

# **BRITTLE STARS OF THE SOUTH-EASTERN ARABIAN SEA**

**USHA V. PARAMESWARAN & N. SARAVANANE**



**Centre for Marine Living Resources & Ecology  
Ministry of Earth Sciences  
July 2021**

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सत्यमेव जयते

**Centre for Marine Living Resources and Ecology  
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**JULY 2021**



डॉ. जी वी एम गुप्ता  
निदेशक  
Dr. G.V.M. Gupta  
DIRECTOR



भारत सरकार  
पृथ्वी विज्ञान मंत्रालय  
समुद्री सजीव संसाधन एवं पारिस्थितिकी केंद्र  
GOVERNMENT OF INDIA  
MINISTRY OF EARTH SCIENCES  
CENTRE FOR MARINE LIVING RESOURCES AND ECOLOGY



## FOREWORD

First Integrated World Ocean Assessment, 2016 under the auspicious of the UN General Assembly stress the importance of taxonomy, systematics, and studies of biodiversity to advance our knowledge of ecology, ecosystem-based management, and understanding/ valuation of ecosystem services. These are especially needed with increasing extinction rates, continued anthropogenic pressures on biodiversity, and the consequences of human-induced climate change. In this sense, biogeographic information about different species is of fundamental importance for discovering marine biodiversity hotspots, detecting and understanding impacts of environmental changes, predicting future distributions, monitoring biodiversity, or supporting conservation and sustainable management strategies.

Among the wide variety of life forms that live in the oceans, the echinoderms (Phylum Echinodermata) which comprise the sea stars and allied organisms, are the most recognizable. Around 700 species of echinoderms are reported from the Indian waters. Among these, the brittle stars, belonging to the class Ophiuroidea are the most widely distributed and species-rich, with about 190 species. The present book "Brittle Stars of the South-eastern Arabian Sea" provides a succinct taxonomic account of all the brittle stars thus far reported from the region. This would also serve as a ready reference for any researchers who are interested in these organisms. I laud the team members of the project Resource Exploration and Inventorization System who have put in great efforts to document brittle star diversity of the Indian seas, not only through field surveys but also by comprehensively compiling historic biodiversity records. It provides a glimpse into the rich biodiversity of Indian seas and remains invaluable reference material to marine biologists seeking to identify and document this diversity.

GVM Gupta  
Director



## **PREFACE**

This is a contribution of the Marine Living Resources Program of the Ministry of Earth Sciences, Govt. of India, prepared as part of the project Resource Exploration and Inventorization System implemented at the Centre for Marine Living Resources & Ecology, Kochi. The catalogue lists the brittle star species collected from the surveys of Fishery Oceanographic Research Vessel *Sagar Sampada* between 2008 and 2019 in the South-eastern Arabian Sea. A total of 32 species, in 24 genera and 15 families are included in this catalogue. Of these, the majority (22 species) are shallow-water species, collected at depths <200 m, while 10 are deep-sea species. The species are arranged according to the latest classification of O'Hara et al. (2018), the collection details are listed and a brief description is also provided. All descriptions are accompanied with photographs of first the dorsal and next the ventral side of the brittle star disc, which together show the key taxonomic characters. The specimens are archived at the FORV Referral Centre, CMLRE, Kochi, India.



## ACKNOWLEDGEMENTS

The support and encouragement of Dr. M. Rajeevan Nair, Secretary, Ministry of Earth Sciences, Govt. of India is gratefully acknowledged with deepest gratitude. The authors wish to thank Dr. G. V. M. Gupta, Director, CMLRE and former Directors Dr. M. V. Ramanamurthy, Dr. M. Sudhakar, Dr. P. Madeswaran and Dr. V. N. Sanjeevan who constantly supported the Resource Exploration and Inventorization program which enabled us to implement the biodiversity surveys and carry out the documentation work. The support rendered by Dr. Sherine Sonia Cubelio, (Scientist E & Theme Leader, Biodiversity & Ecology Program), Dr. Anil Kumar Vijayan (Scientist E) and Dr. Hashim M (Scientist D) who whole heartedly supported the biodiversity documentation of marine benthos are acknowledged with appreciation. The help and constant support provided by the marine benthos team, particularly Dr. Abdul Jaleel K. U. (CSIR-National Institute of Oceanography) and Dr. Aiswarya Gopal (CMLRE) are gratefully acknowledged. We thank the on-board staff and cruise teams of FORV *Sagar Sampada* is acknowledged with due credits for their untiring help rendered during sample collection.





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## **I. AN INTRODUCTION TO BRITTLE STARS**

Echinoderms, such as starfish, brittle stars, sea urchins, sea cucumbers and sea lilies represent a distinct phylum (Phylum Echinodermata) of exclusively marine invertebrates closely related to chordates. Echinoderms, owing to their relatively large size among the sea-floor fauna (benthos) and their diverse feeding habits, are important members of marine food webs.

The brittle stars (Class Ophiuroidea), are the major species rich groups among the echinoderms, which are ecologically important components of the seafloor. There are about 2100 recognised species of brittle stars, which are distributed across all oceans at all depths. Brittle stars are diverse in their feeding modes – from active predation and scavenging, to detritivory and suspension feeding. Like all echinoderms, the endoskeleton of brittle stars is composed of a complex assemblage of calcium carbonate (calcite) ossicles. During their 480-million-year evolution, this group has been affected by major extinction events (e.g. the end-Permian event 250 ma) and it has an excellent fossil record, most frequently as dissociated ossicles. The long evolutionary history of brittle stars, as well as their wide geographic and bathymetric distribution, along make them ideal model organisms to understand patterns of historic faunal turnovers during evolution. In recent years, long standing assumptions about brittle star taxonomy were proven to be incongruous with their phylogeny. Robust molecular analyses from across the brittle star tree of life has led to the suggestion of a new phylogeny, and a new higher classification for the brittle stars. Over 2100 species of ophiuroids, falling in 256 genera and

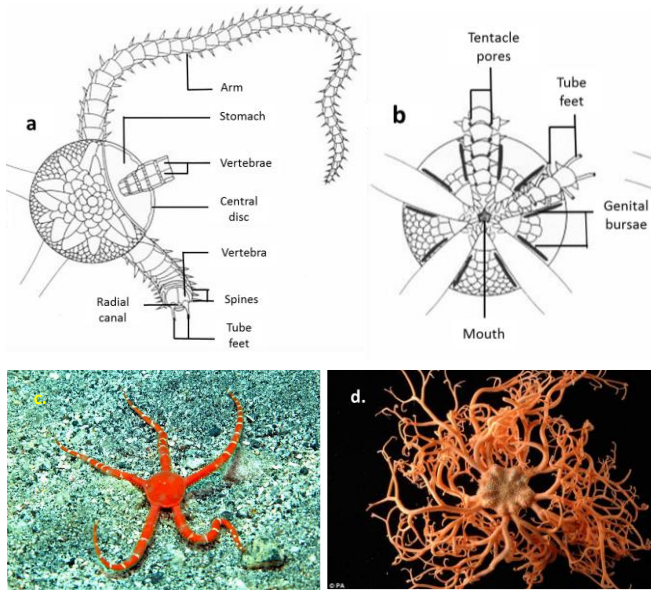
33 families are currently recorded, out of which about 160 species are reported from India.

Brittle stars, like other echinoderms, are highly vulnerable to natural as well as anthropogenic disturbances such as oxygen depletion, climate variability, bottom trawling and other exploitative activities. Many species of echinoderms, particularly amongst the sea urchins and brittle stars have appealing ornamentation and brilliant colour patterns and are widely exploited for use in marine aquaria. Climate variability and the increasing spread of hypoxic conditions in near bottom waters also pose serious threats to echinoderms, as they are known to be highly susceptible to oxygen depleted conditions. Taking these aspects into consideration, documenting the systematics, diversity, distribution and ecology of these organisms is of critical importance.

## **II. MORPHOLOGY AND IDENTIFICATION OF BRITTLE STARS**

Like all echinoderms, brittle stars have a pentamerous radial symmetry. Their body consists of a central disc, with five (sometimes 6-7) radiating arms. The dorsal and ventral surfaces of the disc are covered by skin, usually embedded with scales or plates. The mouth is ventral and armed with five jaws, each with different kinds of shields, plates, papillae and teeth (Figure 1). The arms are covered by a series of dorsal, ventral and lateral plates, which have arm spines and series of tube-feet projecting from them. The basket-stars (Figure 1) are distinguished by their characteristic branching arms, while brittle stars have simple arms. The structure of the jaw apparatus, the nature of the plates on the disc and arms as well as the numbers and shapes of the

arm spines are the key taxonomic characters among the Ophiuroidea. More recently, some new morphological



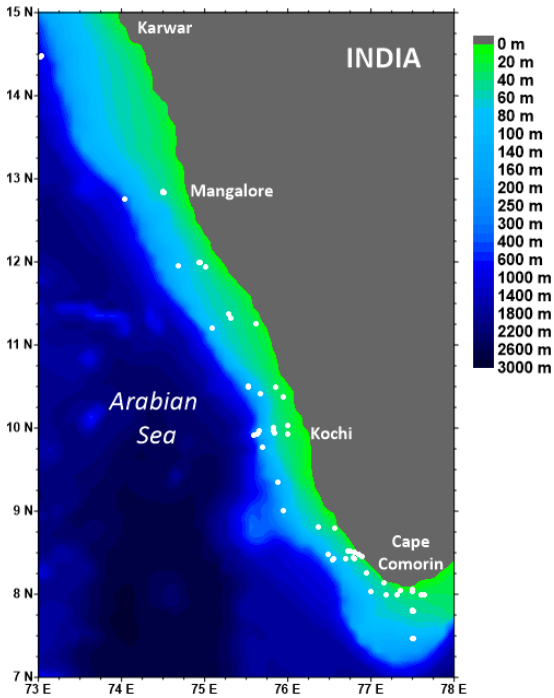
**Figure 1.** Class Ophiuroidea. a. general body plan, oral side, b. general body plan, aboral side, c. brittle star, d. basket star. [Image sources: [www.geo.arizona.edu](http://www.geo.arizona.edu), [islandtimedivers.blogspot.in](http://islandtimedivers.blogspot.in), [thetruthbehindthescenes.wordpress.com](http://thetruthbehindthescenes.wordpress.com)]

characteristics, particularly the articulation sockets of the arm spines on the lateral arm plates, are being used as key characters at family levels which have helped to resolve some taxonomic uncertainties.

### III. STUDY AREA

The study area is located on the continental margin (20 to ~1500m depth zone) off the south-west coast of India (7°-15° N, 73° -78° E), in the South-eastern Arabian Sea (SEAS). Within

the northern Indian Ocean, the South-eastern Arabian Sea (SEAS) is a region with distinctive oceanographic and biological features. It represents a typical Eastern Boundary Upwelling System (EBUS), with moderate to intense coastal upwelling and enhanced biological production during the Summer Monsoon (SM) season (June to September). Intense sub-surface hypoxia is reported in the SEAS during the SM, which effects the distribution of benthic fauna, especially echinoderms. The samples for this catalogue were collected from various locations (Figure 2) in the SEAS using Smith-McIntyre grab, modified naturalist dredge and demersal trawls.



**Figure 2.** Map of south-eastern Arabian Sea showing sampling locations.

#### IV. COLLECTING AND PRESERVING BRITTLE STARS

Brittle stars are epibenthic and cryptobenthic fauna, which live on the surface of sediments or in crevices of rocks etc. In shallow, intertidal depths, they can be collected by hand-picking or using forceps. Care should be taken while picking them as their arms are delicate and tend to break easily. Ideally, the organism must be handled by the central disc portion as much as possible. Beyond intertidal depths, brittle stars can be collected using sediment or bottom sampling gears like grabs, box corers, dredges and trawl nets. As their endoskeletons are made of calcium carbonate, echinoderms including brittle stars, must not be preserved in formaldehyde. The low pH of such preservatives will lead to dissolution of ossicles, which are crucial for species identification. The ideal preservative for brittle stars is 100% ethanol. Prior to preservation, they may also be narcotised with magnesium chloride or menthol.

All specimens described in this catalogue were collected during biodiversity surveys of Fishery Oceanographic Research Vessel *Sagar Sampada* (FORVSS) using a modified naturalist dredge, a Smith-McIntyre grab or a high-speed demersal trawl (crustacean version) net. They were preserved in ethanol. Specimens were photographed using a LEICA (M80) Stereo-zoom microscope fitted with a LEICA (MC170 HD) camera. Taxonomic identification of the shallow-water (up to ~200 m) echinoderms was carried out primarily using the key of Clark & Rowe (1971). Other relevant taxonomic publications such as Koehler (1898, 1910), Koehler & Vaney (1905), H. L. Clark (1909), Fell (1960), A. M. Clark (1968, 1970), James (1970, 1982) and Cherbonnier & Guille (1978) were also used. Deep-sea echinoderms were identified by following the results of the



RIMS *Investigator* and other Indo-Pacific expeditions (Alcock 1893, Wood-Mason & Alcock 1891, Koehler 1897, 1899, 1904, 1922, 1930) and more recent taxonomic works (Madsen 1973, O'Hara & Stöhr 2006 etc.). The status and validity of all taxa were checked and updated using the World Register of Marine Species (WoRMS Editorial Board 2021).

