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A new record of sea star, *Nardoa frianti* Koehler, 1910 (Echinodermata: Asteroidea: Ophidiasteridae) from the Arabian Sea, Western Indian Ocean

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Original Article

Abstract

Nardoa frianti Koehler, 1910 is reported for the first time from the Arabian Sea, Western Indian Ocean, from a depth of 15 m along the east coast of Kavaratti Island during November 2017. *Nardoa frianti,* initially described from the Andaman Sea, Eastern Indian Ocean and the species has subsequently been recorded up to North Pacific Ocean. The present record from the Arabian Sea extends the distribution of this species westwards towards the western Indian Ocean. The paper also includes a checklist of all species of sea stars reported from the Lakshadweep islands, and those archived in the pioneering reference collection for the region- the northernmost segment of Chagos-Maldives-Laccadives oceanic ridge.

Keywords*: Nardoa frianti, Arabian Sea, starfish, coral reef, Chagos-Laccadive Oceanic Ridge*

Introduction

The coral reefs of the Lakshadweep archipelago hold high biodiversity, which has not been comprehensively documented even today. Echinoderms, which constitute an essential group in coral reef ecosystems, have been studied only sporadically, with 93 species being reported so far from Lakshadweep (Sastry, 2007). Among echinoderms, the sea stars are known to be active predators on soft and hard-bodied benthos, and many forms also graze on algae, corals, sponges, etc. Some starfish are also detritivorous and feed by ingesting sediments as a whole, then digesting the organic matter present in them and egesting the undigested sediments (Hyman, 1955; Mah, 2018). Hence the starfishes are one of the most important functional groups intervening different trophic levels of the reef ecosystem.

The earliest reports of sea stars of the Lakshadweep Islands were made by Bell (1902). Subsequent works have reported a few species based on local collections and observations (James, 1969, 1976, 1989; Sivadas, 1977; Marsh and Price, 1991; Sastry, 1991). Even though several reports of sea stars are available from this region, a concerted attempt has not been made to collect and develop a reference

museum collection of these taxa. As a part of the ongoing project 'Marine Biodiversity Documentation of Lakshadweep Archipelago' (implemented at Dept. of Science and Technology, Lakshadweep), regular surveys are being conducted, up to a depth of 30m using SCUBA and snorkelling, to document the marine biodiversity of the archipelago. During these surveys, *Nardoa frianti* was observed from a depth of 15 to 25m, and two specimens were collected for documentation, at a depth of 15m off the east coast of Kavaratti Island. The article reports the first record of the genus *Nardoa* in the Arabian Sea, extending its distribution significantly westwards. In this paper, the specimens are described, and the distribution range of the species is discussed. Existing records of sea star diversity in the archipelago, with the details of species collected and deposited in the reference museum, are also provided (Table 2).

Material and methods

Specimens of *N. frianti* were collected from Kavaratti Island of the Lakshadweep archipelago, Arabian Sea (Fig. 1) by SCUBA diving at a depth of 15 m in November 2017. The specimens were preserved in 5% formaldehyde for further identification and analysis. The species identification was made following (Koehler, 1910; Clark, 1967; Clark and Rowe, 1971). The voucher specimens are deposited in the museum of Marine Taxonomy Reference Laboratory, Department of Science and Technology, Lakshadweep, India (Accession number. MTRLDST E0130 and MTRLDST E0131).

Material Examined: Two specimens, (Radial arm length 5-8cm) were collected from East coast of Kavaratti Island, Lakshadweep Archipelago, India, (10° 33.832'N, 72° 39.067'E) from a depth of 15m, by SCUBA diving, during November 2017 (Fig. 2).

Results and discussion

Systematics

Phylum : Echinodermata Bruguiere, 1791
Class : Asteroidea de Blainville, 1830
Order : Valvatida Perrier, 1884
Family : Ophidiasteridae Verrill, 1870
Genus : *Nardoa* Gray, 1840

Nardoa frianti Koehler, 1910

Nardoa frianti– Koehler, 1910: 158, pl. VII (8), pl. XVII (3, 4).

