

A Revised Checklist of Sea Anemones (Order: Actiniaria) from the Exclusive Economic Zone (EEZ) of India

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ABSTRACT

Actiniaria (sea anemones) are diverse groups of invertebrates found in intertidal rocks, intertidal mudflats, sand and muddy shore which have wide distribution. About 1497 species of sea anemones have been recorded worldwide. For the preparation of the revised checklist on Actiniarians of Indian EEZ, reports and research articles from 1869 to 2021 period were considered. The checklist documents 92 species of sea anemones recorded from Indian waters. The higher number of (46) sea anemone species were recorded from the west coast, whereas thirty species were recorded from the east coast. Among oceanic islands, Andaman-Nicobar Islands have reported more number of species (38) and least from Lakshadweep, only two species. Eventhough the diversity of sea anemones are high in Indian waters, comparatively very less studies were conducted on the distribution of sea anemones and the available information is not properly documented in a comprehensive manner. Present study is an attempt to document the diversity and distribution of sea anemones in Indian EEZ.

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1. Introduction

India is one of the mega-biodiverse countries harbouring a variety of species-rich ecosystems with 8,118 km, spread across the mainland and the Islands of Andaman and Nicobar and Lakshadweep (Gopalakrishnan et al., 2012). The wide intertidal regions, continental shelf and continental slope, provide excellent habitats for many invertebrates and vertebrates. More than 21663 species of fauna and flora were recorded from the marine and coastal environments of India. Among these, 20444 species are faunal communities (Chandra et al., 2016) that inhabit in vast benthic habitats. Sea anemones are one of the prominent benthic inhabitants their occurrence reported across all depths and latitudes (Ammons and Daly, 2008; Schories et al., 2011; Gonzalez-Munoz et al., 2016).

Many marine biological studies focussed on the diversity of benthic communities in Indian waters (Annandale, 1907; Carlgren, 1925; Panikkar, 1936, 1938; Mathew, 1979; Parulekar, 1990; Raghunathan et al., 2014; Shah et al., 2017). By recording the occurrence and abundance of species in a region, we can assess the status of protection of a particular species and ecosystem dynamics (Reiss et al., 2010; Piacenza et al., 2015). There is a need for accurate documentation of biodiversity and genetic resources, as aquatic organisms are important for food, bio-medical research and trade. Hence, awareness on the status of marine biodiversity and ecosystems is important in this era of developing marine biotechnology. Benthic ecosystems are difficult to monitor and assess, but at the same time, proper documentation and the regular assessment of diversity is essential. The present work provides a latest checklist that describes the diversity, occurrence and distribution pattern of sea anemones (Order: Actiniaria) in Indian waters.

The pioneering works about sea anemones in Indian EEZ were mainly focused on the occurrence (Stoliczka, 1869; Annandale, 1907; Carlgren, 1925; Menon, 1927; Panikkar, 1936, 1937, 1938). After a long gap, some observations were made in the east coast, west coast, Andaman-Nicobar Islands and Lakshadweep (Mathew, 1979; Cheriyan, 1964; Parulekar 1966, 1967, 1968a, 1969; Seshaiya and Cutress, 1969; Trivedi, 1975, Misra, 1975; Mathew and Kurian, 1979; Misra and Soota, 1981; Parulekar, 1981; Misra, 1984; Parulekar, 1990; England, 1990; den Hartog and Vennam, 1993; Mishra et al., 1994; Alfred et al., 1998; Bairagi, 1999). Observations on the occurrence of sea anemones were also carried out by Kumar (2001), Bairagi (2001), Ramakrishna and Talukdar (2003), Madhu and Madhu (2007), Ravinesh and Biju Kumar (2013), Raghunathan et al. (2014) Choudhury et al. (2015a, 2015b, 2016), Mahapatro et al. (2015), Bijukumar et al. (2015), Shah et al. (2017), Choudhury (2017), Raghunathan and Choudhury (2017), Choudhury and Raghunathan (2018) and Pati et al. (2018).

This paper presents a comprehensive updated checklist of sea anemones reported from the coastal peninsular India (east and west coast of India) and oceanic islands (Lakshadweep and Andaman and Nicobar Islands).

2. Materials and Methods

The study area considered for the present work is the Indian EEZ (Fig. 1) and subdivided as eastern Arabian Sea, Bay of Bengal, Andaman-Nicobar Islands and Lakshadweep. For the present work on the revised checklist of sea anemone (Order: Actiniaria), all the accessible publications from

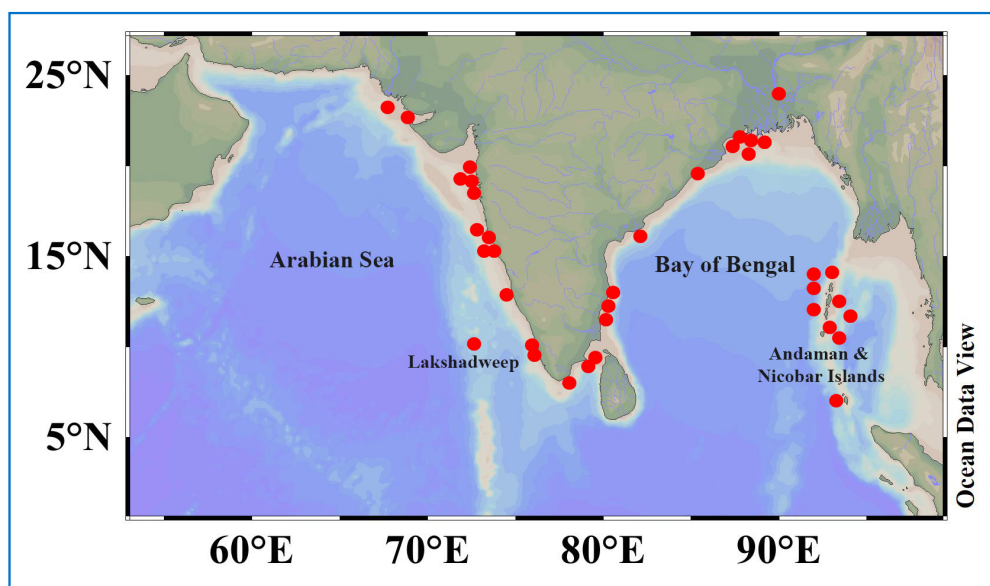


Fig. 1. Map showing the distribution of sea anemones in various regions of Indian EEZ

1869 to 2021 were considered. Data were collected from these Literatures, compiled the species list in a systematic way and summarised into various geographical locations of Indian EEZ. Classification of sea anemones was followed mainly based on the works of Rodriguez et al. (2014) and Daly and Fautin (2021) and the species were arranged phylogenetically. The analysed results were represented in tabular form. The distribution pattern and percentage composition of various families of sea anemones in the eastern Arabian Sea, Bay of Bengal, Lakshadweep and Andaman-Nicobar Islands of Indian EEZ region were represented diagrammatically. All the species names were verified and updated from the WoRMS website (Daly and Fautin, 2021). Similarity indices of the distribution of sea anemones in various regions were found out by PRIMER v6 software (Clarke and Warwick, 2001).

