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Abundance and distribution of marine sponges along the south-west coast of India: An analysis of the 'bycatch' sponge species

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Original Article

Abstract

Marine sponges are diverse, widely distributed and have prospects for the development of novel bioactive compounds. In the present study, the abundance and distribution of marine sponges along the southwest Coast of India were determined using sponges obtained as 'bycatch' in 2010 and 2011. The study area included Kanyakumari, Chinnamuttom and Arokiapuram landing centres. The 'bycatch' specimens of sponges obtained from three types of fishing nets were surveyed. The wet weight of the sponges collected from the gillnet was higher than that of crab net and lobster net. A total of 14 sponge species were collected in varying quantities during the study period.; The most widely distributed species in all three sampling stations was *Echinodictyum gorgonoides.* The study on the distribution and species richness of sponges in three stations for the period of 2010 - 2011 indicated maximum species diversity at Kanyakumari (13 species), followed by an equal number of species at Chinnamuttom and Arokiapuram (10 species).

Keywords*: Marine sponge, distribution, diversity, Kanyakumari coast, bycatch*

Introduction

Research on marine sponges has received much attention in the recent past owing to the presence of novel bioactive compounds in them. Sponges are an important component in many benthic communities and dominate the benthos in some regions in terms of biomass and diversity (Schmahl, 1990; Wilkinson and Cheshire, 1990). The abundance and distribution patterns of sponges can be influenced by water flow and depth (Wilkinson and Evans, 1989; Roberts and Davis, 1996), larval dispersal and recruitment patterns (Maldonado and Young, 1996), predation (Dunlap and Pawlik, 1996), light intensity (Wilkinson and Trott, 1985) and substrate and habitat type (Reiswig, 1974; Adjeroud, 1997). Environmental and biological factors can also generate randomness in sponge distribution (Zea, 2001). The influence or impact of each factor varies among sponge species, often restricting species to a specific area or depth (Wilkinson and Evans, 1989) and exacerbating heterogeneity in community structure between and within reefs or islands.

Their supply is considered one of the major problems hampering marine natural product drug discovery (Montaser and Luesch, 2011). Since sponge collection may diminish their existence in wild, the 'bycatch' seems to be one of the precise sources for the sponge secondary metabolite research. The bycatch or the incidental catch and discarding of undesired organisms in a fishery, occurs when fishing gear catches the non-targetted species whose retention is either not economical or prohibited by law (Dayton *et al*., 1995). The eco-friendly type of collection, though not a targeted catch, will be of much use to assess the potential uses. Bioactivity testing of sponges collected from 'bycatch' was

evidenced by a few earlier studies worldwide (Hentschel *et al.*, 2001; Proksch *et al.*, 2002) and in India (Selvin and Lipton, 2004). The present study attempts to systematically collect and analyse the abundance and diversity of common marine sponges as discards from fishing nets.

Material and methods

Sampling stations

The sampling stations included the extreme southern part and the Gulf of Mannar located on the southeast coast of India from Rameswaram Island in the North to Kanyakumari in the South. The sampling of 'by catches' was carried out from 3 Landing centres (Station: 1. Kanyakumari (N 77°33.720', E 084° 79.724'), Station: 2. Chinnamuttom (N 08° 05.727', E 077° 33.567') and Station: 3. Arokiapuram (N 08° 07.881', E 077° 33.097) in Kanyakumari coast (Fig. 1), between January 2010 and December 2011.

