B 58512

Sea Cucumbers of Northern Australia

museum

K.B.I.N.-I.R.Sc.N.B.
003400X
B 58512

L.R.G. Cannon: Senior Curator, Lower Invertebrates, Queensland Museum

H. Silver: Formerly Zoology Department, University of Queensland

©QLD MUSEUM 1986
This book may be used for scientific research, individual study and educational purposes. Properly acknowledged quotations may be made but queries regarding the re-publication of any material should be addressed to the Director.

Requests for this book should be made to:
Queensland Museum
Queensland Cultural Centre
P.O. Box 300
South Brisbane, Qld 4101
Australia

National Library of Australia
Cataloguing-in-Publication data
Cannon, L.R.G. (Lester Robert Glen), 1940–
Sea cucumbers of northern Australia.
Bibliography.
Includes index.
ISBN 0 7242 1630 8.
1. Holothurians – Australia, Northern – identification.
I. Silver, H. (Howard).
II. Queensland Museum. III. Title.
593.9'6'0994

First printed 1987
Designed and produced by:
Paul Ramsden,
Queensland Museum Art Section
ILLUSTRATIONS BY STEPHEN FRANCIS

Typeset in Cheltenham Light 10/12
by: John the Typesetter, Brisbane.

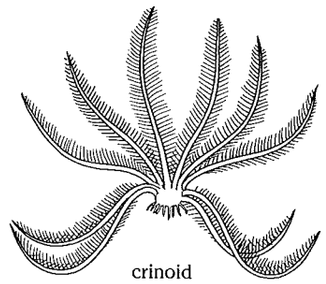
Printed on Media Satin 115 gsm by:
Poly-Graphics Pty Ltd. Brisbane

Preface

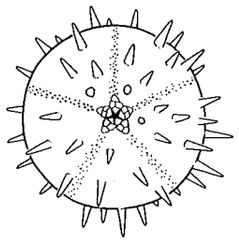
One hundred years ago holothurians were a source of considerable export income for Australia, but their economic importance has now declined. These animals are often large, colourful, conspicuous and distinctive when alive (at least the reef dwelling ones), but, being soft bodied, they tend to loose obvious characteristics when preserved. This has made them among the more difficult of marine groups to identify. Their habits, ubiquity and obvious ecological significance, however, make them worthy subjects of further study. This short guide is designed to help the novice become familiar with the animals. It is restricted to published records: new records (or even new forms) may be expected, especially in areas where collecting has not been so intensive – notably west of Torres Strait. Hopefully the illustrations and notes will facilitate identification and aid in the study of more serious literature.

We are indebted to the Queensland Museum and the University of Queensland for providing an opportunity to pursue this enterprise. We thank the Directors or Officers-in-Charge of the Research Stations on the Great Barrier Reef at Lizard Island, Green Island, Orpheus Island and especially Heron Island for provision of facilities. For critical reading of a preliminary draft of the MS and for their imparted knowledge over the years we wish to thank Alistair Birtles of James Cook University, Townsville and especially Dr Frank Rowe of the Australian Museum, Sydney. Furthermore, we acknowledge the generosity of the Great Barrier Marine Park Authority, Australian Bureau of Flora and Fauna and the Commonwealth Employment Program for contributing to the funds deployed in the preparation of this work. In particular, however, we wish to acknowledge a generous grant from the Australian Marine Science and Technology Committee (MST) which has allowed publication of this work. For initiating the project and for arrangement of this grant as well as for his encouragement we are gratefully indebted to Dr Tom Hailstone of the University of Queensland.

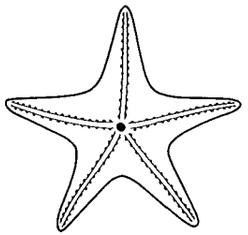
Contents



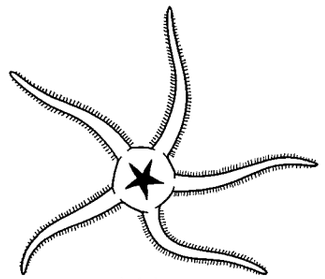
crinoid



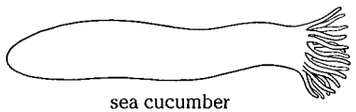
sea urchin



sea star



brittle star



sea cucumber

Introduction

Holothurians are a conspicuous element of the shallow water benthos of tropical waters. They attract the attention of visitors to coral reefs and, increasingly, are becoming subjects of scientific inquiry. Commonly referred to as sea cucumbers, bêche-de-mer, trepang, or sea slugs, holothurians are grouped as one class (Cl. Holothurioidea) of the phylum Echinodermata. They share with other echinoderms (sea stars, brittle stars, sea urchins, and crinoids or sea lilies) a pentaradial body plan and a water vascular system. Echinoderms are restricted to the sea (and with few exceptions are unable to tolerate brackish water), but are common at all latitudes and all depths of the ocean.

Anatomy

Holothurians, as the name 'sea cucumber' implies, are semi-cylindrical, tapering animals covered with papillae, i.e. they can be somewhat like a cucumber. They are also sometimes called 'sea slugs' (a term more appropriately applied to molluscs) and as this implies they can be often soft, pliable and slimy. External characteristics such as size, colour, surface characteristics (form of papillae and their distribution) and texture have proven inadequate to reliably distinguish these animals, especially as these characteristics become even less distinctive on preservation. Nevertheless, holothurians are one of the five major groups of the Echinodermata characterised by, among other things, calcareous plates in their skin. The major anatomical features are seen in Fig. 1a.

The pentaradial body plan (with 5 radiating arms) of the Echinodermata has become horizontal rather than vertical as it is in the other echinoderm groups, i.e. the mouth lies at one end and the anus at the other. The pentaradial plan is organised around the mouth with rings of nervous, haemal (blood) and water vascular tissues with five major trunks of these tissues running along the body. These trunks are most often mirrored externally by tracts of tube feet which are the external and locomotory parts of the water vascular system. These tracks (or trunks) are called the **ambulacra**. Surrounding the mouth or oesophagus internally and protecting the rings of vital tissues is a ring of calcified plates, the **calcareous ring** (Fig. 1b). Surrounding the mouth externally are the **tentacles**, modified tube feet that serve principally for food collecting (Fig. 1c). Lying horizontal as they do has meant the lower surface (often called ventral) of holothurians is more or less modified and differentiated from the upper surfaces. This lower surface may be so flattened as to form a creeping or clinging surface well supplied with tube feet. It is specialised in the family Psolidae where it is called a **sole**.

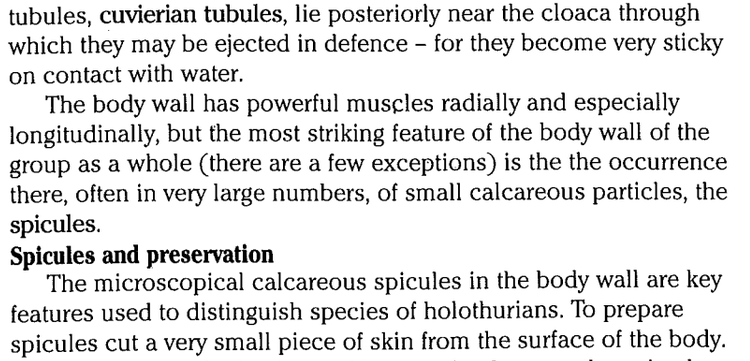
The gut lies in a fluid filled coelomic cavity and diverse cells (coelomocytes) wander through coelom and other tissues performing much as do blood cells of vertebrates. Gonads (ovaries or testes) lie in one or two tufts in the anterior body and open anteriorly. Branched respiratory bodies, **respiratory trees**, lie in the posterior body and open to the cloaca. A fine network of haemal tissue, the **rete mirabile** lies along the gut and functions to disperse nutrients and metabolites. In some holothurians a cluster of white tubules, **cuvierian tubules**, lie posteriorly near the cloaca through which they may be ejected in defence – for they become very sticky on contact with water.

The body wall has powerful muscles radially and especially longitudinally, but the most striking feature of the body wall of the group as a whole (there are a few exceptions) is the the occurrence there, often in very large numbers, of small calcareous particles, the **spicules**.

Spicules and preservation

The microscopical calcareous spicules in the body wall are key features used to distinguish species of holothurians. To prepare spicules cut a very small piece of skin from the surface of the body. Note that this can be be done without undue harm to the animal. Because spicules vary somewhat in form and number in different parts of the body, skin of full depth from various places should be examined. Place the skin on a glass microscope slide and cover with a few drops of household bleach (dilute sodium hypochlorite). After 10-20 minutes gently place a coverslip over the preparation and observe the spicules under a compound microscope.

An alternative method is to dissolve the skin in a hot solution of 5-10% sodium hydroxide (caustic soda) or potassium hydroxide. The spicules can be transfered to a slide with a pipette or eyedropper. WARNING: Sodium hypochlorite, sodium hydroxide, and potassium hydroxide are caustic and contact with the skin and eyes should be avoided. To assist in the interpretation of the keys and for a better appreciation of the photomicrographs, examples of the major spicule forms are shown in Fig. 2 as revealed by the Scanning Electron Microscope.



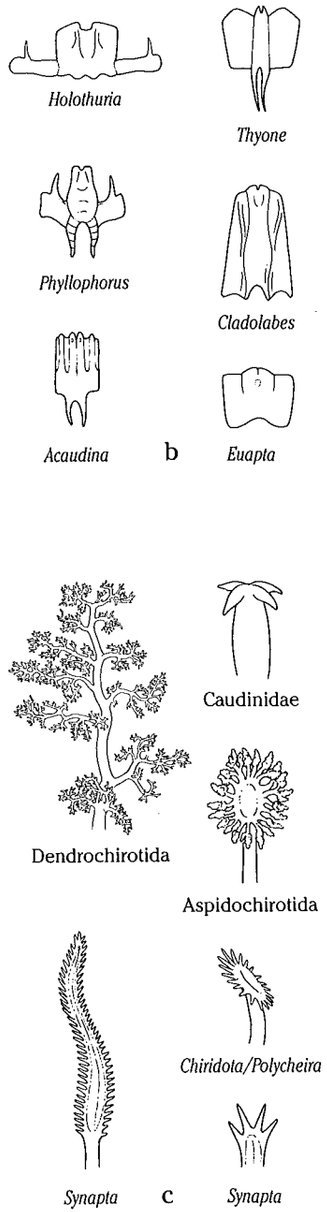


Fig. 1
a, the general anatomy of a holothurian as revealed by dissection;
b, the forms of the calcareous ring of holothurians;
c, the forms of the tentacles of holothurians.

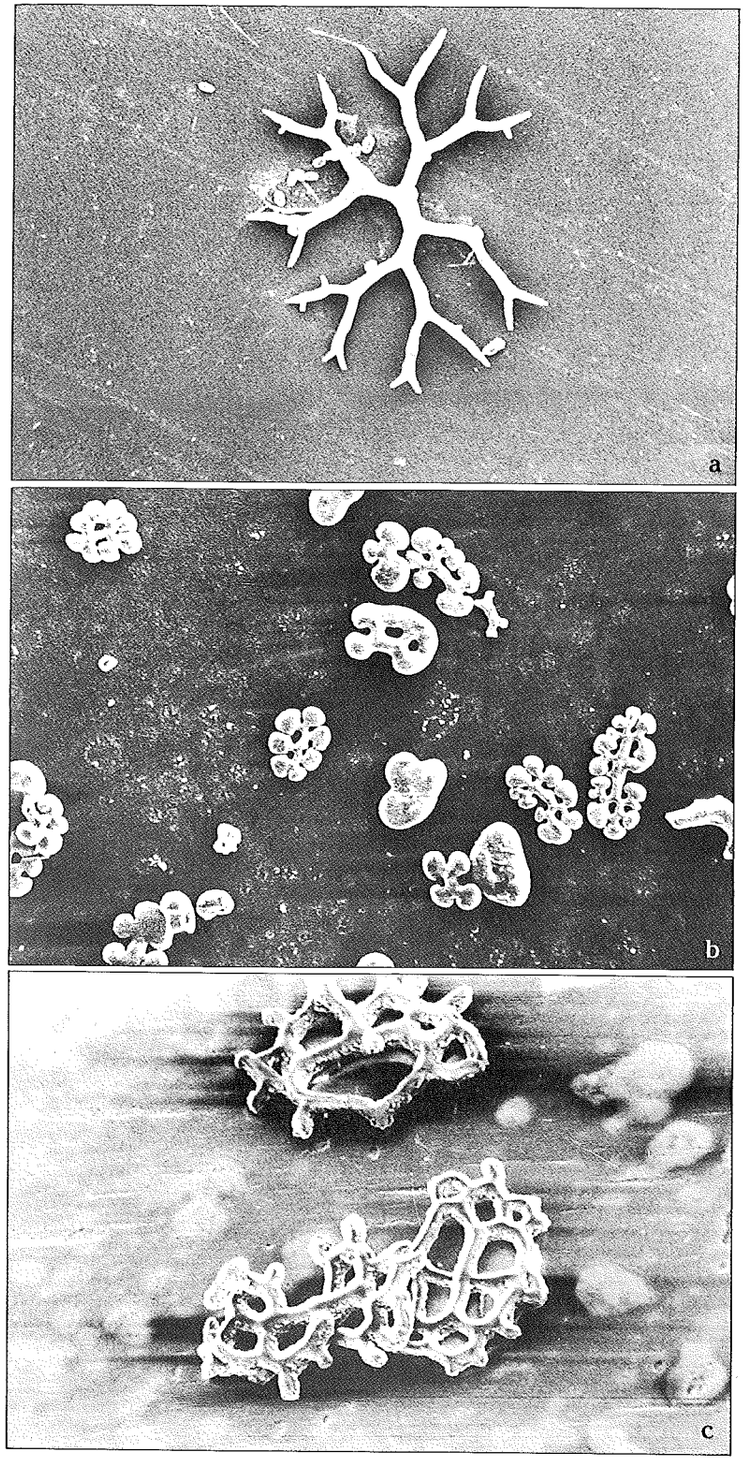
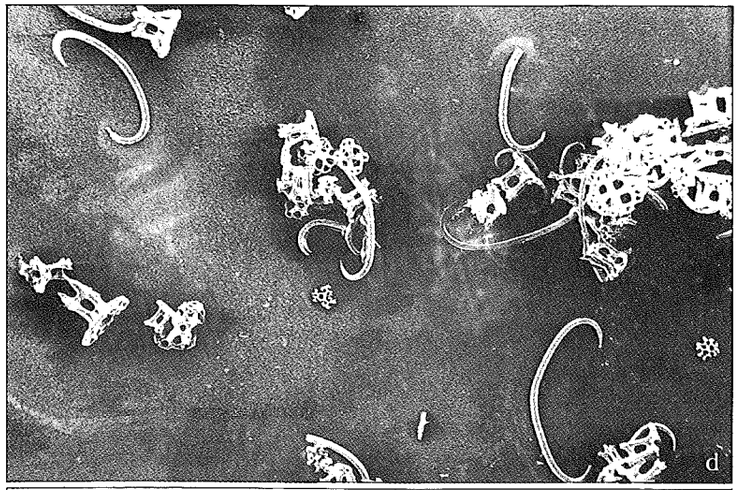
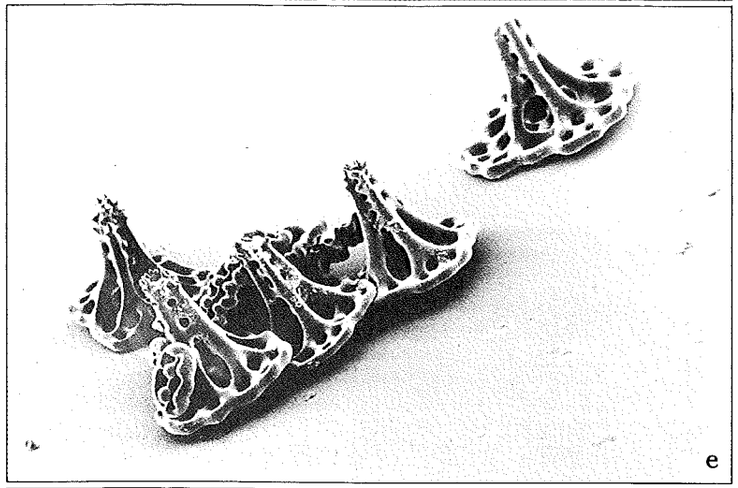


