INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

STATUS OF CORALS (ORDER: SCLERECTINIA) AND ASSOCIATED FAUNA OF THOOTHUKUDI AND VEMBAR GROUP OF ISLANDS, GULF OF MANNAR, INDIA

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ABSTRACT
The Gulf of Mannar is one of the world's richest marine biospheres and occupies an area of 10,500 sq.km. Twenty one coral reef islands and small patchy reefs are present between Lat. 80^0 47'N and Long. 78^0 12' E to Lat. 90^0 15' N and Long. 79^0 14' E. from Pamban to Thoothukudi as an arc. These islands possess a very interesting heterogeneous group of fauna and flora. In the present study we have estimated the coral reef status at Thoothukudi and Vembar group of Islands in the Gulf of Mannar. Maximum live cover was observed at Pulivinichalli Island of Vembar group and minimum at Van Island of Thoothukudi group. Soft coral were abundant at Van Island of Thoothukudi group and 10% in Upputhanni and Nallathanni Islands of Vembar group. The highest number of of dead corals was observed at Van and Nallathanni Islands, while all other islands had lower values. Maximum algae cover was observed in Koswari Island and it was minimum in Nallathanni Island. During the survey we identified 103 species of hard corals under 27 genera and 11 families from the study site. Of these, 24 species were observed at Van Island, 21 species at Kaswari Island, 29 species at Kariyachalli Island, 34 species at Upputhanni Island, 32 species at Pulivinichalli Island and 37 species at Nallathanni Island.

KEYWORDS: Thoothukudi group, Vembar group, Gulf of Mannar, coral reef, Sclerectinian corals.

INTRODUCTION

The coral reefs of the Gulf of Mannar along the Indian coast are found scattered around 21 islands that are distributed in an 8 km wide band between Pamban and Thoothukudi. Thoothukudi (Lat. $8^0$45'N, Long. $78^0$10'E) is located at the southern end of the Gulf of Mannar. The Thoothukudi Group has four Islands and Vembar group includes three islands. As a result of sea erosion caused by excessive coral mining, Vilanguchalli now lies 1 meter below the mean low tide level. Each island has fringing reefs and patchy reefs around them. Narrow fringing reefs are located mostly at a distance of 100 to 150 meters from the islands. Patchy reefs rise from depths of 2 – 9 meters and extend 1 - 2 Kilometers in length with a width of about 50 meters (Patterson Edward *et al*., 2005). Coral reefs provide food, cultural objects, building material; promote tourism and shoreline protection for people living near the coast. There are eight important fishing villages dependent on these seven islands namely Thirespuram, Vellapatti, Tharuvaikulam, Keelavippar, Vembar, Narippaiyur, Mookiyur and Keelamunthal having 450 mechanised boats, 1300 run- mechanized boats (vallams) and 900 catamarams. About 5,428 fisherfolks are directly engaged in fishing using these crafts (CORDIO Report, 2005).

25 families and 1574 species of sclerectenian corals were reported earlier by various researchers (Veron, 2000) worldwide. In 1969, Pillai published a series of six papers on the coral species of the Gulf of Mannar followed by the distribution of corals in Minicoy Atoll, Lakshadweep. Later, Pillai, (1977, 1978, and 1983) published a series of reports on the corals of Andaman and Nicobar islands. Venkataraman *et al*. (2003) reported 208 species of corals in India including 15 families and 60 genera. Mahadevan and Nagappan Nayar, (1972) reported very few species of hard corals in Thoothukudi and Vembar regions. Santhanam and Venkataramanujam, (1996) also reported 18 species of hard corals in Thoothukudi group of islands, Patterson, (2002) reported 22 species under 8 genera in the Thoothukudi group while Patterson Edward, (2004) reported 104 hard corals divided into 38 genera in the Gulf of Mannar.

