Taxonomy, Systematics and Biogeography of South African Echinoidea (Echinodermata)

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A thesis submitted in fulfillment of the degree of Master of Science in the Department of Biological Science, Faculty of Science, University of Cape Town

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“The lack of expertise is neither new to South Africa nor unique. It is depressing that the number of taxonomists is decreasing at a time when our appreciation of marine biological diversity is just starting to develop.” – Gibbons et al. (1999)
Plagiarism declaration

This dissertation has been compiled by Zoleka Filander and the work presented here is a direct result of original research carried out at the Marine Biology Research Center, Biological Science Department, University of Cape Town. This work has not been submitted for a degree at any other university and any assistance I received is fully acknowledged.

In Chapter 3, I have used the species diagnosis of previous authors; rewriting them and adding information were applicable. It is however, important to note that wording of taxonomic texts can be problematic, as meaning is often altered. In every case I have referenced the author of literature used and acknowledged their work.

SIGNITURE: ___________________ DATE: ___________________
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Abstract

The South African Echinoidea (Echinodermata) were last reviewed by Clark & Courtman-Stock (1976) and numerous unidentified specimens and records have accumulated since that time, plus there have been many taxonomic changes within the group. Therefore this study, which forms the first of its kind in 37 years, aims to update knowledge on the diversity and distribution patterns of South African echinoids and to provide a user-friendly, well-illustrated guide to the group. Dry and wet specimens, particularly those within the extensive collections of the Iziko South African Museum, were morphologically examined and identified, and the associated data were added to a database. Other data considered in this study include; historic data from the South African Museum and University of Cape Town catalogues, imagery data from the EchinoMap VM open-online database, trawl by-catch data from the Department of Forestry and Fisheries, and data from published literature. These resulted in 19 new records for the region, of which 84.2% were Indo-Pacific, 5.3% introduced, and the remaining 10.5% non-endemic, raise the total number of known species to 71.

All species were photographically illustrated and a field guide is presented which included synonymy and previous literature for each species, one of more photographic illustrations, a distribution map, description and notes on global distribution. In terms of biogeography the regional echinoid fauna comprises 26.8% endemics, 1.4% introduced, and 71.8% non-endemics; across 14 orders and 29 families. As expected, species richness pattern increased from west to east coast. However, the east coast displayed the lowest number of records; as compared to the South coast, which had the highest. Endemism peaked on the south coast and the west and east coast both supported the same level of endemics. The only introduced species, *Tetrapygus niger*, was from the west coast region. In terms of depth; species richness was highest in < 500 m and lowest in > 500 m. This may be a result of the deep-seas (> 500 m) being severely under-sampled. The lack of full-time taxonomists and lack of expertise to review this group may have contributed to the high number of new records.
Acknowledgements

I would like to express my gratitude to my supervisor, Prof Charles Griffiths; without his endless support, guidance and patience, this project would not have been possible.

Thank you to the Department of Forestry and Fisheries (DAFF) for allowing me to access their trawl datasets to incorporate into the biogeography analysis in Chapter 3; to the Animal Demography Unit (ADU) for providing the platform to establish the EchinoMap VM and to the Iziko South African Museum for accommodating me through the period of this study. A special thank you to Elizabeth Hoenson from the Iziko Museum for tirelessly assisting with extracting data from the catalogues and giving samples accession numbers.

A sincere thanks the following people who contributed to the success of this study in various capacities: Dr Tracey Fairweather and Dr Lara Atkinkson for assisting with the logistics in obtaining data from the Department of Forestry and Fisheries (DAFF); Dr Sean Fennesey from Oceanographic Research Institute (ORI) for sending the samples from the experimental trawl on the KwaZulu-Natal shelf; Ms Jennifer Olbers from Ezemvelo KZN Wildlife for sample records; Ms Sediqa Khatieb and her intern Fhatani Ramwashe for assisting with the GIS training required; Dr Megan Laird for her advise through the writing of this thesis; Dr Carl Palmer for assisting with the photography editing, sample sorting, and for endless support and motivation; Ms Heinke Schultz for assisting with some of the identification, and Dr Kroh Andreas from the World Echinoidea Database (WED) for providing much of the literature used to identifying and describing the group; Prof John Field from the Marine Research Institute (MA-RE) for proof reading Chapter 4; Mr Keith Palmer from Lisle Marsden Primary school (Grimsby in the UK) for taking the time to proof read the entire thesis.

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Chapter 1

General Introduction

1.1 State of knowledge of taxonomy of the marine fauna of South Africa.

Taxonomy is fundamentally the first step in understanding the status and distribution of taxa (Costello et al., 2013); inability to identify species makes it impossible to know which areas are of high conservation priority and difficult to understanding ecosystem services, climate change implications, and ecological functioning. According to Costello et al. (2013), there have been concerns that species go extinct before being discovered, however, currently the rate at which species are described outweighs the extinction rate (Costello et al., 2012), which is estimated to be as high as 2 700 of the known species per annum (Maddison et al., 2012). Furthermore, the emerging marine species databases; such as WoRMS (World Register of Marine Species), OBIS (Ocean Biogeographic Information System), GBIF (Global Biodiversity Information Facility), The Tree of Life, Census of Marine Life and the All Taxa Biodiversity Initiative illustrate the increase in taxonomic efforts globally (Joppa et al., 2011). These developments have thus enhanced communication amongst scientists across the world (Costello et al., 2013). However, it is still notable that the African continent reports relatively fewer new species to science as compared to other regions, such as Asia, North America and Europe, with South Africa delivering most of the African publications (Tancoigne et al., 2011; Costello et al., 2013). South Africa has a rich taxonomic research history, as compared to any other African country and the South African marine fauna has an average state of knowledge index, but is ranked as having the lowest expertise per taxonomic group compared with other regions globally (Costello et al., 2010).

The South African coastline and offshore environment house a wide range of marine taxa which encompasses at least 12 914 described species of which some 32% are endemic (Griffiths et al., 2010), although many benthic taxa still remain poorly understood (Gibbons et al., 1999; Griffiths et al., 2010). This diversity and high level of endemism of species is influenced by the dynamic nature of the oceanographic regimes that surround the continent (Brown & Jarman, 1978; Thandar 1989; Awad et al., 2002; Griffiths et al., 2010) and which result in six main ecoregions (Sink et al., 2012). According to Sink et al. (2012) these ecoregions are subdivided into ecozones, based on differences in physical parameters. The distinction of these zones is largely due to the different water temperatures. The cold, upwelling nutrient-rich Benguela Current along the Atlantic Ocean coastline results in high
biological productivity, which in turn supports high species abundance but low species diversity (Shannon & Nelson, 1996). On the contrary, along the east coast, the warm Agulhas Current brings warm, nutrient poor waters southwards from the Mozambique Channel, which results in low productivity and species abundance but high species diversity in this region (Heydorn et al., 1978). Both these currents interact at the south coast region, resulting in a unique environment, which promotes high endemism patterns for most benthic invertebrate marine taxa (Lutjeharms et al., 2000; Awad et al., 2002).

1.2 Summary of the phylum Echinodermata.

The phylum Echinodermata is globally estimated to be the 8th most diverse marine invertebrate group and compromises approximately 7 219 described species across the five classes (Appeltans et al., 2012). The South African Echinodermata fauna comprises of 408 currently described species, of which two are introduced species and 184 are endemic to the South African EEZ (Table 1). For the Crinoidea, Asteroidea, Ophiuroidea and Echinoidea these numbers were derived by excluding the Mozambique and Namibian entries from the listings in Clark & Courtman-Stock (1976); and for the Holothuroidae the species list was obtained from the EchinoMap VM, as formulated and submitted by Prof Ahmed Thandar. Despite the high endemism represented by this group, it has received inadequate attention over the years and remains poorly understood (Gibbons et al., 1999; Griffiths et al., 2010). This study will therefore focus on the class Echinoidea, commonly known as sea urchins. This is one of the least diverse classes of Echinodermata, with 50 reported species thus far reported in South Africa, 19 of which are endemic (Clark & Courtman-Stock, 1976). Subsequent to the work of Clark & Courtman (1976) two echinoid species, Echinocyamus scaber and Gymnopatagus magnus; were reported on by A.M. Clark (1977), putting the known fauna at 52 species. There still, however, remains a paucity of information in the available guides regarding the diversity of echinoids and this patchy knowledge is a result of a there being few regional taxonomic experts (Gibbons et al., 1999; Griffiths et al., 2010) reviewing the class since the 1970’s.

Table 1: Summary of known Echinodermata species in South Africa, derived from Clark & Courtman-Stock (1976) and A.M. Clark (1977); where class Holothuroidae figures derived from the EchinoMap Vm.

<table>
<thead>
<tr>
<th>Class</th>
<th>Described species</th>
<th>No. of endemic species</th>
<th>No. of undescribed species</th>
<th>No. of introduced species</th>
<th>No. of taxonomic experts</th>
<th>No. of identification guides</th>
</tr>
</thead>
</table>
1.3. Background to the class Echinoidea.

The class Echinoidea is a diversified group inhabiting a range of marine environments from the intertidal to deep waters exceeding 5000 m (Schultz, 2010). Although the public commonly knows only the shallow-water species of this group, it is important to note that the group also contains a significant number of deep-water inhabitants. The class is superficially divided into ‘regular’ and ‘irregular’ groups, based on taxonomic differences in life style, test shape and symmetry (Fig. 1.3.1) (Schultz, 2010a). Some regular echinoid species are dominant grazers in shallow water environments, where species such as the Parechinus angulosus (common Cape urchin) are closely associated with juvenile recruitment of Haliotis midae (abalone) (Blamey et al., 2010). The feeding behavior of some coral reef inhabitants, such as Diadema setosum, Echinometra mathaei, Echinothrix calamaris, function as a major bioeroders in reef communities (Bak, 1994). This group is characterized by a globular test and a pentameral symmetric body plan (Fig. 1.3.1) (Schultz, 2010a). On the contrary, irregular sea urchins live burrowed within sandy substrata, where the locomotory behavior of echinoids such as Brissopsis lyrifera (Mortensen, 1907) may contribute to promoting macro benthos diversity and abundance by increasing depth of oxygen penetration (Widdicombe et al., 2004) and alter sediment structure (Hammond, 1981). They have a flattened test and have evolved a bilateral symmetric plan (Fig. 1.3.1) (Schultz, 2010a). There are two major irregular groups
known to exist today, the disc-shaped sand dollars (Fig. 1.4.2) and the heart-shaped urchins (Fig. 1.4.3).

Fig. 1.3.1. Difference in test shape and body plan of “Regular” and “Irregular” echinoids.

1.4. Terminology of various body parts.

Echinoidea is generally characterized by the presence of a calcium carbonate test (Branch et al., 2010). The test plates radiate from the aboral side (upper side) and converge at the oral side (under side) forming ten columns of plates, five ambulacra and five alternating interambulacra (Fig. 1.4.1) (Clark & Courtman-Stock, 1976; Schultz, 2010a). Each plate has one or two spine-bearing tubercles (Fig. 1.4.1) (Clark & Courtman-Stock, 1976). The ambulacral plates are perforated by pores (mostly in pairs) for the penetration of tube feet, which function as sensory, feeding and respiration structures; and the tiny-stalked defensive pedicellariae (Clark & Courtman-Stock, 1976; Branch et al., 2010; Schultz, 2010a). The apical system of ‘regulars’ is situated on the upper side and made up of an anal opening (periproct), encircled by genital plates and ocular plates (Fig. 1.4.1) (Clark & Courtman-Stock, 1976; Schultz, 2010a).
Fig. 1.4.1. Detail of upper and lower side of "Regular" echinoid (*Stereocidaris excavata*), showing terminology of various body parts.

The arrangement of plates surrounding the periproct varies with species. The periproct opening of ‘irregular’ echinoids has evolved and shifted to the oral side to best suit their lifestyle and may occur below the mouth opening (peristome) in the case of sand dollars (Fig. 1.4.2) and to posterior end of the test in the instance of heart urchins (Fig. 1.4.3) (Clark & Courtman-Stock, 1976; Schultz, 2010a). The ambulacra pores of “irregular” sea urchins are modified into a petal arrangement aborally (Fig. 1.4.2) (Fig. 1.4.3) (Clark & Courtman-Stock, 1976; Schultz, 2010a).

Fig. 1.4.2. Body plan of “Irregular” echinoid or sand dollar (*Clypeaster rarispinus*), showing terminology of various body parts.

Heart-shaped irregulars have an anteriorly positioned peristome (Fig. 1.4.3) (Clark & Courtman-Stock, 1976; Schultz, 2010a). The labrum represents the first interambulacra plates followed by the paired sternal plates usually bearing locomotory spines (Fig. 1.4.3) (Clark & Courtman-Stock, 1976; Schultz, 2010a). To be able to survive in benthic environments heart-
shaped urchins have developed fascioles (Fig. 1.4.3) (Schultz, 2010a). These fascioles are bands of small, closely packed ciliated and mucous-tipped spines that create currents, which sweep away waste materials and assist in food transportation, as well as playing a role in respiration (Schultz, 2010a).

Fig. 1.4.3. The body plan of “Irregular” echinoids or heart urchins (*Echinocardium cordatum*), showing terminology of different body parts.

1.5. History of echinoid systematics in South Africa.

The class Echinoidea was first reported in English literature as “Sea Eggs” by John Edward Gray (1855), and this was regarded as the foundation of echinoid systematics (H.L. Clark, 1925). After his death, Jeffrey Bell took over revising the British Museum echinoid collection, which included specimens from a number of expeditions and materials sent from the South African surveys (H.L. Clark, 1925; Brown, 1999).

Many authors have contributed to the current state of knowledge of echinoid systematics in South Africa and an accumulation curve, showing the total number of reported echinoid
species in of the region over time is shown in Fig. 1. The first three echinoid species in the region (Echinostrephus molaris, Echinometra mathaei and Stomopneustes variolaris) were reported by A. Agassiz (1872-1874). Despite these records being undetected by subsequent papers (H.L. Clark, 1923; H.L. Clark, 1924) they have remained on Clark and Courtman-Stock’s (1976) list and appear to be common Tropical-Natal species. Agassiz (1881) added three more species from South Africa through the H.M.S Challenger Expedition, which spent 51 days in the Cape of Good Hope and Bell (1904) added seven more, raising the echinoid fauna to 13 species. Soon afterthis, Döderlein (1906) documented ten species from the Valdivia echinoid collection and increased the number to 23, of which five were new to science and two to South Africa. Thereafter, H.L. Clark (1923) reported 11 more South African echinoids, increasing the South African sea urchin fauna to 34 species. This report was based on the South African Pieter Faure collections (H.L. Clark, 1923). In the resulting report these South African samples were compared to existing records and were found to contain several errors, thus some records were removed from existing list. Notable discrepancies included locality data of Euclidaris metularia of which A. Agassiz (1881) recorded specimen in Cape of Good Hope, whereas Pieter Faure reported it to be from Mozambique (H.L. Clark, 1923). H.L. Clark (1924) then documented seven more species from the Pickle collection, of which four were new to science and two endemic. Mortensen (1932) then reported on five new South African records, of which two were new to science. The number of South African species reported then remained unchanged for 30 years (Fig. 1) until the regional monograph by Clark and Courtman-Stock (1976), who reported a total of 50 species within 25 families, of which 19 were endemic to South Africa (this number excluding their Namibia and Mozambique records). A year later, A.M. Clark (1977) reported on the Meiring Naude (1976-1977) surveys and documented the extension of range of two additional species into South Africa, raising the known number of species to 52. Since that date there have been no publications that specifically address echinoid systematics in the region, although a few records are to be found in more general publications. The current study therefore reports on these species and other new records, thus causing a marked rise in numbers of known species in 2014, and increasing the echinoid fauna to 71 species (Fig. 1.5.1).
Fig. 1.5.1. Temporal growth in the number of Echinoidea reported from South Africa.

Apart from these taxonomic papers, some research has been undertaken on the biology of South African echinoids. Earliest studies include those on the life history (Cram, 1971b), abundance and distribution (Thum & Allen, 1975), and reproductive ecology (Thum & Allen, 1976) of the large Lamp urchin (*Echinolampas crassa*). Substantial work has also been undertaken on the common Cape urchin (*Parechinus angulosus*); such as the life history (Cram, 1971a), feeding behavior (Fricke, 1979; Anderson & Velimirov, 1982), population dynamics (Fricke, 1980; Farquhar, 1994), and the common Cape urchins role in community structuring in areas of the West coast (Fricke, 1979; Mayfield & Branch, 2000; Day & Branch, 2000b; Day & Branch, 2000a; Blamey *et al.*, 2010). Some studies also analyzed the abundance and distribution of the sand dollar, *Echinodiscus bisperforatus* (Bentley & Cockcroft, 1995), its reproduction (Bentley, 1998), and macro faunal assemblages associated with it (Bentley & Cockcroft, 1995). Most recent studies involve investigating the phylogeography of
Echinometra mathei (Muller et al., 2012); and the effects of feeding on Tripneustes gratilla (Scholtz, 2013). A vast number of other ecological studies have reported distributional records of some of the most abundant species (Echinolampas crassa; Parechinus angulosus; Echinodiscus bisperroratus, Echinometra mathaei). There has also been some analysis on Echinodermata distribution patterns in studies reporting on the zoogeography of marine invertebrates (Thandar, 1989; Marshall et al., 1991; Emanuel et al., 1995; Samyn & Thandar, 2001; Awad et al., 2002; Scott et al., 2012).

2. Aims and objectives of this dissertation.

The identification keys compiled by Clark and Courtman-Stock (1976) are poorly illustrated, lacking images of most species and are too technical for most users to understand. Moreover, since the publication of Clark and Courtman-Stock (1976), an extensive number of additional samples have been collected, but remain unidentified in the collections of the Iziko South African Museum. Therefore, the main aims of this dissertation are to:

- Identify the un-identified material in the Iziko Museum collection, according to the current phylogenetic relationship.
- Produce a revised and updated species checklist, adding all new species and rectifying all uncertainties of previously recorded species.
- Produce a comprehensible identification guide, which gives a detailed, less technical descriptive diagnosis of each species supported by a distribution map and photographic images.
- Produce a biogeography analysis of species richness and endemism patterns in the region.

3. Outline of Chapters.

The objectives of this study will be achieved by the following, four chapters of the dissertation:

Chapter 1: This chapter provides background information and a literature review on the South African Echinoidea fauna. The basic terminology is also included with picture illustrations; more technical definitions are given at the end of the identification guide (Chapter 3) (Appendix 1).
Chapter 2: Documents new additions to and revisions of the South African Echinoidea fauna. This section will include a diagnostic features for each species and details of the date, location and depth of each new record.

Chapter 3: An identification guide to the revised South African Echinoidea. This guide will be presented in a clear manner suitable for both scientific and public users. This will include a paragraph describing diagnostic features of each species, updated synonyms and updated taxonomic grouping of species. Depth range of species will also be provided and spatial distribution of each species will be illustrated on a map, coupled by a picture of the species.

Chapter 4: A biogeography analysis of species richness and endemism patterns, in relation to different depths.

4. Methods
Numerous samples have been collected since Clark and Courtman-Stock (1976) by grab, dredge and trawl, but remain unidentified in the Iziko South African Museum, which also include those of the University of Cape Town (UCT) Ecological Survey. The collection analyzed in this study is therefore a result of 37 years of sampling efforts; other sources considered include literature, species recorded by the Department of Forestry and Fisheries (DAFF), and an open access online database EchinoMap VM.

The first step was to ensure that the archive samples in the identified museum collection were arranged according to the phylogenetic relationship outlined by Kroch & Smith (2010), which corresponds with that of the World Register of Marine Species (WoRMS) - an online open database. Photographs of the specimens in the identified collection were simultaneously taken to compile an identification guide, which assisted with the morphological analysis and identification of the specimens in the unidentified collection. Images from other literature (Branch et al., 2010; Schultz, 2010b; Schultz, 2010c) were also used when collating the guide.

Thereafter, the unidentified archived samples were examined and identified, which sometimes involved a de-spining procedure to expose the microscopic differences distinguishing each species. A 60% domestic bleach solution was prepared for the spine removal procedure and specimens were left submerged in this solution for varied time intervals. The large specimens which were represented by specimens with > 50 mm test
diameter and small < 49 mm test diameter were soaked in solution for 10 minutes maximum and five minutes intervals; respectively. If there were more than one specimen in a sample then spines were removed from the entire test of one specimen, but if only one specimen was available then half the body was de-spined. Only samples within the South African continental Economic Exclusive Zone (EEZ) are considered for this analysis, excluding the Sub-Antarctic Islands echinoid records, as this region lies in an entirely different biogeographic region. Nonetheless, Branch et al. (1993) reviewed the fauna of this region and reported on a number of echinoid species.

Historical data from the South African Museum and the UCT Ecological Survey catalogues, trawl-by-catch data from the Department of Fisheries and Forestry (DAFF) database, and previously published records were digitized, then used for the biogeographic analysis. Other data included photographic data from the EchinoMap VM database, which is a collation of echinoid fauna data rendered by naturalists and members of the public. At the initial stages of the project, various divers from across the country were approached to submit images and this led to over 500 images being submitted for identification and incorporated for analysis of study. The digital database was established through the UCT Animal Demographic Unit (ADU), which is a platform for communities to submit photographs together with biological information of different taxa.
Chapter 2

Additions to and revision of the South African echinoid (Echinodermata: Echinoidea) fauna.

This chapter documents new additions to the South African echinoid fauna and rectifies uncertainties concerning recordings of some previously reported species. The revision forms the first of its kind since the major work of Clark & Courtman-Stock (1976) and hence documents all additions to the fauna since the late 1970’s. Most of these derive from accumulated unidentified material in the Iziko South African Museum collections, which we examined and identified. Also included, though, are new records reported on via the EchinoMap Virtual Museum, those published in the non-taxonomic literature, an elevation of a subspecies, and new taxa derived from taxonomic revision. In total 19 new records, across 12 new genera, are added to the fauna, raising the number of species within South African political borders to 71. Eleven of these entries are reported in South African waters for the first time through this study; these are Stereocidaris alcocki, Plococidaris verticillata, Stylocidaris cingulata, Tromikosoma uranu, Astropyga radiata, Temnotrema siamense, Oligopodia epigonus, Clypeaster fervens, Metallia robillardi, Lovenia elongata, and Podophora auratus. In addition to these eleven, there is one entry (Tromikosoma uranu) that was previously sampled from the west coast and identified by an unknown collector, however, it is counted here as a new record as the original sample is in too poor condition to either confirm or discount this identification. Also counted in the 19 new species are five records that were previously published in non-taxonomic literature; these are represented by Euclidaris metularia, Phyllacanthus imperialis, and Echinoneus cyclostomus - which form part of the specimens collected in the years 1999, 2000 & 2001 by Samyn & Thandar (2003). However, this previous citing does not give a species list, but reports on records that are logged in the Royal Museum of Central Africa database, from which collection data were extracted. The remaining two additions of the five that were previously published are represented by Tetrapyga niger and Toxopneustes pileolus. Tetrapyga niger is an invasive South American species, accidentally introduced along with imported commercial oysters. In addition to these one new record, Echinometra oblonga, was added due to the elevation of a regional subspecies to species rank. The two remaining entries are represented by Acanthocidaris maculicollis and Gionocidaris indica, where the latter record was previously reported at generic level and now identified to species level and former confirms flagged Clark & Courtman (1976) entry.
Taxa are systematically arranged according to the phylogenetic relationship outlined by Kroh & Smith (2010), which corresponds with that of the World Echinoidea Database (WED) linked to the World Register of Marine Species (WoRMS). Each species is entered under the current scientific name; followed by original authors name, year of publication and subsequent synonyms in historical order. Only literature that describes the species fully, or that which reports species in neighboring regions; is included. A brief paragraph on where species were previously reported, together with data of regional records, is included. Photographs of either live specimens in their natural habitat, or of archived specimen, are provided under each entry. A paragraph on the characteristic features of genera reported in South African waters for the first time is also included.
Taxonomic Section.

Class: Echinoidea Leske, 1778
Subclass: Cidaroida Smith, 1984
Order: Cidaroida Claus, 1880
Family: Cidaridae Gray, 1825
Sub-family: Cidarinae Mortensen, 1928b
Genus: Eucidaris Pomel, 1883

Spines banded, stout; sometimes fusiform.

*Eucidaris metularia* (Lamarck, 1816)

Fig. 2.1.

*Cidaris metulari*: A. Agassiz, 1872: 8, 254, 385. Pl. I. Figs 23-24, Pl. XXXV. Fig. 3; Bell, 1904: 138.

*Cidaris (Gymnocidaris) metularia*: Doderlein, 1906: 101.

*Eucidaris metularia*: H.L. Clark, 1923: 370; H.L. Clark, 1925: 20: Mortensen, 1928: 386; Clark & Rowe, 1971: 140, 150. Pl. XX1, Fig. 13; Richmond, 1997: 295-296; Samyn, 2003: Fig. 2A; Schultz, 2010: 36. Figs 61-63.

**Description.**
Features include naked apical system; spines stout, short in some cases, and fusiform in others; correspond well with descriptions given by Mortensen (1928).

**Distribution.**
A. Agassiz (1881) previously reported this species from the “Cape of Good Hope”, however, this record appears dubious. This species is unlikely to occur in the West coast region, as it is a tropical Indo-Pacific species (Mortensen, 1928; H.L. Clark, 1923), of which the *Pieter Faure* collection has a record from Mozambique. Samyn & Thandar (2003) also found seven specimens after three expeditions in KwaZulu-Natal. These records are encoded in the Royal Museum of Central Africa database and are listed below. This study adds 17 more records as also listed below. Previously reported from the Indo-Pacific (Richmond, 1997; Schultz, 2010)
in countries such as Mozambique (Clark & Courtman-Stock, 1976) and Kenya (Samyn, 2003), at 5 – 570 m depth range.

Material examined.
SAM A 22206; Durban; -29.8550 31.0572; no other data available.
SAM A 22233; Port St. Johns; -32.6299 29.5531; no other data available.
SAM A 23712; Jesser Point; -27.5533 32.7167; 85 m; Meiring Naude Dredge Survey; 3 June 1987.
SAM A 28199; Kosi River mouth; -27.0000 32.9333; 47 m; Meiring Naude Dredge Survey; 6 June 1987.
SAM A 28200; Jesser Point; -27.6667 32.7100; 68 m; Meiring Naude Dredge Survey; 3 June 1987.
SAM A 28201; Dog Point; -27.6667 32.8817; 70 m; Meiring Naude Dredge Survey; 4 June 1987.
SAM A 28202; Kosi River; -26.9667 32.9233; 50 m; Meiring Naude Dredge Survey; 7 June 1987.
SAM A 28203; -26.8817 32.9833; 49 m; Meiring Naude Dredge Survey; 3 June 1990.
SAM A 28204; -26.8733 32.9283; 51- 53 m; Meiring Naude Dredge Survey; 3 June 1990.
SAM A 28205; Kosi River mouth; -26.9100 32.8967; 50 m; Meiring Naude Dredge Survey; 7 June 1987.
SAM A 28206; Boteler Point; -27.0178 32.9006; 50 m; Meiring Naude Dredge Survey; 6 June 1987.
SAM A 28226; Landers Reef, off Park Rynie; -27.6833 32.7042; 40 m, SCUBA dive; 15 December 1984.
SAM A 28227; Saxon Reef in Kosi Bay; -26.8667 32.8667; 20 m; SCUBA dive; 7 April 2003.
SAM A 28228; 7 Mile Reef, Sodwana Bay; 23 m; VUB Echinoderm EXP; July 2000.
SAM A 28237; off Lala Nek; -27.2167 32.7833; 78 m; Meiring Naude Dredge Survey; 8 September 1990.

Material from the Royal Museum of Central Africa database.
Reg nb 2602; Sodwana Bay; KwaZulu-Natal; 23 m; July 2000.
Reg nb 2590; Sodwana Bay; KwaZulu-Natal; 15 m; August 1999.
Reg nb 2584; Sodwana Bay; KwaZulu-Natal; 8-12 m; February 2001.
Reg nb 2585; Sodwana Bay; KwaZulu-Natal; 30 m; August 1999.
Reg nb 2573; Alwal Shoal; KwaZulu-Natal; 22 m; August 1999.
Reg nb 2593; Alwal Shoal; KwaZulu-Natal; 20 m; August 1999.
Reg nb 2592; Bhanga Neck; KwaZulu-Natal; intertidal; August 1999.

Additional record.
Photographic record submitted by Prof Charles Griffiths on the *EchinoMaps VM* database; reported from Jesser Point, Sodwana Bay in KwaZulu-Natal; 3 March 2013.
Photographic record submitted by Dr Kerry Sink on the *EchinoMaps VM* database; reported from KwaZulu-Natal; 8 January 2004.

Fig. 2.1. Aboral view of *Eucidaris metularia* SAM A28204 (scale bar: 10 mm).
Genus: *Phyllacanthus* Brandt, 1835

Conjugated pore pairs in double series; primary spines non-crenulate; apical system densely covered by spines; smaller apical system than peristome.

*Phyllacanthus imperialis* (Lamarck, 1816)

Fig. 2.2.

*Phyllacanthus imperialis*: A. Agassiz, 1872: 151, 391. Pl. I. Figs 1-6, Pl. I. Fig. 2; Dördelein, 1906: 98. Pl. XL. Fig. 5. a-e; Mortensen, 1928: 504-509. Pl. LIV. Fig. 4, Pl. LVII. Fig. 3, Pl. LXXIV. Fig. 6, Pl. LXXXVIII. Figs 4-10; Clark & Rowe, 1971: 140, 151. Pl. XX111, Fig. 2; Samyn, 2003: Figs 2B, B; Schultz, 2010: 46. Figs 80-83.

**Description.**

Primary spines have numerous, close, indistinct series of granules (Mortensen, 1928), which are not visible to the naked eye (Schultz, 2010).