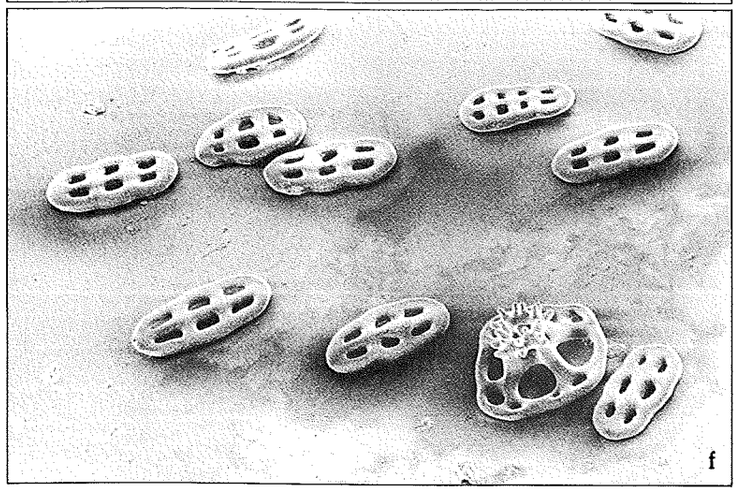
Fig. 2
Types of spicules found in holothurians (Scanning Electron Microscope photomicrographs):
a, dichotomously branched rod (*Thelenota ananas*);
b, rods (*Bohadschia argus*);
c, rosettes (*Holothuria* [*Acanthotrapeza*] *coluber*);



d

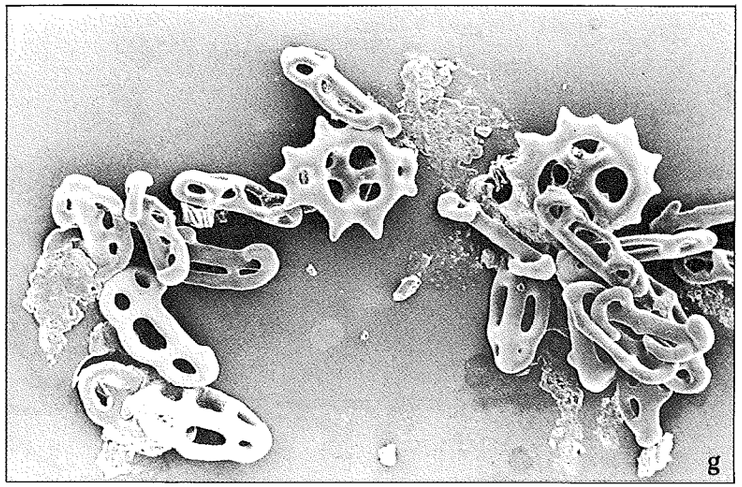


e

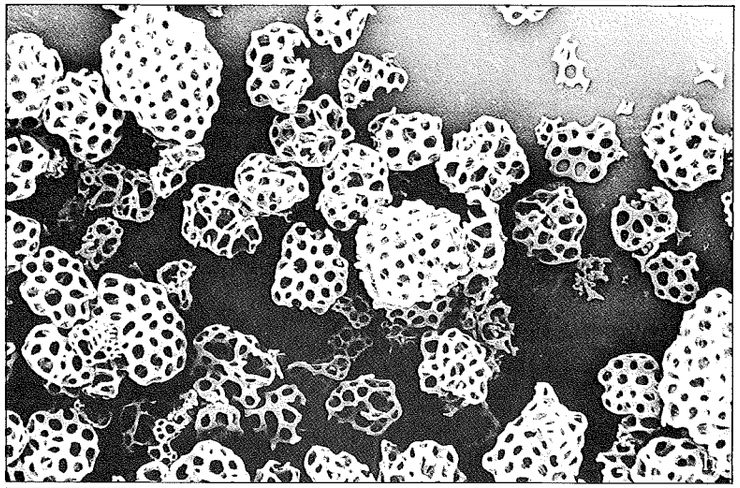


f

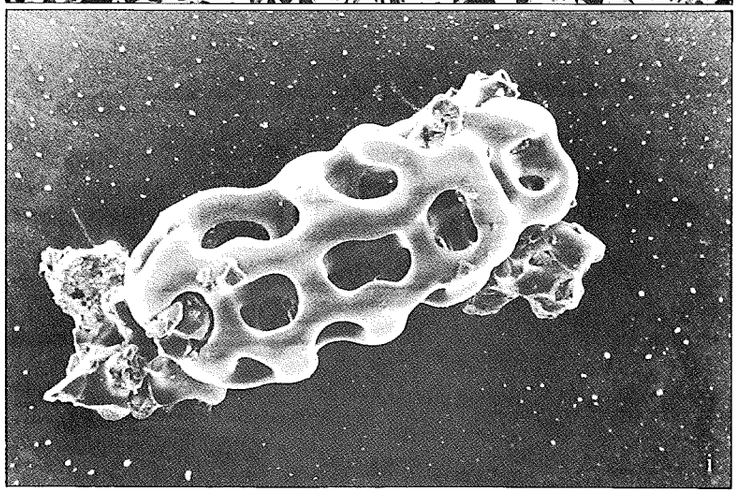
Fig. 2. (cont.)
d, 'C' rods plus tables (*Stichopus horrens*);
e, tables (*H.* [*Metriatyla*] *martensii*);
f, buttons plus table (*H.* [*Thymiosycia*] *arenicola*);



g



h



i

Fig. 2. (cont.)
g, pseudobuttons (*H.* [*Lessonothuria*] *pardalis*);
h, fenestrated spheres (*Pentacta quadrangularis*);
i, fenestrated ellipsoid (*H.* [*Microthele*] *nobilis*);

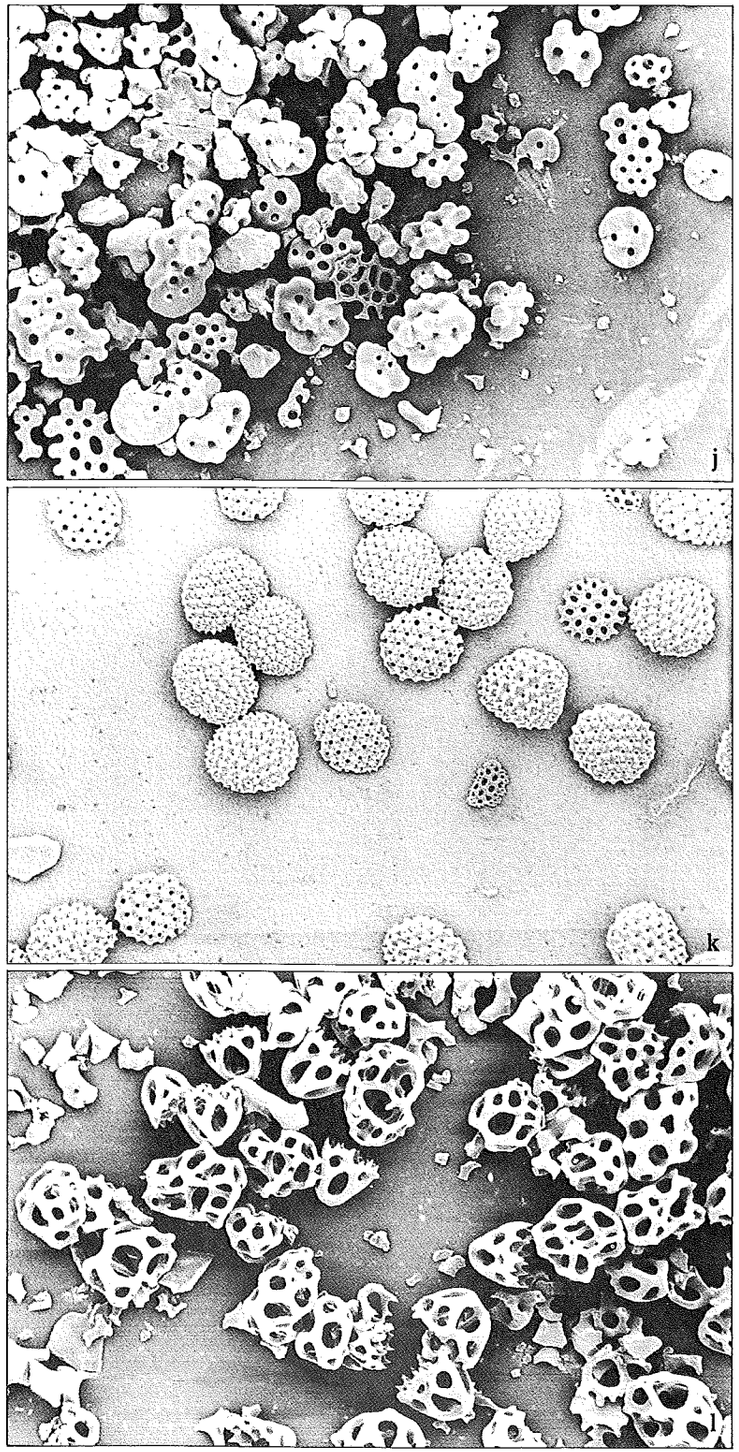


Fig. 2. (cont.)
j, perforated plates, (*Pseudocolochirus axiologus*);
k, lenticulate plate (*Afrocucumis africana*);
l, baskets (*Pentacta anceps*);

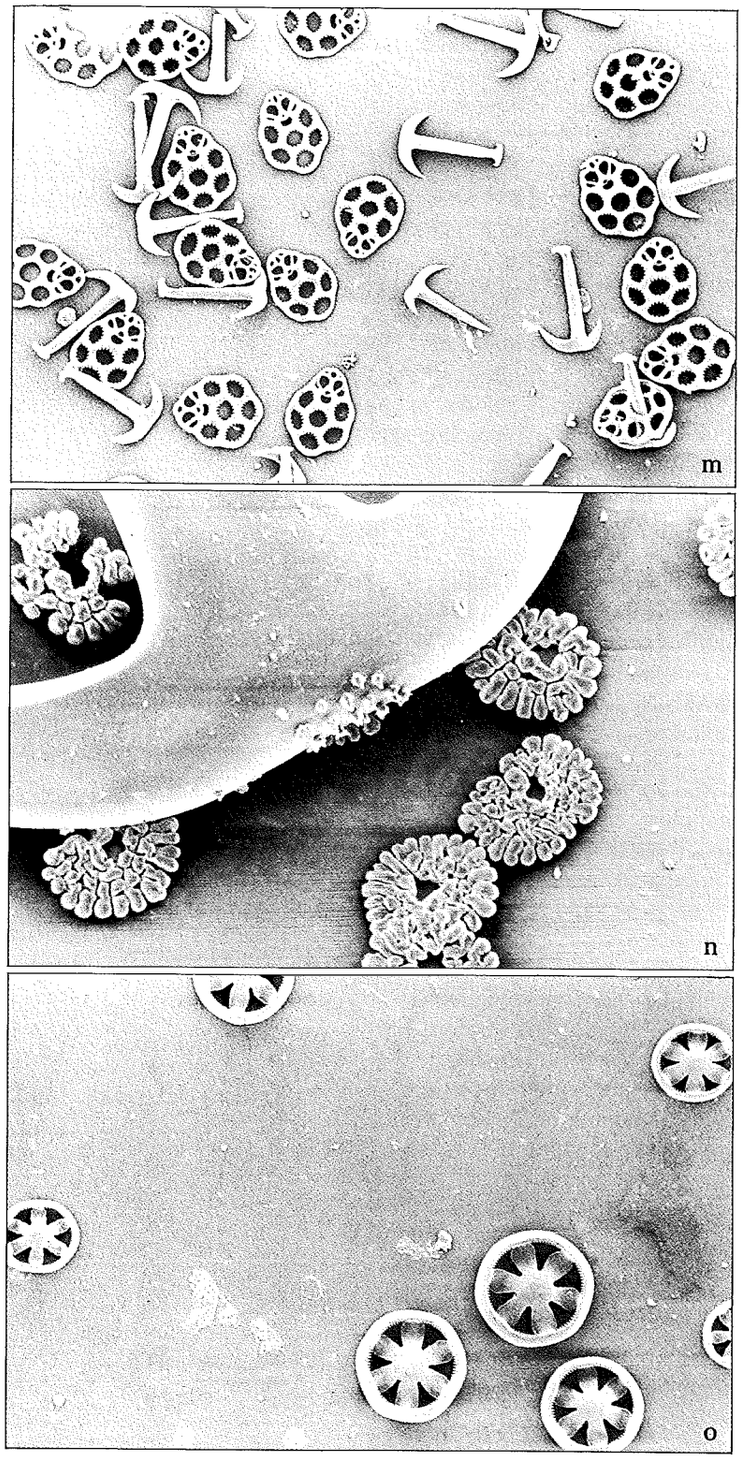


Fig. 2. (cont.)
m, anchors and anchor plates (*Polyplectana kefersteini*);
n, miliary bodies (*Synaptula recta*);
o, wheels (*Chiridota rigida*).

If animals are to be preserved for further study they should be anaesthetised prior to preservation so that the body is relaxed and the tentacles are extended. The usual method is to immerse specimens in a solution of 1-5% magnesium suiphate (epsom salts) or magnesium chloride for several hours. Diethyl ether is also a very effective anaesthetic. (In a sealable container mix a solution of 2% ether in sea water just prior to use and shake vigorously.) Saturated solutions of propylene phenoxetol (5%) have also been used with varying degrees of success.

The anaesthetised animal should be preserved in a solution of 70% alcohol. Place anaesthetised specimens in a tray of alcohol until preserved (12-24hr) and transfer into a fresh solution of alcohol for storage. With large specimens a cut through the body wall will hasten preservation. If alcohol is not available, specimens can be preserved temporarily in buffered formalin. Calcareous sand or shell grit, placed in the container, will suitably buffer the formalin. Specimens must be transferred to alcohol as soon as possible, however, as prolonged immersion in formalin will lead to erosion of calcareous spicules.

Preserved specimens often bear little resemblance to the living animal. It is recommended that new specimens should be photographed (it is helpful to include a scale in the photo which indicates the animal's size) or a sketch and colour notes should be made before they are preserved. WARNING: Permits are required for collecting in marine parks and habitat reserves.

Classification: a note

Animals (for those unfamiliar with zoological names) are classified heirarchically and the simplest (and hardly divisible) unit is the **species**. Species are arranged into like groups called **genera** (singular **genus**). Animal species are usually referred to by the two parts of their name (the binomial), i.e. genus and species. Scientific names are written conventionally in italics, e.g. *Actinopyga echinites*; the genus is *Actinopyga* (note the capital 'A') and the species *echinites*. Genera may similarly be grouped into **families** (conventionally ending in **-idae**), families into **orders** (ending in **-ida**), orders into **classes** (ending in **-oidea**) and classes into **phyla** (singular **phylum**). The animal kingdom has many phyla: their endings are not all consistent. We do not always write out the full classification, but for the above species, *Actinopyga echinites*, it would be:-

Phylum Echinodermata		Ph. Echinodermata
Class Holothurioidea	or	Cl. Holothurioidea
Order Aspidochirotida	abbreviated	O. Aspidochirotida
Family Holothuriidae		F. Holothuriidae
Actinopyga echinites		*A. echinites*

A full classification of the animals treated in this book is presented in the Records (pp.59-60)

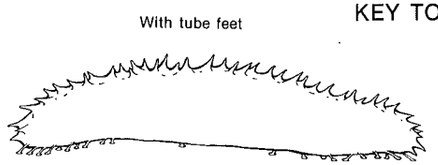
Picture keys

Picture keys to the families and genera of sea cucumbers from northern Australia. (Note: these are not meant to imply phylogenetic relationships.) Numbers refer to key pages not pagination.

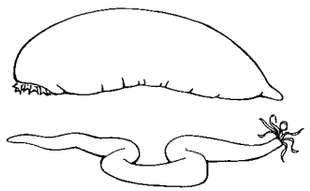
KEY TO HOLOTHURIOIDEA

1

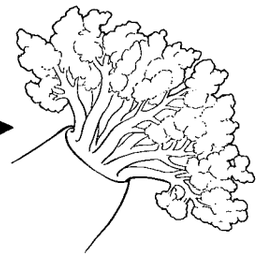
With tube feet



Without tube feet

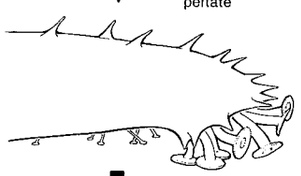


Tentacles dendritic



A

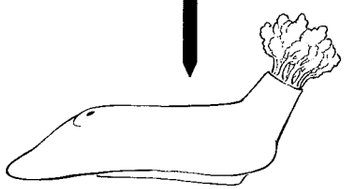
Tentacles peltate



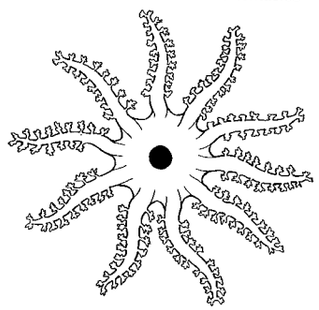
DENDROCHIROTIDA

Without sole (or plates)

Body with well defined sole below (macroscopic plates above)



10 tentacles

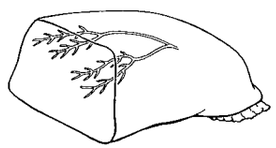


ASPIDOCHIROTIDA

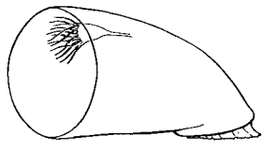
PSOLIDAE 2

CUCUMARIIDAE 5

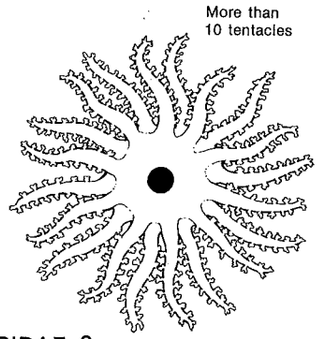
Body usually rectangular Gonads paired



Body usually circular Gonads single



More than 10 tentacles



STICHOPODIDAE 2

HOLOTHURIIDAE 3

PHYLLOPHORIDAE 6

2

A

APODIDA

Vermiform Without respiratory trees

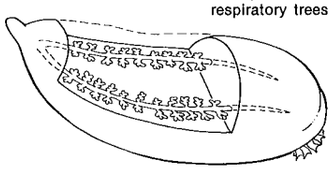
Tentacles pinnate (sometimes reduced)

Tentacles peltato- -digitate

SYNAPTIDAE 7

CHIRIDOTIDAE 8

Sausage shaped With paired respiratory trees



MOLPADIDA

Tentacles with terminal digit

Tentacles without terminal digit

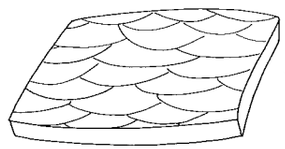
MOLPADIIDAE (Molpadia)

CAUDINIDAE 8

KEY TO GENERA

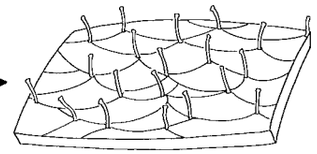
PSOLIDAE

Integument without tube-feet



Psolus

Integument with tube-feet



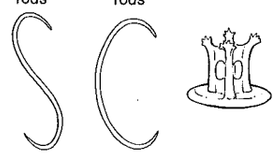
Psolidium

STICHOPODIDAE

'S' shaped rods

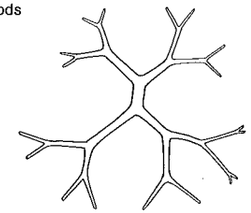
'C' shaped rods

Tables



Stichopus

Dichotomously branched rods

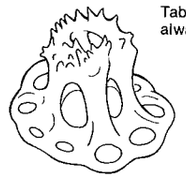


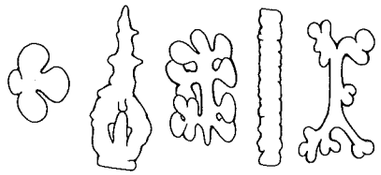
Thelenota

HOLOTHURIIDAE
3

Tables nearly always present

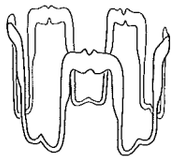
Rods only



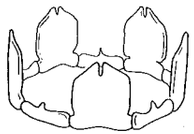


Calcareous ring sinuous

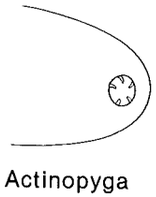
Calcareous ring not sinuous



Labidodemas



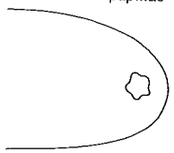
Holothuria



Actinopyga

With 5 calcified papillae (anal teeth)

Without calcified papillae



Bohadschia

Tables(±) but never alone

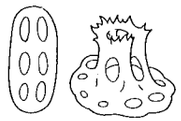
± Tables

± Rosettes

± Rods

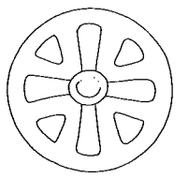
± Perforated plates

Tables always present, either alone or with buttons



± buttons

Tables with cruciform holes



Stauropora

Tables without cruciform holes

A

+ Rosettes
– Rods

Table disc usually well developed

Acanthotrapeza

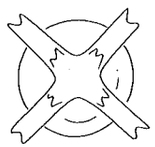
Table disc usually reduced

Halodeima

+ Rods
– Rosettes

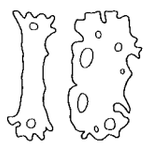
Rods finely spinose

Table disc usually reduced

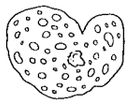


Semperothuria

Rods or plates perforated or thorny



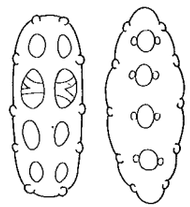
Tables degenerate (if present)



