

New records of brittle stars (Echinodermata: Ophiuroidea) from the Lakshadweep atolls, northern Indian Ocean, with notes on *Indophioderma ganapatii* Sastry, Marimuthu & Rajan, 2019

USHA V. PARAMESWARAN^{1*}, B. MOHAMMED NOWSHAD^{2,3}, SUDHANSHU DIXIT¹,
HASHIM MANJEBRAYAKATH¹, K.K. IDREESBABU² & N. SARAVANANE¹

¹Centre for Marine Living Resources & Ecology, Ministry of Earth Sciences, Puthuvype, Kochi 682508, Kerala, India

²Department of Science and Technology, Kavaratti 682555, Union Territory of Lakshadweep, India

³School of Ocean Science and Technology, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi 682506, Kerala, India

^{1*}  ushaparam25@gmail.com;  <https://orcid.org/0000-0001-5036-568X>

^{2,3}  bnoushb@gmail.com;  <https://orcid.org/0000-0002-1166-8167>

¹  sid2130@gmail.com;  <https://orcid.org/0000-0003-0056-1409>

¹  hashim@cmlre.gov.in;  <https://orcid.org/0000-0001-6556-7364>

²  idreesbabu@gmail.com;  <https://orcid.org/0000-0002-5070-2401>

¹  saravanane@cmlre.gov.in;  <https://orcid.org/0000-0003-3405-4923>

*Corresponding Author

Abstract

The paper presents three new records of brittle stars for Indian waters, collected from the Lakshadweep atolls (northern Indian Ocean)—*Ophiarachnella septemspinosa* (Müller & Troschel, 1842), *Ophiocoma cynthiae* Benavides-Serrato & O'Hara, 2008 & *Ophiomoeris obstricta* (Lyman, 1878). Further, this paper also discusses the validity of two recently described taxa from this archipelago, the genus *Indophioderma* with the species *Indophioderma ganapatii* Sastry, Marimuthu & Rajan, 2019. A checklist of brittle stars reported so far from the Lakshadweep Islands is provided, which includes 40 valid species—32 from shallow (reef) areas and 8 deep-sea (>200m) species.

Keywords: Lakshadweep, biodiversity, Indian Ocean, coral reefs

Introduction

The Lakshadweep Archipelago, located on the northern part of the Chagos-Maldives-Laccadive ridge is one of the major coral reef ecosystems in India. It comprises 12 coral atolls, three reefs and five submerged banks, with a total of 36 islands and islets. The reef-associated biodiversity of the Lakshadweep is known from very few works, particularly regarding brittle stars (Koehler 1898; Bell 1902; James 1969, 1982, 1989; Sastry 1991; Price & Rowe 1996; Sastry *et al.* 2019).

Recent biodiversity surveys around the Lakshadweep atolls have led to the collection of several new records among brittle stars. This paper describes three new records for Indian waters—*Ophiocoma cynthiae* Benavides-Serrato & O'Hara, 2008, *Ophiarachnella septemspinosa* (Müller & Troschel, 1842), and *Ophiomoeris obstricta* (Lyman, 1878) from the Agatti and Kavaratti atolls. Among these, *O. obstricta* was collected incidentally from ~350m depth off Kavaratti. This paper also summarises the known ophiuroid diversity of the Lakshadweep atoll. The validity of recently described genus *Indophioderma* with the species *Indophioderma ganapatii* Sastry, Marimuthu & Rajan, 2019 is discussed.

Materials and methods

Biodiversity surveys were carried out by the Centre for Marine Living Resources & Ecology, Kochi (CMLRE) and by the Department of Science & Technology, Union Territory of Lakshadweep (DST-UTL) to document the biodiversity of echinoderms in the Lakshadweep atolls, by SCUBA diving (outer reef), skin diving and intertidal collections. A specimen of *Ophiarachnella septemspinosa* (Müller & Troschel, 1842) was collected by SCUBA diving from Agatti atoll (Fig.1). *Ophiocoma cynthiae* Benavides-Serrato & O'Hara, 2008 was collected at intertidal depths along the eastern side of Agatti and Kavaratti Islands. The collection of *Ophiomoeris obstricta* (Lyman, 1878) was an incidental one, as it was found in the storage tank of the NIOT Seawater Desalination Facility at Kavaratti, which stores near-bottom seawater from ~350m depth off the northern side of the island. The organisms were all photographed *in situ* and *ex situ*, and preserved in ethanol. Taxonomic identification was carried out following taxonomic keys and references (e.g. Clark & Rowe 1971; O'Hara & Stöhr 2006; O'Hara *et al.* 2018) and specimens were photographed using a LEICA (M80) Stereozoom Microscope fitted with a LEICA (MC170 HD) camera. The disc diameter (d.d.) of *Ophiomoeris obstricta* was measured using the accompanying LEICA LAS4 image analysing software, while those of *Ophiocoma cynthiae* and *Ophiarachnella septemspinosa* were measured using a digital caliper. Dental plates of *Ophiocoma cynthiae* were dissected out, immersed in sodium hypochlorite to remove tissue, and then washed with distilled water before being photographed. A Jeol JSM-IT500 Scanning Electron Microscope at the National Institute of Ocean Technology, Chennai was used to obtain SEM images of *Ophiomoeris obstricta*. Descriptive terminology in this paper follows Stöhr *et al.* (2012) for general morphological features, and Hendler (2018) for buccal armature. All specimens are preserved in ethanol and deposited at the Referral Centre, Centre for Marine Living Resources & Ecology (CMLRE), Kochi and at the Marine Taxonomy Reference Laboratory, Department of Science and Technology (MTRL-DST), Kavaratti.