Nardoa frianti –Clark and Rowe (1971). 36-37 (distribution), 36 (key); (James, 1983). 89; (Sastry, 2005). 41.

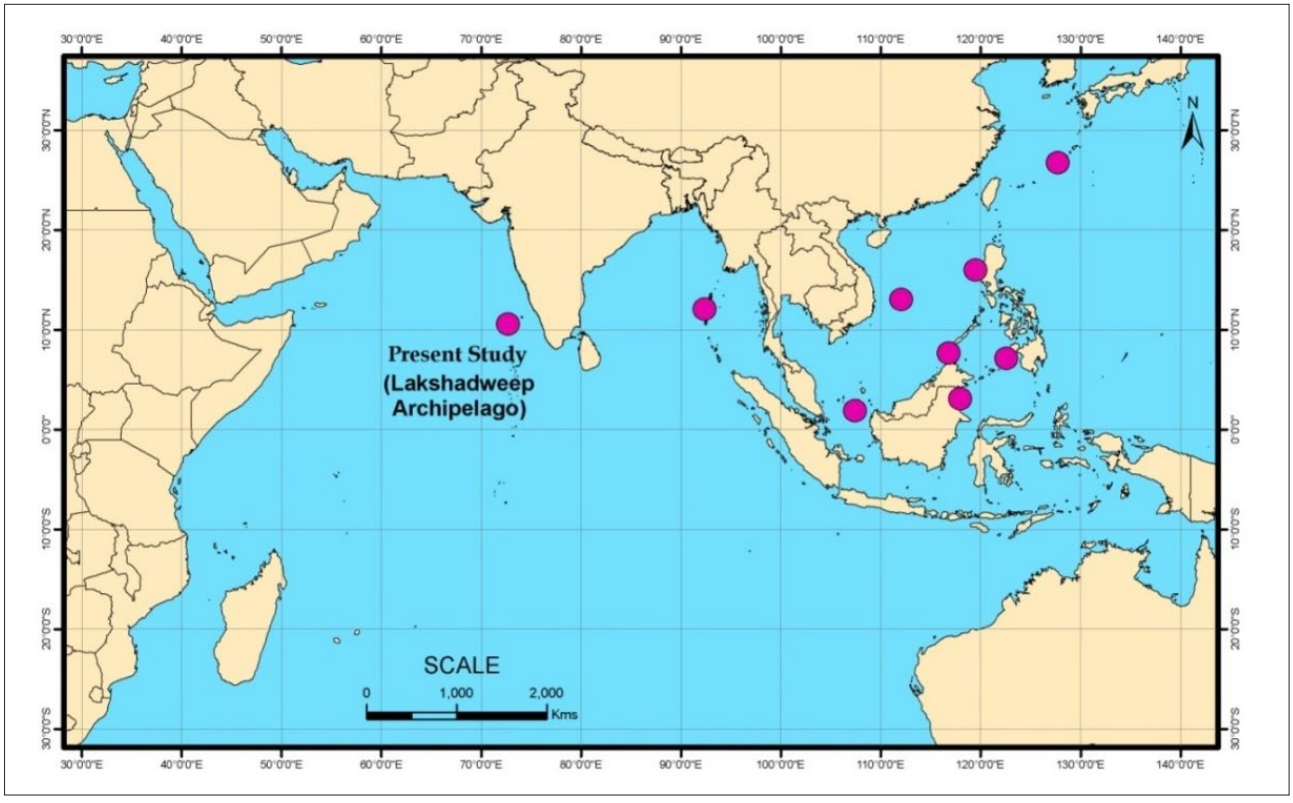

Fig. 1. Distribution of *Nardoa frianti* in different regions of Indo-West Pacific and Lakshadweep.

