Diversity of Echinoderms in Rani Jhansi Marine National Park, Andaman and Nicobar Islands

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Introduction

Echinodermata are most familiar invertebrates exclusively marine and are largely bottom dwellers. The phylum contains some 6500 known species and constitutes the only major group of deuterostome invertebrates. All are relatively large animals, having pentamerous radial symmetrical body, most being at least several centimeters in diameter. Echinoderms are globally distributed in almost all depths, latitudes and environments in the ocean. They reach highest diversity in reef environments but are also widespread on shallow shores, around the poles refugia where crinoids are at their most abundant, and throughout the deep ocean, where bottom-dwelling and burrowing sea cucumbers are common, sometimes accounting for up to 90% of organisms. Whilst almost all echinoderms are benthic, that is, they live on the sea floor and some sea-lilies can swim at great velocity for brief periods of time, and a few deep-sea cucumbers are fully floating. Five extant classes of echinoderms are universally recognized: Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea, and Crinoidea. Recently, a sixth class, Concentricycloidea, was described (Baker *et al.,* 1986). Smith (1988), in a phylogenetic analysis of fossil evidence suggested times of divergence of the five (then) modern classes at 450-590 million years ago.

Echinoderms provide a key ecological role in ecosystems. The grazing of sea urchins reduces the rate of colonization of bare rock; the burrowing of sand dollars and sea cucumbers recycles the nutrients; starfish and brittle stars prevent the growth of algal mats on coral reefs, which would obstruct the filter-feeding constituent organisms. Some sea urchins can bore into solid rock; this bio-erosion can destabilize rock faces and release nutrients into the ocean. The echinoderms are also the staple diet of many organisms, most notably the otter; conversely, many sea cucumbers provide a habitat for parasites, including crabs, worms and snails.