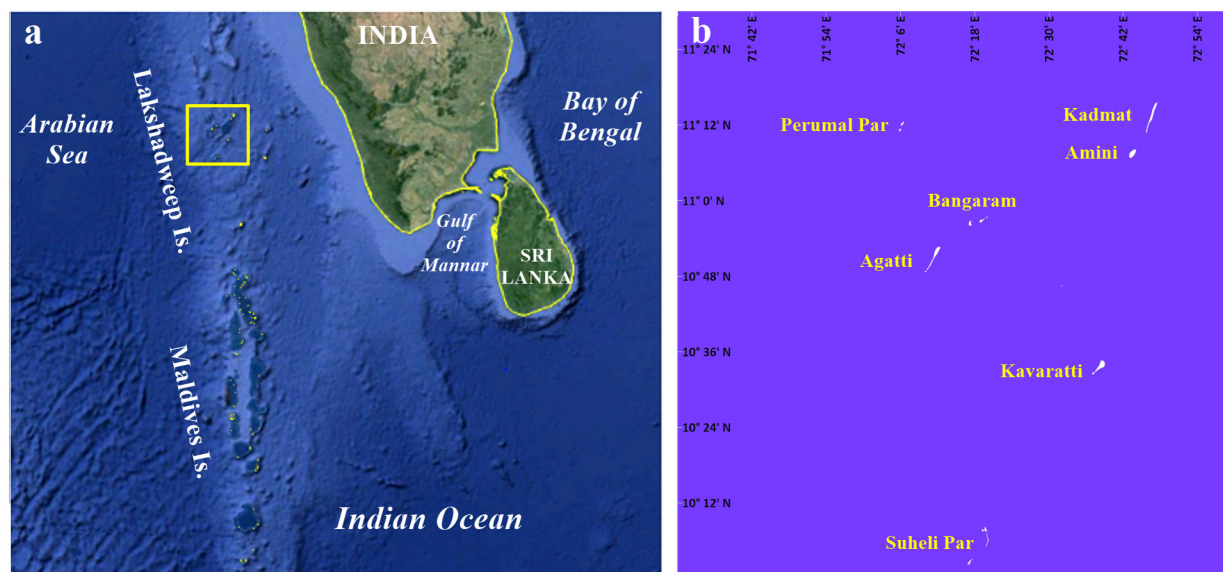


FIGURE 1. Map showing (a) location of the Lakshadweep Islands in the north central Indian Ocean, and (b) map of north-western Islands of the Lakshadweep, including Agatti and Kavaratti islands.

Taxonomic account

Phylum Echinodermata

Class Ophiuroidea Gray, 1840

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

Family Ophiacanthidae Ljungman, 1867

Genus *Ophiomoeris* Koehler, 1904
***Ophiomoeris obstricta* (Lyman, 1878)**
 (Fig. 2a-f)

Ophioceramis (?) *obstricta* Lyman, 1878: 124–125, pl. 6 (164–166).

Ophioceramis (?) *obstricta*—Lyman 1882: 26–27, pl. 11 (1–3).

Ophiomoeris obstricta—Koehler 1904: 17; 1922: 38–39, pl. 5 (3–4); 1930: 55.—Matsumoto 1917: 140.—O'Hara & Stöhr 2006: 120–123, fig. 16(A–G).

Ophiomoeris spinosa Koehler, 1904: 17–18, pl. 4 (1–3).—Koehler 1922: 40; 1930: 55–56.

Ophiurases obstrictus H. L. Clark, 1911: 250–252, fig. 122.

Ophiomoeris projecta Matsumoto, 1915: 65.—Matsumoto 1917: 141–143, fig. 35.—McKnight 1975: 70; 1993: 174, 187.—Imaoka *et al.* 1991: 124, fig. 47.

Ophiomoeris parva H. L. Clark, 1939: 39–41, fig. 4–5.

Ophiomoeris inflata A. H. Clark, 1949: 15–17, fig. 5.

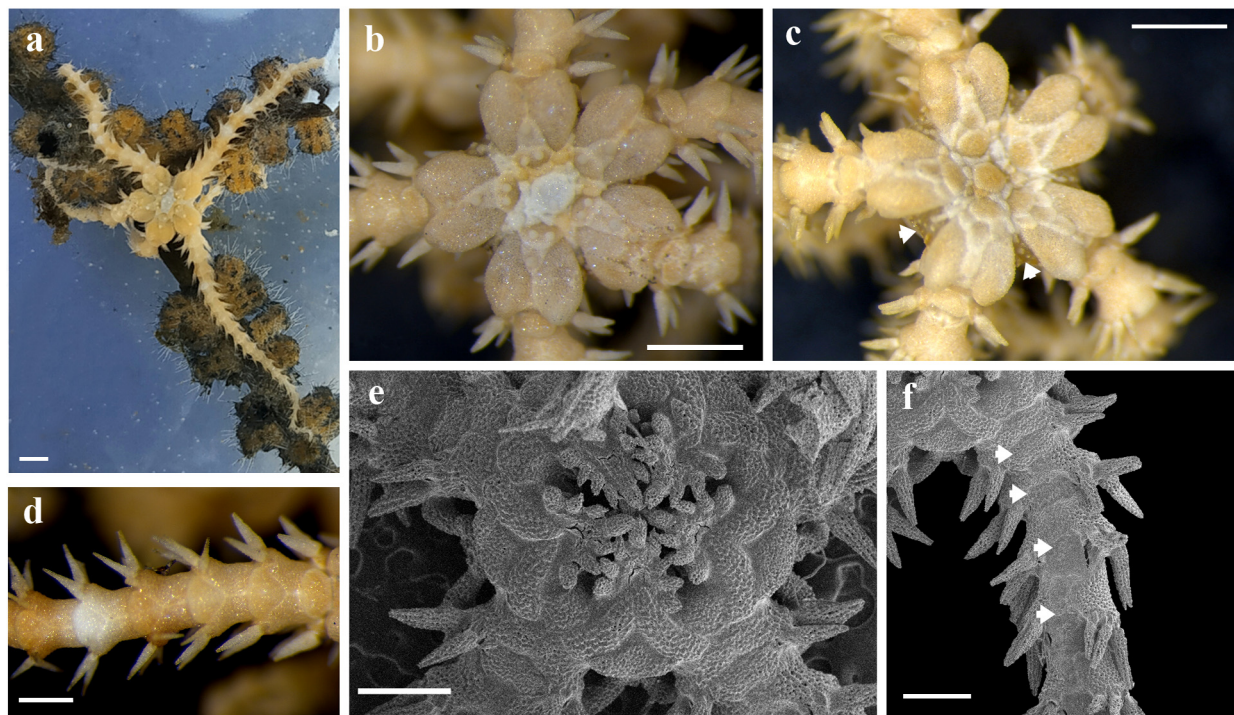


FIGURE 2. *Ophiomoeris obstricta*, a, b, d: IO/SS/ECD/00234, c: MTRL/DST/E0301, e-f: IO/SS/ECD/00235. (a) live specimen, *ex situ*, (b, c) disc, dorsal view, ventro-lateral interradii indicated with arrows, (d) proximal arm, dorsal view, (e) SEM of disc, ventral view, and (f) SEM of proximal arm, ventral view, location of ventral arm plates indicated with arrows. Scale bar: 1mm (a-c) and 0.5mm (d-f).

Material examined: Kavaratti Island—Seawater tank of NIOT Desalination Plant, collecting water from ~350m depth (10° 34.44' N, 72° 38.40' E), coll. M. Nowshad on 12.12.2019, 4 specimens (CMLRE IO/SS/ECD/00234, 00235; MTRL/DST/E0301, E0302).