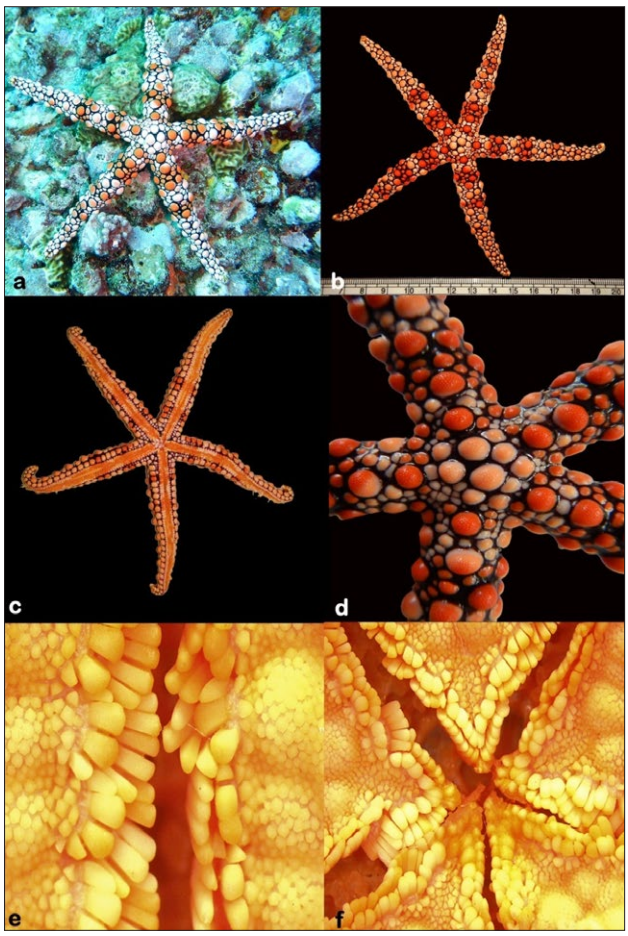

Fig. 2. *Nardoa frianti* a: Live, in-situ photograph; b & c: dorsal and ventral view; d: details of the aboral surface; e: ambulacral armament; f: detailed view of oral armament

Diagnosis

5 rays; R=62 mm, r=10 mm. Disc small; arms long and cylindrical, circular in cross-section, with a flat aboral surface; inter-radial areas small; madreporite distinct. Armament rigid and comprising of granule covered plates; abactinal plates irregular in arrangement, many of them conspicuously domed and measuring up to 4 mm in diameter. Granular armament on the surface larger and more conspicuous in the central part of each plate. Papule present in groups on the abactial side and altogether absent on the actinal side. Marginal plates not distinct, and some proximal superomarginals are also domed, similar to abactinal plates. Actinal plates numbering one or two and granule covered, when present. Adambulacral armament consisting of two rows of short, blunt spines. Colour orange, with bright orange reticulation around the abactinal plates. The characters of the members of the Genus, *Nardoa* is presented in Table 1.

Distribution

Andaman Islands (Koehler, 1910); New Caledonia (Clark, 1954); Philippines, China Sea, South Japan and South Pacific Is (Clark and Rowe, 1971) and Lakshadweep (present record).

The sea star, *N. frianti* was described by Koehler (1910) from the Andaman Sea and the species has subsequently been recorded from Eastern Indian Ocean to the North Pacific Ocean. The present record from the Arabian Sea extends the distribution of this species towards the western Indian Ocean. The specimens collected during the present study are entirely in conformity with all the characters of the *Nardoa frianti* described from the Andaman Islands by Koehler (1910). *Nardoa frianti* is usually found on reef slope and coral rubble. While *N. frianti* is similar to *N. tuberculata,* with smaller disc, cylindrical arms with a flat aboral surface, it is readily distinguished by the prominently wide and hemispherical aboral and superomarginal plates, and two rows of adambulacral spines. Over 1800 species of sea stars are recorded globally, falling in 36 families (Pawson, 2007; Mah, 2018) of which about 160 species have been recorded in Indian waters (Sastry, 2007). The previous literature on Asteroidea from Lakshadweep group of islands records a total of 23 species. The family Ophidiasteridae comprises ten genera with 20 species, which are commonly found in coral reef ecosystems. The genus *Nardoa* consists of 8 species apart from *N. frianti*, all known exclusively from the Indo-west Pacific: *N. galatheae* (Lütken, 1864) [Indo-west Pacific: Red Sea to Papua New Guinea], *N. gomophia* (Perrier, 1875) [Western Pacific: Japan to New Caledonia, N Australia], *N. mamillifera* Livingstone, 1930 [Papua New Guinea, NE Australia], *N. novaecaledoniae* (Perrier, 1875) [Indo-west Pacific: Mauritius to New Caledonia], *N. rosea* (Clark, 1921) [NE Australia], *N. tuberculata* Gray, 1840 [Western Pacific: Japan to New Caledonia; Eastern Indian Ocean: Cocos Island, NW Australia], *N. tumulosa* Fisher, 1917 [Western Pacific: Japan to E Australia], *N. variolata* (Bruzelius, 1805) [Western Indian Ocean: East Africa, Madagascar, Comoros, Maldives]. With the present record, *N. frianti* is the fourth species in the genus reported from the western part of the Indian Ocean. It is also the fourth species of the genus recorded from Indian waters, after *N. galatheae* [Bay of Bengal], *N. novaecaledoniae* [Bay of Bengal: Andaman, Gulf of Mannar, Arabian sea] and *N. tuberculata* [Bay of Bengal: Andaman]. Sea stars reported from the Lakshadweep Islands during the past surveys and observations were compiled and presented in Table 2.