3. Results

3.1. Distribution and species composition of sea anemones in Indian EEZ

A total of 92 species of Actiniarians (Table 1) were recorded from Indian waters. Sea anemones were recorded from various regions of Indian EEZ such as the eastern Arabian Sea, Bay of Bengal, Andaman-Nicobar Islands and Lakshadweep Islands (Fig. 1). Highest contribution of sea anemone to the total species recorded eastern Arabian Sea (39%), followed by Andaman & Nicobar islands (33%), Bay of Bengal (26%) and Lakshadweep (2%). The listed anemones are distributed in 22 families (Fig. 2).

3.1.1. Distribution of sea anemones along East coast of India (Bay of Bengal)

From the Bay of Bengal region, 11 families, 21 genera and 30 species were recorded (Table 1). Maximum number of species (24) were recorded from Tamil Nadu, followed by nine species from West Bengal and seven species from Odisha. Brackish water species were more in these regions. Some of the species were recorded from the deeper slope.

of the south east coast. Eight species were common in West Bengal, Odisha and Tamil Nadu. They were *Edwardsia jonesii*, *E. tinctoria*, *Diadumene schillerianum*, *Pelocoetes minimus*, *Nevadne glauca*, *Mena chilkaea*, *Paracondylactis sinensis* and *Metapeachia tropica*. Members of Edwardsiidae family were more abundant in these regions.

3.1.2. Distribution of sea anemones along west coast of India (eastern Arabian Sea)

About 10 families, 27 genera and 46 species were recorded from eastern Arabian Sea region (Table 1). Out of the 46 species, 21 species were recorded from Maharashtra followed by 19 species from Gujarat, 13 species from Goa, 9 species from Kerala and 4 from Karnataka. Dominant species found in these regions were *Pelocoetes exul*, *Alicia sansibarensis*, *Anthopleura anjunae*, *A. nigrescens*, *A. panikkari*, *Anemonia indica*, *Cribrinopsis robertii*,

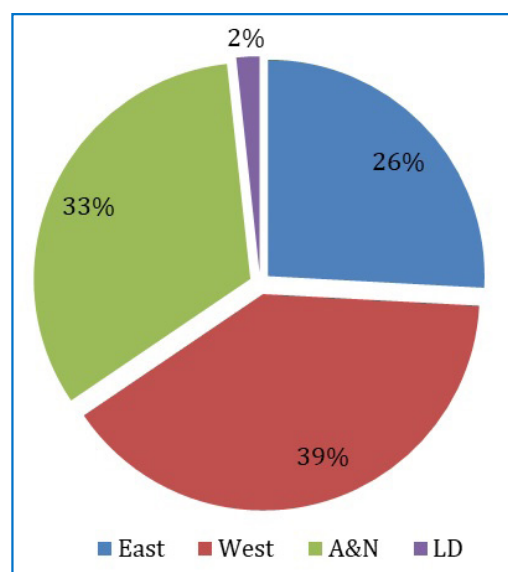


Fig. 2. Percentage composition of species of sea anemones in the eastern Arabian Sea (west coast), Bay of Bengal (east coast) Andaman – Nicobar (A&N) and Lakshadweep (LD) regions of Indian EEZ