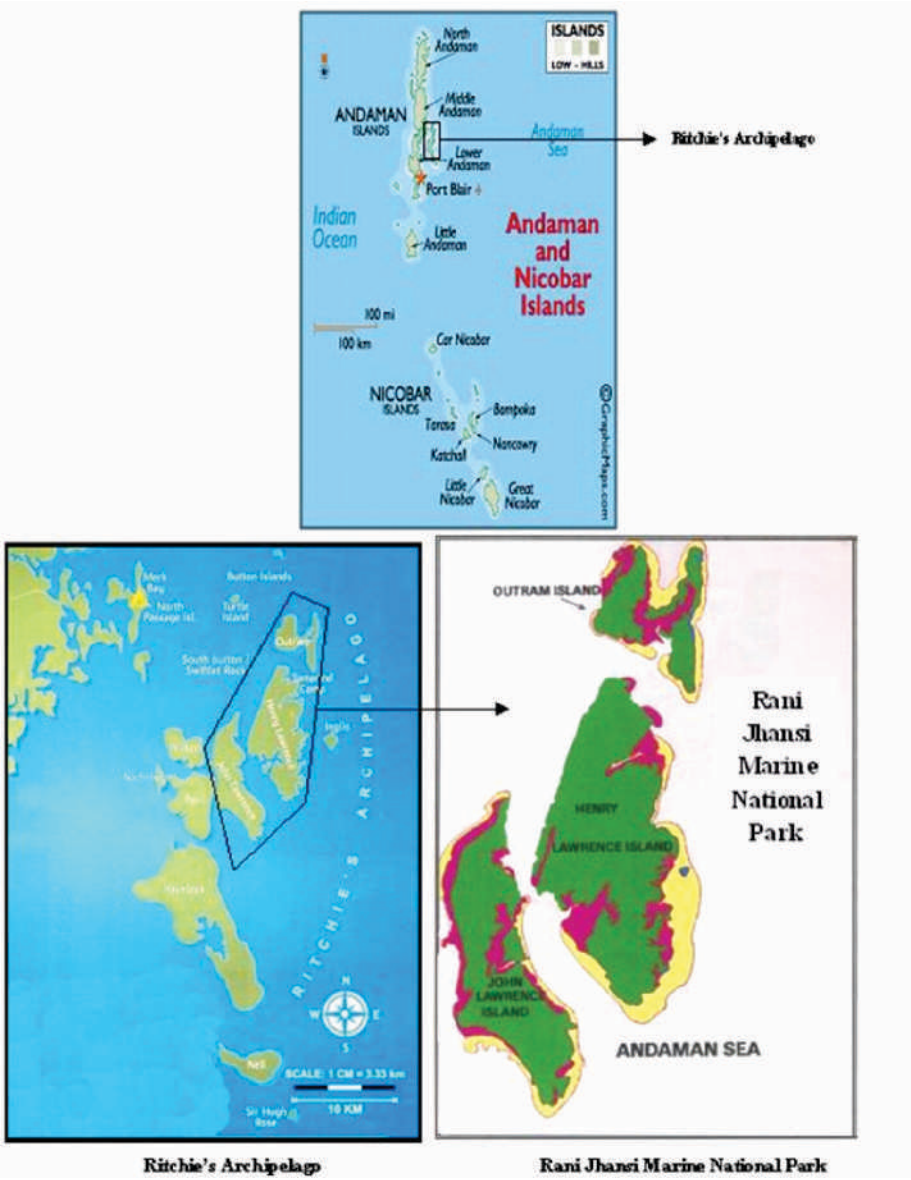


Fig. 1. *Map showing Rani Jhansi Marine National Park*

The extinction of large quantities of echinoderms appears to have caused a subsequent overrunning of ecosystems by seaweed, or the destruction of an entire reef.

Investigation on echinoderms of Indian waters was initiated as early as 1743 by Plancus and Gaultire who has reported few species off Goa (James, 1987). However, there has been not much progress in our knowledge of Indian echinoderms till Marine Survey of Indian Museum took active interest in exploring the marine fauna of Indian subcontinent (Sastry, 2007). During the cruises of Royal Indian Marine Survey Steamer Investigator, several species of echinoderms collected from shallow regions of the coastal areas as well as deep waters. The coastal zones and fringing reefs of Andaman and Nicobar Islands harbour a rich variety of echinoderms which is approximately half the echinoderm fauna of the Indian subcontinent (Sastry, 2007). Bell (1887) for the first time listed the echinoderms from Andaman Islands, besides the earlier stray reports of occurrence of individual species off

these islands, *i.e.* Blainville (1830) reported the asteroid, *Protoreaster lincki* as *Asterias lincki*, Lutken (1872) found the asteroid *Astropecten euryacanthus*, Theel (1886) identified holothurians *Holothuria pardalis* and *Holothuria marenzelleri*. Later the studies on Indian echinoderms gained a momentum and the reports were published as Echinoderma of the Indian Museum. The earlier report made by Clark (1912a,b) on Crinoidea; Wood-Mason and Alcock (1891), Koehler (1909, 1910) on Asteroidea and Crinoidea; Koehler (1897, 1898, 1899, 1900) on Ophiuroidea; Koehler (1914, 1922, 1927) on Echinoidea; Koehler and Vaney (1905, 1908) on Holothuroidea; reports of Anderson (1894, 1907) are worth mentioning. Later James (1986, 1987, 1991), Julka and Das (1978) and Sastry (1977, 2001a,b, 2002, 2005) studied echinoderms of Andaman and Nicobar Islands and added several species. Recently, Koushik Sadhukhan and Raghunathan (2011 a,b) recorded the echinoderms in Rutland Island of Andaman and made first report on two brittle star *Opiothela venusta* and *Dougaloplus echinatus* to India. Reef associated echinoderms, new report on crinoids and asteroid, and community structure of echinoderms in North Andaman were also studied by Koushik Sadhukhan and Raghunathan (2012 a,b,c,d).

The Indian seacoast with its differing ecological habitats supports a large diversity of echinoderm exceeding 649 species. Of these, in Andaman and Nicobar Archipelago alone, 425 species are distributed. However, the present study detailed about the diversity and distribution of the echinoderms in Rani Jhansi Marine National Park of Andaman and Nicobar Islands, which is one of the four marine national parks in India.