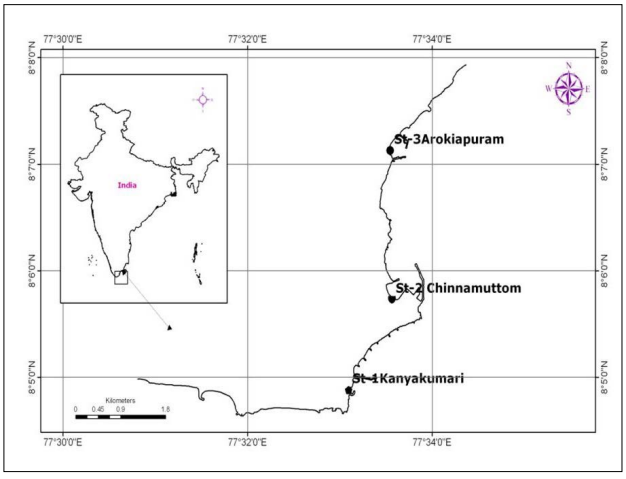

Fig. 1. Location of Sampling stations in Kanyakumari coast, Tamil Nadu, India

Collection

Specimens of the marine sponges were collected from the chosen coasts by "bycatch method" during the active fishing season of 2010 to 2011. Sponges got entangled in the fishing nets while fishing and were segregated after the completion of fishing in the morning hours. They were examined for attached algae and other organisms that were carefully removed. Details of colour, shape, texture, consistency, form and other characteristic features were noted during the time of collection. The sponges of interest were transferred directly to a plastic ice box container containing seawater to prevent contact of sponge tissue with air.

Evaluation of occurrence of sponges in different gears

The samples and relevant data were collected twice a month throughout the study period. Different types of gear were used in the study area. The gears were surveyed during morning hours on each sampling day and were selected based on the types of catches operated. The total catches and the bycatch sponges were weighed using a balance and the representative samples were taken on each sampling day. The collected sponges were sorted into species- wise and the numbers of individuals for each species were counted and percent composition determined.

Biomass of sponges collected as bycatch

Biomass of marine sponges was primarily determined by wet and dry weight collected sponges with different types of net operations. The total bycatch sampling was carried out in 143 fishing Out Board Motor (OBM) vessels in the three stations. All stations operated fishing gears such as ribbon fish net, sardine net, bottom gillnet, lobster net and crab net. Details of fishing nets operated in Out Board Motor (OBM) boats are given in Table 1.

The sponges obtained as bycatches were calculated by random sampling method and the sponge discards were collected and taken to the laboratory. The total amount of sponge bycatch collection per boat and type of net was estimated in terms of wet weight by weighing the discards using a digital weighing balance at the sampling stations.

$$\text{Bycatch Estimate} = \text{Observed Bycatch Rate} \times \text{Total Fishery Effort}$$

$$\text{Observed bycatch rate} = \frac{\%\text{ of incidental takes (Entanglements observed}}{\text{Fishery effort observed}}$$

Total Fishery Effort = Metric tons of fish landed (All of the above were divided up and summed by time, area and gear used)

Table 1. Details of fishing nets operated in (Out Board Motor (OBM) boats from January 2010 to December 2011 at Kanyakumari

Type of net	Net length (m)	Net height (m)	Mesh size (mm)	Operating depth (m)	Operating duration (h)
Ribbonfish net	250	18	20	25-55	5
Sardine net	300	14	83	24-30	12
Bottom gillnet	100-120	5	90	19-25	22
Lobster net	70-80	12	112	18-20	16
Crab net	100-120	7	85	8 - 14	14

Data analysis

Multivariate analyses were performed on presence/absence data based on the Bray-Curtis similarity coefficient (Bray and Curtis, 1957) using Primer-6 software, to analyse the similarity among the sampling stations based on the sponge species diversity and availability in the bycatch collection from the different types of net gear operation. Analysis of variance (ANOVA) was applied to know the sponge availability between study stations, fishing nets and seasonal variations. The statistical analyses were carried out in Microsoft Excel 2010.

Results

Sample collection and identification

The "bycatch" specimens of sponges were obtained from the chosen stations from three types of fishing nets. Concerning the available wet weight of sponges in three fishing gears, the gill nets contributed the highest during 2010 and 2011 (Table 2). The wet weight of the sponges collected from gillnet was 4012 g in 2010, followed by crab net and lobster net at 557 and 461 g respectively. In the year 2011, 1452 g of sponge wet mass was collected from gill net operations. On the whole, concerning all three types of fishing gear, the summer season recorded the highest amount of sponges during both the 2010 and 2011 surveys (Fig. 2).