Table 1. Checklist of sea anemones recorded from various regions of Indian EEZ

Classification	References	Location and Remarks
Phylum: Cnidaria		
Class: Anthozoa		
Subclass: Hexacorallia		
Order: Actiniaria		
Suborder: Anenthemonae Rodríguez & Daly in Rodríguez <i>et al.</i> (2014)		
Super Family: Edwardsioidea Andres, 1881		
Family: Edwardsiidae Andres 1881		
Genus: <i>Edwardsia</i> Quatrefages 1842		
<i>Edwardsia athalyei</i> (England, 1990)	England (1990)	Maharashtra
<i>Edwardsia jonesii</i> (Seshaiya & Cuttress, 1969)	Sheshaiya and Cuttress (1969); Misra (1976); Tikadar <i>et al.</i> (1986); Bairagi (2001) and Pati <i>et al.</i> (2018)	Orissa, West Bengal, Andhra Pradesh, Tamil Nadu; Karnataka
<i>Edwardsia mammillata</i> (Bourne, 1916)	England (1990)	Maharashtra
<i>Edwardsia tinctoria</i> (Annandale, 1915)	Annandale (1915); Sewell and Annandale (1922); Parulekar <i>et al.</i> (1980); Parulekar (1981); Parulekar (1990); Goswami (1992); Misra (1995); Alfred <i>et al.</i> (1998); Harkantra and Rodrigues (2003); Ramakrishna and Talukdar (2003); Mitra (2010) and Pati <i>et al.</i> (2018)	Maharashtra
Genus: <i>Edwardsianthus</i> England 1987		Gulf of Mannar, Andaman and Nicobar Islands
<i>Edwardsianthus pudicus</i> (Klunzinger, 1877)	Menon (1927) and Tikadar <i>et al.</i> (1986)	
Suborder: Enthemonae Rodriguez and Daly in Rodriguez <i>et al.</i> (2014)		Off the west coast of India
Super Family: Actinostoloidea Carlgren, 1932		
Family: Actinostolidae Carlgren 1932		
Genus: <i>Bathydactylus</i> Carlgren 1928		
<i>Bathydactylus valdiviae</i> (Carlgren, 1928)	Parulekar (1990) and Bijukumar and Nair (2014)	
Super Family: Actinoidea Rafinesque, 1815		
Family: Capneidae Gosse 1860		
Genus: <i>Actinoporus</i>		
<i>Actinoporus elongatus</i> (Carlgren 1900)	Menon (1927) and Choudhury and Raghunathan (2018)	Andaman and Nicobar Islands and Tamil Nadu
Family: Phymanthidae Andres 1883		Gujarat
Genus: <i>Phymanthus</i> Milne Edwards and Haime 1851		
<i>Phymanthus buitendijki</i> (Plax 1924)	Shah <i>et al.</i> (2017)	
<i>Phymanthis loligo</i> (Hemprich and Ehrenberg in Ehrenberg 1834)	Menon (1927); Parulekar (1990) and Tikadar <i>et al.</i> (1986)	Andaman and Nicobar Islands, Gujarat, Tamil Nadu, Gulf of Mannar (Tamil Nadu)
<i>Phymanthus pulcher</i> (Andres 1883)	Choudhury <i>et al.</i> (2018)	Andaman and Nicobar Islands
Family: Haloclavidae Verrill 1899	Panikkar (1938); Menon (1927); Goswami (1992); Parulekar <i>et al.</i> (1980); Parulekar, 1981, 1990; Ramakrishna and Talukdar (2003) and Tikadar <i>et al.</i> (1986)	Tamil Nadu, West Bengal
Genus: <i>Metapeachia</i> Carlgren 1943		Maharashtra
<i>Metapeachia tropica</i> (Panikkar 1938)		Goa
Genus: <i>Haloclava</i> Verrill 1899	Parulekar (1990) and Carlgren (1938)	Maharashtra
<i>Haloclava capensis</i> (Carlgren, 1938)		
Family: Bathyphelellidae Carlgren 1932		
Genus: <i>Acontiactis</i>		
<i>Acontiactis gokhaleae</i> (England 1990)	England (1990) and Mishra <i>et al.</i> (1994)	Maharashtra
Family: Actiniidae Rafinesque, 1815		
Genus: <i>Anthopleura</i> Duchassaing de Fombressin & Michelotti, 1860		
<i>Anthopleura anjanae</i> (Den Hartog and Vennam 1993)	Parulekar (1968, 1990) and den Hartog and Vennam (1993)	Maharashtra, Karnataka, Goa, Kerala
<i>Anthopleura annea</i> (Carlgren, 1940)	Gopalakrishnan <i>et al.</i> (2012)	Tamil Nadu
<i>Anthopleura asiatica</i> (Uchida and Muramatsu 1958)	Parulekar (1968, 1981, 1990); Rao (1991) and Tikadar <i>et al.</i> (1986)	Maharashtra, Andaman and Nicobar Islands
<i>Anthopleura buddiemieri</i> (Fautin 2005)	Bijukumar <i>et al.</i> (2015)	Kerala
<i>Anthopleura dixoniana</i> (Haddon and Shackleton 1893)	Shah <i>et al.</i> (2017) and Choudhury <i>et al.</i> (2016)	Gujarat, Andaman and Nicobar Islands
<i>Anthopleura elegantissima</i> (Brandt 1835)	Shah <i>et al.</i> (2017) and Ravinesh and Biju Kumar (2013).	Kerala, Gujarat
<i>Anthopleura handi</i> (Dunn 1978)	Choudhury and Raghunathan (2018)	Andaman and Nicobar Islands
<i>Anthopleura michaelsoni</i> (Pax 1920)	Gopalakrishnan <i>et al.</i> (2012)	Tamil Nadu

<i>Anthopleura nigrescens</i> (Verrill 1928)	Mathew (1979); Tikadar <i>et al.</i> (1986) and England (1987); Parulekar, (1990), Gopalakrishnan <i>et al.</i> (2012)	Maharashtra, Goa, Kerala, Tamil Nadu
<i>Anthopleura panikkarii</i> (Parulekar 1968)	Parulekar (1969, 1981, 1990); Rao (1991); Tikadar <i>et al.</i> (1986)	Andaman and Nicobar islands, Maharashtra, Goa, Karnataka, Kerala
<i>Anthopleura sola</i> Pearse and (Francis 2000)	Shah <i>et al.</i> (2017)	Gujarat
<i>Anthopleura thalia</i> (Gosse, 1854)	Gopalakrishnan <i>et al.</i> (2012)	Tamil Nadu
<i>Anthopleura waridi</i> (Carlgren, 1900)	England (1987)	Tamil Nadu
Genus: <i>Actinia</i> Linnaeus 1767	Mahapatro <i>et al.</i> (2015) and Shah <i>et al.</i> (2017)	Odisha, West Bengal, Gujarat
<i>Actinia equina</i> (Linnaeus 1758)		
Genus: <i>Anemonia</i> Risso 1826		
<i>Anemonia indica</i> (Parulekar 1968)	Parulekar (1968, 1990) and Tikadar <i>et al.</i> (1986)	Andaman and Nicobar Islands, Maharashtra, Mumbai, Goa, Karnataka, Gujarat
<i>Anemonia viridis</i> (Forsskal 1775)	Shah <i>et al.</i> (2017)	Gujarat
Genus: <i>Bunodactis</i> Verrill 1899	Parulekar, 1990	Andaman and Nicobar Island
<i>Bunodactis nikobarica</i> (Carlgren 1928)		
Genus: <i>Bunodosoma</i> Verill 1899	den Hartog and Vennam (1993) and Parulekar (1968)	Goa, Maharashtra, Tamil Nadu, Gujarat, Kerala
<i>Bunodosoma goanense</i> (den Hartog and Vennam 1993)		
<i>Bunodosoma granuliferum</i> (Le Sueur, 1817)	Parulekar (1968a, 1981, 1990) and Tikadar <i>et al.</i> (1986)	Maharashtra, Gujarat, Goa, Andaman and Nicobar Islands, Maharashtra
Genus: <i>Condylactis</i> Duchassing de Fonbressin & Michelotti 1864	Gopalakrishnan <i>et al.</i> (2012)	Tamil Nadu
<i>Condylactis parvicornis</i> (Kwietniewski, 1898)		
Genus: <i>Cribrinopsis</i> Carlgren, 1921		
<i>Cribrinopsis robertii</i> (Parulekar 1971)	Parulekar (1969, 1971, 1981, 1990)	Maharashtra, Goa, Tamil Nadu
Genus: <i>Entacmaea</i> Ehrenberg 1834		Andaman and Nicobar Islands
<i>Entacmaea quadricolor</i> (Leuckart & Ruppel) 1828	Raghunathan <i>et al.</i> (2014)	
Genus: <i>Gyractis</i> Boveri 1893		
<i>Gyractis sesere</i> (Haddon & Shackleton, 1893)	Parulekar (1990), Gopalakrishnan <i>et al.</i> (2012)	Maharashtra and Tamil Nadu
Genus: <i>Glyphoperidium</i> Roule 1909		
<i>Glyphoperidium bursa</i> (Roule, 1909)	Parulekar (1990)	Off south-west coast of India, Kerala
Genus: <i>Isoaulactinia</i> Belém, Herrera Moreno and Schlenz, 1996		
<i>Isoaulactinia stelloides</i> (McMurrich, 1889)	Gopalakrishnan <i>et al.</i> (2012)	Tamil Nadu
Genus: <i>Macroductyla</i> Haddon 1898	Madhu and Madhu (2007) and Shah <i>et al.</i> (2017)	Andaman and Nicobar Islands
<i>Macroductyla dorensis</i> (Quoy & Gaimard, 1833)		
Genus: <i>Parabunodactis</i> Carlgren 1928	Parulekar (1990)	Andaman and Nicobar Islands
<i>Parabunodactis inflexibilis</i> (Carlgren, 1928)		
Genus: <i>Paracondylactis</i> Carlgren 1934		Andaman and Nicobar Islands, West Bengal, Goa, Maharashtra, Gujarat, Tamil Nadu, Karnataka
<i>Paracondylactis sinensis</i> (Carlgren, 1934)	Menon (1927); Carlgren (1949); Misra (1975); Misra (1984); Parulekar (1968, 1981, 1990); Goswami (1992); den Hartog and Vennam (1993); Bairagi (1998); Ramakrishna and Talukdar (2003); Tikadar <i>et al.</i> (1986); Rodrigues (2003); Mitra and Misra (2006); Mitra and Pattnayak (2013); Mitra <i>et al.</i> , (2010); Pati <i>et al.</i> (2018)	
Genus: <i>Paratealia</i> Mathew & Kurian, 1979		
<i>Paratealia keralensis</i> (Mathew & Kurian, 1979)	Mathew and Kurian (1979)	Kerala
Genus: <i>Synantheopsis</i> England 1992	Parulekar (1968); den Hartog and Vennam (1993)	Gujarat, Maharashtra, Kerala
<i>Synantheopsis parulekari</i> (den Hartog and Vennam, 1993)		
Genus: <i>Utricina</i> Ehrenberg 1834	Shah <i>et al.</i> (2017)	Gujarat
<i>Utricina clandenstina</i> (Sanamyan, Sanamyan and McDaniel, 2013)		
Family: Stichodactylidae Andres 1883	den Hartog (1997); Ravinesh and Biju Kumar (2013), Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015b)	
Genus: <i>Heteractis</i> Milne-Edwards and Haime 1851		Andaman and Nicobar Islands
<i>Heteractis aurora</i> (Quoy & Gaimard, 1833)		
<i>Heteractis crisa</i> (Hemprich and Ehrenberg in Ehrenberg, 1834)	Madhu and Madhu (2007) and Raghunathan <i>et al.</i> (2004)	Andaman and Nicobar Islands, Gujarat, Daman and Diu
<i>Heteractis magnifica</i> (Quoy and Gaimard, 1833)	Madhu and Madhu (2007); Ajith Kumar and Balasubhranian (2012); Raghunathan <i>et al.</i> (2014); Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands, Gujarat
<i>Heteractis malu</i> (Haddon and Shackleton, 1893)	Madhu and Madhu (2007)	Andaman and Nicobar Islands
Genus: <i>Stichodactyla</i> Brandt, 1835	Menon (1927); Trivedi (1975); Madhu and Madhu (2007) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands, Gujarat
<i>Stichodactyla gigantea</i> (Forsskal, 1775)		