Study area

Rani Jhansi Marine National Park (RJMNP) is situated in Ritchie's Archipelago, South Andaman (Fig.1). It is the combination of three islands viz. Henry Lawrence Island (Lat. 12°12.598'N, Long. 93°03.883'E), John Lawrence Island (Lat. 12° 04. 075'N, Long. 93° 00.398'E) and Outram Island (Lat. 12°12.346'N, Long.93° 05.753'E). The studies were conducted at different sites in these islands in marine national park to obtain the quantitative as well as qualitative data on echinoderms.

John Lawrence Island: Area of island is about 9 km^2. Maximum elevation is 172 m. Shore packed with coral rocks. Thin strip of sandy beach in laces which devoid of rocks. Live coral patches even in shallow areas. Water is very deep close by. North-west area is covered by mangroves and rocks.

Henry Lawrence Island: Maximum elevation 138 m. Narrow sandy beach, extensive inter-tidal zone in the south-east (50 m broad), live corals up to 10 m depth. Mangrove bushes scattered along shore. Steep rocks occur in intertidal zone, water deep close to island and current swift.

Outram Island: It lies to the north of Henry Lawrence and occupies 13 km^2 area in Ritchie's Archipelago. Mangroves are present on the northern and southern side of the island. The island is surrounded by fringing reefs. The western reef flats are narrow with widths ranging from 50-80m and mainly dominated by coral species of *Acropora* and *Porites*.

Material and Methods

Subtidal and intertidal surveys were conducted from January 2010 to December 2011 at different sites in the three Islands of Rani Jhansi Marine National Park to investigate diversity, density and distribution of echinoderms in coral reef area. The density of echinoderms was estimated by employing quadrat along the Line Intercept Transect on the reef area and the numerical density of echinoderms was calculated for 100 m^2 area of the sea bottom.

The species diversity of corals was evaluated following Shannon-Weaver diversity index formula as described below –

$$H' = -\Sigma pi \log_e pi$$

Where, *pi* = Proportion of number of individual of a particular species and total number of individual of all the species, *H'*= diversity of a theoretically infinite population.

Similarity Index is the simple measure of the extent to which two habitats species in common. The Sørensen index, also known as Sørensen's similarity coefficient, is a statistic used for comparing the similarity of two samples (Sørensen). It has been formulated below –

$$QS = (2C/A + B)$$

Where, *A* and *B* are the species numbers in station *A* and *B* respectively, and *C* is the number of species shared by the two stations.

Results

The results on the diversity, density and distribution of echinoderms reported from three islands viz. John Lawrence, Henry Lawrence and Outram are depicted in Table 1. A total of 56 species of echinoderms belonging to 32 genera, 19 families, 10 orders under five classes such as Crinoidea, Asteroidea, Ophiuroidea, Echinodea and Holothuroidea have identified during the period of study (Plates 1-5). The total number of species varied from 34 to 38 at John Lawrence and Henry Lawrence Islands respectively, where as the genera ranged between 22 and 27 at John Lawrence and Outram Islands respectively. No significant variation observed on the total number of families between the islands, however it ranged from 15 at John Lawrence and 16 at both Henry Lawrence and Outram Islands. The species diversity of echinoderms was also calculated and it was maximum (2.23) at Henry Lawrence Island while minimum (2.18) at John Lawrence Island. The data for numerical density of echinoderms showed higher (148 individuals/100m^2) at Henry Lawrence and lower (134 individuals/100m^2) at both John Lawrence and Outram Islands with the mean density of 139 individuals/100m^2. Among the echinoderm species reported from Rani Jhansi Marine National Park, 20 species are common at all three Islands, while 17 species were restricted to particular islands and remaining species registered different degree of distribution. The numerical density for individual class has also been assessed and it indicated the abundance of echinoderms as Holoturoidea > Echinoidea > Asteroidea > Ophiuroidea > Crinoidea as their average density reported as 45.33, 30.00, 28.00, 24.00 and 10.60 individuals/100m^2 respectively.