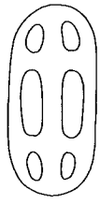
Selenkothuria

A

Buttons knobbed or rugose

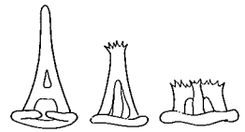


Buttons smooth

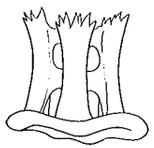


4

Tables squat or tack-like



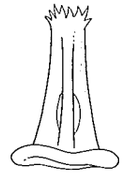
Tables robust



Tables squat

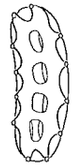
Cystipus

Tables tack-like



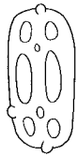
Theelothuria

Buttons usually modified into hollow fenestrated ellipsoids



Microthele

Buttons simpler



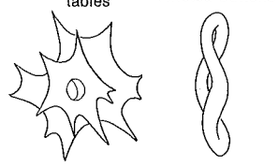
Metriatyla

Table disc smooth

Table disc usually spinose
Buttons mostly irregular

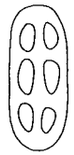
Stellate tables

Twisted buttons



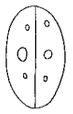
Lessonothuria

Buttons not thin
Holes usually large
Optical discontinuity absent



Thymiosycia

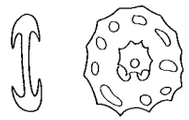
Buttons thin with small holes
Optical discontinuity present



Platyperona

Reduced buttons

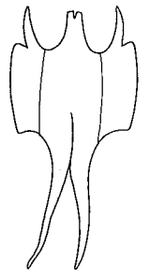
Weak tables



Mertensiothuria

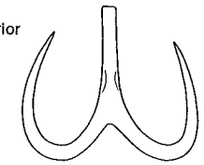
CUCUMARIIDAE

5

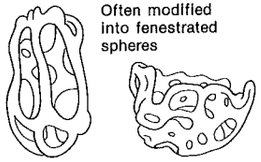


Radial plates with posterior bifurcations

Radial plates without posterior bifurcations



With baskets
Often modified into fenestrated spheres

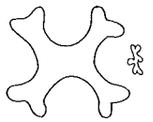


Pentacta

Body wall without spicules (Tentacles with branched or simple rods)

Orbithyone

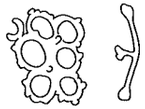
Cruciform plates and minute rods



Staurothyone

Perforated plates (often reduced)

Rods often 3-armed



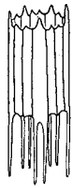
Cucumaria

Without baskets or spheres

With small smooth perforated plates (sometimes absent in large animals)

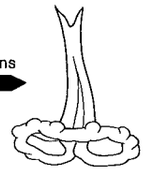
Psuedocolochiris

Calcareous ring long and tubular



Calcareous ring short and stout

With tables Without buttons



Havelockia

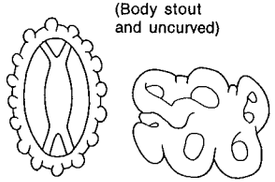
With nodular buttons in body wall Without tables

With tables or table derivatives

Thyone

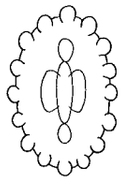
No tables in body wall

With buttons and baskets (Body stout and uncurved)



Plesiocolochirus

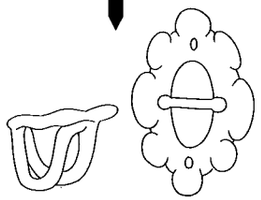
With small nodular buttons (usually 4 holes)



With fenestrated ellipsoids

Stolus

With buttons and baskets (Body slight and curved)

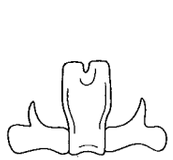


Leptopentacta

Hemithyone

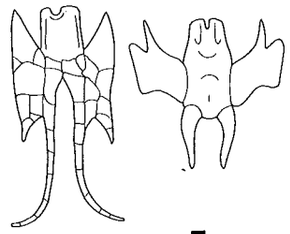
PHYLLOPHORIDAE

6



Radial plates without posterior bifurcations

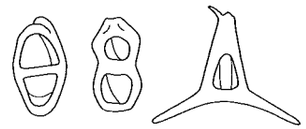
Radial plates with posterior bifurcations



(With 20 tentacles in 1 ring)

With figure 8-shaped fenestrated ellipsoids

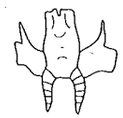
Irregular tables with 4-pillared spires



Actinocucumis

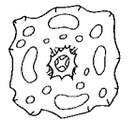
Without figure 8-shaped fenestrated ellipsoids

Inter-radials not fusing to form a mosaic with radials



Phyllophorus

Tables present

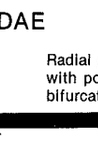


Tables absent

With large lenticular perforated plates

Afrocucumis

Inter-radials fusing to form a mosaic with radials

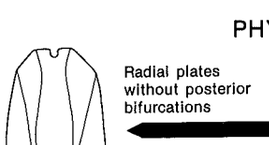


Phyrella

Table spire with 2 pillars joined by bridges

Table disc usually with 4 large and 4 small holes

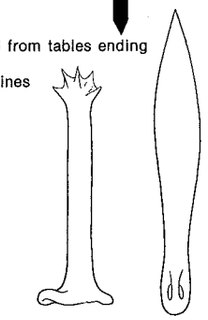
(With 30 tentacles)



Mensamaria

(With 20 tentacles in 2 or 3 rings)

With rods derived from tables ending in a single spine or a cluster of spines



Cladolabes

(With 20 tentacles in 2 rings)

Usually with branched rods

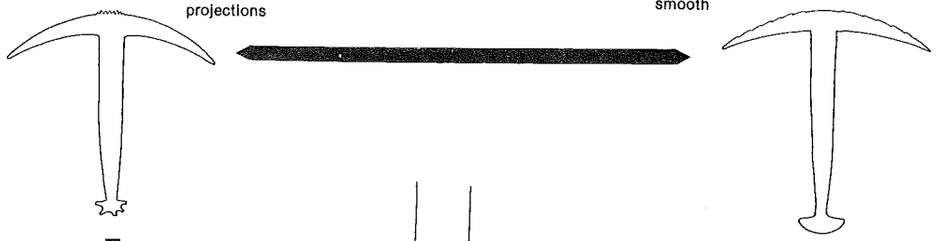
With tables or table derivatives

Neocucumis

SYNAPTIDAE
7

Arms of anchors smooth
Vertex of anchors with knob-like projections

Arms of anchors ± smooth
Vertex always smooth

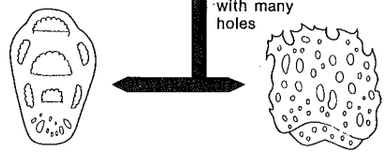


Stock of anchor branched

Stock of anchor unbranched

Anchor plates usually with 7 large toothed holes

Anchor plates ovate and irregular with many holes

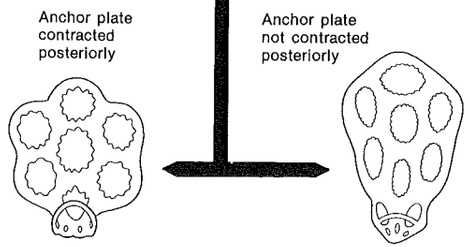


Leptosynapta

Protankyra

Anchor plate contracted posteriorly

Anchor plate not contracted posteriorly



Opheodesoma

Euapta

16-27 tentacles (usually 25)

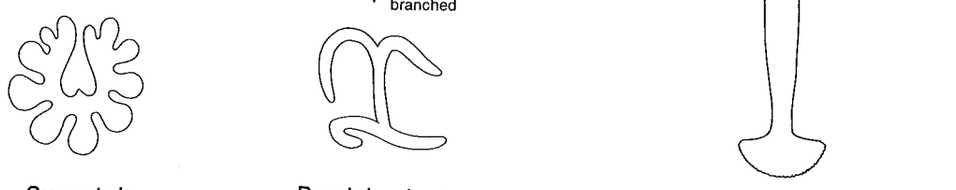
Polyplectana

15 tentacles or less

Spicules not large
Miliary bodies (if present) having the form of curved knobbed rods

Spicules not large
Miliary granules irregularly and dichotomously branched

Spicules very large (ca. 1mm long)



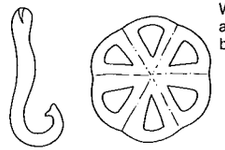
Synaptula

Pendekaplectana

Synapta

CHIRIDOTIDAE
8

With wheels and sigmoid bodies



With wheels, without sigmoid bodies

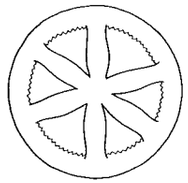
Tentacles 12 (10-14)

Tentacles 18 (16-20)

Chiridota

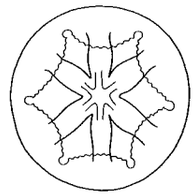
Polycheira

Wheel serrations not arranged in groups



Taeniogyrus

Wheel serrations arranged in groups

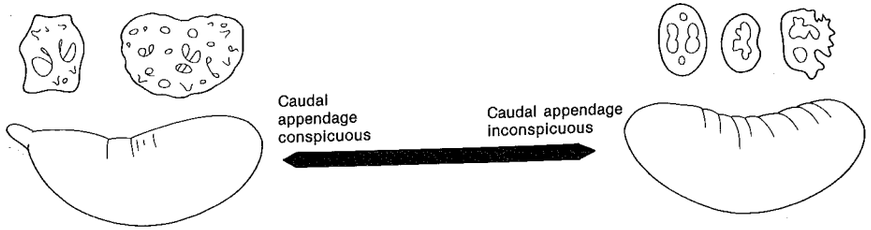


Trochodota

CAUDINIDAE

Thickened and irregular perforated plates

Flattened perforated plates

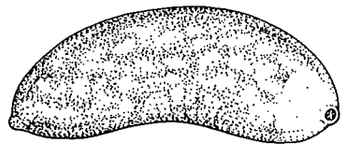


Caudal appendage conspicuous

Caudal appendage inconspicuous

Acaudina

Paracaudina



Actinopyga lecanora

Taxonomic Account

Four orders of holothurians occur in northern Australia. The Order ASPIDOCHIROTIDA contains the largest and most conspicuous holothurians. They are typically sausage shaped animals with thick body walls. Aspidochirote holothurians ingest sand and digest some of the contained biota. The Order DENDROCHIROTIDA contains animals which are suspension feeders. They are often found with their bodies concealed, projecting their feeding tentacles into the water. The Orders APODIDA and MOLPADIDA contain animals lacking tube feet except for their modified feeding tentacles. The apodous holothurians are slender, vermiform animals with thin body walls. In the Family SYNAPTIDAE, species feed by gathering detritus from surfaces. Members of the Family CHIRIDOTIDAE engulf sand, i.e. their feeding is similar to that of aspidochirotes. The molpadid holothurians are sausage shaped animals with a thin body wall. Their bodies taper posteriorly to form what is called a caudal appendage. These animals burrow in sand and mud and feed there.

The absence of external characters which may be reliably preserved has led to a reliance for identification on the characteristic microscopic calcareous particles in the body wall. With practice, however, living animals often can be recognized in the field.

Species and genera are listed alphabetically within families. An illustration of spicule form for each genus (or sub-genus) is given and selected colour illustrations of living animals are included. Habitat notes given must not be considered to exclude suitable habitats outside those types. Because of the great variability in the size of holothurians (often dependent upon the volume of water held within) sizes are given merely as a guide and the following length categories apply – **small** <100mm, **medium** 100 - 300mm, **large** >300mm.

The illustrated keys to the families and genera should assist in identifying the animals. Nevertheless, they are simplified and further guidance should be sought from the notes, colour illustrations and photographs. Most of the commoner, and some less common, holothurians should be identifiable from these aids. Northern Australia, however, shares its marine fauna with the rest of the Indo-west Pacific and numerous species recorded from this vast area stretching from the Red Sea to Tahiti that have not been recorded yet from Australia may well be found there. Reference should bė made to the comprehensive account of Clark & Rowe (1971). Along the east and west coasts some overlap between tropical and temperate faunas can occur. For an account of the temperate forms from Southern Australia consult Rowe (1982).

Order **ASPIDOCHIROTIDA**

Family **HOLOTHURIIDAE**

These are small to very large animals which may be concealed below rocks and rubble, buried in sand or lying exposed. Most are more active at night. Their diversity of colour and patterning makes most species identifiable when alive, though the variations within some species can be great. For a detailed review of the family see Rowe (1969).

Actinopyga

Medium to large, stout, body thick and very firm, tegument usually smooth, cuvierian tubules branched, not ejected, tentacles usually 20: spicules branched rods. Mostly exposed on rubble, sand or seagrass of outer coral reef flat or shallow slope.

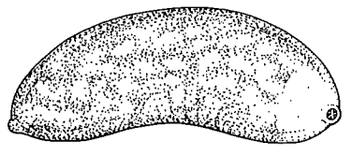
A. echinites (Jaeger, 1833) (Fig. 5a). Brown, tegument rough with numerous papillae, upper surface often covered with sand [see also Rowe & Doty, 1977; fig. 6c (colour)]: spicules include large rods (Fig. 3a). Northern reefs.

A. lecanora (Jaeger, 1833). Light grey or brown, with light speckled patches particularly around the somewhat attenuated posterior end: spicules small rods. Often concealed amongst coral or rubble of reefs.

A. mauritiana (Quoy & Gaimard, 1833). Patches of light chestnut-brown and white, usually white below, densely covered with tube feet, tentacles 25 or more [see Rowe & Doty,1977; fig. 6d (colour)]: spicules include large rough rods. Reefs, in exposed habitats.

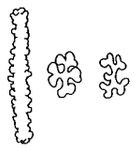
A. miliaris (Quoy & Gaimard, 1833) (Fig. 5b). Black, tegument smooth with small scattered soft papillae: spicules include only small rods. Reefs and coastal waters.

REMARKS: The species are most easily distinguished by their colour and form when alive; spicules may be numerous or rare. Both *A. mauritiana* and *A. lecanora* have mottled colours, though the former has 25 or more tentacles and the latter has a characteristically pale peri-anal region. Colour, tegument and rod size distinguish the two bold coloured species.



Actinopyga lecanora

A. lecanora



A. mauritiana

A. miliaris

Bohadschia

Medium to large, stout to elongate, body firm but usually pliable, tegument mostly smooth but may have numerous tube feet or low papillae, cuvierian tubules thick, white, unbranched, tentacles 20: spicules branched or spinose rods with granules but no tables. Mainly exposed or more or less buried in sand of coral reef flat or shallow slope.

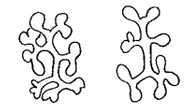
B. argus Jaeger, 1833 (Fig. 5c). Upper surface grey or grey-brown with striking pattern of spots ringed with white, lower surface light yellow-brown, cuvierian tubules readily ejected: spicules branched rods (Fig. 3b). Reefs, exposed and often common.

B. graeffei (Semper, 1868). Pale cream with brown speckling, large, low papillae, long with three longitudinal bands of tube feet below, tentacles black with white crowns [see Rowe & Doty, 1977; fig. 6e (colour)]: spicules resemble a somewhat tack-like bundle of spinose rods described as racquet-like by Rowe (1969). They occur on reefs, exposed on hard subtidal substrates, and are active in daylight.

B. marmorata Jaeger, 1833 (Fig. 5d). A variable mixture of brown and/or yellow, usually with small brown spots on upper surface, but freqently with large angular dark patches [see Rowe & Doty, 1977; figs. 6g and 6h for colour variations], cuvierian tubules readily ejected: spicules short branched rods. Reefs, usually more or less buried in sand of flat or lagoon.

REMARKS: Body colours serve to most easily distinguish between species when alive, e.g., *B. argus* has characteristic white-ringed spots, *B. marmorata* has dark brown spots on a paler base as well as often having dark angular patches. Several species are now considered synonyms of *B. marmorata,* viz. *vitiensis, tenuissima, similis, koellikeri* and *bivittata.* The single record of Endean (1956) of *B. paradoxa* at Low Isles may also be referred to *marmorata*.

Bohadschia graeffei



Bohadschia marmorata

Labidodemas

Small to medium, body soft and leathery, tegument smooth with tube feet along ambulacra, tentacles 20, calcareous ring ribbon-like.

L. semperianum Selenka, 1867 (Fig. 6a). White, almost translucent, with yellow tube feet and a dark posterior end: spicules spinose tables and sometimes buttons and rods (Fig. 3c). Buried in sand below rocks of the outer coral reef flat.

REMARKS: A second species, *L. rugosum* (Ludwig, 1874), yellow, small and warty with spinose tables of moderate spire height has been recorded from the Torres Straits.

Holothuria

A large assemblage of most diverse animals falling into many sub-groups, but all having tables (Fig. 2e) [though sometimes rare] among the spicules and a robust calcareous ring (Fig. 1b). The sub-groups are recognised as sub-genera (written in parentheses) and distinguished by the diversity and complexity of spicules. Small to very large, usually sausage shaped with thin to thick body wall and diverse colour patterns. Some species lie exposed, though most are more or less fugitive below rocks or buried. Most are found on reef flats, lagoons or shallow slopes, but some prefer deeper regions, soft sediments, sea-grasses or coastal regions.

(Acanthotrapeza)

H. (Acanthotrapeza) coluber Semper, 1868 (Fig. 6c). Black with white papillae and 20 yellow tentacles long and firm, tegument tough: spicules include spinose 'cup and saucer' tables and rosettes (Fig. 3d). Reefs, usually with posterior wedged below rocks on reef flat.

(Cystipus)

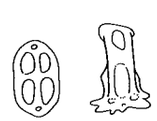
H. (Cystipus) rigida (Selenka, 1867) (Fig. 6b). White to grey, often covered with sand, with double row of dark spots along upper surface and a lateral row of blunt papillae on each side, stout flattened and rigid, 20 tentacles [see also Rowe & Doty, 1977; fig. 7f (colour)]: spicules low tables, fenestrated spheres and knobbed buttons (Fig. 3e). Reef flat, below rocks.

REMARKS: A second species, *H. (Cystipus) inhabilis* recognised by a lack of fenestrated spheres, simpler tables and more irregular buttons has been reported from northern reefs.

(Halodeima)

H. (Halodeima) atra Jaeger, 1833 (Fig. 6d). Black with black tentacles, but frequently covered with sand, small to very large, fissiparous, cylindrical with rounded ends, tegument smooth, body wall pliable, toxic red fluid released from skin on rubbing [see also Rowe & Doty, 1977; fig. 7a (colour)]: spicules tables with reduced disc and moderate spire bearing a 'maltese cross' and rosettes but no buttons (Fig. 3f). Small specimens tend to have a thin coating of sand with open patches of black skin showing through, large specimens are seen either with no sand covering or with a thick unbroken covering above. Animals are conspicuous and common lying exposed on sand flats of reef and coast.