<i>Stichodactyla haddoni</i> (Saville-Kent, 1893)	den Hartog and Vennam (1993); Madhu and Madhu (2007) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands, Gujarat, Goa
<i>Stichodactyla helianthus</i> (Ellis, 1768)	Choudhury <i>et al.</i> (2016)	Andaman and Nicobar Islands
<i>Stichodactyla mertensii</i> (Brandt, 1835)	Madhu and Madhu (2007) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands
<i>Stichodactyla tapetum</i> (Hemprich and Ehrenberg in Ehrenberg, 1834) Family: Thalassianthidae Milne Edwards, 1857	Choudhury and Raghunathan (2018)	Andaman and Nicobar Islands
Genus: <i>Cryptodendrum</i> Klunzinger, 1877		
<i>Cryptodendrum adhaesivum</i> (Klunzinger, 1877)	Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands
Genus: <i>Thalassianthus</i>	Choudhury and Raghunathan (2018)	Andaman and Nicobar Islands
<i>Thalassianthus aster</i> (Ruppell and Leuckart, 1828)		
Genus: <i>Heterodactyla</i> Hemprich and Ehrenberg in Ehrenberg 1834	Choudhury and Raghunathan (2018)	Andaman and Nicobar Islands
<i>Heterodactyla hemprichii</i> (Ehrenberg, 1834)		
Family: Actinodendridae Haddon, 1898		
Genus: <i>Actinodendron</i> Blainville, 1830		
<i>Actinodendron glomeratum</i> (Haddon, 1898)	Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar islands
<i>Actinodendron arboreum</i> (Quoy and Gaimard, 1833) Super Family: Metridioidea Carlgren, 1893	Choudhury and Raghunathan (2017)	South Andaman and Oliver Island, North Andaman
Family: Diadumenidae Stephenson 1920		
Genus: <i>Diadumene</i> Stephenson 1920		
<i>Diadumene schilleriana</i> (Stoliczka 1869)	Stoliczka (1869); Annandale (1915); Ramakrishna and Talukdar (2003); Mitra and Misra (2006); Bairagi (1998); Mitra and Pattanayak (2013) and Pati <i>et al.</i> (2018)	West Bengal, Odisha, Maharashtra
<i>Diadumene lineata</i> (Verrill, 1869)	Parulekar (1990)	Maharashtra, Gujarat, Central and South-West coast of India
<i>Diadumene leucolena</i> (Verrill, 1866)	Choudhury and Raghunathan (2017)	Andaman and Nicobar Islands
Family: Haliactinidae Carlgren 1949		Orissa, West Bengal, Tamil Nadu, Kerala, Goa, Maharashtra, West Bengal, Andaman and Nicobar Island
Genus: <i>Pelocoetes</i> Annandale 1915		
<i>Pelocoetes exul</i> (Annandale, 1907)	Annandale (1907, 1915); Panikkar (1938,1939); Misra, (1995); Bairagi (2001); Mitra and Pattanayak (2013); Choudhury and Raghunathan (2018) and Pati <i>et al.</i> (2018); Panikkar (1938); Parulekar (1990) and Mitra (2010)	Tamil Nadu, West Bengal
<i>Pelocoetes minimus</i> (Panikkar, 1938)		
Genus: <i>Phytocoetes</i> Annandale 1915		
<i>Phytocoetes gangeticus</i> (Annandale, 1915)	Annandale (1915); Panikkar and Aiyar (1937a); Parulekar <i>et al.</i> (1980); Parulekar (1981); Tikadar <i>et al.</i> (1986); Parulekar (1990); Goswami, (1992); Misra (1995); Alfred <i>et al.</i> (1998); Bairagi (2001); Ramakrishna and Talukdar (2003); Mitra (2010) and Pati <i>et al.</i> (2018)	Andaman and Nicobar Islands, West Bengal, Goa, Tamil Nadu, Kerala, Maharashtra
Genus: <i>Phytocoeteopsis</i> Panikkar, 1936		
<i>Phytocoeteopsis ramunnii</i> (Panikkar, 1936)	Panikkar (1936); Cheriyan (1964); Misra and Soota (1981); Tikader <i>et al.</i> (1986) and Bairagi (2001)	Kerala, West Bengal, Andaman and Nicobar Island, Tamil Nadu
Genus: <i>Stephensonactis</i> Panikkar 1936		
<i>Stephensonactis ornata</i> (Panikkar, 1936)	Panikkar and Aiyar (1937); Tikadar <i>et al.</i> (1986) and Parulekar (1990)	Andaman and Nicobar Islands, Tamil Nadu
Family: Nevadneidae Carlgren 1925		
Genus: <i>Nevadne</i> Stephenson 1922		Andaman and Nicobar Islands
<i>Nevadne glauca</i> (Annandale, 1915)	Annandale (1915); Carlgren (1925); Sewell and Annandale (1922); Panikkar (1937c); Tikadar <i>et al.</i> (1986); Parulekar (1990); Misra (1995); Bairagi (1998); Ramakrishna and Talukdar (2003); Mitra (2010); Mitra and Pattanayak (2013) and Pati <i>et al.</i> (2018)	West Bengal, Tamil Nadu, Orissa, Goa
Family: Halcampidae Andres 1883		
Genus: <i>Mena</i> Stephenson 1920		
<i>Mena chilkaea</i> (Annandale, 1915)	Annandale (1915); Carlgren (1925), Tikadar <i>et al.</i> (1986); Mitra (2010) and Pati <i>et al.</i> (2018)	Orissa, West Bengal, Andaman and Nicobar Island
<i>Mena limnicola</i> (Annandale, 1915)	Annandale (1915); Carlgren (1925); Tikadar <i>et al.</i> (1986); Parulekar (1990); Misra (1995); Mitra (2010) and Pati <i>et al.</i> (2018)	Andaman and Nicobar Islands, West Bengal
Family Metridioidae Carlgren 1893		
Genus: <i>Metridium</i> de Blainville 1824		
<i>Metridium dianthus</i> (Ellis, 1768)	Tikadar <i>et al.</i> (1986)	Andaman and Nicobar Islands
<i>Metridium senile</i> (Verrill, 1865)	Parulekar (1968)	Maharashtra
Family: Andvakiidae Daniellssen 1890		Andaman and Nicobar Islands