Table 2. Bycatch collection of sponge wet biomass from 2010 to 2011

Types of Net	Wet biomass in g	
	2010	2011
Lobster net	461	172
Crab Net	557	328
Bottom gill net	4012	1452

Population density

Among the three study stations, Kanyakumari recorded the maximum wet weight quantity and distribution of sponges than the other two study stations during both years (Fig. 2). The wet weight contribution and diversity of sponge species were rich from April to July during the years 2010 and 2011 (Fig. 3).

The maximum wet biomass was recorded with the bottom gill net, *i.e.*, 4012 g in 2010 and 1452 g in 2011 respectively. The Crab net bycatch collections of sponges were much less than the bottom gill net *i.e.*, 557g in 2010 and 328 g in 2011

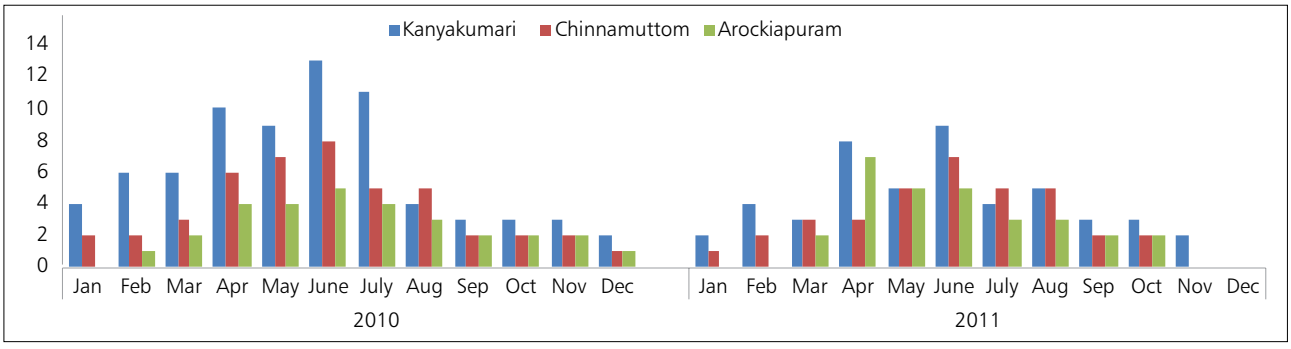

Fig. 2. Monthly variations in species richness (number of species) of the sponge bycatch in small-scale fisheries at the Kanyakumari coast from January 2010 to December 2011. (All values are an average of four observations per month per station)

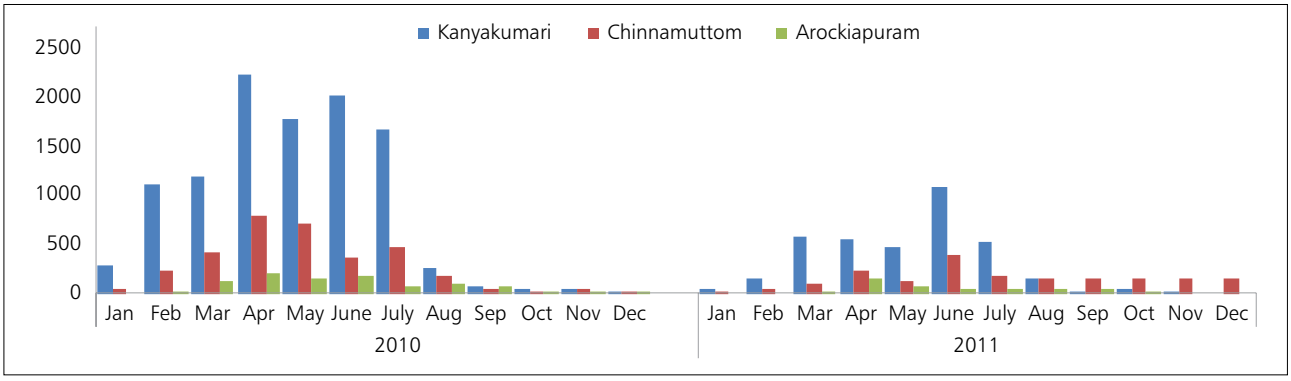

Fig. 3. Monthly variations in population density (wet biomass in g) of the sponge bycatch in small-scale fisheries at Kanyakumari coast from January 2010 to December 2011 (All values were based on total sponge catch by time and area; an average of four observations per month per station)