H. (Halodeima) edulis Lesson, 1830 (Fig. 6f). Dark red/black above pink below, small to large, cylindrical with rounded ends, tegument smooth, body wall pliable [see also Rowe & Doty, 1977; fig. 7b (colour)]: spicules with tables with smaller disc than in *atra.* Reefs, exposed or concealed amongst rubble.



H. (Halodeima) edulis

(Lessonothuria)

H. (Lessonothuria) pardalis Selenka, 1867 (Fig. 6e). Mottled light brown-grey and white, sometimes with dark spots along upper surface, cylindrical and tapering at ends, small, tegument smooth, body thin and pliable: spicules clumsy tables with low to moderate spire and spiny disk, buttons usually irregular (Fig. 3g). Reefs and coastal, below rocks, reef flats, rocky shores and sea-grass areas.

H. (Lessonothuria) verrucosa Selenka, 1867. Deep chocolate brown with upper surface often suffused with orange, medium to large, thick and cylindrical but pliable, taller papillae above tipped with orange, tegument smooth: spicules low tables with spiny disc and irregular buttons. Reefs, largely buried in sand of flat or lagoon with cloaca and part of upper surface exposed.

REMARKS: Another species which has a distinctly flattened lower surface and found on northern reefs may be referable to *H. (Lessonothuria) insignis,* sometimes considered a synonym of *pardalis.*

H. (Lessonothuria) verrucosa

H. (Lessonothuria) verrucosa

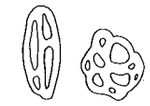
(Mertensiothuria)

H. (Mertensiothuria) fuscocinerea Jaeger, 1833. Grey/brown mottled with dark white-ringed papillae [see Semper (1868) pl. XXVII (colour)], medium to large, cylindrical and pliable with soft tegument: spicules sometimes poorly formed, low tables with often spinose disc, buttons often irregular. Reefs, below rocks on flat.

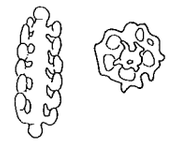
H. (Mertensiothuria) leucospilota (Brandt, 1835) (Fig. 6g). Black/red, medium to large, cylindrical and elongate, body soft and pliable, covered with soft papillae, 20 black tentacles, cuvierian tubules readily ejected [see also Rowe & Doty, 1977; fig. 7g (colour)]: spicules low spired tables and simple buttons (Fig. 3h). Reefs and coastal rocky shores to NSW, usually more or less concealed below rocks, common on reef flats.

H. (Mertensiothuria) pervicax Selenka, 1867 (Fig. 6h). Grey/brown mottled above, with red-brown papillae ringed with white, grey below with dark spots of tube feet, hemicylindrical, somewhat flattened below, medium, body soft and pliable, tegument smooth, with thick translucent cuvierian tubules [see also Rowe & Doty, 1977; fig. 8c (colour)]: spicules rather poorly formed, buttons often like small beaded rods. Reefs, below rocks on flat.

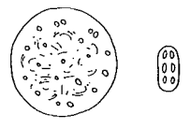
REMARKS: The soft, black *leucospilota* is common and easily recognised. The distinction between *fuscocinerea* and *pervicax* is not too clear; however the latter does have quite reduced spicules. Another holothurian with spicules very like those of *pervicax* is sometimes encountered and may be a colour morph. It is a rich red/brown above and white below.



H. (Mertensiothuria) fuscocinerea



H. (Mertensiothuria) pervicax



H. (Metriatyla) albiventer

(Metriatyla)

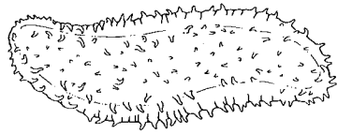
H. (Metriatyla) albiventer Semper, 1868. Green/brown above flecked with black, grey/white below with sparse papillae, 20 tentacles, small to medium, cylindrical: spicules very solid tables larger (x3) than knobbed buttons. Coastal, dredged in northern waters.

H. (Metriatyla) martensii Semper, 1868. Grey/brown with double row of dark spots on upper surface, small, flattened, tegument rough, thin white cuvierian tubules: spicules tables extended to tack-like bodies with 7 bridges (Fig. 2e). Coastal, trawled or from silty foreshores.

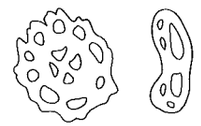
H. (Metriatyla) ocellata Jaeger, 1833. White with brown speckling and characteristic white-ringed spots, white below, medium, with 'sole', firm body and rough tegument with prominent lateral papillae: spicules moderately heavy tables and knobbed buttons. Coastal, trawled.

H. (Metriatyla) scabra Jaeger, 1833 (Fig. 6i). Grey/black above with dark transverse wrinkles, grey/white below, medium, somewhat flattened, firm to pliable: spicules well developed tables and knobbed buttons (Fig. 4a). Reefs and coastal, exposed or partially buried in sand or sea-grass flats.

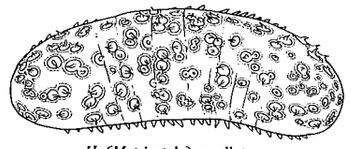
REMARKS: The colour patterns of *ocellata* and the tack-like spicules of *martensii* serve to distinguish these species. The relatively large size of the tables of the *albiventer* may serve to distinguish it from *scabra*. Another species, *H. (Metriatyla) bowensis* may be only a form of *martensii* found in Queensland; it has only 5 bridges on the spire.



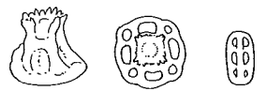
H. (Metriatyla) martensii



H. (Metriatyla) martensii



H. (Metriartyla) ocellata



H. (Metriartyla) ocellata

(Microthele)

H. (Microthele) axiologa Clark, 1921. Yellow with brown flecking and dark transverse wrinkles above, white below, large and stout, distinctly flattened below, body thick and firm, tegument soft (slimy) [see Rowe & Doty, 1977; fig. 7c (colour)]: spicules stout, square tables, buttons fenestrated ellipsoids. It is found on reefs, exposed on deeper fine sediments.

H. (Microthele) nobilis (Selenka, 1867) (Fig. 7a). Black, often with fine sand covering, large, stout, firm and rigid with prominent lateral papillae and anal papillae (usually 5), translucent cuvierian tubules: spicules stout tables and fenestrated ellipsoids (Fig. 4b). Reefs, exposed on rubble or sea-grasses.

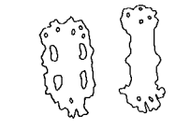
REMARKS: A variegated black and white variant of '*nobilis*' is known in Queensland. This may prove to be *H. (Microthele) fuscogliva* a recently described species (Cherbonnier, 1980).

(Platyperona)

H. (Platyperona) difficilis Semper, 1868 (Fig. 7b). Dark yellow-brown, tentacles yellow, small, cylindrical, pliable, tegument smooth, cuvierian tubules readily ejected: spicules well developed tables, but buttons characteristically flat with a longitudinal optical discontinuity (Fig. 4c). Reefs and coastal, below rocks.

(Selenkothuria)

H. (Selenkothuria) erinaceus Semper, 1868 (Fig. 7c). Grey/brown mottled above with black cloaca, small to medium, cylindrical, flattened lower surface densely crowded with tube feet, long fine papillae on upper surface [see also Rowe & Doty, 1977; fig. 7h (colour)]: spicules flattened plates and rods (Fig. 4d). Reefs and coastal on sandy flats.



H. (Selenkothuria) erinaceus

REMARKS: A second species, *H. (Selenkothuria) moebii*, has been recorded from Lord Howe Is. It is brown with yellow tube feet and has spinose rods. Since tables may be reduced or absent (rare) care must be exercised to distinguish these species from *Bohadschia*.

(Semperothuria)

H. (Semperothuria) cinerascens (Brandt, 1835). Red-brown to purple, small to medium, rather slender and cylindrical, body wall soft and thick, 20 tentacles: spicules finely spinose rods and tables with reduced disk, but bearing a characteristic maltese cross.

REMARKS: Although widespread throughout the Indo-Pacific one specimen has been recorded from southwest Australia.

(Stauropora)

H. (Stauropora) modesta Ludwig, 1874. Grey variegated with shades of brown, purple and white, tentacles short and pale, small, cylindrical, pliable and without papillae: spicules tables with smooth, flat disc and a characteristic cruciform hole, no buttons (Fig. 4e). Coastal below rocks.

REMARKS: A second species, *H. (Stauropora) fuscoolivacea*, has been recorded from Low Isles. It is olive/brown above and grey/brown below: it has small oval rugose buttons.

(Theelothuria)

H. (Theelothuria) michaelseni Erwe, 1913. Black with five white longitudinal stripes, 20 white tentacles, small to medium, hemicylindrical, body wall thin: spicules irregular perforated plates and rods, knobbed buttons sometimes reduced to granules. Recorded from seagrass flats of northwest Australia.

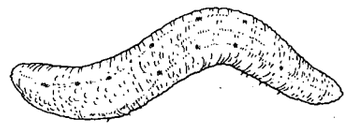
H. (Theelothuria) michaelseni

H. (Theelothuria) notabilis Ludwig, 1874 (Fig. 7d). Dark brown with light papillae, medium size, firm with firm papillae and a rough tegument: spicules irregular tables or normal with spiny disc, small concave plates with perforations, buttons irregular, knobbed with 3 or more pairs of holes (Fig. 4f). Coastal, exposed or buried in sea-grass flats.

REMARKS: A further species, *H. (Theelothuria) spinifera* was originally recorded by Clark (1938) as *H. ocellata* from Broome. It is grey-brown to white and small to medium in size: the spiny disc of the tables distinguishes it from *ocellata.*

(Thymiosycia)

H. (Thymiosycia) arenicola Semper, 1868. Cream/white with a double row of dark red spots along upper surface, small to medium, long and cylindrical, sometimes sand covered, rigid, tegument tough covered with small, hard papillae, cuvierian tubules vestigial: spicules small, square tables and buttons with rather small holes. Reefs and coastal, in sand below rocks.

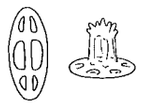


H. (Thymiosycia) arenicola

H. (Thymiosycia) hilla Lesson, 1830 (Fig. 7e). Light to dark brown with prominent pale papillae, small to medium, cylindrical and tapering, thin and soft, tegument loose [see also Rowe & Doty, 1977; fig. 8b (colour)]: spicules rather open tables and buttons with big holes. Reefs, below rocks of reef flat.

H. (Thymiosycia) arenicola

H. (Thymiosycia) impatiens (Forskal, 1775) (Fig. 7f). Variegated pinks and browns with variable dark and light bands of transverse colour are the most common patterns from reef animals, small to large, cylindrical, tegument tough, papillae prominent, body firm but pliable, cuvierian tubules sometimes ejected [see also Rowe & Doty, 1977; fig. 7e (colour)]: spicules well developed square tables and smooth buttons (Fig. 4g). Reefs, below rocks of reef flat.



H. (Thymiosycia) hilla

REMARKS: Colour and pattern serve to distinguish these species when alive, *impatiens* is very variable but much rougher than the rather soft *hilla* with which it could be confused. Spicule form must be used to clearly distinguish *arenicola* from *H. (Lessonothuria) pardalis* or even *H. (Cystipus) rigida* with which it shares a superficial similarity of form and habit. Another species *H. (Thymiosycia) remollescens*, with a dull purple grey colour has been reported from the Torres Straits and *truncata* is poorly known.

A few species are unassigned to a sub-genus. A small white holothurian, *H. cumulus*, with yellow tube feet has been found in northern reef waters below rocks of reef flats; it may be related to *H. (Lessonothuria) pardalis*. Another, *H. conica*, was described by Clark (1938) from a small purple-grey specimen with cream/white tentacles found near Darwin in sandy mud below a rock. Finally, *H. dietrichi* may be a form of *(Mertensiothuria)*: it has not been recorded since originally described.

Family **STICHOPODIDAE**

These are medium to large animals, usually somewhat square in cross section with prominent papillae and distinctly flattened below. They are usually exposed on sand or rubble and most are easily identifiable when alive, although intraspecific variation may be great. This family was reviewed by Clark (1922), but is currently again under review.

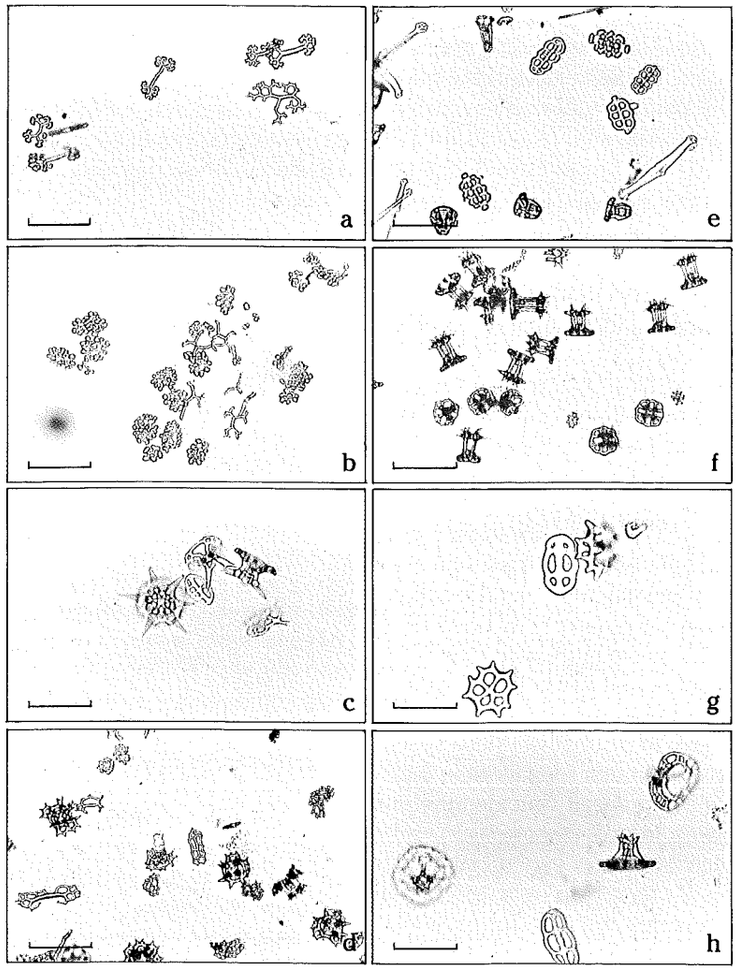


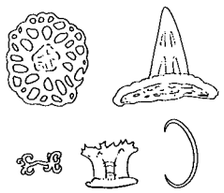
Fig. 3.
Spicule photomicrographs – Aspidochirotida.
(Scale in parentheses).
a, *Actinopyga echinites* (100 μm);
b, *Bohadschia argus* (100 μm);
c, *Labidodemus semperianum* (100 μm);
d, *Holothuria (Acanthotrapeza) coluber* (200 μm);
e, *H. (Cystipus) rigida* (200 μm);
f, *H. (Halodeima) atra* (200 μm);
g, *H. (Lessonothuria) pardalis* (50 μm);
h, *H. (Mertensiothuria) leucospilota* (100 μm).

Stichopus

Medium to large animals with three clearly defined rows of tube feet below. Body wall often with prominent papillae and quite firm, though capable of rapidly disintegrating if animal stressed. Spicules often include distinctive "C" and "S" shapes.

S. chloronotus Brandt, 1835 (Fig. 7h). Deep black-green, with yellow/red tips to the papillae, medium to large, firm but pliable, tegument smooth, square in section with prominent papillae along lateral 'edges' [see also Rowe & Doty, 1977; fig 6a (colour)]: spicules with well developed tables with small disc and "C" rods (Fig. 4h). Reefs, common on rubble of outer reef flat.

S. horrens Selenka, 1867 (Fig. 7g). Variable grey to green/black often variegated with dark patches, medium, tegument smooth but papillae large and irregular [see also Rowe & Doty, 1977; fig. 6b (colour)]: spicules tables and large "C" bodies. Reefs, below rocks on flat.



Stichopus horrens

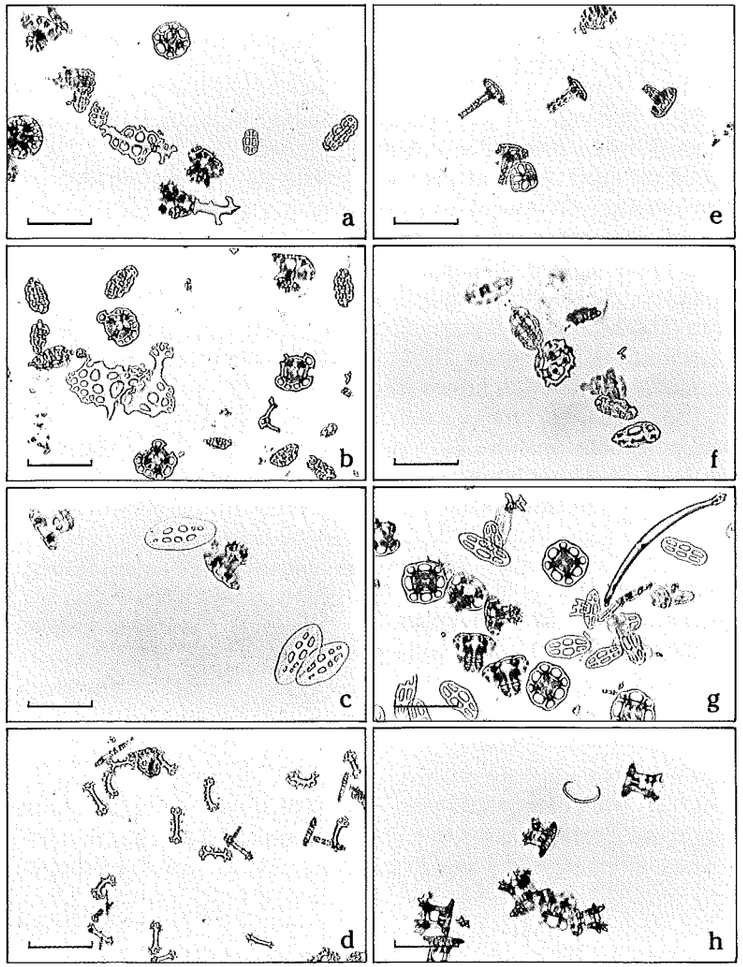


Fig. 4.
Spicule photomicrographs – Aspidochirotida.
(Scale in parentheses).
a, *H. (Metriatyla) scabra* (200 μm);
b, *H. (Microthele) nobilis* (200 μm);
c, *H. (Platyperona) difficilis* (100 μm);
d, *H. (Selenkothuria) erinaceus* (200 μm);
e, *H. (Stauropora) modesta* (200 μm);
f, *H. (Theelothuria) notabilis* (100 μm);
g, *H. (Thymiosycia) impatiens* (200 μm);
h, *Stichopus chloronotus* (100 μm).

A few species are unassigned to a sub-genus. A small white holothurian, *H. cumulus*, with yellow tube feet has been found in northern reef waters below rocks of reef flats; it may be related to *H.* (*Lessonothuria*) *pardalis*. Another, *H. conica*, was described by Clark (1938) from a small purple-grey specimen with cream/white tentacles found near Darwin in sandy mud below a rock. Finally, *H. dietrichi* may be a form of (*Mertensiothuria*): it has not been recorded since originally described.