Genus: <i>Telmatactis</i> Gravier 1916		
<i>Telmatactis cricoides</i> (Duchassing 1850)	Choudhury <i>et al.</i> (2016)	
<i>Telmatactis decora</i> (Hemprich and Ehrenberg in Ehrenberg, 1834)	Menon (1927); Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015a)	Andaman and Nicobar islands
<i>Telmatactis panamensis</i> (Verril 1869)	Menon (1927); Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015a)	Andaman and Nicobar Islands
<i>Telmatactis ternatana</i> (Kwietniewski 1896)	Menon (1927); Raghunathan <i>et al.</i> (2014) and Choudhury <i>et al.</i> (2015)	Andaman and Nicobar Islands
Family: Boloceroididae Carlgren 1924		Tamil Nadu
Genus: <i>Boloceractis</i> Panikkar 1937		
<i>Boloceractis gopalai</i> (Panikkar 1937)	Panikkar (1937)	
Genus: <i>Boloceroides</i> Carlgren 1899		West coast of India
<i>Boloceroides mcmurrichi</i> (Kwietniewski, 1898)	Panikkar (1937 b); Parulekar (1990) and Choudhury <i>et al.</i> (2015b)	Andaman and Nicobar Islands
<i>Bunodeopsis</i> sp. (Andres 1881)	Parulekar (1990)	Tamil Nadu
Family: Acontiophoridae Carlgren, 1938		
Genus: <i>Acontiophorum</i>		
<i>Acontiophorum bombayense</i> (Parulekar 1968)	Parulekar (1967, 1968, 1981, 1990)	Maharashtra, Karnataka
Family: Aiptasiidae Carlgren, 1924		Andaman and Nicobar Islands
Genus: <i>Neoaipiasia</i> Parulekar, 1969		Maharashtra
<i>Neoaipiasia commensali</i> (Parulekar, 1969)	Parulekar (1969, 1981, 1990) and Tikadar <i>et al.</i> (1986)	
Genus: <i>Aiptasia</i> Gosse 1856	Sachithanandam <i>et al.</i> (2011)	South Andaman
<i>Aiptasia mutabilis</i> (Gravenhorst, 1831)		
Genus: <i>Exaipiasia</i> Grajales and Rodriguez 2014		Gujarat
<i>Exaipiasia diaphana</i> (Rapp, 1829)	Shah <i>et al.</i> (2017)	
Genus: <i>Paraipiasia</i> England 1992		Andaman and Nicobar Islands
<i>Paraipiasia radiata</i> (Stimpson, 1856)	Choudhury <i>et al.</i> (2016)	
Genus: <i>Paraphellia</i> Haddon 1889		Maharashtra
<i>Paraphellia sanzoi</i> (Calabresi, 1926)	Parulekar (1990)	
Family: Hormathiidae Carlgren, 1932	Venkatraman <i>et al.</i> (2002)	Tamil Nadu
Genus: <i>Calliactis</i> Verril 1869		
<i>Calliactis parasitica</i> (Couch, 1842)		
<i>Calliactis polypus</i> (Forsk., 1775)	Venkataraman <i>et al.</i> (2012) and Raghunathan <i>et al.</i> (2014)	Andaman and Nicobar Islands
Genus: <i>Hormathia</i> Gosse, 1859		
<i>Hormathia coronata</i> (Gosse, 1858)	Venkataraman <i>et al.</i> (2002)	Andaman and Nicobar Islands
Genus: <i>Paracalliactis</i> Carlgren 1928		
<i>Paracalliactis valdiviae</i> (Carlgren, 1928)	Venkataraman <i>et al.</i> (2002)	Andaman and Nicobar Islands
Family: Nemanthidae Carlgren, 1940		
Genus: <i>Nemanthus</i> Carlgren, 1940		
<i>Nemanthus annamensis</i> (Carlgren, 1943)	Choudhury <i>et al.</i> (2015a)	Andaman and Nicobar Islands
Family: Aliciidae Duerden, 1895		
Genus: <i>Alicia</i> Johnson 1861		
<i>Alicia sansibarensis</i> (Carlgren 1900)	Parulekar (1990)	Southwest coast of India
Genus: <i>Triactis</i> Klunzinger 1877		
<i>Triactis producta</i> (Klunzinger 1877)	Choudhury <i>et al.</i> (2016)	Andaman and Nicobar Islands