Description: D.d. 2–3 mm, disc deeply incised interradially and sunken centrally; arms noded and coiled ventrally below the disc. Central primary plate distinct, surrounded by smaller, polygonal scales; these scales are fewer in smaller specimens (Fig. 2b-c). Radial shields large, 1/3 of d.d., distinctly petal-like—elongate with a rounded distal margin, having a gentle but distinct groove centrally with abradial margin gently curling upwards; pairs separated proximally by 1–2 wedge-shaped radial plates and contiguous distally (completely separated by a single row of plates in IO/SS/ECD/00235); rounded conical granules present on a few or all disc plates and sometimes along inner edge of radial shields (Fig. 2b-c). Ventral inter-radial areas small, skin-covered and embedded with small scale-like plates, some of which are somewhat tumid and granule-like (Fig. 2c). Genital slits small but distinct, more or less vertical (Fig. 2e). Oral frame as wide as long; oral shields fan shaped, 1.5 times wider than long (Fig. 2e). Adoral shields more or less crescent shaped, not separating oral shield from first ventral arm plates. Ventralmost tooth rounded conical; ventrolateral edge of oral plate bearing spaced papillae in the following configuration—one infradental papilla and one (occasionally two) lateral oral papilla—both pointed with rugose margins, along with one short and rounded adoral shield spine (Fig. 2e). Dorsal arm plates fan shaped with rounded distal margin, wider

than long basally, separated from each other throughout (Fig. 2d). Ventral arm plate very thin, oblong, twice as wide as long, with a notched distal margin; first few intact, subsequent plates fragmented (Fig. 2f). Lateral arm plates elongate, broadly in contact dorsally and ventrally, separating dorsal and ventral arm plates throughout. Arm spines conical, two at the first segment, up to six at subsequent segments and decreasing to three distally; dorsal-most spine longest, as long as segment; ventral-most spine half this length, transformed into hooks towards the arm tip (Fig. 2f). A single, minute, spine-like tentacle scale present on first two segments (Fig. 2f).

Colour: Cream with light or white mottling on the disc and arms.

Distribution: Madagascar, Comoros, Maldives, India (Lakshadweep), Indonesia, Papua New Guinea, New Caledonia, Philippines, Vanuatu, Australia, New Zealand, Japan, Hawaii; 35–1100m (OBIS, 2020a).

Biological association: The specimens were found attached to an unidentified gorgonian (Fig. 2a).

Remarks: O'Hara & Stöhr (2006) synonymised *Ophiomoeris spinosa* Koehler, 1904, *O. projecta* Matsumoto, 1915, *O. parva* H. L. Clark, 1939 and *O. inflata* A. H. Clark, 1949 with *O. obstricta* Lyman, 1878 after extensive examination of type and other materials. The characters of the present specimens fall within the range of variations documented for the expanded *O. obstricta* and they are herein assigned to this species. The characters of the present specimens match with the type description of *O. parva* H. L. Clark, 1939, collected off the nearby Maldives Islands, except for the relatively longer proximal arm spines and complete lack of granules in the latter, which O'Hara & Stöhr (2006) considered to be juvenile characters. O'Hara & Stöhr (2006) suggest that the wide range of morphological variation in *Ophiomoeris obstricta* may be indicative of a cryptic species-complex, which can be resolved only with molecular analysis of a wide range of specimens from across its distribution range.

Family Ophiocomidae Ljungman, 1867

Genus *Ophiocoma* L. Agassiz, 1835

Ophiocoma cynthiae Benavides-Serrato & O'Hara, 2008

(Fig. 3a–f)

Ophiocoma cynthiae Benavides-Serrato & O'Hara, 2008: 51–55, fig. 1–2.—Boissin *et al.* 2016: 283, fig. 4a.

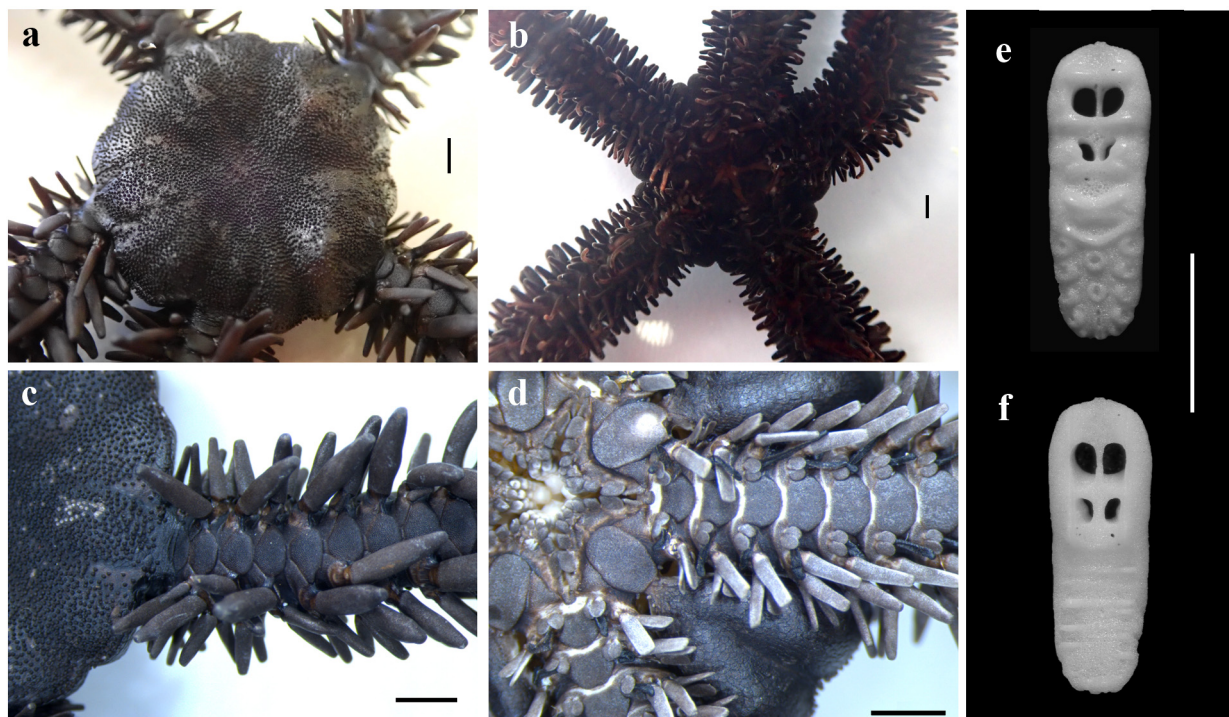


FIGURE 3. *Ophiocoma cynthiae*, a–d: IO/SS/ECD/00229, e–f: IO/SS/ECD/00230. (a) live specimen, *ex situ*, (b) disc, dorsal view, (c) proximal arm, dorsal view, (d) disc and proximal arm, ventral view, (e, f) dental plate, external and internal view, respectively. Scale bar: 2mm.

Material examined: Agatti Island—intertidal, eastern side (10° 50.73' N, 72° 11.35' E), coll. U. Parameswaran on 05.11.2018 by hand, 2 specimens (CMLRE IO/SS/ECD/00229, 00230); Kavaratti Island—intertidal, eastern side (10° 30.18' N, 72° 27.06' E), coll. M. Nowshad on 28.11.2018, 1 specimen (MTRL/DST/E00303).