The reefs of Thoothukudi are under severe threat due to unlawful human interference and threatening natural changes (Malik and Murti, 2005). Coral reefs typically grow in relatively clear waters. Land use practices such as overgrazing as well as industrial and coastal development can increase the supply of sediment to the near shore where most coral reefs develop, creating a situation of stress or even killing corals (Fortes, 2000; Rogers, 1990; Buddemeir and Hopley, 1998). High suspended sediment concentrations can attenuate photosynthethically available radiation, which in turn reduces coral growth rates (Dodge *et al*., 1974; Dodge and Vaisnys, 1977; Hubbard and Scature, 1985; Edmunds and Spencer- Davies, 1989), decreases net productivity (Rogers, 1979; Edmunds and Spencer- Davies,

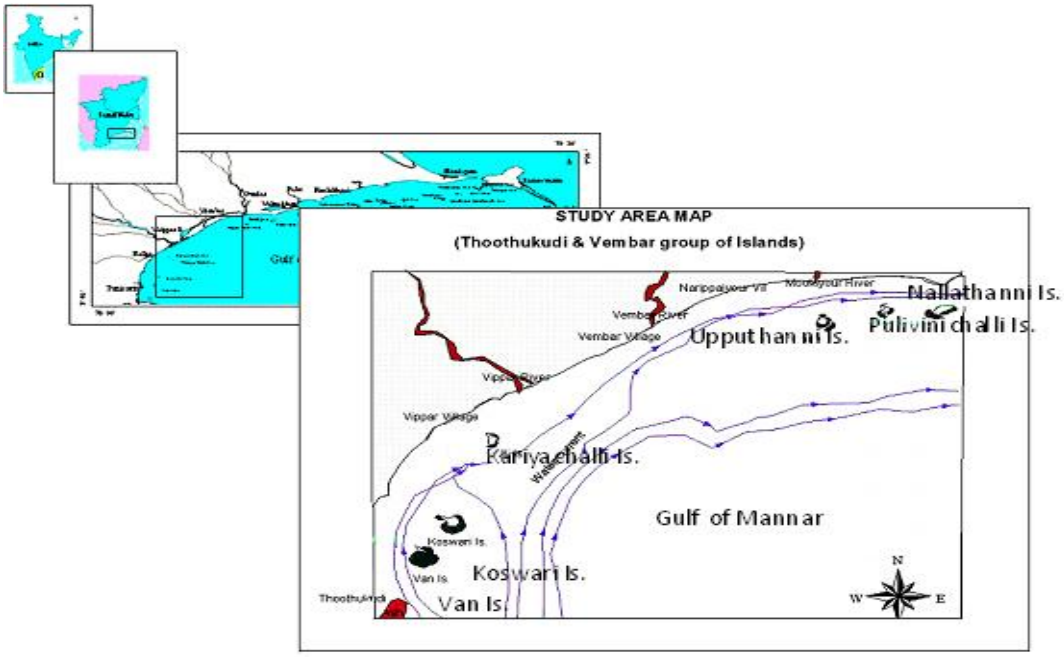
1989) and induces coral stress (Van Katwijk *et al.,* 1993). Suspended sediment can also be a vector for the introduction of nutrients, toxic substances and heavy metals to reefs that can cause stress or kill corals (Dickson *et al*., 1987; Souter *et al*., 1993; Bastidas *et al*., 1999). As discussed by Marszalek, (1981), Rogers (1990) and Larcombe *et al*., (1996) issues such as the frequency and duration of suspension events and sediment type must be evaluated to determine the impact of sediment on coral reef health.

The studies on scleractinian corals in the southern part of Thoothukudi and Vembar group of islands, Gulf of Mannar is very limited. The first report of corals from this area is that of Pillai, (1972) who reported 21 species of corals. Later on Patterson *et al*., (2004) reported 32 species of corals in this region. The present study deals with the assessment of current status of coral reef from the study area.

MATERIALS AND METHODS

This study was conducted by employing SCUBA diving during July 2007 to March 2008. A survey was initiated by mapping the patchy reef and island reef areas, using Manta tow Method (Done *et al*., 1982). It was used to investigate issues at a broad level (Kenchington, 1978).

FIGURE 1. Map showing the study areas.



In order to estimate the coral cover, the line intercept transects (LIT) of 100 meters length were laid along the reef area, parallel to the depth contours of the reefs, using a flexible fiberglass measuring tape. The tape was laid at depths ranging from 1 meter to 6 meters. Depending on the size of the reefs, around 8 to 12 transects were laid on each of the six Islands of the Thoothukudi and Vembar groups. Each and every change in the life forms were recorded along the transects. The percentage cover of each life form category was then calculated following the method of English *et al.*, (1997).

$$\text{Percentage cover} = \frac{\text{Total length of Category}}{\text{Length of transect}} \times 100$$

Diversity Indices: Various indices like species diversity, richness and evenness were applied on the data using the standard formulae given below:

Shannon-Wiener diversity Indices (H): Species diversity was calculated using the following formula (Shannon *et al.,* 1949).

$$H' = \frac{3.3219\ (N \log N - \sum ni \log ni)}{N}$$

Where

H'= Species diversity

Ni= No.of individuals of the i^{th} species

N= Total number of the individuals in the collection = Sum

Simpson index (D'): Species richness (D) was calculated using the following formula proposed by Simpson, (1949).