during the fishing period at all stations (Table 3). The single factor ANOVA revealed a significant difference in the sponge bycatch in lobster, crab and bottom set gill nets during 2010 and 2011 ($P < 0.05$). The bycatch collected marine sponge wet biomass was very high (2.250 kg) during the month of May to July 2010 and June 2011 (Table 4).

The percentage similarity between the sampling stations based on the sponge species diversity recorded by bycatch was analysed by Bray-Curtis cluster analysis (Fig. 4), which showed a 73.9 % similarity between the Kanyakumari and the other two sampling stations but 80% similarity between Chinnamuttom and Arockiapuram. The stations Kanyakumari, Chinnamuttom and Arokiapuram formed a cluster indicating the similarity of species in these stations. According to the Bray Curtis similarity Index, the sponge richness was highest in Kanyakumari followed by Chinnamuttom and Arokiapuram.

Table 3. Sponge wet weight (in g) of different fishing gears in three study stations during all the seasons of 2010 and 2011

Month	Sponge bycatch (g)					
	2010			2011		
	Lobster net	Crab net	Gill net	Lobster net	Crab net	Gill net
January	12	12	124	0	0	18
February	38	132	405	0	0	60
March	71	120	492	38	59	152
April	87	105	670	34	34	234
May	70	88	704	31	34	156
June	73	67	696	51	121	352
July	110	33	503	18	55	213
August	0	0	232	0	7	101
September	0	0	69	0	0	36
October	0	0	42	0	0	46
November	0	0	57	0	0	7
December	0	0	18	0	0	0

Table 4. Sponge wet weight (in g) different fishing gears in three study stations during all the seasons of 2010 and 2011

Month	Sponge bycatch (g)					
	2010			2011		
	Station I	Station II	Station III	Station I	Station II	Station III
January	291	56	0	37	18	0
February	1118	235	32	156	54	0
March	1190	414	119	576	112	28
April	2220	790	211	563	226	143
May	1770	714	154	480	137	73.5
June	2032	357	183	1082	405	53
July	1675	469	81	524	185	45.5
August	269	186	101	162	142.5	44.5
September	67	41	63	27	45.5	34
October	50	29	17	53	65	18
November	48	44	31	22	0	0
December	26	14	14	0	0	0

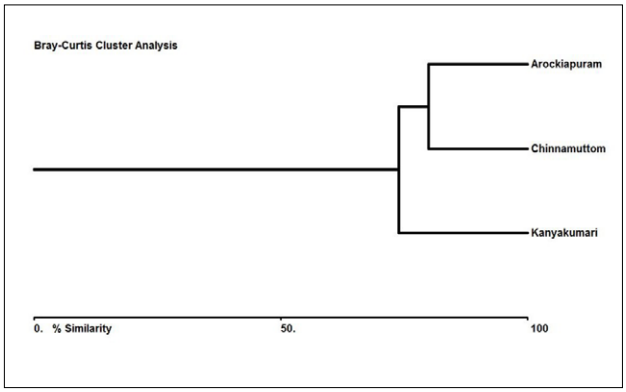

Fig. 4. Dendrogram showing the percentage similarity between the sampling stations based on the sponge species diversity recorded in the bycatch along the Kanyakumari coast from January 2010 to December 2011 using group average clustering (Bray-Curtis similarity).

