-572	<i>Psilaster acuminatus</i> (2)
	5652	276	<i>Psilaster acuminatus</i> (6)
	5654	482-483	<i>Psilaster acuminatus</i> (3)
	5655	539-555	<i>Psilaster acuminatus</i> (3)
Chatham Islands, near	6616	482	<i>Psilaster acuminatus</i> (2)
	6618	482	<i>Radiaster gracilis</i> (1)
Chatham Rise	4465	-	<i>Proserpinaster neozelanicus</i> (1)
	6291	232	<i>Psilaster acuminatus</i> (3)
Chatham Rise	1242	538-526	<i>Dipsacaster magnificus</i> (1)
	4473	1292-1395	<i>Plutonaster fragilis</i> (9)
	4476	1262	<i>Plutonaster fragilis</i> (39)
	4489	1568	<i>Plutonaster fragilis</i> (1)
	4490	1514-1489	<i>Plutonaster fragilis</i> (2)
	4491	1792	<i>Plutonaster fragilis</i> (1)
	4493	1723-1549	<i>Plutonaster fragilis</i> (22)
	1245	550-560	<i>Plutonaster knoxi</i> (2)
	3909	780	<i>Plutonaster knoxi</i> (1)
	4308	-	<i>Plutonaster knoxi</i> (7)
	4474	999-984	<i>Plutonaster knoxi</i> (3)
	4479	1792	<i>Plutonaster knoxi</i> (5)
	6330	-	<i>Proserpinaster neozelanicus</i> (1)
	7458	368-411	<i>Proserpinaster neozelanicus</i> (3)
	4183	770	<i>Psilaster acuminatus</i> (2)
	4185	1100	<i>Psilaster acuminatus</i> (2)
	4186	1050	<i>Psilaster acuminatus</i> (2)
	4498	999-984	<i>Psilaster acuminatus</i> (6)
	4523	500-518	<i>Psilaster acuminatus</i> (1)
	4534	415-416	<i>Psilaster acuminatus</i> (2)
6636	970-975	<i>Psilaster acuminatus</i> (1)	
7410	368-411	<i>Psilaster acuminatus</i> (5)	
6471	-	<i>Radiaster gracilis</i> (3)	
Christchurch, near	5368	1568	<i>Radiaster rowei</i> (1)
	4198	1090	<i>Dipsacaster magnificus</i> (1)
	7441	450	<i>Dipsacaster magnificus</i> (3)
Clarence River mouth, near	7349	1178-1190	<i>Psilaster acuminatus</i> (1)
	4514	860-790	<i>Psilaster acuminatus</i> (6)



Location	Cat. No. (Ech.)	Depth (m)	Species and number	
Cloudy Bay	4518	127–142	<i>Psilaster acuminatus</i> (10)	
Cook Strait	4323	183	<i>Luidia neozelanica</i> (1)	
	5639	101	<i>Luidia neozelanica</i> (1)	
	6254	183	<i>Luidia neozelanica</i> (1)	
	4441	132–119	<i>Astromesites primigenius</i> (1)	
	5231	–	<i>Dipsacaster magnificus</i> (1)	
	5261	–	<i>Proserpinaster neozelanicus</i> (1)	
	5266	91–1829	<i>Psilaster acuminatus</i> (1)	
	Cuvier Island	594	73	<i>Astropecten polyacanthus</i> (1)
Doubtful Sound	5649	146	<i>Astromesites primigenius</i> (2)	
East Cape, near	4392	79–83	<i>Luidia maculata</i> (1)	
	4393	94	<i>Luidia maculata</i> (1)	
	4397	94–89	<i>Luidia maculata</i> (1)	
	1011	128	<i>Luidia neozelanica</i> (1)	
	4341	124–129	<i>Luidia neozelanica</i> (1)	
	1681	1517	<i>Psilaster acuminatus</i> (2)	
	3883	340–505	<i>Psilaster acuminatus</i> (3)	
	3914	625–658	<i>Psilaster acuminatus</i> (4)	
	Farewell Spit / Cape	951	73	<i>Luidia neozelanica</i> (1)
		1247	241–244	<i>Proserpinaster neozelanicus</i> (2)
1251		241–244	<i>Psilaster acuminatus</i> (2)	
Gibson Point, near Kaikoura	2154	–	<i>Radiaster gracilis</i> (1)	
	2396	–	<i>Radiaster gracilis</i> (1)	
	5369	–	<i>Radiaster gracilis</i> (1)	
Great Barrier Island	5235	630–645	<i>Psilaster acuminatus</i> (1)	
Greymouth, off	1248	405–423	<i>Psilaster acuminatus</i> (1)	
Hauraki Gulf	4390	52	<i>Luidia maculata</i> (1)	
Hawke Bay	6416	783–891	<i>Psilaster acuminatus</i> (4)	
	6425	1094–1013	<i>Psilaster acuminatus</i> (1)	
	6554	857–880	<i>Psilaster acuminatus</i> (18)	
	6588	915–1095	<i>Psilaster acuminatus</i> (1)	
	7419	332	<i>Psilaster acuminatus</i> (2)	
	Heaphy River, off	4505	–	<i>Psilaster acuminatus</i> (1)
4536		350–400	<i>Psilaster acuminatus</i> (1)	
5653		160–165	<i>Psilaster acuminatus</i> (2)	
Hicks Bay, near	4335	99–102	<i>Luidia neozelanica</i> (1)	
	4504	685–705	<i>Psilaster acuminatus</i> (2)	
Hikurangi Trough	4178	1025	<i>Plutonaster knoxi</i> (2)	
	6574	920–914	<i>Plutonaster knoxi</i> (2)	
Hikurangi Trough	6594	1185–1204	<i>Plutonaster knoxi</i> (3)	
	7412	456	<i>Proserpinaster neozelanicus</i> (1)	
	7420	316	<i>Proserpinaster neozelanicus</i> (1)	
	7428	450	<i>Proserpinaster neozelanicus</i> (1)	
	Hokianga Harbour	1479	260	<i>Luidia neozelanica</i> (6)
1250		260	<i>Psilaster acuminatus</i> (17)	
Kahurangi Point	4454	408–472	<i>Dipsacaster magnificus</i> (1)	
	3432	570–590	<i>Proserpinaster neozelanicus</i> (1)	
	4458	408–472	<i>Proserpinaster neozelanicus</i> (2)	
	4466	573–578	<i>Proserpinaster neozelanicus</i> (1)	
	4501	408–472	<i>Psilaster acuminatus</i> (1)	
	4522	570–590	<i>Psilaster acuminatus</i> (1)	
	4533	408–472	<i>Psilaster acuminatus</i> (3)	
	5234	208–264	<i>Psilaster acuminatus</i> (1)	
	Kaikoura	4524	632	<i>Psilaster acuminatus</i> (44)
5662		786	<i>Psilaster acuminatus</i> (4)	
5663		1006–1097	<i>Psilaster acuminatus</i> (1)	
6566		–	<i>Psilaster acuminatus</i> (1)	