**V. CLASSIFICATION OF BRITTLE STARS OF THE  
SOUTH-EASTERN ARABIAN SEA**

**Phylum Echinodermata Bruguière, 1791 [ex Klein, 1734]**

**Class Ophiuroidea Gray, 1840**

**Order Amphilepidida O'Hara, Hugall, Thuy, Stöhr &  
Martynov, 2017**

**Family Amphiuridae Ljungman, 1867**

**Genus *Amphioplus* Verrill, 1899**

1. *Amphioplus (Lymanella) depressus* (Ljungman, 1867)

**Genus *Amphipholis* Ljungman, 1866**

2. *Amphipholis misera* (Koehler, 1899)

**Genus *Amphiura* Forbes, 1843**

3. *Amphiura (Amphiura) ambigua* Koehler, 1905
4. *Amphiura (Amphiura) constricta* Lyman, 1879
5. *Amphiura (Amphiura) duncani* Lyman, 1882
6. *Amphiura (Amphiura) micra* H.L. Clark, 1938
7. *Amphiura (Fellaria) heptacantha* (Mortensen, 1940)

**Genus *Dougaloplus* A.M. Clark, 1970**

8. *Dougaloplus echinatus* (Ljungman, 1867)

**Genus *Ophiodaphne* Koehler, 1930**

9. *Ophiodaphne scripta* (Koehler, 1904)

**Genus *Ophiosphaera* Brock, 1888**

10. *Ophiosphaera insignis* Brock, 1888

**Family Ophionereididae Ljungman, 1867**

**Genus *Ophiochiton* Lyman, 1878**

11. *Ophiochiton ambulator* Koehler, 1897

**Family Ophiopsilidae Matsumoto, 1915**

**Genus *Ophiopsila* Forbes, 1843**

12. *Ophiopsila pantherina* Koehler, 1898

**Family Ophiothamnidae O'Hara, Stöhr, Hugall, Thuy &  
Martynov, 2018**

**Genus *Histampica* A.M. Clark, 1970**

13. *Histampica duplicata* (Lyman, 1875)

**Family Ophiotrichidae Ljungman, 1867**

**Genus *Ophiocnemis* Müller & Troschel, 1842**

14. *Ophiocnemis marmorata* (Lamarck, 1816)

**Genus *Ophiopteron* Ludwig, 1888**

15. *Ophiopteron elegans* Ludwig, 1888

**Genus *Ophiothrix* Müller & Troschel, 1840**

16. *Ophiothrix (Acanthophiothrix) proteus* Koehler, 1905  
17. *Ophiothrix (Acanthophiothrix) purpurea* von Martens, 1867  
18. *Ophiothrix (Ophiothrix) aristulata* Lyman, 1879  
19. *Ophiothrix (Ophiothrix) foveolata* Marktanner-Turneretscher, 1887  
20. *Ophiothrix (Ophiothrix) savignyi* (Müller & Troschel, 1842)

**Order Euryalida Lamarck, 1816**

**Family Asteronychidae Ljungman, 1867**

**Genus *Asteronyx* Müller & Troschel, 1842**

21. *Asteronyx loveni* Müller & Troschel, 1842

**Family Euryalidae Gray, 1840**

**Genus *Asteroschema* Örstedt & Lütken in Lütken, 1856**

22. *Asteroschema sampadae* Parameswaran & Jaleel, 2012

**Family Gorgonocephalidae Ljungman, 1867**

**Genus *Astrothorax* Döderlein, 1911**

23. *Astrothorax waitei* (Benham, 1909)

**Order Ophiacanthida O'Hara, Hugall, Thuy, Stöhr & Martynov, 2017**

**Family Ophiacanthidae Ljungman, 1867**

**Genus *Ophiacantha* Müller & Troschel, 1842**

24. *Ophiacantha dallassi* Duncan, 1879

**Genus *Ophiomoeris* Koehler, 1904**

25. *Ophiomoeris tenera* (Koehler, 1897)

**Family Ophiocomidae Ljungman, 1867**

**Genus *Breviturma* Stöhr, Boissin & Hoareau, 2013**

26. *Breviturma brevipes* (Peters, 1851)

**Family Ophiodermatidae Ljungman, 1867**

**Genus *Bathypectinura* H.L. Clark, 1909**

27. *Bathypectinura heros* (Lyman, 1879)

**Genus *Ophiarachnella* Ljungman, 1872**

28. *Ophiarachnella infernalis* (Müller & Troschel, 1842)

**Family Ophiomyxidae Ljungman, 1867**

**Genus *Ophioconis* Lütken, 1869**

29. *Ophioconis cupida* Koehler, 1905

**Family Ophiotomidae Paterson, 1985**

**Genus *Ophiotreta* Verrill, 1899**

30. *Ophiotreta stimulea* (Lyman, 1878)

**Order Ophiurida Müller & Troschel, 1840 sensu O'Hara et al., 2017**

**Family Ophiopyrgidae Perrier, 1893**

**Genus *Amphiophiura* Matsumoto, 1915**

31. *Amphiophiura sordida* (Koehler, 1897)

**Family Ophiuridae Müller & Troschel, 1840**

**Genus *Ophiuroglypha* Hertz, 1927**

32. *Ophiuroglypha kinbergi* (Ljungman, 1866)

## VI. DESCRIPTIVE ACCOUNT OF THE BRITTLE STARS OF THE SOUTH-EASTERN ARABIAN SEA

### 1. *Amphiplus (Lymanella) depressus* (Ljungman, 1867)

**Collection locations: Cape Comorin-Mangalore, 24-100 m.**  
CAPE COMORIN – 8° 3.411' N, 77° 29.811' E, 24 m, 16.5.2010 (FORVSS 275, St. 15). – 7° 48.582' N, 77° 29.613' E, 51 m, 16.5.2010 (FORVSS 275, St. 17). – 7° 48.108' N, 77° 30.703' E, 53 m, 8.9.2013 (FORVSS 319, St. 6). TRIVANDRUM – 8° 30' N, 76° 48' E, 50 m, 31.8.2011 (FORVSS 289, St. 20). – 8° 30' N, 76° 48' E, 52 m, 6.9.2011 (FORVSS 289, St. 45). – 8° 30' N, 76° 48' E, 52 m, 7.9.2011 (FORVSS 289, St. 49). – 8° 30' N, 76° 48' E, 51 m, 8.9.2011 (FORVSS 289, St. 53). – 8° 25.448' N, 76° 33.084' E, 84 m, 16.7.2013 (FORVSS 316, St. 5). – 8° 28.562' N, 76° 51.5' E, 37 m, 11.9.2013 (FORVSS 319, St. 10). KOLLAM – 8° 48.02' N, 76° 33.58' E, 33 m, 25.10.2014 (FORVSS 330, St. 79). – 8° 48.19' N, 76° 22.33' E, 52 m, 25.10.2014 (FORVSS 330, St. 80). KOCHI – 9° 56.395' N, 75° 38.305' E, 98 m, 13.6.2009 (FORVSS 267II, St. 22). – 9° 58.353' N, 75° 49.661' E, 54 m, 30.7.2013 (FORVSS 317, St. 2). – 9° 58.138' N, 75° 39.155' E, 100 m, 31.7.2013 (FORVSS 317, St. 3). – 10° 22.53' N, 75° 56.676' E, 30 m, 2.8.2013 (FORVSS 317, St. 9). – 10° 29.82' N, 75° 51.4' E, 30 m, 12.10.2014 (FORVSS 330, St. 28). – 12° 49.75' N, 74° 30.35' E, 52 m, 15.12.2014 (FORVSS 333, St. 8). CALICUT – 11° 22.7' N, 75° 17.71' E, 53 m, 9.10.2014 (FORVSS 330, St. 16). KANNUR – 11° 59.407' N, 74° 56.339' E, 53 m, 8.8.2013 (FORVSS 317, St. 14). – 11° 59.52' N, 74° 57.18' E, 52 m, 8.10.2014 (FORVSS 330, St. 13). MANGALORE – 12° 51.02' N, 74° 29.71' E, 53 m, 27.9.2014 (FORVSS 329, St. 33). – 12° 50.32' N, 47° 30.26' E, 51 m, 4.10.2014 (FORVSS 330, St. 2). Naturalist dredge and Smith-McIntyre grab.

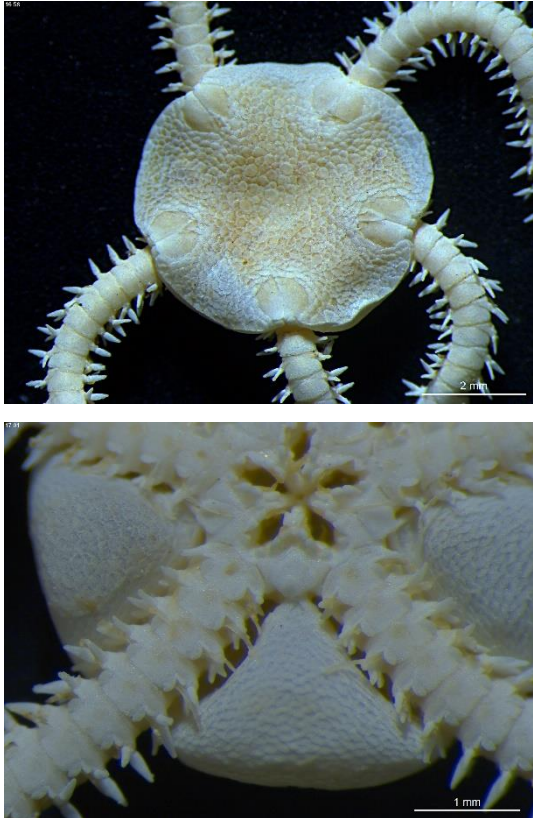
**Voucher specimen No.:** CMLRE IO/SS/ECD/00088, 00135, 00202

**Diagnosis:** Disc diameter 3-5 mm, arms about 10 times this length. Disc covered uniformly with small scales on dorsal and ventral side, primary rosette discernible in some smaller (juvenile) specimens; a well demarcated marginal row of scales thickened scales around the disc, though not conspicuously projecting; radial shields contiguous except at the proximal end, just longer than wide, less than half the disc radius. Oral shield diamond shaped; four contiguous, scale-like oral papillae, capable of closing over the jaw completely, the third one the largest. Two tentacle scales, three arm spines throughout. Colour white.

**Substratum:** Sandy, silty and clayey sediments.

**Distribution:** Madagascar, Pakistan, India, Australia, Malaysia, China, Philippines, Papua New Guinea, Vanuatu.

**Remarks:** *Amphiura relict* Koehler, 1898 reported from Indian waters is a synonym (Liao, 2004).



**Figure 3.** *Amphioplus (Lymanella) depressus* (Ljungman, 1867). Disc and arm base, dorsal and ventral view.

## 2. *Amphipholis misera* (Koehler, 1899)

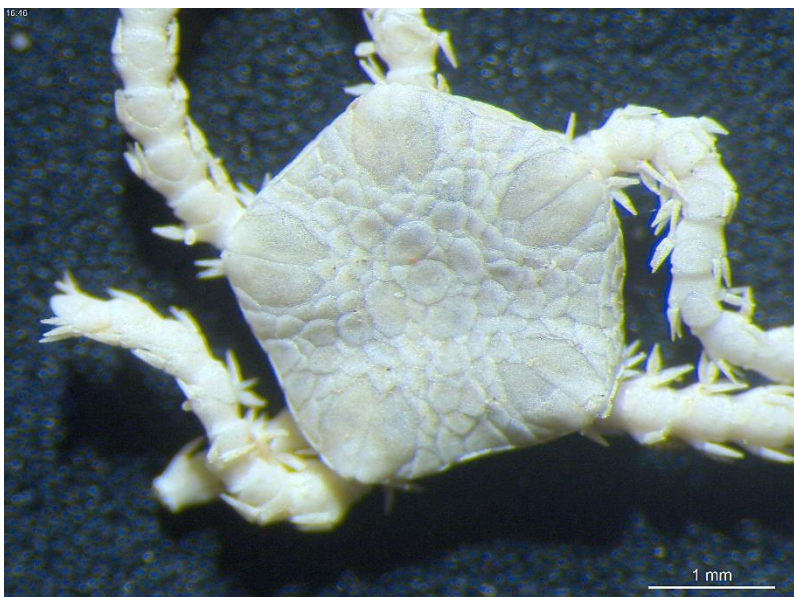
**Collection locations:** Cape Comorin-Kochi, 51-116 m. CAPE COMORIN – 7° 47.649' N, 77° 30.26' E, 52 m, 30.5.2009 (FORVSS 267I, St. 2). TRIVANDRUM – 8° 30' N, 76° 48' E, 51 m, 4.9.2011 (FORVSS 289, St. 38). – 8° 30' N, 76° 48' E, 53 m, 8.9.2011 (FORVSS 289, St. 52). – 8° 30' N, 76° 48' E, 51 m, 8.9.2011 (FORVSS 289, St. 53). KOCHI – 9° 54.546' N, 75° 35.493' E, 116 m, 13.5.2010 (FORVSS 275, St. 2). – 10° 29.57' N, 75° 31.7' E, 88 m, 12.10.2014 (FORVSS 330, St. 26). Naturalist dredge and Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00089, 00271

**Diagnosis:** Disc diameter 2-4 mm, composed of small plates, primary rosette always distinct. Oral shields spear-head shaped, longer than wide, 3 contiguous oral papillae, outer-most operculiform, about twice as wide as the second. Two flat tentacle scales. Colour white.

**Substratum:** Sandy and silty sediments.

**Distribution:** India, Indonesia, Australia, Philippines.



**Figure 4.** *Amphipholis misera* (Koehler, 1899). Disc and arm base, dorsal and ventral view.



### 3. *Amphiura (Amphiura) ambigua* Koehler, 1905

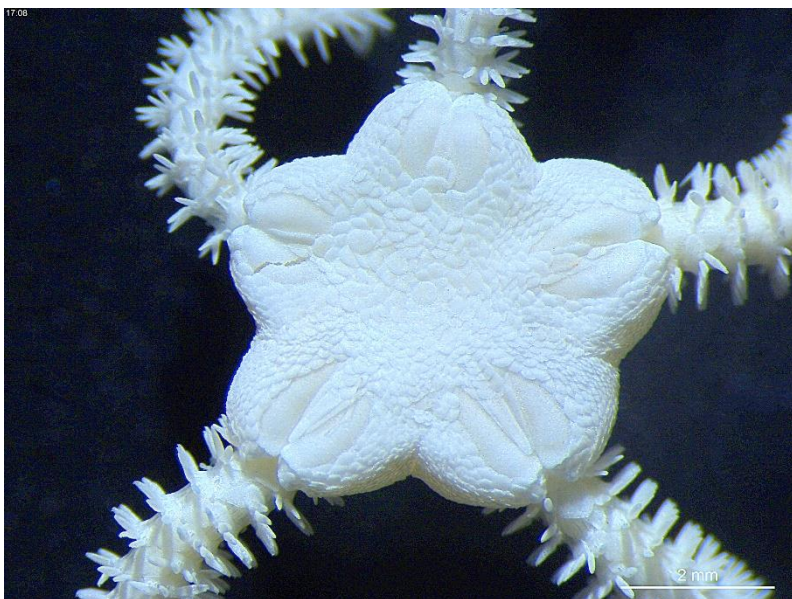
**Collection locations: Cape Comorin, 32-100 m.** CAPE COMORIN – 8° 3' N, 77° 21' E, 32 m, 5.8.2005 (FORVSS 236, St. 21). – 7° 59.264' N, 77° 36.646' E, 32 m, 18.8.2009 (FORVSS 270II, St. 19). – 7° 27.925' N, 77° 31.141' E, 100 m, 16.5.2010 (FORVSS 275, St. 18). Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00090

**Diagnosis:** Disc diameter 2-4 mm, arms about 7-8 times this length, disc covered entirely with imbricating scales; radial shields 2-3 times as long as wide, separated proximally and just meeting at the distal edge; primary rosettes distinct. Oral papillae spear-head shaped with a rounded distal edge, one distal oral papilla on each side. Two tentacle scales. About 6-8 arm spines, the middle ones squared off, with distally directed hooks. Colour white.