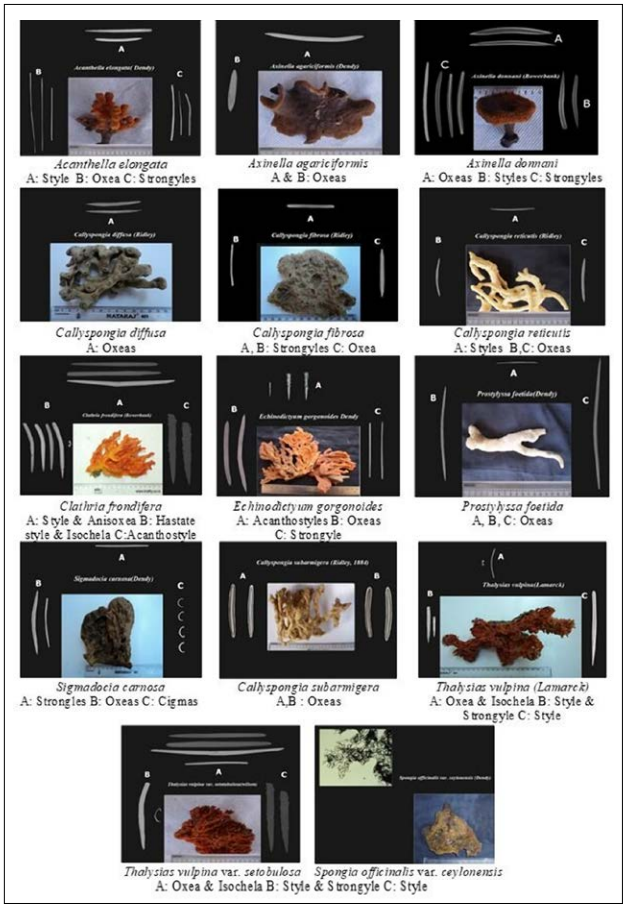

Fig. 5. Morphology and spicule characteristics of the collected sponge species

Table 5. Distribution of Demospongiae order observed during 2010-2011 (the values in the parentheses indicate the percentage of sponges collected under different families, genera, and species)

Order	Family	Genus	Species
Halichondria	3 (34)	2 (20)	3(21)
Haplosclerida	2 (22)	4 (40)	5(36)
Poecilosclerida	2 (22)	2 (20)	4(29)
Keratosida Grant	1 (11)	1(10)	1(7)
Epipolasida	1(11)	1(10)	1(7)
Total	9	10	14

The samples were analysed using light microscopy with the identification keys available in Hooper and Van Soest (2002) and further confirmed with the specific spicule characteristics (Fig. 5). The exact taxonomical position of the sponge specimens was later confirmed by the renowned sponge taxonomist Dr P. A. Thomas. A total of 14 sponge species were collected in varying quantities during the study period (2010 - 2011) from the three localities over a two-year sampling period (Fig. 5). The most widely distributed species in all the three sampling stations was *Echinodictyum gorgonoides.*

Among the total collection of marine sponges belonging to the order demospongiae, the family Halichondria (34.0 %) predominated in all the sampling stations (Table 5). The *Haplosclerida* genus distribution was 40% during the collection duration.

The most abundant species in Station I was *Echinodictyum gorgonoides*, *Clathria frondifera*, *Spongia officinalis var. ceylonensis, Thalysias vulpina var. setotubulosa* and followed by *Callyspongia* sps. At Station III, one new species of marine sponge *Prostylyssafoetida* was recorded. The results of the present study indicated that the maximum number of sponge genera occurred from May to August at three stations and the distribution was much higher in Station I. The study on the distribution and species richness of sponges in three stations for the period of 2010-2011 indicated maximum species diversity at Kanyakumari (13 species), followed by an equal number of species at Chinnamuttom and Arokiapuram (10 species).

Discussion

The study area Kanyakumari District (lat. between 8° 5' and 8° 21 ' N and long, between 77° 6' and 77° 34' E) is situated on the southern extremity of the Indian Peninsula and sampling stations were from Kanyakumari to Arokiapuram on the east coast. The inshore area is sandy, strewn with rocky beds. There are about 6 fish landing centres along the selected area. Higher density of fishermen population, presence of maximum types of traditional fishing methods and high expertise in certain fishing techniques were some of the unique features noticed in this area. The present study revealed that the physical habitat variables play a key role in the distribution of sponges on the southeast coast.