The current record extends the distribution of *N. frianti* species significantly to western Longitudes, highlighting the importance of extensive biodiversity surveys in remote coral habitats like Lakshadweep atolls, where mass poaching and present scenario of climate change is posing a significant threat to the reef ecosystem and its resident biodiversity.

Table 1. General Characters of various members of the Genus Nardoa Gray, 1840

S.No	Species	Descriptions*
1	*Nardoa tuberculata* Gray, 1840	Ventral marginal plates very large and convex, dorsal marginal row with several plates forming large tuberosities, while dorsal and ventral marginal plates are almost flat. Tubercular plates low, infrequent and restricted to distal part of arms. Plates all similar and slightly convex, and actinal plates run for nearly entire length of the arm.
2	*Nardoa novaecaledoniae* (Perrier, 1875)	Plates of the ventral side with more regularity. Spine of interambulacral plates forming a triple row, where prismatic spines lie in tight series. Each plate carries three spines in a row. Granulations polygonal, those on ventral plates much larger than on the furrow separating them, and that of the poriferous areas, which contain from five to ten spaced pores. Dorsal skeletal plates are more or less circular.
3	*Nardoa gomophia* (Perrier, 1875)	Ambulacral spine very clearly arranged on two ranks at least. Each interambulacral plate four feet wide. Spines obtuse, resembling granules on ventral side. Dorsal plates elliptical, a little convex, and touch each other by the tops of their major axes, All this skeletal system wholly granule covered Madreporite small, and at half distance from the centre of disc.
4	*Nardoa mamillifera* Livingstone, 1930	Arms taper slightly, though distinctly, towards tips semi-circular dorsally and flattened ventrally. Abactinal skeleton composed of plates that are extremely variable in size and shape. Tubercles clothed in granules visible to the naked eye, particularly in the central areas where they are largest.Entire abactinal surface covered by coarse and spaced granules of varying sizes. Pores more numerous on disc than elsewhere. Madreporite is small and somewhat diamond-shaped. Actinal surface is made up of three regular series of plates counting the infero marginal series. Every plate of the three series covered by many stout well-spaced granules, the biggest of which occur in the centre of the plate.First series of ventral plates, the adambulacral series, are arranged in regular order. Most plates in this series are rectangular, slightly ovate, their width being about half their length. Armature of adambulacral plates consists of furrow series of 4 to 5 (usually 4) stout, flat-sided, long and bluntly pointed spine lets.
5	*Nardoa rosea* H.L. Clark, 1921	Abactinal skeleton made up of plates, more or less convex or swollen. Whole abactinal surface is covered with rather coarse, spaced, rough granules. Papular areas rather small with 3 to 10 papulae; papulae often single near the tip of the arms. Madreporite small, rounded, triangular, little closer centre of the disc than margin. Terminal plate small, covered with coarse granules, of which a few are conspicuously bigger than the others. Supero marginals short and nearly flat while others, though of moderate size, are distinctly convex with a coarse granulation, especially near the centre of the plate and particularly near the tip of the arm. Adambulacral plates rather large, averaging about 3 to each pair of infero marginals; their armature consists of furrow series of 4 subequal, flattened, but thick spine lets, with rounded and sometimes a little thickened tips.
6	*Nardoa tumulosa* Fisher, 1917	Abactinal plates are large, hemispherical in proportion to width regularly rounded or dome-shaped. Abactinal surface and proximal two-thirds of the arm; plates of the distal third of ray small, crowded, convex.