**Substratum:** Sandy sediments.

**Distribution:** Seychelles, India, Australia, Malaysia.



**Figure 5.** *Amphiura (Amphiura) ambigua* Koehler, 1905. Disc and arm base, dorsal and ventral view.

#### 4. *Amphiura (Amphiura) constricta* Lyman, 1879

**Collection locations:** Trivandrum-Kannur, 52-106 m.

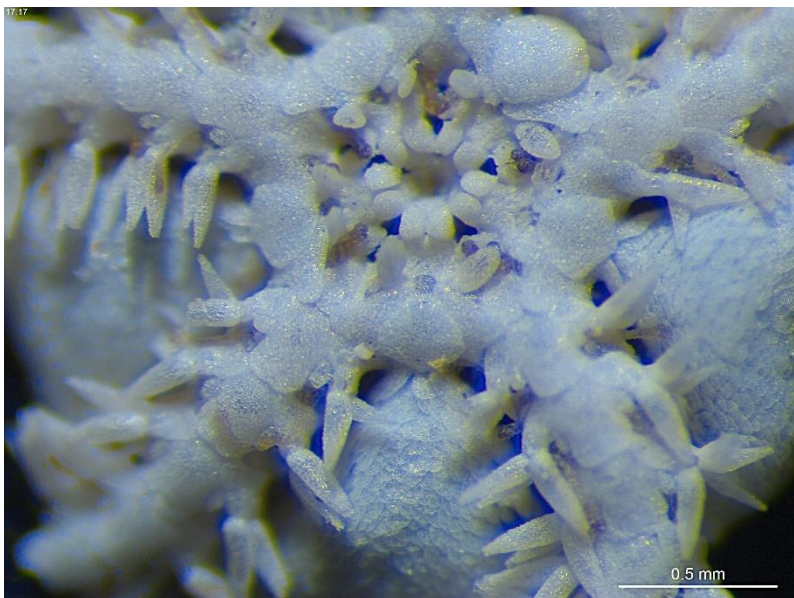
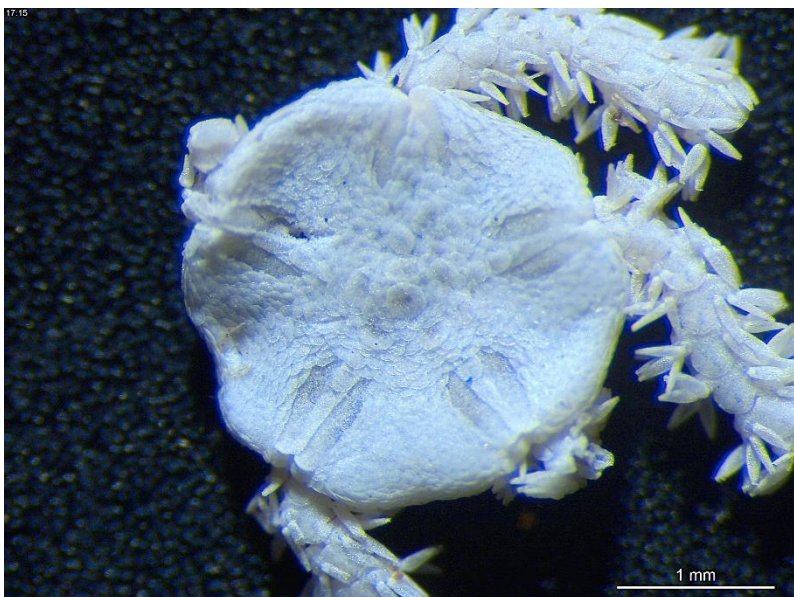
TRIVANDRUM – 8° 24.983' N, 76° 32.466' E, 106 m, 30.8.2011 (FORVSS 289, St. 16). KANNUR – 11° 59.52' N, 74° 57.18' E, 52 m, 8.10.2014 (FORVSS 330, St. 13). Naturalist dredge and Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00123

**Diagnosis:** Disc diameter 3-5 mm, arms about 7-8 times this length, disc covered entirely with small imbricating scales; radial shields narrow, elongate, over thrice as long as wide; primary rosettes distinct. Oral shields spear-head shaped, with a small distal prolongation; one, long, spine-like distal oral papilla on each side. One tentacle scale. Six arm spines at the base of the arm, the second ventral most spine with a small, glassy, distally directed hook; dorsal spine larger than the rest. Colour white.

**Substratum:** Sandy and silty sediments.

**Distribution:** India, Australia, Philippines.



**Figure 6.** *Amphiura (Amphiura) constricta* Lyman, 1879. Disc and arm base, dorsal and ventral view.

**5. *Amphiura (Amphiura) duncani* Lyman, 1882**

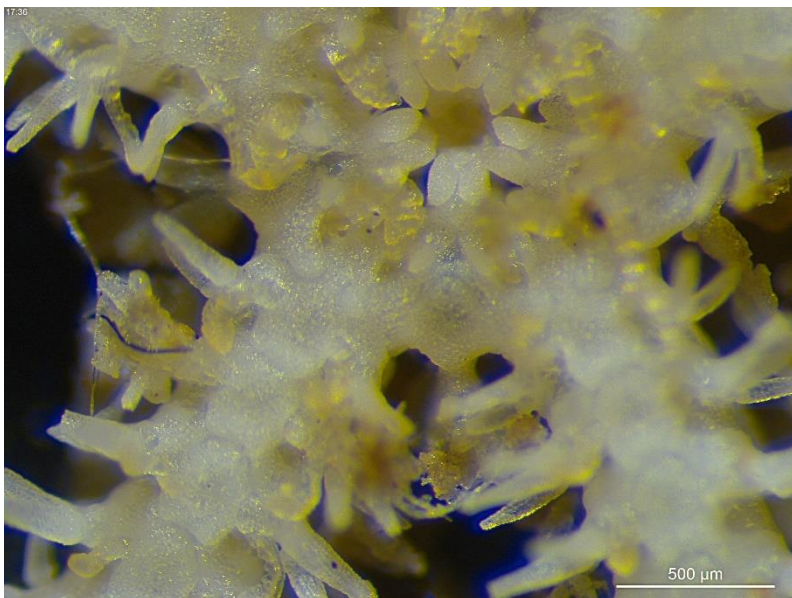
**Collection locations: Kochi-Calicut, 52-109 m.** KOCHI – 9° 55.492' N, 75° 38.056' E, 109 m, 26.8.2011 (FORVSS 289, St. 3). – 9° 58.138' N, 75° 39.155' E, 100 m, 31.7.2013 (FORVSS 317, St. 3). CALICUT – 11° 19.179' N, 75° 18.903' E, 52 m, 22.2.2012 (FORVSS 295, St. 3). Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00091

**Diagnosis:** Disc diameter 2-3 mm; arm always broken; disc covered above and below by small but thick imbricating scales; primary rosette indistinct; radial shields about half of disc radius, meeting distally. Oral shields rhombic, much broader than long; infra-dental papillae large and prominent on the oral plates; one leaf-shaped distal oral papilla. One rounded tentacle scale. Usually 4-5 arm spines, of which the ventral-most is distinctly longer, about 1.45 times the corresponding segment. Colour white.

**Substratum:** Sandy and silty sediments.

**Distribution:** Mauritius, Tanzania, Kenya, Somalia, Oman, India, Myanmar, Australia, Fiji.



**Figure 7.** *Amphiura (Amphiura) duncani* Lyman, 1882. Disc and arm base, dorsal and ventral view.

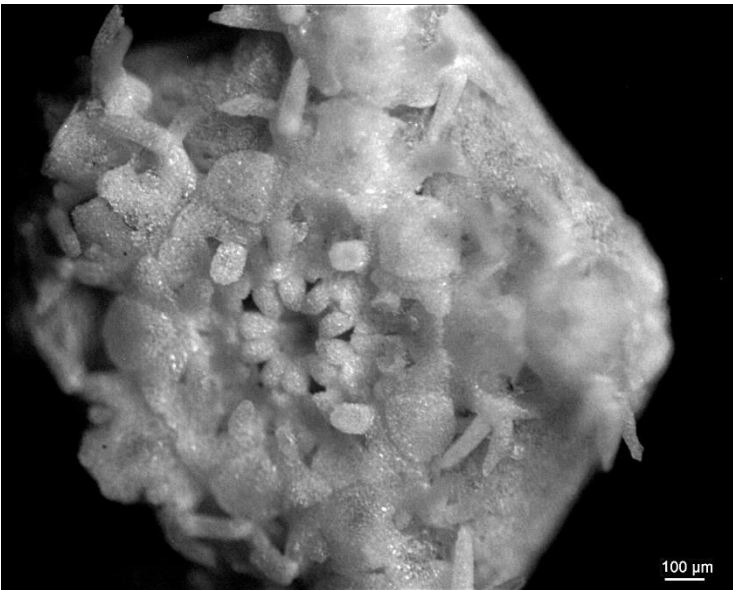
**6. *Amphiura (Amphiura) micra* H.L. Clark, 1938**

***Collection locations:* Cape Comorin, 24 m. CAPE COMORIN – 8° 3.411' N, 77° 29.811' E, 24 m, 16.5.2010 (FORVSS 275, St. 15). Smith-McIntyre grab.**

***Diagnosis:*** Disc diameter 2 mm, arms about 7-8 times this length, disc covered entirely with small imbricating scales; radial shields short, wide, about twice as long as wide and meeting only at the distal edge; primary rosettes distinct. Oral shields triangular, with a rounded distal edge; one distal scale like oral papilla on each side, which is longer than wide. One tentacle scale. Six arm spines at the base of the arm, the second ventral most spine with a small, glassy, distally directed hook; dorsal spine larger than the rest. Colour white.

***Substratum:*** Sandy sediments.

***Distribution:*** India, Australia, New Zealand.



**Figure 8.** *Amphiura (Amphiura) micra* H.L. Clark, 1938. Disc and arm base, dorsal and ventral view.



**7. *Amphiura (Fellaria) heptacantha* (Mortensen, 1940)**

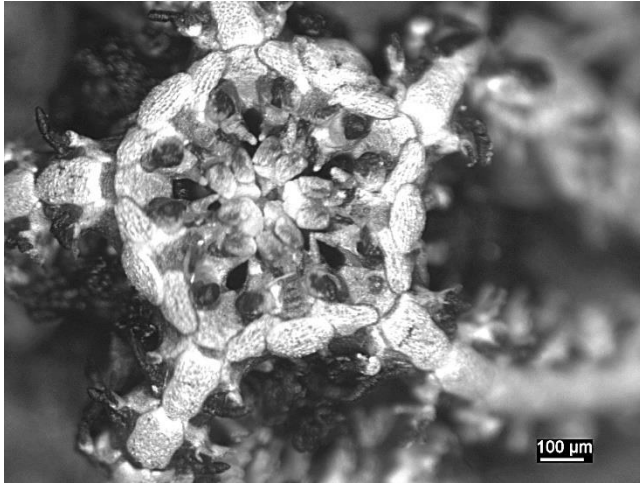
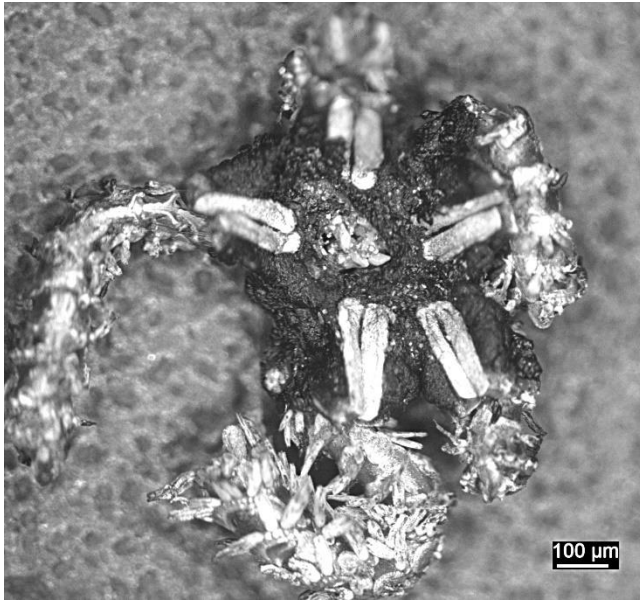
**Collection locations:** Cape Comorin, 31 m. CAPE COMORIN – 8° 2.207' N, 77° 29.956' E, 31 m, 16.5.2010 (FORVSS 275, St. 16). Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00093

**Diagnosis:** Disc diameter 2 mm; scales present only around the radial shields, which are long and bar-like, with a small gap between them, rest of the disc naked, highly contorted; arms very long, all broken. Distal oral papillae not present on all jaws (possibly lost), scale-like with a rounded distal edge. Tentacle scales absent. Arm spines number 7, all flattened, and most with a very rugose tip. Colour white.

**Substratum:** Sandy sediments.

**Distribution:** Mozambique, India, Australia.



**Figure 9.** *Amphiura (Fellaria) heptacantha* (Mortensen, 1940).  
Disc and arm base, dorsal and ventral view.

**8. *Dougaloplus echinatus* (Ljungman, 1867)**

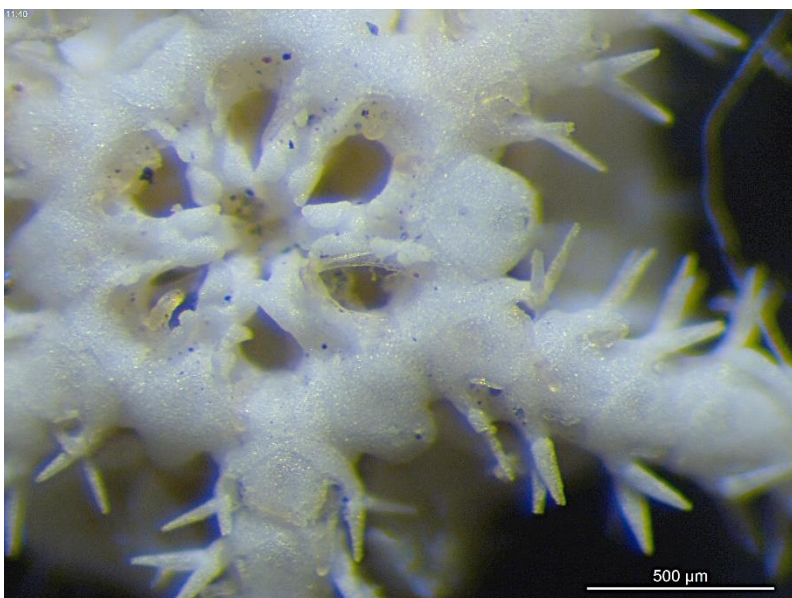
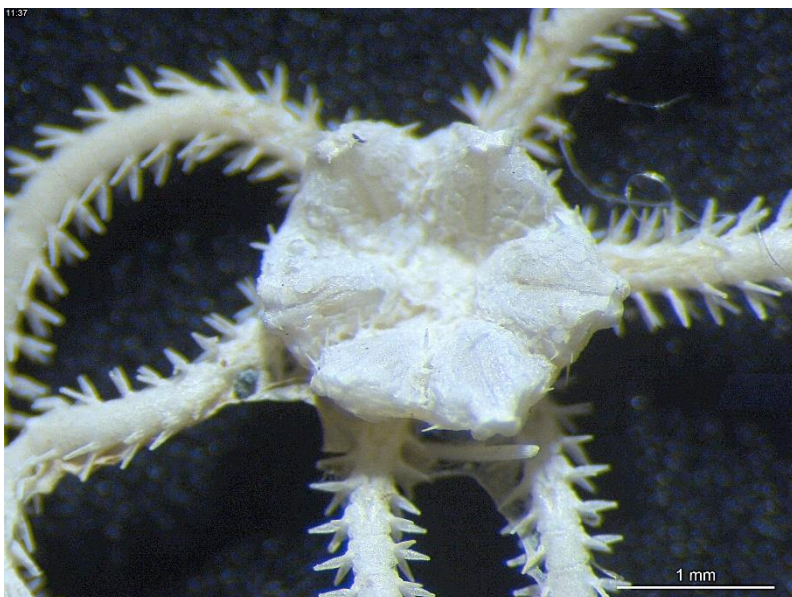
**Collection locations: Trivandrum, 49 m.** TRIVANDRUM – 8° 30.914' N, 76° 45.067' E, 49 m, 16.7.2013 (FORVSS 316, St. 4). Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00120

**Diagnosis:** Disc diameter 5 mm, with spines on the dorsal side, damaged; arms 6, all broken, but more than 5 times this length. Oral shield with an acute proximal edge and rounded distal edge, three oral papillae, the third one largest. Dorsal arm plates fan shaped and carinate; three to four arm spines. Colour white.