Description: D.d. up to 25 mm, disc rounded with scalloped margin; arms ~4 times d.d. Disc covered dorsally and ventrally with fine scales; dorsal side bearing large, rounded granules which are packed more densely in the centre (Fig. 3a, c); ventral side lacking armament except rounded or tall granules bordering the genital slits and oral shield (Fig. 3d). Oral shield oblong to oval, longer than broad; adoral shields, small, triangular, not contiguous radially or inter-radially (Fig. 3d). Dental plate oblong, with two foramina, the septum of the second much thicker than the first; dental papillae in three columns in the upper third of the plate (Fig. 3e-f). Teeth square-tipped with hyaline edges; apex of dental plate with cluster of ~10 tooth papillae in three columns; one short infradental papilla on each side, followed by a leaf-like secondary adoral shield spine and a much wider adoral shield spine; Lyman's ossicle projecting between the adoral shield spine and first ventral arm plate (Fig. 3d). Dorsal arm plates thick, fan-shaped, wider than long; each overlain proximally by the preceding plate (Fig. 3c). Ventral arm plates with straight proximal margin, broadly rounded distal margin and recurved lateral margin (Fig. 3d). Arm spines two at first segment, increasing up to five, and alternating in number through much of the arm; basal arm spines flattened and long, subsequently becoming cylindrical with rounded tips; alternating dorsal-most arm spine distinctly longer and club-shaped, widest in the middle or just beyond the middle; three arm spines in the distal third of arm, all long, slender and tapering (Fig. 3a-d). Two overlapping oval tentacle scales, decreasing to one in the distal end of arm (Fig. 3d).

Colour: In life, uniformly black with dull brownish-grey tentacles (Fig. 3b); preserved specimen black to grey, including tentacles (Fig. 3a, c-d).

Distribution: Saudi Arabia, Djibouti, Comoros, Reunion, India (Lakshadweep), Papua New Guinea, Australia, New Caledonia, Fiji, Micronesia, Philippines, Taiwan, Japan; intertidal-26m (OBIS, 2020b).

Remarks: *Ophiocoma cynthiae* was separated from *O. erinaceus* Müller & Troschel, 1842 by Benavides-Serrato & O'Hara (2008) based on molecular evidence (O'Hara *et al.* 2004). The two species can be distinguished chiefly by the nature of ventral disc granulation (nearly complete in *O. erinaceus* and nearly absent in *O. cynthiae*), the colour of tube feet in live specimens (bright red in *O. erinaceus* and grey in *O. cynthiae*), and the morphology of the dental plate. Based on these characters, the present specimens from Lakshadweep clearly belong to *O. cynthiae*. Extensive field surveys in recent years by the authors (particularly MNB & IBKK) have observed this species (with brown-grey tentacles) commonly in all atolls of the Lakshadweep, but have not retrieved a single specimen with red tentacles (characteristic of *O. erinaceus*). While *O. erinaceus* has been reported from the Lakshadweep (Koehler 1898; Bell 1902; James 1969, 1982; Sastry 1991; Price & Rowe 1996; Sastry *et al.* 2019), it is possible that these actually represent records of *O. cynthiae*.

Family Ophiidermatidae Ljungman, 1867

Genus *Ophioarachnella* Ljungman, 1872

Ophiarachnella septemspinosa (Müller & Troschel, 1842)

(Fig. 4a-f)

Ophiarachna septemspinosa Müller & Troschel, 1842: 105–106.

Pectinura septemspinosa—Lütken 1869: 15.—Lyman 1882: 17.—Döderlein 1888: 830–831, pl. 32(4a–c).—de Lorient 1893: 395–397, pl. 13(2).—Koehler 1905: 9.

Pectinura rigida Lyman, 1874: 224.

Ophiarachna armata Troschel, 1879: 137–138.

Ophiarachnella septemspinosa—H. L. Clark 1909: 126; 1938: 349–350; 1946: 263–264.—Koehler 1930: 273.—Cherbonnier & Guille 1978: 218–219, pl. 16(1–2).—Guille & Vadon 1985: 64.—Marsh *et al.* 1993: 62.—Olbers *et al.* 2015: 110–111, fig. 9(A–B).—Boissin *et al.* 2016: 288–289, fig. 5(e).

Material examined: Agatti Island—western reef (10° 51.97' N, 72° 12.42' E, 20m), coll. S. Dixit on 06.11.2018 by SCUBA diving, 1 specimen (CMLRE IO/SS/ECD/00235).

Description: D.d. 36 mm, disc pentagonal, arms 7–8 times d.d. Disc covered uniformly with rounded granules, on dorsal and ventral side, leaving only small, dark, circular radial shields bare (Fig 4a-c). Oral shield large, spear-

head shaped, longer than broad; supplementary oral shields small, broadly oval, some bare; adoral shields small, triangular, not contiguous; oral plates covered by granules (Fig. 4d). Teeth broadly rounded; 1–2 large, rounded, scale like tooth papillae, followed by three scale-like oral papillae—corresponding with infradental papilla, secondary adoral shield spine and adoral shield spine; Lyman’s ossicle projecting between the latter and the first ventral arm plate (Fig. 4d). Genital slits long, reaching edge of the disc (Fig. 4d). Dorsal arm plates rectangular, faintly carinate, over twice as wide as long, distal edge distinctly scalloped (Fig. 4b–c). Ventral arm plates with concave inner and convex outer margins (Fig. 4d–e). Arm spines increasing from two to nine in the basal segments; spines adpressed, flat and pointed; spines as long as segment, except the ventral-most which is twice as long, distinctly flattened with squared-off tips (Fig. 4e–f). Two rounded leaf-like tentacle scales basally, becoming one distally (Fig. 4e).