Family **STICHOPODIDAE**

These are medium to large animals, usually somewhat square in cross section with prominent papillae and distinctly flattened below. They are usually exposed on sand or rubble and most are easily identifiable when alive, although intraspecific variation may be great. This family was reviewed by Clark (1922), but is currently again under review.

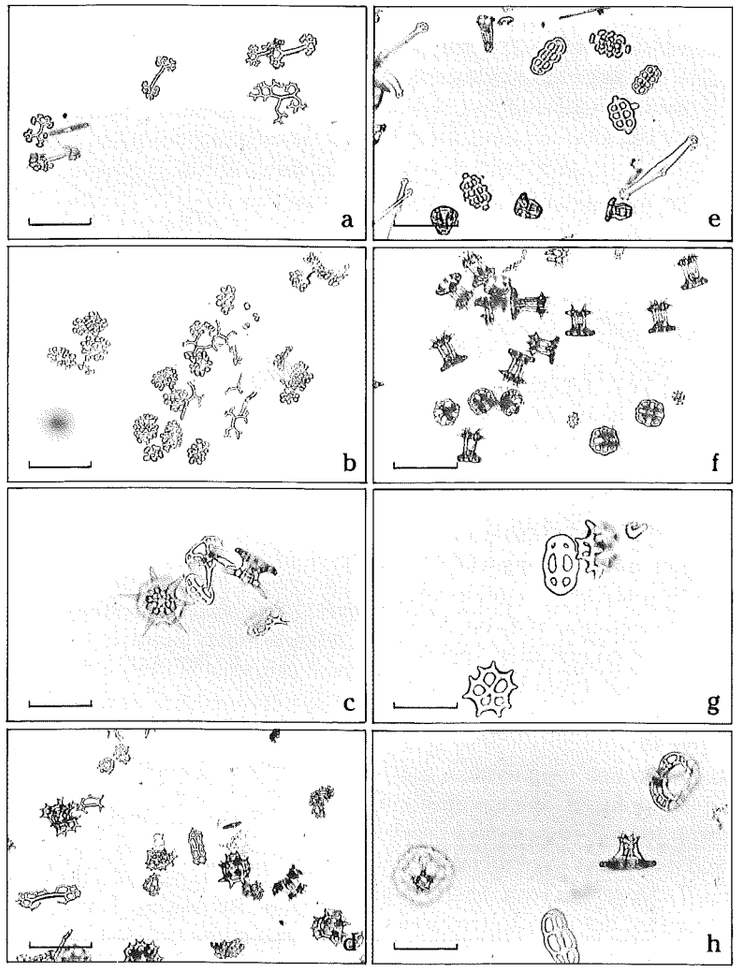


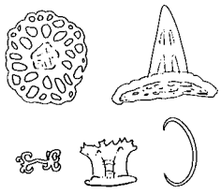
Fig. 3.
Spicule photomicrographs – Aspidochirotida.
(Scale in parentheses).
a, *Actinopyga echinites* (100 μm);
b, *Bohadschia argus* (100 μm);
c, *Labidodemus semperianum* (100 μm);
d, *Holothuria* (*Acanthotrapeza*) *coluber* (200 μm);
e, *H.* (*Cystipus*) *rigida* (200 μm);
f, *H.* (*Halodeima*) *atra* (200 μm);
g, *H.* (*Lessonothuria*) *pardalis* (50 μm);
h, *H.* (*Mertensiothuria*) *leucospilota* (100 μm).

Stichopus

Medium to large animals with three clearly defined rows of tube feet below. Body wall often with prominent papillae and quite firm, though capable of rapidly disintegrating if animal stressed. Spicules often include distinctive "C" and "S" shapes.

S. chloronotus Brandt, 1835 (Fig. 7h). Deep black-green, with yellow/red tips to the papillae, medium to large, firm but pliable, tegument smooth, square in section with prominent papillae along lateral 'edges' [see also Rowe & Doty, 1977; fig 6a (colour)]: spicules with well developed tables with small disc and "C" rods (Fig. 4h). Reefs, common on rubble of outer reef flat.

S. horrens Selenka, 1867 (Fig. 7g). Variable grey to green/black often variegated with dark patches, medium, tegument smooth but papillae large and irregular [see also Rowe & Doty, 1977; fig. 6b (colour)]: spicules tables and large "C" bodies. Reefs, below rocks on flat.



Stichopus horrens

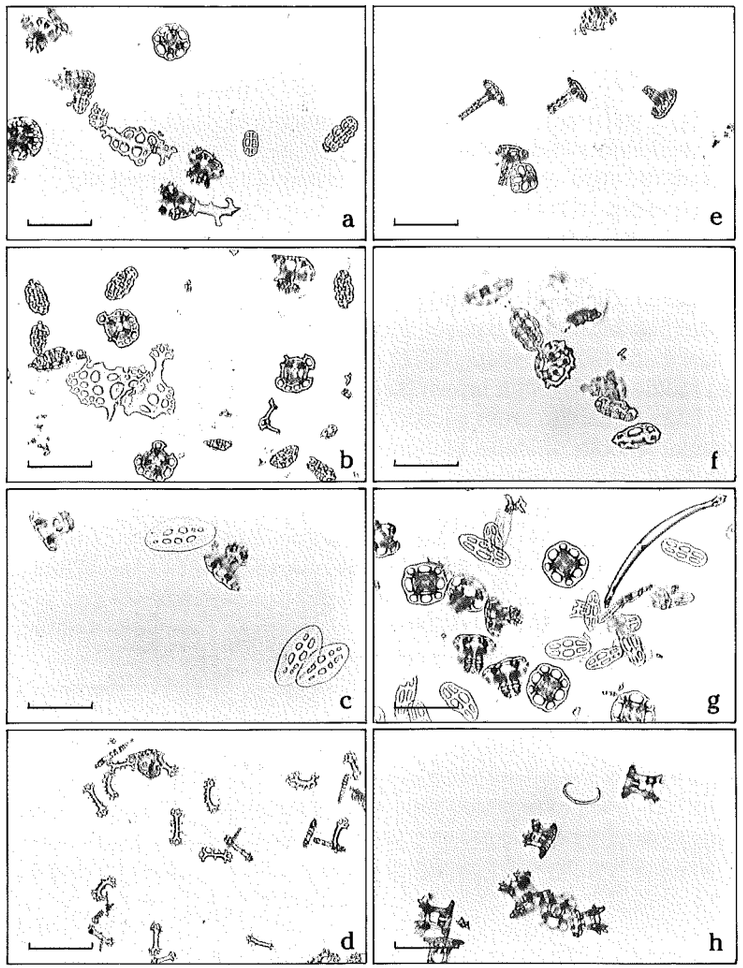
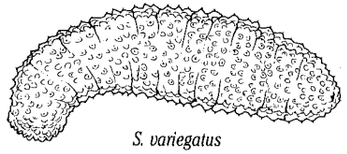


Fig. 4.
Spicule photomicrographs – Aspidochirotida.
(Scale in parentheses).
a, *H.* (*Metriatyla*) *scabra* (200 μm);
b, *H.* (*Microthele*) *nobilis* (200 μm);
c, *H.* (*Platyperona*) *difficilis* (100 μm);
d, *H.* (*Selenkothuria*) *erinaceus* (200 μm);
e, *H.* (*Stauropora*) *modesta* (200 μm);
f, *H.* (*Theelothuria*) *notabilis* (100 μm);
g, *H.* (*Thymiosycia*) *impatiens* (200 μm);
h, *Stichopus chloronotus* (100 μm).

S. variegatus Semper, 1868. Yellow/brown and covered with small dark spots, medium to large, stout thick and firm, papillae low, tegument moderately smooth: spicules well developed tables. Reefs, common on sand flats.

REMARKS: The species of *Stichopus* can best be distinguished by colour and form when alive, however, considerable variation can occur. Some of the variations are ones with alternating dark and light green swirls, or pale green/grey with prominent dark spots. Another is grey-green or with black or orange patchwork, of medium size, square in section with very prominent papillae irregularly arranged on upper surface. Its spicules include well developed tables, rods and large "C" rods. It is found on coastal sea-grass beds. All these forms have been identified as *S. variegatus* . Clark (1938) described a further species as *S. ellipes* from a single specimen near Broome. It was brown-grey with darker grey blotches along the sides and was covered with minute dark spots. It lacked "C" rods or rosettes. The genus is in much need of revision. Finally, the specimen identified as *S. paradoxus* seems likely to have been *H. leucospilota* and not a *Stichopus*.



S. variegatus

S. variegatus

Thelenota

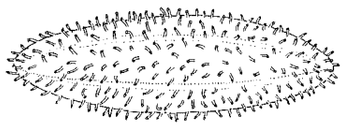
Large animals, square, well flattened below crowded with tube feet found in usually deeper waters off the crest of coral reefs.

T. ananas Jaeger, 1833 (Fig. 7i). Grey, orange, red often with a purple cast, very large (to 600mm), square in cross section with prominent 'cockscomb' papillae over upper surface of thick but pliable body, tegument smooth: spicules delicate dichotomously branched rods without lateral spines (Fig. 2a). Reefs, exposed on rubble.

T. anax Clark, 1921. Cream/brown mottled with red or brown [see Clark (1921) pl. 18, fig. 3 (colour)], large, square in cross section, lacking large ridged papillae, tegument smooth: spicules branched rods with fine lateral spines. Reefs, deep on soft sediments.

Family **SYNALLACTIDAE**

Although unlikely to be met with by most, there is a report from deep water (400m) off the Great Barrier Reef of a small to medium sized holothurian in this family, *Mesothuria parva*: grey with darker tentacles, spicules include well developed tables.



Mesothuria parva

Mesothuria parva

Order **DENDROCHIROTIDA**

Family **PSOLIDAE**

A group of small mostly inconspicuous animals found below rocks. They are characterised by a well developed creeping sole below and conspicuous calcareous plates above. *Psolus* lacks papillae above; some are present in *Psolidium*, although they are hard to see.

Psolus

P. spinuliferus Clark, 1938. Translucent white, yellow terminally, covered with small scales above, small: spicules spiny, perforated plates. Uncommon, collected near Broome.

REMARKS: Clark (1946) suggests the small, white species with yellow tentacles, *P. minutus,* from Lord Howe Is. may be found on the N.S.W. and Queensland coast. A further grey-black species, *Psolidium nigrescens*, is known from N.S.W.

Family **CUCUMARIIDAE**

These are small to medium sized animals, characteristically with 10 arborescent (dendritic) tentacles of which the lower (ventral) two are often somewhat smaller. Many are found in deeper water, on soft bottoms and away from coral reefs. They use their tentacles to filter food from the water around them.

Cucumaria

C. adela Clark, 1946. This is the name given by Clark to a small, stocky specimen treated by Ekman (1918) and collected southwest of Broome.

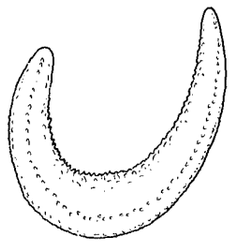
Havlockia

H. versicolor (Semper, 1867). Variably coloured from cream to purple, mostly brown with red-tipped, conical papillae irregularly scattered on upper surface [see Clark (1938) pl. 16, fig. 3 (colour)], small, square in section: spicules squarish tables with two pillars (Fig. 9a). Coastal, tropical, intertidal to 15m among sponges, soft corals and algae.

REMARKS: James (1976) stated *H. mirabilis* was a synonym of *H. versicolor*.

Hemithyone

H. semperi (Bell, 1884). Variably coloured white-brown and red with purple tentacles and tube feet (the latter confined to the ambulacra), small, body pliable: spicules fenestrated ellipsoids and perforated plates (Fig. 9b). Coastal, tropical, intertidal and below.



Leptopentacta grisea

Leptopentacta

L. grisea Clark, 1938. Grey above, white below, small, elongate with

a thin, pentagonal, body which is rigid and curved into a "U" with mouth and cloaca turned up: spicules are smooth, nodular buttons, baskets and lenticular plates. They live immobile in "U-shaped" burrows.

Orbithyone

O. megapodia Clark, 1938. Dull grey/brown, small, cylindrical, tapering posteriorly with a short anal projection, thick body wall covered with numerous scattered tube feet: spicules are lacking from the body wall, but the tube feet have plates and the tentacles rosettes. They are trawled from muddy regions.

Pentacta

These are small to medium sized animals distinctly flattened below with three distinct rows of tube feet, most tube feet confined to ambulacra, tentacles tend to be of equal size, body wall firm, heavily laden with baskets and fenestrated spheres.

P. anceps (Quoy & Gaimard, 1833) (Fig. 8b). Yellow and pink (especially terminally), small, stout and square, body rigid with low papillae, anal papillae prominent, tegument rough [see also Clark, 1938; pl. XVI, fig. 2 (colour)]: spicules small baskets lacking knobs and large flat ellipsoidal bodies (Fig. 9c). Reefs and coastal, intertidal and deeper, exposed on hard or soft substrates.

P. armatus (von Marenzeller, 1881). Grey-brown to white with dark spots, small: spicules thin branched rods and perforated plates and spheres. Found on sea-grass flats from Bunbury to Shark Bay, W.A.

P. australis (Ludwig, 1874). Grey to orange, small papillae more or less evident along corners of the somewhat square firm body, tegument rough: spicules homogeneous sized baskets. Reefs and coastal, concealed among rubble, reef flat and rocky shore.

P. crassa (Ekman, 1918). Grey with pink below, medium [see Clark, 1938; pl. XVI, fig. 1 (colour)]: spicules small stout baskets or plates, both with large knobs, and irregular rods. They are found inert on mud.

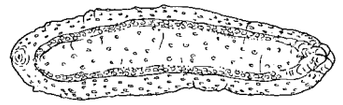
P. quadrangularis (Lesson, 1883). Grey, small to medium with prominent tapering papillae along corners of somewhat square body [see Semper (1868) pl. XI, fig.1 (colour) and Clark (1938); pl. XVI, figs. 4 and 5 (colour)]: spicules baskets and perforated ellipsoids. Coastal, dredged and trawled.

REMARKS: *P. quadrangularis* and *P. anceps* are fairly distinctive: *P. australis* is somewhat more variable. A further species *P. jaegeri* may be difficult to distinguish from *P. quadrangularis*. *P. cucumis* and *P. minuta* are not well known. *P. armatus* was considered a variety of *australis* by Erwe (1913); *P. robusta* and *P. dispar* are 2 small species from W.A. recorded by Ekman (1918), the latter may be a form of *australis*.

Plesiocolochirus

Small to medium species in which the tube feet are not confined to the ambulacra (at least below) and the body is crowded with spicules.

P. challengeri (Theel, 1886). Brown with white spots, green tentacles and yellow tube feet, medium, trapezoidal in section and tapering towards the ends, rigid and rough with numerous white calcareous protuberances: spicules small nodular buttons, baskets and large plates (Fig. 9d). Coastal, dredged in 15-60m.



Plesiocolochirus challengeri

P. spinosus (Quoy & Gaimard, 1833). Dull grey and red, small and stocky, with series of lateral papillae: spicules nodular buttons and baskets. Recorded from NSW and China.

REMARKS: A further small species, *P. gazelle*, is brilliant red and was taken in 2-6m of water in N.W. Australia by the 'Gazelle' expedition.

Pseudocolochirus

These are stout with papillae on upper surface and tube feet on lower more or less confined to the ambulacra: spicules are depauperate.

P. axiologus (Clark, 1914) (Fig. 8c). Ambulacra bright red, inter-ambulacra yellow to blue, medium to large, stout and cylindrical, oral end turned up and tapering, body pliable, tegument smooth and slippery: spicules small perforated plates, sometimes absent in larger specimens (Fig. 9e). Reefs and coastal, exposed on hard substrates, found below 10m.

REMARKS: Another species *P. violaceus* from S.E. Asia has been reported – from collections in the British Museum – from northern Australia (Clark & Rowe, 1971).

Staurothyone

Small with ten equal tentacles: spicules are sparse, but scattered all over body; they are stout cruciform plates and tiny rosettes.

S. distincta Clark, 1938. Grey-brown, cyclindrical (not tapering at ends), tube feet yellow-brown, numerous, but denser below: spicules distinctive, even cruciform plates, minute rosettes and rods. Dredged from Broome, W.A.

REMARKS: A further species, probably *rosacea*, was found off northwestern Australia by the 'Gazelle' expedition (see Clark, 1938).

Stolus

Small animals with tube feet scattered equally over the body, ten tentacles (lower two smaller): spicules are buttons not tables.

S. buccalis (Stimpson, 1855). Dark, purple-black, brown or grey, small, firm and cylindrical, tegument smooth: spicules small nodular buttons (Fig. 9f). Coastal to temperate regions, below stones, intertidal flats.

Thyone

Small to medium, tube feet scattered over body, ten tentacles (lower two are smaller): spicules when present tables not buttons.

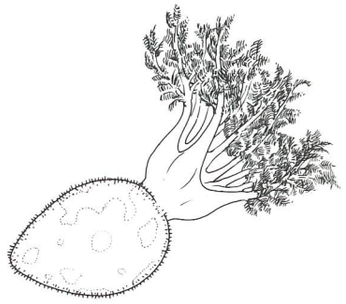
T. grisea Clark, 1938. Grey or red-brown, even purple, small, tapering to ends and covered with papillae: spicules numerous stout tables with oval perforated disks, spire low, the 2 pillars lean together. Dredged, from northwest.

T. micra Clark, 1938. Pale brown with darker tentacles, small, elongate, cylindrical and tapering: spicules abundant tables with stout elongate disk with 4 holes and 2 low spires not always touching. Buried in sandy mud with shells, northwest coast.

T. okeni Bell, 1884. Mottled red-brown, small, short, cylindrical, tapering to posterior, body thin and pliable [see Rowe & Doty, 1977; fig. 8a (colour)]: spicules absent from body wall and only terminal plates seen in tube feet. Coastal, buried in sand flats.

T. papuensis Theel, 1886. Brown-black, small, firm and cylindrical: spicules rather open tables (Fig. 9g). Reefs and coastal, buried in sand flats.

REMARKS: Clark (1932) reported another species, *T. perforata*, from Low Isles, dredged from mud and gravel in 20m, it was grey, small, cylindrical with brown tentacles and hard anal papillae. Clark (1938) reported on two other species, a small white form, *T. dura*, (called *alba* by Clark) from sandy mud and a larger white form with dark papillae, and *T. perissa* – a species of doubtful status, from a rock hole from northwestern Australia. A revision of this genus would seem warranted.



Thyone papuensis

Family **PHYLLOPHORIDAE**

Small to medium sized dendrochirotes with more than ten tentacles in one to three rings, typically the outer tentacles are longer for feeding and the inner ones shorter for cleaning. Most occur below boulders or buried in the substrate.