Location	Cat. No. (Ech.)	Depth (m)	Species and number	
Kaikoura Canyon, lower	4477	1514–1489	<i>Plutonaster knoxi</i> (3)	
	4487	1514–1489	<i>Plutonaster knoxi</i> (13)	
	4490	1514–1489	<i>Plutonaster knoxi</i> (2)	
Kapiti Island area	4459	55	<i>Proserpinaster neozelanicus</i> (1)	
Kawhia Harbour	4374	83	<i>Luidia neozelanicus</i> (5)	
	4416	83	<i>Astropecten polyacanthus</i> (5)	
Kermadec Islands	6292	31–45	<i>Luidia maculata</i> (1)	
	5219	146–201	<i>Luidia neozelanicus</i> (1)	
	4407	135	<i>Luidia prionota</i> (1)	
	5641	42–47	<i>Luidia prionota</i> (1)	
	598	22	<i>Astropecten polyacanthus</i> (1)	
	1559	14–18	<i>Astropecten polyacanthus</i> (1)	
Mahia Peninsula, near	4432	1189–1226	<i>Astropecten</i> sp. (1)	
	4434	258–306	<i>Luidia neozelanicus</i> (1)	
	4438	127–134	<i>Luidia neozelanicus</i> (2)	
	4485	413–453	<i>Plutonaster</i> sp. (1, small)	
	5263	258–306	<i>Proserpinaster neozelanicus</i> (1)	
	1008	64	<i>Psilaster acuminatus</i> (2)	
	4499	413–453	<i>Psilaster acuminatus</i> (1)	
	6555	800–860	<i>Psilaster acuminatus</i> (4)	
	6422	783–891	<i>Radiaster gracilis</i> (1)	
	Manukau Harbour	192	20	<i>Astropecten polyacanthus</i> (1)
Marlborough Sounds	6579	73	<i>Psilaster acuminatus</i> (1)	
Mernoo Bank / Slope	642	112	<i>Astromesites primigenius</i> (1)	
	4434	253	<i>Astromesites primigenius</i> (1)	
	4436	148–150	<i>Astromesites primigenius</i> (2)	
	4437	124–129	<i>Astromesites primigenius</i> (1)	
	5510	999–984	<i>Astromesites primigenius</i> (1)	
	1243	365–416	<i>Dipsacaster magnificus</i> (1)	
	2399	610	<i>Dipsacaster magnificus</i> (5)	
	4493	1723–1549	<i>Plutonaster</i> sp. (13, small)	
	4474	999–984	<i>Plutonaster knoxi</i> (3), <i>Plutonaster</i> sp. (3)	
	4479	1792	<i>Plutonaster knoxi</i> (5)	
	5368	1568	<i>Radiaster rowei</i> (1)	
	Milford Sound	4515	–	<i>Radiaster gracilis</i> (3)
New Plymouth, near	4336	88	<i>Luidia neozelanicus</i> (1)	
	4416	83	<i>Astropecten polyacanthus</i> (5)	
Ninety Mile Beach	1249	274	<i>Psilaster acuminatus</i> (3)	
Norfolk Ridge	4377	487–357	<i>Luidia neozelanicus</i> (1)	
North Cape, near	3885	620–635	<i>Psilaster acuminatus</i> (1)	
	4512	256	<i>Psilaster acuminatus</i> (4)	
Northland	1565	–	<i>Astropecten polyacanthus</i> (1)	
	4315	30	<i>Astropecten polyacanthus</i> (1)	
	4411	63–65	<i>Astropecten polyacanthus</i> (2)	
	4413	90	<i>Astropecten polyacanthus</i> (1)	
	4421	23	<i>Astropecten polyacanthus</i> (4)	
	4422	25	<i>Astropecten polyacanthus</i> (7)	
	5228	207–222	<i>Astropecten polyacanthus</i> (1)	
	4182	625	<i>Proserpinaster neozelanicus</i> (1)	
	Nugget Point	2390	218	<i>Astromesites primigenius</i> (14)
		2649	140	<i>Astromesites primigenius</i> (4)
3099		770	<i>Astromesites primigenius</i> (1)	
Oamaru, off	508	457–549	<i>Astromesites primigenius</i> (1)	
	762	37–65	<i>Psilaster acuminatus</i> (2)	
Otago, off	5237	–	<i>Psilaster acuminatus</i> (5)	
	4302	82	<i>Astromesites primigenius</i> (3)	
	4310	–	<i>Astromesites primigenius</i> (1)	
	4312	135	<i>Astromesites primigenius</i> (1)	