Bunodosoma goanense, *B. granuliferum*, *Synanthopsis parulekari*, *Paracondylactis sinensis*, *Diadumene lineata*, *Stichodactyla haddoni*. Members of the family Actiniidae were abundant in eastern Arabian Sea region. Brackish water sea anemones were very less.

3.1.3. Common species from the Bay of Bengal and eastern Arabian Sea regions

A total of 13 species are commonly present in the Bay of Bengal and eastern Arabian sea coasts. They are *Edwardsia mammilata*, *E. tinctoria*, *Pelocoetus exul*, *Phytococeteopsis ramunnii*, *Nevadne glauca*, *Acontiophorum bombayense*, *Metapeachia tropica*, *Anthopleura nigrescens*, *A. panikkari*, *A. anjunae*, *Actinia equina*, *Paracondylactis sinensis* and *Hormathia coronata*.

3.1.4. Distribution of sea anemones around the Oceanic Islands

Oceanic islands of Indian EEZ include Lakshadweep and Andaman-Nicobar Islands. From these insular ecosystems of Andaman and Nicobar Islands, 18 families, 33 genera and 38 species were recorded, whereas 2 families, 2 genera and 2 species were reported from Lakshadweep islands (Table 1).

Analysis of community structure on the basis of regional scale by MDS and cluster analysis shown that eastern Arabian Sea and Bay of Bengal regions showed the similarity whereas the oceanic islands has distinct species composition (Fig 4. and Fig 5).

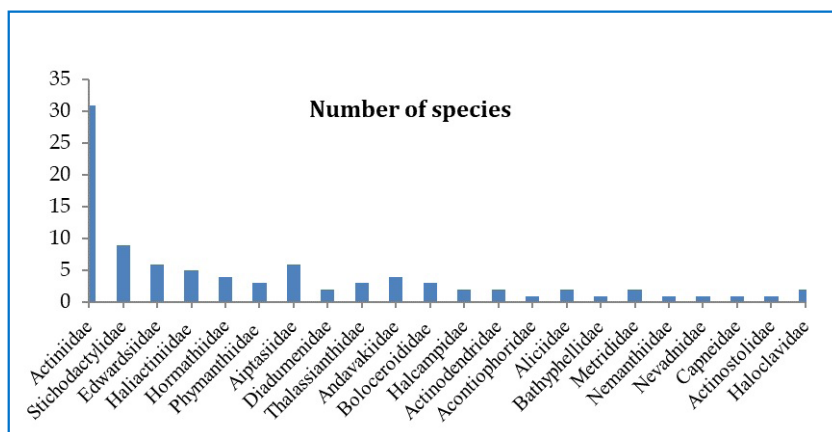


Fig. 3. Number of species in the families of sea anemones (Order: Actinaria) recorded from various regions of Indian EEZ

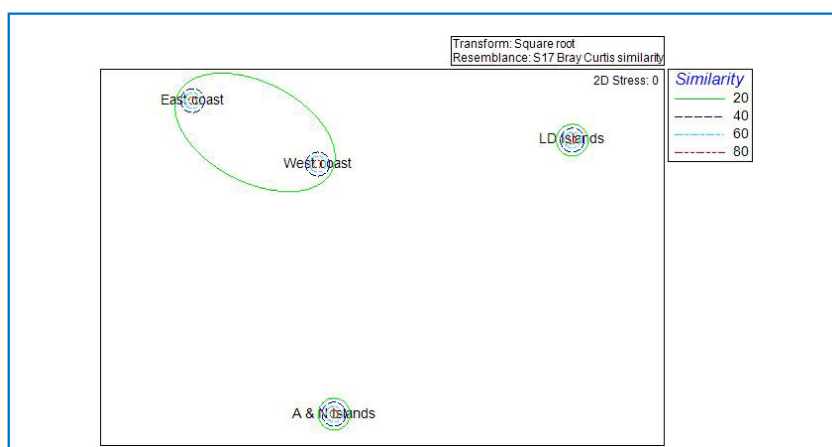


Fig. 4. Multidimensional scaling plot (MDS) plot showing the distribution pattern of sea anemones in different regions of Indian EEZ

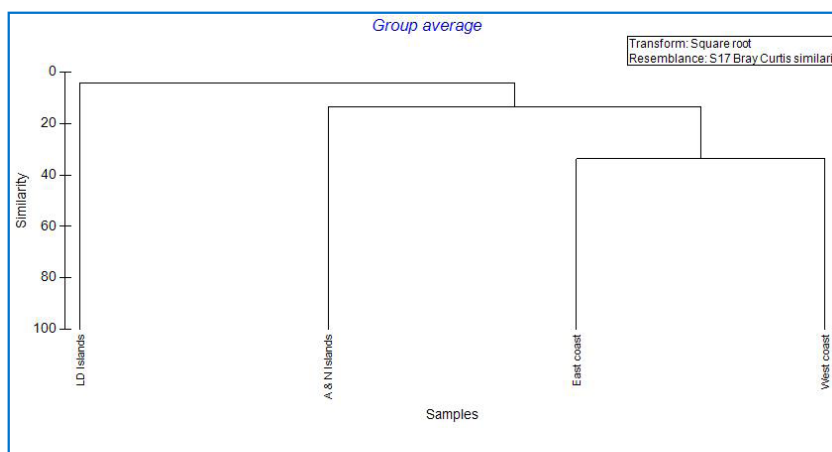


Fig. 5. Dendrogram showing similarity in the distribution pattern of sea anemones in Indian EEZ

3.1.5. Habitat wise distribution of sea anemones

The anemones present in the littoral zone were Edwardsiidae, Diadumenidae, Haliactinidae, Halcampidae, Nevadnidae, Metrididae, Andvakiidae, Boloceroiidae, Aiptasiidae, Phymanthidae and Actiniidae. These were present at a depth range from 0-450m. Family Edwardsiidae, Haliactinidae, Nevadnidae, Halcampidae are mostly found in brackish water upto to 6m depth. Actiniidae mostly found attached to rocks (Table 2). Some species were found attached to

polychaete tubes, cirripeds and algae. *Paracondylactis sinensis* found in the sand.