The percentage composition of echinoderms reported under different classes at RJMNP is presented in Table 2. It is estimated that about 13.18% of echinoderm species reported from Andaman and Nicobar Islands contributed from this national park. Data on class wise species contribution predicted that, 18.18% of holothuroids, 13.46% of asteroids, 12.50% of echinoids, 11.65% of ophiuroids and 8.00% of crinoids reported form of Andaman and Nicobar archipelago found at this national park alone.

Among three islands, the species reported from Henry Lawrence *Vs.* John Lawrence Islands shown high (0.70) similarity index followed by Henry Lawrence *Vs.* Outram (0.60), where as it was low (0.57) at John Lawrence Vs. Outram Islands (Table 3).

Discussion

The Ehinodermata is one of the best characterized and most distinct phyla of animal kingdom (Bather, 1900). The echinoderms being common and conspicuous marine animals have been known since ancient times. They found at every ocean depth, from the intertidal zone to the abyssal zone. The first definitive members of the phylum appeared near the start of the Cambrian period. The echinoderms are important both biologically and geologically: biologically because few other groupings are abundant in the biotic desert of the deep sea, as well as the shallower oceans, and geologically as their ossified skeletons are major contributors to many limestone formations, and can provide valuable clues as to the geological environment. Further, it is held by some that the radiation of echinoderms was responsible for the Mesozoic revolution of marine life. Among the 6500 known extant echinoderms in world oceans, 700 species under Crinoidea, 1800 species under Asteroidea, 2000 species under Ophiuroidea, 900 species under Echinoidea and 1200 species under Holothuroidea have been reported (Hendler *et al.*, 1995). In Andaman and Nicobar Islands 425 species of echinoderms reported from reef ecosystem against the total of 649 recorded from Indian seas. Sastry (1997) reported 12 species of echinoderms in Ritchie's archipelago which is comprised of 14 islands including the 3 islands of RJMNP. Later, 44 species were recorded from this archipelago (Sastry, 2001). However, the present study registered 56 species of echinoderms from the three islands alone i.e. John Lawrence, Henry Lawrence and Outram. RJMNP harbours wide range of marine biodiversity including corals, sponges, octo-corals, crustaceans, molluscs, fishes, mammals and also seaweeds and seagrasses. A total of 27.15 km^2 area of corals covered on the fringing reef provides ideal environment of coral associates

Table 1: **Diversity, density and distribution of Echinoderms in RJMNP**

Sl. No.	Species	John Lawrence Island	Henry Lawrence Island	Outram Island
	Class: CRINOIDEA Order: Comatulida Family: Himerometridae			
1.	*Himerometra robustipinna* (P.H.Carpenter, 1912)	-	-	+
2.	*Heterometra crenulata* (P.H.Carpenter, 1882) Family: Comasteridae	+	+	-
3.	*Comanthina nobilis* (P.H.Carpenter, 1884)	+	+	+
4.	*Oxycomanthus bennetti* (Muller, 1841)	+	-	+
	Numerical density (No./100m^2)	**12**	**8**	**12**
	Class: ASTEROIDEA Order: Valvatida Family: Oreasteridae			
5.	*Culcita novaguineae* (Muller & Troschel, 1842) Family: Ophidiasteridae	+	+	+
6.	*Linckia laevigata* (Linneaus, 1758)	+	+	+
7.	*Linckia guildingi* (Gray, 1840)	+	+	
8.	*Linckia multifora* (Lamarck, 1816)			+
9.	*Fromia monilis* (Perrier, 1869)	+	+	+
10.	*Fromia milleporella* (Lamarck, 1816)		+	
11.	*Fromia indica* (Perrier, 1867)	+	-	-
12.	*Dactylosaster cylindricus cylindricus* (Lamarck,1816)			+
13.	*Nardoa galatheae* (Lutken, 1865) Family: Asterinidae	+	+	
14.	*Asterina sarsini* (de Loriol, 1897)	-	+	+
15	*Asterina burtoni* Gray			
16.	*Asterina cepheus* (Muller & Troschel, 1842)			+
17.	*Asteropsis carinifera* (Lamarck,1816) Family: Acanthasteridae	+		
18.	Acanthaster planci (Linneaus, 1758)	+	+	+
	Numerical density (No./100m^2)	**24**	**24**	**36**
	Class: OPHIUROIDEA Order: Ophiurida Family: Ophiocomidae			
19.	*Ophiocoma erinaceus* (Muller & Troschel, 1842)	-	+	-
20.	*Ophiocoma brevipes* (Peters, 1851)	-	-	+
21.	*Ophiocoma anaglyptica* (Ely, 1944)	+	+	
22.	*Ophiosammus yoldii* (Quelch, 1885)	+		+