**Distribution.**

Previously reported in neighboring countries, such as Kenya (Samyn, 2003), Zanzibar and Mozambique (A. Agassiz, 1863). Samyn & Thandar (2003) found eight specimens after three expeditions in KwaZulu-Natal. These records are encoded in the Royal Museum of Central Africa database and are reproduced below. The present study adds two more records.

**Material examined.**

SAM A 23447; Landers Reef, off Park Rynie, KwaZulu-Natal; -27.6833 32.7042; 30 m; SCUBA dive; 7 July 1987.

**Material from the Royal Museum of Central Africa database.**

Reg nb 2531; Sodwana Bay; KwaZulu-Natal; 13m; August 1999.
Reg nb 2577; Sodwana Bay; KwaZulu-Natal; 23 m; July 2000.
Reg nb 2578; Sodwana Bay; KwaZulu-Natal; 23 m; July 2000.
Reg nb 2580; Sodwana Bay; KwaZulu-Natal; 18 m; August 1999.
Reg nb 2598; Sodwana Bay; KwaZulu-Natal; 15 m; August 1999.
Reg nb 2570; Sodwana Bay; KwaZulu-Natal; 36 m; August 1999.
Reg nb 2586; Sodwana Bay; KwaZulu-Natal; 18 m; February 2001.
Reg nb 2582; Umkomaas; KwaZulu-Natal; 25 m; July 2000.

Additional record.
Photographic record submitted by Dr Kerry Sink on EchinoMaps VM database; reported from the “Two mile reef” in Kwazulu-Natal; -27.5342 32.6785; 9 January 2004.

Fig. 2.2. Aboral view of Phyllacanthus imperialis SAM A23447 (scale bar: 10 mm).
Sub-family: Goniocidarinae Mortensen, 1928a
Genus: *Gionocidaris* Aggasiz & Desor, 1846

*Gionocidaris indica* Mortensen, 1939

Fig. 2.3.


**Description.**
As outlined by Schultz (2010), the distinguishing feature of this species are the umbrella-like flanges at bases of aboral primary spines.

**Distribution.**
Previously reported from Maldives and Tanzania (Schultz, 2010), this study therefore extends the distribution into South African waters.

**Material examined.**
SAM A 28224; Still Bay Shelf; -35.3667 22.5167; 200 m; *UCT Ecological Survey*, Dredge; 20 June 1972.
SAM A 28207; -34.9500 23.8167; 184 m; *Africana Bottom Trawl*; 30 June 1993.
SAM A 28235; -34.7833 24.000; 170 m; *Africana Bottom Trawl*; 23 June 1988.
SAM A 28232; -34.8750 23.6650; 230 m; *Africana Bottom Trawl*; 4 May 1993.
SAM A 28241; -36.6000 20.6167; 174 m; *Africana Bottom Trawl*; 6 April 2007.

**Remarks.**
Clark and Courtman-Stock (1976) were unable to identify their specimen *Gionocidaris sp* to species level, due to the only sample being a broken test. This study therefore confirms Clark and Courtman’s (1976) specimen to be *Gionocidaris indica*. 
Fig. 2.3. Aboral view of *Gionocidaris indica* SAM 28224 (scale bar: 10 mm).
Sub-family: Stereocidarinae Lambert, 1900
Genus: Stereocidaris Pomel, 1883

*Stereocidaris alcocki* (Anderson, 1984)
Fig. 2.4.

*Stereocidaris tricarinata*: Dordelein, 1906: 112-114. Pl. X, Fig. 7. Pl. XXXVI, Fig. 3.
*Stereocidaris alcocki*: Mortensen, 1928: 266. Pl. LXXI, Fig. 8. Pl. LXXXII, Fig. 18; Schultz, 2010: 1037.

Description.
Primary spines have three basal keels, and this agrees with the features outlined by Mortensen (1928) and Schultz (2010).

Distribution.
Species reported to be restricted to the Indian Ocean (Schultz, 2010). The following record thus extends the distribution southwards into South African waters.

Material examined.
SAM A 28229; South of Durban, KwaZulu-Natal; -30.7511 30.5186; 850 m; *Meiring Naude Dredge Survey*; 11 May 1977.
Fig. 2.4. Aboral view of *Stereocidaris alcocki* SAM A 28229 (scale bar: 10 mm).
Sub-family: Stylocidarinae Mortensen, 1903
Genus: Acanthocidaris Mortensen, 1903b

Acanthocidaris maculicollis (de Meijer, 1904)

Fig. 2.5.

Acanthocidaris maculicollis: Mortensen, 1928: 329-333. Pl. XLIII, Figs 1-2. Pl. XLIV, Fig. 1. Pl. LIV, Figs 5-6. Pl. LXXXIII, Figs 12-15; Mortensen, 1932: 157-158. Pl. V. Fig. 6. Pl. XI, Fig. 5; Clark & Courtman-Stock, 1976: 214.


Description.
Collar of primary spines has red spots; shaft banded red and white (Mortensen, 1928; Mortensen, 1932

Distribution.
Previously reported from Japan to the Malay Archipelago Mortensen (1928), and from the Indian Ocean (Mortensen, 1932). The Indian Ocean records are represented by samples examined by Koehler (1927), without any locality. Mortensen (1932) then reports on a sample from the Natal Museum that was shipped to him, which he identified as A. maculicollis, but which had no locality record label associated to it. The location of that record is thus flagged in Clark & Courtman-Stock (1976) and this is the first confirmed record from the region.

Material examined.
SAM A28233; Rocktail Bay; -27.1850 32.8483; 100 m; Meiring Naude Dredge Survey; 7 June 1990.

Remarks.
This study therefore confirms Mortensen’s (1932) record and Clark-Courtman Stock’s (1976) uncertainty of this species occurring in KwaZulu-Natal.
Schultz (2010) synonymized this species with Acanthocidaris curvatispinis, on the basis of WED 2010 database, which now recognizes the two as separate valid species.
Fig. 2.5. Side-view of *Acanthocidaris maculicollis*: SAM A28233 (scale bar: 10 mm).
Genus: *Plococidaris* Mortensen, 1909

Pores typically non-conjugated; spines and test peculiarly molted, spines having 3 – 4 distinctive whorls.

*Plococidaris verticillata* (Lamark, 1816)

Fig. 2.6.


*Prionocidaris verticillata*: Clark & Rowe, 1971: 140, 151. Fig 61 a; Richmond, 1997: 294; Samyn, 2003: Figs 2E, E.

**Description.**

The crown-like structures on spines coincide well with detailed descriptions given by Mortensen (1928) and Schultz (2010).

**Distribution.**

The only species in this genus, and reported to have a wide Indo-West Pacific distribution (Mortensen 1928; Clark & Rowe, 1971; Schultz, 2010), previously reported from Kenya (Samyn, 2003); Eastern Africa & Madagascar (Clark & Rowe, 1971); to Fiji and Hawaiian islands (Mortensen, 1928; Schultz, 2010), and from southern Japan to Australian east coast (Mortensen, 1928; Schultz, 2010), known from intertidal to 50 m depth. This study reports the species in South Africa for the first time.

**Material examined.**

SAM A 28236; Landers Reef, off Park Rynie; -27.6833 33.1167; 40 m; *SCUBA dive*; 15 December 1984.

**Additional record.**

DNSM ECH 4; Durban harbor; KwaZulu-Natal.

**Remarks.**

Additional record is from the Natal Museum and is reported by Olbers *et al.* (in press).
Fig. 2.6. Aboral view of *Plococidaris verticillata*: (scale bar: 10 mm).
Genus: *Stylocidaris* Mortensen, 1909

Characterized by tapering, slender, pointed spines; areoles round and well-developed, pedicellariae without end tooth.

*Stylocidaris cingulata* Mortensen, 1932

Fig. 2.7.

*Stylocidaris cingulata* Mortensen, 1932: 162-164. Pl. I, Fig. 6. Pl. XI, Fig. 6. Pl. XIII. Figs 8-10; Schultz, 2010: 925. Figs 1565-1566.

**Description.**

Mortensen (1932) gives an exceptionally good description and the present specimens conform to it, except that ocular plates are not in contact with periproctal membrane.

**Distribution.**

The holotype specimen is presumed to be from the Indian Ocean, but exact locality is unknown (Mortensen, 1932).

**Material examined.**

SAM A 28217; off Port Edward; -31.1022 30.2856; 120 -125 m; *Meiring Naude Dredge Survey*; 8 July 1985.

SAM A 28231; off Mtamvuna River, Port Edward; -31.1525 30.2503; 140 m; *Meiring Naude Dredge Survey*; August 1981.

**Remarks.**

Description by Mortensen (1932) seems to be based on one specimen, which may suggest that observation of oculars may be a variation within species.
Fig. 2.7. Side-view of *Stylocidaris cingulata* SAM A28217 (scale bar: 10 mm).
Family: Echinothuriidae Thomson, 1872a
Genus: *Tromikosoma* Mortensen, 1903
Lacks buccal notches and sacs.

*Tromikosoma c.f. uranus* (Thomson, 1877)
Fig. 2.8.

*Phormosoma uranus*: A. Agassiz, 1881: 103.

**Description.**
Species has large, irregularly arranged tubercles (Agassiz, 1881); where orally they are found outside the pore-series in distal part of the ambulacra (Mortensen, 1935).

**Distribution.**
Species previously reported from Portugal to West Africa; at 850-2750 m depths (Schultz, 2010), this study therefore reports on species in the South African EEZ for the first time.

**Material examined.**
SAM A 22122; -33.8167 16.500; 2743 m; *African Beam trawl*; 7 August 1959.

**Remarks.**
Species was in identified collection, but never reported. Identified by unknown collector and sample in poor condition thus unable to confirm identification which remains uncertain.
Fig. 2.8. Oral view of *Tromikosoma uranus* SAM A 22122 (scale bar: 100mm).
Subclass: Euechinoidea Bronn, 1860
Order: Diadematioda Duncan, 1889
Family: Diadematidae Gray, 1855
Genus: Astropyga Gray, 1825

Test flattened orally, aborally slightly convex; periproctal membrane conspicuously raised or sometimes flat.

Astropyga radiata (Leske, 1778)

Fig. 2.9.


Description.
Test with v-shaped naked zones aborally; with dark spots, iridescent blue in live specimen (Schultz, 2010).

Distribution.
Indo-Pacific species reported from neighboring regions, such as Kenya (Samyn, 2003); Eastern Africa and Madagascar (Clark & Rowe, 1971; Schultz, 2010), and Mozambique (Clark & Courtman-Stock, 1976) to Queensland, Australia (Schultz, 2010), and Hawaiian islands (Schultz, 2010); this study reports species for the first time in South African waters.

Material examined.
SAM A 22214; Tugela River; KwaZulu-Natal; -29.4376 31.6073; 77 m;
SAM A 28211; Sodwana Bay, KwaZulu-Natal; -27.0083 32.9233; 71 m; Meiring Naude Dredge Survey; 2 September 1990.
Fig. 2.9. Side-view of *Astropyga radiata*, live specimen (no scale bar available).
**SuperOrder:** Echinacea Claus, 1876  
**Order:** Arbacioida Gregory, 1900  
**Family:** Arbaciidae Gray, 1825  
**Genus:** *Tetrapygus* L. Agassiz, 1841b

Characterized by five pore-pairs per ambulacra plate, interambulacra tubercles large with smaller ones above them.

*Tetrapygus niger* (Molina, 1782)

Fig. 2.10.

*Tetrapygus niger*: H.L. Clark, 1925: 17; Branch *et al.*, 2010: 236, Fig. 106.3; Haupt *et al.*, 2010; Schultz, 2010: 128, Figs 233-235.

**Description**

Spines black having glassy distal caps. Cleaned test white with radiating violet bands, tubercle tips also violet, violet bands disappearing towards the oral side (Schultz, 2010).

**Distribution.**

A shallow-water species reported from West Coast of South America in Peru and Chile. Accidentally introduced by commercial oysters, first reported from the Northern Cape Alexander oyster farm in 2007 (Branch *et al.*, 2010; Haupt *et al.*, 2010).

**Material examined.**

SAM A 28054; Alexander oyster farm, Northern Cape; -28.6714 16.5028; collected from oyster basket.

**Remarks.**

May be mistaken for *Stomopneustes variolaris*, but differs in geographic distribution range, where *S. varioles* is reported from KwaZulu-Natal and *Tetrapyga niger* from the Northern Cape.
Fig. 2.10. Aboral view of *Tetrapyga niger*, live specimen (no scale bar available).
Order: Camarodonta Jackson, 1912
Family: Echinometridae Gray, 1855
Genus: Colobocentrotus Brandt, 1835
Sub-genus: Colobocentrotus (Podophora) L. Agassiz 1840

Aboral ambulcra plates with one tubercle; spines having pentagonal outline, closely packed forming compact mosaic.

Colobocentrotus (Podophora) atratus (Linnaeus, 1758)

Fig. 2.11.

Colobocentrotus auratus: A. Agassiz, 1872: 102, 424. Pl. XXXVI, Figs 6-7. Pl. XXXVIII, Figs 11-12; Clark & Rowe, 1971: 142, 158. Pl. XXIII, Fig. 7; Samyn, 2003: 204. Fig. 3D.

Colobocentrotus (Podophora) atratus: Mortensen, 1943: 434-439. Pl. L, Figs 1-2. Pl. LII, Figs 1-2. Pl. LXV, Fig. 7.


Description.
Flat, tessellated spines (Agassiz, 1872; Mortensen, 1948; Schultz, 2010). Mortensen (1948) advised to use Podophora as a sub-genus of Colobocentrotus because the difference in tuberculation of ambulacra, spine outline and arrangement of spines amongst the two are of small generic value.

Distribution.
Mortensen (1943) reports this species from Natal, but gives no reference for entry or where specimen is lodged. Previously reported from Kenya (Samyn, 2003), Eastern Africa and Madagascar (Clark & Rowe, 1971), and Hawaiian islands (Mortensen, 1943). This study therefore confirms Mortensen’s (1948) record of the species in KwaZulu-Natal, although entry was for unknown reasons omitted from the Clark & Courtman-Stock’s (1976) list.

Material examined.
Permit to sample Sodwana Bay was not granted for this study, thus addition of the species is based on a photographic record from Sodwana Bay submitted to the EchinoMap VM by Prof Charles Griffiths.
Species reported from Jesser Point in KwaZulu-Natal; -27.5424 32.6785; intertidal; 4 October 2009.

Fig. 2.11. Aboral view of *Podophora auratus*, live specimen (no scale bar available).
Family: Temnopleuridae Agassiz, 1872
Genus: Temnotrema Agassiz, 1864

Characterized by deep furrows along horizontal sutures, pore-pairs in straight line.

*Temnotrema siamense* (Mortensen, 1904)

Fig. 2.13.

*Temnotrema siamense*: Clark & Rowe, 1971: 142, 155; Richmond, 1997: 296; Schultz, 2010: 1226. Figs 2168-2169

Description.

Test small, with radiating white and pinkish rows, and deep horizontal sutures; eccentric apical system; banded spines (Schultz, 2010).

Distribution.

Species reported here for the first time in South African political borders, although it is widespread in the Indo-Pacific (Richmond, 1997), from East Africa to North East Australia and South China Sea (Schultz, 2010). Previously reported from Eastern Africa and Madagascar (Clark & Rowe, 1971).

Material examined.

SAM A28209; Sodwana Bay, KwaZulu-Natal; -27.5300 32.7133; 70 m; *Meiring Naude Dredge Survey*; 2 June 1990.

SAM A 23713; Boteler Point, KwaZulu-Natal; -27.0133 32.9183; 70 m; *Meiring Naude Dredge Survey*; 6 June 1987.
Fig. 2.13. Aboral view of *Temnotrema siamense* SAM A 23713 (scale bar: 10 mm).
Genus: *Echinometra* Gray, 1825

*Echinometra oblonga* (Blainville, 1825)

Fig. 2.12.

*Echinometra oblonga*: A. Agassiz, 1872: 116, 433. Pl. XXXVI. Fig. 5; Clark, 1925: 144; Schultz, 2010: 1276. Fig. 2275.


**Description:**

Spines of dark, uniform color, without white tips (Schultz, 2010).

**Distribution:**

Reported from East Africa, Mauritius and the Maldives through the Philippines, Indonesia and Papua-New Guinea to Okinawa, Guam and Hawaii, from South Pacific Islands to Clarion and Socorro Island of Mexico, Costa Rica and Galapagos Island, strictly littoral (Schultz, 2010).

Maher (2011) reports species in KwaZulu-Natal as a separate species and not a subspecies, as in Mortensen (1948).

**Material examined:**

Park Rynie; KwaZulu-Natal; -30.3178 30.7424; intertidal; 27 June 2012.


**Remarks:**

Record of this species is based on a study investigating the phylogeography of the population structure of *Echinometra mathaei* undertaken in KwaZulu-Natal, which revealed that *E. oblonga* is a close relative of *E. mathaei* and not a morph (Landry, 2003; Maher, 2012).
Fig. 2.12. Aboral view of *Echinometra oblonga* (Schultz, 2010).
Family: Toxopneustidae Troschel, 1872
Genus: Toxopneustes Agassiz, 1841

Characterized by sub-conical or low hemispherical test, three pore-pairs per ambulacra plate (trigeminate).

*Toxopneustes pileolus* (Lamarck, 1816)

Fig. 2.14.

*Toxopneustes pileolus*: H.L. Clark, 1923: 386; Clark & Rowe, 1971: 142, 156. Pl. XXIV, Fig. 7. Pl. XXXI, Fig. 15; Clark & Courtman-Stock, 1976: 234; Richmond, 1997: 298; Samyn, 2003: 210. Figs 4F, F'; Branch *et al.*, 2010: 234. Fig. 105.7; Schultz, 2010: 270. Figs 518-522.

**Description.**
Tropical reef species easily distinguished by pedicelleria forming a dense, poisonous flower-like appearance. A detailed species description is given by Schultz (2010).

**Distribution.**
Species previously reported from adjacent countries, such as Mozambique (Clark and Courtman-Stock, 1976) and Kenya (Samyn, 2003). This study compliments Branch et al. ‘s (2010) photographic record of the species in South African localities.

**Material examined.**
SAM A 28208; Jesser Point, KwaZulu-Natal; -27.5267 32.6967; 40 m; Meiring Naude Dredge Survey; 9 June 1987.
Fig. 2.14. Side-view of *Toxopneustes pileolus*, live specimen (no scale bar available available) (Branch *et al.*, 2010).
Subclass: Euechinoidea Bronn, 1860
Infraclass: Irregularia Latreille, 1825
Order: Echinoneoida H.L. Clark, 1925
Family: Echinoneidae L. Agassiz & Desor, 1847
Genus: Echinoneus Leske, 1778

Test variation, oval or sometimes elongated, moderately sized; imperforated tubercles, spines short, simple; lantern and auricles present in young.

Echinoneus cyclostomus Leske, 1778

Description.
Easily distinguishable by its glassy tubercles; plated peristome, and elongated test (Mortensen, 1948; Schultz, 2010).

Distribution.
Previously reported from Eastern Africa and Madagascar (Clark & Rowe, 1971); Zanzibar (A. Agassiz, 1872). Mortensen (1948) reports it from Natal but does not give a reference for entry. However, Samyn & Thandar (2003) found three specimens after three expeditions in KwaZulu-Natal and these records are encoded in the Royal Museum of Central Africa database. This study adds four more records.

Materials examined.
SAM A 28212; Aliwal Shoal, North of Scottburgh, KwaZulu-Natal; -30.2833 30.7500; 30 m; SCUBA dive; June 1980.
SAM A 28221; Umhlali Shore Station; -29.4589 31.2783; intertidal; UCT Ecological Survey; 3 December 1938.
SAM A 28255; South of Scotburgh, -30.2833 30.7500; KwaZulu-Natal; intertidal; SCUBA dive; 18 June 1987.
SAM A 28234; Nthloniane River; -32.2867 29.0917; 345 – 400 m; Meiring Naude Dredge Survey; 5 July 1985.
Material from the *Royal Museum of Central Africa* database.

Reg nb 2552; Sodwana Bay; KwaZulu-Natal; 6 m; February 2001.
Reg nb 2557; Sodwana Bay; KwaZulu-Natal; 16 m; July 2000.
Reg nb 2558; Sodwana Bay; KwaZulu-Natal; 8 m; July 2000..

![Image](image_url)

Fig. 2.15. Aboral view of *Echinoneus cyclostomus* SAM A28212 (scale bar: 10 mm).
Order: Cassiduloida Claus, 1880
Family: Cassidulidae L. Agassiz & Desor, 1847
Genus: Oligopodia Duncan, 1889

Test small, ovoid shaped, aboral side low arched; posterior interambulacra slightly raised forming keel and small beak above periproct; petals distinctively opened distally; peristome slightly elongated distinct phyllodes; periproct on truncated posterior end; spines smooth, simple, somewhat curved.

**Oligopodia epigonus v. Martens, 1865**

Fig. 2.16.

*Nucleolites epigonus*: A. Agassiz, 1872: 147. Pl. XIX, Figs b. 4-6.


**Description.**
Species distinguishable by slightly raised interambulacra, forming keel above posterior margin. Species corresponds with the description given by Mortensen (1948) and Schultz (2010).

**Distribution.**
Reported from the Indo-West Pacific, from East Africa over Malayan region to the Bonin Island, Tonga Island and New Zealand (Schultz, 2010). Mortensen (1948) has previously reported to have dredged specimens off the Natal coast; there is, however, no entry of this species in Clark & Courtman-Stock’s (1976) report on species in the region. Thus study thus reports on a reliable record from with South African localities for the first time.

**Materials examined.**
SAM A 28218; Sodwana Bay, KwaZulu-Natal; -27.5172 32.7017; 61 m; Meiring Naude Dredge Survey; 2 June 1990.

SAM A 28222; South east of Umzimbazi River, KwaZulu-Natal; -30.1339 30.9347; 65 m; Meiring Naude Dredge Survey; 8 July 1986.
Fig. 2.16. Aboral view of *Oligopodia epigonus* SAM A28218 (scale bar: 10 mm).
Order: Clypeasteroida A. Agassiz, 1872
Family: L. Agassiz, 1835
Genus: Clypeaster Lamarck, 1801

*Clypeaster fervens* Koehler, 1922

Fig. 2.17.

*Clypeaster (Rhaphidoclypus) fervens*: Mortensen, 1948: 84-86. Pl XIII, Figs 2,3. Pl. XXII, Figs 1-11. Pl. XXVI, Fig. 2. Pl. LXV, Figs 7-9,12, 20.

**Description.**
Species distinguished by broad, closed petals; except for the anterior one (Schultz, 2010). A more detailed description is given by Mortensen (1948) and Schultz (2010).

**Distribution.**
An Indo-Pacific species reported from Eastern Africa and Madagascar (Clark & Rowe, 1971), this study reports species for the first time in South African localities.

**Material examined.**
SAM A 28220; Rocktail Bay; -27.1844 32.8500; 100 m; *Meiring Naude Dredge Survey*; 4 June 1987.
SAM A 28214; Liefeldts Rock; -27.7172 32.6519; 50 m; *Meiring Naude Dredge Survey*; 8 June 1988.
Fig. 2.17. Aboral view of *Clypeaster fervens* SAM A 28220 (scale bar: 100 mm).
Order: Spatangoida L. Agassiz, 1840a
Family: Brissidae Gray, 1855
Genus: Metalia Gray, 1855

Test oval, with shallow anterior notch; subanal fasciole shield-shaped, with anal branches.

*Metalia robillardi* (de Loriol, 1876)

Fig. 2.18.

*Metalia robillardi*: Mortensen, 1951: 537; Clark & Rowe, 1971: 146, 166; Schultz, 2010: 394.

**Description.**
Species with test anteriorly raised, sloping gradually towards the posterior end (Mortensen, 1951; Schultz, 2010).

**Distribution.**
A shallow-water Indo-Pacific species reported from East Africa, Madagascar and Mauritius (Clark & Rowe, 1971; Schultz, 2010).

**Material examined.**
SAM A 28230; Jesser Point; -32.7033 32.7000; 50 m; *Meiring Naude Dredge Survey*; 3 June 1987.

![Fig. 2.18. Aboral view of Metalia robillardi SAM A28230 (scale bar: 100 mm).](image)
Family: Loveniidae Lambert, 1905

Genus: Lovenia Desor, in Desor & Agassiz, 1847

Test delicate, heart-shaped, depressed areoles on upper side; large lateral tubercles orally, aboral spines curved backwards, one side thorny or entirely smooth in other species.

Lovenia elongata (Gray 1845)

Fig. 2.19.

Lovenia elongata: A. Agassiz, 1872: 139, 575. Pl. XIX. Figs 1-4. Pl. XXV. Fig. 3. Pl. XXVI. Fig. 35-36. Pl. XXXVII. Figs 18-19. Pl. XXXVIII. Figs 27-28; Doderlein, 1906: 265. Pl. XLVII. Fig. 5; Mortensen, 1951: 97-104. Pl. VII, Figs 1-10. Pl. VIII, Fig. I. Pl. XII, Fig. 5. Pl. XLVII, Figs 10-23; H.L. Clark, 1923: 404; Clark & Rowe, 1971: 146, 164. Pl. XXV, Figs 14-15; Clark & Courtman-Stock, 1976: 252; Richmond, 1997: 300-301; Schultz, 2010: 419. Fig. 789.

Description.
Test delicate, kidney-shaped; as outlined by Mortensen (1951) and Schultz (2010).

Distribution.
Species widely distributed throughout the Indo-Pacific, from the Red Sea along East Africa, and from southern Japan to the east coast of Australia (Clark & Rowe, 1971; Schultz, 2010) and reported from close-by regions, such as Mozambique (Clark and Courtman-Stock, 1976). This study thus reports species in South Africa for the first time.

Material examined.
SAM A 28215; Kosi River; -26.7014 32.9022; 42 – 44 m; Meiring Naude Dredge Survey; 3 June 1990.
SAM A 28216; Hully Point; -27.3339 32.7672; 60 m; Meiring Naude Dredge Survey; 5 June 1987.
SAM A 28219; Kosi River; -26.8681 32.9022; 50 m; Meiring Naude Dredge Survey; 8 July 1987.

Remarks.
“Cape of Good Hope” record of species by A. Agassiz (1881) is dubious, as species is a well-known Indo-Pacific species; and therefore his record has been identified as Lovenia gregalis (Mortensen, 1951; Clark and Courtman-Stock, 1976).
Fig. 2.19. Aboral view of *Lovenia elongata* SAM A28215 (scale bar: 10 mm)
Chapter 3.

Field guide to South African echinoids (Echinodermata: Echinoidea).

The existing South African echinoid guide by Clark & Courtman-Stock (1976) is now outdated, plus is too poorly illustrated and too technical for most users. Furthermore, it reviews the echiniod fauna of the broader southern African region, including southern Mozambique and Namibia, rather than that of South Africa specifically.

This chapter therefore aims to produce a comprehensible, photographically-illustrated identification field guide to all currently known South African echinoids, suitable for use by naturalists; even those with little background in taxonomy. Species reported from Namibia and Mozambique by Clark & Courtman-Stock (1976) are thus omitted in this study; leaving the number of South African echinoid species as reported in that study at 50. Subsequent to Clark & Courtman-Stock (1976) only two additional species, originating from the 1975 -1976 Meiring Naude Survey, have been taxonomically reported and added to the fauna by A.M. Clark (1977), increasing the number of known species at the start of this study to 52 species. To this are now added the 19 new records documented in Chapter 2, raising the known number of South African echinoidea species to 71, representing 14 orders and 29 families.

As in Chapter 2, taxa are arranged according to the phylogenetic and alphabetic sequence outlined by Kroch & Smith (2010), which conforms to that of the World Echinoid Database (WED). Each species is entered in bold font under its current binomial nomenclature; followed by the author and year of publication (brackets around author indicating genus change since or original description). The new records described in Chapter 2 are denoted by an asterisk. Below are synonym entries of the main literature used to describe each species. A point-form paragraph giving the description and/or diagnosis is given for each entry. An indication of maximum size is also included, either based on personal observation and measurement of specimens within the Iziko South African Museum collection, or derived from literature cited within the entry. The global distribution, the South African records and depth range of the species form another paragraph, with updated information included from the current study’s findings. Following are the remarks, which include notes on the biology; with taxonomic notes highlighting the variation within the species, or morphological differences distinguishing it from other species. Main features of family and genus of each species entry are also given in point form. Each entry is accompanied by photographic illustrations and a map showing known distribution records around South Africa. For ease of reference the West
coast region has been defined as the zone extending from the Namibian border to Cape Point, the South coast region as the zone stretching eastwards from Cape Point to Mbashe River and the East coast as the zone extending from Mbashe River northwards to the Mozambique border.

A glossary on the terminology used in the text (appendix 1) and a revised species list arranged in the current recognized phylogenetic sequence of Kroh & Smith (2010) (appendix 2) are also provided. This species list includes all name changes subsequent to Clark & Courtman-Stock (1976) and all species added to the fauna subsequent to that monograph are highlighted in bold.

**Morphological characters**

The figures below are extracted from Clark & Rowe (1971) (Fig. 3.1) and Clark & Courtman-Stock (1976) (Figs 3.2-3.5); and show some of the different morphological features mentioned in the taxonomic section of this chapter.

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**Fig. 3.1.** Whole test of typical echinoid showing main body parts.
Apical systems:

Fig. 3.2. Parts of apical disc of: a. *Stomopneustes variolaris* (apical system exert. i.e. ocular plates not in contact with periproctal area; periproct plated, tuberculated), b. *Coelopleurus maillardi* (apical system exert- ocular plates not in contact with periproctal area; periproct with four plates, no tubercles), c. *Astropyga radiata* (apical system insert. i.e. ocular plates touching periproctal area; periproct inflated into cone), d. *Diadema savignyi* (apical system with some ocular plates in contact with periproctal area, others not; periproct inflated in to cone), e. *Temnopleurus reveesii* (apical system exert. i.e. ocular plates not in contact with periproctal area; periproct plated, tuberculated).