Phymanthidae families are mostly attached to rock, intertidal, seawall or crevices of the rocks. *Phymanthus loligo* found attached to corals, some Stichodactyliidae species also found attached to corals (0-40). Actinodendridae found in 15-23m. Only one species *Diadumene lineata* was found attached to rocks or shells of the other animals and present in brackish water too. Aiptasiidae family mostly attached

Table 2. Habitat wise distribution of sea anemones recorded from various regions of Indian EEZ

Species	Inter-tidal rocks	Sand/mud	Depth of Occurrence (m)	Association with invertebrates
<i>Edwardsia tinctoria</i> (Annandale, 1915)		√	0-2m	
<i>E. jonesii</i> (Seshaiya and Cuttress, 1969)		√	0-2	
<i>E. mammilata</i> (Bourne 1916)		√	0-2	
<i>E. athalyei</i> (England, 1990)		√	0-2	
<i>Edwardsianthus pudicus</i> Klunzinger, 1877)		√	0-2	
<i>Diadumene schillerianum</i> (Stoliczka, 1869)		√	0-10	Cirripedes
<i>Diadumene lineata</i> (Verrill, 1869)	√	√	0-2	Mollusc
<i>D. leucolea</i> (Verrill, 1866)			0-2	
<i>Pelocoetes exul</i> (Annandale, 1907)		√	0-2	
<i>P. minimus</i> (Panikkar, 1938)			0-2	
<i>Phytocoetes gangeticus</i> (Annandale, 1915)		√	0-2	
<i>Phytocoeteopsis ramunnii</i> (Panikkar, 1936)	√	√	0-2	
<i>Stephensonactis ornate</i> (Panikkar, 1936)	√	√	0-5	
<i>Nevadne glauca</i> (Annandale, 1915)	√	√	20-40m	
<i>Mena chilkaea</i> (Annandale, 1915)		√	0-1	
<i>Mena limnicola</i> (Annandale, 1915)		√	0-1	
<i>Metridium dianthus</i> (Ellis, 1768)			0-15	
<i>Metridium senile</i> (Linnaeus, 1761)			5-30	
<i>Telmatactis cricoides</i> (Duchasssing, 1850)			0-20	
<i>Telmatactis decora</i> (Hemprich and Ehrenberg in Ehrenberg, 1834)			0-30m	
<i>Telmatactis panamensis</i> (Verrill, 1869)			0-20	
<i>Telmatactis ternatana</i> Kwietniewski, 1896)			0-20	
<i>Boloceractis gopalai</i> (Panikkar, 1937)		√	-	
<i>Boloceroides mcmurichi</i> (Kwietniewski, 1898)			5-40m	
<i>Acontiophorum bombayense</i> Parulekar, 1968)	√		0-2	Mollusc
<i>Neoaipiasia commensali</i> (Parulekar, 1969)			0-2	Mollusc
<i>Aiptasia mutabilis</i> (Gravenhorst, 1831)			0-2	
<i>Exaipiasia diaphana</i> (Rapp, 1829)			0-2	
<i>Paraipiasia radiata</i> (Stimpson, 1856)			0-2	
<i>Paraphelia sanzoi</i> (Calabresi, 1926)			40m	
<i>Calliactis parasitica</i> (Couch, 1842)			0-2	
<i>Calliactis polypus</i> (Forsk. 1775)	√		0-15m	
<i>Hormathia coronata</i> (Gosse, 1858)			0-2	
<i>Paracalliactis valdiviae</i> (Carlgren, 1928)			0-2	
<i>Nemanthus annamensis</i> (Carlgren, 1943)			18	
<i>Alicia sansibarensis</i> (Carlgren, 1900)	√		20-40	Crabs
<i>Triactis product</i> (Klunzinger, 1877)			10-20	
<i>Actinoporus elongatus</i> (Carlgren, 1900)			0-30	
<i>Phymanthus buitendijki</i> (Plax, 1924)	√		0-30m	
<i>Phymanthus loligo</i> (Hemprich and Ehrenberg in Ehrenberg, 1834)	√		0-15	Corals
<i>Phymanthus pulcher</i> (Andres, 883)	√		0-1	
<i>Metapeachia tropica</i> (Panikkar, 1938)	√	√	0-2	
<i>Haloclava capensis</i> (Carlgren, 1938)			100-300m	
<i>Acontiactis gokhaleae</i> England, 1990		√	0-1	
<i>Anthopleura anjunae</i> (DenHartog and Vennam, 1993)	√		0-1	
<i>A. annea</i> (Carlgren, 1940)	√		0-1	
<i>A. asiatica</i> (Uchida and Muramatsu, 1958)	√		0-2	Mollusc
<i>A. buddiemieri</i> (Fautin, 2005)	√		0-1	
<i>A. dixoniana</i> (Haddon and Shackelton, 1893)	√		0-1	
<i>A. elegantissima</i> (Brandt, 1835)	√		0-1	
<i>A. handi</i> (Dunn, 1978)	√		2-3m	
<i>A. michaelseni</i> (Pax, 1920)	√		0-1	
<i>A. nigrescens</i> (Verrill, 1928)	√		0-1	Zoantharians
<i>A. panikkari</i> (Parulekar, 1968)	√		0-10m	Mollusc
<i>A. sola</i> (Pearse and Francis, 2000)	√		0-1	