The "bycatch" sponge collections from Station I Kanyakumari, Station - II Chinnamuttom, and Station - III Arokiapuram possessed bioactivity even though they were dislodged from the natural environment. Earlier studies carried out using "bycatch" sponges, yielded novel marine natural products (Selvin and Lipton, 2004; 2006a, 2006b; Annie *et al*., 2008; Aishwarya *et al*., 2013). Ovenden and Capon (1999) utilized *Sigmasceptrella* spp. obtained from trawling operation in the Great Australian Bight for bioactivity screening and chemical elucidation of potent active compounds. The studies by Urban *et al.* (1994) showed that *Dendrillacatos* collected as trawler bycatch yielded two new aromatic compounds *viz*., lamellarins O and P. As inferred by García-de-Vinuesa *et al.* (2021), the resources, which are being thrown away or dumped at sea as part of the fisheries' discards, contain many species, which produce different bioactive compounds that represent an added-value resource.

The corals and sponges can create habitats that can be occupied by communities with high biodiversity and can be feeding and spawning stations and sources of shelter for invertebrates and fish. Despite the role of large sponges as habitat-forming structures and their vulnerability, the sponge-dominated biotopes (sponge grounds) have not been well investigated along the Kanyakumari coast. Mass occurrence of sponges was recorded as part of the bycatch in the present survey stations located on the Kanyakumari coast. Such large bycatches could indicate the presence of sponge grounds in the area, but additional research is needed to identify this sponge-dominated habitat. The data on the bycatch records in terms of sponge discard diversity in small-scale fisheries recorded from January 2010 to December 2011could be utilized as background information for evaluating the distribution and destruction of marine sponges in the complex benthic environment of the Kanyakumari fishing ground.

The study by Pham *et al.* (2020) highlighted the large extent and importance of sponge grounds in a productive fishing ground. Sponges contribute a significant part to all types of bottom-touching fishing gears (Osinga *et al*., 1999). The diversity and abundance of bycatch sponges vary spatially and temporally. It is due to the regional availability of sponges and their seasonal favourable environment. Variation of species diversity and abundance depends on favourable environmental conditions (Osinga *et al*., 1999). The favourable condition in the study area in the study period attributed to the higher availability of *C. frondifera, E. gorgonoides* and *S. officinalis var. ceylonensis* could be recorded.

The earlier studies by Thomas (1985) reported the richness of sponge species in the Gulf of Mannar. The monograph on

sponges indicated the prevalence of about 275 species under 38 families and 136 genera. In the present study, the eco-friendly collection of the marine sponges detected a total of 10 families, 8 genera, and 14 species of marine sponge from 2010 to 2011 in the study area with representatives of Demospongiae present along with Calcareae and Hexactinellidae.

Among the different nets examined for bycatches of sponges, the bottom set gillnet brought maximum wet biomass (4012 g in 2010 and 1452 g in 2011). Sainsbury *et al.* (1993) attributed much of this change to alterations in benthic structure, especially the loss of sponges caused by trawling. It was observed in the present study that the population density of sponges in the fishing gears which was recorded as 15.1 kg in 2010 was reduced to 5.5 kg in 2011. The results of the present study and previous estimates indicate that the ecological impacts of small-scale fisheries can be severe and even comparable to those of large-scale industrial fisheries per unit of catch as reported earlier (D'agrosa *et al.*, 2000; Peckham *et al.*, 2007). Several researchers have worked on strategies to mitigate the loss of biodiversity due to trawling and bycatch; however, it still presents a challenge for fishery managers and stakeholders (Squires *et al.*, 2021).

The cluster results indicated that the three stations were very unique in nature about the sponge species diversity. Bray-Curtis cluster analysis revealed a slight differentiation in species composition of discard between the three stations reflecting unique benthic habitats.

Conclusion

The diversity of marine sponges was maximum in the Kanyakumari area while the sponge species *Echinodictyum gorgonoides* predominated in all three sampling sites. The study provides prospects for the availability of diverse species of sponges with bioactivity along the southwest coast of India.

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