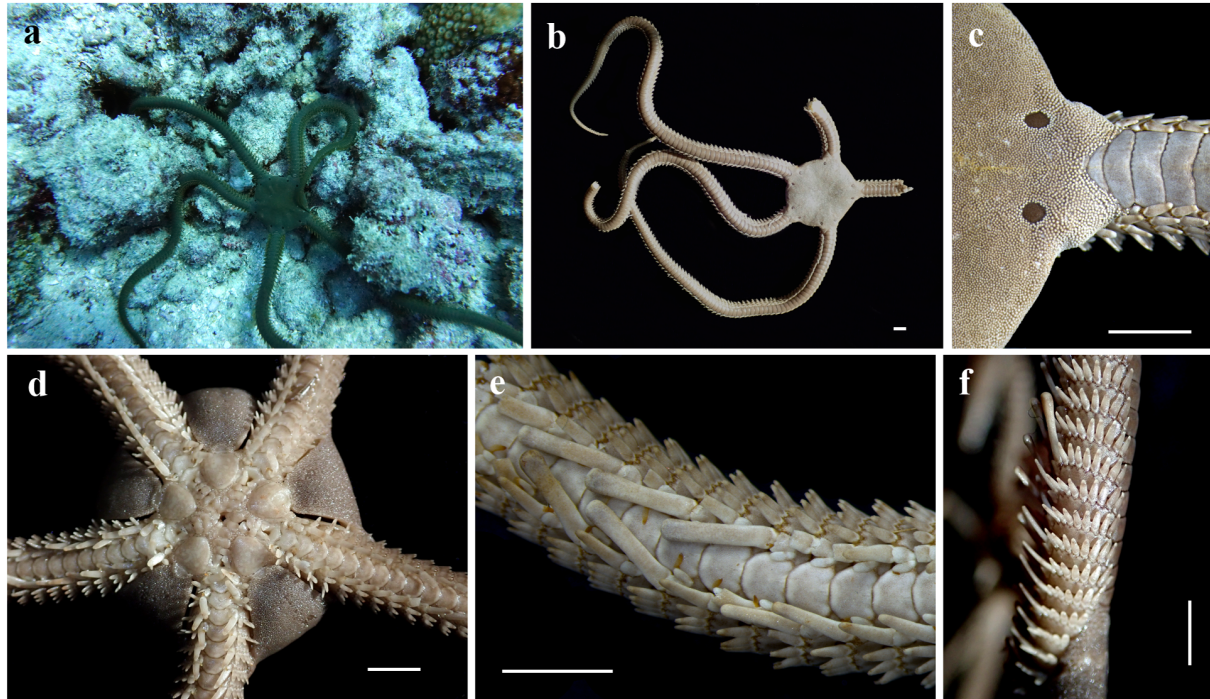


FIGURE 4. *Ophiarachnella septemspinosa*, IO/SS/ECD/00235. (a) live specimen, *in situ*, (b) preserved specimen, (c) arm base, dorsal view showing radial shields and dorsal arm plates, (d) disc, ventral view showing jaw apparatus, and proximal part of arms, (e) middle arm, ventral view showing enlarged ventral arm spines, and (f) proximal part of arm, lateral view showing number, size and arrangement of arm spines. Scale bar: 4mm.

Colour: In life, uniformly greyish-green with dark green radial shields; preserved specimen dull grey with dark brownish-grey radial shields.

Distribution: Saudi Arabia, Kenya, South Africa, Madagascar, Reunion, Mauritius, Maldives, Sri Lanka, Indonesia, Christmas Island, Papua New Guinea, Australia, New Caledonia, Fiji, Philippines, Japan; intertidal to 50m (OBIS, 2020c).

Remarks: This species has never previously been collected from Indian waters, and therefore does not appear in the detailed annotated list of Indian echinoderms compiled by Sastry (2007). It has been recorded from Sri Lanka by Döderlein (1888) and from the Maldives by Clark & Davies (1965). James (1986), thus, included it in his table of shallow-water species from ‘Indian Seas’, with positive records for ‘Sri Lanka’ as well as the ‘Maldives & Lakshadweep’ regions. Based on this, Samuel *et al.* (2017) erroneously included it in their ‘updated checklist of echinoderms from Indian waters’. However, the present collection represents the first valid report of this species from the India’s exclusive economic zone (EEZ).

Discussion

A literature survey reveals that a total of 40 brittle star species (Table 1) have been reported from the Lakshadweep Islands, including the three species reported herein—32 species from shallow (reef) areas and eight species from deep-sea (>200m). The earliest report of shallow-water brittle stars from the Lakshadweep was made by Koehler

(1898) based on collections of the RIMS *Investigator*. Subsequent reports were made by Bell (1902), James (1969, 1982, 1989), Price & Rowe (1996), Sastry (1991) and Sastry *et al.* (2019). The deep-sea fauna (beyond coral reefs) around the Lakshadweep was known only from a handful of trawls by RIMS *Investigator* (around Kavaratti, Minicoy and Androth Islands at ~1300-2200m depths), which collected a total of seven species (Koehler 1897, 1899).

Sastry *et al.* (2019) listed 38 brittle star species which were known from the Lakshadweep, out of which *Ophiocoma lubrica* Koehler, 1898 is considered a synonym of *Ophiocoma scolopendrina* (Lamarck, 1816) and is therefore excluded in Table 1. The following five deep-sea species listed by Sastry *et al.* (2019) are also excluded, as their original collection locations fall outside the Lakshadweep region (as inferred from Koehler 1897 & Sastry 2007): *Asteronyx loveni* Müller & Troschel, 1842, *Ophiotreta matura* (Koehler, 1904), *Amphiura dispar* Koehler, 1897, *Histampica duplicata* (Lyman, 1874), *Amphiura lorioli* (Koehler, 1897).

The most recent work on Lakshadweep echinoderms described a new genus and species—*Indophioderma ganapatii* Sastry, Marimuthu & Rajan, 2019 from Agatti Island, based on a single specimen (ZSI/GNC/E2160/2). The exact collection location (coordinates, depth etc.) of the holotype has not been provided by the authors. Images of the type specimen match well with the genus *Ophiopeza* Peters, 1851, most importantly the enlarged and convex, granule-covered, marginal disc plates, which is a distinguishing character for this genus (Vail & Rowe 1989). This assessment is expressed in the World Register of Marine Species as well, where the genus *Indophioderma* is categorised as *taxon inquirendum* (Stöhr *et al.* 2020). Biodiversity surveys by Centre for Marine Living Resources & Ecology (CMLRE) have photographed an *Ophiopeza* species at ~20m depth off the north eastern side of Agatti Island (Fig. 5). In the photographs presented by Sastry *et al.* (2019) (pg. 367), the enlarged and completely granule-covered marginal disc plates, the shape of the dorsal and ventral arm plates as well as plates of the oral apparatus, the numbers and shape of arm spines, oral papillae, colour of the specimen etc. are comparable with *O. spinosa* (Ljungman, 1867), a species widely distributed in the Indo-west Pacific (including nearby Maldives and Sri Lanka). In describing the type specimen of *I. ganapatii*, the authors have overlooked the enlarged marginal plates which are noticeable in their photograph. While the description notes only one tentacle scale, two are clearly discernible in the photos, the outer one overlapping the base of the ventral-most arm spine, as described for *O. spinosa* (see Vail & Rowe 1989). The only difference between the pictured specimen and descriptions of *O. spinosa* is the absence of granules on the oral plates in the former, which could have been lost during collection or preservation, or could represent a localized morphological variation. Thus, there remains very little justification for the erection of not only a new species for the Lakshadweep material, but also a new genus based on a single specimen. Apart from this species, the photo provided by Sastry *et al.* (2019) for *Breviturma dentata* (Müller & Troschel, 1842) are actually of *B. pica* (Müller & Troschel, 1842) and the photo for *Ophiocoma erinaceus* (Müller & Troschel, 1842) indicates that it may be a misidentification of *O. cynthiae* Benavides-Serrato & O'Hara, 2008. Although historic records of *O. erinaceus* from the Lakshadweep are unreliable due to the confusion with *O. cynthiae* (see remarks above), both species are retained in the checklist (Table 1), since lack of recent observations does not justify complete removal of a species from the list.