Location	Cat. No. (Ech.)	Depth (m)	Species and number
Otago, off	4318	146	<i>Astromesites primigenius</i> (1)
	4431	244	<i>Astromesites primigenius</i> (2)
	5226	105	<i>Astromesites primigenius</i> (2)
	5265	-	<i>Psilaster acuminatus</i> (4)
Otaki Beach	1563	shallow	<i>Astropecten polyacanthus</i> (1)
Palliser Bay / Cape Palliser	4475		<i>Plutonaster knoxi</i> (1)
	4305	183	<i>Proserpinaster neozelanicus</i> (1)
	6497	427-529	<i>Proserpinaster neozelanicus</i> (1)
	648	365-549	<i>Psilaster acuminatus</i> (1)
	871	110	<i>Psilaster acuminatus</i> (2)
	4305	183	<i>Psilaster acuminatus</i> (9)
	4495	461	<i>Psilaster acuminatus</i> (6)
	4550	-	<i>Porcellanaster ceruleus</i> (3)
	4551	-	<i>Porcellanaster ceruleus</i> (7)
	4552	-	<i>Porcellanaster ceruleus</i> (2)
	4553	-	<i>Porcellanaster ceruleus</i> (1)
	5240	-	<i>Porcellanaster ceruleus</i> (1)
	Papanui Canyon	5224	420
5227		-	<i>Astromesites primigenius</i> (2)
5258		220-348	<i>Astromesites primigenius</i> (1)
5230		-	<i>Dipsacaster magnificus</i> (1)
Pegasus Bay	1246	585	<i>Proserpinaster neozelanicus</i> (2)
Poor Knights Islands	4389	110	<i>Luidia neozelanica</i> (1)
	1678	256-269	<i>Psilaster acuminatus</i> (9)
	5516	-	<i>Porcellanaster ceruleus</i> (1)
Pukaki Rise	2004	484-487	<i>Psilaster acuminatus</i> (1)
	2006	466-480	<i>Psilaster acuminatus</i> (1)
Puysegur Point	2650	400	<i>Astromesites primigenius</i> (2)
	6332	566-576	<i>Astromesites primigenius</i> (1)
Rangitikei River	5640	75-82	<i>Luidia neozelanica</i> (1)
Snares Islands area	2012	455-496	<i>Astromesites primigenius</i> (8)
	2014	386-410	<i>Astromesites primigenius</i> (8)
	2015	210-292	<i>Astromesites primigenius</i> (2)
	2169	130-165	<i>Astromesites primigenius</i> (1)
	5650	130	<i>Astromesites primigenius</i> (5)
Solander Trough	4438	496	<i>Astromesites primigenius</i> (1)
	1252	320	<i>Psilaster acuminatus</i> (1)
Stewart Island, near	1241	560-595	<i>Dipsacaster magnificus</i> (1)
	3101	120	<i>Dipsacaster magnificus</i> (4)
	6511	200-600	<i>Dipsacaster magnificus</i> (1)
Takapuna	191	-	<i>Astropecten polyacanthus</i> (3)
	679	shallow	<i>Astropecten polyacanthus</i> (2)
Three Kings Islands	5642	294-291	<i>Luidia neozelanica</i> (1)
	4547	944-946	<i>Astromesites regis</i> (1)
	5659	291-294	<i>Proserpinaster neozelanicus</i> (1)
	5263	-	<i>Psilaster acuminatus</i> (1)
	5658	985-1003	<i>Psilaster acuminatus</i> (1)
Tolaga Bay	4376	139	<i>Luidia neozelanica</i> (1)
	5245	161	<i>Luidia neozelanica</i> (1)
Turakirae Head	4542	253-533	<i>Psilaster acuminatus</i> (1)
	5661	640	<i>Psilaster acuminatus</i> (5)
Waiau River, off Westland	4516	640-512	<i>Psilaster acuminatus</i> (1)
	4449	-	<i>Dipsacaster magnificus</i> (2)
Westland	4450	512-562	<i>Dipsacaster magnificus</i> (1)
	4456	570-608	<i>Dipsacaster magnificus</i> (1)
	4460	556-598	<i>Proserpinaster neozelanicus</i> (2)
	4463	350-400	<i>Proserpinaster neozelanicus</i> (9)