Ambulacral plates:

Fig. 3.3. Ambulacral plates from oral side of: a. *Araeosoma paucispinum* (small lozenge around pore-pairs, arcs horizontal), b. *Sperosoma biseriatum* (primary plates sub-divided;
arcs oblique); ambulacral plates of: c. *Toxopneustes pileolus* (trigemate- arcs forming three verticle series, in oblique arcs), and d. *Tripneustes gratilla* (pore-pairs nearly in horizontal arc)

**Interambulacra plates.**

![Interambulacra plates](image)

Fig. 3.4. Interambulacral plates of: a. *Trigonocidaris monoli* (sculptures horizontally positioned) and b. *Temnopleurus reveesii* (angular pits formed at the edges of the sutures).

**Tubercles.**

![Tubercles](image)

Fig. 3.5. Tubercles of: a. *Chaetodiadema africanum* (perforated and crenulated), b. *Salenia sp* (non-perforated but crenulated), c. *Stereocidaris squamous* (perforated but no traces of crenulation), d. *Coelopleurus maillardi* (non-perforated nor crenuated)
Spines.

Fig. 3.6. Tips of primary spines of: a. *Diadema setosum* (fusiform with blades meeting at tip), b. *Echinothrix calamaris* (needle-like with backward directed barbs), c. *Stereocidaris squamous* (spines with continuous ridges), d. *Prionocidaris pistillaris* (rigorous, but without continuous ridges); tips of miliary spines of e. *Echinus gilchristi* (projections directed distally), f. *Dermichinus horridus* (projections at right angles to shaft).
Taxonomic section.

Class: Echinoidea Leske, 1778
Subclass: Cidaroida Smith, 1984
Order: Cidaroida Claus, 1880
Superfamily: Histocidaroida Lambert, 1900
Family: Histocidaridae Lambert, 1900

Primary tubercles strongly crenulated.

Genus: Histocidaris Mortensen, 1903

Characterized by tessellate sutures, perforated and strongly crenulated tubercles; primary spines long, cylindrical; secondaries slender, not flattened.

*Histocidaris elegans* (A. Agassiz, 1879)

Figs 3.6-3.7 A-B.


*Histocidaris elegans*: Döderlein, 1906: 117. Pl. XIII. Figs 1-3, Pl. XL. Fig. 3; H.L. Clark, 1925: 37; Mortensen, 1928: 72-77. Pls I. Figs 1-5, Pl. II. Figs 1-3, Pl. LXVIII. Figs 6, Pl. LXXV. Fig. 16, Pl. LXXVI. Figs 9-13; Clark & Courtman-Stock, 1976: 215-216; Schultz, 2010a: 26. Fig. 49.

**Diagnosis:** Test with round outline; primary spines long, thin, serrated orally, numerous scrobular spines; whole specimen yellow in color.

**Description:** Test high, flattened both sides. Apical system exsert, mostly bare, with few tubercles on plates; female pores larger than males. Peristome slightly plated. Ambulacra sunken; marginal tubercles slightly irregular, smaller than usual; interperiforous zones narrow, with irregular alternating series of small tubercles from between ambulacral and interambulacral zones to margin; pore-pairs not sunken, pores of equal size, separated by narrow zone. Interambulacra swollen, areoles not deepened. Primary spines long, strongly serrated, secondaries slender, ending in a blunt point. Preserved specimen with white primary spines, test and scrobicular spines yellowish.

**Size:** Maximum horizontal diameter 67 mm.
**Global distribution:** South Japan to South Australia, New Zealand and South Africa, 200 – 2,000 m depth (Schultz, 2010a).

**South African record of Histocidaris elegans:** Represented by one sample in the Iziko collection, but this specimen lacks any associated data. It thus seems likely that that specimen is the same one reported on, also without locality data, by Mortensen (1932). The species thus remains a dubious record for South Africa and more samples are needed to document its true distribution in South African waters.

![Fig. 3.6. Distribution of Histocidaris elegans.](image)

**Fig. 3.6.** Distribution of *Histocidaris elegans.*

![Fig. 3.7. Histocidaris elegans. A. Side view of preserved specimen (scale bar 100 mm). B. Apical system of preserved specimen (scale bar 10 mm).](image)
Family: Cidaridae Gray, 1825
Primary tubercles perforate, with some traces of crenulation on aboral tubercles.

Sub-family: Cidarinae Mortensen, 1928
Scrobicular tubercles larger than the surrounding ones, no pits or grooves.

Genus: Eucidaris Pomel, 1883
Spines banded, some cases stout, ending into a crown; in other cases spines fusiform; oculars triangular, exsert, barely insert.

*Eucidarisa metularia* (Lamarck, 1816)
Figs 3.8-3.9 A-B.

*Gymnocidarisa metularia*: A. Agassiz, 1863: 17.
*Cidarisa metularia*: A. Agassiz, 1872-1874: 98, 254, 385. Pl. I. Figs 23-24, Pl. XXXV. Fig. 3.
*Cidarisa (Gymnocidarisa) metularia*: Bell, 1904: 138; Döderlein, 1906: 101.
Figs 1-8, Pl. LXXIII. Fig. 6. Pl. LXXXVI. Figs 11-14; Richmond, 1997: 295-296; Samyn, 2003: 197. Fig. 2A; Schultz, 2010a: 36. Figs 61-63.

**Diagnosis**: Apical system flat, elevated in some cases, smaller than protruding peristome, plates outline conspicuous. Spines short, stout, distally crown-shaped and sometimes tapered, distinctively banded, with longitudinal ridges distally.

**Description**: Test moderately thick, round outline, aborally flattened. Apical system larger in young specimens, sometimes entirely sunken, in other cases slightly sunken, encircled by tubercles, plates granulated with tubercles along the outer edges of plates, dicyclic (occasionally oculars I, IV, V insert), oculars triangular shaped, madreporite slightly larger than plates. Peristome larger than apical system, somewhat conically raised. Ambulacra narrow, median zone naked, each marginal tubercle coupled with smaller inner one. Interambulacra median area tuberculated, up to 7 plates per column covered with tubercles, areoles large. Primary spines thick and robust, banded brown and whitish, shaft set with spinules arranged in *c.a* 12-18 longitudinal ridges forming crown-end, short collar, smooth inconspicuous neck. Secondary spines closely arranged, scrobicular spines broad, flat, basal concave narrowing to point, closely packed around primary spines; marginal ambulacra
spines more slender. Denuded test white, with brownish or purplish tints; primary spines banded white and brown, secondaries brown; apical system darker with white borders, interporiferous zones white.

**Size:** Maximum horizontal diameter 30 mm.

**Global distribution:** Mozambique and Red Sea to Fiji, Gilbert and Hawaiian Islands, and from South Japan to north coast of Australia, at 5 – 570 m depth (Mortensen, 1928; Schultz, 2010a).

**South African records of *Eucidaris metularia:*** formally reported for the first time in South Africa through this study, but previously collected by Samyn & Thandar (2003) who logged specimens in the *Royal Museum of Africa*. All records from the East coast region of South Africa.

**Remarks:** Feeds on encrusted algae, bryozoans, sponges and detritus.

**Taxonomic notes:** Mortensen (1928) highlights variations within the species, which include spines of some specimens being stout and blunt, whereas in other cases spines are fusiform, latter usually a feature of deep-water specimens. Deep-water specimens may be mistaken with *Prionocidaris pistillaris* in having fusiform spines, but differs in lacking stripes on collar. Color variation exists amongst adults and juveniles may, where young specimens more vividly colored than adults. The number of longitudinal ridges may also vary with age, being greater in adults than in juveniles.
Fig. 3.8. Distribution of *Eucidaris metularia*.

Fig. 3.9. *Eucidaris metularia*. **A.** Aboral view of preserved specimen. **B.** Aboral view of preserved specimen (scale bar: 10 mm).
**Genus: Kionocidaris Mortensen, 1932**

Primary spines thick, striated and smooth; ambulacral pore-pairs not conjugate, upper primary tubercles crenulated.

**Kionocidaris striata Mortensen, 1932**

Figs 3.10-3.11 A-B.


**Diagnosis:** Spines thick, solid, serrated, fusiform, tapering to a simple end; creamish in color.

**Description:** Generic features include test being low, flattened above, arched sides. Apical system bare, except along inner edge of madreporite, madreporite enlarged, oculars insert, pores larger in females than males, periproct slighted elevated. Peristome raised, same size as apical area. Ambulacra narrow, interporiferous larger than pore zones, marginal tubercles regularly arranged; inner space narrow, leaving space for single, incomplete series of tubercles, alternately placed on one or the other side of midline. Interambulacral areoles not deepened, separated, lowermost confluent, two to three uppermost primary tubercles large, diminishing in size towards mouth, scrobicular tubercles larger than marginal ones, midline naked and sunken. Primary spines robust, thick, tapering into simple point, smooth, with longitudinal ridges; oral spines simple, flattened, not serrated; secondaries simple, flat, narrowing towards point; scrobicular ones long, not strongly appressed. Denuded test white; upper tubercles and apical system creamish, sometimes olive, genital plate with small dark spot in middle; primary spines uniformaly cream, with faint tint of olive green; secondaries white with greenish median stripe.

**Size:** Maximum horizontal diameter 27 mm.

**Global distribution:** Endemic to the East coast region of South Africa, at 126 m depth (Mortensen, 1932; Clark & Courtman-Stock, 1976; Schultz, 2010).
Remarks: According to Schultz (2010c), Clark & Courtman-Stock (1976) referred to the type in their report and no other specimen has been recorded. This species is represented by a single Iziko sample, which is the type.

Fig. 3.10. Distribution of *Kionocidaris striata*.

Fig. 3.11. *Kionocidaris striata*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 10 mm).
Genus: *Phyllacanthus* Brandt, 1835

Conjugated pore pairs, which extend onto peristome in double series; enlarged madreporite; primary spines granuled.

*Phyllacanthus imperialis* (Lamarck, 1816)

Figs 3.12-3.13 A, B.

*Phyllacanthus fustigera*: A. Agassiz, 1863: 17.

*Phyllacanthus imperialis*: A. Agassiz, 1872-1874: 151, 391. Pl. I. Figs 1-6, Pl. I. Fig. 2; Döderlein, 1906: 98. Pl. XL. Fig. 5. a-e; Mortensen, 1928: 504-509. Pl. LIV. Fig. 4, Pl. LVII. Fig. 3, Pl. LXXIV. Fig. 6, Pl. LXXXVIII. Figs 4- 10; Samyn, 2003: 197. Fig. 2B, B'; Schultz, 2010a: 46. Figs 80-83.

**Diagnosis:** Primary spines dark brown, granulated with longitudinal ridged tips; secondary spines lighter brown, smooth and somewhat fusiform; apical system sunken, dark in color; conspicuous madreporite.

**Description:** Test solid, flattened aborally. Apical system small, tuberculated, with enlarged madreporite; genital plates exsert, densely tuberculated. Ambulacra sinuous, marginal tubercles arranged regularly, median zone filled by tubercles, pore-zones depressed, and pore-pairs joined by shallow furrows. Interambulacra tubercles large, areoles sunken, 6-7 plates per column, tubercles covering median area, irregular lines crossing median zone. Primary spines distally crowned, dark brown, banded; secondaries appear smooth and lighter; scrobicular thick, robust, somewhat broader, surround base of primaries; miliaries short, dark, densely scattered over apical system. Denuded test lilac- brownish with white tubercles.

**Size:** Maximum horizontal diameter 80 mm.

**Global distribution:** Red Sea and Madagascar to the Tonga Islands, from Rui-Kui Islands to Australia; at depth 5 -70 m (Mortensen, 1928; Schultz, 2010a).

**South African record of Phyllacanthus imperialis:** Species formally reported in South Africa for the first time here, but previously collected by Samyn & Thandar (2003) who
encoded records in the *Royal Museum of Central Africa*. All records are from the East coast region of South Africa.

**Remarks:** Species displays nocturnal foraging behaviour and remains inactive during the day.

**Taxonomic notes:** Differs from *Eucidaris metularia* in spine characteristics, of which *Phyllacanthus imperialis* has long primaries whereas *E. metularia* has short, stout ones.

![Fig. 3.12. Distribution of Phyllacanthus imperialis.](image)

![Fig. 3.13. Phyllacanthus imperialis. Aboral view of preserved specimen (scale bar: 10 mm).](image)
**Sub-family: Goniocidarinae Mortensen, 1928a**

Distinctive pits and grooves in horizontal suture.

**Genus: Goniocidaris Desor, in Agassiz & Desor, 1846**

Primary spines with large basal or terminal discs, sometimes having both.

**Sub-genus: Goniocidaris (Aspidocidaris) Desor, in Agassiz & Desor**

Basal discs more or less developed; terminal discs well-developed, disc usually covering the adapical area.

*Goniocidaris (Aspidocidaris) indica* Mortensen, 1939

Figs 3.14-3.15.


**Diagnosis:** Spines thorny, well-developed basal disc.

**Description:** Test sub-conical, yellowish. Apical system half test diameter; ocular plates insert, uniformly tuberculated, gonopores distally positioned, larger in females than in males, periproct pentagonal. Peristome smaller than apical disc. Ambulacra inner space set with small tubercles; pits along sutures. Interambulacra with no median naked space; horizontal sutures deepened forming distinct pits. Primary spines long, white, tapered with basal disc; oral slender and short; scrobicular thick and smooth, marginal similar, but more slender and short. Denuded test creamish.

**Size:** Maximum horizontal diameter 25 mm.

**Global distribution:** Maldives, Tanzania at 162 – 620 m depth (Clark & Courtman-Stock, 1976; Schultz, 2010c).

**South African record of Goniocidaris (Aspidocidaris) indica:** Confirmation record collected from the south coast region of South Africa. Clark & Courtman-Stock (1976) reported on the genus, but they were unable to identify their specimen to species level due to it being damaged. This study therefore confirms their record to be Gionocidaris indica.
**Taxonomic notes:** Schultz (2010c) reported this species under the sub-genus *Aspidocidaris*, but admits that sub-generic grouping remains problematic.

Fig. 3.14. Distribution of *Goniocidaris (Aspidocidaris) indica*.

Fig. 3.15. *Goniocidaris (Aspidocidaris) indica*. Aboral view of preserved specimen (scale bar: 10 mm).
Sub-family: Stereocidarinae Lambert, 1900
Characterized by primary tubercles carrying non-functional spine.

Genus: Stereocidaris Pomel, 1883
Uppermost interambulacral tubercles hardly crenulated.

*Stereocidaris alcocki* (Anderson, 1984)
Figs 3.16-3.17 A-B.

*Stereocidaris tricarinata*: Döderlein, 1906: 112-114. Pl. X, Fig. 7. Pl. XXXVI, Fig. 3.
*Stereocidaris alcocki*: Mortensen, 1928: 266. Pl. LXXI, Fig. 8. Pl. LXXXII, Fig. 18; Schultz, 2010c: 1037.

**Diagnosis:** Primary spines with three keels basally, two arranged laterally and one on underside.

**Description:** Test globular, solid, aborally flattened. Apical system dicyclic, sometimes oculars slightly insert; genital plates high, raising periproct; all plates tuberculated. Ambulacra pore pairs narrow; interporiferous zones with regular, vertical row of marginal tubercles, smaller inner tubercles arranged horizontally. Interambulacra having deeply sunken areoles; 8 plates per column; ambitus with vertical sutures forming sunken space. Primary spines white, typically distinguishable by three keels; scrobicular with longitudinal furrows. Cleaned test white.

**Size:** Maximum horizontal diameter 32 mm.

**Global distribution:** Restricted to Indian Ocean (Schultz, 2010c), depth 371 – 850 m.

**South African record of Stereocidaris alcocki:** New record collected from the East coast region of South Africa, at 850 m, extending depth range 100 m deeper than the previously known maximum depth of 750 m.
Fig. 3.16. Distribution of *Stereocidaris alcocki*.

Fig. 3.17. *Stereocidaris alcocki*. **A.** Aboral view of preserved specimen. **B.** Spines of preserved specimen (scale bar: 10 mm).
**Stereocidaris capensis** Döderlein, 1901

Figs 3.18-3.19 A-B.

*Stereocidaris capensis*: Döderlein, 1906: 110-112. Pl. X, Figs 3-6. Pl. XII, Fig. 2. Pl. XXXVI, Fig. 4. Pl. XXXVII, Fig. 1. H.L. Clark, 1925: 25; Mortensen, 1928: 369. Pl. LXXI, Fig. 1; Clark & Courtman-Stock, 1976: 217; Schultz, 2010c: 1039. Figs 1796-1799.

**Diagnosis:** Spines long, tapered, stout, with about 20 longitudinal ridges.

**Description:** Main generic features, differs from other species in test being moderately high, convex aborally. Apical system large, evenly raised, all plates exsert, genital pores distally positioned. Primary spines stout, somewhat fusiform, with 20 longitudinal ridges. Scrobicular spines keeled, marginal ones broadened and flattened.

**Size:** Maximum horizontal diameter 36 mm.

**Global distribution:** Endemic to the South coast region of South Africa (Clark & Courtman-Stock, 1976); at 475-900 m. Specimen identified through this study extends previously known distribution northwards towards Durban. Record also illustrates a 345 m deeper depth extension from the previously known maximum depth of 555 m to 900 m.

**Taxonomic notes:** The smallest species of genus found in South African waters.

Fig. 3.18. Distribution of *Stereocidaris capensis.*
Fig. 3.19. *Stereocidaris capensis*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 10 mm).
**Stereocidaris excavata** Mortensen, 1932.
Figs 3.20-3.21 A-B.

*Stereocidaris excavata* Mortensen, 1932. 151-154. Pl. II, Figs 1-5. Pl. IV, Fig. 2. Pl. XI, Fig. 1-2; Clark & Courtman-Stock, 1976: 217; Schultz, 2010c: 1040. Figs 1800-1801.

**Diagnosis:** Similar to *Stereocidaris capensis*; but differs in primary spines being slender, somewhat fluted, rigose, with about 12 finely serrate, low ridges; secondaries appressed, chisel-like in shape. Denuded test creamish, with green tint.

**Size:** Maximum horizontal diameter 69 mm.

**Global distribution:** Endemic to the South coast region South Africa, at 120-177 m depth (Mortensen, 1932; Clark & Courtman-Stock, 1976; Schultz, 2010c).

**Taxonomic notes:** Both *S. capensis* and *S. excavata* are restricted to South African waters; they may, however, be differentiated in primary spines and apical systems. *S. capensis* has fusiform, stout primary spines with 20 longitudinal ridges and an elevated apical system with distally arranged gonopores; whilst *S. excavata* has fluted, slender primary spines with 12 low serrations and a distinctively sunken apical system with centrally positioned, elevated gonopores.

![Fig. 3.20. Distribution of Stereocidaris excavata.](image-url)
Fig. 3.21. *Stereocidaris excavata*. **A.** Side view of preserved specimen. **B.** Side view of denuded test (scale bar: 10 mm).
**Stereocidaris squamosa** Mortensen, 1928.

Figs 3.22-3.23 A-B.

*Stereocidaris squamosa* Mortensen, 1928: 245-247. Pl. XX, Figs 4-6, Pl. LXX, Fig. 7. Pl. LXXX. Figs 10-16; Mortensen, 1932: 151; Clark & Courtman-Stock, 1976: 218; Schultz, 2010c: 1060. Figs 1844-1845.

**Diagnosis:** Has main generic features, with a less aborally elevated test, and gonopores centrally positioned, as in *S. capensis*. Differs from *S. capensis* in that primary spines have broad tips and about 15 longitudinal ridges, yellowish, slightly tapered, dark line towards neck; naked lines along plates.

**Size:** Maximum horizontal diameter 47 mm.

**Global distribution:** Tanzania, South Africa, Saya da Malha Bank, at 270-374 m depth (Clark & Courtman-Stock, 1976).

**South African record of Stereocidaris squamosus:** East coast region.

**Taxonomic notes:** Differs from the two endemic *S. capensis* and *S. excavata* in primary spines and genital plates, respectively. Both *S. capensis* and *S. squamous* have slightly elevated genital plates with distally positioned gonopores, but differ in the number of longitudinal ridges on the spine; where latter has about 15 and the former 12 ridges. Differs from *S. excavata* in having a raised apical system, rather than a sunken one.
Fig. 3.22. Distribution of *Stereocidaris squamous*.

Fig. 3.23. *Stereocidaris squamous*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 10 mm).
Sub-family: Stylocidarinae Mortensen, 1903

Genus: Acanthocidaris Mortensen, 1903

Tubercles distinctively crenulate; primary spines long, flattened, with long collar.

*Acanthocidaris maculicollis* (de Meijere, 1904)

Figs 3.24-3.25 A-B.

*Acanthocidaris maculicollis*: Mortensen, 1928: 329-333. Pl. XLIII, Figs 1-2. Pl. XLIV, Fig. 1. Pl. LIV, Figs 5-6. Pl. LXXXIII, Figs 12-15; Mortensen, 1932: 157-158. Pl. V. Fig. 6. Pl. XI, Fig. 5; Clark & Courtman-Stock, 1976: 214.


**Diagnosis:** Spines long, collar conspicuously marked with red spots.

**Description:** Main characteristics include test being flattened above and below, outline circular. Apical system large, oculars usually insert, tuberculated. Ambulacral pore-pairs horizontally arranged, marginal tubercles small, median zone sunken; one large primary tubercle per plate, interporiferous zone filled with small tubercles. Interambulacral primary tubercles perforated, crenulated, areoles separated, except towards mouth. Distinguished by long, tapering spines, collar long, with spots, with white and greenish tints; secondaries erect.

**Size:** Maximum horizontal diameter 61 mm.

**Global distribution:** South Africa, East Indies and South of Japan (Clark & Courtman-Stock, 1976); at 40-225 m depth (Mortensen, 1928).

**South African record of Acanthocidaris maculicollis:** Mortensen (1932) reported on a specimen from the Durban Museum, lacking exact locality data. Clark & Courtman (1976) also report this species as occurring ‘Off Natal’, likely based on the same specimen Mortensen (1932) reported on. This study therefore confirms the presence of *Acanthocidaris maculicollis* in off the east coast region of South Africa, based on the single sample from southern KwaZulu-Natal shown in Fig 3.24.
Fig. 3.24. Distribution record of *Acanthocidaris maculicollis*.

Fig. 3.25. *Acanthocidaris maculicollus*. A. Preserved specimen. B. Spine close-up of preserved specimen (scale bar: 10 mm).
**Genus: Plococidaris Mortensen, 1909**

Primary spines distinctly verticillate; test green-mottled; oculars insert.

*Plococidaris verticillata* (Lamarck, 1816)

Fig. 3.26-3.27 A-B.

*Phyllacanthus verticillata:* A. Agassiz, 1881: 40.


**Diagnosis:** Test robust; apical system star-shaped, dark; peristome conically raised; primary spines with three to four crown-like structures, with sharp ends.

**Description:** Test with circular outline. Apical system large, ocular plates insert, with series of tubercles along inner edge, periproct tubercuated. Peristome same-size as apical area; raised. Ambulacral pore-pairs conjugated, median space naked and not sunken. Interambulacra with separate areoles, not deepened, median space naked and slightly sunken. Primary spines with prominent whorls, distally ending into crown, space between whorls filled with regularly arranged thorns and spots. Ambulacral secondary spines flattened, scrobicular broader, apical ones leaf-shaped. Test greenish; primary spines somewhat banded, secondaries white with green, apical system and ambulacra dark.

**Size:** Maximum horizontal diameter 40 mm.

**Global distribution:** Kenya (Samyn, 2003), Zanzibar, South Africa, East Africa to the Fiji and Hawaiian Islands, from southern Japan to the Australian east coast; from littoral to 50 m (Schultz, 2010a).

**South African record of Plococidaris verticillata:** New record collected from the East coast region of South Africa.

**Remarks:** Only species in genus.
**Taxonomic notes:** Distinguishable from *Acanthocidaris maculicollis* by its stout spins, bearing 3-4 crown structures; and its conically raised peristome.

![Fig. 3.26. Distribution of *Plococidaris verticillata.*](image)

*Fig. 3.26. Distribution of *Plococidaris verticillata.**

![Fig. 3.27. *Plococidaris verticillata.* Aboral view of preserved specimen (scale bar: 10 mm).](image)

*Fig. 3.27. *Plococidaris verticillata.* Aboral view of preserved specimen (scale bar: 10 mm).*
Genus: Prionocidaris A. Agassiz, 1863

Pores distinctly conjugate, in adults; collar of primary spines usually with red or purple spots, or stripes; oculars broadly insert.

Prionocidaris pistillaris (Lamarck, 1816)

Figs 3.28-3.29 A-B.

Prionocidaris pistillaris: A. Agassiz, 1863: 18; Mortensen, 1928: 452-456. Pl. XLIX. Pl. L. Pl. LI. Fig. 1. Pl. LXXIII. Fig. 18. Pl. LXXXVI. Figs 20-21; Clark & Courtman-Stock, 1976: 216-217; Richmond, 1997: 295; Samyn, 2003: 200. Figs 2D, D', D"; Branch et al., 2010: 236. Fig. 106.1; Schultz, 2010a: 61. Fig. 111.

Cidaris sp: Bell, 1904: 168.


Diagnosis: Spines uniformly set with thorns, collar striped.

Description: Test flattened above and below, circular in outline. Apical system tuberculated, oculars broadly insert, periproct elevated or flat. Peristome with well-developed interradial plates, not reaching mouth opening. Ambulacra straight, with marginal zone densely covered by small tubercles, no distinct median line. Interambulacral areoles not deepened, well separated, median line scarcely sunken, not naked. Primary spines set with thorny structures, with distal longitudinal ridges, scrobicular ones long and flat, marginal ones more pointed, appressed. Denuded test greenish, primary spines uniformly brownish, without bands, thorns white, collar with purple and white alternating longitudinal stripes; secondaries purplish brown or lilac, with lighter tips.

Size: Maximum horizontal diameter 60 mm.

Global distribution: Kenya (Samyn, 2002), Mauritius, Seychelles, Madagascar and East Africa from Tanzania to South Africa (Schultz, 2010a); from littoral to 200 m depth.

South African records of Prionocidaris pistillaris: East coast region. Iziko samples identified through this study illustrate a 109 m depth extension from the previously known maximum depth of 91 m, to 200 m.
**Taxonomic notes:** Adults and juvenile differ in appearance, with juveniles having fewer spines and being more vivid in color (Branch *et al.*, 2010). Species is similar to *Plococidaris verticillata* in oculars being insert, distinguished from one another in the spines, where *P. verticillata* has distinct whorls and *P. pistillaris* has a striped collar.

![Distribution of Prionocidaris pistillaris.](image)

Fig. 3.28. Distribution of *Prionocidaris pistillaris*.

![Prionocidaris pistillaris. A. Side view of adult preserved specimen. B. Side view of juvenile preserved specimen (scale bar: 10 mm).](image)

Fig. 3.29. *Prionocidaris pistillaris*. **A.** Side view of adult preserved specimen. **B.** Side view of juvenile preserved specimen (scale bar: 10 mm).
**Genus: Stylocidaris Mortensen, 1909**

Characterized by tapering, slender, pointed spines; areoles round and well developed.

*Stylocidaris cingulata* Mortensen, 1932

Figs 3.30-3.31 A-B.

*Stylocidaris cingulata* Mortensen, 1932: 162-164. Pl. I, Fig. 6. Pl. XI, Fig. 6. Pl. XIII. Figs 8-10; Schultz, 2010c: 925. Figs 1565-1566.

**Diagnosis:** Apical system dark green, star-shaped, tuberculated inner and outer edges, periproct conspicuously raised. Spines white, banded with pinkish tints.

**Description:** Test stout, adapically raised. Apical system half the size of test, dark, ocular plates exsert (sometimes insert), small tubercles scattered on inner and outer margin. Peristome slightly raised. Ambulcra interporiferous zones having similar width as pore zones, median line a bit sunken, pores distant where outer larger. Interambulacra having large areoles, separated, single row secondaries circle alternating scrobiculars. Spines long, fusiform, slender, with shiny neck, shaft with tiny beads, pinkish bands; secondaries having narrow greenish stripes. Denuded test whitish, with green tints, periproctal area distinctively darker.

**Size:** Maximum horizontal diameter 13 mm.

**Global distribution:** Reported from the Indian Ocean at 120-125 m depth (Mortensen, 1932; Schultz 2010c).

**South African record of Stylocidaris cingulata:** New record from the East coast region.

**Remarks:** Mortensen (1932) reported on holotype which lacked locality data, specimen was however, stored alongside an eastern Indian Ocean specimen, *Stylocidaris albidens*, and therefore it was presumed that *Stylocidaris cingulata* was most likely an Indian Ocean species. The current record thus confirms this.
Fig. 3.30. Distribution of *Stylocidaris cingulata*.

Fig. 3.31. *Stylocidaris cingulata*. A. Side view of preserved specimen. B. Apical system of preserved specimen (scale bar: 10 mm).
**Subclass: Euechinoidea Bronn, 1860.**
**Order: Echinothurioda Clause 1880.**
**Family: Echinothuriidae Thomson, 1872**
Characterized by having distal hoofs on oral primary spines.

**Genus: Araeosoma Mortensen, 1903**
Test leathery; large coronal plates with membranous interstices; gonopores open outside genital plates; peristome with double series pore-pairs.

*Araeosoma paucispinum* H.L. Clark, 1924
Figs 3.32-3.33 A-B.


**Diagnosis:** Tridentate pedicellariae with strongly involute, curved valves absent; secondary ambulacra plates reduced to tablet around pore-pairs, slightly horizontal arcs.

**Description:** Has main generic characteristics and recognized by small, widely-spaced apical plates; madreporite divided into two or more parts; genital plates sometimes extending into periproctal plates; genital plates never invading interambulacra space. Ambulcra primary tubercles scarce orally, in regular longitudinal series; aboral tubercles smaller, numerous, irregularly arranged. Interambulacra primary tubercles in regular series as well, one tubercle per plate; aboral primary tubercles irregularly arranged. Ambulacra narrower than interambulacra. Oral spines curved, long with conspicuous white hoofs; aboral spines dense. Specimen violet in color.