Sl. No.	Species	John Lawrence Island	Henry Lawrence Island	Outram Island
23.	*Ophiocoma pussila* (Brock, 1888) Family: Ophiactidae	-	+	-
24.	*Ophiactis savignyi* (Muller & Troschel, 1842) Family: Ophiuridae	+	+	+
25.	*Ophiolepis superba* (Clark, H.L, 1842)		+	
26.	*Ophiomastix annulosa* (Lamarck, 1816) Family: Ophiodermatidae	+		+
27.	*Ophiarachna incrassata* (Lamarck, 1816) Family: Ophiocanthidae		+	
28.	*Ophiacantha indica* (Ljungman, 1899) Family: Ophiothircidae	+	+	
29.	*Macrophiothrix longipedia* (Lamarck, 1816)			+
30	*Ophiothrix nereidina* (Lamarck, 1816)			
	Numerical density (No./100m^2)	**20**	**32**	**20**
	Class: ECHINOIDEA Order: Cidaroida Family- Cidariidae			
31.	*Phyllacanthus imperialis* (Lamarck, 1816) Order: Echinoida Family: Echinometridae	+	+	+
32.	*Echinometra mathei* (de Blainville, 1825)	+	+	+
33.	*Heterocentrotus trigonarius* (Lamarck, 1816) Family: Diadematidae		+	+
34.	*Diadema setosum* (Leske,1778)	+	+	+
35.	*Diadema savignyi* (Michelin, 1845)	+	-	-
36.	*Echinothrix calamaris* (Pallas, 1774)	-	+	-
37.	*Echinothrix diadema* (Linnaeus) Order: Temnopleuroida Family: Temnopleuridae		+	
38.	*Mespilia globulus* (Linneaus, 1758)	+	+	+
39.	*Temnopleurs alexendri* (Bell) Order: Spatangoida Family: Brissidae	+		
40.	*Brissus latecarinatus* (Leske, 1778)			+
	Numerical density (No./100m^2)	**30**	**30**	**30**
	Class: HOLOTHUROIDEA			
	Order: Aspidochirotida			
	Family: Holothuriidae			

Sl. No.	Species	John Lawrence Island	Henry Lawrence Island	Outram Island
41.	*Holthuria atra* (Jaeger, 1833)	+	+	+
42.	*Holothuria impatiens* (Forskal, 1775)	+	+	+
43.	*Holothuria edulis* (Lesson,1830)	+	+	+
44.	*Holothuria fusicocinerea* (Jaeger, 1833)	+	+	-
45.	*Holothuria cinerascens* (Brandt, 1835)		-	+
46.	*Bohadschia marmorata* (Jaeger, 1833)	+	+	+
47.	*Actinopyga mauritiana* (Quoy & Gaimard, 1833)	+	+	+
48.	*Actinopyga miliaris*(Quoy & Gaimard, 1833)	+	+	
49.	*Holothuria pyxis* (Selenka, 1867)	+	+	+
50.	*Holothuria hilla* (Lesson, 1830)	+	+	+
51.	*Holothuria leucospilota* (Brandt, 1835) Family: Stichopodidae		+	
52.	*Stichopus chloranatus* (Brandt,1835)	+	+	+
53.	*Stichopus vastus* (Sluiter, 1887)	+	-	+
54.	*Thelenota ananas* (Jaeger, 1833) Order: Apodida Family: Synaptidae	-	+	+
55.	*Synapta maculata* (Chamisso 1821) Order: Molpadiida Family Caudinidae	+	+	
56.	*Acaudina malpadioides* (Semper, 1868)			+
	Numerical density of (No./100m^2)	**48**	**52**	**36**
	Total numerical density (No./100m^2)	**134**	**146**	**134**
	Number of Family	**15**	**16**	**16**
	Number of Genera	**22**	**25**	**27**
	Number of Species	**34**	**38**	**35**
	Species diversity (H')	**2.18**	**2.23**	**2.20**