<i>A. thalia</i> (Gosse, 1854)	√		0-1	
<i>A. waridi</i> (Carlgren, 1900)	√		0-1	
<i>Actinia equine</i> (Linnaeus, 1758)	√		0-1	
<i>Anemonia indica</i> (Parulekar, 1968)		√	5-15	Mollusc
<i>A. viridis</i> (Forskkaal, 1775)			0-5	
<i>Bunodactis nikobarica</i> (Carlgren, 1908)	√		0-200m	Corals
<i>Bunodosoma goanense</i> (den Hartog and Vennam, 1993)	√		0-1	
<i>B. granuliferum</i> (Lesur, 1877)			0-2	
<i>Condylactis parvicornis</i> (Kwietnewski, 1898)			0-10	
<i>Cribrinopsis robertii</i> (Parulekar, 1971)	√		0-1	Zoantharians
<i>Entacmaea quadricolor</i> (Leuckart and Ruppel, 1828)			1-25m	
<i>Gyractis sesere</i> (Haddon and Shackelton, 1899)	√		0-1	
<i>Glyphoperidium bursa</i> (Roule, 1909)			500m	Mollusc
<i>Isoauctinia stelloides</i> (Mcmurich, 1889)				
<i>Macroactyla doreensis</i> (Quoy and Gaimard, 1833)			9-11m	
<i>Parabunodactis inflexibilis</i> Carlgren, 1928)			450m	
<i>Paracondylactis sinensis</i> (Carlgren, 1934)	√		0-1	Other species
<i>Paratealia keralensis</i> (Mathew and Kurian, 1979)			150m	
<i>Synantheopsis parulekari</i> (denHartog and Vennam, 1993)		√	0-1	
<i>Utricina clandestine</i> (Sanamyan <i>et al.</i> , 2013)			0-1	
<i>Heteractis aurora</i> (Quoy and Gaimard, 1833)			2-30m	
<i>Heteractis crista</i> (Hemprich and Ehrenberg in Ehrenberg, 1834)			5-30m	
<i>H. magnifica</i> (Quoy and Gaimard, 1833)			5-40m	
<i>H. malu</i> (Haddon and Shackelton, 1893)			10-30m	
<i>Stichodactyla gigantea</i> (Forskkaal, 1775)	√		0-20m	Corals
<i>S. haddoni</i> (Saville-Kent, 1893)			10-40 m	
<i>S. helianthus</i> (Ellis, 1768)			0-2	
<i>S. mertensii</i> (Brandt, 1835)			6-9m	
<i>S. tapetum</i> (Hemprich and Ehrenberg in Ehrenberg 1834)			0-2	
<i>Cryptodendrum adhaesivum</i> (Kluzinger, 1877)			0-30m	
<i>Thalassianthus aster</i> (Ruppel and Leuckart, 1828)			0-2	
<i>Heterodactyla hemprichii</i> (Ehrenberg, 1834)			0-2	
<i>Actinodendron glomeratum</i> (Haddon, 1898)			0-2	
<i>Actinodendron arboretum</i> (Quoy and Gaimard, 1833)			15-23m	
<i>Bathydactylus valdiviae</i> (Carlgren, 1928)			4000m	

to gastropods, bivalves or crabs showing the symbiotic relationship with other animals. Some species of sea anemones such as *Haloclava capensis* (300m), *Bunodactis nikobarica* (200m), *Parabunodactis inflexibilis* (450m) and *Paratealia keralensis* (150m) were located in deeper slope of benthic region.

4. Discussion

4.1. Diversity and Distribution

Sea anemones were the cosmopolitan species and found in the intertidal and subtidal rocks, coral reefs and estuaries. So far, a total of 92 species of Actiniarians were recorded from Indian waters. Based on Rodriguez *et al.* (2014), they belong to One Order (Order: Actinaria), two sub Orders (Sub Orders: Enthemonae and Anenthemonae), four super families, namely Edwardsioidea, Metridioidea, Actinioidea and Actinostolidea; 22 families and 54 genera. On the basis of this checklist, these super families comprised of the families Edwardsiidae, Diadumenidae, Haliactinidae, Nevadneidae, Halcampidae, Metrididae, Andavakidae, Boloceroiidae, Acontiophoridae, Aiptasiidae, Hormathidae, Nemanthidae, Alicidae, Capneidae, Phymanthidae, Haloclavidae, Bathypheidae, Actiniidae,

Stichodactylidae, Thalassianthidae, Actinostolidae and Actinodendridae. Metridioidea contains 12 families and 24 genera whereas Actinostolidae contain one family and one genus. Actinioidea contains 8 families and 27 genera and Edwardsioidea contain one family and two genera. Actiniidae has the highest number of 31 species, Stichodactylidae are of nine species, Edwardsiidae have five species, Haliactinidae and Hormathiidae have five species each and Phymanthidae and Aiptasiidae have four species each. Diadumenidae, Thalassianthidae and Andvakiidae have three species each, Boloceroiidae, Halcampidae, Actinodendridae has two species each, and the rest Acontiophoridae, Alicidae, Bathypheidae, Metrididae, Nemanthidae, Nevadneidae, Capneidae, Actinostolidae has one species each.

Among the various regions of Indian EEZ, eastern Arabian Sea region showed highest percentage of 38% of species, followed by Bay of Bengal region (34%), Andaman-Nicobar islands (26%) and Lakshadweep (2%). From Andaman and Nicobar Islands, 33 species, 20 genera and 13 families were reported. Two species *Glyphoperidium bursa*, *Heteractis magnifica* were reported from Lakshadweep. The Andaman-Nicobar islands are a group of oceanic coral islands with fringing and barrier

reefs, which harbours high diversity of marine organisms. Comparatively high abundance of sea anemones (26%) in these islands is supported by healthy coral reefs. Since, the Lakshadweep islands are small coral atolls, the distribution of sea anemones are limited. As shown in the MDS and cluster analysis results, it is observed that the species composition of sea anemones in east and west coast showed higher similarity (33.7%), whereas the oceanic islands such as Andaman-Nicobar and Lakshadweep showed significant differences (13.45% and 4.4%) in similarity of species composition.

Sea anemones inhabit sandy, muddy, or rocky habitats and sometimes attach themselves to the hard parts or products of other organisms (Sebens, 1998). In the present analysis, the members of the family Actiniidae were found attached to rocky substratum. Artificial coastal structures also provides habitat for sea anemones. Generally, most of the anemones were living in the intertidal or sub-tidal regions having hard substratum or as symbiotic with other organisms.

5. Conclusion

Taxonomists have the main role of not only describing the species, but also protecting the ecosystem by recording the

data on species occurrence and abundance in accordance with geography. Present check list on the species composition and distribution pattern of sea anemones (Order: Actiniaria) provides the latest record in the Indian EEZ. A total of 92 species of Actiniarians were recorded from various regions of Indian EEZ. By recording the occurrence and abundance of sea anemones in various regions of Indian EEZ, we can suggest management strategies for conservation of anemones in the regional scale with reference to ecological, economical, anthropogenic and natural disturbances.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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