D = 1- C

C = . Pi 2

Pi = ni/N

Ni = no. of individuals of i1,i2, so on and

N = Total number of individuals

Pielou's Evenness (J'): Evenness or equitability (S) was calculated using the formula proposed by Pielou, (1966)

J' = H'/Jns or H'/log25

Where

J' = Evenness

H' = Species diversity and

S = Total number of species.

RESULTS

A total of 103 species of hard corals under 27 genera and 11 families were identified from the study location. 24 species were oserved in Van Island, 21 species in Kaswari Island, 29 species in Kariyachalli Island, 34 species in Upputhanni Island, 32 in Pulivinichalli Island and 37 species in Nallathanni Island were recorded (Table 1). The underwater photographs taken from the study sites during the study period are presented as plates numbered 1-10.

Maximum live cover was observed in Pulivinichalli Island (50.63%) of the Vembar group and minimum was in Van Island (30.63%) of the Thoothukudi group. More soft corals were observed in Van Island of the Thoothukudi group (10.63%) whereas only 10% each was observed in both Upputhanni and Nallathanni Islands of the Vembar group. A higher value of dead corals was observed in Van (13.75%) and Nallathanni Islands (10.75%), while all other islands had lower values. Maximum algae cover was observed in Koswari island (10.63%) and minimum was in Nallathanni Island (6.88%). Coral associated organisms were less in Nallathanni Island (Table 2).

TABLE 1. List of corals identified on each island during the study period (July 2007 to June 2008)

S.No	Name of the species	1	2	3	4	5	6
	Family : Acroporidae (Verrill, 1902)						
	Genus : *Acropora* (Oken, 1815)						
1	*Acropora abrotanoides* (Lamarck,1816)	-	-	-	+	-	-
2	*Acropora arabensis* (Hodgson and Carpentrer, 1995)	-	-	-	+	-	-
3	*Acropora branchi* (Riegl,1995)	-	-	-	-	+	-
4	*Acropora cophodactyla* (Brook,1892)	-	+	-	-	-	+
5	*Acropora copiosa* (Nemenzo, 1967)	-	-	-	-	+	-
6	*Acropora cuneata* (Dana,1846)	+	-	+	+	-	+
7	*Acropora divaricata* (Dana,1846)	-	-	-	-	-	+
8	*Acropora florida* (Dana,1846)	-	+	+	+	-	-
9	*Acropora formosa* (Dana,1846)	-	-	-	-	+	+
10	*Acropora gemmifera,* (Brook, 1892)	-	-	-	-	-	+
11	*Acropora glauca* (Brook,1893)	+	-	+	-	+	-
12	*Acropora granulosa* (Milne Edwards and Haime, 1860)	-	-	-	+	-	-
13	*Acropora lamarcki* (Veron 2000)	-	-	+	+	+	-
14	*Acropora latistella* (Brook, 1891)	-	-	-	-	-	+
15	*Acropora microphthalma* (Verrill, 1859)	-	-	-	-	+	-
16	*Acropora millepora* (Ehrenberg,1834)	-	-	-	+	-	+
17	*Acropora nobilis* (Dana,1846)	-	-	-	-	+	-
18	*Acropora parahemprichii* (Veron, 2000)	-	+	+	+	+	+
19	*Acropora plantaginea* (Lamarck,1816)	+	+	-	+	+	+
20	*Acropora robusta* (Dana,1846)	-	-	+	+	-	+
21	*Acropora rudis* (Rehberg,1892)	+	-	+	+		+
22	*Acropora samoensis* (Brook,1891)	-	-	-	-	+	-
23	*Acropora scherzeriana* (Bruggemann,1877)	-	-	+	+	-	+
24	*Acropora selago* (Studer,1878)	-	+	+	-	+	+
25	*Acropora spicifera,* (Dana, 1846)	+	+	+	+	+	+
26	*Acropora squarrosa* (Ehrenberg,1834)	-	-	-	-	+	-
27	*Acropora vermiculata,* (Nemenzo, 1967)	-	-	+	-	-	+
28	*Acropora verweyi* (Veron and Wallace,1984)	+	-	-	-	+	-
	Genus : *Astreopora* (Blainvile, 1830)						
29	*Astreopora myriophthalma* (Lamarck,1816)	-	-	-	-	-	+
	Genus : *Montipora* (Blainville, 1830)						
30	*Montipora aequituberculata* (Bernard,1897)	+	+	+	+	-	+
31	*Montipora crassituberculata* (Bernard,1897)	+	+	+	+	-	+
32	*Montipora digitata* (Dana, 1846)	+	+	+	+	-	-
33	*Montipora efflorescens* (Bernard,1897)	-	-	-	-	-	+
34	*Montipora flabellate* (Studer,1901)	+	+	+	-	+	+
35	*Montipora florida* (Nemenzo, 1967)	-	-	-	-	+	-
36	*Montipora foliosa* (Pallas,1766)	-	-	-	-	+	-
37	*Montipora friabilis* (Bernard, 1897)	-	-	+	-	+	-
38	*Montipora informis* (Bernard, 1897)	-	-	-	-	+	-
39	*Montipora nodosa* (Dana,1846)	+	+	+		+	+