**Size:** Maximum horizontal diameter 135 mm.

**Global distribution:** Endemic to the East coast region of South Africa, at 360-454 m depth (Clark & Courtman-Stock, 1976).
Fig. 3.32. Distribution of *Araeosoma paucispinum*.

Fig. 3.33. *Araeosoma paucispinum*. **A.** Aboral-side of preserved specimen. **B.** Oral-side of preserved specimen (scale bar: 100 mm).
Sub-family: Hygrosomatinae Smith & Wright, 1990
Genus: Hygrosoma Mortensen, 1903
Pore-pars in single series orally.

*Hygrosoma petersii* (A. Agassiz, 1880)
Figs 3.34-3.35 A-B.


*Hygrosoma petersii*: Mortensen, 1935: 202-208. Pls XIII-XVII. Pl. XVIII, Fig. 2. Pl. XIX, Fig. 2. Pl. LXXVIII, Figs I, 3-5, 24, 25; Schultz, 2010c: 1099. Figs 1923-1924.

**Diagnosis:** Collapsed test purple, tubercles disappearing towards the peristome.

**Description:** Test low hemispherical; outline pentagonal. Periproctal plates well developed; apical plates well-defined, genital membranous prolongation short. Ambulacra pore-pairs in single series, demiplates in center of ambulacra plates; aboral pore-pairs in series of two or three, demiplates in contact with outer edges. Interambulca plate sutures without distinct areas. Ambulca and interambulca tubercles large orally, disappearing towards peristome; smaller aborally. Oral spines with conical hoof; aboral spines without bag, bearing poisonous glands. Dark violet in color.

**Size:** Maximum test diameter 180 mm.

**Global distribution:** Widely distributed North Atlantic species; from off South-West Ireland to the Azores and Senegal and from off New Jersey, United States of America, to the West Indies, also reported from South Africa; at 200 - 3 200 m depth range (Schultz, 2010c).

**South African records of *Hygrosoma petersii***: West coast region of South Africa. Clark & Courtman-Stock (1976) have flagged the East coast record of species as dubious, as they point out it “is queried by Mortensen as unlikely to refer to this Atlantic species”.

**Taxonomic notes:** Differs from *Araeosoma paucispinum* in arrangement of pore-pairs, where *Hygrosoma petersii* has pore-pairs in a single series and *A. paucispinum* in oblique arcs forming three ventral series.
Fig. 3.34. Distribution of *Hygrosoma petersii*.

Fig. 3.35. *Hygrosoma petersii*. **A.** Aboral side of preserved specimen. **B.** Oral side (scale bar: 100 mm). **C.** Close-up view of disappearing tubercles towards mouth (scale bar: 10 mm).
**Sub-family Sperosomatinae Smith & Wright, 1990**

**Genus Sperosoma Koehler, 1897**

Secondary ambulacral plates irregularly arranged orally, bearing a tubercle and pore-pair per plate, not differentiated from primary plates, which are sub-divided.

**Sperosoma biseriatum Dördelein, 1901**

Figs 3.36-3.37 A-B.

*Sperosoma biseriatum:* Döderlein, 1906: 150-153. Pl. XIX, Fig. I. Pl. XL, Fig. I; Mortensen, 1935: 191-193. Pl. XI, Figs 1-2. Pl. LXXVI, Fig. 13; Clark & Courtman-Stock, 1976: 221; Schultz, 2010c: 1102. Figs 1930-1931.

**Diagnosis:** Secondary ambulacra plates in irregular series orally, bearing one large tubercle coupled with a pore-pair per plate, secondary primary plates divided; arranged in oblique arcs.

**Description:** Test low, thin, fragile, rounded in outline. Apical system with divided, large madreporite; membranous prolongation inconspicuous. Oral ambulacra plates fragmented, irregularly arranged; large secondary plates with tubercle and pore-pairs forming three series arranged in oblique arcs. Aboral ambulacra primary plates continuous, but not reaching pore-pairs; irregular, smaller, in one series; only third plate from above subdivided, reaching margin. Oral interambulacra tubercles large, smaller towards peristome. Aboral interambulacra irregular, in vertical rows; no membranes spaces between plates. Oral spines with skin bags, aborally ones bearing poisonous glands. Brownish-red in color.

**Size:** Maximum horizontal diameter 120 mm.

**Global distribution:** East Africa and Arabian Sea, and South Africa, at 800 – 1 020 m depth (Clark & Courtman-Stock, 1976).

**South African record of Sperosoma biseriatum:** East coast region of South Africa. Mortensen (1935) reports on specimens from the “South African Marine Survey” but neglects giving locality data. Record of species in Natal is based on Mortensen (1935) suspecting Clark’s (1925) *Echinosoma petersii* entries to be *S. biseriatum* (Clark & Courtman-Stock, 1976).
**Taxonomic notes:** Differs from *Hygrosoma petersii* in that the tubercles diminish in size towards mouth, rather than totally disappearing.

![Map of South Africa showing distribution of Sperosoma biseriatum](image)

Fig. 3.36. Distribution of *Sperosoma biseriatum*.

![Images of Sperosoma biseriatum](image)

Fig. 3.37. *Sperosoma biseriatum.* **A.** Aboral view of preserved specimen. **B.** Oral view of preserved specimen (120 mm) (Schultz, 2010).
Genus: *Tromikosoma* (Mortensen, 1903)

Lacks buccal notches and sacs.

* *Tromikosoma* c.f *uranus* (Thomson, 1877)

Figs 3.38-3.39 A-B.

**Phormosoma** *uranus*: A. Agassiz, 1881: 103.


**Diagnosis:** Delicate test with circular outline; non-denuded test purple.

**Description:** Test flattened, hemispherically raised, rounded outline. Apical system may be sub-divided; in large specimens, the gonopores extend into interambulacra, and membranous gaps may be present. Peristome without notches or sacs. Ambulacra broader than interambulacra at amabitus; adapical demiplates large, in contact with outer sutures; adoral plates much smaller far from both sides; pore-pairs in center of plates; oral ambulacral plates associated with one large primary tubercle, forming an oblique appearance, approaching each other towards ambitus. Interambulacral primary tubercles larger orally than aborally. Oral spines with conical hoofs, aboral ones with venomous glands. Purple in color.

**Size:** Maximum horizontal diameter 125 mm.

**Global distribution:** Portugal to West Africa, at 850-2750 m depth (Schultz, 2010c).

**South African record of *Tromikosoma* c.f *uranus*:** West coast coast region of South Africa. Record based on a single identified sample from the Iziko South African Museum, but identifier unknown. Moreover, was unable to check identification, as specimen was in very bad condition.

**Taxonomic notes:** Type specimen had its madreporite divided into 3-4 parts, but this seems to be an individual variation (Mortensen, 1935).
Fig. 3.38. Distribution of Tromikosoma uranus.

Fig. 3.39. Tromikosoma uranus. A. Aboral view of preserved specimen. B. Oral view of preserved specimen (scale bar: 100 mm).
Family: Phormosomitidae Mortensen, 1934.
Characterized by spines distally covered by thick skin bag.

Genus: Phormosoma Thomson, 1872b.
Deepened areoles orally, disappearing towards ambitus.

Phormosoma bursarium A. Agassiz 1881
Figs 3.40-3.41 A-B.


Diagnosis: Upper primary spines curved.

Description: Test soft; low hemispherical aborally; slightly arched orally. Variation in apical system plate arrangement; madreporite pores sometimes extend into plates; largest periproctal plate with spine-bearing tubercle. Ambulacra tubercles in regular series, pore pairs arranged in a straight line, demiplates on edge of suture; aboral tubercles irregularly arranged, pore pairs in arcs of three, not reaching vertical sutures. Interambulacra twice as broad as ambulacra towards ambitus; three tubercles per plate, in horizontal sutures; aborally irregularly arranged; primary tubercles smaller than oral ones, distally positioned; row of secondaries around margin. Oral spines with fleshy sac, aborally curved, course. Collapsed test beige.

Size: Maximum horizontal diameter 128 mm.

Global distribution: South Africa and the Arabian Sea to Japan, Hawaii and New Zealand; at 170 – 2340 m depth (Mortensen, 1935; Schultz, 2010c).

South African records of Phormosoma bursarium: East coast region of South Africa.

Taxonomic notes: Species shows variation in many characters, such as the number of tubercles orally and aborally and the arrangement of tubercles, which may be limited to distal parts, or extend to apex.
Fig. 3.40. Distribution of *Phormosoma bursarium*.

Fig. 3.41. *Phormosoma bursarium*. A. Aboral side of preserved specimen B. Oral side of preserved specimen (scale bar: 100 mm).
**Phormosoma placenta var. africana** Mortensen, 1935.

Figs 3.42-3.43 A-B.

*Phormosoma placenta var. africana* Mortensen, 1935: 132-133. Pl II, Fig. 10; Clark & Courtman-Stock, 1976: 221.


**Diagnosis:** Differs from *Phormosoma busarium* in having straight aboral primary spines.

**Size:** Maximum horizontal diameter 120 mm.

**Global distribution:** *P. placenta* is a widely distributed Atlantic species of which the South African form, *P. placenta var. africana* is restricted to the Southern Atlantic, at 50 – 3 700 m depth range.

**South African records of Phormosoma placenta var. africana:** West coast region.

**Remarks:** Mortensen (1935) distinguished the South African *P. placenta* from the Atlantic *P. placenta* because of the presence of large tubercles, which suggests larger spines and the feature of species reaching a considerably larger size. Therefore he placed South African *P. placenta* in a separate variety, *P. placenta var. africana*.

**Taxonomic notes:** Differs from *P. bursarium* in having a distinctive sharper outline and finer tubercles, and by geographic distribution: *P. bursarium* being known from the Indian Ocean and *P. placenta var. africana* from the Atlantic Ocean.
Fig. 3.42. Distribution of *Phormosoma placenta var. africana*.

Fig. 3.43. *Phormosoma placenta var. africana*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. (scale bar: 100 mm). C. Close-up view of areoles diminishing towards mouth (scale bar: 10 mm).
Order: Aspidodiadematoida Kroh & Smith, 2010
Family: Aspidodiadematidae Duncan, 1889
Test small, sub-globular; tubercles perforated and crenulated; apical plates fixed firmly in membrane, not attached to main skeletal system; spines brittle, curved, ending in a hoof.

Genus: Aspidodiadema A. Agassiz, 1878
Compound plates in three elements; ambulacra and interambulacra tubercles at ambitus same-sized.

Aspidodiadema africanum Mortensen, 1939
Figs 3.44-3.45 A-B.


Diagnosis: Spines brittle, hollow, with serrations. Peristome encircled by club-shaped spines, and buccal plates.

Description: Test small, somewhat cone-shaped. Apical plates carrying one large tubercle, smaller ones at inner margin. Ambulacra plates with large primary tubercle, elongated, oval in shape, disappearing at ambitus; pore-pairs in straight line. Interambulacra tubercles similar to ambulacra plates in shape, with large areoles; secondaries few and small. Primary spines long, slender, curved, appearing rigose; secondary spines shorter and smooth. Preserved specimen brownish in color, spines white.

Size: Maximum horizontal diameter 16 mm.

Fig. 3.44. Distribution of *Aspidodiadema africanum*.

Fig. 3.45. *Aspidodiadema africanum*. Oral side of preserved specimen (scale bar: 10 mm).
Order: Diadematioda Duncan, 1889
Family: Diadematidae Gray, 1855
Test depressed, genital plates extending into interambulacra.

Genus: Astropyga Gray, 1825
Test flattened orally, aborally slightly convex; periproctal membrane conspicuously raised or sometimes flat.

*Astropyga radiata (Leske, 1778)*
Figs 3.46-3.47 A-B.


**Diagnosis:** Test red, with v-shaped naked interambulacra zones aborally, with dark spots, shining blue in live animal; pore-pairs almost in contact orally, distant aborally; madreporite extending into interambulacra.

**Description:** Test orally and aborally flattened, outline circular; apical system depressed with conspicuous anal cone, with plates extending into interambulacra; except oculars. Ambulacra inflated aborally, primary ambulacra irregularly arranged. Interambulacra tubercles in two series, upper-side naked, giving distinct V-shape, with spots arranged along interambulacram. Spines fragile, hollow, thorny, shorter orally. Denuded test reddish-brown.

**Size:** Maximum horizontal diameter 118 mm.

**Global distribution:** Kenya (Samyn, 2003), Zanzibar to Queensland, Australia, and Hawaiian Islands; littoral to 60 m depth (Schultz, 2010a).

**South African records of Astropyga radiata:** New record from the East coast region.

**Remarks:** Found in sea grasses and reef areas. A predator of encrusting and free-living organisms, such as bryozoans, molluscs and crabs. Group in the day and are active at night. Some fish have a commensal relationship with this species (Schultz, 2010a).
**Taxonomic notes:** Variation of spines in adults and juveniles exist with juvenile spines banded white and purplish brown and adults a uniform color.

![Fig. 3.46. Distribution of *Astropyga radiata*.](image)

![Fig. 3.47. *Astropyga radiata*. A. Live adult. B. Aboral view of preserved juvenile (scale bar: 10 mm).](image)
**Genus: Chaetodiadema Mortensen, 1903**

Test wheel-shaped, peristomial pore-pairs distant from each other; plates high; from ambitus upwards plates in three segments; inner oral area with uniform, dense spine-bearing tubercles.

**Chaetodiadema africanum** H.L. Clark, 1924

Figs 3.48-3.49 A-B.

*Astropyga radiata*: Bell, 1904: 168-169.


**Diagnosis:** Test yellow-greenish; aboral interambulacra naked, v-shaped, blue iridescent spots in live animal, appearing as dark marks in preserved specimen, but yellow on cleaned test.

**Description:** Apical system being large; genital plates pointed; oculars broad, touching periproctal area. Ambulacra primary tubercles in two series, irregularly arranged, disappearing towards ambtius; oral plates with single pore-pair; three pore-pairs aborally, arcs not well developed. Interambulacra tubercles in short series aborally, tubercles extending towards peristome, no traces of crenulation. Spines on upper side long, somewhat serrated; aboral spines smooth and short. Adults pinkish in color, juveniles white with greenish tint.

**Size:** Maximum horizontal diameter 45 mm.

**Global distribution:** Endemic to South Africa, at 85 – 325 m depth (Schultz, 2010c).

**South African records of Chaetodiadema africanum:** East coast region.

**Taxonomic notes:** May be mistaken for *Astropyga radiata*, but differs in test shape as *C. africanum* is flattened orally and aborally; whereas upper side of *A. radiata* is more convex. Color also distinguishes the two species, where adult *A. radiata* is red with blue spots on naked interambulara zones and adult *C. africanum* pinkish. The genital plates and enlarged
medreporite extending into the interambulacral area may also distinguish *A. radiata* from *C. africanum*.

Fig. 3.48. Distribution of *Chaetodiadema africanum*.

Fig. 3.49. *Chaetodiadema africanum*. **A**. Aboral view of adult preserved specimen. **B**. Aboral view of young preserved specimen (scale bar: 10 mm).
Genus: *Diadema* Gray, 1825

Characterized by enlarged periproctal cone, without platelets; distinctive buccal notches; tongue-like, smooth structure around notches; membrane naked.

*Diadema savignyi* (Audouin, 1829)

Fig. 3.50-3.51 A-B.

*Diadema savignyi*: Clark & Courtman-Stock, 1976: 225; Coleman, 1991: 169; Samyn, 2003: 201. Fig. 2g; Schultz, 2010a: 102, Figs 183-186.

**Diagnosis**: Maximum of five interambulacra tubercles, in horizontal series. Blue iridescent lines along aboral plates, interambulacra with white spots; anal cone black.

**Description**: Test moderately high, black in live. Apical system usually insert; madreporite not extremely elongated, black conspicuous anal tube. Ambulacra primary tubercles in series of two; three pore-pairs per plate; pore zones somewhat narrow at mouth. Interambulacra tubercles also in two series; secondaries of equal size; four to six interambulacra tubercles arranged horizontally. Spines uniformly black, in juvenile banded. Species black, blue iridescent lines bordering plates.

**Size**: Maximum horizontal diameter 100 m.

**Global distribution**: Kenya (Samyn, 2003), Red Sea to South Africa, eastwards to the Easter Islands, from Japan to Australia; littoral to 70 m depth (Schultz, 2010a).

**South African records of Diadema savignyi**: East coast region.

**Taxonomic notes**: Unlike *Chaetodiadema africanum*, aboral interambulacra area is not distinctively naked.
Fig. 3.50. Distribution of *Diadema savignyi*.

Fig. 3.51. *Diadema savignyi*. Live specimen.
Diadema setosum (Leske, 1778)

Fig 3.52-3.53 A-B.


**Diagnosis:** Maximum of five interambulacra tubercles in horizontal series; Genital plates with blue spots, white spots on interambulacra midline; anal opening encircled by orange band.

**Description:** Unlike *D. savignyi* test aborally and orally flattened; genital plates extend into interambulacra area; ocular plates I, II and III not touching peripoc (exsert). Distinguishable by anal cone protruding, black, encircled by orange band; ambulacra and interambulacral primary tubercles in two series, no ambulacral secondary tubercles; numerous interamblacra tubercles at ambitus, and orally; secondaries in shorter series at median area; six to seven tubercle columns around ambitus; interambulacra naked, distinct median areas. Primary spines hollow, long, somewhat rigose; secondary spines smaller. Spines and test black, spines banded black and white in juveniles.

**Size:** Maximum horizontal diameter 90 mm.

**Global distribution:** East coast of Africa, South Africa to Australia and from Japan to Tonga; from littoral to 70 m (Schultz, 2010a).

**South African records of Diadema setosum:** East coast region.

**Remarks:** Shallow water; tropical species found in coral reefs, open sandy bottoms, and in sea grass. The long, pointed spines are dangerous, as the distal part penetrates easily through human skin, transferring bacteria and debris into wound, thus infecting it (Branch et al., 2010).

**Taxonomic notes:** Distribution ranges of both *D. savignyi* and *D. setosum* overlap, thus species may be confused. However, differences exist in color of anal cone, which in *D. savignyi* an entirely black rather than orange banded in *D. setosum*. The number of interambulacra
tubercles in the horizontal series also distinguishes species, as *D. savignyi* has a maximum of five tubercles and *D. setosum* has up to seven.

![Diagram](image1)

**Fig. 3.52.** Distribution of *Diadema setosum*.

![Image](image2)

**Fig. 3.53.** *Diadema setosum*. Live juvenile.
**Genus: Echinothrix Peters, 1853**

Characterized by ambulacra widened adapically, strongly inflated; large anal cone with conspicuous white spots.

**Echinothrix calamaris (Pallas, 1774)**

Figs 3.54-3.55 A-B.

*Echinothrix calamaris*: H.L. Clark, 1923: 373; Clark & Courtman-Stock, 1976: 226; Richmond, 1997: 296; Samyn, 2003: 203. Fig. 3B; Branch et al., 2010: 236. Fig. 106.4; Schultz, 2010a: 108. Fig. 193-194.

**Diagnosis:** Test with green, naked areas aborally; large anal cone, with spots; primary tubercles in two series, tubercles 4 – 6; secondaries present in interporiferous zones.

**Description:** Test flattened orally and aborally, circular in outline. Apical system sunken; genital plates extending into interambulacra area; anal cone with distinct white spots. Peristome larger; buccal notches deeply indented, coupled with tags around; auricles delicate. Ambulacra wide; primary tubercles arranged in two series; median space densely packed with sub-equal secondary tubercles; narrower orally, with large tubercles, secondaries small and few; pore-pairs in three arcs, narrow towards peristome. Interambulacra naked area usually green; primary tubercles arranged in vertical series; extending from peristome to apical disc, median zone naked. Interambulacra spines long, hollow, thorny; ambulacra spines thin, fragile. Spines variable in color, banded black and white, uniformly black or white, sometimes with greenish bands; test greenish, interambulacra lighter; cleaned test brown with green tints.

**Size:** Maximum horizontal diameter 160 mm.

**Global distribution:** Red Sea and East Africa, South Africa to the Malayan Archipelago, from South Japan to North Australia and the South Sea Islands from littoral (Schultz, 2010a).

**South African records of Echinothrix calamaris:** East coast region. Specimens identified in this study show that species may inhabit waters of 50 m deeper than previously known.
**Remarks:** Herbivorous, feeding on algae. Inhabits reef and rocky shore habitats (Branch *et al.*, 2010).

**Taxonomic notes:** *Echinothrix calamaris* differ from the two *Diadema* species in its spotted anal cone, and presence of secondary tubercles in interporiferous zone.

![Map of South Africa](image1)

**Fig. 3.54.** Distribution of *Echinothrix calamaris*.

![Images of *Echinothrix calamaris*](image2)

**Fig. 3.55.** *Echinothrix calamaris*. **A.** Live specimen. **B.** Aboral view of preserved specimen (scale bar: 10 mm).
Order: Pedinoida Mortensen, 1939
Family: Pedinidae Pomel, 1833
Genital plates only touching periproct; tubercles perforated and non-crenulated; solid primary spines.

Genus: Caenopedina A. Agassiz, 1869
Apical system with only genital plates in contact with periproctal outline, ocular plates in outer circle (dicyclic); tubercles almost filling plate height.

Caenopedina capensis H.L. Clark, 1923
Fig. 3.56-3.57 A-B.


Diagnosis: Test flattened aborally; apical system bright purple, with tubercles encircling periproct; primary spines somewhat purplish distally, base reddish.

Description: Test relatively low, flattened aborally. Apical system dicyclic; genital plates wider than oculars, plates with small tubercles; periproct large, uniformly covered by platelets. Peristome having distinct buccal notches; peristomal membrane covered by small platelets. Ambulacra pore pairs in arcs of three (trigeminate), arranged in a vertical series. Interambulacra tubercles large. Uppermost plates without tubercles. Primary spines with longitudinal ridges, secondaries similar, but smaller. Preserved specimen brownish in color, apical area conspicuously purplish; primary aboral spines purple, basally reddish pink.

Size: Maximum horizontal diameter 16 mm.

Global distribution: Endemic to the West coast region of South Africa, at 1 200 – 1 650 m depth (Clark & Courtman-Stock, 1976).
Fig. 3.56. Distribution of *Caenopedina capensis*.

Fig. 3.57. *Caenopedina capensis*. Aboral view of preserved specimen (scale bar: 10 mm).
**Order: Salenioda Delage & Hérouard, 1903**
Characterized by keel teeth; apical system large, angular suranal plate present; interambulacra primary tubercles imperforated, partially crenulated.

**Family: Saleniidae L. Agassiz, 1838**
Suranal plate surrounded by apical plates, periproct shifted towards ocular plate I.

**Genus: Salenia Gray, 1835**
Periproct eccentric, with enlarged suranal plate.

*Salenia phoinissa* A. Agassiz & H.L. Clark, 1908
Figs 3.58-3.59 A-B.

*Salenia pettersoni*: Döderlein, 1906: 179-180. Pl. II, Fig. 2. Pl. XLV, Fig. 4.
*Salenia phoinissa*: Mortensen, 1935: 377-379. Pl. LXXXIV, Fig. 1; Clark & Courtman-Stock, 1976: 227.
*Bathysalenia phoinissa*: Schultz, 2010c: 1170. Fig. 2065.

**Diagnosis**: Test with v-shaped structures below genital plates and above oculars; spines yellow, with red bands.

**Description**: Test sub-spherical, of moderate size. Apical system eccentric, dicyclic, with large suranal plate, granulated plates. Peristome with faint buccal notches, smaller than apical system. Ambulacra tubercles arranged in series of two i.e. one tubercle associated with two pore-pairs (bigeminate); pores crowded at peristomial edge. Interambulacra tubercles larger than ambulacra ones, secondaries few, and smaller. Primary spines cylindrical, long, rough; base swollen, collar naked. Test cream-greenish; V-shaped structures conspicuously darker; primary spines banded red and light green; secondaries creamish.

**Size**: Maximum horizontal diameter 11 mm.

**Global distribution**: Endemic to the south and east coast region of South Africa (Clark & Courtman-Stock, 1976; Schultz, 2010c), at 100-150 m depth.
Specimens identified through this study extend previously known distribution northwards towards the Durban area and extend depth range from the previously known maximum depth of 102 m to 150 m.

**Remarks:** Schultz (2010c) reports this species as *Bathysalenia phoinissa*, however, as mentioned above all species are entered according to the phylogenetic and name sequence outlined in the WED database, which corresponds with the WoRMS database.

Fig. 3.58. Distribution of *Salenia phionissa*.

Fig. 3.59. *Salenia phionissa*. **A.** Side-view of preserved specimen. **B.** Apical system (scale bar: 10 mm).
Order: Stomopneustoida Kroh & Smith, 2010  
Family: Stomopneustidae Mortensen, 1903

Test hemispherical, non-sculptured; plates fused, sharing one compound primary tubercle, tubercles not crenulated.

Genus: Stomopneustes L. Agassiz, 1841

Only genus in family.

Stomopneustes variolaris (Lamarck, 1816)

Figs 3.60-3.61 A-B.

Stomopneustes variolaris: H.L. Clark, 1923: 378; Mortensen, 1935: 507-512. Pl. LXXI, Figs 3-5. Pl. LXXII, Figs 1-2. Pl. LXXXIX, Figs 16-26; Clark & Courtman-Stock, 1976: 228; Richmond, 1997: 296; Samyn, 2003: 208. Fig. 4A; Branch et al., 2010: 234. Fig. 105.3; Schultz, 2010a: 114. Figs 203-206.

Description: Test solid, arched aborally, flattened orally. Apical system small; madreporite distinctively enlarged; ocular plates exsert, except for oculars I and V which are broadly insert; each apical plate having one primary tubercle, and some miliaries; periproct plated, plates having spine-bearing tubercles. Peristome larger than apical disc; naked; but with small, elongated plates embedded in membrane. Ambulcra pore-zones far apart below ambitus, approaching each other towards apical system; pores irregularly arranged in three vertical series; trigeminate plates fused, sharing single primary tubercle. Interambulacrana narrow towards peristome; tubercles arranged vertically, regular, largest around ambitus. Spines striated, robust, cylindrical; orally more slender, slightly flattened; smaller orally than aborally. Spines black, orally lighter; cleaned test greyish.

Size: Maximum horizontal diameter 110 mm.

Global distribution: Widely distributed in Indo-Pacific, from East Africa to the Samoa Islands, from Japan to north Australia and New Caledonia; littoral (Mortensen, 1935; Schultz, 2010).

South African records of Stomopneustes variolaris: East coast region.
**Remarks:** Littoral species, mostly found between coral rubble or on rocky shores, often hiding in crevices. Known to sit on shorter spines thus exposing longer ones as a defense mechanism against predators (Mortensen, 1935; Schultz, 2010a).

**Taxonomic notes:** The only species in this family.

![Distribution of Stomopneustes variolaris.](image)

**Fig. 3.60.** Distribution of *Stomopneustes variolaris*.

![Stomopneustes variolaris.](image)

**Fig. 3.61.** *Stomopneustes variolaris*. **A.** Live specimen. **B.** Aboral view of preserved test (scale bar: 100 mm).
Order: Arbacioida Gregory 1900
Family: Arbaciidae Gray 1825

Test small to moderate size, low hemispherical, not sculptured. Ambulacra trigeminate, pore-pairs may be in arcs or vertical series, interambulacra smaller than ambulacra. Spines long.

Genus: Coelopleurus L. Agassiz, 1840

Primary ambulacra tubercles larger than interambulacra ones, in regular series. Interambulacra tubercles restricted to oral side, disappearing aborally, giving peculiar naked area aborally.

Coelopleurus interruptus Döderlein, 1910

Figs 3.62-3.63 A-B.

Coelopleurus floridanus: Döderlein, 1906: 181-182. Pl. XLV, Fig. 2.
Coelopleurus interruptus: H.L. Clark, 1923: 379-381. Pl. XXI, Fig. 3; Mortensen, 1935: 626. Pl. LXXXVIII, Fig. 30; Clark & Courtman-Stock, 1976: 229; Schultz, 2010a: 124.

Diagnosis: Naked interambulacra zone brown with transverse light violet bands, white lateral borders.

Description: Test low hemispherical. Apical system dicyclic, periproct having 4-5 large distinctive valves. Peristome larger than apical system. Ambulacra primary tubercles largest at ambitus, decreasing towards apical peristomial area, plates trigeminate. Interambulacra absent aborally, naked area with patterns of colorful oblique patches. Primary spines long, curved, smooth distally. Test dark reddish, naked areas bordered by white lines, predominately brown with violet patches; primary spines a dull green with red bands.

Size: Maximum horizontal diameter 40 mm.

Global distribution: Endemic to the South (Mortensen, 1935; Clark & Courtman-Stock, 1976) and East coast region of South Africa; at 55 – 140 m depth (Mortensen, 1935). Samples identified through current study extend the previously known distribution northwards towards Durban.
Fig. 3.62. Distribution of *Coelopleurus interruptus*.

Fig. 3.63. *Coelopleurus interruptus*. A. Side view of preserved specimen. B. Close-up of interambulacra (scale bar: 10 mm).
Coelopleurus maillardi (Michelin, 1862)
Figs 3.64-3.65 A-B.

Coelopleurus maillardi: A. Agassiz, 1872-1874: 104, 406; Döderlein, 1906: 182. Pl. XLV, Fig. 1; Mortensen, 1935: 627-631. Pl. LXVII, Fig. 3. Pl. LXVIII, Fig. 4. Pl. LXIX, Figs 1-3. Pl. LXXXVIII, Figs 22-23; Clark & Courtman-Stock, 1976: 229; Schultz, 2010a: 126. Figs 229-232.

**Diagnosis:** Has main generic features; diagnosed by striated, long, tapered distally, slightly curved primary spines; oral spines smaller; secondaries short. Test creamish; conspicuous naked interambulacra, naked zone pink to light lilac, with yellow patches, bordered by a red line. Primary spines appearing somewhat spotted or banded reddish, secondaries red.

**Size:** Maximum horizontal diameter 40 mm.

**Global distribution:** Malayan region from the east coast of Africa to Philippines at 70 – 300 m depth (Mortensen, 1935; Schultz, 2010a).