Table 2: **Percentage composition of different class of echinoderms in RJMNP**

Sl. No.	Class	No. of species in A&N Islands*	Number of species in RJMNP	Percentage at RJMNP
1.	Crinoidea	50	04	08.00%
2.	Asteroidea	104	14	13.46%
3.	Ophiuroidea	103	12	11.65%
4.	Echinoidea	80	09	12.50%
5.	Holothuroidea	88	16	18.18%
	Total	**425**	**56**	**13.18%**

* (Sastry, 2005)

Table 3: **Similarity Index between the islands in RJMNP**

Sl. No.	Island	Sorensen Similarity Index
1.	John Lawrence *Vs.* Henry Lawrence	0.70
2.	John Lawrence *Vs.* Outram	0.57
3.	Henry Lawrence *Vs.* Outram	0.60

including echinoderms. In general most of the species were observed between the intertidal and up to the maximum depth of 25m in the study area.

Out of five classes of echinoderms, holothuroids were dominant in terms of species diversity as well as numerical abundance in the RJMNP. *Holothuria atra, Holothuria edulis, Bohadschia marmorata, Actinopyga mauritiana, Holothuria pyxis* and *Stichopus chloronatus* were frequently occurred holothurians in the study area and their abundance also generally high *i.e.* 10-16 individuals/100 m^2. All the species of holothurians are protected under Wildlife (Protection) Act, 1972 under Schedule-I category since 2001, as their natural population was depleted rapidly due to over exploitation. However, present data indicated considerable improvement in the population size of holothurians in RJMNP. Echinoidea and Asteroidea also showed the good number of species in RJMNP. *Echinometra mathei, Daidema setosum, Diadema savignyi* and *Echinothrix calamaris* under Echonoidea; *Linkia laevigata* and *Fromia monilis* under Asteroidea were dominantly observed. The diversity and numerical abundance of Crinoidea was very less and it was represented by only 4 species. Though, crinoids are very common in shallow water and found in the dead branches and bases of corals, they are cryptic during day time. Probably this might be a reason for the recording less number of crinoids in the area during the period of study, as surveys conducted only in day hours. Normally at night, crinoids lay perched on vertical surface to feed on the floating microorganisms filtered by pinnules of spread out arms. Crinoids helps corals by trapping the silt particles through feeding in mucus secreted coral surface (Sastry, 2002).

Sastry (2005) stated that a total 224 species were estimated to be exclusively associated with the coral habitats of Andaman and Nicobar Islands. He also observed that in the reef habitats Ophiuroidea is represented by highest number of species (64) while the other have lower but nearly equal presences (23-48 species). As for the relative abundance in the reef habitats, Crinoidea and Ophiuroidea are present in higher percentage (64% and 62% respectively) of their diversity in the islands while 46% for Asteroidea, 49% for Echinoidea and 45% for Holothuroidea (Sastry, 2005). Similarly, Koushik Sadhukhan and Raghunathan (2011a) reported the diversity of Holothuroidea with highest percentage of species composition in Rutland Island, South Andaman constituting 35.09% of echinoderms in this particular island, whereas Crinoidea, Asteroidea, Echinoidea and Ophiuroidea represented by 7.02, 12.28, 31.58 and 14.04% respectively. The species composition of echinoderms in Rutland Island was 57, which is about 13.4% of the echinoderm diversity reported in Andaman and Nicobar Islands (Koushik Sadhukhan and Raghunathan, 2011a). The data obtained from the present study i.e. 13.18% of echinoderm species distributed at RJMNP is quite comparable with the earlier findings at Rutland Island.