* Source: Original description of the species

Table 2. Updated checklist of Sea Stars (Class Asteroidea) of the Laccadive Sea and details of voucher specimen kept in marine taxonomy Reference Museum, Lakshadeep, India

Sl.no.	Species	Reference and Acession Number in MTRLDST
Family Acanthasteridae Sladen, 1889		
1.	**Acanthaster planci* (Linnaeus, 1758)	James, 1969; Sivadas, 1977; Sastry, 1991 [Access no. MTRLDST E0000118]
Family Asterinidae Gray, 1840		
2.	**Aquilonastra cepheus* (Muller & Troschel, 1842)	Sastry, 1991[Access no. MTRLDST E0000120]
3.	*Disasterina ceylanica* Doderlein, 1888	Sastry, 1991
4.	*Cryptasterina pentagona* (Muller & Troschel,1842)	James, 1989; Sastry, 1991
5.	**Tegulaster leptalacantha* (H.L. Clark, 1916)	Sastry, 1991 [Access no. MTRLDST E0000121]
Family Asteropseidae Fisher, 1908		
6.	**Asteropsis carinifera* (Lamarck, 1816)	Sastry, 1991 [Access no. MTRLDST E0000122]
Family Goniasteridae Forbes, 1841		
7.	**Fromia indica* (Perrier, 1869)	James, 1989; Sastry, 1991 [Access no. MTRLDST E0000123]
8.	**Fromia milleporella* (Lamarck, 1816)	James, 1989; Sastry, 1991 [Access no. MTRLDST E0000124]
9.	**Fromia monilis* (Perrier, 1869)	Marsh and Prince, 1991 [Access no. MTRLDST E0000125]
10.	*Siraster tuberculatus* H.L. Clark,1915	James, 1986; James, 1997;
Family Ophidiasteridae Verrill, 1870		
11.	**Cistina columbiae* Gray, 1840	James, 1989; Sastry, 1991 [Access no. MTRLDST E0000126]
12.	*Dactylosaster cylindricus* (Lamarck,1816)	Bell, 1902; James, 1969; Sastry,1991
13.	**Leiaster leachi* (Gray,1840)	James, 1969; Sastry, 1991 MTRLDST E0000133]
14.	**Linckia guildingi* Gray 1840	Bell, 1902; Sastry, 1991 [Access no. MTRLDST E0000127]

15.	**Linckia leavigata* (Linnaeus, 1758)	Bell, 1902; James, 1969; Sastry, 1991 [Access no. MTRLDST E0000128]
16.	**Linckia multifora* (Lamarck, 1816)	Bell, 1902; James, 1969; Sastry, 1991 [Access no. MTRLDST E0000129]
17.	*Nardoa novaecaledoniae* (Perrier, 1875)	Bell, 1902
18.	**Nardoa frianti* (Koehler,1910)	Present Study [Access no. MTRLDST E0000130]
19.	*Paraferdina laccadivensis* James,1976	James, 1976
Family Oreasteridae Fisher, 1911		
20.	**Culcita novaeguineae* Muller & Troschel, 1842	James, 1969; Sastry, 1991 MTRLDST E0000119]
21.	**Culcita schmideliana* (Retzius, 1805)	Sastry, 1991 [Accession. No. MTRLDST E0000132]
22.	*Halityle regularis* Fisher, 1913	James, 1989; Sastry, 1991
23.	*Pentaceraster regulus* (Muller & Troschel, 1842)	James, 1969; Sastry, 1991

* Collected, identified and deposited during the present study (MTRLDST-Marine Taxonomy Research Laboratory Department of Science and Technology)

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