**South African records of Coelopleurus maillardi:** East coast region. Samples identified through this study extend previously known distribution northwards towards the southern Mozambique border.

**Taxonomic notes:** Color may distinguish the two species; the naked interambulcra zones of *C. maillardi* are violet with orange tints bordered by a red line; whereas *C. interruptus* has a brown naked patch with transverse violet bands and lateral white lines.
Figs. 3.64. Distribution of *Coelopleurus maillardi*.

Fig. 3.65. *Coelopleurus maillardi*. A. Side view of adult preserved specimen. B. Close-up of juvenile (scale bar: 10 mm).
Genus: *Tetrapygas* A. Agassiz, 1841b
Characterized by polyporous ambulacra, secondary tubercles on interambulacra.

* *Tetrapygas* niger* (Molina, 1782)
Figs 3.66-3.67 A-B.

*Tetrapygas* niger: H.L. Clark, 1925: 17; Branch *et al*., 2010: 236, Fig. 106.3; Haupt *et al*., 2010; Schultz, 2010a: 128, Figs 233-235; Picker & Griffiths, 2011: 77.

**Diagnosis:** Cleaned test purplish with dark pore zones, apical system black, interambulacra median zone purplish, tubercles head violet.

**Description:** Test solid, low hemispherical. Terminal plates of apical system insert, four conspicuous anal plates, enlarged madreporite. Ambulacra narrow aborally, each plate having 4-5 pore pairs, pore zones widened orally. Tubercles in two regular series, smaller scattered tubercles between. Interambulacra tubercles vary in size aborally; lower tubercles large and upper small, irregularly arranged. Color in life black to dark purple, fairly short spines, longest around the equator.

**Size:** Maximum horizontal diameter 75 mm.

**Global distribution:** West Coast of South America in Peru and Chile, littoral to 10 m (Schultz, 2010).

**South African record** *Tetrapygas* niger: West coast region. Accidentally introduced with oyster spat, first recorded in South Africa in 2007 (Branch *et al*., 2010; Haupt *et al*., 2010)

**Taxonomic notes:** Shallow-water specimens have stout and short aboral spines, whereas in deep-water specimens spines may be longer and slender (Schultz, 2010a).
Fig. 3.66. Distribution of *Tetrayga niger*.

Fig. 3.67. *Tetrayga niger*. **A.** Live specimen. **B.** Denuded test.
**Order:** Camarodonta Jackson, 1912  
**Family:** Temnopleuridae A. Agassiz, 1872  
Characterized by depressed horizontal sutures, pits developed sometimes at angles of plates.

**Genus: Salmaciella Mortensen, 1942**
Test sub-conical; anal opening eccentrically arranged towards periproctal edge; ambulacra plates reduced on alternate plates aborally; angular pits distinctive orally.

*Salmaciella erythracis* H.L. Clark, 1912  
Figs 3.68-3.69 A-B.

*Salmaciella erythracis*: Schultz, 2010a: 156.

**Diagnosis:** Equatorial spines long, facing downwards, thus forming a fringe appearance; eccentric anal opening.

**Description:** Test moderately sized, sub-conical. Apical system plated, periproct eccentric. Persitome strongly depressed. Primary ambulacra tubercles at ambitus arranged alternatively between inner and outer parts of plates; disappearing towards apical system, few around peristome; tubercles crenulated. Ambital spines extended forming a fringe. Test creamish with light brown bands along interambulacra median zones; spines white with brown and greenish bands.

**Size:** Maximum horizontal diameter 50 mm.

**Global distribution:** East African coast and Seychelles Islands at 10-70 (Schultz, 2010a).

**South African records Salmaciella erythracis:** East coast region.
**Taxonomic notes:** Schultz (2010a) reports species has having more reddish spines; there are, however, no traces of red in the Iziko Museum specimens, which have alternating green and brown bands.

![Fig. 3.68. Distribution of *Salmaciela erythracis*.](image)

![Fig. 3.69. *Salmaciela erythracis*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 10 mm).](image)
Genus: *Salmacis* L. Agassiz, 1841

Test conical; periproct encircled by tubercles; ambulacral tubercles enlarged on each plate; small pits at plate edge.

*Salmacis bicolor* L. Agassiz in L. Agassiz & Desor, 1846

Figs 3.70-3.71 A-B.

*Salmacis bicolor*: H.L. Clark, 1923: 382; H.L. Clark, 1924: 5; Clark & Courtman-Stock, 1976: 231; Richmond, 1997: 296; Samyn, 2003: 209. Fig. 4C; Branch *et. al.*, 2010: 234. Fig. 105.4; Schultz, 2010a: 162. Fig. 300.

**Diagnosis:** Test sub-conically raised; spines brightly banded red and yellow; apical zone bare, without tubercles except for tubercles circling periproct.

**Description:** Test slightly conical. Apical system surrounded by tubercles. Peristome depressed. Ambulcral primary tubercles regularly arranged in vertical series, secondaries less regular. Interambulacral primary tubercles in two rows from ambitus towards oral side, secondaries forming a horizontal series. Test brownish. Spines short, slender, banded red and yellow.

**Size:** Maximum horizontal diameter 100 mm.

**Global distribution:** Red Sea to East Africa (Clark & Rowe, 1971) and Ceylon to Java and the Phillipines, from littoral to 120 m (Schultz, 2010a).

**South African records of *Salmacis bicolor***: East coast region.

**Remarks:** Inhabits shallow lagoons and reefs among algae (Richmond, 1997).

**Taxonomic notes:** Closely resembles *Salmaciella erythracs*, but differs in test shape, apical system and appearance of ambulacral tubercles. *S. erythracs* has a low test, anal opening eccentrically positioned towards periproctal margin and ambulacra reduced on alternating
plates towards the aboral side; whilst *S. bicolor* has a conically test, a periproct surrounded by tubercles and large tubercles disappearing towards the apical area.

![Distribution of Salmacis bicolor.](image)

**Fig. 3.70.** Distribution of *Salmacis bicolor.*

![Live specimen and preserved test of juvenile.](image)

**Fig. 3.71.** *Salmacis bicolor.* **A.** Live specimen. **B.** Preserved test of juvenile (scale bar: 10 mm).
Genus: *Temnopleurus* L. Agassiz, 1841

Apical system with eccentric suranal plate; distinctly deep pits of various size and shape.

*Temnopleurus reevesii* (Gray, 1855)

Figs 3.72-3.73 A-B.


**Diagnosis:** Suranal plate conspicuously large, genital plates having ring of tubercles on inner parts; pits broad or shallow below primary spines, and sometimes angular at edges of plate.

**Description:** Test sub-conical, fragile. Apical system peculiar; with genital plates smooth distally, row of tubercles around inner edge; ocular plates subtly tuberculated; suranal plate larger than other plates. Peristome naked. Ambulacral primary in a regular series, ambitus with two secondaries running parallel; pore-pairs in straight line. Three interambulacra tubercles per plate around ambitus; one primary with a secondary tubercle on each side. Primary spines longer than thorny secondaries. Naked test greenish aborally, naked zones darker, white orally; spines appearing brown with green tints.

**Size:** Maximum horizontal diameter 35 mm.

**Global distribution:** Japan to China Sea, through Malayan Archipelago to East Africa (Clark & Rowe, 1971; Schultz, 2010a), at 5-565 m depth (Schultz, 2010a).

**South African records of *Temnopleurus reevesii***: South and East coast region.
Fig. 3.72. Distribution of *Temnopleurus reveesii*.

Fig. 3.73. *Temnopleurus reveesii*. Aboral view of preserved specimen (scale bar: 10 mm).
Genus: *Temnotrema* Agassiz, 1864

Test small, strongly sculptured; tubercles lacking crenulation.

*Temnotrema siamense* (Mortensen, 1904)

Figs 3.74-3.75 A-B.


**Diagnosis:** Test small, brown with radiating white-pinkish rows; apical system red, encircled by tubercles; spines short, banded; elongated deep pits in horizontal sutures.

**Description:** Apical system dicyclic, tubercles encircle periproct, genital plates with tubercles on inner edge, gonopores distally positioned on plate. Ambulacra plating trigeminate, pore-pairs in a single straight series, one tubercle per plate. Interambulacra primary tubercles surrounded by small secondaries. Deep pits along horizontal sutures of both ambulacra and interambulacra. Peristome small, without buccal notches. Denuded test brownish with pinkish radiating stripes, interambulacra as the darker shaded stripe; spines short, uniform, white and orange-brownish banded with subtle longitudinal ridges.

**Size:** Maximum horizontal diameter 20 mm.

**Global distribution:** East Africa (Clark & Rowe, 1971) to North East Australia and South China; at 5 – 350 m depth (Schultz, 2010c).

**South African records of Temnotrema siamense:** New record from the East coast region.

**Taxonomic notes:** Differs from *Temnopleurus reevesii* in elongated pits in horizontal sutures, in small test size and weakly crenulated tubercles.
Fig. 3.74. Distribution of *Temnotrema siamense*.

Fig. 3.75. *Temnotrema siamense*. A. Aboral view of preserved specimen. B. Side view (scale bar: 10 mm).
Family: **Trigonocidaridae Mortensen, 1903**

Indented pits lie on plates (epistromal).

Genus: **Trigonocidaris A. Agassiz, 1869**

Periproctal with four, large plates; shifting anal opening towards ocular plate I.

*Trigonocidaris nitidus* (Döderlein, 1905)

Figs 3.76-3.77 A-B.


**Diagnosis**: Apical system smooth; tubercles not crenulated.

**Description**: Test small, low hemispherical. Apical system exsert, some specimens with numerous pores per genital plates; periproctal plates shiny, suranal plate the largest. Peristome naked, except buccal plates. Ambulacral primary tubercles regular, pore-pairs in a straight row. Interambulacral somewhat sculptured, plates with one primary tubercle surrounded by secondaries. Spines relatively short, somewhat serrated. Naked test white to creamish, spines similar in color.

**Size**: Maximum horizontal diameter 15 mm.

**Global distribution**: Endemic to South Africa, at 500 m depth (Clark & Courtman-Stock, 1976; Schultz, 2010c).

**South African records of Trigonocidaris nitidus**: Single record off the South coast region. Not represented in the Iziko collection.
Fig. 3.76. Distribution of *Trigonocidaris nitidus*.

Fig. 3.77. *Trigonocidaris nitidus*. Aboral view of preserved specimen (14 mm) (Schultz, 2010c).
**Trigonocidaris monolini** (A. Agassiz, 1879)

Figs 3.78-3.76 A-B.

*Orechinus monolini*: Döderlein, 1906: 196-198. Pl. XXV, Fig. 1. Pl. XXXV, Fig. 6. Pl. XLVI, Fig. 5; H.L. Clark, 1923: 383; Clark & Courtman-Stock, 1976: 230-231.


**Diagnosis:** Tubercles encircling apical system, gonopores on elevated ridges.

**Size:** Maximum horizontal diameter 14 mm.

**Global distribution:** Hawaii through the Malayan region and Kermadec Island to South Africa, at 318 – 2 300 m depth (Schultz, 2010c).

**South African record of** *Trigonocidaris monolini:* Single record off the South coast region. Not represented in Iziko collection.

**Taxonomic notes:** Similar South African distribution range as *T. nitidus*, but *T. monolini* has a tuberculated apical system and *T. nitidus* has a smooth one.

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Fig. 3.78. Distribution of *Trigonocidaris monolini*. 138
Fig. 3.79. *Trigonocidaris monolini*. Aboral view of preserved specimen (13 mm) (Schultz, 2010c).
**Family: Echinidae Gray, 1825**

Test fragile, not sculptured, apical system with all oculars not in contact with peristomial area (dicyclic).

**Genus: Dermechinus Mortensen, 1942**

Peristome smaller that apical system.

*Dermechinus horridus* (A. Agassiz, 1879)

Figs 3.80-3.81 A-B.


**Diagnosis:** Test melon-shaped. Ambulacra sunken, corresponding interambulacra raised, giving distinctive appearance. Miliary spines numerous.

**Description:** Test globular, high. Apical system plated, with genital plates extending into interambulacra, ocular plates small and exsert. Persitome small, buccal notches naked. Ambulacra with sunken horizontal sutures, curving under regularly arranged primary, primary tubercles smaller in size than interambulacral ones; pore-pairs inconspicuous, trigeminate; at ambitus upper pore situated towards plate center, other two towards the edge; aborally pore-pairs arranged in straight line; numerous secondary tubercles scattered on plates, in pore-zones and slightly enlarged ones on the ambital region, giving a horizontal series. Interambulacra primary tubercles small, covering the whole test, in regular vertical series, sparsely distributed towards apical system. Ambulacra slightly smaller than interambulacra, aborally larger. Primary spines slender, long, conspicuously longer than secondaries. Test red, pore-zones and space between interambulacra and ambulacra white, giving a radiating appearance, genital plates red distally; spines red.

**Size:** Maximum horizontal diameter 90 mm, maximum vertical height 120 mm.
**Global distribution:** South America, South Africa, south Australia and Tasmania, Southern New Zealand and Antarctic, at 30 – 1020 mm depth (Mortensen, 1943; Schultz, 2010a).

**South African records of Dermechinus horridus:** West and South coast region.

**Remarks:** Only species representing genus in South African waters, inhabits rocky to muddy bottoms.

**Taxonomic notes:** Variation in test height exists, but is not of taxonomic value, as short and high populations co-exist and all the other characters match (Mortensen, 1943). According to Mortensen (1943) the South African species is not identical to the Chilean and Australian species.

![Distribution of Dermechinus horridus](image)

Fig. 3.80. Distribution of *Dermechinus horridus*. 

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Fig. 3.81. *Dermechinus horridus*. Side view of preserved specimen (scale bar: 100 mm)
Genus: *Echinus* Linnaeus, 1758

Peristome larger than apical disc.

*Echinus gilchristi* Bell, 1904

Figs 3.82-3.83 A-C.

*Echinus gilchristi* Bell, 1904: 170-171; Döderlein, 1906: 213-216. Pl. XXVI, Fig. I. Pl. XXXV, Figs 10, 14. Pl. XLVI. Fig. 9; Mortensen, 1943: 57-60. Pl. XV, Figs 7-12, Pl. XVI, Figs 1-9, Pl. LV, Fig. 14, 16, 20, 26, 27; H.L. Clark, 1923: 384-385. Pl. XIII; H.L. Clark, 1924: 6-7; H.L Clark, 1925: 112; Clark & Courtman-Stock, 1976: 236; Schultz, 2010a: 188. Figs 348-351.

**Diagnosis:** Mouth with protruding teeth, encircled by fleshy lip.

**Description:** Has main characteristics of genus, such as the peristome being small, with numerous pedicellariae giving dark appearance in area; distinct buccal notches, buccal membrane plated. Ambulacral primary tubercles disappearing aborally, only secondaries aborally, ambulacra tubercles densely surrounded by secondaries, giving naked median line; sometimes small and large tubercles alternating; pore-pairs three per plate. Interambulacral primary tubercles irregularly developed, alternating on every second plate, oral tubercles enlarged. Primary spines short, below ambitus flattened, widened distally; numerous short secondaries, forming dense coat. Test brownish, orally lighter; primary spines white, secondaries red-brownish, sometimes greenish.

**Size:** Maximum horizontal diameter 84 mm.

**Global distribution:** Endemic to South Africa, at 40 – 500 m depth (Mortensen, 1943; Schultz, 2010a).

**South African records of Echinus gilchristi:** West and South coast region.

**Remarks:** Feeds on bryozoans and sponges (Mortensen, 1943).
**Taxonomic notes:** This species differs from *Dermichinus horridus* in its small, low test; and fleshy lip around the peristome. Furthermore, *D. horridus* has genital plates extending into interambulacra, whilst those of *E. gilchristi* are confined to apical area.

![Fig. 3.82. Distribution of *Echinus gilchristi.*)](image-url)
Fig. 3.83. *Echinus gilchristi*. **A.** Aboral view of preserved specimen. **B.** Side view of test. **C.** Fleshy mouth (scale bar: 10 mm).
Genus: *Polyechinus* Mortensen, 1942
Characterized by four pore-pairs per plate, rarely three or five.

*Polyechinus agulhensis* (Dördelein, 1905)
Figs 3.84-3.85 A-B.

*Paracentrotus agulhensis*: Döderlein, 1906: 207-210. Pl. XXVII, Figs 1-4. Pl. XXXV. Fig. 17. Pl. XLVII. Fig. 1.


Description: Test from globular to low hemispherical. Apical system with oculars widely exsert, enlarged madreporite; genital plates distally naked, inner part tuberculated; periproct plated; suranal distinctive in adults. Peristome sometimes larger than apical disc, in other cases smaller. Ambulacral primary tubercles in regular series; smaller than interambulacral ones; large areole, sometime inconspicuous cause of miliary tubercles continuing to base; median line naked; secondaries not forming vertical series; pore-pairs in four series per plate. Interambulacral primary tubercles large; aborally decreasing in size; areoles conspicuous, sometimes indistinctive as in ambulacra, joint on oral side, apart aborally; secondaries small, scattered, forming horizontal or vertical series. Median line for both ambulacra and interambulacra naked. Primary spines stout but brittle. Denuded test and spines white.

Size: Maximum horizontal diameter 80 mm.

Global distribution: Endemic to South Africa, at 200 – 1080 m (Mortensen, 1943; Schultz, 2010c).

South African records of *Polyechinus agulhensis*: West and South coast region.
**Taxonomic notes:** Distinguished from *Echinus gilchristi* by the number of pore-pairs per plate, where *P. agulhensis* commonly has four, rarely three or five, and *E. gilchristi* has two. *P. agulhensis* is the only species representing genus.

Fig. 3.84. Distribution of *Polyechinus agulhensis*.

Fig. 3.85. *Polyechinus agulhensis*. Side view of preserved specimen (scale bar: 100 mm).
Family: Parechinidae Mortensen, 1903
Genus: Parechinus Mortensen 1903

Test medium sized; apical system dicyclic, sometimes ocular I and V insert; tuberculation not coarse; secondaries distinct.

*Parechinus angulosus* (Leske, 1778)

Figs 3.86-3.87 A-B.

*Echinus angulosus*: A. Agassiz, 1881: 115; A. Agassiz, 1872-1874: 22, 489. Pl. VII. Fig. 3a; Bell, 1904: 169-170.

*Echinus juv*: Bell, 1904: 171.

*Protocentrotus angulosus*: Dördelein, 1906: 204-207. Pl. XXVII. Figs 6-8. Pl. XXXV, Fig. 16. Pl. XLVII, Fig. 6.

*Parechinus angulosus var. pallidus*: H.L. Clark, 1924: 9.


**Diagnosis:** Tube feet thick, long, densely arranged, between spines of various colors.

**Description:** Moderately sized test, round to pentagonal outline. Apical system smaller than peristome; dicyclic, two oculars occasionally insert; gonpores arranged distally; periproct plated, plates large in adults, carrying spine-bearing tubercles; suranal conspicuous in juveniles. Peristome small, triangular; ten equidistant plates; notches small but distinctive. Ambulacra wider than interambulacra; pore-pairs in low, oblique arcs of three; pore arcs wide, almost as wide as interporiferous zones; primary tubercles in regular, dense arrangement; secondaries irregularly sequenced. Interambulacral primary tubercles not densely arranged, separated by small tubercles; larger secondaries somewhat irregular; space between them covered by smaller tubercles. Primary spines slender, not longer than 13 mm; littoral species having more robust, short spines. Spines vary in color; from green, dark purple with violet or intense red with white tips, occasionally uniformly red or white; test uniformly green, with brownish median zones.
Size: Maximum test diameter 60 mm.

Global distribution: Reported from Angola round the Cape, northward to Mozambique, in littoral zones to 180 m depth (Schultz, 2010a).

South African records of Parechinus angulosus: Common throughout the South African coastline

Remarks: Only species in genus. A very common littoral and shallow reef species, found in rock pools or between or under rocks. Feeds mainly on algae and organisms that may co-exist in rocky environments (Mortensen, 1943). Several ecological studies have been undertaken on this common Cape urchin (Cram, 1971a; Fricke, 1979; Fricke, 1980; Anderson & Velimirov, 1982; Farquhar, 1994; Mayfield & Branch, 2000; Day & Branch, 2000a; Day & Branch, 2000b; Blamey et al., 2010).

Taxonomic notes: Extraordinary variety of color-morph is displayed within species, where some specimens are of uniform color and others with white tipped spines (Mortensen, 1943; Schultz, 2010a). Variation in adult and juvenile forms was also reported, with juveniles having banded spines and a conspicuous suranal plate (Schultz, 2010a).

Fig. 3.86. Distribution of Parechinus angulosus.
Fig. 3.87. *Parechinus angulosus*. **A.** Live specimen. (No scale bar available) **B.** Denuded test.
Family: Echinometridae Gray, 1855
Test elongated.

Genus: *Colobocentrotus* Brandt, 1835

Sub-genus: *Colobocentrotus (Podophora)* A. Agassiz, 1840
Spines compressed into flat tile appearance, closely packed, forming compact mosaic.

* *Colobocentrotus (Podophora) atratus* (Linnaeus, 1758)
  Figs 3.88-3.89 A-B.

*Colobocentrotus auratus*: A. Agassiz, 1872-1874: 102, 424. Pl. XXXVI, Figs 6-7. Pl. XXXVIII, Figs 11-12; Samyn, 2002: 204. Fig. 3D.

*Colobocentrotus (Podophora) atratus*: Mortensen, 1948: 434-439. Pl. L, Figs 1-2. Pl. LII, Figs 1-2. Pl. LXV, Fig. 7.


**Diagnosis:** Spines eccentric, closely packed, flat, forming tessellate arrangement ending in a fringe; purple coloration.

**Description:** Test solid, transversely elongated. Apical system dicyclic, tuberculated, except conspicuous madreporite, gonopores distally positioned. Ambulacra having distinct arcs, 8-12 pore-pairs per plate; pore zones wide orally, primary tubercles in two series; aboral pore zones much narrower, miliary spines in median space; no secondaries. Aboral interambulacra primary tubercles in two regular vertical series, secondaries slightly smaller; primary tubercles dominant at equator, decreasing in size towards oral side giving fringe appearance. Peristome large, elongated; buccal notches not distinctive. Spines dark purple, lighter on oral side; cleaned test light purple orally, turning white towards ambitus downwards.

**Diameter:** Maximum horizontal diameter 65 mm.

**Global distribution:** East Africa to Malayan Archipelago, as far as Hawaii; restricted to littoral zones (Schultz, 2010).
**South African records of *Podophora auratus***: New reliable record from the East coast region.

**Remarks**: New record and only species representing genus in South Africa. The test morphology is strongly adapted for attachment to strongly wave-exposed rocks, thus minimizing possibility of being washed away by wave action. Reported to feed on encrusting organisms.

**Taxonomic notes**: Mortensen (1948) considers *Podophora* as a sub-genus of *Colobocentrotus*, as differences between the two holds little generic value. However, this study only enters species under the binomial nomenclature.

Fig. 3.88. Distribution of *Podophora auratus*. 
Fig. 3.89. *Podophora auratus*. Live specimen. (No scale bar available)
**Genus: Echinometra Gray, 1825**

Test elongated, axis of elongation runs through ambulacra IV and interambulacra I; apical plates tuberculated.

**Echinometra mathaei (de Blainville, 1825)**

Figs 3.90-3.91 A-B.


**Diagnosis:** Test strongly elongated, rarely somewhat circular; spines stout, with white basal flange (milled ring).

**Description:** Main generic features include test being stout, elongated, aborally highly convex, orally concave. Apical system plated, with varying tuberculation; set with spine-bearing tubercles; madreporite enlarged; dicyclic. Peristome, large, elongated; membrane with few plates; buccal notches distinct. Ambulacral plates with four pore-pairs, rarely five; pore-zones narrow towards mouth; aboral pore-pairs enlarged; large primary tubercle per plate, with smaller corresponding secondaries, forming regular vertical series. Interambulacral secondary tubercles vary in size, sometimes as large as, or smaller than, primaries; primary tubercles in two regular series; secondaries somewhat in regular, vertical rows; primary and secondary tubercles of sub-equal size at ambitus; minute miliaries around areoles. Stout primary spines at ambitus long; orally and aborally shorter, usually tapered, sometimes shorter and thicker; towards mouth flattened, but not widened; few, tiny, pointed miliary spines. Distinguished by color, of which cleaned test white, with faint light purple tint; spines vary in color, from white to brown, sometimes greenish or purplish, often tips and milled ring white.

**Size:** Maximum horizontal diameter 90 mm.
**Global distribution:** Suez to South Africa, from Japan to Australia, and from Hawaii to the South Sea Islands; from littoral to 30 m (Schultz, 2010a).

**South African records of Echinometra mathaei:** East coast region.

**Remarks:** Inhabits holes and tunnels amongst coral blocks, suspected to be a rock borer (Mortensen, 1943). Known to feed on algae and encrusting organisms, especially sponges (Mortensen, 1943; Schultz, 2010a).

**Taxonomic notes:** Maher (2011) indicates that there is no genetic divergence amongst the color morphs in *E. mathei* populations of which variation may be attributed to environmental parameters. However, the observed intraspecific variation may suggest a slow speciation process (Rahman & Uehara, 2004).

![Fig. 3.90. Distribution of *Echinometra mathaei.*](image-url)
Fig. 3.91. *Echinometra mathaei*. **A.** Aboral view of preserved specimen. **B.** Side view of denuded test (scale bar: 10 mm)
*Echinometra oblonga* (Blainville, 1825)

Figs 3.92-3.93 A-B.

*Echinometra oblonga*: A. Agassiz, 1863: 21; A. Agassiz, 1872-1874: 116, 433. Pl. XXXVI. Fig. 5; H.L. Clark, 1925: 144; Schultz, 2010c: 1276. Fig. 2275.


**Diagnosis:** Closely related to *Echinometra mathei*, from which it is distinguished by its darker spines, lacking white tips.

**Size:** Maximum test diameter 90 mm.

**Global distribution:** East Africa, Mauritius and Maldives through the Phillipines, Indonesia and New Guinea to Okinawa, Guam and Hawaii, plus south Pacific Islands; strictly littoral (Schultz, 2010c).

**South African records of Echinometra oblonga:** East coast region.

**Remarks:** Not easily differentiated from *E. mathaei* as they co-exist, however, there are differences in their distribution on shores; *E. mathaei* generally inhabits the shallow subtidal and lower intertidal regions, while *E. oblonga* is commonly found in the upper intertidal zone (Hiratsuka & Uehara, 2007); furthermore *E. oblonga* is strictly a littoral form, whereas *E. mathaei* is known to inhabit shallow waters. There are also differences in the spine tips, where *E. mathaei* has white tips, whilst the spines of *E. oblonga* are a uniform color.

**Taxonomic notes:** Previously recognized as a morph of *E. mathaei* (Mortensen, 1943); however subsequent genetic (Palumbi and Metz 1991, Landry *et al*., 2003), reproductive (Rahman & Uehara 2004) and ecological (Nishihira *et al*., 1991) studies led to recognition of the two as separate species. Maher (2012) documents *E. oblonga* in South African waters for the first time.
Fig. 3.92. Distribution records of *Echinometra oblonga*.

Fig. 3.93. *Echinometra oblonga*. Aboral view (No scale bar available) (61 mm) (Schultz, 2010).
Genus: *Echinostrephus* A. Agassiz, 1863

Test circular; apical plates smooth; anal opening with tube.

*Echinostrephus molaris* (de Blainville, 1825)

Figs 3.94-3.95 A-B.


*Echinostrephus molaris*: Mortensen, 1943: 311-316. Pl. XXXV, Figs 1-10. Pl. LVIII, Figs I, 2, 4, 9; Clark & Courtman-Stock, 1976: 239; Richmond, 1997: 298; Samyn, 2003: 205. Fig. 3F; Branch *et al.*, 2010: 236. Fig. 106.2; Schultz, 2010a: 207. Figs 385-389.

**Diagnosis:** Test small, flattened aborally and orally, upper-side broader; spines cylindrical, needle-shaped, longest on aboral side.

**Description:** Test with circular outline. Apical system dicyclic, apical plates smooth, anal opening small. Ambulacra narrow; having three pore-pairs per plate; pore-pairs in oblique arcs; uppermost aboral tubercles largest; primary tubercles in two series; secondaries irregularly arranged in pore zones, alternating along median line. Interambulacral primary tubercles large, arranged in two series, secondaries distributed on both sides, of same size, forming horizontal rows of three or four tubercles; miliaries small, scattered. Spines long, thin, pointed at tip; aboral ones longest, shorter around ambitus, somewhat curved on oral side. Denuded test light green, sometimes with purplish tint, apical plates darker, white around mouth; spines dark purple, white around mouth.

**Size:** Maximum horizontal diameter 23 mm.

**Global distribution:** Red Sea and east coast of Africa, southward to South Africa, from the Bonin Islands to Australia and the Fiji Islands; from littoral zone to 50 m (Schultz, 2010a).

**South African records of Echinostrephus molaris:** East coast region.
**Remarks:** Specialized spines enable this species to bore vertical cylindrical tunnels into coral substratum. Known to feed on food particles, such as algae or detritus, washed by wave action into the burrow (Mortensen, 1943; Schultz, 2010a).

**Taxonomic notes:** Distinguished from *Echinometra* species in test shape and spine size. *E. oblonga* has a more ovate test and the stout, short spines are projecting sideways; on the other hand *Echinostrephus molaris* has a circular test with slender, cylindrical spines projecting vertically.

![Fig. 3.94. Distribution of *Echinostrephus molaris*.](image)

![Fig. 3.95. *Echinostrephus molaris*. Live specimen. (No scale bar available).](image)
**Family: Toxopneustidae Troschel, 1872**

Notches deeply indented, where buccal sacs protrude.

**Genus: Toxopneustes Agassiz, 1841**

Characterized by sub-conical or low hemispherical test, three pore-pairs per ambulacra plate in oblique arcs.

*Toxopneustes pileolus* (Lamarck, 1816)

Figs 3.96-3.97 A-B.