Location	Cat. No. (Ech.)	Depth (m)	Species and number
Westland	4464	556–598	<i>Proserpinaster neozelanicus</i> (3)
	4467	517–526	<i>Proserpinaster neozelanicus</i> (2)
	4468	473–400	<i>Proserpinaster neozelanicus</i> (1)
	5653	160–165	<i>Proserpinaster neozelanicus</i> (2)
Westport, off	4455	492–528	<i>Dipsacaster magnificus</i> (1)
Westport, off	4521	312–332	<i>Psilaster acuminatus</i> (1)
	4496	492–528	<i>Psilaster acuminatus</i> (4)
Whangarei Harbour	5250	–	<i>Astropecten polyacanthus</i> (2)

### **Eltanin Stations**

In 1966, in late November and December, the USNS research vessel *Eltanin* took material (both hydrographical and biological) from 36 stations in New Zealand waters. The area covered was between 38° and 47°S and between 160° and 175°E, in depths ranging from 25 to 4956 m. Asteroids were collected from eight stations only. Eighty-four specimens from six stations are recorded here.

Stn No	Date	Latitude (°S)	Longitude (°E)	Depth (m)	Species and number
1837	11.12.66	45 38' –	160 12' –	4804–	<i>Damnaster tasmani</i> (2)
		45 44'	160 09'	4868	
1844	15.12.66	46 40' –	165 18' –	2104–	<i>Damnaster tasmani</i> (1), <i>Eremicaster vicinus</i> (1), <i>Styracaster horridus</i> (1)
		46 44'		2470	
1846	17.12.66	43 54' –	167 43' –	16 47	<i>Plutonaster fragilis</i> (43), <i>Proserpinaster neozelanicus</i> (1), <i>Damnaster tasmani</i> (3)
		43 48'	167 46'	1693	
1847	19.12.66	41 32' –	174 34' –	192–	<i>Psilaster acuminatus</i> (3)
		41 31'	174 32'	238	
1848	20.12.66	41 35' –	175 00' –	220–	<i>Psilaster acuminatus</i> (27)
		41 32'		490	
1849	20.12.66	41 36'	175 02' –	311	<i>Psilaster acuminatus</i> (2)
			175 04'	403	



## APPENDIX 2

### LIST OF STOMACH CONTENTS from dissected species

*Astromesites primigenius* (Mortensen), *Astropecten polyacanthus* Müller & Troschel, and *Psilaster acuminatus* Sladen (family Astropectinidae), with a large number of specimens present in the collections, prompted many dissections. Most of the stomach contents were molluscs and we are very grateful to Bruce Marshall (NMNZ) for his care with identifications and to Steve O'Shea (NIWA) for listing specimens for us.

A figure in brackets after the station number, (e.g., B577 (2) in *Astromesites primigenius*) means that the mollusc recorded was found in two dissected specimens from the station listed.

#### *Astromesites primigenius* (Mortensen)

#### MOLLUSCA

##### Class GASTROPODA

##### Family Buccinidae

*Buccinulum pertinax* (Martens) B196

*Cominella otagoensis* (Finlay) B196

##### Family Columbellidae

*Zemitrella sulcata* (Hutton) E832

*Zemitrella* sp. B577

##### Family Conidae

*Tomopleura albula* (Hutton) G881

##### Family Cylichnidae

*Cylichnina striata* (Hutton) B196 (2)

##### Family Drilliidae

*Splendrillia* sp. B487, B577

##### Family Naticidae

*Tanea zelandica* (Quoy & Gaimard) D133, I718

*Uberella vitrea* (Hutton) F93, G881, I719

*Uberella* sp. F93

##### Family Pyramidellidae

*Besla* sp. (smooth) B591

*Odostomia vaga* Laws (smooth) B591

*Odostomia* sp. B196, B591

##### Family Rissoidae

*Powellisetia retusa* (Powell) B487

*Powellisetia* sp. B196, B487

##### Family Trochidae

*Brookula rotula* (Suter) B577

*Micrelenchus mortenseni* (Odhner) D133, E832

*Solariella semireticulata* (Suter) E832

*Spectamen semireticulata* (Suter) B487, E832

##### Family Turbinidae

*Argalista* sp. B577 (2)