**Substratum:** Sandy sediments.

**Distribution:** India, Australia, Malaysia, China, Philippines, Fiji.



**Figure 10.** *Dougaloplus echinatus* (Ljungman, 1867). Disc and arm base, dorsal and ventral view.

## 9. *Ophiodaphne scripta* (Koehler, 1904)

**Collection locations: Cape Comorin-Kollam, 38-111 m.** CAPE COMORIN – 7° 47.649' N, 77° 30.26' E, 52 m, 30.5.2009 (FORVSS 267I, St. 2). TRIVANDRUM – 8° 26.014' N, 76° 47.946' E, 53 m, 20.11.2010 (FORVSS 282, St. 10). – 8° 27.052' N, 76° 53.967' E, 38 m, 30.8.2011 (FORVSS 289, St. 18). – 8° 30' N, 76° 48' E, 51 m, 2.9.2011 (FORVSS 289, St. 29). – 8° 30' N, 76° 48' E, 52 m, 4.9.2011 (FORVSS 289, St. 37). – 8° 30' N, 76° 48' E, 51 m, 4.9.2011 (FORVSS 289, St. 38). – 8° 30' N, 76° 48' E, 52 m, 5.9.2011 (FORVSS 289, St. 41). – 8° 30' N, 76° 48' E, 52 m, 6.9.2011 (FORVSS 289, St. 45). – 8° 30' N, 76° 48' E, 52 m, 7.9.2011 (FORVSS 289, St. 49). – 9° 20.971' N, 75° 52.841' E, 111 m, 14.5.2010 (FORVSS 275, St. 7). Naturalist dredge and Smith-McIntyre grab.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00071, 00294

**Diagnosis: Female** – Disc diameter up to 4 mm and arms about 1.5 to 2 times this length. Disc covered above and below with small imbricating scales, with primary rosette and radial shields clearly distinguished. Radial shields about one half of disc radius, contiguous along most of their length and separated by a few small scaled; transverse parallel grooves along inner edge or across entire surface of radial shields. Small grooves also visible on remaining dorsal disc scales of most specimens. Oral shields small and rhomboid with a rounded distal edge; adoral shields large; oral plates distinct. Infradental papillae extremely small and poorly distinguished; oral papillae more or less fused together, forming a continuous row along the sides of jaws; provided with numerous minute thorns on their edge. Oral and adoral shields along with sunken oral plates, bearing minute inwardly directed spinules. Teeth conspicuous, rounded and conical structures, 4-5 in a vertical row. Dorsal arm plates pentagonal with rounded distal edges, just contiguous proximally, becoming fan-shaped and separated distally; ventral

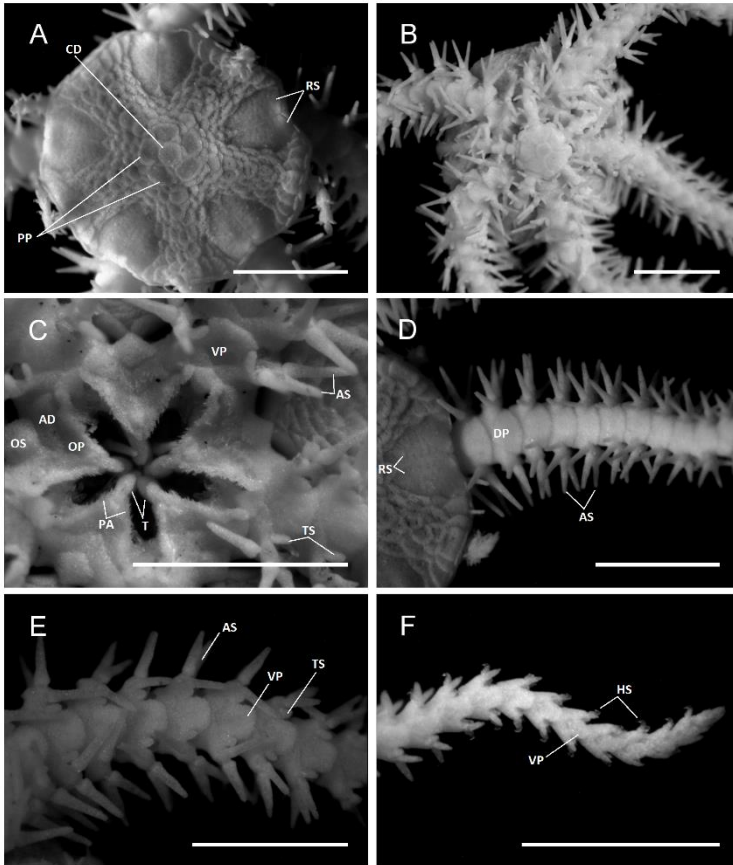
arm plates more or less square, contiguous proximally, reducing in size and becoming separated distally. Five rounded conical arm spines at the arm base; 4 arm spines distally, of which the two dorsal-most are transformed into hooks; and last few segments bearing only two hook-shaped arm spines. A single leaf-like tentacle scale present throughout the arm.

*Male* – Disc diameter up to 1 mm, arms about 4-5 times this length; slightly tumid in inter-radii. Dorsal disc completely covered by large rounded primary rosette plates; ventral side of disc paved by small imbricating scales. Genital slits and jaw structures minute and poorly developed. As in females, a continuous row of fused, thorny oral papillae present, bearing minute thorns. Teeth rounded and conical. Dorsal arm plates fan-shaped and separated throughout arm; ventral arm plates pentagonal and separated throughout arm. Tentacle scales absent; 3 short cylindrical arm spines at the arm base; two in number and sometimes ending in glassy thorns; transformed into curved hooks at the distal arm. Colour white.

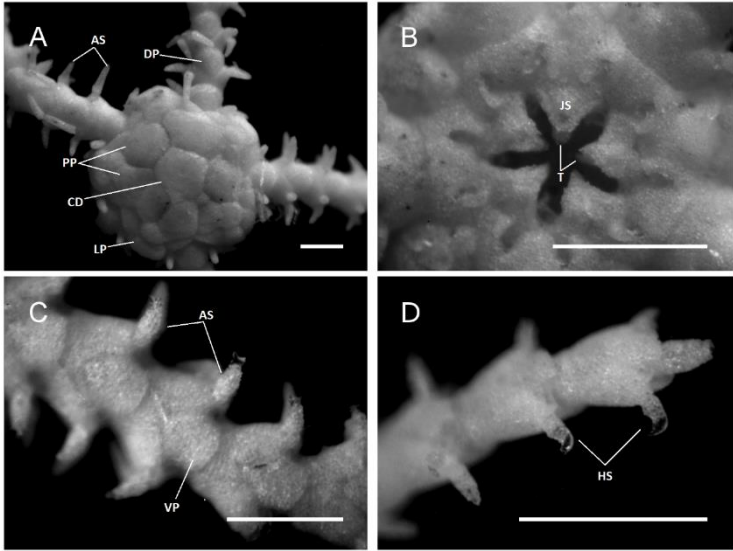
***Substratum:*** Sandy sediments.

***Distribution:*** Mozambique, India, Indonesia, Philippines, Australia.

***Remarks:*** Collected as epibiont on *Sculpsitechinus auritus* (Leske, 1778). This rare, sexually dimorphic species represents a new record from the Indian waters, and was published along with notes on systematics of *Ophiodaphne* and the adaptations for its unique life habit.



**Figure 11.** *Ophiodaphne scripta* (Koehler, 1904). female; **a** dorsal aspect of disc; **b** ventral aspect of disc, with male covering over mouth; **c** jaw structures; **d** dorsal aspect of arm; **e** ventral aspect of arm, proximal segments; **f** ventral aspect of arm, distal segments. CD centrodorsal plate, PP primary plates, RS radial shields, OS oral shield, AD adoral shield, OP oral plate, PA oral papillae, T teeth, VP ventral arm plate, AS arm spines, TS tentacle scales, DP dorsal arm plates, HS hooked arm spines. Scale bar=1 mm.



**Figure 12.** *Ophiodaphne scripta*, male; **a** dorsal aspect; **b** jaw structures; **c** ventral aspect of arm, proximal segments; **d** ventral aspect of arm, distal segments. CD centrodorsal plate, PP primary plates, LP lateral disc plates, AS arm spines, DP dorsal arm plate, JS jaw structure, T teeth, VP ventral arm plate, HS hooked arm spines. Scale bar=0.1 mm



**10. *Ophiosphaera insignis* Brock, 1888**

**Collection locations: Cape Comorin, 49 m.** CAPE COMORIN – 7° 59.26' N, 77° 10.767' E, 49 m, 15.11.2010 (FORVSS 282, St. 8). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00094

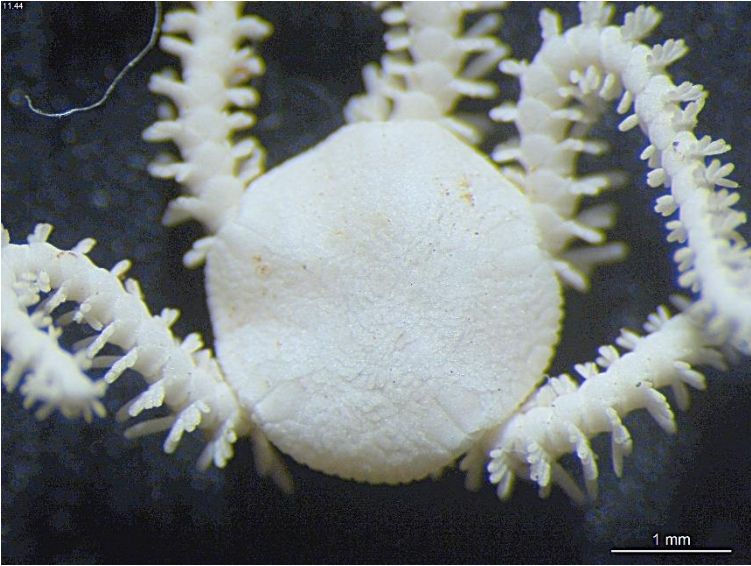
**Diagnosis:** Disc diameter 2-3 mm, arms about 2-3 times this length. Disc distinctly domed and composed of a mosaic of small, hard scale-like plates; radial shields small, twice as long as wide, contiguous; outer edge of disc demarcated by a row of erect scales. Oral apparatus small; three glassy apical oral papillae, separated from two scale-like distal oral papillae by a wide diastema. Arm spines 3 at the base of the arm, increasing to 6 at segment 4-5, decreasing beyond proximal part of the arm; lowermost arm spine conspicuously enlarged, about two times corresponding segment length, club-like and hollow, spines decreasing in length towards the dorsal side. Colour cream.

**Substratum:** Sandy sediments.

**Distribution:** Seychelles, Saudi Arabia, India, Australia, Papua New Guinea, New Caledonia.

**Remarks:** Specimen was collected in association with echinoid *Salmaciella dussumieri* L. Agassiz in L. Agassiz & Desor, 1846 and is known to be epibiont on echinoids. This species is also known to show sexual dimorphism; with a dwarf male being attached to the oral side of a larger female (Koehler 1930). Only

two females were collected during the present study, without any epibiont males.



**Figure 13.** *Ophiosphaera insignis* Brock, 1888. Disc and arm base, dorsal and ventral view.

## 11. *Ophiochiton ambulator* Koehler, 1897

**Collection locations: Cape Comorin-Kannur, 523-1241 m.** CAPE COMORIN – 8° 0.845' N, 76° 25.91' E, 1154 m, 10.12.2013 (FORVSS 321, St. 16). TRIVANDRUM – 8° 25.107' N, 75° 55.18' E, 1241 m, 11.12.2013 (FORVSS 321, St. 18). CALICUT – 10° 59.29' N, 74° 59.52' E, 992 m, 14.4.2005 (FORVSS 233, St. 15). – 11° 56.54' N, 74° 22.66' E, 523 m, 17.4.2005 (FORVSS 233, St. 17). – 12° 53.45' N, 73° 47' E, 1000 m, 18.4.2005 (FORVSS 233, St. 21). KANNUR – 11° 55.93' N, 74° 23.13' E, 525 m, 21.12.2003 (FORVSS 219, St. 17). Demersal trawl & naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00096, 00206

**Diagnosis:** Disc diameter up to 2.5 cm, arms about 8-10 times this length; disc usually clearly incised, covered with small imbricating scales, among which the primary rosette is usually distinguishable. Radial shields long and triangular, about half disc radius; separated on their distal edge by a row of wide scales. Oral shield nearly triangular, 5-6 conical oral papillae. Arms prominently keeled above and below, two tentacle scales of which the outer one is larger; 3 long conical arm spines, as long as two arm segments. Colour salmon to cream.

**Substratum:** No information.

**Distribution:** India.



**Figure 14.** *Ophiochiton ambulator* Kohler, 1897. Disc and arm base, dorsal and ventral view.

**12. *Ophiopsila pantherina* Koehler, 1898**

**Collection locations: Cape Comorin, 49 m.** CAPE COMORIN – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00282

**Diagnosis:** Disc diameter 3 mm; arms broken; disc covered by small scales. Two tentacle scales, of which the outer is rounded, and the inner is much elongate, crossing the corresponding scale of the other side – the two scales resembling a pair of crossed swords. Arms spines numbering 7-9, short, stout and hollow. Colour grey.

**Substratum:** Sandy sediments.

**Distribution:** India, Myanmar, Australia, Vietnam, China.



**Figure 15.** *Ophiopsila pantherina* Koehler, 1898. Disc and arm base, dorsal and ventral view.

**13. *Histampica duplicata* (Lyman, 1875)**

**Collection locations:** Karwar, 957 m. KARWAR – 14° 29.024' N, 73° 02.279' E, 957 m, 28.01.2018 (FORVSS 372, St. 5). Demersal trawl.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00164, 00202

**Diagnosis:** Disc diameter 6 mm, arms about 10 times this length. Disc scales large, thin and imbricating, primary rosette distinct. Radial shields small, with a straight internal margin and rounded external margin; separated by one or two rows of disc scales, and meeting only distally. Genital slits long and distinct. Oral shield rhombic, longer than wide, with a short distal lobe. Adoral shields long and narrow, bracketing the lateral angles of the oral shield. Four oral papillae along each side of the jaw, of which the middle two are wider and longer, with rounded distal margins and the distalmost is somewhat bilobed. Dorsal arm plates fan-shaped, just in contact. The first ventral arm plate is divided into two by a transverse furrow – the proximal part pentagonal and the distal part is divided longitudinally into two by another furrow; subsequent ventral arm plates pentagonal. Three short, conical arm spines on each segment. Two tentacle scales, of which the external is much longer and the internal is very small. Colour cream or white.

**Substratum:** No information.

**Distribution:** Comoros, Reunion, India, Sri Lanka, Indonesia, Australia, Philippines, Papua New Guinea, New Caledonia, New Zealand, U.S.A., Marquesas Islands, Galapagos, Mexico, Cuba, Anguilla, Grenada, French Guiana, Spain.