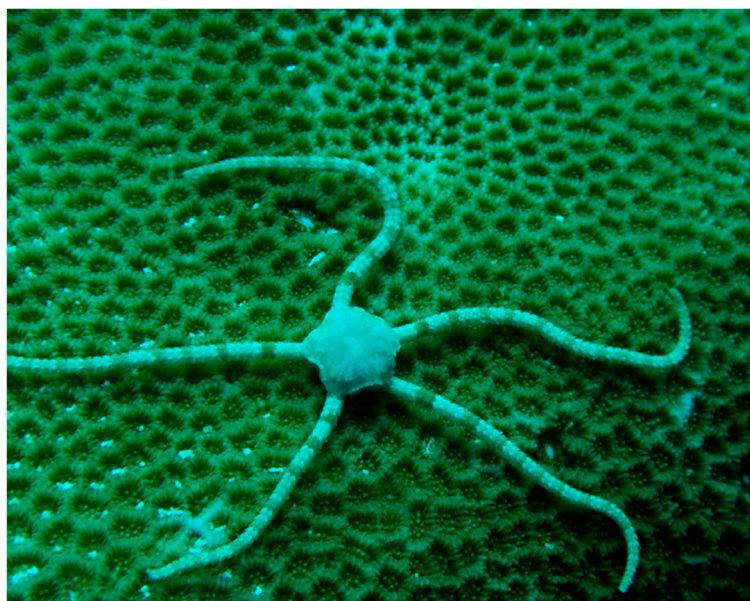


FIGURE 5. *Ophiopeza* sp. photographed *in situ* at 20m depth off Agatti Island on 06.11.2018 (S. Dixit)

Thirty-two species of reef-associated brittle stars have been reported thus far from the Lakshadweep atolls. In comparison, the two other coral archipelagos of the northern Indian Ocean—the Andaman & Nicobar archipelago and the Maldives archipelago are reported to harbour ~85 and ~23 shallow-water brittle star species, respectively (sources: Sastry 2007 and OBIS, respectively). The relatively higher diversity in the Andaman & Nicobar Islands may be due to their larger geographic area, and also since they fall within the Indo-Pacific hotspot of brittle-star diversity (Stöhr *et al.* 2012). It is to be noted that when compared to the Lakshadweep, relatively more work has been published on the brittle stars of the Andaman & Nicobar (summarised in Sastry 2005). Brittle star records in the Lakshadweep are almost all from three of the 12 atolls—Kavaratti, Minicoy and Agatti, with very few exceptions (e.g. James 1969, Sastry 1991, Price & Rowe 1996), and many atolls have never been surveyed at all. Considering that intensified surveys in recent years added seven species to the inventory of Lakshadweep brittle stars (Sastry *et al.* 2019 and the present work), it is more likely that the regional diversity is underreported. Based on available information, it appears that the species composition of the Lakshadweep and nearby Maldives Islands are more or less similar; but this cannot be treated as a conclusive statement, since both regions are relatively poorly studied, and little to no information has been published on the brittle stars of the Maldives for several decades (Clark & Davies 1965). Sampling efforts in ecologically significant but poorly explored regions like the Lakshadweep should be intensified, for better understanding and conserving marine biodiversity.

TABLE 1. List of brittle stars reported from the Lakshadweep region

No.	Species	Source
1	<i>Amphiophiura paupera</i> (Koehler, 1897) [§]	Koehler (1897)
2	<i>Amphiophiura radiata</i> (Lyman, 1878) [§]	Koehler (1897)
3	<i>Amphipholis squamata</i> (Delle Chiaje, 1828)	James (1989), Sastry (1991)
4	<i>Bathypectinura heros</i> (Lyman, 1879) [§]	Koehler (1897)
5	<i>Breviturma brevipes</i> (Peters, 1851)	Koehler (1898), Bell (1902), James (1969, 1982), Sastry (1991)
6	<i>Breviturma dentata</i> (Müller & Troschel, 1842)	James (1969, 1982), Sastry (1991), Sastry <i>et al.</i> (2019)
7	<i>Breviturma pica</i> (Müller & Troschel, 1842)	James (1969, 1982), Sastry (1991), Price & Rowe (1996), Sastry <i>et al.</i> (2019)
8	<i>Cryptopelta granulifera</i> (H. L. Clark, 1909)	Price & Rowe (1996)
9	<i>Gymnolophus obscura</i> (Ljungman, 1867)	Sastry <i>et al.</i> (2019)
10	<i>Indophioderma ganapatii</i> Sastry, Marimuthu & Rajan (2019) [#]	Sastry <i>et al.</i> (2019)
11	<i>Macrophiothrix demessa</i> (Lyman, 1861)	Sastry (1991), Price & Rowe (1996)
12	<i>Macrophiothrix longipeda</i> (Lamarck, 1816)	Sastry (1991), Price & Rowe (1996), Sastry <i>et al.</i> (2019)
13	<i>Macrophiothrix nereidina</i> (Lamarck, 1816)	Bell (1902), James (1969), Sastry (1991)
14	<i>Macrophiothrix propinqua</i> (Lyman, 1861)	Sastry (1991)
15	<i>Ophiactis savignyi</i> (Müller & Troschel, 1842)	James (1969), Sastry (1991)
16	<i>Ophiarachnella septemspinosa</i> (Müller & Troschel, 1842) [*]	Present paper
17	<i>Ophiochaeta hirsuta</i> Lütken, 1869	Price & Rowe (1996)
18	<i>Ophiocoma anaglyptica</i> Ely, 1944	James (1969), 1982, Sastry (1991)
19	<i>Ophiocoma cynthiae</i> Benavides-Serrato & O'Hara, 2008 [*]	Present study
20	<i>Ophiocoma erinaceus</i> Müller & Troschel, 1842	Koehler (1898), Bell (1902), James (1969, 1982), Sastry (1991), Price & Rowe (1996), Sastry <i>et al.</i> (2019)
21	<i>Ophiocoma scolopendrina</i> (Lamarck, 1816)	Koehler (1898), Bell (1902), James (1969, 1982), Sastry (1991)
22	<i>Ophiocomella sexradia</i> (Duncan, 1887)	James (1969), Sastry (1991)
23	<i>Ophiocomella valenciae</i> (Müller & Troschel, 1842)	Bell (1902)

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TABLE 1. (continued)

No.	Species	Source
24	<i>Ophiolepis cincta</i> Müller & Troschel, 1842	James (1989), Sastry (1991)
25	<i>Ophiolepis superba</i> H.L. Clark, 1915	James (1989), Sastry (1991), Price & Rowe (1996)
26	<i>Ophiomastix annulosa</i> (Lamarck, 1816)	Bell (1902), James (1969), Sastry (1991)
27	<i>Ophiomastix elegans</i> (Peters, 1851)	Sastry <i>et al.</i> (2019)
28	<i>Ophiomoeris obstricta</i> (Lyman, 1878) ^{§*}	Present paper
29	<i>Ophiomyxa australis</i> Lütken, 1869	James (1969), Sastry (1991)
30	<i>Ophionereis porrecta</i> Lyman, 1860	Koehler (1898), Sastry (1991)
31	<i>Ophioplinthaca rudis</i> Koehler, 1897 [§]	Koehler (1897)
32	<i>Ophiothrix (Acanthophiothrix) lepidus</i> de Loriol, 1893	Koehler (1898)
33	<i>Ophiothrix (Acanthophiothrix) purpurea</i> von Martens, 1867	Sastry (1991), Sastry <i>et al.</i> (2019)
34	<i>Ophiothrix (Acanthophiothrix) vigelandi</i> A.M. Clark, 1968	Sastry (1991), Sastry <i>et al.</i> (2019)
35	<i>Ophiothrix (Keystonea) nereidina</i> (Lamarck, 1816)	James (1969), Sastry (1991)
36	<i>Ophiothrix (Ophiothrix) marginata</i> Koehler, 1905	Sastry <i>et al.</i> (2019)
37	<i>Ophiothrix (Ophiothrix) trilineata</i> Lütken, 1869	Sastry (1991)
38	<i>Ophiotrochus panniculus</i> Lyman, 1878 [§]	Koehler (1897)
39	<i>Ophiura aequalis</i> (Lyman, 1878) [§]	Koehler (1897)
40	<i>Ophiura irrorata</i> (Lyman, 1878) [§]	Koehler (1897)