##### Family Turritellidae

*Zeacolpus symmetricus* (Hutton) E832

##### Family Velutinidae

*Lamellaria cerebroides* F93

##### Class SCAPHOPODA

##### Family Gadilidae

*Cadulus teliger* Finlay B487

##### Class BIVALVIA

##### Family Cardiidae

*Pratulum pulchellum* (Gray) E127

##### Family Carditidae

*Pleuromeris ultima* Dell B577

##### Family Cyamiidae

*Perrierina* sp. F93

##### Family Neoleptonidae

*Neolepton antipodum* (Filhol) B577 (2)

*Pachykellya* sp. B577

##### Family Tellinidae

*Elliptotellina urinatoria* (Suter) B196, B487, B577, D133

Barnacle fragment E832

##### BRYOZOA

*Adeonellopsis* sp. E820

*Caberea* sp. fragments D133

*Cellaria* sp. fragments D133, I718

*Cellaria tenuirostris* (Busk) E820

*Chaperiopsis* sp. fragments D173

*Chaperiopsis spiculata* Uttley B577

*Chiastosella enigma* Brown D173

*Diaperoecia* sp. fragments D133

*Figularia* sp. fragments D173

*Foveolaria cyclops* I718

*Galeopsis* sp. fragments D133

*Galeopsis polyporus* (Brown) E820  
*Hippothoa divaricata pacifica* Gordon D173  
*Micropora gracilis* (Uttley) B577  
*Microporella agonistes* Gordon B577  
*Microporella* sp. fragments D173  
*Notoplites* sp. fragments D133  
*Orthoscuticella* sp. fragments D133  
*Osthimosia* sp. fragments D173  
*Otionellina* sp. fragments I718  
*Valdemunitella fraudatrix* Gordon D173

*Astropecten dubiosus* Mortensen, 1925

## MOLLUSCA

### Class GASTROPODA

Family Conidae

*Antiguralea* sp. I363 (2)

Family Trochidae

*Spectamen plicatulum* (Murdoch & Suter) I363 (6)

### Class BIVALVIA

Family Nuculidae

*Nucula nitidula* A. Adams I363 (1)

*Astropecten polyacanthus* Müller & Troschel

## MOLLUSCA

### Class POLYPLACOPHORA

Family Chitonidae

*Rhyssoplax* sp. Z8943

Family Ischnochitonidae

*Ischnochiton luteoroseus* Suter Z8943, Z8951

### Class GASTROPODA

Family Architectonicidae

*Adelphotectonica reevei* (Hanley) Z8844

Family Anabathridae

*Pisinna zosterophila* (Webster) Z8510 (7)

Family Buccinidae

*Austrofusus glans* (Röding) I339, Z8643, Z8644, Z8664

*Cominella adpersa* (Brugière) Z8510 (2, juvenile), Z8966

*Cominella quoyana* A. Adams Z8510 (1), Z8954

*Penion sulcatus* (Lamarck) Z8642

Family Calyptraeidae

*Crepidula costata* (Sowerby) Z8953

*Zegalerus tenuis* (Gray) Z8845, Z8943, Z8956, Z8962

Family Columbelloidea

*Zemitrella* sp. Z8643

Family Conidae

*Neoguraleus* sp. Z8643

*Phenatoma zealandica* (E.A. Smith) Z8845

Family Cylichnidae

*Cylichna thetidis* Hedley Z8642, Z8661

Family Eatoniellidae

*Eatoniella limbata* (Hutton) Z8510 (1)

Family Epitoniidae

*Epitoneum jukesianum* (Fobes) Z8951

*Epitoneum minora* (Iredale) I339

Family Lottiidae

*Notoacmea* sp. Z8951

Family Muricidae

*Xymene ambiguus* (Philippi) Z8943

*Xymene gouldi* (Suter) Z8510 (1)

*Xymene pusillus* (Suter) Z8510, Z8943, Z8956

Family Naticidae

*Tanea zelandica* (Quoy & Gaimard) Z8642, Z8661, Z8833, Z8962

Family Olividae

*Amalda australis* (Sowerby) Z8845

*Amalda depressa* (Sowerby) Z8510

*Amalda novaezelandiae* (Sowerby) I339 (2)

Family Pyramidellidae

*Chemnitzia* sp. I339, Z8510

*Turbonilla* sp. Z8510 (1)

Family Rissoidae

*Rissoina achatina* Odhner Z8661, Z8833, Z8962

Family Struthiolariidae

*Struthiolaria papulosa* (Martyn) Z8966

Family Terebridae

*Pervicacia tristis* (Deshayes) Z8642, Z8966

Family Trochidae

*Antisolarium egenum* (Gould) I339, Z8642, Z8845, Z8952, Z8954

*Micrelenchus rufozonus* (A. Adams) Z8642, Z8943, Z8962

*Spectamen tryphenense* (Powell) Z8651

*Trochus tiaratus* Quoy & Gaimard Z8642 (2), Z8943 (2), Z8951 (4)