Actinocucumis

A. typicus Ludwig, 1874 (Fig. 8a). Red-brown to purple, small to medium, slender, tapering towards ends, body rigid, tegument tough, tube feet confined to ambulacra, 20 tentacles: spicules figure-of-eight fenestrated ellipsoids (Fig. 9h) and irregular tables. Coastal, below rocks or dredged from deeper water (>10m).

Afrocucumis

A. africana (Semper, 1868) (Fig. 8d) . Black to purple, small, cylindrical, tapering at the ends, covered with tube feet, body thin but firm, tegument smooth, 20 tentacles: spicules large lenticular plates (Fig. 2k). Reefs and coastal, below rocks on reef flat and rocky shores.

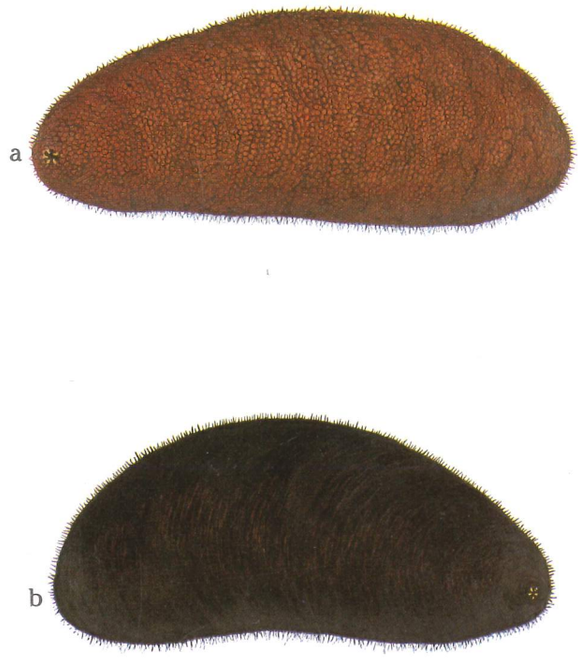


Fig 5.
Some commoner sea cucumbers.
a, *Actinopyga echinites;*
b, *A. miliaris;*
c, *Bohadschia argus;*
d, *B. marmorata;*

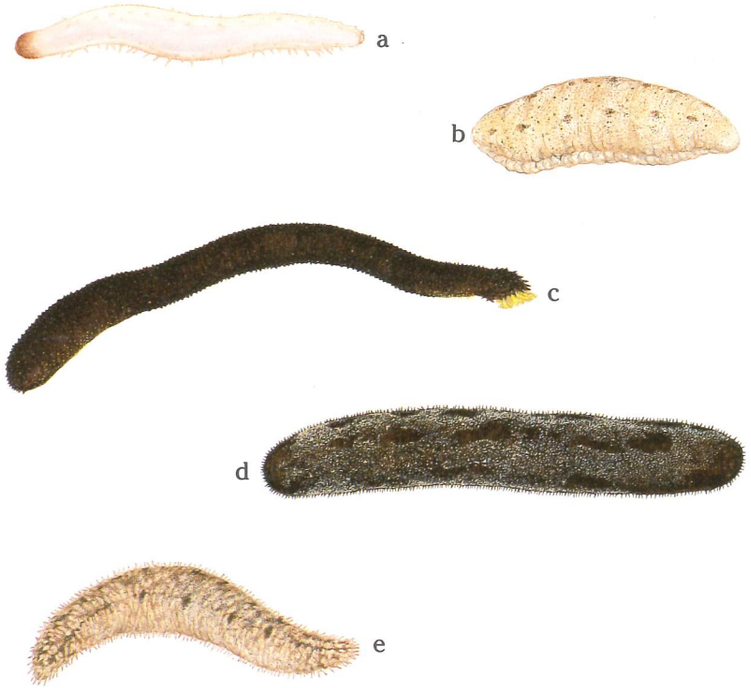


Fig. 6.
Some commoner sea cucumbers.
a, *Labidodemas semperianum;*
b, *Holothuria (Cystipus) rigida;*
c, *H. (Acanthotrapeza) coluber,*
d, *H. (Halodeima) atra;*
e, *H. (Lessonthuria) pardalis;*
f, *H. (Halodeima) edulis.*
g, *H. (Mertensiothuria) leucospilota;*
h, *H. (Mertensiothuria) pervicax;*
i, *H. (Metriatyla) scabra;*

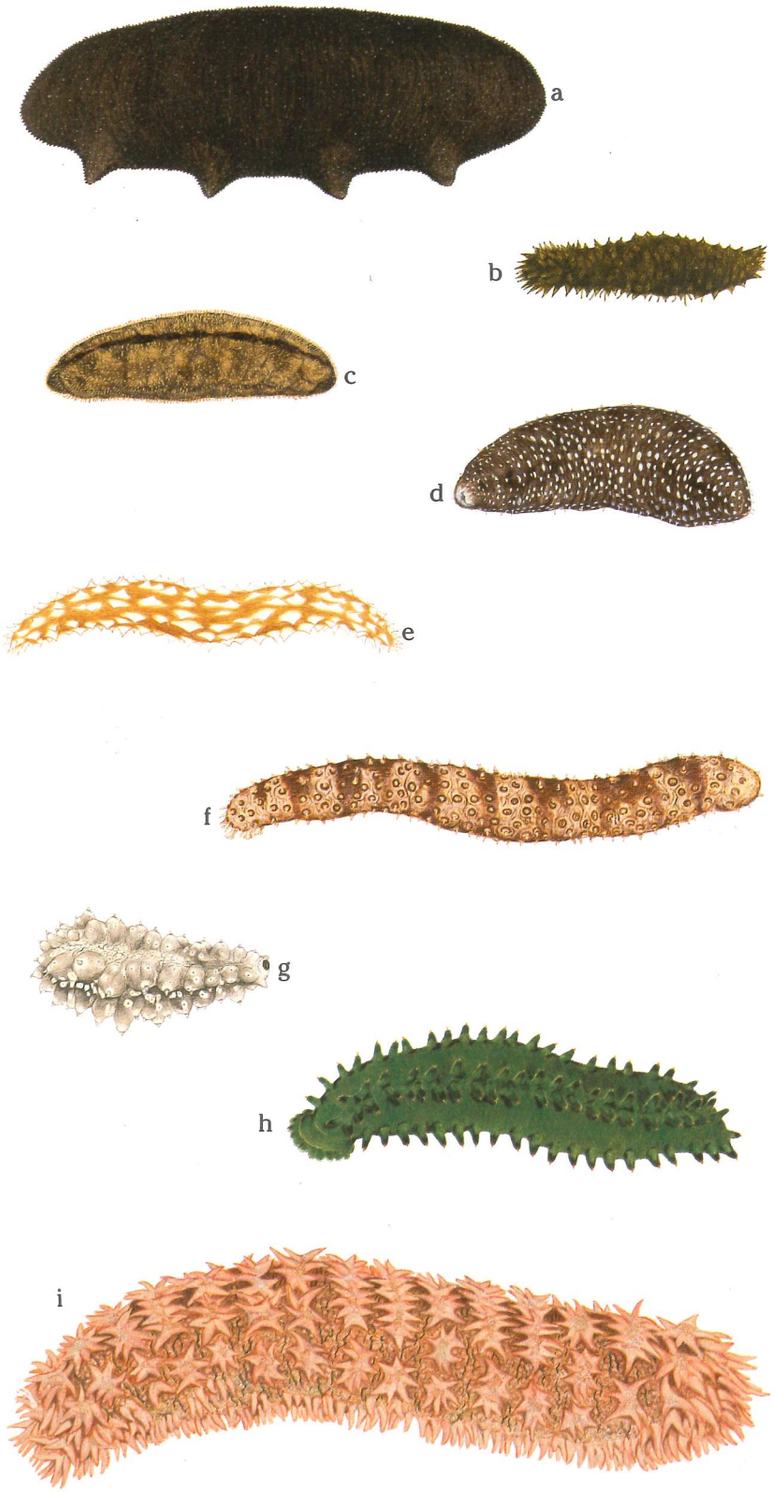


Fig. 7.
Some commoner sea cucumbers.
a, *Holothuria (Microthele) nobilis;*
b, *H. (Platyperona) difficilis;*
c, *H. (Selenkothuria) erinaceus;*
d, *H. (Theelothuria) notabilis;*
e, *H. (Thymiosycia) hilla;*
f, *H. (Thymiosycia) impatiens;*
g, *Stichopus horrens;*
h, *S. chloronotus;*
i, *Thelenota ananas;*

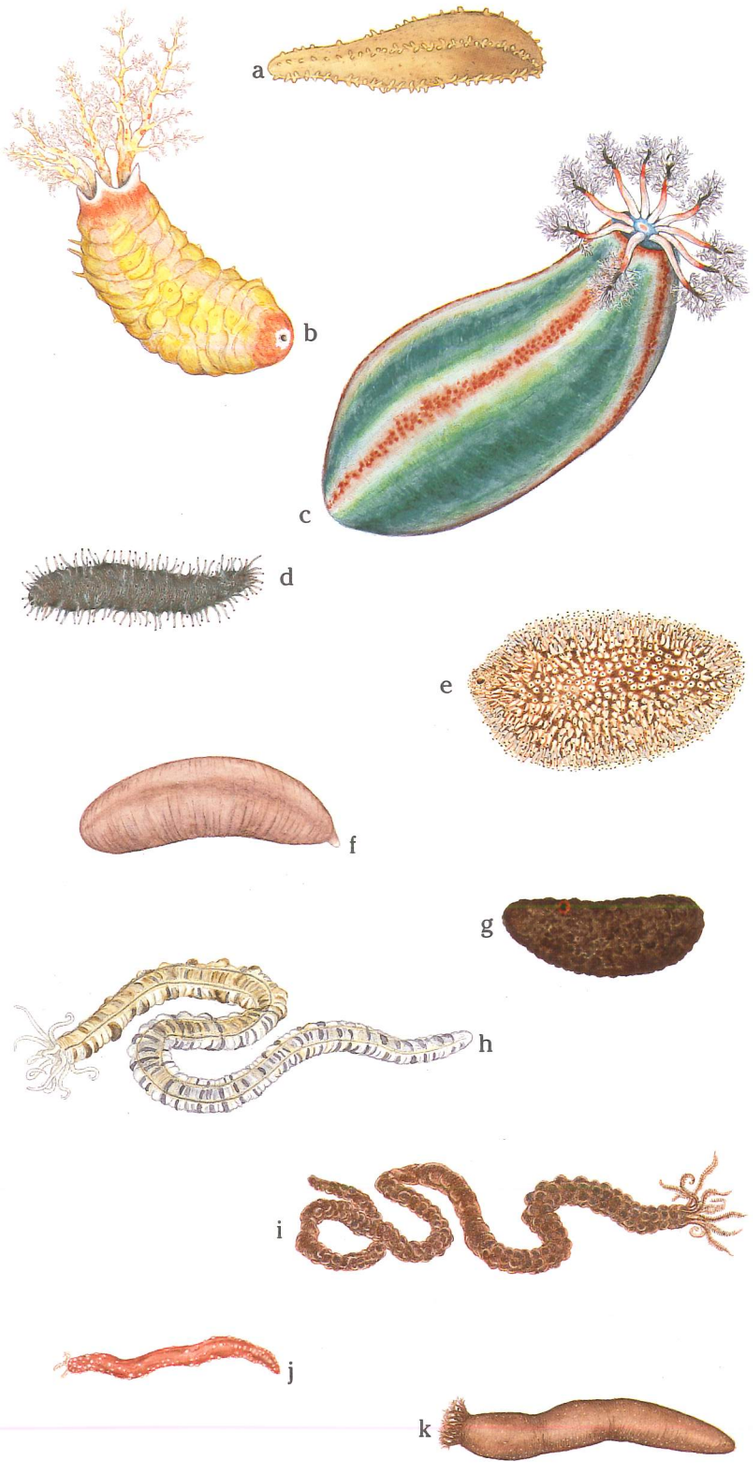


Fig. 8.
Some commoner sea cucumbers.
a, *Actinocucumis typicus;*
b, *Pentacta anceps;*
c, *Pseudocolochirus axiologus;*
d, *Afrocucumis africana;*
e, *Cladolabes perspicillum;*
f, *Paracaudina australis;*
g, *Phyllophorus (Urodemella) holothurioides;*
h, *Euapta godeffroyi;*
i, *Synaptula recta;*
j, *Chiridota rigidia;*
k, *Polycheira rufescens.*

Cladolabes

Small to medium size, 20 tentacles in three rows, spicules characteristically unbranched rods.

C. acicula (Semper, 1868). Orange, brown or black, small, short, covered with tube feet, tentacles brown speckled with white [see Clark (1921) pl. 19, fig. 2 (colour)]: spicules short smooth sharp rods. Reefs, below rocks.

C. perspicillum (Selenka, 1867) (Fig. 8e). Orange-red with white tube feet all over, small to medium, stout and ovoid, body firm, tegument smooth: spicules short rods. Coastal, buried in sea-grass beds.

C. schmeltzi (Ludwig, 1874). Light to dark brown, small, short, covered with tube feet: spicules short spiked rods(Fig. 10a) Reefs and coastal, below rocks and rubble.

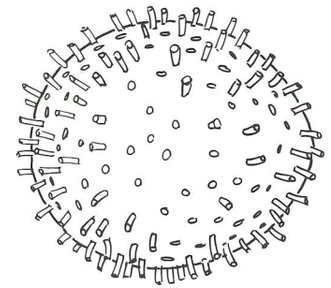
REMARKS: These animals are distinguishable alive, but the spicules provide good confirmation. A single tiny specimen of a further species, *C. hamatus*, was found near Broome (Ekman, 1918).

Mensamaria

M. intercedens (Lampert, 1885). Blue-black with bright red ambulacra [see Clark (1938) pl. 16, fig. 6 (colour)], small, cylindrical, tapering at both ends, tube feet concentrated along ambulacra, body thin and pliable, tegument smooth, 30 tentacles: spicules tables with high spinous spire, pillar with two bridges, disc with four large and four small holes(Fig. 10b) Coastal, intertidal flats, in "U-shaped" burrows or entwined in rhizomes of sea-grasses.

Neocucumis

N. proteus (Lampert, 1885). Red, brown, grey or purple, small to medium, plump and ovoid, covered with large stiff tube feet, body soft and pliable, 20 tentacles in 2 rings: spicules low spinous tables (often knobbed) and branched rods(Fig. 10c) Reefs and coastal, on sand.



Neocucumis proteus

Phyllophorus

P. (Phyllophorella) parvipedes Clark (1938). Pale grey with dark red-brown blotches, small, body wall thin, papillae not regular: spicules low tables with only one bridge. Reported from Broome, W.A.

P. (Phyllothuria) cebuensis (Semper, 1868). Brownish grey, papillae irregular, small [see Semper, 1868; pl. XII, fig. 5 (colour)]: spicules high spired tables with several bridges. Recorded from W.A., poorly known.

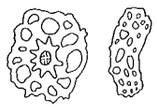
P. (Urodemella) brocki Ludwig, 1888. Yellow brown, a few large papillae, dark purple at the tips: spicules reduced tables with imperfect spire and thorny plates. Reported from W.A.

P. (Urodemella) holothuroides Ludwig, 1874 (Fig. 8g). Brown to grey, small, firm, tube feet scattered, 20 tentacles in two rings: spicules reduced tables, thorny plates(Fig. 10d) Dredged.

REMARKS: The sub-genera of *Phyllophorus* are separated upon spicule characteristics, thus (*Urodemella*) have reduced tables and thorny plates, (*Phyllothuria*) have high-spired tables with several bridges and (*Phyllophorella*) have low tables with only one bridge.

Phyrella

P. trapeza (Clark, 1932). Yellow-brown with brown tentacles, small, cylindrical and curved, tapering towards ends, covered with tube feet, 20 tentacles in two rings: spicules low spired tables and perforated plates(Fig. 10e) Dredged from shell and gravel.



Phyrella trapeza

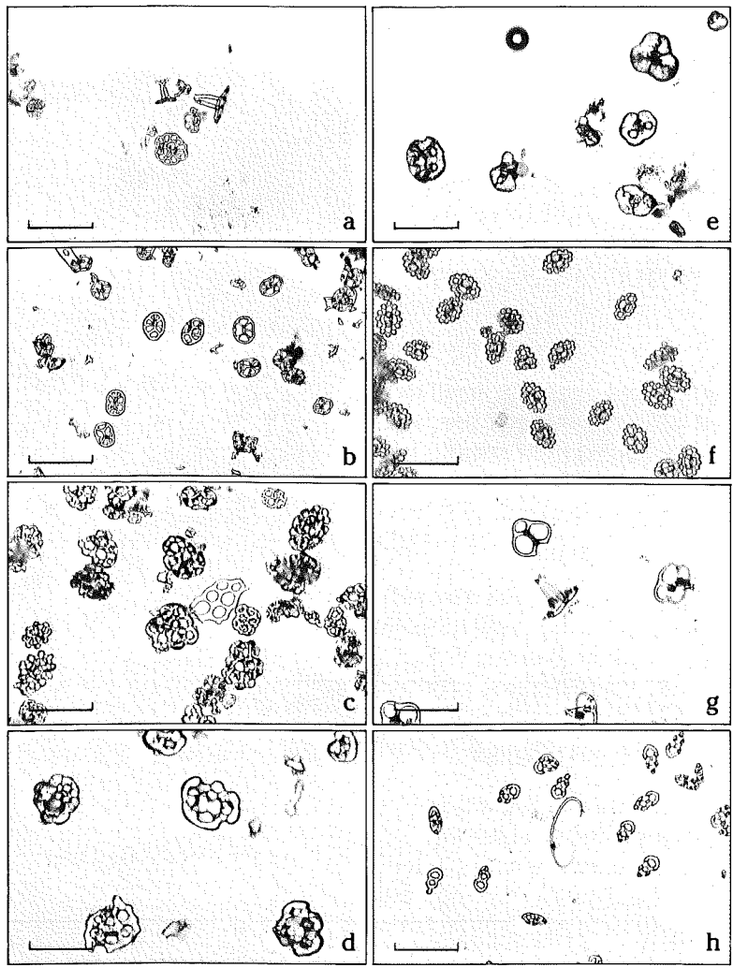


Fig. 9.
Spicule photomicropgraphs – Dendrochirotida.
(Scale in parentheses).
a, *Havlockia versicolor* (200 μm);
b, *Hemithyone semperi* (200 μm);
c, *Pentacta anceps* (200 μm);
d, *Plesiocolochirus challengeri* (200 μm);
e, *Pseudocolochirus axiologus* (200 μm);
f, *Stolus buccalis* (200 μm);
g, *Thyone papuensis* (200 μm);
h, *Actinocucumis typicus* (200 μm);

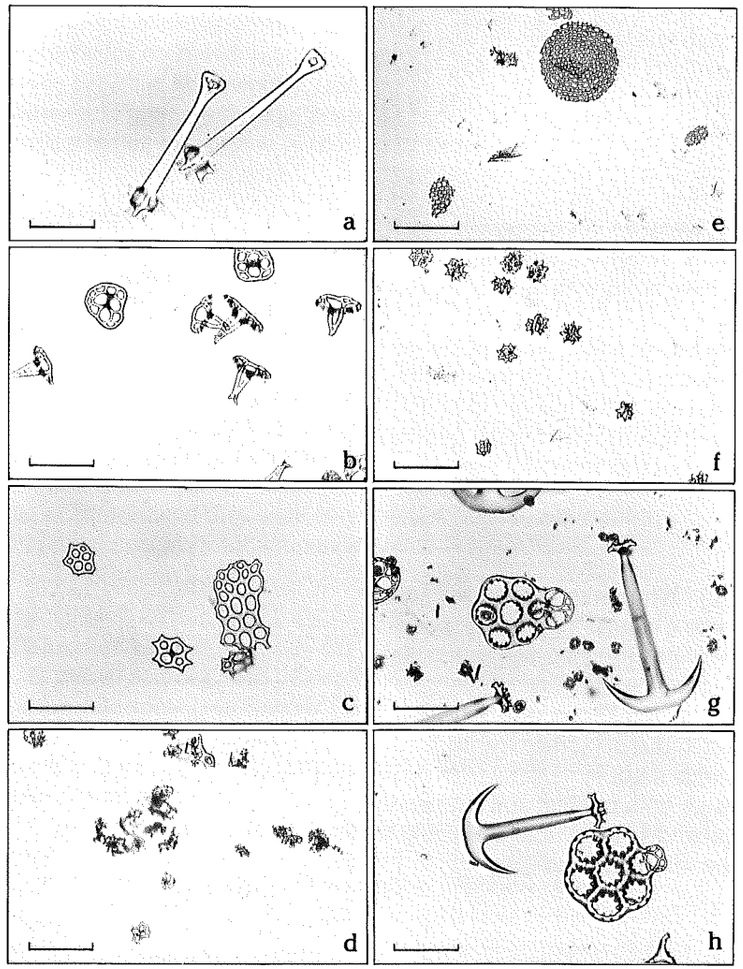


Fig. 10.
Spicule photomicrographs – Dendrochirotida: Molpadida: Apodida.
(Scale in parentheses).
a, *Cladolabes schmeltzi* (50 μm);
b, *Mensamaria intercedens* (200 μm);
c, *Neocucumis proteus* (200 μm);
d, *Phyllophorus* (*Urodemella*) *holothurioides* (200 μm);
e, *Phyrella trapeza* (500 μm);
f, *Paracaudina australis* (200 μm);
g, *Euapta godeffroyi* (200 μm);
h, *Opheodesoma glabra* (200 μm).