**Figure 16.** *Histampica duplicata* (Lyman, 1875). Disc and arm base, dorsal and ventral view.



#### 14. *Ophiocnemis marmorata* (Lamarck, 1816)

**Collection locations: Cape Comorin-Trivandrum, 49-52 m.**

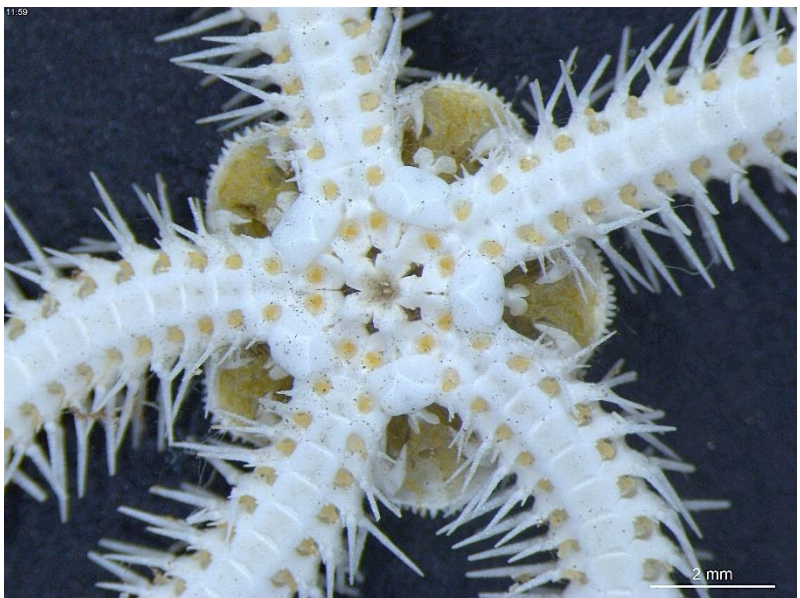
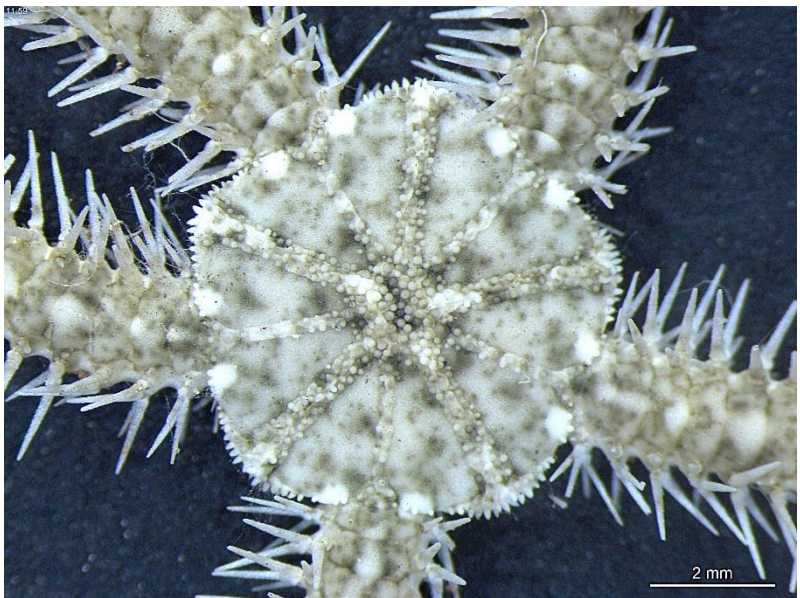
CAPE COMORIN – 7° 59.26' N, 77° 10.767' E, 49 m, 15.11.2010 (FORVSS 282, St. 8). TRIVANDRUM – 8° 30' N, 76° 48' E, 52 m, 7.9.2011 (FORVSS 289, St. 49). – 8° 30' N, 76° 48' E, 51 m, 8.9.2011 (FORVSS 289, St. 53). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00101

**Diagnosis:** Disc diameter 1 cm, arms about 3 times this length. Disc dominated on the dorsal side by the large radial shields, which are flat, triangular and bare, separated by narrow bands of plates covered with prominent, rounded granules; equidistant inter-radially and radially. Ventral side of the disc covered by thin skin. Oral shields triangular with a wide, rounded distal edge; a cluster of small tooth papillae at the jaw apex. Tentacle scales lacking. Colour light with greyish-green mottling.

**Substratum:** Sandy sediments.

**Distribution:** India, Myanmar, Thailand, Australia, China, Philippines, Russia.



**Figure 17.** *Ophiocnemis marmorata* (Lamarck, 1816). Disc and arm base, dorsal and ventral view.

**15. *Ophiopteron elegans* Ludwig, 1888**

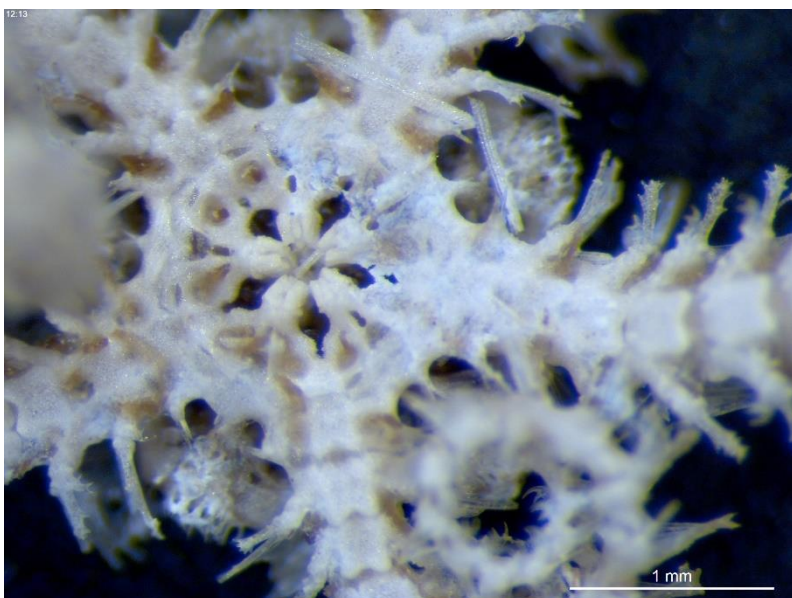
**Collection locations:** Cape Comorin, 49 m. CAPE COMORIN – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00102

**Diagnosis:** Disc diameter 1 mm, arms about 5-6 mm. Disc covered with spaced, short stumps; radial shields not distinct. A cluster of tooth papillae at the apex of each jaw. Arm spines of each side webbed together throughout the length of the arm, and in the first 2-3 segments, the webs of each side linked dorsally. Colour orange.

**Substratum:** Sandy sediments. Epibiont on gorgonids and sponges.

**Distribution:** Maldives, India, Thailand, Indonesia, Australia, Philippines, China, Japan, Solomon Islands, New Caledonia.



**Figure 18.** *Ophiopteron elegans* Ludwig, 1888. Disc and arm base, dorsal and ventral view.

**16. *Ophiothrix (Acanthophiothrix) proteus* Koehler, 1905**

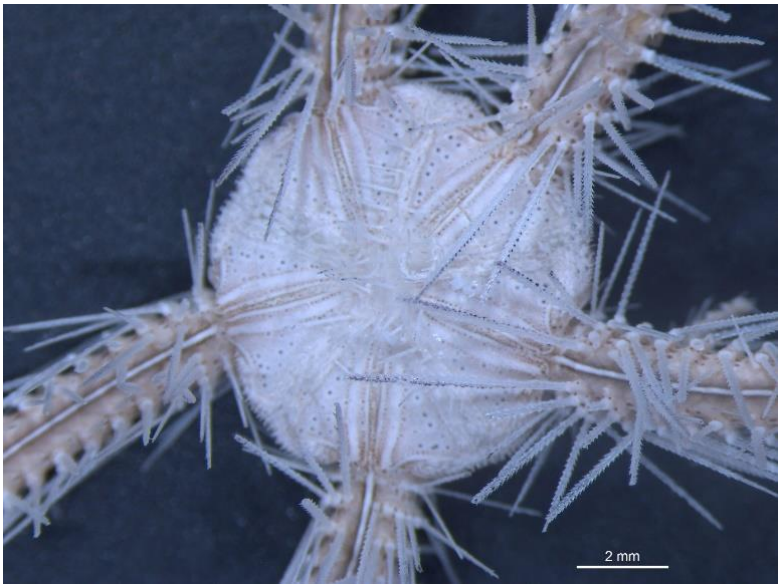
**Collection locations:** Trivandrum, 52 m. TRIVANDRUM – 8° 26.303' N, 76° 47.163' E, 52 m, 30.8.2011 (FORVSS 289, St. 17). – 8° 30' N, 76° 48' E, 52 m, 7.9.2011 (FORVSS 289, St. 49). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00183

**Diagnosis:** Disc diameter 3 mm; arms broken but more than 4 times this length. Dorsal side of disc covered with short multifid stumps as well as a few very long spines (which are mostly broken); radial shields about two-thirds of the disc radius, bare except for a row of stumps along the adradial margins. Oral apparatus small, with a cluster of tooth papillae at the apex of the jaw. Arm segments attenuated; dorsal arm plates longer than wide, more or less fan-shaped and contiguous throughout; a pale median line along the length of the arm, bordered by two thin dark lines. Ventral arm plates with a straight distal edge. Up to 10 arm spines, of which the dorsal-most is the longest, more than 4 times corresponding arm segment. Colour light cream.

**Substratum:** Sandy sediments.

**Distribution:** South Africa, Mozambique, India, Sri Lanka, Myanmar, Thailand, Vietnam, Australia, China, Philippines, Japan, Papua New Guinea, New Caledonia.



**Figure 19.** *Ophiothrix (Acanthophiothrix) proteus* Koehler, 1905. Disc and arm base, dorsal and ventral view.

**17. *Ophiothrix (Acanthophiothrix) purpurea* von Martens, 1867**

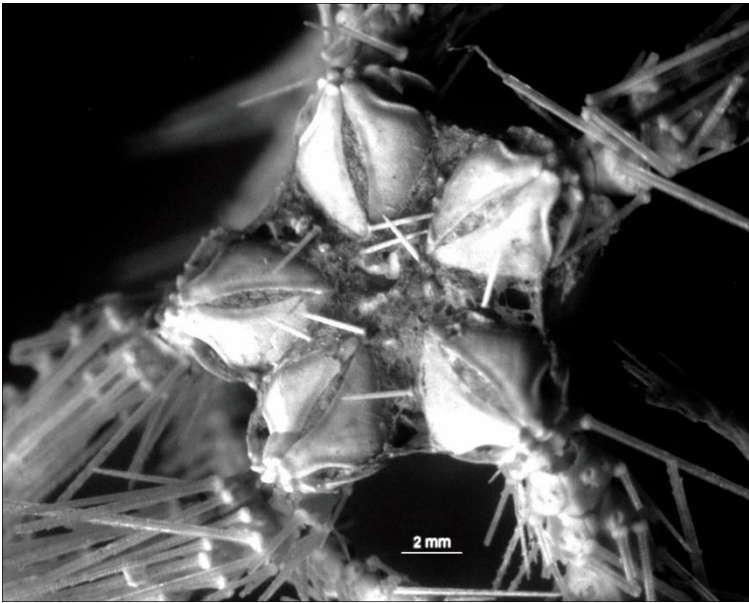
**Collection locations: Cape Comorin, 51-52 m.** CAPE COMORIN – 7° 47.649' N, 77° 30.26' E, 52 m, 30.5.2009 (FORVSS 267I, St. 2). – 8° 15.041' N, 76° 57.085' E, 51 m, 7.9.2013 (FORVSS 319, St. 1). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00176, 00302, 00311

**Diagnosis:** Disc diameter 4-6 mm; arms broken but more than 3 times this length. Dorsal side of disc dominated by radial shields, which is more than two-thirds of the disc radius and bare, their inter-radial length shorter, so that the radial shield is widest at the middle portion; remainder of the disc covered in short stumps or spines. Oral apparatus small, with a cluster of tooth papillae at the apex of the jaw. Dorsal arm plates longer than wide, more or less fan-shaped and contiguous throughout; a pale median bright red line along the length of the arm, bordered by two thin light, yellow lines. Up to 10 arm spines, of which the dorsal-most appear longer, more than 3 times corresponding arm segment, though most spines are broken. Colour white with red and yellow marking across the disc, and longitudinal red line along arm, bordered by yellow lines.

**Substratum:** Sandy sediments.

**Distribution:** South Africa, Mozambique, Madagascar, Reunion, Comoros, Tanzania, Somalia, Djibouti, Saudi Arabia, India, Maldives, Thailand, Christmas Island, Australia, Indonesia, China, Japan, Philippines, Guam, Palau, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia.



**Figure 20.** *Ophiothrix (Acanthophiothrix) purpurea* von Martens, 1867. Disc and arm base, dorsal and ventral view.



**18. *Ophiothrix (Ophiothrix) aristulata* Lyman, 1879**

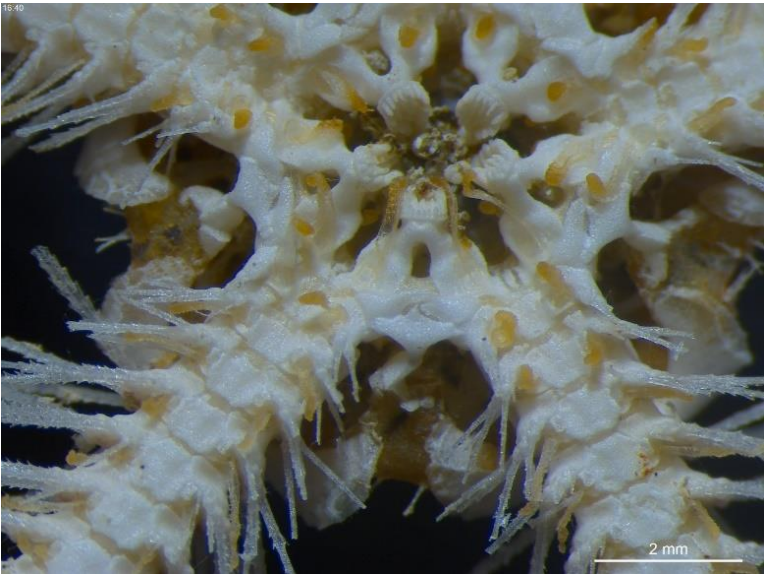
**Collection locations:** Kochi, 500 m. KOCHI – 9° 56.28' N, 75° 82.99' E, 500 m, 23.4.2005 (FORVSS 233, St. 11). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/000103, 00169

**Diagnosis:** Disc diameter 6-10 mm; arms about 6 times this length. Dorsal side of disc covered with short thorny spines, along with a few shorter multifid stumps at the edge of the disc – which all arise of small scales imbedded in a thin skin; radial shields about two-thirds of the disc radius, bare except for a couple of spines on some. Oral apparatus small, with a cluster of tooth papillae at the apex of the jaw. Dorsal arm plates longer than wide, rhombic and contiguous throughout; a pale median line along the length of the arm, bordered by two thin dark lines. Ventral arm plates with a convexity along the distal edge. Arm spines numbering 10-12, with rows of short thorns along their length, about 3 times corresponding arm segment; ventral-most arm spines transforming to hooks in the distal part of the arms. Colour salmon to cream.

**Substratum:** No information.

**Distribution:** India, Australia, Philippines, New Zealand.



**Figure 21.** *Ophiothrix (Ophiothrix) aristulata* Lyman, 1879. Disc and arm base, dorsal and ventral view.

**19. *Ophiothrix (Ophiothrix) foveolata* Marktanner-Turneretscher, 1887**

**Collection locations:** Cape Comorin, 49 m. CAPE COMORIN – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). Naturalist dredge.