*Toxopneustes pileolus*:


**Diagnosis:** Globiferous pedicellaria valves blossom giving flower-like appearance.

**Description:** Main generic features include test hemispherical, sunken towards peristome. Apical system with plates I and V insert, madreporite distinctively larger than plates, one tubercle per plate, peculiar periproct opening. Ambulcra primary tubercle on every second (or third) plate, median space covered with irregular secondaries of same size and smaller ones, trigeminate with arcs forming three vertical series. Interambulacra primary tubercles in two series, numerous small miliary tubercles, median area naked. Primary tubercles of ambulacra and interambulacra of same size. Peristome elongated, indented buccal notches, membrane set with small pedicellariae. Distinguishable from other species in denuded test showing brownish, greenish or purplish radial stripes; specimen examined with purplish-banded spines, in other cases may be banded in greenish, whitish or reddish shades; periproctal plates white.

**Size:** Maximum horizontal diameter 135 mm.

**Global distribution:** East Africa to Fiji Islands and New Caledonia, and from central Japan to Australia; from littoral zone to 90 m (Schultz, 2010a).

**South African record of Toxopneustes pileolus:** New record from the East coast region.
**Remarks:** Test densely covered by flower-like pedicellariae, equipped with poisonous glands. This tropical reef species is commonly known as the flower urchin. Uses seaweed or shells to shelter itself from sun (Branch *et al.*, 2010).

![Fig. 3.96. Distribution of *Toxopneustes pileolus*.](image)

![Fig. 3.97. *Toxopneustes pileolus*. Live specimen (No scale bar available) (Branch *et al.*, 2010).](image)
Genus: *Tripneustes* L.Agassiz, 1841
Pore-pairs in vertical series arranged in horizontal arcs.

*Tripneustes gratilla* (Linnaeus, 1758)
Figs 3.98-3.99 A-B.

*Tripneustes gratilla:* H.L. Clark, 1923: 387; Clark & Courtman-Stock, 1976: 234; Richmond, 1997: 298; Samyn, 2003: 210. Fig. 4G; Branch *et al.*, 2010: 234. Fig. 105.5; Schultz, 2010a: 275. Figs 527-533.

**Diagnosis:** Ambulacra and interambulacra with naked median zones, dark.

**Description:** Generic features include test being small, hemispherical, margin circular. Apical system with tuberculated periproct, ocular plate I and V insert, madreporite enlarged, inner part of plates with few tubercles. Peristome small, raised, distinct buccal notches, membrane with platelets. Ambulacral pore-zones broad, pore-pairs in three series, tubercles irregular separating vertically arranged pore-pairs; smaller secondaries, irregularly arranged in vertical rows, as in primary tubercles. Interambulacra narrower, primary tubercles small, in two series; secondaries same-sized, densely tuberculated orally. Distiguished from other species in both ambulacral and interambulacral adapical median zones naked, dark. Spines short, thin. Denuded test creamish, pores lighter; primary spines variable in color, may be orange, purplish or whitish; secondaries white.

**Size:** Maximum horizontal diameter 145 mm.

**Global distribution:** Red Sea to South Africa, from central Japan to Australia and from the Norfolk Islands to Hawaii; littoral to 75 m (Schultz, 2010a).

**South African records of Tripneustes gratilla:** West and south coast region. Samples from the Iziko identified collection extend previously known distribution from the East coast region westward towards Kleinmond.
**Taxonomic notes:** *T. gratilla* differs from *Toxopneustes pileolus* by its naked, dark median zones and test color.

Fig. 3.98. Distribution record *Tripneustes gratilla*.

Fig. 3.99. *Tripneustes gratilla*. **A.** Live specimen. (No scale bar available). **B.** Aboral view of preserved specimen (scale bar 10 mm).
Irregularia

Subclass: Euechinoidea Bronn, 1860
Order: Echinoneoida H.L Clark, 1925
Infraclasse: Irregularia Latreille, 1825
Family: Echinoneidae L. Agassiz & Desor, 1847

Oral ambulacra not forming phyllodes; peristome centrally positioned, usually oblique, without gill slits nor buccal plates; tubercles not in vertical series.

Genus: Echinoneus Leske, 1778

Test shape variable oval or sometimes elongated, moderately sized; imperforated tubercles, spines short, simple; lantern and auricles present in young.

*Echinoneus cyclostomus Leske, 1778*

Figs 3.100-3.101 A-B.

Echinoneus elegans: A. Agassiz, 1863: 25.

**Diagnosis:** Test oval to elongated, covered by conspicuous glassy tubercles; peristome irregular and plated.

**Description:** Test elongated, slightly doomed aborally, orally concave. Apical system small, five ocular plates and one genital plate (monobasal). Ambulacra pore zones narrow - not forming petaloid, depressed, three tubercles per plate. Surface densely covered by imperforated tubercles, surrounded by small secondaries, conspicuous knobs aborally. Peristome triangular shaped, centrally positioned. Denuded test light brown. Spines short, brownish, uniform.

**Size:** Maximum test length 50 mm.

**Global distribution:** Atlantic Ocean, from Caribbean to Brazil and Tropical West Africa; also Indo-Pacific, from the east coast of Africa to Hawaii and the Easter Islands and from Japan to northern Australia and the Lord Howe Island; littoral to 570 m (Mortensen, 1948; Schultz, 2010a).
**South African records of Echinoneus cyclostomus:** Formally reported in South Africa for the first time, however, previously collected by Samyn & Thandar (2003) who encoded records in the *Royal Museum of Central Africa*. All records from the East coast region of South Africa.

**Remarks:** Filter-feeders, which prefers shallow waters, but may sometimes be found in deep waters (Schultz, 2010a).

**Taxonomic notes:** There used to be two species in this genus. The second species—*Echinoneus abnormalis*, was moved to its own genus (*Koehleraster*) based on absence of glassy tubercles and perforated tubercles (Schultz, 2010a).

![Fig. 3.100. Distribution of *Echinoneus cyclostomus*.](image)
Fig. 3.101. *Echinoneus cyclostomus*. A. Aboral view of preserved specimen. B. Aboral view of denuded test (scale bar: 10 mm).
Order: Cassiduloida Claus, 1880
Family: Cassidulidae L. Agassiz & Desor, 1847

Periproct opening aborally positioned, either just above ambitus or on vertical posterior edge; naked zones at posterior oral interambulacra and ambulacra towards mouth.

Genus: *Oligopodia* Duncan, 1889
Phyllodes distinctively well-developed.

* *Oligopodia epigonus* v. Martens, 1865
Figs 3.102-3.103 A-B.

*Nucleolites epigonus*: A. Agassiz, 1872-1874: 147. Pl. XIX, Figs b. 4-6.

**Diagnosis:** Test creamish, slightly raised, posterior keel forming beak above periproct; petals more or less equally long, distally opened, four gonopores; distinct phyllodes.

**Description:** Test small, ovoid, aborally arched, orally concave, depressed towards peristome. Apical system monobasal, somewhat anteriorly positioned. Ambulacra petals distinct, opening distally. Posterior interambulacra forms keel above periproct. Periproct elongated, on truncated posterior side.

**Size:** Maximum test length 17 mm.

**Global distribution:** East Africa, over the Malayan region to Bonin Islands, Tonga Islands and New Zealand; at 35 - 141 m (Mortensen, 1948; Schultz, 2010b).

**South African records of Oligopodia epigonus:** New record from the East coast region.

**Remarks:** Known to bury itself under coarse sandy or gravel.

**Taxonomic notes:** Reported to have the widest geographic distribution of all recent cassiduloids.
Fig. 3.102. Distribution of *Oligopodia epigonus*.

Fig. 3.103. *Oligopodia epigonus*. A. Aboral view of preserved denuded test. B. Oral view of preserved denuded test (scale bar: 10 mm).
Family: Cassiduloida incertae sedis
Genus: Tropholampas H.L. Clark, 1923
Small form, raised aborally, non-petaloid.

*Tropholampas loveni* (Studer, 1880)
Figs 3.104-3.105 A-B.


**Diagnosis:** Apical system of females eccentrically evolved to a deep, elongated hole for breeding purposes, in males monobasal.

**Description:** Test fragile, small, aborally raised. Apical system monobasal in males, four gonopores; in females evolved to a brooding structure. Peristome sub-central, no bourrelets. Ambulacra simple, non-petaliod arrangement, pores small orally, none aboral. Primary tubercles slightly perforated, crenulated. Spines short, uniform, densely covering marsupium. Test and spines white.

**Size:** Maximum test length 8 mm.

**Global distribution:** Endemic to South Africa at 135 – 350 m depth (Mortensen, 1948; Clark & Courtman-Stock, 1976; Schultz, 2010b).

**South African records of *Tropholampas loveni***: West and South coast region.

**Remarks:** This deep-water species displays sexual dimorphism, where females have evolved to a deep and elongated apical system; and males having a monobasal apical system.
Fig. 3.104. Distribution of *Tropholampas loveni*.

Fig. 3.105. *Tropholampas loveni* (male). **A**. Aboral view of preserved specimen. **B**. Oral view of preserved specimen (scale bar: 10 mm).
Family: Echinolampadidae Gray, 1851
Periproct positioned below posterior margin.

Genus: Echinolampas Gray, 1825
Test more elongated; ambulacral pore-pairs forming distally opened petals.

Echinolampas crassa (Bell, 1880)
Figs 3.106-3.107 A-C.

Echinolampas crassa: H.L. Clark, 1923: 397; H.L. Clark, 1924: 11-12; H.L. Clark, 1925: 182-185; Branch et al., 2010: 236. Fig. 106.7; Schultz, 2010b: 521. Figs 877-879.
Echinolampas (Palaeolampas) crassa: Clark & Courtman-Stock, 1976: 244.

Diagnosis: Test high, subconical, sharp edges, robust and thick; densely covered with short spines.

Description: Generic features include test being moderate to large, aborally raised, slightly elongated. Apical system anteriorly positioned, monobasal, with four gonopores. Peristome wider than long, transverse elongated or oval, sub-centrally positioned, bourrelets and phylodes distinct. Distinguished from other species in ambulacra forming five well-developed petals, extending to edge, distally opened; pore-pairs small, anterior-lateral petals being the shortest, sub-equal, anterior pore-pairs somewhat shorter than posterior, pores conjugate, interior pore round and small, outer pores elongated, ridges between consecutive pores-pairs carries miliary tubercles, in regular transverse series, sometimes irregular; interporiferous zones broad, carrying primary tubercles. Posterior interambulacra sometimes having a naked space, not raised towards peristome, tuberculation dense, uniform, becoming sparse towards peristomial area. Primary spines smooth, short, aborally twice as long as oral ones, miliary spines with few serrations distally. Test brown and denuded test white.

Size: Maximum test length 125 mm.

Global distribution: Endemic to the South coast of South Africa, at 15 – 500 m depth (Clark & Courtman-Stock, 1976).
Remarks: Feeds on detritus by lifting particles to mouth with use of oral podia and bourelets. Demonstrates particle selection, as larger particles are discarded due to the size of mouth and smaller ones are hard to handle. Some work has been undertaken on the ecology of this large lamp urchin in South Africa (Cram, 1971b; Thum & Allen, 1975; Thum & Allen, 1976).

Taxonomic notes: Differs from *Tropholampas loveni* in lacking obvious sexual dimorphism.

Fig. 3.106. Distribution records of *Echinolampas crassa*. 
Fig. 3.107. *Echinolampas crassa*. **A.** Aboral view of live specimen. **B.** Aboral view of denuded test. **C.** Side view of denuded test (scale bar: 100 mm).
Order: Clypeasteroida
Family: Clypeasteridae L. Agassiz, 1835
Well-developed internal double lantern, supporting internal ambulacral plates next to peristome.

Genus: Clypeaster Lamarck 1801
Test moderate to large, well-developed petals, apical system monobasal, with five gonopores and ocular plates, orally flattened except towards peristome; five food grooves extending towards margin, sometimes continuing to aboral side

*Clypeaster eurychorius* H.L. Clark, 1924
Fig. 3.108-3.109 A-C.

*Clypeaster humulis* H.L. Clark, 1923: 392.
*Clypeaster (Stolonclypus) eurychorius*: Mortensen, 1948: 94-96. Pl. XXX, Fig. 2. Pl. XXXI, Figs 2, 3. Pl. XXXII, Fig. 3. Pl. XXXIII, Fig. 2.

**Diagnosis:** Test convex centrally, margin thickened; petals closed distally.

**Description:** Distinguished from other species in rounded pentagonal test outline, flat except at elevated petal area, margin thick. Petals short, opened distally, pore-zones narrow, interporiforous zones wider. Primary tubercles sparse, miliaries smaller than primaries. Primary spines small, slender, longer towards mouth; miliaries slender, with thick tip. Preserved specimens brown in color.

**Size:** Maximum test length 145 mm.

**Global distribution:** South Africa, northward to Pemba Strait and off Mauritius, at 125 – 320 m depth (Mortensen, 1948; Schultz, 2010b).

**South African records of Clypeaster eurychorius:** South and East coast region.
**Remarks:** Deep-water species, burrows in the uppermost layer of sediment, where it feeds on organic particles

![Map of South Africa](image)

Fig. 3.108. Distribution of *Clypeaster eurychorius*.

![Images of *Clypeaster eurychorius*](image)

Fig. 3.109. *Clypeaster eurychorius* (juvenile). **A.** Aboral view of preserved specimen. **B.** Oral view of preserved specimen. **C.** Side view of preserved specimen (scale bar: 10 mm).
*Clypeaster fervens* Koehler, 1922

Figs 3.110-3.111 A-C.

*Clypeaster (Rhaphidoclypus) fervens*: Mortensen, 1948: 84-86. Pl XIII, Figs 2,3. Pl. XXII, Figs 1-11. Pl. XXVI, Fig. 2. Pl. LXV, Figs 7-9,12, 20.

*Clypeaster fervens*: Schultz, 2010b: 541. Figs 917-920.

**Diagnosis:** Petals broad, closed, except anterior one, which is open distally.

**Description:** Test oval, slightly elevated aborally towards petaliod area; petals broad, anterior one opened distally; interporiferous zone inflated, maximum of 5 primary tubercles on pore-pair ridges connecting shallow furrows. Live specimens reddish brown in color; denuded test white.

**Size:** Maximum test length 90 m.

**Global distribution:** Red Sea and East Africa to the Malayan Archipelago; at 13 – 110 m depth (Schultz, 2010b).

**South African records of Clypeaster fervens:** New record from the East coast region.

**Taxonomic notes:** Species differs from *C. eurychorius* in its broad petals, with the anterior one opened.
Fig. 3.110. Distribution of *Clypeaster fervens*.

Fig. 3.111. *Clypeaster fervens*. **A.** Aboral view of preserved specimen. **B.** Oral view of preserved specimen. **C.** Side view of preserved specimen (scale bar: 10 mm).
Clypeaster rarispinus de Meijere, 1902
Figs 3.112-3.113 A-C.


**Diagnosis:** Petals narrow, opened distally, zig-zag bands along food grooves.

**Description:** Differs from other species in test being pentagonal, longer than wider, concave sides, posterior side convex, margin sometimes thickened; petaloid area slightly raised, petals opened; zig-zag bands along food grooves. Live animal yellowish-green, oral bands along food grooves darker.

**Size:** Maximum test length 190 m.

**Global distribution:** Red Sea to South Africa, from the Persian Gulf over the Indian Ocean to Malayan Archipelago (Schultz, 2010b); from littoral to 369 m

**South African records of Clypeaster rarispinus:** East coast region. Samples from the Iziko identified collection document a 100 m increase from the previously known maximum depth of 269 m to 369 m.

**Taxonomic notes:** Variation amongst specimens exists in the test outline of which prominent edge thickening is known to exist in KwaZulu-Natal species (Mortensen, 1948). Differs from *C. fervens* in having narrow, distally opened petals.
Fig. 3.112. Distribution records of Clypeaster rarispinus.

Fig. 3.113. Clypeaster rarispinus. A. Aboral view of preserved specimen. B. Oral view of preserved specimen (different specimen from A and C). C. Side view of preserved specimen (scale bar: 10 mm).
Family: Laganidae Desor, 1858
Characterized by eccentric apical system, with a monobasal madreporite, and fused oculars, four to five gonopores.

Genus: Laganum Link, 1807
Four gonopores.

*Laganum fudyisama var. africanum* Mortensen, 1948
Figs 3.114-3.115 A-C.

*Laganum fudyisama*: Schultz, 2010b: 568. Fig. 974.

**Diagnosis:** Test thin, centrally high, fragile, round shaped; narrow petals; distinct food grooves.

**Description:** Test flat, raised center. Apical system subcentral. Peristome also subcentrally centered; round periproct positioned between peristome and posterior edge. Petals narrow, flexed, sometimes closed, in other cases opened. Spines short. Yellow or brownish in color.

**Size:** Maximum length 73 mm.

**Global distribution:** East Africa to Malayan region, Phillipines, southern Japan and Hawaii; at 50-645 m depth (Schultz, 2010b).

**South African records of Laganum fudyisama:** East coast region. Samples identified in current study and samples from the Iziko identified collection extend previously known distribution southwards towards East London.

**Taxonomic notes:** Species may be mistaken for *Clypeaster rarispinus*, distinguishable in periproct being further away from edge.
Fig. 3.114. Distribution of *Laganum fudsyama var africanum*.

Fig. 3.115. *Laganum fudsyama var africanum*. A. Aboral view of preserved juvenile specimen. B. Oral view of preserved juvenile specimen. C. Side view of preserved juvenile specimen (scale bar: 10 mm).
Family: Echinocyamidae Lambert & Thiéry, 1914
Genus: *Echinocyamus* van Phelsum, 1774

Test small, ovate, flattened.

*Echinocyamus elegans* Mazzetti, 1893

Fig. 3.116-3.117 A-B.

*Echinocyamus elegans*: H.L. Clark, 1923: 393-394; Clark & Courtman-Stock, 1976: 242; Schultz, 2010b: 558. Fig. 954.d.

**Diagnosis:** Well developed petals, parallel pore-pairs, extending towards ambitus, pores large.

**Description:** Small test, oval to sub-circular; simple radial internal buttresses, along interambulacral margin; peristomial membrane naked; periproct covered by several radiating plates; periproct smaller than peristome, between peristome and posterior edge; gonopores four; petals small; spines short and simple. Differs from other species in test being convex aborally, concave orally; petals well-developed, almost extending to ambitus, pores large, maximum of eight pore-pairs, conspicuous, pore zones as wide as interporiferous zones, not meeting distally. Specimen white.

**Size:** Maximum test length 6 mm.

**Global distribution:** Red Sea to South Africa, and Iran Gulf; at 110 – 275 m depth (Mortensen, 1948; Schultz, 2010b).

**South African records of *Echinocyamus elegans***: West and East coast region. Samples from the Iziko identified collection extend distribution westwards towards Saldanha Bay.

**Remarks:** Inhabits sandy and/or muddy bottoms (Mortensen, 1948).

**Taxonomic notes:** Species of this genus very similar and difficult to distinguish (Schultz, 2010).
Fig. 3.116. Distribution of *Echinocyamus elegans*.

Fig. 3.117. *Echinocyamus elegans*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen (scale bar: 10 mm).
Echinocyamus scaber de Meijere, 1902
Figs 3.118-3.119 A-B.


Diagnosis: Glassy tubercles scattered aborally and orally.

Description: Differs from other species in test having an oval outline, aborally lowly convex; apical disc inflated; petals well developed, with maximum of five pore-pairs; glassy knobs higher than primary tubercles, covering aboral and oral sides; periproct with spines.

Size: Maximum test length 8 mm.

Global distribution: East Africa to the Philippines, eastern Australia and Hawaii; at 200 – 1886 m (Schultz, 2010b).

South African records of Echinocyamus scaber: East coast region.

Taxonomic notes: Distinguished from E. elegans by the glassy tubercles scattered on test, shorter petals and number of pore-pairs; where E. scaber has a maximum of five pore-pairs and E. elegans nine.
Fig. 3.118. Distribution of *Echinocyamus scaber*.

Fig. 3.119. *Echinocyamus scaber*. A. Aboral view of preserved specimen. B. Oral view of denuded test (scale bar: 10 mm).
**Family: Astriclypeidae Stefanini, 1912**
Characterized by thin, fragile test; petals short; slits on test; periproct midway between peristome and posterior margin.

**Genus: Echinodiscus Leske, 1778**
Test extremely thin and fragile, posterior slits.

**Echinodiscus bisperforatus Leske, 1778**
Figs 3.120-3.121 A-C.

*Echinodiscus bifora*: Gray, 1825: 428. Pl. XXVI.
*Echinodiscus bisperforatus*: H.L. Clark, 1923: 394-395; H.L. Clark, 1925: 170; Mortensen, 1948: 406-411. Pl. LVIII, Figs 2, 6-8. Pl. LXXI, Figs 6-9, 18; Clark & Courtman-Stock, 1976: 243; Richmond, 1997: 300; Branch et al., 2010: 236. Fig. 106.8; Schultz, 2010a: 341. Figs 645-646.

**Diagnosis:** Two posterior slits, not cutting through edge.

**Description:** Species with main generic features which include test being thin, fragile, highest point above apical system; apical system with four gonopores; petals short; posteriorly truncated, two posterior slits; oral side with pressure drainage channels passing to anterior margin and to posterior slits; branching food grooves with distal side branches; spines aborally short, orally long. Distinguished by test outline being broadly trapezoid, with two slits not extending through margin. Live specimen uniformly purple, denuded test white.

**Size:** Maximum test length 118 mm.

**Global distribution:** Red Sea to South Africa, Thailand, Malayan Archipelago and New Caledonia; from littoral to 50 m (Schultz, 2010a).

**South African records of Echinodiscus bisperforatus:** South and East coast region.

**Remarks:** Shallow water species known to inhabit sheltered waters half buried in sandy bottoms. Feeds on organic particles from sediments. Some studies have been undertaken on
the ecology of this widely distributed pansy shell urchin (Bentley & Cockcroft, 1995a; Bentley & Cockcroft, 1995b; Bentley & Cockcroft 1998).

**Taxonomic notes:** Variation occurs in the length of slits and in shape of posterior petals.

Fig. 3.120. Distribution of *Echinodiscus bisperforatus*.

Fig. 3.121. *Echinodiscus bisperforatus*. **A.** Aboral view of live specimen. **B.** Aboral view of denuded test. **C.** Side view of denuded test (scale bar: 10 mm).
**Order: Holasterioda Durham & Melville, 1957**
Labrum elongated, connected to one sternal plate, followed by two episternal plates; apical system narrow, elongated, O II and O IV connect and separate anteriorly at G II and G III, and posteriorly at G IV and G1, O 1 and OI posteriorly positioned.

**Family: Pourtalesiidae A. Agassiz, 1881**
Deep peristomial groove; apical system separated, with one anterior genital plate, with maximum two gonopores, followed by two oculars with pores; posterior genital plated separated without pores, followed by oculars; oral interambulacral V interrupted.

**Genus: Pourtalesia A. Agassiz, 1869**
Test laterally compressed, with hook-like structure posteriorly.

*Pourtalesia alcocki* Koehler, 1914
Figs 3.122-3.123 A- B.

*Pourtalesia carinata*: Bell, 1904: 172.


**Diagnosis:** Main characteristics of genus include test being compact, somewhat differentiated rostrum, which is prominent in juveniles; apical system with four gonopores, divided into three parts, labrum and sternal plates separated; peristome vertically positioned, at end of groove, periproct on lower side, above rostrum. Test more vertical than wide, vase-shape, with an eccentric posterior hook above periproct; but differs in having a more profound plastronal keel orally.

**Size:** Maximum test length 50 mm.

**Global distribution:** Western Indian Ocean from the Gulf of Oman to off South Africa, at 1450 - 2380 m depth (Schultz, 2010b).

**South African records of Pourtalesia alcocki:** West coast region.

**Remarks:** Inhabit deep-waters at continental slope, where they feed by burrowing through the uppermost layer of the substrate.
Fig. 3.122. Distribution record of *Pourtalesia alcocki*.

Fig. 3.123. *Pourtalesia alcocki*. **A.** Side view of preserved juvenile specimen. **B.** Oboral view of preserved juvenile specimen. **C.** Aboral view of preserved juvenile specimen (scale bar: 10 mm).
Family: Urechinidae Duncan, 1889

Test thin, plated; labrum and sternum not separated; apical system compact; ambulacra non-petaloid, with single pores; sub-anal fasciole present in some species.

Genus: Urechinus A. Agassiz, 1879

Apical system elongated, gonopores three, pores absent from genital plate II; labrum and sternal plate not separated.

Urechinus naresianus A. Agassiz, 1979

Figs 3.124-3.125 A-B.


Diagnosis: Main characteristics of genus with test oval shaped; tapering posteriorly to blunt end, sunken towards peristome. Interambulacra V slightly inflated, hood above periproct. Sub-anal fasciole distinctive in juveniles, less so in adults.

Size: Maximum test length 50 mm.

Global distribution: Atlantic, sub-Antarctic and North Pacific waters, at 770 – 4400 m depth (Schultz, 2010b).

South African records of Urechinus naresianus: West coast region.

Taxonomic notes: Differs from Pourtalsia alcocki in lacking the distinctive keel running along the upper side and hook above periproct. The labrum and sternal plates of U. naresianus are not separated as in P. alcolck.
Fig. 3.124. Distribution of *Urechinus naresianus*.

Fig. 3.125. *Urechinus naresianus*. **A**. Aboral view of preserved specimen. **B**. Oral view of preserved specimen (scale bar: 10 mm).
Order: Spatangoida L. Agassiz, 1840
Narrow labrum connected to two sternal plates, followed by episternal plates; apical system compact, enlarged genital plates, madreporite extends to posterior end- separating G I and G IV, and O I and O V.

Family: Brissidae Gray, 1855
Both peripetalous and subanal fasciole present; anal branch occasionally present in some genera.

Genus: Brissopsis L. Agassiz, 1840
Anterior ambulacrum with differentiated pore-pairs.

**Brissopsis lyrifera var. capensis** Mortensen, 1907

Figs 3.126-3.127 A-C.

*Brissopsis lyrifera:* A. Agassiz, 1881: 189; Bell, 1904: 175; Dördelein, 1906: 256-258. Pl XXXIV. Figs 4-8, Pl XLIX. Figs 1-2; H.L. Clark, 1923: 401; H.L. Clark, 1924: 12-13; H.L. Clark, 1925: 213-214; Mortensen, 1951: 380-390. Pls. XXX, Figs. 1-4, 7-13, Pl XXXII, Figs 15, 20, 22; Pl LVII, Fig. 15: Schultz, 2010a: 381. Figs 720-721.


**Diagnosis:** Test heart-shaped; petals straight and divergent.

**Description:** Test medium-sized, thin elongated, anterior notch. Apical system with expanded madreporite, maximum of four gonopores. Anterior ambulacrum with differentiated pores, associated with tube feet. Petals with reduced inner pores. Peripetalous, bilobed subanal fascioles present. May differ in the apical system being sub-central; sternal plates tuberculated.

**Size:** Maximum test length 70 mm.

**Global distribution:** Eastern Atlantic from the Lofoten islands, Norway, to Iceland, along the European coasts of the Mediterranean and southward to the Canaries and West Africa (Mortensen, 1951; Schultz, 2010a) and East coast region of South Africa; at 5-1400 m (Mortensen, 1951; Schultz, 2010a)
South African records of *Brissopsis lyrifera var. capensis*: West and East coast region. Two samples identified through this study extend previously known distribution eastwards towards Richards Bay and Sodwana Bay.

**Remarks:** Inhabits shallow waters on the continental shelf, where burrows a few centimeters below the surface (Schultz, 2010a).

**Taxonomic notes:** According to Mortensen (1951) there are variations in the size of the posterior petals amongst the South African and Atlantic-Mediterranean species. Thus *B. lyrifera* (Forbes, 1841) was separated into two sub-species *B. lyrifera var. capensis* (South African species) and *B. lyrifera lyrifera* (Atlantic-Mediterranean species). Furthermore, *B. lyrifera var. capensis* has pedicellaria densely packed in the posterior ambulacram and around the peristome, seldom on the aboral side; whereas the pedicellaria are found on the aboral side in the midline of the interambulacram, in the case of *B. lyrifera var. lyrifera*.

![Fig. 3.126. Distribution of *Brissopsis lyrifera var. capensis*.](image)
Fig. 3.127. *Brissopsis lyrifera var. capensis*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (scale bar: 10 mm).
Genus: *Metalia* (Gray, 1855)

Test oval, with shallow anterior notch; subanal fasciole shield-shaped, with anal branches.

*Metalia robillardi*

Figs 3.128-3.129 A-B.

*Metalia robillardi*: Clark & Rowe, 1971: 166; Schultz, 2010a: 394. Fig. 742.

**Diagnosis:** Test anteriorly raised, sloping towards posterior region.

**Description:** Specimen large, test oval, anterior side steep, with deep notch. Apical system anteriorly positioned, with four gonopores. Anterior ambulacra narrow, somewhat sunken, simple pore-pairs; anterior petals directed downwards, posterior petals more flexed. Oral side with short, narrow labrum, slightly covering peristome; large periproct at short posterior end. Subanal fasciole tapering to one point, with five (to six) pores on either side; peripetalous fasciole with shallow indentions in interambulacra, tubercles large, especially along ambulacra. Preserved specimen white, with short spines.

**Size:** Maximum test length 125 mm.

**Global distribution:** East coast of Australia, Mauritius, Réunion and Madagascar (Schultz, 2010a); at 2-50 m depth.

**South African record of *Metalia robillardi***: New record from the East coast region. New record shows that species may inhabit deeper waters of 50 m than the previously reported 14 m.

**Taxonomic notes:** Distinguished from *Brissopsis lyrifera var. capensis* by anterior part of test distinctively raised; by anterior petals being directed downwards and by its white color.
Fig. 3.128. Distribution of *Metalia robillardi*.