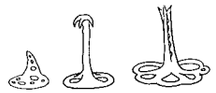
Order **MOLPADIDA**

Family **MOLPADIIDAE**

These are small, smooth or slimy creatures that live in soft sediments often in deeper water. They are sluggish. Only one has been recorded from northern Australia and this was found in the Northern Territory.

Molpadia

M. altimensis Clark, 1938. Rusty red, tentacles and tip of tail white, body thin but rough: spicules tables with moderate spire and numerous cross bars; there are similar forms with 4 recurved spines at the top. Dredged from soft black mud.



Molpadida altimensis

Family **CAUDINIDAE**

Small to medium sausage-shaped animals with thin body wall and lacking tube feet. These sluggish animals burrow in soft sediments and have the often attenuated caudal region extended to the surface, presumably for respiration for they possess respiratory trees.

Acaudina

A. delicata (Clark, 1938). Pale grey, tentacles yellow-brown, small, body wall thin and delicate: spicules widely scattered delicate perforated plates, the larger ones have holes with dentate margins. Reported from sandy mud in W.A.

A. leucoprocta (Clark, 1938). Purple-brown with a white posterior and cloacal lining, medium, cylindrical and tapering to a blunt posterior with a thick and soft body wall and a smooth or slimy tegument, 15 tentacles: spicules are short rods and small perforated plates. Reported from W.A., they are coastal, intertidal and below, and live buried in sand or mud.

Paracaudina

P. australis (Semper, 1968) (Fig. 8f) . White with a pink cast, small to medium, cylindrical, tapering with a caudal appendage, body thin and soft, tegument smooth: spicules irregular perforated plates (Fig. 10f) Coastal, buried in soft intertidal sediments.

P. chiliensis (Müller, 1928). White with purple cast near posterior, small to medium: spicules perforated plates (some cup-like). Coastal, buried 10–20cm below sandy mud.

REMARKS: *P. australis* is known from both tropical and temperate Australia. *P. chiliensis* is wide spread in the Pacific and according to Clark (1938) in Australia it is of the variety *ransonetti.*

Order **APODIDA**

Family **SYNAPTIDAE**

Small to quite large (*Synapta maculata* grows to 2m in length), long and snake-like. They lack both respiratory trees and tube feet. They are reasonably active, propelling themselves with waves of peristaltic contractions and aided by the adhesive nature of their tegument. The adhesion derives from their anchor-like spicules which may protrude through the skin. While some species can be very variable in colour and size, many species bear a close resemblance to one another – identification must be checked on spicule form. Clark (1907) and Heding (1928) should be consulted for an overview of this family.

Euapta

E. godeffroyi (Semper, 1868) (Fig. 8h) . Mottled cream-white with grey, green or brown longitudinal stripes, medium to large, 15 tentacles each with numerous pairs of digits [see also Rowe & Doty, 1977; fig. 8b (colour)]: spicules anchors with tiny knobs on vertex and plates with large posterior holes (Fig. 10g) Reefs, concealed among rubble of reef flat or slope.

Leptosynapta

L. dyscrita Clark, 1938. Translucent white, small and worm-like: spicules anchors and plates, but with small miliary granules and rods in the longitudinal muscles and tentacles. Found in sandy mud, W.A.

L. latipatina Clark, 1921. White with minute pink spots, small, 12 tentacles: spicules anchors and plates and mainly small 'C' shaped miliary granules. It is known only from the one specimen which Clark collected under a rock in Torres Strait.

REMARKS: Although Clark erected the species *dyscrita* and *latipatina* he acknowledged they were very like *L. dolabrifera*, a common intertidal species from temperate Australia [(see Rowe, 1982; fig. 32-4 (colour)].

Opheodesoma

O. glabra (Semper, 1868). Deep brown or grey sometimes flecked with white spots [see Semper (1868) pl. II (colour)], large, 15 tentacles: spicules anchors have knobs on vertex, anchor plates have a sharp posterior constriction (Fig. 10h) Reefs or coastal, sea-grass or mud flats.

O. grisea (Semper, 1868). Colour variable – white, green, grey, red, medium to large, 15-17 tentacles [see Rowe & Doty, 1977; fig. 8g (colour)]: spicules anchors with knobs on vertex, plates with a sharp posterior constriction. Reefs, below rocks of reef flat and deeper.

REMARKS: There are records also of *australiensis* and *ramispicula*: but there is doubt as to the distinction between the species of *Opheodesoma*, though *glabra* is recorded with smaller (<275 µm), narrower (half of length) anchors than *grisea*.

Pendekaplectana

P. nigra (Semper, 1868). Dark brown, brown tentacles with a dark stripe on outer side, large, 15 tentacles: spicules anchors with knobs at vertex, bases unbranched and small branched miliary bodies (Fig. 11a). Reefs, on flat.

Polyplectana

P. kefersteini (Selenka, 1867). Brown flecked with white, large, usually 25 tentacles (16-27) [see Rowe & Doty, 1977; fig. 8f (colour)]: spicules anchors with knobs at vertex, bases unbranched (Fig. 11b). Reefs, amongst rubble on flat.

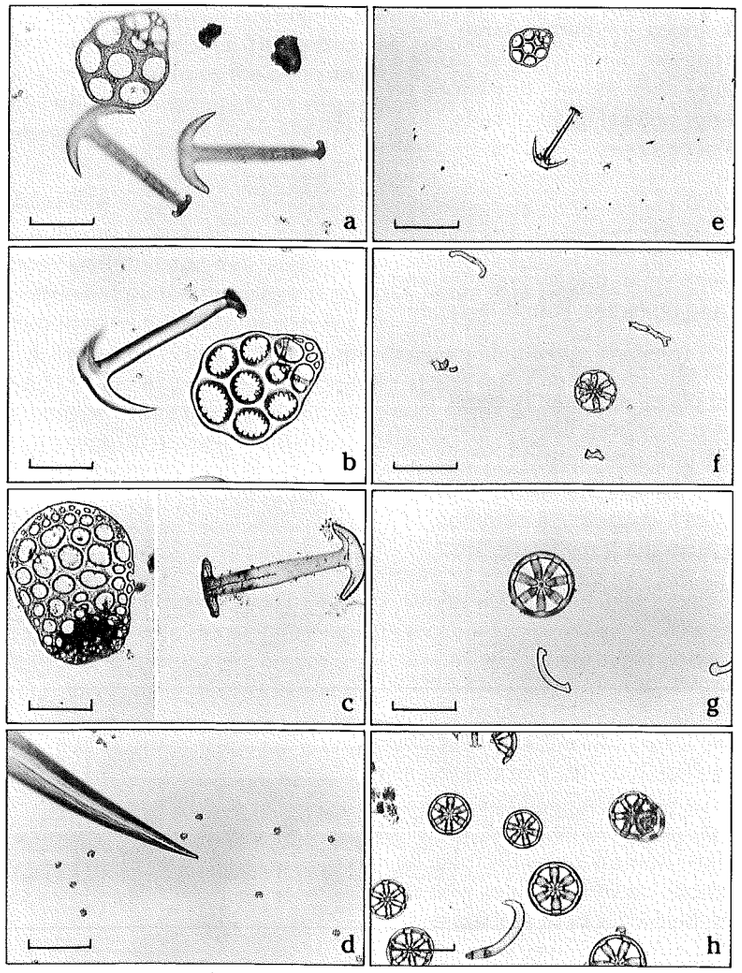


Fig. 11.
Spicule photomicrographs – Apodida.
(Scale in parentheses).
a, *Pendekaplectana nigra* (200 µm);
b, *Polyplectana kefersteini* (200 µm);
c, *Protankyra verrilli* (200 µm);
d, *Synapta maculata* (200 µm);
e, *Synaptula recta* (500 µm);
f, *Chiridota rigida* (100 µm);
g, *Polycheira rufescens* (100 µm);
h, *Taeniogyrus australianus* (200 µm);

Protankyra

P. similis (Semper, 1868). Translucent red, small, ten tentacles each with four digits [see Clark, 1907; pl. II, fig. 2 (colour)]: spicules anchors with smooth vertex and long arms, plates irregular with numerous small holes. Coastal mangroves and brackish areas.

P. verrilli (Theel, 1886). White with scattered red spots, small [see Clark (1938) pl. 15, fig. 4 (colour)]: spicules anchor arms short (Fig. 11c). On firm sand, deeper water.

REMARKS: A typographical error in Clark & Rowe (1971) assigns the record of *verrilli* to the Philippines.

Synapta

S. maculata (Chamisso & Eysenhardt, 1821). Variable colours (brown-yellow) with broad longitudinal stripes and large dark patches, large, 15 tentacles [see Clark, 1907; pl. I, fig. 1 (colour) and Rowe & Doty, 1977; fig. 8e (colour)]: spicules characteristically very large anchors (500 µm-2000 µm long) with smooth vertex (Fig. 11d). Reefs, exposed on sea-grasses, weeds, or below rubble.

Synaptula

S. recta (Semper, 1868) (Fig. 8i). Colour variable often dark, medium to large, 13 tentacles: spicules anchors with knobs at vertex, bases unbranched and small, curved, knobbly miliary bodies (Fig. 11e). Reefs and coastal, exposed on sea-grass and sand flats.

REMARKS: Reference to the records (p. 59) will show several species of *Synaptula* including *boweniensis, indivisa, macra, reticulata* and *rubra*. Clark (1946) urged a revision of the group. Evidently *recta* is by far the most common form.

Family **CHIRIDOTIDAE**

Small, worm-like animals with thin smooth body wall, lacking tube feet: spicules include characteristic wheels in most species. Many species are superficially alike when alive.

Chiridota

C. rigida Semper, 1868 (Fig. 8j). Red or pink, somewhat translucent with white speckles made up of the spicule clusters, small, 12 white tentacles [see also Rowe & Doty, 1977; fig. 8d (colour)]: spicules characteristic wheels but lacking sigmoid bodies (Fig. 11f). Reefs and coastal, below sand under rocks.

Polycheira

P. rufescens (Brandt, 1835) (Fig. 8k). Brown or red-black, small, soft and wrinkled, 18 tentacles: spicules wheels but no sigmoid bodies (Fig. 11g). Reefs and coastal in tropics, under rocks inshore.

Taeniogyrus

T. australianus (Stimpson, 1856). Yellow, translucent, small, with 10 tentacles: spicules wheels in which the inner serrations are not

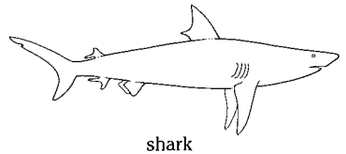
grouped and sigmoid bodies (Fig. 11h). This is a temperate species from the coast of N.S.W. [see Bennett, 1966; plate 158 (b)].

Trochodota

T. maculata Clark, 1921. Pale pink, spotted with darker pink, small, with 10 tentacles: spicules wheels in which the inner serrations are grouped and sigmoid bodies. Found in sand, reef and coastal. A related temperate species, *T. shepardi*, is illustrated in Rowe (1982) [see fig. 32 – 5 (colour)].

Biology

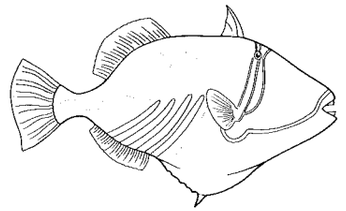
Although holothurians are typically sluggish they are able to move about in several ways. They can walk with their tube feet, pull themselves along with their tentacles, or creep along the bottom with peristaltic contractions of the body wall. Some members of the family Stichopodidae are able to swim short distances by undulating their bodies. All species are capable of locomotion, but many are sedentary, particularly burrowing species and suspension feeders.



shark

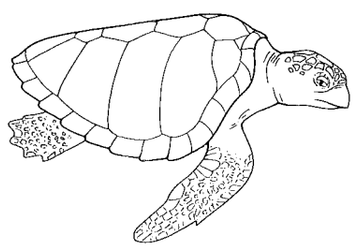
Holothurians may ingest large quantities of sand and mud from which they consume bacteria and detritus or suspended matter for those that use their tentacles as filter feeding structures. Larger organisms such as algae and meiofauna, if ingested, can pass through the digestive tract undamaged. Food particles within the gut are engulfed and digested by coelomocytes, motile cells which pass through the wall of the gut. There are several types of coelomocytes which are found throughout the body and perform a variety of functions, e.g. transport of nutrients and oxygen, elimination of wastes, wound healing and regeneration.

Most holothurians are more active at night than during daylight. Even species seen feeding during the day tend to increase their activity at night. A walk or snorkel on the reef at night will reveal species feeding in the open which are normally found under rocks or concealed in crevasses during the day. This nocturnal activity pattern, found in many tropical invertebrates, is thought to have evolved as a response to predation by fish. There are 19 species of fish which have been reported to eat holothurians, including species of snapper, bream, triggerfish, wrasse, and sharks. Holothurians, however, are only an occasional part of the diet of these fish. The large and medium sized holothurians which are found in the open, often in great numbers, appear to successfully avoid significant predation. Large, firm-bodied species such as *Thelenota* and *Actinopyga* may be too large (or too tough) to be eaten. In addition tropical holothurians have compounds in their body wall which renders them toxic and unpalatable to most predators. A relatively small species, *Holothuria atra*, which is commonly found exposed, has high concentrations of the toxin, **holothurin**, in its body wall. Other small and moderate sized holothurians such as the *Pentacta* species have body walls heavily armoured with calcareous spicules.



trigger fish

There are some predators for which holothurians are important prey. In tropical waters the principal predators on adult holothurians are large predatory gastropods such as tritons, bailers, and *Tonna* species. Loggerhead turtles are known to eat *Stichopus chloronotus*. Some crustaceans have also been reported to attack and



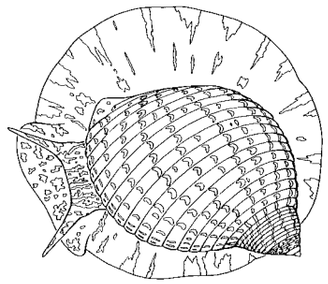
turtle

eat holothurians. Holothurians, however, are probably most vulnerable to predation in their larval and juvenile stages. Juveniles are not commonly collected and they are usually well concealed.

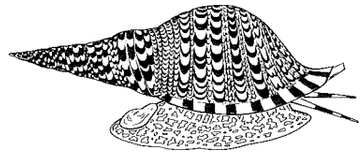
Two noteworthy defence mechanisms are found in aspidochirote holothurians. In the family Holothuriidae many species possess **cuvierian tubules**. Cuvierian tubules are attached to the base of the respiratory trees which are diverticula off the cloaca. When an animal possessing cuvierian tubules is disturbed, it can direct its cloaca towards the source of disturbance and tubules may be released through a small rupture in the cloaca. As the tubules are released they lengthen and become very sticky, adhering to and entangling the disturbing object such as a crab's claw or the hand of a careless collector. An even more unusual defensive behaviour is seen in the Stichopodidae. Many collectors have had the experience of collecting an apparently healthy *Stichopus* only to have it literally disintegrate in their hands: the substance which holds the connective tissue of the body wall together suddenly loses its cohesive properties and the body wall liquifies and falls away. If the animal is returned to seawater and not disturbed the disintegrating process is quickly reversed. This seemingly pathological behaviour appears to be an antipredator device. It has been observed that when specimens of *Stichopus chloronotus* and *S. horrens* were attacked by a predatory gastropod in an aquarium they shed portions of their body wall in contact with the predator and rapidly moved away.

Another unusual behaviour exhibited by aspidochirote and dendrochirote holothurians is their ability to eviscerate, i.e., to eject their internal organs. The viscera are either expelled anteriorly as occurs in *Thyone* or more commonly they are expelled through the cloaca. It is presumed an antipredator mechanism. While it is possible to induce evisceration in most species by chemical treatment, electrical shock, poor aquarium conditions or physical abuse no one has reported observing evisceration in nature. In the tropics very few animals are ever collected which show signs of having recently undergone evisceration. This may be because lost viscera are rapidly regenerated. *Holothuria scabra*, for example, can regenerate a functional gut within nine days following induced evisceration and most species that have been studied regenerate their viscera within two months.