Family Turridae

*Aoteadrillia wanganuiensis* (Hutton) Z8651

Family Turritellidae

*Maoricolpus roseus* (Quoy & Gaimard) Z8651

*Zeacolpus pagoda* (Reeve) I339, Z8661, Z8664, Z8962

## Class BIVALVIA

Family Carditidae

*Pleuromeris zelandica* (Deshayes) Z8642 (2), Z8966

*Venericardia purpurata* (Deshayes) Z8642, Z8850



Family Cunidae  
*Volupicuna* sp. Z8642

Family Crassatellidae  
*Talabrica bellula* (A. Adams) Z8833

Family Cardiidae  
*Pratulium pulchellum* (Gray) Z8643, Z8675, Z8835

Family Corbulidae  
*Corbula zelandica* Quoy & Gaimard Z8644, Z8943, Z8955, Z8956

Family Glycymeridae  
*Glycymeris modesta* (Angas) Z8833, Z8651, Z8955, Z8956

Family Mactridae  
*Scalpomactra scalpellum* (Reeve) Z8951, Z8956

Family Myochamidae  
*Myadora novaezelandiae* E.A. Smith 8510

Family Nuculidae  
*Nucula nitidula* A. Adams Z8661, Z8850, Z8943

Family Pinnidae  
*Atrina pectinata* (Gray) Z8943 (juvenile)

Family Psammobiidae  
*Gari lineolata* (Gray) Z8951 (fragments, juvenile)

Family Veneridae  
*Dosinia lambata* (Gould) J672 (1)  
*Dosinia subrosea* (Gray) Z8845  
*Notocallista multistriata* (Sowerby) Z8835  
*Tawera laticostata* J672 (23)  
*Tawera spissa* (Deshayes) J672 (3), Z8510 (1), Z8644, Z8659, Z8661, Z8665, Z8675, Z8845, Z8854, Z8943, Z8951 (3), Z8956, Z8960, Z8962

### ***Psilaster acuminatus* Sladen**

## **MOLLUSCA**

### **Class GASTROPODA**

Family Acteonidae  
*Pupa kirki* (Hutton) Z8938

Family Buccinidae  
*Belomitra climacella* (Dall) C694  
*Belomitra* sp. Q84  
*Cominella* sp. E433 (juvenile)

Family Cancellariidae  
*Oamaruia* sp. I6

Family Capulidae  
*Malluvium calcareum* (Suter) Z2368

Family Cavolinidae  
*Creseis acicula* (Rang) I6 ("not food – from sediment")

Family Conidae  
gen. et sp. indet. I6, Q84, W248

Family Cylichnidae  
*Cylichna bulloides* Dell s127  
*Scaphander otagoensis* Dell E888, F754

Family Epitoniidae  
*Epitoneum* sp. I6

Family Marginellidae  
marginellid sp. I672

Family Naticidae  
*Falsilunatica ambigua* (Suter) D211, E889, G928, S66, S174, W248 (2)  
*Tanea zelandica* (Quoy & Gaimard) S63, T21, T489  
*Uberella vitrea* (Hutton) B638, E888, E889, G668, G900, I356, S52, Z8857

Family Olividae  
*Amalda benthicola* (Dell) S174  
*Amalda novaezelandiae* (Sowerby) I6, I345

Family Philinidae  
*Philine powelli* Rudman C694  
*Philine* sp. Z513

Family Pyramidellidae  
*Agatha georgiana* (Hutton) E806  
*Chemnitzia* sp. Q40

Family Retusidae  
*Retusa pachys* (Watson) S127  
*Retusa simplex* (Murdoch & Suter) E888, I6, Z2368  
*Retusa* sp. D211, G668  
*Volvulella truncata* Dell C694

Family Ringiculidae  
*Ringicula delecta* Murdoch & Suter E888, I6  
*Ringicula* sp. E888

Family Rissoidae  
*Pusillina semireticulata* (Murdoch & Suter) I6

Family Seguenziidae  
*Lissotesta* sp. B556, C694, Q84  
*Seguenzia* sp. G823

Family Skeneidae  
*Dilwynella* sp. Q84

Family Trochidae  
*Archiminolia meridiana* (Dell) B556, I31, I345, S52, S174, X513  
*Calliostoma* sp. I31 (juvenile)  
*Spectamen semireticulata* (Suter) I6, I684  
*Zetela textilis* (Murdoch & Suter) I6 (2), I359, Z8492  
*Zetela variabilis* (Dell) G928

Family Turridae  
*Antiguraleus* sp. Z8857  
*Lucerapex angustatus* (Powell) Z8554, Z8555, Z8557

Family Vitrinellidae  
*Scrupus hyalinus* (Odhner) I6

**Class SCAPHOPODA**

Family Dentaliidae  
*Antalis nana* (Hutton) E806, Z2368  
gen. et sp. indet. E806, G699