[§] Deep-sea species (recorded only >200m depth)

[#] *Taxon inquirendum* (Stöhr *et al.* 2020), likely junior synonym of *Ophiopeza spinosa* (Ljungman, 1867) [see discussion]

* New records

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Reference

- Bell, F.J. (1902) The actinogonidiate echinoderms of the Maldivian and Laccadive Islands. In: Gardiner, J.S. (Ed.), *The Fauna and Geography of the Maldivian and Laccadive Archipelagoes*, 1 (16), pp. 223–233.
- Benavides-Serrato, M. & O'Hara, T.D. (2008) A new species in the *Ophiocoma erinaceus* complex from the South-west Pacific Ocean (Echinodermata: Ophiuroidea: Ophiocomidae). *Memoirs of Museum Victoria*, 65, 51–56.
<https://doi.org/10.24199/j.mmv.2008.65.4>
- Boissin, E., Hoareau, T.B., Paulay, G. & Bruggemann, J.H. (2016) Shallow-water reef ophiuroids (Echinodermata: Ophiuroidea) of Réunion (Mascarene Islands), with biogeographic considerations. *Zootaxa*, 4098 (2), 273–297.
<https://doi.org/10.11646/zootaxa.4098.2.4>
- Cherbonnier, G. & Guille, A. (1978) *Echinodermes: Ophiurides. Faune de Madagascar*. 48. Editions du Centre National de la Recherche Scientifique (CNRS), Paris, 272 pp.
- Clark, A.H. (1949) Ophiuroidea of the Hawaiian Islands. *Bulletin of the Bernice P. Bishop Museum*, 195, 3–133.
- Clark, A.M. & Davies, P.S. (1965) Echinoderms of the Maldivian Islands. *Annals and Magazine of Natural History*, Series 13, 8 (94), 597–612.
<https://doi.org/10.1080/00222936508651619>
- Clark, A.M. & Rowe, F.W.E. (1971) *Monograph of Shallow-water Indo-West Pacific Echinoderms*. Trustees of the British Mu-

- seum (Natural History), London, 238 pp.
- Clark, H.L. (1909) Notes on some Australian and Indo-Pacific echinoderms. *Bulletin of the Museum of Comparative Zoology*, 52 (7), 109–135.
- Clark, H.L. (1911) North Pacific Ophiurans in the collection of the United States National Museum. *Smithsonian Institution United States National Museum Bulletin*, 75, 1–302.
<https://doi.org/10.5479/si.03629236.75.1>
- Clark, H.L. (1938) Echinoderms from Australia, an account of collections made in 1929 and 1932. *Memoirs of the Museum of Comparative Zoology at Harvard College*, 55, 1–727.
- Clark, H.L. (1939) Ophiuroidea. *Scientific Reports of the John Murray Expedition*, 6, 29–136.
- Clark, H.L. (1946) *The echinoderm fauna of Australia. Its composition and its origin*. Carnegie Institution of Washington Publication. No. 566. Carnegie Institution, Washington, D.C., 567 pp.
- De Loriol, P. (1893) Echinodermes de la Baie d'Amboine. *Revue Suisse de Zoologie*, 1, 359–426.
- Döderlein, L. (1888) Echinoderme von Ceylon. Bericht über die von den Herren Dres. Sarasingesammelten Asteroidea, Ophiuroidea und Echinoidea. *Zoologische Jahrbücher*, 3, 822–846.
<https://doi.org/10.5962/bhl.part.1933>
- Guille, A. & Vadon, C. (1985) Les Ophiures littorales de Nouvelle-Calédonie. *Bulletin du Muséum national d'histoire naturelle, Paris*, 4e Serie, Section A, 7 (1), 61–72.
- Hendler, G. (2018) Armed to the teeth: a new paradigm for the buccal skeleton of brittle stars (Echinodermata: Ophiuroidea). *Contributions in Science*, 526, 189–311.
- Imaoka, T., Irimura, S., Okutani, T., Oguro, C., Oji, T. & Kanazawa, K. (1991) *Echinoderms of the Continental Shelf and Slope around Japan*. Vol. 2. Japan Fisheries Resource Conservation Association, Tokyo, 184 pp.
- James, D.B. (1969) Catalogue of echinoderms in the reference collections of the Central Marine Fisheries Research Institute, Mandapam. *Bulletin of the Central Marine Fisheries Research Institute*, 7, 51–62.
- James, D.B. (1982) Studies on Indian Echinoderms. 10: *Ophiocoma anaglyptica* (Ophiuroidea: Ophiocomidae), a new record from the Indian Ocean with notes on other species of *Ophiocoma* from Indian Seas. *Journal of the Marine Biological Association of India*, 24 (1), 36–41.
- James, D.B. (1986) Zoogeography of the shallow-water echinoderms of the Indian Seas. In: James, P.S.B.R. (Ed.), *Recent advances in Marine Biology*. Today and Tomorrows Printers and Publishers, New Delhi, pp. 569–591.
- James, D.B. (1989) Echinoderms of Lakshadweep and their zoogeography. *CMFRI Bulletin Marine living resources of the union territory of Lakshadweep: An Indicative Survey With Suggestions For Development*, 43, 97–144.
- Koehler, R. (1897) Echinodermes recueillis par "l'Investigator" dans l'Océan Indien. I. Les Ophiures de mer profonde. *Annales des Sciences Naturelles*, Zoologie Series, 8 (4), 277–372, pls. 5–9.
- Koehler, R. (1898) Echinoderms recueillis par l'Investigator dans l'Océan Indien, II les Ophiures littorales. *Bulletin scientifique de la France et de la Belgique*, 31, 55–126, pls. 2–5.
- Koehler, R. (1899) *An account of the deep-sea Ophiuroidea collected by the Royal Indian Marine Survey Ship Investigator: I (1)*. Trustees of the Indian Museum, Calcutta, 74 pp., 14 pls.
<https://doi.org/10.5962/bhl.title.16134>
- Koehler, R. (1904) Ophiures de l'expédition du Siboga. Part 1. Ophiures de mer profonde. *Siboga Expedition Monographs*, 45a, 1–176.
<https://doi.org/10.5962/bhl.title.11682>
- Koehler, R. (1905) Ophiures de l'expédition du Siboga. Part 2. Ophiures littorales. *Siboga Expedition Monographs*, 45b, 1–140.
<https://doi.org/10.5962/bhl.title.11682>
- Koehler, R. (1922) Ophiurians of the Philippine seas and adjacent waters. *Bulletin of the United States National Museum* 100 (5), 1–597.
- Koehler, R. (1930) Ophiures recueillies par le Docteur Th. Mortensen dans les Mers d'Australie et dans l'Archipel Malais. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i København*, 89, 1–295.
- Lütken, C.F. (1869) Additamenta ad historiam Ophiuridarum. Tredie Afdelning. Det kongelige danske Videnskabernes Selskaps Skrifter. 5 Raekke. *Naturvidenskabelig og matematisk Afdelning*, 8, 20–109.
- Lyman, T. (1874) Ophiuridae and Astrophytidae, new and old. *Bulletin of the Museum of Comparative Zoology, Harvard College*, 3 (10), 221–272.
- Lyman, T. (1878) Ophiuridae and Astrophytidae of the exploring Voyage of H.M.S. "Challenger", under Prof. Sir Wyville Thomson, F.R.S. *Bulletin of the Museum of Comparative Zoology*, 5 (7), 65–168.
- Lyman, T. (1882) Challenger Reports: Ophiuroidea. In: Wyville Thomson, C. (Ed.), *Challenger Reports*. Published by Order of her Majesty's Government, London, 386 pp.
- Marsh, L.M., Vail, L., Hoggett, A.K. & Rowe, F.W.E. (1993) Echinoderms of Ashmore Reef and Cartier Island, north-western Australia. *Records of the Western Australian Museum Supplement*, 44, 53–65.
- Matsumoto, H. (1915) A new classification of the Ophiuroidea: with descriptions of new genera and species. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 67 (1), 43–92.
- Matsumoto, H. (1917) A monograph of Japanese Ophiuroidea, arranged according to a new classification. *Journal of the College of Science, Imperial University, Tokyo*, 38 (2), 1–408.