Fig. 3.129. *Metalia robillardi*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 100 mm).
Family: Eurypatagidae Kroh, 2007
Apical system compact, genital plate II extending posteriorly between posterior genital plate I and IV, and ocular plates I and V (ethmolytic), four gonopores.

Genus: Eurypatagus Mortensen, 1948
Petals long, narrow, distally opened, somewhat parallel pore zones; lacks fascioles, subanal fasciole only present in young.

Eurypatagus parvituberculatus H.L. Clark, 1924
Figs 3.130-3.131 A-C.


Diagnosis: Pore-pairs extremely small; aboral posterior interambulacram inflated, with distinct keel, sternal plates seldom with tubercules; frontal tube feet white.

Description: Test outline ovoid, flat, without frontal notch. Apical system anteriorly positioned, with generic features. Peristome kidney-shaped, further from anterior margin. Ambulacra pores small, pore zones sub-parallel, pore-pairs conjugated; paired ambulacrum petals extending towards ambitus, anterior pair flexed anteriorly, posterior straighter. Aboral primary tubercles large, crenulated and perforated. Oral side flat, phyllodes well-developed, Labral plate long, separated from sternal plates by adjacent ambulacral plates, sternal plates short, tubercles with large areoles laterally bordering naked space. Spines long, serrated distally and curved at base. Red in color, with partially white spines.

Size: Maximum test length 75 mm.

Global distribution: South Africa and Mauritius (Mortensen, 1950; Schultz, 2010b), at 30-325 m depth

South African records of Eurypatagus parvituberculatus: East coast region. Samples identified through this study show that species can be found in shallower waters of 30 m than the previously thought 50 m.
**Taxonomic notes:** Holotype is from the Natal coast of South Africa (H.L. Clark, 1924).

Fig. 3.126. Distribution of *Eurypatagus parvituberculatus*.

Fig. 3.127. *Eurypatagus parvituberculatus*. **A.** Aboral view of preserved specimen. **B.** Oral view of preserved specimen. **C.** Side view of preserved specimen (scale bar: 10 mm).
Family: Loveniidae Lambert, 1905
Internal fasciole present, usually combine with subanal fasciole; pore-pairs in outer part of petals well-developed, outer pore-pairs small and rudimentary.

Genus: Echinocardium Gray, 1825
Labral plate short, relatively broad.

Echinocardium capense Mortensen, 1907
Figs 3.128-3.129 A-C.

Echinocardium flavescens: A. Agassiz, 1881: 175.
Echinocardium capense: H.L. Clark, 1923: 405. Pl. XIII; H.L Clark, 1924: 15; H.L. Clark, 1925: 232; Schultz, 2010b: 416. Fig. 785.

Diagnosis: Test oval, with short internal fasciole, lacks anterior notch.

Description: Test with oval outline. Apical system somewhat sunken, saddle-like in appearance. Anterior aboral ambulacra flushed; petals not widened at short internal fasciole, parallel. Anal fasciole and subanal fasciole joined. Preserved specimen brown, with short spines.

Size: Maximum test length 50 mm.


South African records of Echinocardium capense: West and South coast region.

Taxonomic notes: According to Schultz (2010b), this species has been synonymized with the Mediterranean E. mortensenii and the Japanese E. lymani, however, the WED has suggested that more information on the pedicellaria variation amongst these species is needed before such conclusions are confirmed.
Fig. 3.128. Distribution of *Echinocardium capense*.

Fig. 3.129. *Echinocardium capense*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (scale bar: 10 mm).
**Echinocraduim cordatum** (Pennant, 1777)
Figs 3.130-3.131 A-C.


*Echinocardium australis*: A. Agassiz, 1872-1874: 109; 580. Pl. XXXVII, Fig. 15; Bell, 1904: 174.


**Diagnosis:** Test with frontal notch, anterior ambulacra distinctively sunken.

**Description:** Test moderately high, with deep anterior notch. Apical system posteriorly positioned. Peristome somewhat anterior, labrum prominent, plastron appearing keeled. Anterior ambulacrum distinctively sunken, two-series of irregularly arranged, large pores, associated with tube feet; paired petals sunken, wide at internal faciole, tapering distally. Periproct opening at truncated end, variable in shape. Internal fasciole conspicuously long, subanal fasciole shield-shaped, with four pore-pairs, pointed at end; anal fasciole extending along periproct, onto upper side, separated from subanal fasciole. Spines uniform. Live specimen brownish, denuded test white.

**Size:** Maximum test length 90 mm.

**Global distribution:** Cosmopolitan from northern Norway along European coasts into the Mediterranean and Morocco, in South Africa, Japan, New Zealand and southern Australia; from littoral to 500 m (Schultz, 2010a).

**South African records of Echinocraduim cordatum:** West to East coast region. Samples identified in current study extend previously know distribution northwards towards Sodwana Bay.

**Taxonomic notes:** Species differs from *E. capense* in large shield shape internal fasciole and frontal notch.
Fig. 3.130. Distribution of *Echinocardium cordatum*.

Fig. 3.131. *Echinocardium cordatum*. **A.** Aboral view of denuded test. **B.** Oral view of denuded test. **C.** Side view of denuded test (scale bar: 10 mm).
Genus: *Lovenia* Desor, in Agassiz & Desor, 1847

Test delicate, depressed, large tubercles with deep areaoles aborally, giving a worm-like appearance on inner surface of test.

* Lovenia elongata (Gray, 1825)
  
  Figs 3.132-3.133 A-B.

*Lovenia elongata*: A. Agassiz, 1872-1874: 139, 575. Pl. XIX. Figs 1-4, Pl. XXV. Fig. 3. Pl. XXVI. Fig. 35-36. Pl. XXXVII. Figs 18-19, Pl. XXXVIII. Figs 27-28; Doderlein, 1906: 265. Pl. XLVIII. Fig. 5; Mortensen, 1951: 97-104. Pl. VII, Figs 1-10. Pl. VIII, Fig. I. Pl. XII, Fig. 5. Pl. XLVII, Figs 10-23; H.L. Clark, 1923: 404; Clark & Courtman-Stock, 1976: 252; Richmond, 1997: 300-301; Schultz, 2010a: 419. Fig. 789.

**Diagnosis:** Posterior end of test sunken, forming anal tunnel; test broader anteriorly; subanal fasciole pore-pairs six or more in adult; aboral spines banded.

**Description:** Test delicate, elongated, conspicuous anterior notch. Apical system subcentral, with four gonopores. Peristome kidney shaped; labral plate narrow, elongated; sternal plates appearing naked, posteriorly tuberculated. Anterior ambulacrum somewhat indented, with pore-pairs differentiated; paired petals, wide at internal fasciole, narrowing towards distal ends. Primary tubercles large, with deep areoles. Periproct positioned at upper side of posterior invagination. Spines long, aboral ones longer and banded. Denuded test white, live specimen brown to reddish.

**Size:** Maximum test length 85 mm.

**Global distribution:** Red Sea to Mozambique along East Africa, and from south Japan to the east coast of Australia, from littoral to 94 m (Mortensen, 1951; Schultz, 2010a).

**South African records:** New record from the East coast region.

**Remarks:** A shallow water species that buries itself under sandy or gravel sediments. Uses its long oral spines to move within substrate and the aboral ones function as a defense structure from predators (Schultz, 2010).
**Taxonomic notes:** May be mistaken for *E. parvituberculata*, however, differs in having an anterior notch and deep aboral areoles.

Fig. 3.132. Distribution of *Lovenia elongata*.

Fig. 3.133. *Lovenia elongata*. A. Aboral view of preserved specimen. B. Side view of preserved specimen (scale bar: 10 mm).
Family: Maretiidae Lambert, 1905
Labral plate long, wedge-shaped; sternal plates triangular; strongly indented episternal plates; subanal fasciole shield-shaped, usually with plates at ends of posterior petals.

Genus: Spatagobrissus H.L. Clark, 1923
Peripetalous fasciole convex between anterior and posterior petals; no frontal notch.

Spatagobrissus mirabilis H.L. Clark, 1923
Figs 3.134-3.135 A-D.


Diagnosis: Test large, with round outline, pointed at posterior end, aboral side somewhat sloping; petals broad, short, closed distally, with peripetalous fasciole running at distal ends;

Description: Test outlines oval, pointed at posterior end. Apical system subcentral, with four gonopores, ethymolytic, madreporite expanding to posterior plates. Petals broad, seldom closed; pore-zones sunken, pores conjugate; interporiferous zones broad, elevated, with irregularly arranged tubercles. Peristome anteriorly positioned, half moon-shaped; labrum fairly prominent, extending posteriorly to sternal plates; sternum tuberculated, triangular, widening towards posterior end. Peripetalous fasciole distinctively bordering distal ends of petals, not bending inwards; subanal fasciole shield-shaped, anteriorly pointed; no anal fasciole. Spines short and numerous. Live brown in color, denuded test white.

Size: Maximum test length 110 mm.

Known from the west and south coast region of South Africa. Samples from the Iziko identified collection extend previously known distribution westwards to False Bay

Taxonomic notes: Species combines features of genera Spatangus and Brissus of which the petals, mouth and posterior part of test resembles Spatangus spp whilst the presence of the
peripetalous and position of periproct resembles *Brissus spp* (H.L. Clark, 1923). Species varies from *E. parvituberculata* in the test slightly sloping on the upper-side, the presence of the conspicuous peripetalous fasciole and in having shorter petals.

Fig. 3.134. Distribution records of *Spatagobrissus mirabilis*.
Fig. 3.135. *Spatagobrissus mirabilis*. **A.** Aboral view of live specimen (Branch *et al.*, 2010). **B.** Aboral view of denuded test. **C.** Oral view of denuded test. **D.** Side view of denuded test (scale bar: 100 mm).
Genus: *Gymnopatagus* Dördelien, 1901

Spines long within the peripetalous fasciole, much shorter on the rest of the test

*Gymnopatagus magnus* A. Agassiz & H.L. Clark, 1907

Figs 3.136-3.137 A-C.


**Diagnosis:** Test heart-shaped, relatively low, highest at apical system, sloping towards the posterior end; somewhat distally closed petals.

**Description:** Test delicate, heart-shaped, outline more elongated than wide. Apical system anteriorly positioned, madreporite extends posteriorly, separating ocular plates I and V, gonopores four, positioned on the inner part of genital plates. Periproct d-shaped. Anterior ambulacrum slightly sunken towards marginal area, with small pore-pairs; anterior pore zones of anterior petal curved, giving it an s-shape. Labrum long, narrow, adjoining sternal plates tuberculated. Subanal fasciole shield-shaped, with two pore-pairs on either side. Preserved specimen yellowish, denuded test light brown.

**Size:** Maximum test length 111 mm.

**Distribution:** Japan to the Indian Ocean, South Africa; at 730-2350 m (Schultz, 2010b).

**South African record of Gymnopatagus magnus:** East coast region.

**Taxonomic notes:** Species distinguished from *Spatagobrissus mirabilis* by possessing a frontal notch.
Fig. 3.136. Distribution of *Gymnopatagus magnus*.

Fig. 3.137. *Gymnopatagus magnus*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (111 mm) (Schultz, 2010b).
**Family: Spatangidae Gray, 1825**

Well-developed sub-anal fascioles, aboral fascioles absent; primary spines long on aboral side; anterior petals reduced.

**Genus: Spatangus Gray, 1825**

Test with frontal notch; anterior pore-pairs rudimentary adapically; primary tubercles restricted to aboral interamulacra.

*Spatangus capensis* Dördelein, 1905

Figs 3.138-3.139- A-C.

*Spatangus capensis*: Döderlein, 1906: 261-263. Pl. XXXIII. Fig. 1, Pl. XLVIII. Fig. 4; H.L. Clark, 1923: 404. Pl. XIII; H.L. Clark, 1924: 13; H.L. Clark, 1925: 224; Mortensen, 1951: 16. Pl. I. Figs 1-3; Clark & Courtman-Stock, 1976: 253; Schultz, 2010a: 430.

**Diagnosis:** Test heart-shaped; lacking tubercles in ambulacrum outside petals, small primary tubercles rarely found towards ambitus in anterior ambulacra, no tubercles in the posterior ambulacra; spines short; species purple in color.

**Description:** Test with anterior frontal notch, oblique at posterior end. Apical system ethomylitic, with four gonopores. Paired petals narrow, with large conjugated pore-pairs; anterior petal pores rudimentary, small and simple. Primary tubercles simple, scattered on aboral side. Labrum covering peristome. Subanal fasciole shield-shaped. Spines short. Specimen purple in color.

**Size:** Maximum test length 125 mm.

**Global distribution:** Endemic to the West and South coast region of South Africa, at 37 – 500 m depth (Clark & Courtman-Stock, 1976).

**Taxonomic notes:** Species differs from *Spatagobrissus mirabilis* in lacking peripetalous facioles and having an anterior frontal notch.
Fig. 3.138. Distribution records of *Spatangus capensis*.

Fig. 3.139. *Spatangus capensis*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (scale bar: 100 mm).
Family: Schizasteridae Lambert, 1905

Characterized by marginal fasciole passing immediately below end of anterior petals.

Genus: Brisaster Gray, 1855

Gonopores three.

Brisaster capensis (Studer, 1880)

Figs 3.140-3.141 A-C.

Schizaster fragilis: A. Agassiz, 1881: 201-202; Bell, 1904: 175
Brisaster capensis: Mortensen, 1951: 286-288. Pl XXV. Figs 4-10; Clark & Courtman-Stock, 1976: 248; Schultz, 2010b: 791. Fig. 1367.

Diagnosis: Test low, heart-shaped, truncated posteriorly, with distinctive anterior groove; genital pores three.

Description: Test sub-circular, with narrow, deep, anterior notch. Apical system ethymolytic, with three gonopores, more posteriorly positioned than anteriorly. Persitome covered by labrum; labral plate short, extending to first adjacent ambulacral plate; sternal plates symmetrical. Periproct posteriorly positioned. Anterior ambulacra narrow; petals straight, not flexed distally, anterior petals much longer than posterior ones. Marginal and peripetalous fascioles well developed.

Size: Maximum length 50 mm.

Fig. 3.140. Distribution of *Brisaster capensis*.

Fig. 3.141. *Brisaster capensis*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (scale bar: 10 mm).
Genus: *Schizaster* L. Agassiz, 1835

Gonopores two.

*Schizaster lacunosus* (Linnaeus, 1758)

Figs 3.142-3.143 A-C.

*Schizaster ventricosus*: A. Agassiz, 1872-1874: 158, 614.

*Schizaster japonicus*: A. Agassiz, 1881: 202, Pl. XXXVI. Figs 8-13. Pl. XLIII. Fig. 26. Pl. LXV. Figs 7-10; Döderlein, 1906: 254.


*Ova (Aplospatangus) lacunosus*: Schultz, 2010a: 443. Fig. 826.

**Diagnosis:** Test heart-shaped, pointed towards the end, very high posteriorly, with indented anterior ambulacra, adjoining interambulacra rising as vertical wall covering frontal pore-pairs, posterior interambulacra keeled, forming a hook above periproct; genital pores two.

**Description:** Test oval, with broad outline, pointed and high posteriorly. Apical system ethymolytic, with two gonopores, posteriorly positioned. Peristome sunken, anteriorly positioned; labrum prominent, extension not reaching first adjacent ambulacral plates, in contact with symmetrical sternum. Periproct on truncated posterior end, where interambulacra forms a hook above periproct. Petals deeply sunken, anterior ones curved distally, posterior ones more straight, anterior ones much longer than posterior ones; anterior ambulacrum pore-pairs in regular single series, on both sides. Peripetalous and latero-anal fascioles well-developed.

**Size:** Maximum test length 82 mm.

**Global distribution:** Japan, South Africa, East Coast of Africa, Northeast Australia (Mortensen, 1951), at 5 – 198 m depth

**South African records of *Schizaster lacunosus***: South and East coast region. Samples identified in this study extend previously known distribution southwards off Port Elizabeth; and illustrates that species may be found in deeper waters of 198 m than the previously
thought 90 m.

**Taxonomic notes:** Very similar to *Brisaster capensis*, however, differs in the number of gonopores of which *S. lacunosus* has two and *B. capensis* three. Other differences that distinguish the two species are the posterior keel and the two vertical walls formed by the adjoining anterior interambulacra in *S. lacunosus*, *B. capensis* lacking these features.

Schultz (2010a) reported this species as *Ova (Aplospatangus) lacunos* on the basis of fossil type known to have four gonopores, thus resulting to the genus *Schizaster* being synonymized with *Paraster* and species with two gonopores being transferred to genus *Ova*. However, this change has not been implemented on the WED database. This study follows the taxonomic naming of the WED database.

Fig. 3.142. Distribution records of *Schizaster lacunosus*.
Fig. 3.143. *Schizaster lacunosus*. A. Aboral view of preserved specimen. B. Oral view of preserved specimen. C. Side view of preserved specimen (scale bar: 10 mm).
### Appendix 1:

**Glossary of terms**

Definitions extracted from Schultz (2010a) and KROH & SMITH (2011).

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td><strong>Aboral</strong></td>
<td>The side or direction away from the mouth.</td>
</tr>
<tr>
<td><strong>Ambitus</strong></td>
<td>The point of widest circumference on the test.</td>
</tr>
<tr>
<td><strong>Ambulacra</strong></td>
<td>The zone of plates associated with the water vascular system. There are five ambulacral zones on the test of extant echinoids.</td>
</tr>
<tr>
<td><strong>Apical disc/Apical system</strong></td>
<td>The small area of plates forming the aboral surface of the test at the apex of the ambulacral and interambulacral zones. Composed of ocular and genital plates, which (in regulars) surround the periproct.</td>
</tr>
<tr>
<td><strong>Areole</strong></td>
<td>A flat platform marking the attachment site of spine muscle on a tubercle.</td>
</tr>
<tr>
<td><strong>Auricle</strong></td>
<td>An internal structure associated with muscle attachment.</td>
</tr>
<tr>
<td><strong>Begeminate</strong></td>
<td>A compound plate composed of two elements.</td>
</tr>
<tr>
<td><strong>Bourrelets</strong></td>
<td>A swollen plate, forming a tooth-like or knob-like projection away from the test surface. The five bourrelets often form a star-like opening to the peristome, and support a grill of spines that cover the opening.</td>
</tr>
<tr>
<td><strong>Buccal notches</strong></td>
<td>Indentations of the peristomial margin marking the place where pharyngeal expansion sacs emerge</td>
</tr>
<tr>
<td><strong>Buccal plates</strong></td>
<td>Ovate ambulacral plates that lie in the peristomial membrane and support tube-feet. There are 10 buccal plates in most regular echinoids, one pair in each ambulacral zone</td>
</tr>
<tr>
<td><strong>Buccal sacs</strong></td>
<td>Soft-tissue organs that are external extensions of the pharyngeal coelom. They allow coelomic fluids to move in and out of the test to compensate for movement of the lantern in and out of the test during feeding. They were originally thought to have had a role in respiration, hence their older name &quot;gills&quot;</td>
</tr>
<tr>
<td><strong>Compact disc</strong></td>
<td>An apical disc in which the ocular and genital plates form a single contiguous area not surrounding the periproct.</td>
</tr>
<tr>
<td><strong>Compound plate</strong></td>
<td>An ambulacral plate that is composed of two or more individual elements.</td>
</tr>
<tr>
<td><strong>Conjugate</strong></td>
<td>A pore-pair where the two pores are connected by a shallow furrow or groove. These are always associated with specialized respiratory tube-feet.</td>
</tr>
<tr>
<td><strong>Crenulate</strong></td>
<td>A tubercle with a toothed or noded platform surrounding the mamelon.</td>
</tr>
<tr>
<td><strong>Demiplate</strong></td>
<td>An ambulacral element of a compound plate that contacts the adradial suture but extends only part of the way across the interambulacral column and thus ends before reaching the perradius.</td>
</tr>
<tr>
<td><strong>Dicyclic</strong></td>
<td>An apical disc in which all of the ocular plates are separated from the periproct by genital plates, the genital plates forming a contiguous ring.</td>
</tr>
</tbody>
</table>
| **Episternal**              | In the posterior interambulacrum, plates, which follow the sternal
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>plates</td>
<td>plates and form the posterior part of the plastron; in some cases.</td>
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<tr>
<td>Exsert</td>
<td>An arrangement of apical disc plates in which the ocular plates are separated from the periproct opening by genital plates.</td>
</tr>
<tr>
<td>Fasciole</td>
<td>A band of fine ciliary and mucous-gland tipped spines. These are used to create ciliary currents within the burrows of infaunal taxa and generate a protective mucous coat. The fine, dense tubercles form a distinct finely granular band on the test.</td>
</tr>
<tr>
<td>Food groove</td>
<td>Smooth tubercle and spine-free channel leading towards the mouth and used for the transportation of fine particles; may be simple or distally branched and usually confined to the oral surface.</td>
</tr>
<tr>
<td>Hoofed spines</td>
<td>A spine that ends in a cone-shaped sac.</td>
</tr>
<tr>
<td>Horizontal diameter (h.d)</td>
<td>Distance from the midline of an interambulacrum to the midline of the opposing interambulacrum.</td>
</tr>
<tr>
<td>Hydropores</td>
<td>Small perforations usually confined to genital plate 2, which mark the external opening to the water vascular system. The plate is also know as a madreporite.</td>
</tr>
<tr>
<td>Insert</td>
<td>An arrangement of apical disc plates in which the ocular plates are in contact with the periproct.</td>
</tr>
<tr>
<td>Interambulcra</td>
<td>Alternating plates separating ambulacra.</td>
</tr>
<tr>
<td>Internal fasciole</td>
<td>Fasciole surrounding apical system, crossing al petals.</td>
</tr>
<tr>
<td>Interporiferous zone</td>
<td>Area between inner part of ambulacral pores.</td>
</tr>
<tr>
<td>Irregular</td>
<td>Sea urchins with periporct/anal opening outside genital plate circle.</td>
</tr>
<tr>
<td>Labrum/ labral plates</td>
<td>The unpaired plates in interambulacrum V (IV). This forms the anterior part of the plastron.</td>
</tr>
<tr>
<td>Lantern/ Aristoles lantern</td>
<td>Jaw apparatus, for mastication.</td>
</tr>
<tr>
<td>Latero-anal fasciole</td>
<td>A fasciole band that runs from just behind the anterior paired petals and passes beneath the periproct. At its anterior it connects to the peripetalous fasciole.</td>
</tr>
<tr>
<td>Lovenian system</td>
<td>The standard reference system by which the various ambulacral (A) and interambulacral (IA) zones are numbered. The key tie point is that the madreporic plate lies in IA 2.</td>
</tr>
<tr>
<td>Madreporite</td>
<td>Perforated plate, part of the genitak plate in the apical ring (See also “Hydropores”).</td>
</tr>
<tr>
<td>Marginal fasciole</td>
<td>A fasciole band that runs around the ambitus of the test, passing beneath the periproct at the posterior.</td>
</tr>
<tr>
<td>Milled ring</td>
<td>A small flange near the base of the spine marking the distal most limit of muscle attachment onto the spine base.</td>
</tr>
<tr>
<td>Miliary tubercle</td>
<td>Small tubercles set with the smallest spines.</td>
</tr>
<tr>
<td>Monobasal</td>
<td>An apical disc with five ocular plates but only one genital plate (G2). This genital plate dominates.</td>
</tr>
<tr>
<td>Monocyclic</td>
<td>An apical disc in which all of the ocular plates are in contact with the periproct, and separate adjacent genital plates.</td>
</tr>
<tr>
<td>Ocular plates</td>
<td>Plates of the apical disc that lie perradially, at the apex of an ambulacrum zone.</td>
</tr>
<tr>
<td>Oral</td>
<td>The surface of the test bearing the peristome opening.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pedicellaria (ae)</td>
<td>A stalked appendage that ends in a valved head (usually with three valves but occasionally with two, four or five). These valves area connected at their base and are able to open and close. They are used to defense, to deter skin parasite, and to clean the test surface.</td>
</tr>
<tr>
<td>Perforate</td>
<td>A tubercle whose mamelon has a central pore. This pore houses ligament, which binds the overlying spine to the tubercle.</td>
</tr>
<tr>
<td>Peripetalous (fasciole)</td>
<td>An aboral fasciole band that encircles the petals.</td>
</tr>
<tr>
<td>Periproctal membrane</td>
<td>A flexible, usually plated, membrane that covers the periproct and through which the anus opens.</td>
</tr>
<tr>
<td>Peristome</td>
<td>The opening through the test associated with the mouth.</td>
</tr>
<tr>
<td>Peristomial membrane</td>
<td>A flexible, usually plated, membrane that covers the peristome and through which the mouth opens.</td>
</tr>
<tr>
<td>Petal</td>
<td>A zone of enlarged pore-pairs bearing specialized respiratory tube-feet forming the adapical part of an ambulacrum.</td>
</tr>
<tr>
<td>Phylloide</td>
<td>An expanded zone of specialized pore-pairs (and tube-feet) close to the peristome.</td>
</tr>
<tr>
<td>Plastraon</td>
<td>The interambulacral plates immediately to the posterior of the mouth in atelostomes, comprising the labral plate (L), sternal plates and sometimes episternal plates.</td>
</tr>
<tr>
<td>Plates</td>
<td>Single flattened, skeletal element. Columns of plates form the test.</td>
</tr>
<tr>
<td>Podia</td>
<td>Tube feet.</td>
</tr>
<tr>
<td>Polygeminate (plating)</td>
<td>A compound plate composed of four or more elements.</td>
</tr>
<tr>
<td>Pore-pairs</td>
<td>The double pores (one inhalent, the other exhalent) that connect the external tube-foot to the internal water vascular system.</td>
</tr>
<tr>
<td>Pores</td>
<td>A single or double perforation through ambulacral plates which connects the external tube-foot to the internal water vascular system.</td>
</tr>
<tr>
<td>Primary spines</td>
<td>The spine associated with the largest tubercle on each ambulacral or interambulacral plate.</td>
</tr>
<tr>
<td>Primary tubercle</td>
<td>A distinctly larger primary tubercle that forms at the growth centre of the plate. There is one primary tubercle to each plate.</td>
</tr>
<tr>
<td>Regular</td>
<td>Sea urchin with periproct/anal opening within ring of plates.</td>
</tr>
<tr>
<td>Scrobicular spines</td>
<td>Specialized flattened spines that form a protective pallisade around the base of primary spines and cover their muscle ring.</td>
</tr>
<tr>
<td>Scrobicular tubercles</td>
<td>A small tubercle immediately surrounding the primary tubercle and bearing a specialized flattened spine that protects the muscle of the adjacent primary spine.</td>
</tr>
<tr>
<td>Secondary spines</td>
<td>A spine attached to mammelate tubercles on ambulacral or interambulacral plates, which flank the primary spine and tubercle.</td>
</tr>
<tr>
<td>Secondary tubercles</td>
<td>A smaller tubercle flanking the primary tubercle.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shaft</td>
<td>The part of a spine that lies distal to the basal attachment.</td>
</tr>
<tr>
<td>Spines</td>
<td>An articulated appendage used for defence or locomotion.</td>
</tr>
<tr>
<td>Sternal plates</td>
<td>Plates below labrum, bearing locomotary spines.</td>
</tr>
<tr>
<td>Sub-anal fasciole</td>
<td>An ovate, bilobed or shield-shaped fasciole near the base of the posterior face beneath the periproct.</td>
</tr>
<tr>
<td>Suranal plate</td>
<td>An enlarged periproctal plate. In saleniids the suranal plate(s) form an integral part of the apical disc. In Echinoida they are present only in early development.</td>
</tr>
<tr>
<td>Sutures</td>
<td>The boundary between two adjacent abutting plates of the test.</td>
</tr>
<tr>
<td>Sutural pits</td>
<td>Deep pits usually positioned at the junction of three plate sutures on the exterior of the test.</td>
</tr>
<tr>
<td>Tag</td>
<td>A smooth, slightly elevated, tongue-like flange that borders the buccal notch and runs along the adradial margin of interambulacral plates. It supports the buccal sacks.</td>
</tr>
<tr>
<td>Test</td>
<td>Collective name for calcite plates.</td>
</tr>
<tr>
<td>Trigeminate</td>
<td>A compound ambulacral plate composed of three elements.</td>
</tr>
<tr>
<td>Tube foot</td>
<td>Water vascular structures.</td>
</tr>
<tr>
<td>Tubercles</td>
<td>A knob-like projection on the plate surface that bears a spine. Unlike granules, tubercles have a distinct mamelon on which the spine articulates.</td>
</tr>
<tr>
<td>Verticle diameter (v.d)</td>
<td>Height of the test.</td>
</tr>
</tbody>
</table>
Appendix 2:

Revised checklist of South African Echinidea species; only taxonomic changes subsequent to Clark & Courtman (1976) are documented under ‘Previous family’ and ‘Previous name’. Bolded entries represent species not reported by Clark & Courtman-Stock (1976)