Present study reported the mean numerical density of 139 individuals /100m^2 belonging to 56 species under five Classes in RJMNP. Vazquez-Bader et al. (2008) assessed the density of echinoderms based on 181 surveys using Otter Trawl in southeastern Gulf of Mexico and it resulted 59 species. The Campenche Bank in Gulf of Mexico was the area with the largest catch 32,286 individuals (mean catch 88 ind/ha) at the depth of 15-30 meters on the carbonate sand substrate (Vazquez-Bader *et al.,* 2008). It indicates that the density and diversity of echinoderms were quite higher in Andaman and Nicobar Islands when compared to other Indo-Pacific regions. Species richness was greatest in summer and in other seasons the species presented little changes in (Vazquez-Bader *et al.,* 2008).

Based on the assessment made in the present study, it is concluded that the RJMNP is one of the areas in Andaman and Nicobar Islands having richest assemblage of echinoderms in terms of species composition and density. However, these resources especially holothurians (sea cucumbers) posing danger

PLATE -1 : **Echinoderms of Rani Jhansi Marine National Park - Class: CRINOIDEA**

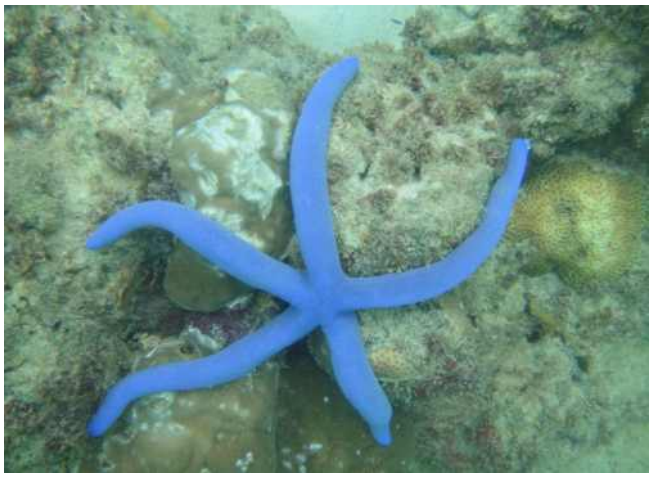
Comanthina nobilis (P.H. Carpenter, 1884)

Oxycomanthus benneti (Muller, 1841)

Himerometra robustipinna (P.H.Carpenter, 1912)

PLATE - 2 : **Echinoderms of Rani Jhansi Marine National Park - Class: ASTEROIDEA**

Fromia indica (Perrier, 1867)



Linckia laevigata (Linneaus, 1758)

Fromia monilis (Perrier, 1869)

PLATE - 3 : **Echinoderms of Rani Jhansi Marine National Park - Class: OPHIUROIDEA**

Ophiocoma erinaceus (Muller & Troschel, 1842)

Macrophiothrix longipeda (Lamarck, 1816)

Ophiothrix nereidina (Lamarck, 1816)

PLATE - 4 : **Echinoderms of Rani Jhansi Marine National Park - Class: ECHINOIDEA**

Mespilia globulus (Linneaus, 1758)

Echinometra mathei (de Blainville, 1825)

Echinothrix calamaris (Pallas, 1774)

PLATE - 5 : **Echinoderms of Rani Jhansi Marine National Park - Class: HOLOTHUROIDEA**

Actinopyga mauritiana (Quoy & Gaimard, 1833)

Holothuria hilla (Lesson, 1830)

Acaudina malpadioides (Semper, 1868)

of persistent poaching activity as these islands having closer proximity to neighboring countries bordering Andaman Sea. In the year 2011-12 alone more than 500 foreign poachers along with huge quantity of sea cucumbers were apprehended by Indian Coast Guard and punished them under Indian law. Further, strengthening of coastal security as well as holding bilateral dialogue with the neighbouring countries could be an only solution to address the issue.

Acknowledgements

The authors are grateful to the Ministry of Environment and Forests, Government of India for financial assistance. The authorities of Department of Environment and Forests, Andaman and Nicobar Administration are duly acknowledged for logistic support to undertake field studies.

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