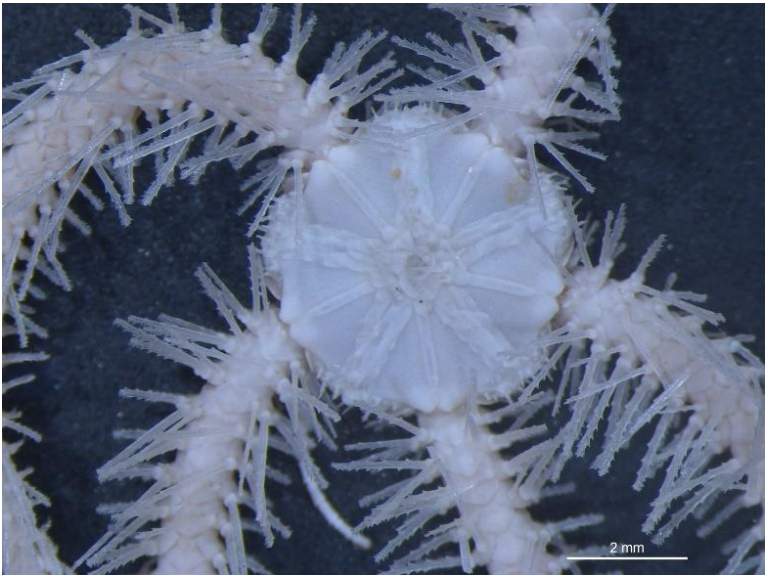
**Voucher specimen No.:** CMLRE IO/SS/ECD/00122

**Diagnosis:** Disc diameter 4 mm; arms broken but more than 3 times this length. Disc with a few short trifold stumps, but radial shields more or less bare and with a dark line along their inner margins. Dorsal arm plates wider than long; ventral arm plates with a concave distal margin; arm spines numbering 8-10, 3 times corresponding segment length, bearing two rows of prominent thorns along their length. Transverse markings across the dorsal and ventral side of the arms, corresponding to each segment. Colour cream.

**Substratum:** Sandy sediments.

**Distribution:** South Africa, Mozambique, Comoros, India, Australia, Malaysia, Papua New Guinea.

**Remarks:** *Ophiothrix insidiosa* Koehler, 1898 reported from Indian waters, is a synonym (Koehler 1905).



**Figure 22.** *Ophiothrix (Ophiothrix) foveolata* Marktanner-Turneretscher, 1887. Disc and arm base, dorsal and ventral view.

**20. *Ophiothrix (Ophiothrix) savignyi* (Müller & Troschel, 1842)**

**Collection locations: Cape Comorin, 31-52 m.** CAPE COMORIN – 7° 47.649' N, 77° 30.26' E, 52 m, 30.5.2009 (FORVSS 267I, St. 2). – 8° 2.207' N, 77° 29.956' E, 31 m, 16.5.2010 (FORVSS 275, St. 16). Naturalist dredge.

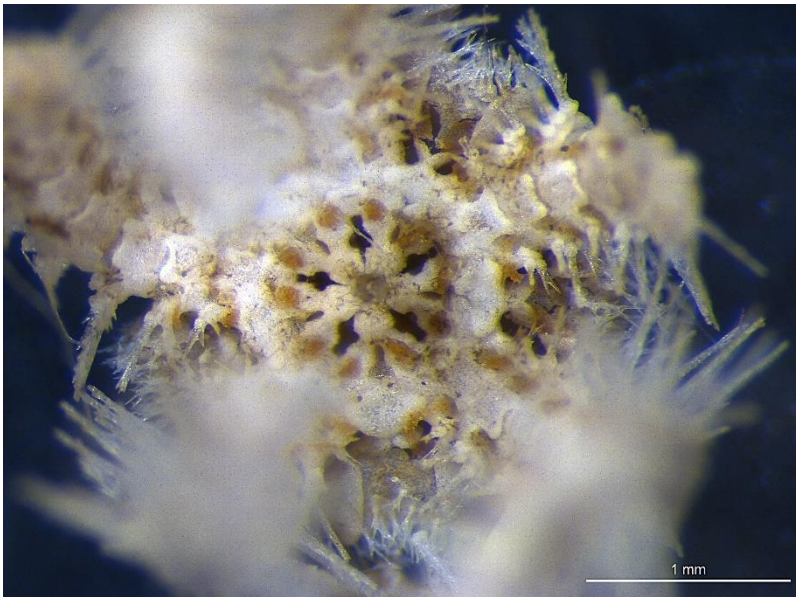
**Voucher specimen No.:** CMLRE IO/SS/ECD/00145

**Diagnosis:** Disc diameter 3-5 mm; arms broken. Disc covered with short trifold stumps, which also obscure radial shields which are small and separated. Dorsal arm plates wider than long; ventral arm plates with a concave distal margin, the proximal ones with some stumps, similar to that of the disc; arm spines numbering 8-10, 3 times corresponding segment length, bearing two rows of prominent thorns along their length. Colour cream.

**Substratum:** Sandy sediments.

**Distribution:** Comoros, Kenya, Egypt, Saudi Arabia, India, New Caledonia.

**Remarks:** *Ophiothrix otiosa* Koehler, 1898 reported from Indian waters, is a synonym (Koehler 1905).



**Figure 23.** *Ophiothrix* (*Ophiothrix*) *savignyi* (Müller & Troschel, 1842). Disc and arm base, dorsal and ventral view.

## 21. *Asteronyx loveni* Müller & Troschel, 1842

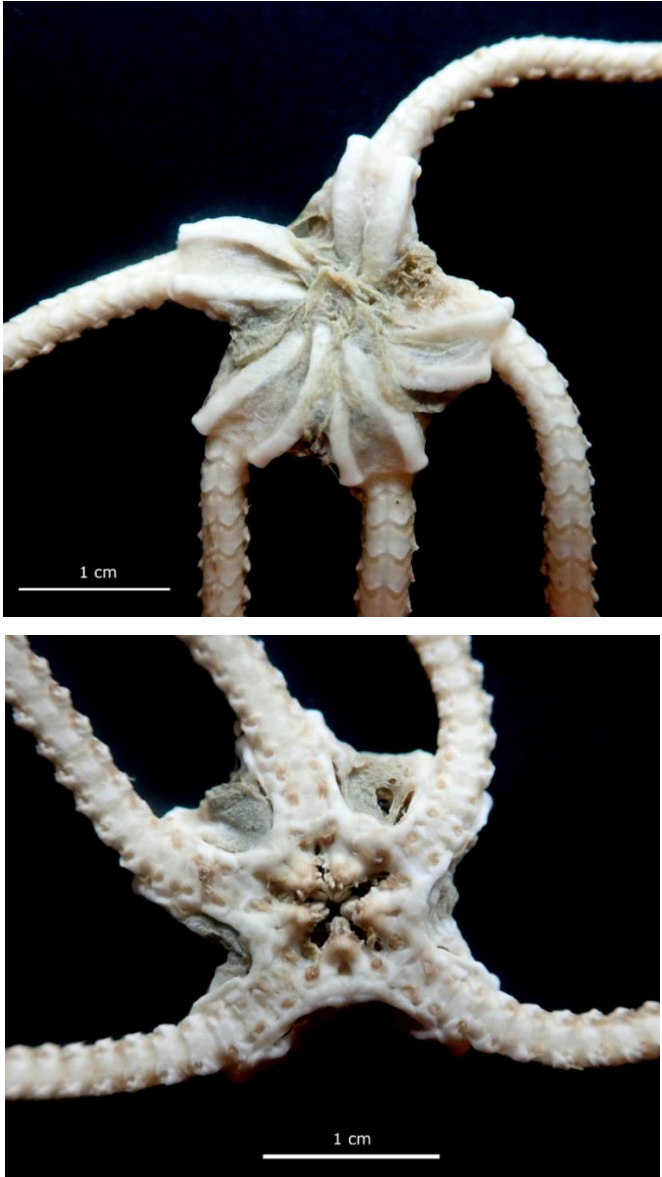
**Collection locations:** Karwar, 957 m. KARWAR – 14° 29.024' N, 73° 02.279' E, 957 m, 28.01.2018 (FORVSS 372, St. 5). Demersal trawl.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00201

**Diagnosis:** Disc diameter up to 20 mm, arms up to 10 times this length. Disc covered in smooth, naked skin; radial shields visible as long, narrow, raised bars below the skin; completely separated along their entire length. Ventral interradii of disc skin covered, genital slits long. Oral shields minute, discernible below the skin, adoral shields large, contiguous radially. Teeth spiniform, 3-4 spiniform oral papillae. Dorsal arm plates absent, lateral arm plates prominent with latero-ventral protrusions which bear up to 9 arm spines, with long, terminal hooks. Colour cream.

**Substratum:** No information.

**Distribution:** Crozet Islands, India, Australia, Indonesia, China, Philippines, Papua New Guinea, New Caledonia, New Zealand, Japan, Russia, Samoa, U.S.A., Galapagos, Mexico, Panama, Ecuador, Puerto Rico, Brazil, Norway, U.K., Ireland, Spain.



**Figure 24.** *Asteronyx loveni* Müller & Troschel, 1842. Disc and arm base, dorsal and ventral view.



## **22. *Asteroschema sampadae* Parameswaran & Jaleel, 2012**

**Collection locations:** Cape Comorin, 545 m. CAPE COMORIN – 7° 10.02' N, 77° 19.21' E, 454 m, 20.5.2007 (FORVSS 254, St. 1). Smith-McIntyre Grab.

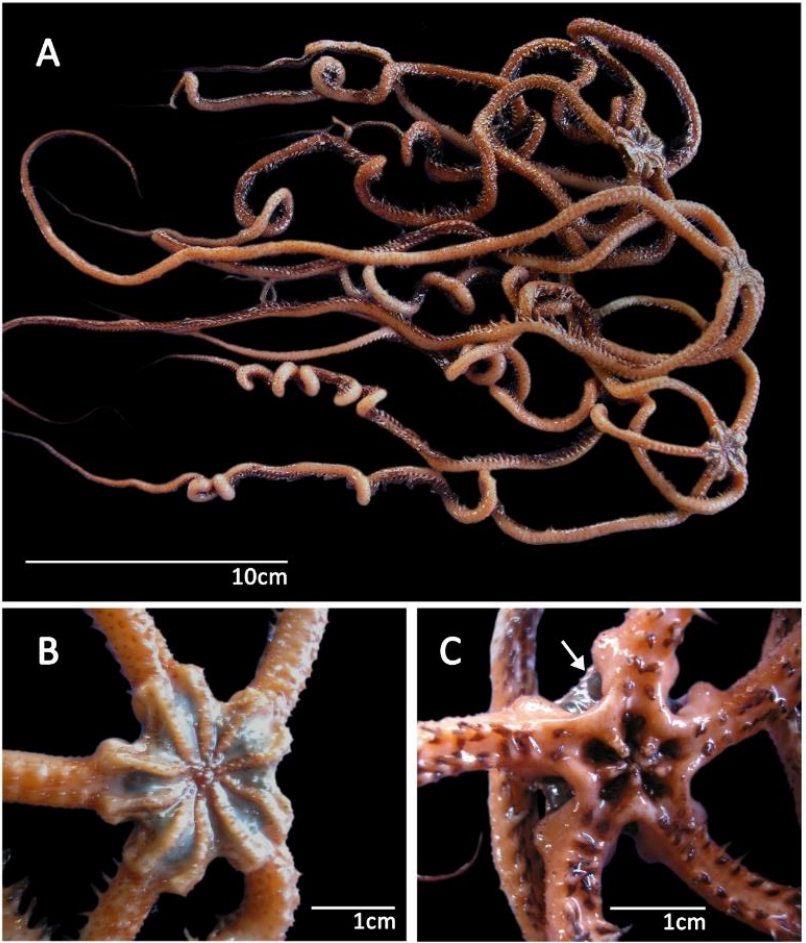
**Voucher specimen No.:** CMLRE IO/SS/ECD/00021

**Diagnosis:** Disc diameter 2 cm, arms about 38-45 mm (21-23 times disc diameter). Disc and arms covered by skin with small, scattered, distinctly conical epidermal ossicles on aboral side and minute spherical granular ossicles on oral side. Conical ossicles bearing a crown of minute spinous terminal projections. Dorsal ornamentation not closely packed anywhere on the body so that large parts of the disc and arms are overlaid by naked skin; but epidermal ossicles somewhat more dense on radial shields and at base of arms. Two arm spines from fourth arm segment; inner spine larger and approximately one third of the arm segment length, becoming twice the length of the arm segment and bearing distinct thorny projections on the inner edge. Arm spines at the distal end of the arm are represented as small hook-shaped spines. Colour light fawn.

**Substratum:** Hard substrate, epibiont on gorgonid.

**Distribution:** India.

**Remarks:** Species described as part of the present study (Full paper: Appendix 1). Specimens were collected in association with a gorgonid of family Primnoidae.



**Figure 25.** *Asteroschema sampadae* Parameswaran & Jaleel, 2012, **a** entire organism, **b** disc and arm base, dorsal view and **c** same ventral view.

### 23. *Astrothorax waitei* (Benham, 1909)

**Collection locations:** Karwar, 953-957m. KARWAR – 14° 29.02' N, 73° 02.28' E, 957m (FORVSS 372, St. 5), 28.02.2018, demersal trawl, 1 specimen; 14° 29.02' N, 73° 01.52' E, 953m (FORVSS 374, St. 10), 09.04.2018, demersal trawl.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00257, 00258, 00259

**Diagnosis:** Disc margin excavate; d.d. up to 2.5 mm; arms–6 times d.d. Disc scales on the dorsal side composed of small, polygonal and flattened scales interspersed with larger, tumid, flat-topped or conical tubercles, usually bearing short spinules on the apex. Ventral surface of the disc, including the jaws paved with small, rounded scales. Ventral teeth long, pointed and numerous, arranged in a cluster; long, pointed papillae along the latero-ventral margin of the jaw. Girdle bands of arms beginning at the disc margin. Girdle hooklets with a secondary tooth. Ventral surface of the arm skin-covered, with dense or spaced paving of polygonal plates of varying sizes. Ventral projections of the lateral arm plates clearly visible as raised transverse bars along the arm. Arm spines absent on first segment, 2-3 subequal, cylindrical spines with numerous glassy points on second segment, subsequently increasing to about 6; arm spines on distal segments reduced to ~2 flat hooks with a strong primary tooth and short secondary tooth. Colour cream.

**Substratum:** No information.

**Distribution:** South Africa, India, Australia, Indonesia, Solomon Islands, New Caledonia, Norfolk Ridge, New Zealand, Campbell Plateau.



**Figure 26.** *Astrothorax waitei* (Benham, 1909). Disc and arm base, dorsal and ventral view.

**24. *Ophiacantha dallassi* Duncan, 1879**

**Collection locations:** Cape Comorin, 49 m. CAPE COMORIN – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). Naturalist dredge.

