Actiniarian Sea Anemone diversity in Andaman and Nicobar Islands

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Introduction

Andaman and Nicobar Islands is one of the largest islands in the north-eastern part of the Bay of Bengal. It is about 800 km long, with a land area of about 8249 sq. km. The eastern landscape of the coast is gently sloping while at the west it is characterized by steep rocks and vertical cliffs. The coastal Andaman and Nicobar archipelago is a large marine ecosystem characterized by coral reefs, mangroves, and sea grasses, but including other environments, such as sandy beaches and rocky shores. These tropical ecosystems incorporate a high diversity of associated flora and fauna, and the nations that border the Andaman and Nicobar Islands collectively encompass a major marine biodiversity hot spot.

The most characteristic ecosystems in the Andaman and Nicobar Islands are coral reefs covering about 2000 sq. km., and mangroves at nearly 615 sq. km. A total of 6061 marine species are reported from the Andaman and Nicobar Islands region which account for 45.31% of the total Indian marine fauna. Although, Andaman Sea contains the greatest concentration of scleractinian corals, but actiniarian fauna of cnidarians is a least studied group in India as well as in Andaman and Nicobar Islands as it received scant attention.

Studies on the Actiniarian sea anemones of Indian waters were made available from the contribution of Annandale (1907 & 1915) and Panikkar (1936, 1937a-c, & 1939). Annandale (1907) described the actinian *Metridium schillerianum* from the brackish ponds at Port Canning. Panikkar (1937) described Boloceroidarian from brackish-water near Madras. Later, Studies on actiniarian fauna in Indian waters are made by Parulekar (1967, 1968, 1969a, b & 1971). Parulekar (1990) has enumerated 40 species of sea anemones from India, of which 13 species were reported for the first time. The fauna of Actiniarian sea anemone of the eastern Andaman Sea is still insufficiently studied. There are a handful of faunistic papers available: (Parulekar 1969a, b, 1971 & 1990), Madhu and Madhu (2007) and Raghunathan *et al.* (2014). Parulekar (1990) has included *Anthoplerua panikkarii, Bunodactis nicobarica, Parabunodactis inflexibilis* and *Metridium senile* from Andaman and Nicobar Islands. Madhu and Madhu (2007) reported the occurrence of 10 species of sea anemones at 14 sites from Andamans. Raghunathan *et al.* (2014) have given a more recent review of Indian fauna with at least 54 species known. Moreover, they reported **15 species of Actiniarian sea anemones belonging to 11 genera and 8 families** from the Andaman and Nicobar Islands of which 5 species, *Actinodendron glomeratum* Hadden, 1898; *Calliactis miriam* Hadden and Shackleton 1893; *Anthopleura handi* Dunn, 1978; *Phymanthus buitendijki* Pax, 1924; *Telmatactis decora* were new record to India and *Boloceroides mcmurrichi* Kwiteriewski, 1898 was new distributional record to Andaman and Nicobar Island.

This paper summarizes the data on the diversity and distribution along with depth occurrence and substrate preference of 20 sea anemone species in Andaman and Nicobar Islands.

Material and Methods

Specimen Collection

Surveys on the occurrence of sea anemones

Fig. 1 : Map showing the study areas in Andaman and Nicobar Islands

along the fringing reefs of North Andaman, Middle Andaman, South Andaman, Little Andaman and Nicobar regions in Andaman and Nicobar Islands (Fig.1) were conducted during 2010-2014 from intertidal to the subtidal region up to the depth of 40 meters. The specimens of different species were observed and studied in subtidal areas by snorkeling and at greater depth with SCUBA devices. Actiniarian sea anemones have been photographed in-situ with Sony Cyber shot (DSC T900) and Canon - A 580 camera with underwater housing. The coordinates of the study area were collected using GARMIN 12 Channel GPS.

Specimen Preservation

Collected specimens were relaxed by the addition of magnesium chloride crystals with seawater in the field and later fixed in 10% phosphate buffered formalin (PBF) and were then preserved in 70% ethyl alcohol in the laboratory (Haussermann, 2004).

Taxonomical identification

The external characters of specimens were critically observed in *in situ* (Fig. 3) and also examined under stereozoom microscope (Leica M205A) in the laboratory. The taxonomic characters were identified by observing the peculiarity of tentacular structures, the arrangement of tentacles in sea anemones, column pattern of sea anemones and presence of nematocysts in different body part. All sea anemone specimens were identified to the species level following keys made by Mariscal (1974); England (1988); Fautin & Allen (1992); Gomes *et al.* (1998); Fautin *et al.* (2007); Fautin *et al.* (2008); Fautin *et al.* (2009); Acuna *et al.* (2012) and Eash-Loucks and Fautin, 2012).