40	*Montipora peltiformis* (Bernard, 1897)	+	+	+	+	+	+
41	*Montipora tuberculosa* (Lamarck,1816)	-	-	-	+	-	+
	Family : Agariciidae (Gray, 1847)						
	Genus : *Pavona* (Lamarck,1801)						
42	*Pavona gigantean* (Verrill, 1896)	-	-	+	+	-	+
	Family : Dendrophylliidae (Gray, 1847)						
	Genus : *Tubastreae*						
43	*Tubastreae coccinea* (Lesson, 1829)	-	+	-	-	+	+
	Genus : *Turbinaria* (Oken, 1815)						
44	*Turbinaria mesenterina* (Lamarck, 1816)	-	-	-	+	-	+
45	*Turbinaria frondens* (Dana, 1846)	-	-	-	+	+	-
46	*Turbinaria mesenterina* (Lamarck, 1816)	+	-	-	-	+	-
47	*Turbinaria patula* (Dana, 1846)	-	-	-	+	-	-
48	*Turbinaria peltata* (Esper, 1794)	-	+	+		-	+
	Family : Faviidae (Gregory, 1900)						
	Genus : *Diploastrea* (Matthai, 1914)						
49	*Diploastrea heliopora* (Lamarck,1816)	+	+	-	+	-	-
	Genus : *Diploria* (Milne Edwards and Haime, 1848)						
50	*Diploria strigosa* (Dana, 1848)	-	-	-	-	+	-
	Genus : *Echinopora* (Lamarck, 1816)						
51	*Echinopora lamellose* (Esper,1795)	+	-	-	-	-	-
	Genus : *Favia* (Oken, 1815)						
52	*Favia favus* (Forskal, 1775)	+	-	-	+	-	-
53	*Favia lizardensis* (Veron & Pichon,1977)	-	-	-	+	-	-
54	*Favia maritima* (Nemenzo,1971)	+	-	+	-	-	+
55	*Favia matthaii* (Vaughan, 1918)	-	-	+	-	-	-
56	*Favia speciosa* (Dana, 1846)	-	+	+	-	-	-
57	*Favia stelligera* (Dana, 1846)	+	+	+	+	+	+
58	*Favia veroni* (Moll & Borel-Best, 1984)	-	+	-	-	+	+
	Genus : *Favites* (Link, 1807)						
59	*Favites abdita* (Ellis & Solander 1786)	-	+	+	-	+	-
60	*Favites chinensis* (Verrill, 1866)	-	-	+	-	-	+
61	*Favites complanata* (Eherenberg, 1834)	+	-	+	+	-	-
62	*Favites halicora* (Eherenberg,1834)	+	-	-	-	+	-
63	*Favites vasta* (Klunzinger, 1879)	-	-	-	-	+	-
	Genus : *Goniastrea* (Milne Edwards and Haime, 1848)						
64	*Goniastrea edwardsi* (Chevalier,1971)	-	-	-	+	-	+
65	*Goniastrea minuta* (Veron, 2000)	-	-	+	-	+	-
66	*Goniastrea peresi* (Faure and Pichon, 1978)	+	-	-	-	-	-
67	*Goniastrea retiformis* (Lamarck, 1816)	+	-	+	-	+	-
	Genus : *Leptastrea* (Milne Edwards and Haime, 1848)						
68	*Leptastrea purpurea* (Dana,1846)	-	-	-	+	-	-
	Genus : *Leptoria* (Milne Edwards and Haime, 1848)						
69	*Leptoria Phrygia* (Ellis and Solander, 1786)	-	+	+	-	-	-
	Genus : *Montastrea* (Blainville, 1830)						
70	*Montastrea colemani* (Veron, 2000)	+	+	+	-	+	-
	Genus : *Oulophyllia* (Milne Edwards and Haime, 1848)						
71	*Oulophyllia crispa* (Lamarck, 1816)	-	-	-	-	-	+
	Genus : *Platygyra* (Ehrenberg, 1834)						
72	*Platygyra daedalea* (Ellis and Solander, 1786)	-	+	+	-	+	-
73	*Platygyra acta* (Veron, 2000)	+	-	-	-	-	+
74	*Platygyra acuta* (Ellis & Solander, 1786)	-	-	-	+	-	+
75	*Platygyra lamellina* (Ehrenberg,1834)	-	-	-	+	-	-
76	*Platygyra pini* (Chevalier, 1975)	+	-	+	-	-	-
77	*Platygyra sinensis* (Milne Edwards and Haime,1849)	-		+	-	+	-
78	*Platygyra verweyi* (Wijsman-Best, 1976)	-	+	-	-	+	+