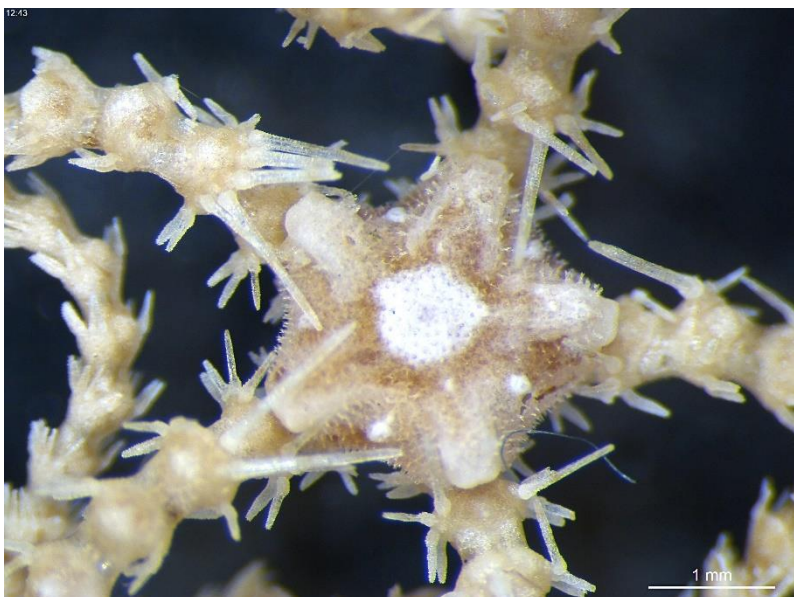
**Voucher specimen No.:** CMLRE IO/SS/ECD/00121, 00279, 00291

**Diagnosis:** Small epibionts, disc diameter 3 mm, disc covered above and below by short trifold stumps, more or less obscuring radial shields. Oral shields roughly triangular with a rounded distal margin; adoral shields larger than oral shields, with distal prolongations which extend beyond the lateral margins of the oral shields; three oral papillae on each side, the outer one larger, but less than twice as wide as long. Arm distinctly moniliform. Small spiniform tentacle scales on basal arm segments. Up to 7 arm spines; on the second free arm segment, spines from either side contiguous, and dorsal row of spines more than twice as long as other spines. Colour greyish white.

**Substratum:** Sandy sediments. Epibiont on gorgonids and soft corals.

**Distribution:** Madagascar, Reunion, India, Australia, Indonesia, Philippines, China, Papua New Guinea, New Caledonia.

**Remarks:** Specimens collected in association with a gorgonid.



**Figure 27.** *Ophiacantha dallassi* Duncan, 1879. Disc and arm base, dorsal and ventral view.

**25. *Ophiomoeris tenera* (Koehler, 1897)**

***Collection locations:* Cape Comorin-Trivandrum, 1241-1154 m.**

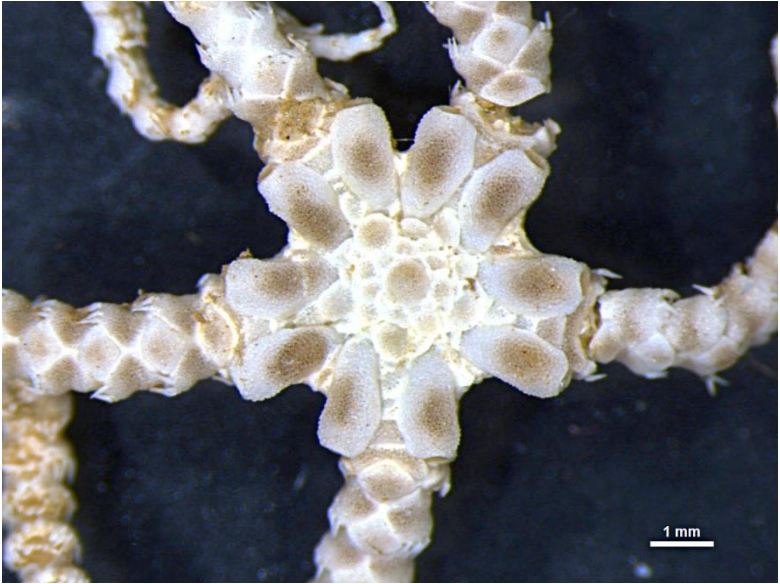
CAPE COMORIN – 8° 0.845' N, 76° 25.91' E, 1154 m, 10.12.2013 (FORVSS 321, St. 16). TRIVANDRUM – 8° 25.107' N, 75° 55.18' E, 1241 m, 11.12.2013 (FORVSS 321, St. 18). Naturalist dredge and demersal trawl.

***Voucher specimen No.:*** CMLRE IO/SS/ECD/00199

***Diagnosis:*** Disc diameter 6-8 mm, arms 2-3 times this length; disc intended inter-radially, and covered with rounded tumid plates. Of these, the radial shields are the largest (>half disc radius), elliptical, protruding at the periphery of the disc; they are well separated radially by a row three plates, of which the distal one is very broad; inter-radially, they are closer together, being separated by a single narrow elongate plate. Ventral inter-radii occupied by a few small plates; oral shields small and triangular; adoral shields large, thick and crescent shaped; oral papillae large, wide, 3 on each side, besides a single conical oral papilla. First dorsal arm plate twice as wide as long, subsequent triangular. One rounded tentacle scale; three arm spines, just shorter than corresponding segments. Colour white.

***Substratum:*** No information. Epibiont on stalked crinoid *Teliocrinus springeri* (A. H. Clark, 1909).

***Distribution:*** India, Philippines, Papua New Guinea.



**Figure 28.** *Ophiomoeris tenera* (Koehler, 1897). Disc and arm base, dorsal and ventral view.



**26. *Breviturma brevipes* (Peters, 1851)**

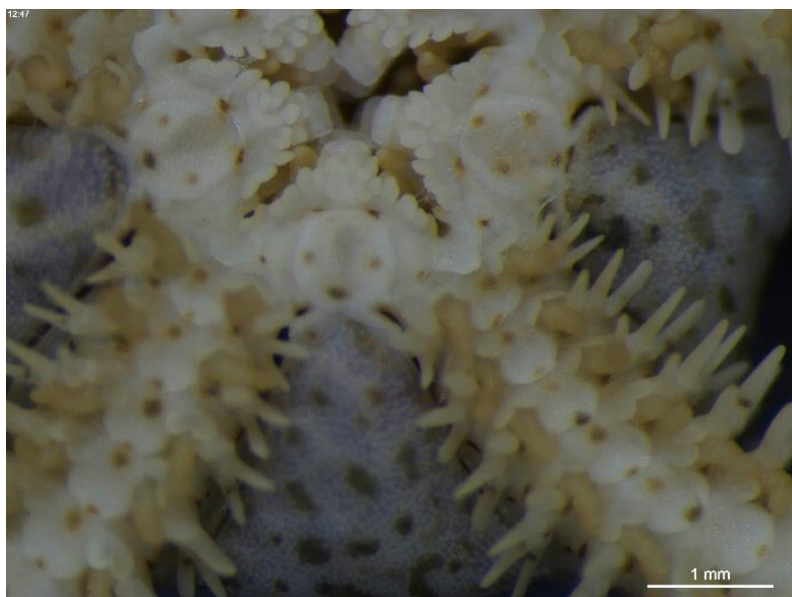
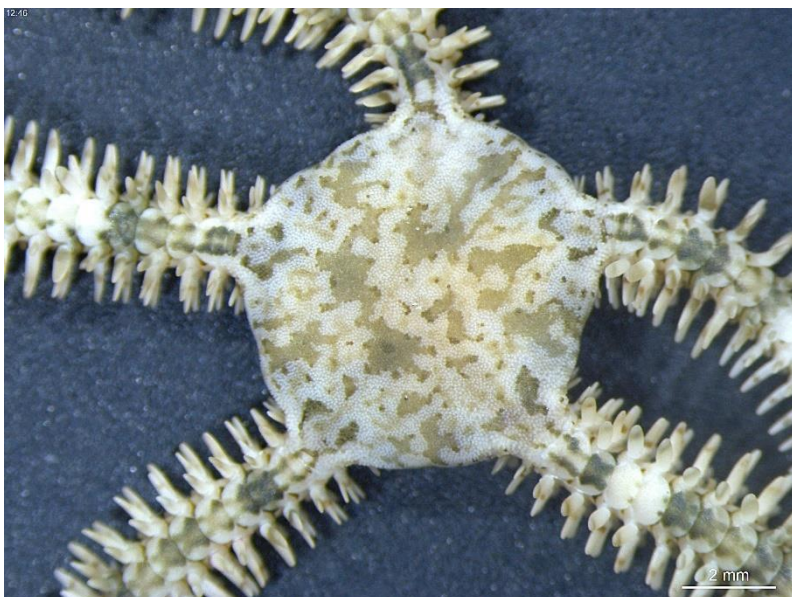
**Collection locations:** Cape Comorin, 49 m. CAPE COMORIN – 7° 59.26' N, 77° 10.767' E, 49 m, 15.11.2010 (FORVSS 282, St. 8). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00275

**Diagnosis:** Disc diameter 12 mm; arms about 5 times this length; disc covered with rounded granules above and below. Apical tooth papillae forming a cluster at the apex of the jaw, and oral papillae present along the jaw angle. Tentacle scales 2. Arm spines hollow, shorter than the width of corresponding arm segment. Colour of disc pale green, arms lightly banded.

**Substratum:** Sandy sediments.

**Distribution:** South Africa, Mozambique, Reunion, Comoros, Kenya, Seychelles, Saudi Arabia, India, Maldives, Sri Lanka, Thailand, Philippines, Australia, Papua New Guinea, New Caledonia, Fiji, Guam, Mariana Islands, Solomon Islands, Micronesia, Japan.



**Figure 29.** *Breviturma brevipes* (Peters, 1851). Disc and arm base, dorsal and ventral view.

**27. *Bathypectinura heros* (Lyman, 1879)**

**Collection locations: Trivandrum-Kochi, 835-1241 m.**

TRIVANDRUM – 8° 25.107' N, 75° 55.18' E, 1241 m, 11.12.2013 (FORVSS 321, St. 18). KOCHI – 9° 50.16' N, 75° 32.87' E, 835 m, 3.5.2007 (FORVSS 254, St. 12). – 9° 54' N, 75° 31.44' E, 1120 m, 8.8.2010 (FORVSS 278, St. 2).  
Naturalist dredge and demersal trawls.

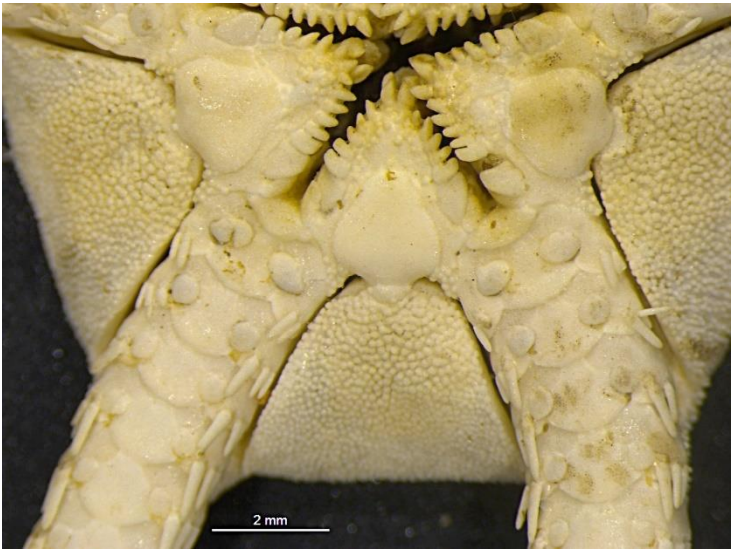
**Voucher specimen No.:** CMLRE IO/SS/ECD/00098, 00179, 00198

**Diagnosis:** Disc diameter 2-3.5 cm, arms about 2-3 times this length; disc covered above and below by fine granulation, with only the distal ends of the radial shields exposed. Oral shields large and bare, triangular with a rounded distal edge; adoral shields and oral plates obscured by granulation, similar to the disc; a single conical apical oral papilla and 7 papillae along the inner side of the, which increase in size from the proximal to the distal-most one. Arms strongly carinate dorsally, dorsal arm plates twice as wide as long; usually 4 arm spines which are shorter than the corresponding arm segments and adpressed to it. Tentacle scales very large and rounded. Colour bright orange.

**Substratum:** No information.

**Distribution:** India, Australia, Indonesia, China, Philippines, Papua New Guinea, Solomon Islands, New Caledonia, New Zealand, U.S.A., Mexico, Cuba, Colombia, French Guiana, Azores, Morocco, Cameroon, Gabon, Angola.

**Remarks:** *Pectinura conspicua* Koehler, 1897 reported from Indian waters is a synonym (Madsen 1973).



**Figure 30.** *Bathypectinura heros* (Lyman, 1879). Disc and arm base, dorsal and ventral view.

**28. *Ophiarchnella infernalis* (Müller & Troschel, 1842)**

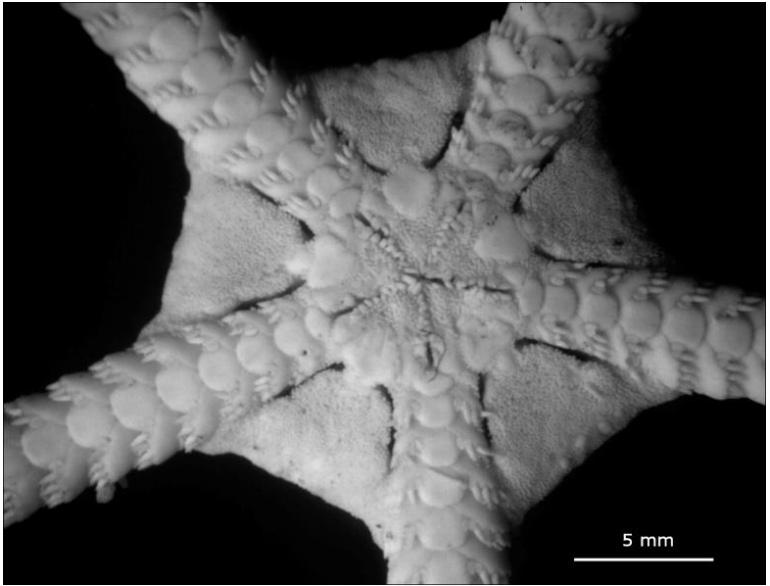
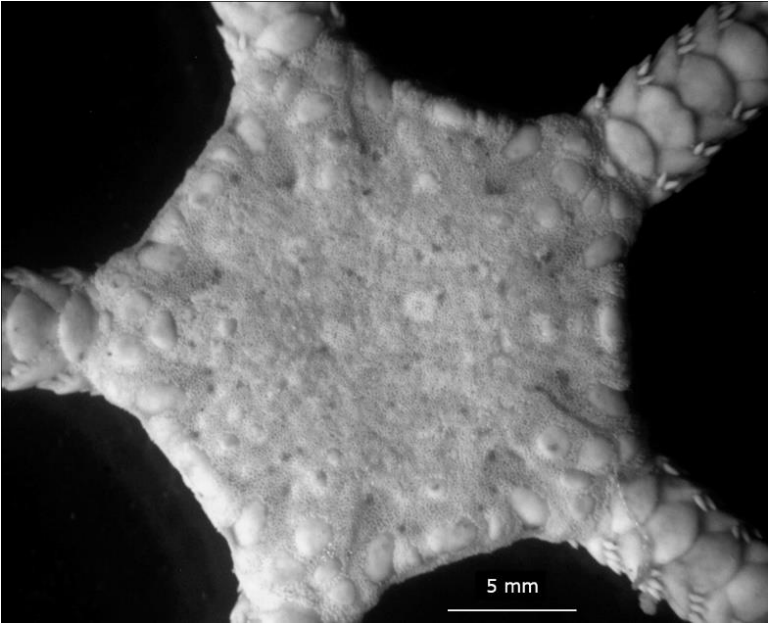
**Collection locations:** Cape Comorin, 51 m. CAPE COMORIN – 8° 15.041' N, 76° 57.085' E, 51 m, 7.9.2013 (FORVSS 319, St. 1). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00099

**Diagnosis:** Disc diameter 2 cm; arms about 4-5 times this length; disc covered above and below by rounded granulation, but with several bare, flat-topped plates along the periphery, including the radial shields which are small, elliptical and set widely apart. Oral plates free bare, triangular, and with a partially exposed supplementary oral shield just distal to it; adoral shields and oral plates covered by granulation; 6-7 oral papillae on each side, apart from the apical one; proximal papillae conical, while the distal ones somewhat scale like. Doral and ventral arm plates fan-shaped; arm spines 7 in number; shorter than the corresponding segment, and adpressed. Two tentacle scales, of which the inner one is bigger and rounded, outer scale smaller and overlapping the base of the ventral-most arm spine. Colour cream with brown or olive mottling.