<table>
<thead>
<tr>
<th>CURRENT FAMILY</th>
<th>CURRENT NAME</th>
<th>AUTHORITY</th>
<th>PREVIOUS FAMILY</th>
<th>PREVIOUS NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Histocidaridae</td>
<td>Histocidaris elegans</td>
<td>(A. Agassiz, 1879)</td>
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</tr>
<tr>
<td>2. Cidaridae</td>
<td>Eucidaris metularia</td>
<td>(Lamarck, 1816)</td>
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<tr>
<td>3. Cidaridae</td>
<td>Kionocidaris striata</td>
<td>Mortensen, 1932</td>
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<tr>
<td>4. Cidaridae</td>
<td>Phyllacanthus imperialis</td>
<td>(Lamarck, 1816)</td>
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<tr>
<td>5. Cidaridae</td>
<td>Goniocidaris indica</td>
<td>Mortensen, 1939</td>
<td></td>
<td>Gionocidaris sp</td>
</tr>
<tr>
<td>6. Cidaridae</td>
<td>Stereocidaris alcocki</td>
<td>(Anderson, 1894)</td>
<td></td>
<td></td>
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<tr>
<td>7. Cidaridae</td>
<td>Stereocidaris capensis</td>
<td>Dördelein, 1901</td>
<td></td>
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<tr>
<td>8. Cidaridae</td>
<td>Stereocidaris excavata</td>
<td>Mortensen, 1932</td>
<td></td>
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<tr>
<td>9. Cidaridae</td>
<td>Stereocidaris squamosa</td>
<td>Mortensen, 1928</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Cidaridae</td>
<td>Acanthocidaris maculicollis</td>
<td>(de Meijere, 1904)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Cidaridae</td>
<td>Plococidaris vertillata</td>
<td>(Lamarck, 1816)</td>
<td></td>
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<tr>
<td>12. Cidaridae</td>
<td>Prionocidaris pistilaris</td>
<td>(Lamarck, 1816)</td>
<td></td>
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</tr>
<tr>
<td>13. Cidaridae</td>
<td>Stylocidaris cingulata</td>
<td>Mortensen, 1932</td>
<td></td>
<td></td>
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<tr>
<td>14. Echinothuriidae</td>
<td>Araeosoma paucispinum</td>
<td>H.L. Clark, 1924</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Echinothuriidae</td>
<td>Hygrosoma petersii</td>
<td>(A. Agassiz, 1880)</td>
<td></td>
<td>Hygrosoma petersi</td>
</tr>
<tr>
<td>16. Echinothuriidae</td>
<td>Sperosoma biseriatum</td>
<td>Dördelein, 1901</td>
<td></td>
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</tr>
<tr>
<td>17. Echinothuriidae</td>
<td>Tromikosoma uranus</td>
<td>(Thomson, 1877)</td>
<td></td>
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<tr>
<td>18. Echinothuriidae</td>
<td>Phormosoma bursarium</td>
<td>A. Agassiz, 1881</td>
<td></td>
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<td>19. Echinothuriidae</td>
<td>Phormosoma placenta</td>
<td>Thomson, 1872</td>
<td></td>
<td>Phormosoma placenta</td>
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<tr>
<td></td>
<td>africana</td>
<td></td>
<td></td>
<td>africana</td>
</tr>
<tr>
<td>20. Aspidodiadematidae</td>
<td>Aspidodiadema africana</td>
<td>Mortensen, 1939</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Diademataidae</td>
<td>Astropyga radiata</td>
<td>(Leske, 1778)</td>
<td></td>
<td></td>
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<tr>
<td>22. Diademataidae</td>
<td>Chaetodiadema africana</td>
<td>H.L. Clark, 1924</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Family</td>
<td>Species</td>
<td>Authors</td>
<td></td>
</tr>
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<td>---</td>
<td>--------------</td>
<td>--------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Diadematidae</td>
<td><em>Diadema savignyi</em></td>
<td>(Audouin, 1829)</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Diadematidae</td>
<td><em>Diadema setosum</em></td>
<td>(Leske, 1778)</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Diadematidae</td>
<td><em>Echinothrix calamatus</em></td>
<td>(Pallas, 1774)</td>
<td></td>
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<tr>
<td>26.</td>
<td>Pedinidae</td>
<td><em>Caenopedia capensis</em></td>
<td>H.L. Clark, 1923</td>
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<tr>
<td>27.</td>
<td>Saleniidae</td>
<td><em>Salenia phoinissa</em></td>
<td>A. Agassiz &amp; H.L. Clark, 1908</td>
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<td>28.</td>
<td>Stomopneustidae</td>
<td><em>Stomopneustes variolaris</em></td>
<td>(Lamarck, 1816)</td>
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<tr>
<td>29.</td>
<td>Arbaciidae</td>
<td><em>Coelopleurus interruptus</em></td>
<td>Döderlein, 1910</td>
<td></td>
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<tr>
<td>30.</td>
<td>Arbaciidae</td>
<td><em>Coelopleurus maillardi</em></td>
<td>(Michelin, 1862)</td>
<td></td>
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<tr>
<td>31.</td>
<td>Arbaciidae</td>
<td><em>Tetrapygus niger</em></td>
<td>(Molina, 1782)</td>
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<td>32.</td>
<td>Temnopleuridae</td>
<td><em>Salmaciella erythracis</em></td>
<td>H.L. Clark, 1912</td>
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<tr>
<td>33.</td>
<td>Temnopleuridae</td>
<td><em>Salmacis bicolor</em></td>
<td>L. Agassiz in L. Agassiz &amp; Desor, 1846</td>
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<tr>
<td>34.</td>
<td>Temnopleuridae</td>
<td><em>Temnopleurus reevesii</em></td>
<td>(Gray, 1855)</td>
<td></td>
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<tr>
<td>35.</td>
<td>Temnopleuridae</td>
<td><em>Temnotrema siamense</em></td>
<td>(Mortensen, 1904)</td>
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<td>36.</td>
<td>Temnopleuridae</td>
<td><em>Trigonocidaris nitidus</em></td>
<td>(Döderlein, 1905)</td>
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<td>37.</td>
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<td><em>Trigonocidaris monoloni</em></td>
<td>(A. Agassiz, 1879)</td>
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<td>38.</td>
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<td><em>Dermechinus horridus</em></td>
<td>(A. Agassiz, 1879)</td>
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<td><em>Echinus gilchristi</em></td>
<td>Bell, 1904</td>
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<td><em>Polyechinus aquilhensis</em></td>
<td>(Dördelein, 1905)</td>
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<td>Echinidae</td>
<td><em>Parechinus angulosus</em></td>
<td>(Leske, 1778)</td>
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<td>42.</td>
<td>Echinometridae</td>
<td><em>Colobocentrotus (Podophora) auratus</em></td>
<td>Linnaeus, 1758</td>
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<td>43.</td>
<td>Echinometridae</td>
<td><em>Échinometra mathaei</em></td>
<td>(Blainville, 1825)</td>
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<td>Echinometridae</td>
<td><em>Echinometra oblonga</em></td>
<td>(Blainville, 1825)</td>
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<td><em>Echinostrephus molaris</em></td>
<td>(de Blainville, 1825)</td>
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<td>46.</td>
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<td><em>Toxopneustes pileolus</em></td>
<td>(Lamarck, 1816)</td>
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<td><em>Tripneustes gratilla</em></td>
<td>(Linnaeus, 1758)</td>
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<td>No.</td>
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<td>Author</td>
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<td>Echinoneidae</td>
<td><em>Echinoneus cyclostomus</em></td>
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<td>49</td>
<td>Cassidulidae</td>
<td><em>Oligopodia epigonus</em></td>
<td>v. Martens, 1865</td>
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<td><em>Tropholampas loveni</em></td>
<td>Studer, 1880</td>
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<td><em>Echinolampas</em> (Palaeolampas) crassa</td>
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<td><em>Clypeaster rarispinus</em></td>
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<td>Mazzetti, 1893</td>
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<td><em>Echinocyamus scaber</em></td>
<td>Meijere, 1902</td>
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<td><em>Eurypatagus parvituberculatus</em></td>
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<td><em>Echinocardium cordatum</em></td>
<td>Pennant, 1777</td>
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<td><em>Lovenia elongata</em></td>
<td>(Gray, 1825)</td>
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<td>Maretiidae</td>
<td><em>Spatogobrissus marabilis</em></td>
<td>H.L. Clark, 1923</td>
<td>Brissidae</td>
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<tr>
<td>67</td>
<td>Maretiidae</td>
<td><em>Gymnopatagus magnus</em></td>
<td>Agassiz &amp; H.L. Clark, 1907</td>
<td>Brissidae</td>
</tr>
<tr>
<td>68</td>
<td>Spatangidae</td>
<td><em>Spatangus capensis</em></td>
<td>Dördelein, 1905</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Schizasteridae</td>
<td><em>Brisaster capensis</em></td>
<td>Studer, 1880</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Schizasteridae</td>
<td><em>Schizaster lacunosus</em></td>
<td>Linnaeus, 1758</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 4.

Biogeographic patterns of species richness and endemicity within the South African Echinoidea.

Introduction.

The fact that the South Africa coast supports a great variety of species is generally attributed to the country's unique and highly variable marine environment. The South African marine biota is currently known to comprise at least 12 914 species (Griffiths et al., 2010), and therefore this region is ranked amongst countries that display the highest species richness per unit area; despite the fact that many invertebrate taxa in the region are still poorly studied (Costello, 2010; Griffiths et al., 2010).

South Africa has a continental coastline of 3 650 km, with an Economic Exclusive Zone (EEZ) of 1,068,659 km$^2$ and extending up to 5000 m depth (Sink et al., 2012). Although the Prince Edward Islands are politically part of the South African EEZ, they are not included in this study, as they comprise a quite separate biogeographic region. The EEZ of continental South Africa consists of two distinctive oceans, the Indian and the Atlantic, which connect at the southernmost tip of the continent. The cold Benguela Current on the west coast (Nelson & Hutchings, 1983; Shannon & Nelson, 1996) and the warm Agulhas Current on the east coast (Heydorn et al., 1978; Lutjeharms et al., 2000) result in two different ocean regimes and associated ecosystems. According to Sink et al. (2012) the disparity in productivity, dissolved oxygen and temperature between these regimes has resulted in the formation of six distinct ecoregions.

Substantial research has been undertaken on biogeographic patterns of various marine invertebrate taxa around the South African coastline. Most studies have examined individual taxa, such as the decapod crustaceans (Barnard, 1950), barnacles (Biccard, 2012), polychaetes (Day, 1967 a & b), hydroids (Millard, 1975); amphipods (Griffiths, 1976); echinoderms (Clark & Courtman-Stock 1976), isopods (Kensley, 1978), molluscs (Kilburn & Ripley, 1982), nudibranchs (Goslinger, 1987), holothurians (Thandar, 1989), octocorals, (Williams, 1992), euphausiids (Gibbons et al., 1995), ascidians (Monniot et al., 2001) and Actiniaria (Acuña & Griffiths, 2004; Laird, 2012). Some authors have also provided comparative analyses of various combined invertebrate groups (Awad et al., 2002; Griffiths et al., 2010; Scott et al.,
However, sampling has concentrated mostly on coastal and shallow waters and only a few samples are available from depths < 1000 m (Griffiths et al., 2012), which results in very limited understanding of the structure and functioning of deep water ecosystem in the region.

According to Awad et al. (2002) geographic patterns in species richness vary according to the invertebrate group being studied; where groups such as bivalves, gastropods, echinoderms and brachyurans display species richness increasing from West to East. On the contrary; taxa such as amphipods, isopods, ascidians, octocorals and polychaetes show their highest species richness on the South coast. For almost all groups endemism rates peak along the South coast, which may be a result of the region being the furthest from South African political borders, meaning that species in that region can have very wide distributional ranges but still remain endemic, as their range does not extend beyond the political borders of the country (Awad et al., 2002). Few previous studies have analyzed the biogeography of echinoderms and none specifically that of echinoids. Thandar (1989) analyzed patterns of holothurians and Awad et al. (2002) those of all the echinoderm groups combined. This chapter reports on the biogeography and depth distribution patterns of the revised South African Echinoidea fauna (as listed in Chapter 3), which includes the 20 new records (detailed in Chapter 2) and numerous distributional records not included by Awad et al. (2002). These new records therefore enable a more comprehensive and accurate analysis of distribution patterns.

**Methods**

Data considered in this study included historical data from the Iziko South African Museum (SAM) collection and from the University of Cape Town (UCT) Ecological Survey. These data were extracted from the catalogues and digitized. The unidentified samples were morphologically analyzed and identified; associated data were also added to the database. Additional data from the literature were also considered; including those of Clark & Courtman-Stock (1976), A.M. Clark (1977) Haupt et al. (2010), Maher (2012) and Olbers et al. (in press). Photographic identification data from the EchinoMap VM provided by recreational divers were also incorporated in the database for analysis, together with trawl by-catch data generously provided by the Department of Forestry and Fisheries (DAFF). All data examined are shown in the individual species distributional analyses in Chapter 3.
The above-mentioned data also assisted in collating a complete Echinoidea species checklist (see Chapter 3), which includes all known species to the South African region. Synonyms of species were resolved with the help of databases such as the World Echinoidea Database (WED), which is linked to the World Register of Marine Species (WoRMS). In addition Dr Andrea Kroh, the taxonomic editor of WED, kindly provided additional literature, which was also consulted to assist in resolving synonyms. However, in some cases literature with original descriptions was inaccessible.

Each species record was entered into ArcGis 10.1 and a shape file of the 22 different ecozones established by Sink et al. (2012) was added (Fig. 4.1) (Fig. 4.2). Ecoregion and ecozone shape-files used were kindly provided by Dr Megan Laird. The inshore (< 29 m) and offshore (30 < 3500) data were assigned different sample units, of which offshore data were too sparse to analyze, resulting in only the coastal data being analyzed.

For the inshore data, the South African coastline was divided into 29 separate 100 km segments extending from west to east coast; which correspond with those of Laird (2012) and Biccard (2012) (Fig. 4.3). Each of the 29 segments was treated as a single sample, where each unit was represented by a list of echinoids. This enabled categorization of the ecoregion each record was associated with. In cases where two ecoregions were represented in a segment, it was assigned to that ecoregion which occupied the majority of the unit. Depth information was obtained from the archive catalogues. In cases where depth data associated with a record were not available, depth was read off a bathymetric map.

Thereafter, a presence/absence matrix was compiled based on the coastal sample units. The data were then entered into the PRIMER version 6 software package (Clarke & Warwick, 2001) for multivariate analysis, to ascertain whether the biogeography of echinoids conforms with that outlined by Sink et al. (2012). The dataset was not transformed, as it consisted of absence/presence data, thus standardization was not necessary. A Bray-Curtis similarity measure was performed to produce a resemblance matrix. Then, a cluster analysis was run, and thereafter each sample was coded by ecoregion. A similarity profile test (SIMPROF) was conducted to determine which samples did not differ significantly, based on the presence/absence of various echinoid species. A Multi-Dimensional Scaling (MDS) plot was performed, to determine which spatial units clustered by ecoregion. An ANOSIM was then performed to test the significance of groups assigned by a factor (i.e. biogeography). Each
significant cluster was assigned a group and mapped in ArcGIS (Fig. 4.4) to aid in comparing the clustering with the ecoregions defined by Sink et al. (2012).

Each species was then classified as being endemic (restricted only to South African localities); non-endemic (species known to inhabit South African localities as well as other countries), or introduced (species that originate from other parts of the world and invaded South Africa as a result of human activities.
Fig. 4.1. Plot showing locations of all samples used in this study. Shading indicates the 22 ecozones established by Sink et al. (2012).
Fig. 4.2. Higher resolution plots showing coastal samples in two heavily sampled regions a. (left) False Bay and the Cape Peninsula region, b. The Sodwana Bay region (right), just south of the Mozambique border. Shading indicates the ecozones identified by Sink et al. (2012).
Fig. 4.3. The South African coast divided into 29 segments of 100 km. Section 1 was the most north-westerly section which started at the Namibian border, section 6 was at Saldanha Bay, section 9 was at False Bay, section 14 was at Mossel Bay, section 18 was at Port Elizabeth, section 20 was at East London, section 22 at Mbashe River, section 25 was at Durban, section 27 was at Richards Bay and section 29 was at the Mozambique border
Results and Discussion.

Of the species on the revised echinoid list (Chapter 3); one (Histocidaris elegans) lacks locality data and therefore only data for the remaining 70 species are included in the analysis. For ease of reference the West coast region was defined as the zone extending from the Namibian border to Cape Point, the South coast region as the zone stretching eastwards from Cape Point to Mbashe River and the East coast as the zone extending from Mbashe River northwards to the Mozambique border. Based on Sink et al. (2012) the inshore is categorized as < 29 m, deep-water (shelf) 30- 499 m, and deep-sea as > 500 m. The deep-sea can then be further categorized as upper bathyal (500-1299 m), lower bathyal (1300-3499 m), and abyss as > 3500 m.

Spatial distribution.
Species richness is highest in the East coast region, with 46 species (Fig. 4.4). The South coast region, with 25 species has the second highest species richness; and lowest species richness is in the West coast region (18 species) (Fig. 4.4). This observation is keeping in with the current understanding of echinoderm species richness increasing from the West to East coast region (Awad et al., 2002; Thandar, 1989). The endemism pattern also agrees with that of Awad et al. (2002). The South coast region has the highest endemism, with 13 species; with the West and East coasts both supporting seven endemics (Fig. 4.4.). The currently reported number of endemic echinoids is 19 species, which is lower than the 23 species reported by Thandar (1989), or the 25 by Gibbons et al. (1999). Reduction in numbers of endemics can be a result of previously endemic species being reported from Namibia or Mozambique. The number of endemics species reported in the current study is also higher than the 12 species reported by Awad et al. (2010) for all echinoderm group combined, but this could be because that Awad et al. (2010) restricted their analysis to depths less that 100m, and therefore excludes the deeper water endemics. Note also that the 20 new records added to the echinoid fauna reported in Chapter 2, were all know from adjacent countries, so do not add to the endemic fauna, in fact they reduce the proportions of endemic species. The only introduced species, Tetrapyga niger, was recorded from an oyster farm in the West coast region. This suggests that sea urchins have a low invasion profile.
Of the 70 total echinoid species, which are represented by 1452 records; 37 species are restricted to the East coast region, seven to the South coast region, and eight to the West coast region (Fig. 4.5). This high number of Indo-Pacific species roughly corresponds with the 31 species reported by Thandar (1989), however in his analysis he included species from Namibia and southern Mozambique. Therefore it is likely the 20 new records reported through this study, and the Namibian and southern Mozambique records may have largely cancelled out each other, resulting in a net gain of six species. The remaining 18 species from the 70 total have wide distribution ranges, with four species (*Parechinus angulosus*, *Echinocyamus elegans*, *Brissopsis lyrifera* and *Echinocardium cordatum*) found across the entire South African coastline, six species in both the West and South coast regions (*Echinus gilchristi, Polyechinus agulhensis, Tropholampas loveni, Echinocardium capense, Spatogobrissus marabilis* and *Spatangus capensis*), and eight in both South and East coast regions (*Stereocidaris capensis, Prionocidaris pistillaris, Salenia phionissa, Coelopleurus interruptus, Temnopluerus reevesii, Clypeaster eurychorius, Echinodiscus bisp Perezatus and Schizaster lacunosus*). The wide distribution range portrayed by these species suggests that echinoids are adapted to withstand variable conditions.
The trend of increasing species richness from the West to East coast, presented in this study, corresponds with the similar pattern shown by Clark & Courtman-Stock (1976) (Fig. 4.5). The observed doubling of species richness along the East coast region found in the current study is a result of the 20 additional records (see Chapter 2) to the echinoid fauna added here, most of which are from the East coast. The majority of these additions (85 %) are well-known Indo-Pacific species first reported here from just inside South Africa, therefore doubling the number of species recorded in the East coast region since Clark & Courtman-Stock (1976) (Fig. 4.5).

![Graph showing species richness in different regions](image)

**Fig. 4.5.** Number of species found in each region, where red represents species reported by Clark & Courtman-Stock (1976) and blue the current study.

Despite the increase of species richness from west to east, presented in the current study it is important to note that the East Coast region has relatively fewer distributional records (298) as compared to either the South (679), or the West (598 records) coasts (Fig. 4.6). This is a result of biased sampling across the three regions. The two regions showing highest records, the South and West coast, support the majority of South Africa’s fishing resources, so have been subject of more intense sampling effort by government agencies responsible for fisheries management; as compared to the East coast region, which showed the lowest number of
records and supports few commercial resources. Its should, however, be noted that number of locality records cannot be directly related to sampling effort, since ‘negative records’ (samples taken that do not include any echinoids) are not recorded, while single samples in species rich areas might result in several separate locality records of different species. The different lengths of each region may also contribute to the different number of records associated with each region; where the West coast is 800 km, the South coast is 1 400 km and the shortest at the East coast- 700 km.

![Fig. 4.6. Number of records found in each region of the current study.](image)

**Sampling intensity.**

Many South African echinoid species are known from relatively few records; for example, 14 species are known from just a single record and 12 species from only two. On the other end of the scale only four species are known from over 100 records (Fig. 4.7). Nonetheless, the three species- *Echinus gilchristi, Spatangus capensis and Brissopsis lyrifera* representing the 75 % are also found in shallow waters (< 29 m). The ability of these species to have a wide depth range could be an explanation of the high number of records. This observation is of great interest and concern as it highlights the severe under sampling of the class and likelihood of further species turning up if additional samples are taken, particularly in deeper waters.
Inshore data

Data for inshore (< 29 m) echinoids was quite patchy and therefore I used the same method as earlier authors (Awad et al., 2002, Scott et al., 2012) of assuming that species reported irregularly along the coastline, in fact have a continuous distribution between the most widely spaced records i.e. if a species was recorded in segment 1 and 9, then it was assumed that species also occurred in segments 2-8 (Awad et al., 2002; Scott et al., 2012). Only 28 species out of the total of 71 species were found in waters < 29 m depth.

The ANISOM revealed that the Southern Benguela ecoregion differed significantly from the Agulhas ecoregion (R= 0.84, P= 0.001); the Natal ecoregion (R= 0.979, P= 0.001); and the Delagoa ecoregion (R= 0.998, P= 0.018). The Agulhus ecoregion was also significantly different from the Natal ecoregion (R= 0.851, P= 0.001); and the Delagoa ecoregion (R= 1.000, P= 0.01). The Natal and Delagoa ecoregions also significantly differed from one another (R= 0.855; P= 0.048).

The SIMPER results show that highest dissimilarity was between the Southern Benguela and Delagoa ecoregions (average dissimiliarity of 92.88 %), with Clypeaster rarispinus, Coelopleurus maillardi, Diadema savignyi, Diadema setosum, Echinothrix calamaris and
*Eucidaris metalaria* each contributing 9.18%. The lowest dissimilarity was between Natal and Delagoa ecoregions (average dissimilarity of 59.04 %), with *Clypeaster rarispinus, Coelopleurus maillardi*, *Diadema setosum* and *Schizaster lacunosus* each contributing 9.33%; and *Echinostrephus molaris* and *Tripneustes gratilla* each contributing 7.44%.

The significant clusters of the sample segments are shown below by the red lines (Fig. 4.8). Five significant groups are produced at a 55 % level of similarity. This is further displayed by the MDS plot, which also produced five significant groups at a 55 % significant level (Fig. 4.9). Group A, coded blue, consists of samples from the Southern Benguela; group B (grey) comprises samples from the Southern Benguela, group C (green) samples from both the Agulhas and Natal ecoregion; group D (yellow) samples from the Natal ecoregions; and group E (red) samples from the Delagoa ecoregion. These five groups were then mapped in ArcGIS to ascertain whether echinoids do indeed fall in the ecoregions demarcated by Sink *et al.* (2012) (Fig. 4.10).

![Fig. 4.8. Cluster analysis with bioregions added as a factor. Significant clusters denoted by red lines. The analysis was performed using a Bray-Curtis similarity measure on untransformed data. Significant clusters were assigned names in ArcGIS (Fig.9).]
Fig. 4.9. Multi-dimensional Scaling (MDS) plot with ecoregions added as a factor and similarity levels indicated by circles. The analysis was performed using a Bray-Curtis similarity measure on untransformed data.

Results from the multivariate analysis revealed that the coastal assemblage of echinoids closely conforms to the biogeographic pattern established by Sink *et al.* (2012). The two exceptions to this were i) that the west coast Southern Benguela ecoregion was divided into two separate groups; and ii) the Agulhas and Natal ecoregions shared some species and therefore combined as significant group (Fig. 4.10 and 4.11). The key species that contributed to the separation of the Southern Benguela are *Echinocyamus elegans* and *Echinocardium cordatum*, which were both absent in the northern West coast (segments 1-5), but present in the southern West coast (6-9). It is rather surprising that these species were not present in the northern West coast, as they have a wide distribution range (see Chapter 3: Figs 3.116 & 3.130) and therefore this may be a result of biased sampling. However, Emanuel *et al.* (1992) also observed a split of the west coast, but rather at an 80 % level of similarity, than at a 55 % level as in current study. Another interesting outcome is the grouping of samples from the Agulhus ecoregion with some from the Natal ecoregion, where *Parechinus angulosus, Tripneustes gratilla, Echinocardium cordatum* and *Echinocyamus elegans*, were the key species found in all segments (10-25). These species all have a wide distribution and are able to survive in a very variable environments and are therefore poor indicators of biogeographic division.
Fig. 4.10. Significant groups (from Figs 8 & 9) mapped in ArcGIS.
The number of species recorded in each 100 km segment may have also influenced the significant grouping (Fig. 4.11). Segments 1-5 had *Parechinus angulosus* as the only record in each segment; segment 1 being an exception with two records, *Parechinus angulosus* and the only introduced species *Tetrapygys niger*. A general increase in species richness was then observed from segment 6 (with two species) to segment 15 (eight species). Thereafter, there is a general decrease in trend of species richness, with a minimum of four species in segment 22. The drop in species richness in segment 22 may be attributed to biased sampling, or possibly due to this region (Mbashe River) being a transitional zone between the Agulhas and Natal ecoregions (Albertus *et al.*, 2013). Following this, the species richness generally again increases towards the Mozambique border, with an anomalously high value in segment 26 (16 species). This may be a product of high sampling efforts by the *Meiring Naudé* (Louw, 1977; Louw, 1980). Endemism peaked in segments 10-15, which represent the Agulhas ecoregion. No endemism was observed in segments 1-8, 17, and 19-25. Close to the Mozambique border (26-29) a very low level of endemism was observed. Endemism was expected to peak in the Agulhas ecoregion (South coast) as it is furthest from the political borders (Awad *et al.*, 2002)

![Figure 4.11](image.png)

Fig. 4.11. Number of inshore species found in each 100 km segment according to the four ecoregions established by Sink *et al.* (2012): Southern Benguela (West coast), Agulhas ecoregion (South coast); and the Natal and Delagoa ecoregion (East coast). The status of each species indicated by shading: endemic (red), non-endemic (green); and introduced (purple).
Offshore data.
The offshore data (> 30 m) were too patchy and sparse for analysis on a fine scale, such as degree cells, which contained a low number of species each. The 57 offshore species records were thus simply allocated to the six ecoregions described by Sink et al. (2010) (Fig. 4.12). A general increase in species richness from west to east was observed. The Southwest Indian had the highest number of species (39), with five endemic and 35 non-endemic species. The lowest species richness was found in the Southeast Atlantic ecoregion (10), with three endemics and seven non-endemics. As expected, the Agulhas ecoregion displayed the highest endemism; representing 11 of the 19 recognized endemic species known from South African waters.

![Ecoregions](image)

Fig. 4.12. Number of species found in each of the deep offshore ecoregions as described by Sink et al. (2012): Southern Benguela (SB) and Southeast Atlantic (SA) ecoregions; the Agulhas ecoregion (A); the Natal (N); the Delagoa (D) ecoregion; and the Southwest Indian Ocean (SW) ecoregions. The status of each species indicated by shading; endemic (red), non-endemic (green); no deepwater species are introduced.
Fig. 4.13 shows the number of species found in each of the different depth categories, where deep-water is represented by 30-499 m, upper bathyl by 500-1299 m, lower bathyl by 1300-3499 m, and abyssal by > 3500m. No species were recorded in the lower bathyl (1300-3499 m), and in the abyssal (> 3500 m) of the Delagoa, Natal, and Southwest Indian Ocean ecoregions. The East coast region is generally known to have a narrow continental shelf and trawl surveys usually take place in the Tugela Bank, as reefs dominate this region. As a result deeper waters in these regions still remain severely under-sampled.

![Graph showing species distribution across different depths and ecoregions](image)

**Ecoregions**

Fig. 4.13. Number of species recorded in each depth category; where deep-water (30-499 m) is represented by blue, upper bathyl (500-1299 m) by red, lower bathyl (1300-3499 m) by green, and abyssal (> 3500 m) by purple.

**Depth distributions**

The inshore (< 29 m) zone was represented by 22 species, of which five were restricted to that zone and 17 non-restricted. Deep-water (30-499 m) was represented by the highest number of species (74), with 16 restricted species to this depth range and 58 non-restricted species (Fig. 4.14). The upper bathyal (500-1299 m) depth category was represented by four
restricted species and 28 non-restricted ones; and the lower bathyal by 11 species, all being non-restricted. Only one species was recorded in the abyss category and it was a non-restricted species. These data illustrate that echinoids have a wide depth range and therefore only a few species are depth-restricted (Fig. 4.26).

Fig. 4.14 shows the depth distributions of each of the 70 species of South African echinoid fauna arranged in order of increasing depth penetration. Twenty-eight of the total 71 species, including the new records (see Chapter 2) are found in waters > 500 m (Fig. 4.15).

![Graph showing depth distributions of species](image)

Fig. 4.14. Number of species recorded in each depth category demarcated by Sink et al. (2012); where IN= Inshore, DW= Deep-water, UB= Upper bathyl, LU= Lower bathyl, and A= Abyss. Species restricted to certain a depth range is coded red, and non-recorded species coded blue.
Fig. 4.15. Depth ranges for all 71 South African echinoid species. Species on y-axis arranged shallow to deep sea, depth range on x-axis.
In conclusion, echinoids show the general invertebrate trend of increasing species richness from west to east, and endemism patterns peaking in the south coast; as in bivalves, gastropods and brachyurans (Thandar, 1989; Awad et al., 2002). The current echinoid endemism of 27.14 % is lower than the 39 % reported on by Thandar (1989) and the 42.37 % by Gibbons (1999); which may be a result of the class Echinoidea being revised for the first time, separately; and elimination of Namibia and southern Mozambique records in the case of Thandar's (1989) results. However, the high endemism observed by Gibbon et al. (1999) is rather surprising, as he investigated the South African marine fauna; and therefore this may have been an error.

Although the 20 new records are mostly of broad Indo-Pacific origin and most were found just across the Mozambique border in northern KwaZulu-Natal, they greatly increased the number of species reported from that area. It is important to note, though, that the East coast region is still severely under-sampled, especially in deeper waters and therefore future sampling should concentrate on this region. Deep-seas throughout the region are also another area of concern; and as indicated deep-sea species are represented by 39.4 % and are mostly known from less then four records.
Chapter 5

References


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