**Class BIVALVIA**

Family Anomiidae  
*Pododesmus zealandicus* (Gray) J25

Family Arcidae  
*Bathyarca cybaea* Hedley Z8492

Family Limidae  
*Escalima regularis* Powell E888

Family Manzanellidae  
*Nucinella maoriana* (Hedley) E806 (4), I359

Family Neilonellidae  
*Austrotindaria* sp. P927

Family Neoleptonidae  
*Neolepton* sp. B556

Family Nuculidae  
*Leionucula strangei* (A. Adams) E433, E888, I6, I31, X513,  
Z2368, Z8555  
*Nucula* sp. B556  
*Varinucula gallinacea* (Finlay) G668, Z2368  
*Varinucula* sp. E806 (4), E888, I356, T489

Family Nuculanidae  
*Poroleda lanceolata* (Hutton) I6  
*Sacella hedleyi* (Fleming) Z8492

Family Pectinidae  
*Cycloclamys* sp. I31

Family Propeamussidae  
*Parvamussium maorium* (Dell) E888

Family Sareptidae  
*Yoldiella* sp. I6, P65 (2)

worm tube: J25



## TAXONOMIC INDEX

This index has been compiled from the text. It does not include species names in Appendix 1 (List of stations).  
Bold numbers indicate a plate and/or figure illustrations.

- Acanthaster planci* 8  
*Albatrossaster richardi* 124  
*richardi* 124  
*semimarginalis* 124  
*Albatrossia semimarginalis* 124  
*Archaster bifrons* 68  
*Asterias*  
*aurantiacus* 40  
*subinermis* 105  
*Astrogonium*  
*miliare* 8  
*pulchellum* 8  
*Astromesites* 30, 31, 37  
*compactus* 11, 31, 32, 40, 133, 134, 135  
*primigenius* 5, 11, 31, 34, 35, 36, 37, 40, 96, 133, 134, 135  
*regis* 11, 31, 38, 39, 40, 133, 134, 135  
*Astropecten* 31, 37, 38, 40, 56  
*armatus* 8,  
*burbonica* 48  
*celebensis* 11, 41, 42, 46, 133, 134, 135, 157  
*chinensis* 48  
*dubiosus* 11, 40, 41, 43, 44, 57, 133, 134, 135  
*edwardsii* 8, 48  
*ensifer* 48  
*eremicus* 53  
*eucnemis* 53  
*hystrix* 48  
*monacanthus* 11, 40, 45, 46, 47, 133, 134, 135  
*notograptus* 45  
*pectinatus* 31  
*polyacanthus* 5, 8, 11, 41, 48, 49, 50, 51, 52, 54, 133, 134, 135  
*phragmorus* 48  
*primigenius* 37  
*pusillulus* 53  
*samoensis* 48  
*schayeri* 31, 37  
*squamosus* 45  
*syntomus* 31, 37  
*tenellus* 57  
*tasmanicus* 11, 40, 53, 54, 133, 134, 135  
*umbrinus* 48  
*sp.* 11, 40, 53, 56, 57, 133, 134, 135
- ASTROPECTINIDAE 5, 11, 14, 30, 93, 99, 131, 133, 134, 135  
 ASTROPECTININAE 30
- Benthopecten* 136  
*munidae* 11, 136, 138, 139, 140, 156, 1577  
*pikei* 11, 136, 140, 141, 142, 156, 157  
 var. *australis* 140  
*pentacanthus* 11, 136, 137, 156, 157  
*spinus* 136
- BENTHOPECTINIDAE 5, 11, 136, 156  
*Betelgeusia reidi* 109  
*Bollonaster* 31, 37  
*pectinatus* 37  
*primigenius* 30, 31, 34, 37
- Caulaster* 124, 125  
*pedunculatus* 124  
*sladeni* 124  
*Cheiraster* 136, 143  
*gazellae* 143  
*inops* 148  
*ludgwiigi* 11, 143, 144, 145, 156  
*monopedicellaris* 11, 143, 144, 145, 146, 157  
*niascus* 145, 148  
*otagoensis* 11, 143, 147, 148, 156, 157  
*richardsoni* 11, 143, 149, 156, 157  
*subtuberculatus* 11, 143, 149, 150, 156, 157  
*teres* 151, 156, 157  
*triplacanthus* 11, 143, 151, 152, 156, 157  
*trullipes* 148  
*sp.* 157  
*(Luidiaster) teres* 11, 143, 151, 153  
*(Luidiaster) sp.* 11, 154  
*Chunaster scapanephorus* 130  
*Ctenopleura astropectinides* 104
- Damnaster* 114, 116, 117, 119, 125  
*tasmani* 11, 116, 118, 119, 133, 134, 135  
*Diplodontias miliaris* 8  
*Dipsacaster* 31, 57, 59, 69  
*antillensis* 57
- magnificus* 11, 57, 59, 60, 133, 134, 135  
*sladeni* 57  
*sladeni capensis* 57  
*Dytaster* 31, 61, 68  
*aequivocus* 68  
*felli* 13, 62, 64, 133, 134, 135  
*insignis* 62, 63  
*nobilis* 62  
*pedicellaris* 13, 62, 65, 67, 133, 134, 135
- Eremicaster* 114, 116, 120  
*pacificus* 119  
*vicinus* 119, 121  
*sp.* 119
- GONIOPECTINIDAE 8
- Hyphalaster* 114, 116, 120  
*antonii* 120  
*forgis* 120  
*giganteus* 120  
*gracilis* 120  
*hyalinus* 120  
*inermis* 13, 120, 123, 133, 134, 136  
*moseri* 120  
*parfaiti* 120  
*scotiae* 120
- Lonchotaster magnificus* 58  
*Luidia* 14, 19, 20, 27, 29  
*australasiae* 14  
*avicularia* 21, 23, 24  
*forficifer* 14, 15, 17  
*forficifera* 15  
*fragilissima* 14  
*hardwickii* 13, 14, 15, 16, 17, 29, 133, 134, 135  
*maculata* 13, 14, 15, 17, 18, 19, 20, 21, 133, 134, 135  
 var. *ceylonica* 17  
 var. *herdmani* 17  
*moroisoana* 13, 14, 15, 21, 22, 23, 24, 133, 134, 135  
*neozelanica* 13, 14, 15, 24, 25, 26, 29, 133, 134, 135  
*prionota* 13, 14, 15, 27, 28, 29, 133, 134, 135  
*sarsi* 19