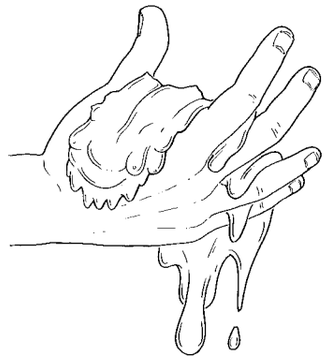
Most animals are host to a diverse assemblage of symbionts (parasites, commensals). Vertebrates, such as fishes, have parasites, especially worms (roundworms, tapeworms), which often use molluscs and crustaceans as hosts of developmental stages. Echinoderms, and holothurians in particular, have symbionts which range from turbellarian worms (a normally free-living group) living in the gut or coelom, to fishes (*Carapus*) which live in the respiratory trees or body cavity. On reefs of the Great Barrier Reef one often finds scaled polychaetes, their colours closely matching that of their host's body, crawling over the surface. In the cloaca of many



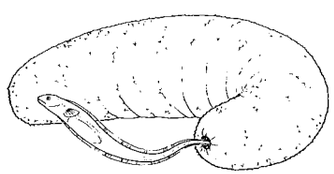
Tonna sp.



triton



Stichopus disintegrating

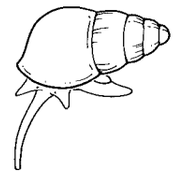


Carapus

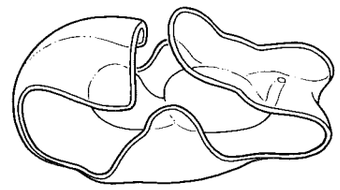
holothurians live small speckled crabs or tiny clams with a reduced shell. In the cloaca and on the tentacles are tiny snails with piercing mouthparts which are used to suck body fluids. Some of the most unusual symbionts are the parasitic gastropods which have become so specialized that the body has been reduced to a sausage-shaped, pink, transluscent tube (up to 150 mm by 20 mm) filled with veliger larvae – the characteristic larvae of gastropods.

Some species are known to undergo asexual fission i.e. are **fissiparous** and there are a few species of hermaphroditic holothurians but the majority are dioecious. Their gonads consist of tubules attached to the anterior portion of the dorsal mesentery and sexes are externally indistinguishable. A few apodus species brood their young but most species release their gametes into the water and fertilization is external. The gametes are released from a genital pore on the anterior mid-dorsal surface. Aspidochirotes spawn by rearing up like a snake and slowly swaying back and forth in the water while dispersing sperm or eggs. Members of the same species within the same area spawn simultaneously for about 20 minutes. Most species reach their peak spawning period during the spring and summer months and some species have a second winter peak.

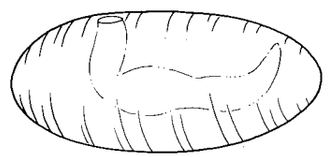
In species with external fertilization the embryo develops into a flagellated, free-swimming larva, an AURICULARIA, in about three days. The auricularia transforms into a DOLIOLARIA larva which develops a water vascular system and a digestive tract. When the larva possesses the five primary tentacles and a few podia it has reached the PENTACTULA stage and is ready to settle out of the plankton as a juvenile.



parasitic snail

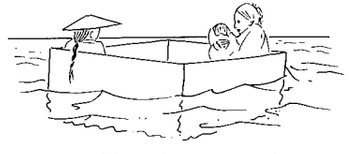


auricularia



doliolaria

pentactula



Mrs Watson's trepang pot

The Bêche-de-mer fishery

Trepang and bêche-de-mer are the common names for the edible species of holothurians. The commercially fished species are large, have thick body walls, and lack sticky cuvierian tubules, i.e. principally *Thelenota ananas* (prickly red-fish), *Actinopyga* spp. (stone-fish, red-fish, black-fish) and *H. (Microthele) nobilis* (teat-fish). The Chinese prepare bêche-de-mer by drying; the animal is cleaned, boiled, and sun-dried or smoked by fishermen. Consumption of bêche-de-mer was first recorded in the 1500s and records of importation of bêche-de-mer date from the 1700s.

When Matthew Flinders sailed through Torres Strait in 1803 he encountered a fleet of Macassan fishing boats (praus). This fleet made yearly trips to northern Australia collecting turtle shell and trepang which they cured. The Macassan fishery began between 1650 and 1700 and may have been the first significant cultural contact between aboriginial and non-Australian societies in pre-colonial times. When South Australia which then controlled what is now the Northern Territory began taxing Macassan praus fishing in Australian waters in 1881 the fishery began to decline and in 1907 the South Australian government ceased issuing licences to Macassan praus.

Matthew Flinders was the first European to note the potential of bêche-de-mer as a profitable industry in Australia. Between the 1840s and 1870s bêche-de-mer was fished on the Great Barrier Reef to satisfy the demand of the Australian Chinese community. Export to Hong Kong and China began in 1874 and by 1880 the industry was flourishing. At its height there were over 100 ships fishing bêche-de-mer. In the early 1900s a Royal Commission was called to investigate possible overfishing and determine how the industry should be regulated. In fact, bêche-de-mer fishing has declined and had virtually disappeared by the end of the World War II. There has been some recent research to see if it could again be economic, but this has shown that costs and hygiene will likely preclude a hunting based industry from ever becoming viable in Australia. A small fishery still exists in some parts of the Indo-west Pacific.

The most famous incident in the history of bêche-de-mer fishing in Australia is the tragic story of the Watson family. The Watsons operated a bêche-de-mer station on Lizard Island. The station was attacked by aborigines but Mrs. Watson with the aid of a chinese servant managed to escape with her baby using a trepang boiling pot as a life-raft. This is now housed in the Queensland Museum. They safely landed on a nearby island only to perish from thirst shortly before they were found by searchers. Today Lizard Island is the site of a research station run by the Australian Museum as well as tourist lodge.

Bêche-de-mer – a favoured dish.

Recipes

Without a permit it is not legal to collect holothurians from marine parks, however, bêche-de-mer may be available through some eastern food outlets. The dried skin of selected species (notably *Actinopyga* spp., *Holothuria (Microthele) nobilis* and *Thelenota ananas*) may be pickled or added to soups and stews. It has a very high protein content and is much prized in some areas of Asia, especially China. The reasons the chinese favour these animals may relate to their enthusiasm for aphrodisiacs – certainly some holothurians are quite phallic and the habit of some to extrude white cuvierian tubules adds to the image. The preparation of sea cucumbers for sale is arduous. Firstly, the fresh animal is washed well and boiled: the larger ones are split open and the guts removed, smaller ones are treated whole. It may then be immersed in sand for two nights after which it is brushed firmly to remove sand and the outer skin layer. Boiling water is then poured over it prior to drying it over a fire.

The purchased dry sea cucumber must be pre-conditioned before cooking.

i Cover with cold water and soak for 12 hours.
ii Simmer for 1-2 hours; ensure always covered with water.
iii Cool to room temperature and drain. Slit open and remove guts if necessary. This procedure may be repeated several times to ensure the animals are thoroughly cleaned.
iv Finally soak for 1-2 hours immediately prior to cooking as they must be soft and swollen.

Below are some recipes for the culinary adventurer.

Pork Balls and Sea-Cucumbers

Cantonese dish to serve 12.

500g pre-conditioned sea cucumber
3 cups oil for frying
1 tbsp cornstarch

2 stalks green onion
2 slices ginger root
1 tbsp rice wine
5 cups water

1/2 tsp salt
1/4 tsp MSG
1/2 egg
1 tbsp cornstarch

250g chopped pork
1 tbsp rice wine
1 tbsp water

1 tbsp black bean paste
1/2 tbsp chopped garlic

1 tbsp oyster sauce
1/2 tsp MSG
1 tsp sugar
1 tsp sesame oil
1/4 tsp black pepper
1 cup stock

Cut sea cucumbers into small pieces and cook for 5 minutes in onion, ginger, wine and water. Drain and discard liquid.

Mix pork with egg, salt, MSG and cornstarch. Roll into 14 balls and deep fry over medium heat for 2 minutes. Remove and drain.

Heat pan and 3 tbsp of oil and stir-fry bean paste and garlic, add 1 tbsp of wine and oyster sauce, stock and spices and bring to a boil. Add sea cucumbers and pork balls and simmer until sauce nearly dry (about 10 minutes), add cornstarch and 1 tbsp of oil to thicken and toss ingredients to cover in sauce.

Remove and serve.

Hoy Sum

A basic recipe from Hong Kong.

6 sea cucumbers (pre-conditioned)
1 tbsp lard
1 clove garlic (chopped)
1/2 tsp minced onion
1/2 tsp minced ginger
1/2 soupbowl chicken stock
1 tbsp Chinese wine

1 tsp light soy sauce
salt to taste
a little MSG
a dash of dark soy sauce
1/2 tsp cornstarch in water

Boil sea cucumbers in water for a few minutes and discard the water.

Heat lard in a pan and briefly fry garlic, onion and ginger before adding other ingredients except the cornstarch. Simmer for 10 minutes, thicken sauce with cornstarch and pour over the sea cucumbers and serve.

Braised Stuffed Sea-Cucumbers

Cantonese dish to serve 12.

500g sea cucumber (4 whole animals)
2 tbsp cornstarch
2 tbsp chopped, fried and dried fish i.e.'bien yu gan'

2 stalks green onion
2 stalks ginger
1 tbsp rice wine
4 cups water

3 cups stock (+ 1/2 tsp sesame oil)
1/2 tsp salt (+ 1/4 tsp black pepper)
1/2 tsp MSG

250g chopped pork
8 toothpicks
1/2 tbsp rice wine

1 tsp cornstarch
1/4 cup water

1/2 tsp MSG
1/4 tsp black pepper
1 tsp salt
1 tsp sesame oil
1 tbsp rice wine
1 tbsp water

Stir fry onion and ginger in pan with 1 tbsp of oil, add 1 tbsp of rice wine and 4 cups of water and bring to a boil. Add pre-conditioned sea cucumbers and cook for 5 minutes over medium heat. Remove from heat, drain and discard liquid.

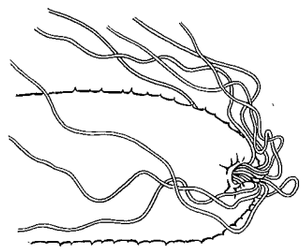
Mix filling: pork, 2 tbsp cornstarch and fried, dried fish.

Dust inside of each animal with cornstarch and stuff with filling, secure with toothpicks.

Reheat pan and 2 tbsp of oil, add 1/2 tbsp rice wine and stock, salt and MSG and bring to boil. Add stuffed sea cucumbers, cover and simmer for 25 minutes to reduce liquid to about 1 cup. Remove sea-cucumbers, discard toothpicks; heat remaining liquid and add 1 tsp of cornstarch and 1/4 cup of water to thicken sauce.

Pour sauce over sea cucumbers and serve.

Bon appetit!



cuvierian tubules discharging

Glossary

AMBULACRA: Five radial, longitudinal regions containing the longitudinal body wall muscles, radial canals of the water vascular system, and the radial nerves.

ANAL TEETH: Triangular calcified papillae (often five) placed radially around the anus.

AQUAPHARYNGEAL BULB: see ORAL COMPLEX.

CALCAREOUS RING: An internal ring of calcareous plates circling the pharynx.

CUVIERIAN TUBULES: Tubules attached to the base of the respiratory trees of some of the Holothuriidae. In some species the tubules are ejected through the cloaca when animal is disturbed.

INTROVERT: The anterior end of dendrochirotid holothurians is modified into a thin-walled structure which contains the oral complex and tentacles. The introvert can be withdrawn inside the body by pharyngeal retractor muscles.

LONGITUDINAL BODY WALL MUSCLES: Five muscles which are attached to the inner side of the body wall and run the length of the body.

ORAL COMPLEX: Consists of the calcareous ring, the water ring and its associated structures, nerve ring, cartilagenous ring (if present), and the pharynx.

PAPILLAE: Fleshy projections of the body wall, usually conical, with a sensory tube foot at its apex. On the upper surface of aspidochirotes these may be modified.

PHARYNGEAL RETRACTOR MUSCLES: Offshoots of the longitudinal body muscles which insert upon the radial plates of the calcareous ring (found only in the Dendrochirotida).

PODIA: see tube feet.

RESPIRATORY TREES: A type of water lung which arise as two diverticula of the cloaca (absent in the Apodida).

RETE MIRABILE: A fine network of haemal tissue that lies along the gut and functions to disperse nutrients and metabolites.

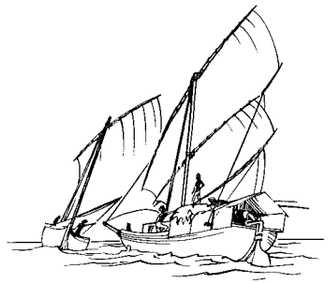
SOLE: A flattened lower (ventral) surface with tube feet for locomotion and attachment. Strictly only in Psolidae, but a well defined flattened lower surface can be recognized in many species.

SPICULES: Minute calcareous particles which comprise the skeleton of the body wall.

TEGUMENT: The outer skin.

TENTACLES: Modified tube feet which surround the mouth. Used for feeding, locomotion, and exploration.

TUBE FEET: Projections of the water vascular system through the body wall which function as locomotory and sensory organs.



Macassan praus

Bibliography

BAIRD, R.H., 1974. (Ed.) 'Bêche-de-mer of the South Pacific Islands: a handbook for fishermen.' (Noumea:South Pacific Commission), 27pp.

BAKUS, G.J., 1968. Defense mechanisms and ecology of some tropical holothurians. *Marine Biology* 2: 23-32.

BAKUS, G.J., 1973. The biology and ecology of tropical holothurians. pp. 325-67. In JONES, O.A. and ENDEAN, R. (Eds.) 'Biology and Geology of Coral Reefs. vol. 2' (New York:Academic Press).

BELL, F.J., 1884. Echinodermata. In COPPINGER, R.W. (Ed.) 'Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of *H.M.S. Alert,* 1881-2' (London:British Museum).

BENNETT, I. 1966. 'The Fringe of the Sea.' (Sydney:Rigby Ltd.).

CHERBONNIER, G., 1980. Holothuries de Nouvelle-Caledonie. *Bulletin du Muséum d'histoire naturelle, Paris.* IV ser. 2: 615-67.

CLARK, A.M. and ROWE, F.W.E., 1971. 'Monograph of shallow water Indo-west Pacific Echinoderms.' (London:British Museum).

CLARK, H.L. 1907. The apodous holothurians. *Smithsonian Contributions to Knowledge* 35: 1-206.

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.

CLARK, H.L., 1922. Holothurians of the genus *Stichopus. Bulletin of the Museum of Comparative Zoology at Harvard* 65: 39-74.

CLARK, H.L., 1938. Echinoderms from Australia. *Memoirs of the Museum of Comparative Zoology of the Harvard College* 55: 1-596.

CLARK, H.L., 1946. The Echinoderm Fauna of Australia: its composition and its origin. *Publications of the Carnegie Institution of Washington* 566: 1-567.

EKMAN, S., 1918 Holothurioidea of Dr Mjoberg's Expedition to Australia. *Kunglia Svenska vetenskapsakademiens handlinger. Stockholm.* 58(6): 70pp.

ENDEAN, R., 1953. Queensland faunistic records. Pt. III. Echinodermata (excluding Crinoidea). *Papers. Department of Zoology, University of Queensland* 1(3): 53-60.

ENDEAN, R., 1956. Queensland faunistic records. Pt. IV. Further records of Echinodermata (excluding Crinoidea), *Papers. Department of Zoology, University of Queensland* 1(5): 121-40.

ENDEAN, R., 1961. Queensland faunistic records. Pt. VII. Additional records of Echinodermata (excluding Crinoidea). *Papers. Department of Zoology, University of Queensland* 1(13): 289-98.

ENDEAN, R., 1965. Queensland faunistic records. Pt. VIII. Further records of Echinodermata (excluding Crinoidea) from Southern Queensland. *Papers. Department of Zoology, University of Queensland* 2(11): 229-35.

ERWE, W., 1913. Holothurioidea. pp. 349-402. In MICHAELSEN, W. & HARTMEYER, R. (Eds.) 'Die Fauna Südwest-Australiens, Vol. 4.' (Jena: Fischer).

FISHER, W.K., 1907. The holothurians of the Hawaiian Islands. *Proceedings of the United States National Museum* 32: 637-744.

HEDING, G.S., 1928. Synaptidae. *Videnskapelige Meddeleser fra Dansk naturhistorisk Forening i Kjobenhavn* 85: 105-323.

HEDING, G.S., 1931. On the classification of the Molpadids. *Videnskapelige Meddeleser fra Dansk naturhistorisk Forening i Kjobenhavn* 92: 275-84.

HEDING, G.S. and PANNING, A., 1954. Phyllophoridae. Eine Bearbeitung der polytentaculaten dendrochiroten Holothurien des zoologishen Museums in Kopenhagen. *Spolia zoologica Musei hauniensis* 13: 7-209.

HYMAN, L.H., 1955. 'The Invertebrates. IV. Echinodermata' (New York: McGraw-Hill).

JAMES, D.B., 1976. Studies on Indian echinoderms. 6. Redescription of two little known holothurians with a note on an early juvenile of *Holothuria scabra* Jaeger from Indian seas. *Journal of the Marine Biological Association of India* 18: 55-61.

LAMBERSON, J.O., 1978. Notes on the morphology, ecology and distribution of *Thelenota ananas. Micronesica* 14: 115-22.

LUDWIG, H., 1875. Beiträge zur Kenntniss der Holothurien. *Arbeiten aus dem zoologisch-zootomischen Institut in Würzburg* 2: 77-120.

MacNIGHT, C.C., 1976. The voyage to Marege': Macassan trepangers in northern Australia. (Melbourne:Melbourne University Press).

ROBERTS, C., 1979. Deposit feeding mechanisms and resource partioning in tropical holothurians. *Journals of Experimental Marine Biology and Ecology* 37: 43-56.

ROWE, F.W.E., 1969. A review of the family Holothuriidae (Holothurioidea Aspidochirotida). *Bulletin of the British Museum (Natural History)* (Zoology). 18: 119-70.

ROWE, F.W.E., 1982. Sea cucumbers (Class Holothurioidea). pp. 454-476. In SHEPARD, S.A. and THOMAS, I.M., (Eds.) 'Marine Invertebrates of Southern Australia. Part I.' (Adelaide: Government of South Australia).

ROWE, F.W.E. and DOTY, J.E., 1977. The shallow water holothurians of Guam. *Micronesica* 13: 217-50.

SEMPER, C., 1868. Holothurien. In 'Reisen im Archipel der Philippinen. 2. Wissenschaftliche Resultate.' (Wiesbaden: Kreidel).

SLOAN, N.A., CLARK, A.M. and TAYLOR, J.D., 1980. The echinoderms of Aldabra and their habitats. *Bulletin of the British Museum (Natural History)* (Zoology). 37: 81-128.

SLUITER, C.P., 1901. Die Holothurien der Siboga Expedition. *Siboga Expeditie* 44: 1-142.

THEEL, H., 1886. Holothurioidea. Pt. 2. *Report on the Scientific Results of the Voyage of the H.M.S. 'Challenger'* (Zoology) 39: 1-290.

TRACEY, D.J., 1972. Evisceration and regeneration in *Thyone okeni* (Bell, 1884). *Proceedings of the Linnean Society of New South Wales* 97: 72-81.

Records from Northern Australia

Holothurians (Class Holothurioidea: Phylum Echinodermata) from northern Australia (Clark & Rowe, 1971) and including some overlap with temperate species (Rowe, 1982). (Numbers refer to pagination).