Statistical Applications

The species diversity of sea anemones was calculated according to the Shanon-Weiner formula.

$H' = -\sum Pi \log_e Pi$

Where Pi = proportion of the *i*th species in the collection and H'= Diversity of a theoretically infinite population.

Similarity Index was calculated using the formula given below.

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

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

Results

Geographical distributions of Sea anemones in Andaman and Nicobar Islands

The present study summarizes 20 species of Actiniarian sea anemones belonging to 14 genera

Telmatactis decora (Hemprich and Ehrenberg in Ehrenberg, 1834)

Boloceroides mcmurrichi (Kwietniewski, 1898)

Actinodendron glomeratum Haddon, 1898

Heteractis magnifica (Quoy and Gaimard, 1833)

Entacmaea quadricolor (Rueppel, Leuckar, 1828)

Macrodactyla doreensis (Quoy & Gaimard 1833)

Figure 3 : Actiniarian sea anemones observed in Andaman and Nicobar Islands

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Stichodactyla gigantea (Forskål, 1775)

Stichodactyla mertensii (Brandt, 1835)

Stichodactyla haddoni (Saville - Kent, 1893)

Cryptodendrum adhaesivum Milne Edwards, 1857

Heteractis aurora (Quoy and Gaimard, 1833)

Heteractis crispa (Hemprich & Ehrenberg in Ehrenberg, 1834)

Table 1: Number of sea anemones species with their geographical distribution, depth ranges and substrate preference in Andaman & Nicobar Islands.

Sl. No.	Phylum/Class/Order/Family/Genus/ Species	NA	MA	SA	LA	NI	Depth in m	Substrates
	Phylum: CNIDARIA **Class: ANTHOZOA** **Order: ACTINIARIA Haeckel, 1896** **Family: ACTINIIDAE Rafinesque, 1815** Genus: *Entacmaea Ehrenberg*, 1834							
1.	*Entacmaea quadricolor* (Rueppel and Leuckar, 1828) Genus: *Anthopleura* Duchassaing de Fonbressin and Michelotti, 1860	o	o	o	o		5- 30	R, C
2.	*Anthopleura panikkarii* Parulekar, 1969			o			0-10	G
3.	*Anthopleura handi* Dunn, 1978 Genus: *Bunodactis* Verrill, 1869	o	o	o	o		0-15	G, CL
4	*Bunodactis nicobarica* Carlgren, 1928 Genus: *Parabunodactis* Carlgren, 1928					o	0-10	CB, L
5.	*Parabunodactis inflexibilis* Carlgren, 1928 Genus: *Macrodactyla* Haddon, 1898	o			o		5-15	L
6.	*Macrodactyla doreensis* (Quoy & Gaimard, 1833) **Family: ACTINODENDRONIDAE Haddon, 1898** Genus: *Actinodendron* de Blainville, 1830	o	o				10-30	L, S
7.	*Actinodendron glomeratum* Haddon, 1898 **Family: HORMATHIIDAE Carlgren, 1932** Genus: *Calliactis* Verrill, 1869	o	o	o			10-30	L
8.	*Calliactis miriam* Haddon & Shackleton, 1893 **Family: ISOPHELLIIDAE Stephenson, 1935** Genus: *Telmatactis* Gravier, 1916			o			0-15	M
9.	*Telmatactis decora* (Hemprich and Ehrenberg in Ehrenberg, 1834) **Family: METRIDIIDAE (Carlgren 1893)** Genus: *Metridium* de Blainville, 1824	o	o	o			0-30	G, CB, R
10.	*Metridium senile* (Linnaeus, 1761) **Family: PHYMANTHIDAE Andres, 1883** Genus: *Phymanthus* Milne Edwards, 1857			o			5-30	G, R
11.	*Phymanthus buitendijki* Pax, 1924 **Family: STICHODACTYLIDAE Andres, 1883** Genus: *Heteractis* Milne Edwards, 1857	o	o	o			5-25	C, CB, G
12.	*Heteractis aurora* (Quoy and Gaimard, 1833)	o		o			10-30	G, L, S
13.	*Heteractis crispa* (Hemprich & Ehrenberg in Ehrenberg, 1834)	o	o	o	o	o	5-30	CB, R
14.	*Heteractis magnifica* (Quoy and Gaimard, 1833)	o	o	o	o	o	5-40	CB, R
15.	*Heteractis malu* (Haddon & Shackleton, 1893) Genus: *Stichodactyla* Brandt, 1835	o	o	o			10-30	G, L
16.	*Stichodactyla gigantea* (Forskål, 1775)	o		o			0-20	G, C, S