	Family : Fungiidae (Dana, 1846)						
	Genus : *Cycloseris* (Milne Edwards and Haime, 1849)						
79	*Cycloseris cyclolites* (Lamarck, 1801)	-	+	+	-	-	-
	Family : Merulinidae (Verrill, 1866)						
	Genus : *Hydnophora* (Fischer de Waldheim, 1807)						
80	*Hydnophora microconus* (Lamarck, 1816)	-	+	-	-	-	+
81	*Hydnophora pilosa* (Veron,1985)	+	+	-	+	+	+
	Family : Mussidae (Ortmann, 1890)						
	Genus : *Australomussa* (Veron, 1985)						
82	*Australomussa rowleyensis* (Veron, 1985)	+	-	-	+	-	-
	Genus : *Symphillia* (Milne Edwards and Haime, 1848)						
83	*Symphillia radians* (Milne Edwards & Haime, 1849)	-	+	-	-	-	+
84	*Symphillia recta* (Dana, 1846)	-	-		-	+	-
85	*Symphyllia valenciennesii* (Milne Edwards & Haime,1849)	-	-	+	-	-	-
	Family : Pectiniidae (Vaughan and Wells, 1943)						
	Genus : *Echinophyllia* (Klunzinger,1879)						
86	*Echinophyllia aspera* (Ellis & Solander, 1788)	+	-	-	-	+	+
87	*Echinophyllia echinoporoides* (Veron and Pichon,1980)	+	+	+	+	-	-
	Family : Pocilloporidae (Gray, 1842)						
	Genus : *Pocillopora* (Lamarck, 1816)						
88	*Pocillopora damicornis* (Linnaeus, 1758)	-	-	-	+	+	+
	Family : Poritidae (Gray, 1842)						
	Genus : *Goniopora* (Blainville, 1830)						
89	*Goniopora albiconus* (Veron, 2000)	-	-	-	+	+	-
90	*Goniopora columna* (Dana,1846)	+	-	-	+	-	-
91	*Goniopora planulata* (Ehrenberg,1834)	-	-		+	+	-
92	*Goniopora stokesi* (Milne Edwards and Haime, 1851)	+	+	+	-	-	+
93	*Goniopora stutchburyi* (Wells,1955)	-	-	-	+	-	-
	Genus : *Porites* (Link, 1807)						
94	*Porites arnaudi* (Reyes-Bonilla and Carricart-Ganivet,2000)	+	+	+	+	+	+
95	*Porites australiensis* (Vaughan, 1918)	-	-	-	+	+	-
96	*Porites cumulatus* (Nemenzo,1955)	-	-	-	+	-	-
97	*Porites latistella* (Quelch, 1886)	-	+	+	-	-	+
98	*Porites lobata* (Dana,1846)	+	+	+	+	+	+
99	*Porites lutea* (Milne Edwards and Haime,1851)	-	-	+	+	+	-
100	*Porites mayeri* (Vaughan,1918)	-	-	+	+	+	+
101	*Porites solida* (Forskal,1775)	-	-	-	-	+	-
	Genus : *Poritipora* (Veron, 2000)						
102	*poritipora paliformis* (veron,2002)	-	-	-	-	-	+
	Family : Siderastreidae (Blainville, 1830)						
	Genus : *Psammocora* (Dana, 1846)						
103	*Psammocora nierstraszi* (Horst, 1921)	-	-	-	+	-	-