- varia* 14, 17, 20  
 sp. 15, 24  
 LUIDIIDAE 5, 11, 14, 131, 133, 134, 135  
 LUIDIINAE 14
- Mimaster* 114  
*gracilis* 109  
*notabilis* 114  
 MIMASTERIDAE 108
- Notomyotida 5, 13, 136
- Paxillosida 5, 8, 13, 14, 133  
*Pectinaster* 136, 154  
*filholi* 154  
*mimicus* 13, 154, 155, 156, 157  
*Pentagonaster* 8  
*pulchellus* 8  
*Peribolaster* 38  
*Persephonaster* 97, 104  
*anchistus* 93  
*euryactis* 93, 99  
*luzonicus* 93  
*neozelanicus* 93  
*Petalaster hardwickii* 15, 17  
*Plutonaster* 31, 58, 68, 69, 77, 80, 88, 89, 90  
*agassizi* 68, 87  
*ambiguus* 68, 88  
*bifrons* 68, 87, 88  
*complexus* 13, 69, 71, 72, 73, 82, 84, 89, 133, 134, 135  
*fragilis* 13, 68, 71, 73, 74, 75, 76, 80, 82, 88, 89, 133, 134, 135  
*hikurangi* 13, 71, 73, 77, 78, 79, 80, 81, 84, 133, 134, 135
- jonathani* 13, 71, 73, 80, 81, 82, 83, 84, 134, 135  
*knoxi* 13, 68, 71, 73, 76, 82, 84, 85, 86, 87, 88, 89, 133, 134, 135  
 sp. A 87, 89  
 sp. B 88, 91  
 spp. 13, 73, 74, 133, 134, 135  
 PLUTONASTERINAE 30
- Pontaster*  
*mimicus* 155  
*subtuberculatus* 150  
*teres* 151
- Porcellanaster* 7, 114, 117, 119, 122, 124  
*caeruleus* 116, 124  
*caulifer* 124  
*ceruleus* 13, 114, 119, 124, 125, 126, 131, 133, 134, 135  
*eremicus* 116, 117, 119, 124  
*granulosus* 124  
*inermis* 124  
*ivanovi* 117, 124  
*irregularis* 124  
*tuberosus* 124  
*vicinus* 119  
 var. *inermis* 119  
 (*Eremicaster*) *tenebrarius* 119
- PORCELLANASTERIDAE 5, 7, 13, 125, 131, 133, 134, 135
- Proserpinaster* 31, 92, 97  
*neozelanicus* 13, 92, 94, 97, 133, 134, 135  
 sp. 13, 96, 97, 98, 133, 134, 135
- Pseudechinus* 38  
*Psilaster* 31, 38, 99, 100, 104
- acuminatus* 5, 8, 13, 38, 99, 100, 101, 102, 103–105, 133, 134, 135  
*andromeda* 99, 104  
*charcoti* 13, 99, 104, 106  
*florae* 104
- Radiaster* 108, 109, 113  
*elegans* 109, 110  
*gracilis* 13, 109, 110, 111, 112, 114, 133, 134, 135  
*notabilis* 114  
*rowei* 13, 19, 113, 114, 115, 133, 134, 135  
*tizardi* 110  
 (*Mimaster*) 109
- RADIASTERIDAE 5, 13, 108, 109, 133, 131, 134, 135
- Sidonaster* 117  
*Stephanaster elegans* 8  
*Styracaster* 114, 116, 125, 131, 133  
*armatus* 13, 125, 128, 129, 130, 131, 133, 134  
*chumi* 13, 125, 130, 133, 134  
 var. *groenlandica* 130  
*edwardsi* 125  
*horridus* 13, 125, 130, 132, 133, 134, 135  
*spinus* 125, 130, 131  
 sp. 129, 130
- Tethyaster* 31, 105, 108  
*aulophora* 108  
*subinermis* 108  
*tangaroae* 13, 105, 107, 108, 133, 134, 135