Sl. No.	Phylum/Class/Order/Family/Genus/ Species	NA	MA	SA	LA	NI	Depth in mm	Substrates
17.	*Stichodactyla haddoni* (Saville-Kent, 1893)	o	o	o			10-40	L, G, S
18.	*Stichodactyla mertensii* (Brandt, 1835) **Family: THALASSIANTHIDAE Milne Edwards, 1857** Genus: *Cryptodendrum* Klunzinger, 1877	o	o	o			5-25	C, CB, G, R
19.	*Cryptodendrum adhaesivum* Milne Edwards, 1857 **Family: BOLOCEROIDAE Carlgren, 1924** Genus: *Boloceroides* Carlgren, 1899	o	o	o	o	o	0-30	C, G, ,R
20.	Boloceroides mcmurrichi (Kwietniewski, 1898)	o	o	o	o	o	5-40	C, G, CB, L, S, SG
	Number of species	**16**	**13**	**17**	**7**	**5**		
	Number of genera	**10**	**10**	**11**	**6**	**4**		
	Number of families	**7**	**7**	**9**	**4**	**4**		
	Species Diversity (H')	**2.479**	**2.31**	**2.622**	**1.036**	**0.802**		

Bottom type codes: G =gravel, pebbles; L = loose stones, cobbles; R =rock; S = sand; C= crevices; M= mollusca; CB= coral boulders; SG= sea grasses; CL= Clay matter

o= Present; NA= North Andaman; MA= Middle Andaman; SA= South Andaman; LA= Little Andaman; NI=Nicobar Isalnd

and 9 families along the areas surveyed in 5 regions of Andaman and Nicobar Islands with depth and substrate (Table 1). In the present survey, 12 species are observed in gravels and pebbles, 8 species in loose stones, 8 species in rocks, 7 species in coral boulders, 6 species in crevices, 5 species in sand in the sea bottom. The substrate like sea grasses, molluscs and clay matter each represent only one species *viz. Boloceroides mcmurrichi, Calliactis miriam* and *Anthopleura handi* respectively. Other than sea grasses, *Boloceroides mcmurrichi* is also settled in all substrates due to its swimming behavior. Interestingly, *Calliactis miriam* is only restricted its association to one substrate i.e., gastropods. Moreover, it is observed that the settlement of three species also found restricted to one particular substrate such as gravels for *Anthopleura panikkarii* and loose stones for both *Parabunodactis inflexibilis* and *Actinodendron glomeratum*.

The diversity of sea anemones found to be maximum in South Andaman as it was represented by 17 species under 10 genera and 7 families with H' value of 2.622, whereas, minimum density of these organisms reported at Nicobar in which their occurrence was 5 species under 4 genera and 4 families with H' value of 0.8021. Among the species found, *Cryptodendrum adhaesivum, Heteractis magnifica, Heteractis crispa* and *Boloceroides mcmurrichi* were the only species found in all the regions of study. *Anthopleura handi* and *Entacmaea quadricolor* were distributed in most of the regions of study except Nicobar regions. The distribution of five species found restricted to one particular region of the study area (Table 1), they were *Bunodactis nicobarica* in Nicobar Islands; *Anthopleura panikkarii, Calliactis miriam* and *Metridium senile* in South Andaman. The depth at which 20 sea anemones are recorded varied from 0 to 40m. The occurrence of *Heteractis magnifica* was found in hundreds at a depth of 30m in Little Andaman and *Anthopleura handi* was found as dozens of at a depth of 1m in South Andaman. *Cryptodendrum adhaesivum* is recorded in shallower in South Andaman and in deeper waters in other regions. The density and distribution of other species were sporadic in nature (Fig. 3).

Similarity Index

The data calculated for species similarity index

on the distributional pattern of sea anemones in Andaman and Nicobar Islands is depicted in Table 2. In Andaman and Nicobar Islands, the maximum similarity of species (0.89) was observed between North Andaman and Middle Andaman while minimum (0.36) was found between South Andaman & Nicobar Island.

Table 2: Similarity Index of Sea anemones distribution in Andaman and Nicobar Islands

	NA	MA	SA	LA	NI
NA		0.89	0.79	0.61	0.38
MA			0.8	0.6	0.44
SA				0.5	0.36
LA					0.66
NI					

Species Diversity

Table 3 and figure 2 depict that Stichodactylidae is the well represented family, with 7 species in Andaman and Nicobar Islands. According to recent classification of Hoeksema (2014), the species composition of the family Stichodactylidae is 10 in world. Hence, the Stichodactylidae shows high species diversity in this region (70% in comparison with world and 100% with Indian waters). The families Actinodendronidae, Isophellidae, Metridiidae and Thalassianthidae also show 100% species diversity in comparison with India. According to Raghunathan *et al.* (2014), six species under this family Stichodactylidae are restricted to Andaman and Nicobar Islands only and *Heteractis* is the major genera which comprises four species in Andaman and Nicobar Islands.