- McKnight, D.G. (1975) Some echinoderms from the northern Tasman Sea. *New Zealand Oceanographic Institute Records*, 2 (5), 49–76.
- Müller, J.H. & Troschel, F.H. (1842) *System der Asteriden*. F. Vieweg & Sohn, Braunschweig, 134 pp.
- O'Hara, T.D. & Stöhr, S. (2006) Deep water Ophiuroidea (Echinodermata) of New Caledonia: Ophiacanthidae and Hemieuryalidae. *Mémoires du Muséum national d'histoire naturelle*, 193, 33–141.
- O'Hara, T.D., Byrne, M. & Cisternas, P.A. (2004) The *Ophiocoma erinaceus* complex: another case of cryptic speciation in echinoderms. *11th International Echinoderm Conference, 6-10 October, Munich, Germany*. A.A. Balkema, Rotterdam, pp. 537–542.
- O'Hara, T.D., Stöhr, S., Hugall, A.F., Thuy, B. & Martynov, A. (2018) Morphological diagnoses of higher taxa in Ophiuroidea (Echinodermata) in support of a new classification. *European Journal of Taxonomy*, 416, 1–35.
<https://doi.org/10.5852/ejt.2018.416>
- OBIS (2020a) Distribution records of *Ophiomoeris obstricta* (Lyman, 1878), Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Available from: <https://obis.org/taxon/243791/> (accessed 26 March 2020)
- OBIS (2020b) Distribution records of *Ophiocoma cynthiae* Benavides-Serrato & O'Hara, 2008, Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Available from: <https://obis.org/taxon/382770/> (accessed 26 March 2020)
- OBIS (2020c) Distribution records of *Ophiarachnella septemspinosa* (Müller & Troschel, 1842), Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Available from: <https://obis.org/taxon/213217/> (accessed 26 March 2020)
- Olbers, J.M., Samyn, Y. & Griffiths, C.L. (2015) New or notable records of brittle stars (Echinodermata: Ophiuroidea) from South Africa. *African Natural History*, 11, 83–116.
<https://doi.org/10.17159/2305-7963/2015/v11n1a3>
- Price, A.R.G. & Rowe, F.W.E. (1996) Indian Ocean echinoderms collected during the Sinbad Voyage (1980–1981): 3. Ophiuroidea and Echinoidea. *Bulletin of the Natural History Museum of London, Zoology*, 62 (2), 71–82.
- Samuel, V.K.D., Pandian, K., Sreeraj, C.R., Chamundeeswari, K., Parthiban, C., Sekar, V., Patro, S., Saravanan, R., Abhilash, K.R., Ramachandran, P. & Ramesh, R. (2017) An updated checklist of Echinoderms from Indian waters. *Zootaxa*, 4354 (1), 1–68.
<https://doi.org/10.11646/zootaxa.4354.1.1>
- Sastry, D.R.K. (1991) Echinodermata: Asteroidea, Ophiuroidea, Echinoidea. In: *State fauna Series 2. Fauna of Lakshadweep*. Zoological Survey of India, Calcutta, pp. 363–397.
- Sastry, D.R.K. (2005) Echinodermata of Andaman and Nicobar Islands, Bay of Bengal. *Records of Zoological Survey of India, Occasional Paper No. 233*. Zoological Survey of India, Calcutta, 207 pp.
- Sastry, D.R.K. (2007) Annotated Checklist of Echinoderms from Indian. *Records of Zoological Survey of India, Occasional Paper No. 271*. Zoological Survey of India, Calcutta, 387 pp.
- Sastry, D.R.K., Marimuthu, N. & Rajan, R. (2019) Echinodermata of Lakshadweep, Arabian Sea with the description of a new genus and a species. *Record of the zoological Survey of India*, 119 (4), 348–372.
- Stöhr, S., O'Hara, T.D. & Thuy, B. (2012) Global diversity of brittle stars (Echinodermata: Ophiuroidea). *PLoS One*, 7 (3), 1–14.
<https://doi.org/10.1371/journal.pone.0031940>
- Stöhr, S., O'Hara, T.D. & Thuy, B. (Eds.) (2020) World Ophiuroidea Database. *Indophioderma* Sastry, Marimuthu & Rajan, 2019. Accessed through: World Register of Marine Species. Available from: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=1418012> (accessed 24 March 2020)
- Troschel, F.H. (1879) Eine neue Art der Ophiuridengattung *Ophiarachna*. *Sitzungsberichte der niederrheinischen Gesellschaft fuer Naturund Heilkunde in Bonn*, 1879, 135–138.
- Vail, L. & Rowe, F.W.E. (1989) Status of the genera *Ophiopeza* and *Ophiopsammus* (Echinodermata: Ophiuroidea) in Australian waters, with the description of a new species. *Proceedings of the Linnean Society of New South Wales*, 110 (3), 267–288.