**Substratum:** Sandy sediments.

**Distribution:** India, Thailand, Australia, Malaysia, Papua New Guinea, Palau, Guam, Japan.



**Figure 31.** *Ophiarchnella infernalis* (Müller & Troschel, 1842).  
Disc and arm base, dorsal and ventral view.

**29. *Ophioconis cupida* Koehler, 1905**

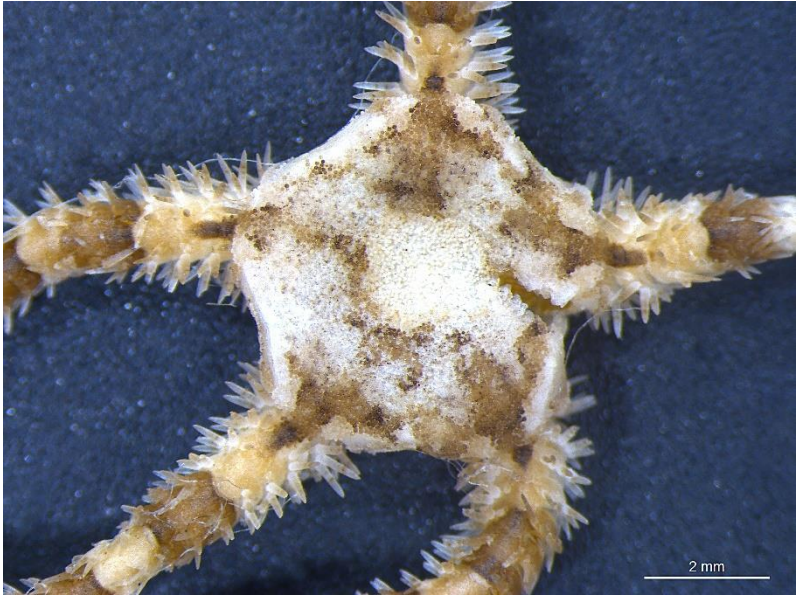
**Collection locations: Cape Comorin, 49 m.** CAPE COMORIN – 7° 59.26' N, 77° 10.767' E, 49 m, 15.11.2010 (FORVSS 282, St. 8). – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). Naturalist dredge.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00100, 00148

**Diagnosis:** Disc diameter 5 mm, arms 2-3 times this length; disc with a well-defined dorsolateral margin, and wholly covered with uniform rounded granulation, though these are dislodged rather easily to reveal very thin imbricating scales underneath; radial shields indistinct. Oral shields rounded or sub-triangular, covered partly by granulation, as are the adoral shield and oral plates; apical oral papillae indistinguishable from these granules; a row of 3 oral papillae along the edge of jaw. Teeth extremely wide, with a rounded, hyaline edge. Arm spines numbering 7-9, flattened, as long as the corresponding segment. Colour white light grey with dark mottling.

**Substratum:** Sandy sediments.

**Distribution:** Reunion, Saudi Arabia, India, Australia, Solomon Islands, New Caledonia, Guam, Japan.



**Figure 32.** *Ophioconis cupida* Koehler, 1905. Disc and arm base, dorsal and ventral view.



**30. *Ophiotreta stimulea* (Lyman, 1878)**

**Collection locations: Mangalore-Karwar, 553-953 m.**

MANGALORE – 12° 45.205' N, 74° 02.654' E, 553 m, 03.01.2019 (FORVSS 380, St. 4). KARWAR – 14° 27.99' N, 73° 01.52' E, 953 m, 09.04.2018 (FORVSS 374, St. 10). Naturalist dredge and demersal trawls.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00163

**Diagnosis:** Disc diameter up to 14 mm, arms 5-7 times this length; disc scales small, thin, overlapping; elongated bluntly tapering disc spines, 2-7 times as high as wide, with thorny spines on the sides. Distal margins of radial shields exposed. Oral shields as wide as long or wider; rhombic with a distal lobe; adoral shields long and narrow; 5-6 oral papillae on each side, the inner spiniform and outer ones with rounded margins. Dorsal arm plates fan-shaped, just in contact; basal plates with thorny spinelets along the distal margin, similar to disc spines. Ventral arm plates wider than long, broadly in contact, distal margins notched. Arm spines up to 10; long, bluntly pointed, not meeting along the dorsal mid-line. One oval tentacle scale. Colour grey to fawn.

**Substratum:** No information.

**Distribution:** Mozambique, Madagascar, Comoros, India, Australia, Indonesia, Philippines, China, Papua New Guinea, Solomon Islands, New Caledonia, Fiji, New Zealand, Taiwan, Japan.



**Figure 33.** *Ophiotreta stimulea* (Lyman, 1878). Disc and arm base, dorsal and ventral view.

### 31. *Ophiosphalma familiare* (Koehler, 1897)

**Collection locations:** Karwar, 953 m. KARWAR – 14° 27.99' N, 73° 01.52' E, 953 m, 09.04.2018 (FORVSS 374, St. 10). Demersal trawls.

**Voucher specimen No.:** CMLRE IO/SS/ECD/00217

**Diagnosis:** Disc diameter 12 mm, disc scales, arms about 3 times this length. Disc scales small and fine; radial shields large, oval, prominent; separated radially by a single row of wide disc scales. Small, conical genital papillae present along entire length of the genital slit. Oral shield spear-head shaped, with a prominent distal lobe; adoral shields long with widened distal lobes, nearly meeting radially and entirely contiguous proximally. Oral papillae numbering up to 8 on each side; wide, block-like and not separated. Dorsal arm plates small but present along entire length of arm, fan-shaped. First ventral arm plate very small, the subsequent four are large and decrease in size thereafter. Five short arm spines, separated from each other by about equal distances. Tentacle pores present on first 3 segments. Colour white.

**Substratum:** No information.

**Distribution:** Tanzania, India, Maldives.



**Figure 34.** *Ophiosphalma familiare* (Koehler, 1897). Disc and arm base, dorsal and ventral view.

## 32. *Ophiuroglypha kinbergi* (Ljungman, 1866)

### **Collection locations: Cape Comorin-Mangalore, 30-155 m.**

CAPE COMORIN – 7° 59.285' N, 77° 38.709' E, 30 m, 30.5.2009 (FORVSS 267I, St. 1). – 7° 47.649' N, 77° 30.26' E, 52 m, 30.5.2009 (FORVSS 267I, St. 2). – 8° 3' N, 77° 21' E, 32 m, 5.8.2005 (FORVSS 236, St. 21). – 7° 27.837' N, 77° 30.099' E, 100 m, 18.8.2009 (FORVSS 270II, St. 21). – 8° 2.207' N, 77° 29.956' E, 31 m, 16.5.2010 (FORVSS 275, St. 16). – 7° 48.582' N, 77° 29.613' E, 51 m, 16.5.2010 (FORVSS 275, St. 17). – 7° 59.26' N, 77° 10.767' E, 49 m, 15.11.2010 (FORVSS 282, St. 8). – 8° 15.041' N, 76° 57.085' E, 51 m, 7.9.2013 (FORVSS 319, St. 1). – 8° 8.634' N, 77° 9.403' E, 49 m, 9.12.2013 (FORVSS 321, St. 13). – 8° 2.041' N, 76° 59.838' E, 56 m, 9.12.2013 (FORVSS 321, St. 14). – 7° 59.373' N, 77° 18.765' E, 48 m, 9.12.2013 (FORVSS 321, St. 12). TRIVANDRUM – 8° 25.8' N, 76° 42' E, 58 m, 5.8.2005 (FORVSS 236, St. 19). – 8° 28.71' N, 76° 28.998' E, 102 m, 15.5.2010 (FORVSS 275, St. 12). – 8° 30' N, 76° 48' E, 51 m, 2.9.2011 (FORVSS 289, St. 29). – 8° 30.88' N, 76° 43.5' E, 50 m, 24.10.2014 (FORVSS 330, St. 77). KOLLAM – 9° 20.971' N, 75° 52.841' E, 111 m, 14.5.2010 (FORVSS 275, St. 7). – 9° 0.127' N, 75° 56.805' E, 155 m, 28.8.2011 (FORVSS 289, St. 9). KOCHI – 10° 2.347' N, 75° 59.773' E, 32 m, 26.12.2008 (FORVSS 260, St. 65). – 9° 56.189' N, 75° 50.576' E, 52 m, 8.8.2009 (FORVSS 270I, St. 23). – 9° 55.94' N, 76° 0.04' E, 33 m, 8.8.2009 (FORVSS 270I, St. 24). – 9° 54.546' N, 75° 35.493' E, 116 m, 13.5.2010 (FORVSS 275, St. 2). – 10° 30.535' N, 75° 31.676' E, 84 m, 4.8.2011 (FORVSS 288, St. 3). – 9° 46.075' N, 75° 41.438' E, 98 m, 27.2.2012 (FORVSS 295, St. 20). – 10° 24.5' N, 75° 39.9' E, 60 m, 8.7.2013 (FORVSS 315, St. 6). – 9° 58.353' N, 75° 49.661' E, 54 m, 30.7.2013 (FORVSS 317, St. 2). – 9° 58.138' N, 75° 39.155' E, 100 m, 31.7.2013 (FORVSS 317, St. 3). – 10° 29.57' N, 75° 31.7' E, 88 m, 12.10.2014 (FORVSS 330, St. 26). – 12° 49.75' N, 74° 30.35' E, 52 m, 15.12.2014 (FORVSS 333, St. 8). CALICUT – 11° 15.293' N, 75° 37.197' E, 30 m, 7.8.2009 (FORVSS 270I, St. 18). – 11° 12.421' N, 75° 5.558' E, 81 m, 7.8.2011 (FORVSS 288, St. 6). – 11° 19.179' N, 75° 18.903' E, 52 m, 22.2.2012 (FORVSS 295, St. 3). KANNUR – 11° 57.521' N, 74° 41.169' E, 83 m, 8.8.2011 (FORVSS 288, St. 10). KANNUR – 11° 56.195' N, 75° 0.762' E, 51 m, 23.2.2012 (FORVSS 295, St. 6). MANGALORE – 10° 0.08' N, 75° 49.99' E, 52 m, 13.12.2014 (FORVSS 333, St. 2). Naturalist dredge and Smith-McIntyre grab.

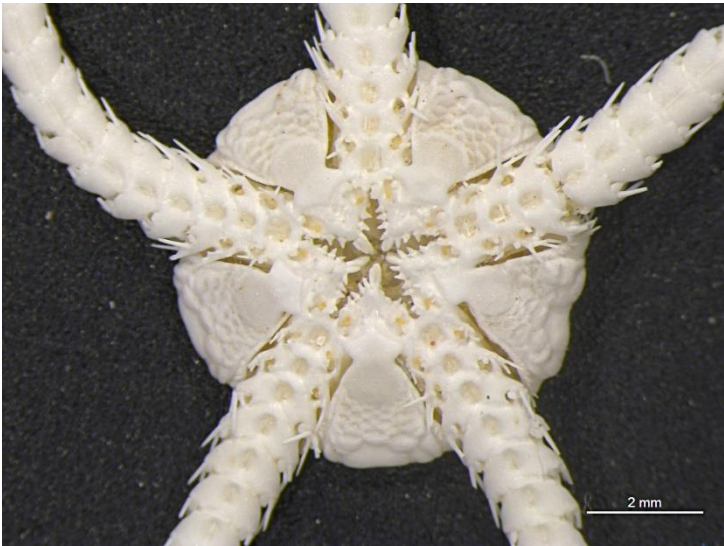
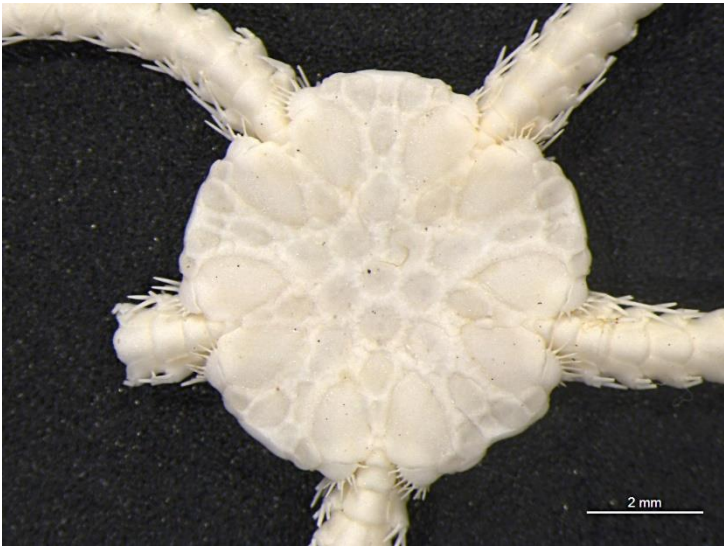
**Voucher specimen No.:** CMLRE IO/SS/ECD/00023-25, 00277, 00288

**Diagnosis:** Disc diameter up to 1 cm; arms 3-4 times this length. Disc flat, covered dorsally by thin plates and scales, of which the primaries and radial shields are distinct. Radial shields are tear-drop shaped and entirely separated. A pair of prominent arm combs, with long needle-like spines. Oral shield large; adoral shields prominent, 3-4 conical oral papillae on each side. Dorsal arm plates wider at the base and narrowing distally; ventral arm plates reduced; lateral arm plates meeting in the ventral mid line, where an oval depression is present; 8-10 needle-like arm spines, most as long as corresponding segment. First oral tentacle pore opening outside oral slit and surrounded by 5-6 scales; consequent tentacle pores with 2-4 scales, distally one or none. Colour mottled light and dark olive green dorsally, light ventrally.

**Substratum:** Sandy and silty sediments.

**Distribution:** Madagascar, Reunion, Egypt, Oman, Iran, India, Maldives, Myanmar, Thailand, Australia, Malaysia, Philippines, China, Papua New Guinea, Guam, Micronesia, New Zealand, U.S.A. (Hawaii).

**Remarks:** *Ophiuglypha sinensis* Lyman, 1871 reported from Indian waters, is a synonym (Rowe & Gates 1995).



**Figure 35.** *Ophiuroglypha kinbergi* (Ljungman, 1866). Disc and arm base, dorsal and ventral view.

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