Table 3: Species Diversity of sea anemone in Andaman and Nicobar Islands

Sl. No.	Phylum/Order/Family	No. of species in India	No. of species in ANI	Species Percentage at ANI in comparison with India
	Phylum: CNIDARIA Order: ACTINIARIA Haeckel, 1896			
1	Family: ACTINIIDAE Rafinesque, 1815	18	6	33.3
2.	Family:ACTINODENDRONIDAE Haddon, 1898	1	1	100
3.	Family: HORMATHIIDAE Carlgren, 1932	2	1	50
4.	Family: ISOPHELLIIDAE Stephenson, 1935	1	1	100
5.	Family: METRIDIIDAE (Carlgren 1893)	1	1	100
6.	Family: PHYMANTHIDAE Andres, 1883	2	1	50
7.	Family: STICHODACTYLIDAE Andres, 1883	7	7	100
8.	Family: THALASSIANTHIDAE Milne Edwards, 1857	1	1	100
9.	Family: BOLOCEROIDAE Carlgren, 1924	3	1	33.3

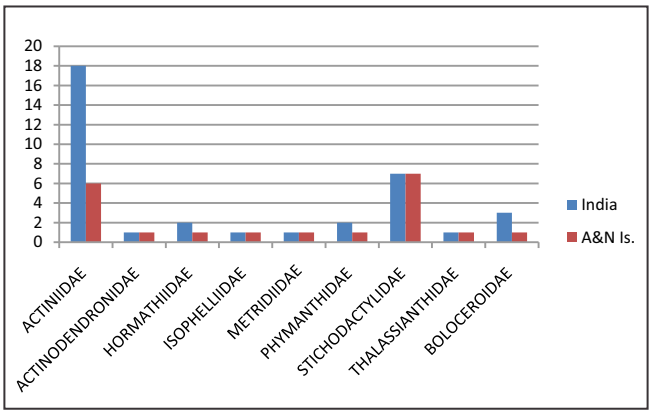

Figure 2 : Species Diversity of sea anemone in Andaman and Nicobar Islands in comparison with India

Discussion

This study represents the sea anemone fauna of A & N islands that contribute 37% of a total of 54 species reported from India. Globally, a total of 1107 species of Actiniarian sea anemones are reported (Hoeksema, 2014), of which only 10 species are host to anemone fishes (Fautin and Allen, 1992). All 10 host species are found to be occurred in Andaman and Nicobar Islands. Most of the species belonging to family Actiniidae and Stichodactylidae harbour a number of symbiotic species, both algae and anemone fishes. Earlier, the commensal mechanism was observed between the sea anemone *Neoaiptasia commensali* and hermit crab in Indian waters (Parulekar, 1969). *Cryptodendrum adhaesivum* is associated with sea anemone crabs, shrimps and *Actinodendron glomeratum* is also associated with shrimps. In the present study, it is noticed that *Stichodactyla haddoni* under the genus Stichodactyla is found singly at depths of 40m on soft sandy bottoms where as *Stichodactyla mertensii* and *Stichodactyla gigentea* are found on the rock, rubble reef and crevices at depth of 25m.

According to Raghunathan *et al.* (2014), 16 species are restricted to these islands, only 4 species found in peninsular coast of mainland India. Earlier *Boloceroides mcmurrichi* was known from Nicobar Islands; in this present observation, this species extends geographical distribution throughout Andaman and Nicobar Islands. Reporting of 20 species of sea anemones in Andaman and Nicobar Islands is quite high when compared with east coast of Indian waters as well as in other tropical and subtropical regions such as 19 species from east coast of India (Raghunathan *et al.*, 2014), 16 species from Singapore (Fautin *et al.*, 2009), 16 species from Costa Rica (Acuna *et al.*, 2013), 26 species from Panama (Garese *et al.*, 2009), 14 species from abyssal plain (> 1000 m depth) of northwestern Pacific Ocean (Eash-Loucks and Fautin, 2012), 16 species from Antarctic and sub-Antarctic waters (Dunn, 1983; Daly *et al.*, 2013), 8 species from Galapagos Islands (Fautin *et al.*,2007), 22 species from Madang Province (Fautin, 1988) and 13 species from Caribbean sea (Fourzan *et al.*, 2012).

Further, Andaman and Nicobar Islands should be target of numerous explorations to unravel actiniarian species richness and diversity beyond 40m depth.

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