1- Van, 2- Koswari, 3- Kariyachalli, 4- Upputhanni, 5- Pulivinichalli and 6- Nallathanni islands, (+) Present and (-) Absent

The island wise details of density and diversity of corals and their associated communities are given below.

VAN ISLAND

Van Island is non-elongate in shape with a sharp corner. It has a low and narrow sandy coast with coral rubble. Coral rubble are seen along the south, southeast and southwest coasts. Small scale sand dunes are seen inside the island. Sand dunes at the central and southern side of the island were covered with shrubs. Topographically the height of the island was 1 meter above the mean sea level. The reef observed in this island is fringing type and extends upto a depth of 3 meters. The fringing reef along the windward side of the island protects the island from direct wave action, but due to illegal mining, the wave hits the southern side. As a result, the windward side of the island is getting reduced and the leeward side of the island is accreted.

Reef developments are extensive on the southeast, southwest and northeast direction of the island with an average distance of 1km from the island. The result of LIT studies showed that, Van Island has an average of 30.63 % of live coral cover, 13.75 % of dead coral, 10.63 % of soft corals, 3.75 % sponges, 9.38 % of algae, 14.38 % of abiotic and 6.88 % of

others (Table 2). The live coral cover of this island is considered as 'fair' and the order of dominance of live coral categories and their percentage are *Porites* > *Acropora* > *Goniopora* > *Pocillopora* > *Pavano* > *Platygyra* and others is given in Table 3. Among the live coral categories, *Porities* are dominant. Most of the live corals are seen in the southeast side of the island. The dead corals are found to be the substratum for many types of seaweed. The rubbles are found sprayed on the southeast side having 4.38 % and abiotics was 14.38 % (Table 2).

TABLE 2. Percentage of coral and associated organism coverage of Thoothukudi and Vembar group of islands during the study period (July 2007 to June 2008).

Benthos	Van	Koswari	Kariyachalli	Upputhanni	Pulivinichalli	Nallathanni
Live coral (%)	30.625	36.875	40.625	41.875	50.625	46.75
Soft coral (%)	10.625	9.375	6.25	10	8.75	10
Dead coral (%)	13.75	8.125	8.75	9.375	8.125	10.75
Algae (%)	9.375	10.625	8.125	8.75	8.125	6.875
Sponges (%)	3.75	3.75	4.375	3.75	5.625	5
Others (%)	6.875	6.25	6.875	6.25	4.375	3.125
Rubbles (%)	4.375	2.5	3.125	3.125	3.75	6.25
Abiotic (%)	14.375	28.75	21.875	16.875	10.625	11.25

TABLE 3. Percentage of species coverage of each island during the study period (July 2007 to June 2008).

Genus	Van (%)	Koswari (%)	Kariyachalli (%)	Upputhanni (%)	Pulivinichalli (%)	Nallathanni (%)
Montipora	10.17	5.08	6.78	11.86	20.3	11.86
Acropora	16.95	18.6	30.5	23.73	35.6	32.2
Asreopora	0	0	1.69	0	3.39	0
Diploria	0	0	0	0	1.69	0
Pocillopora	6.78	3.39	3.39	5.085	3.39	5.085
Diplastrea	0	0	1.69	1.695	0	1.695
Oulophyllia	0	1.69	0	1.695	1.69	3.39
Australomussa	1.695	0	0	1.695	3.39	0
Psammocora	1.695	0	0	0	1.69	0
Ehinophyllia	0	0	0	1.695	0	0
Pavona	6.78	3.39	1.69	1.695	1.69	1.695
Cycloseris	1.695	0	0	1.695	0	0
Tubastre	0	0	0	1.695	0	0
Hydnophora	1.695	1.69	5.08	0	1.69	1.695
Turbinaria	1.695	3.39	1.69	1.695	6.78	3.39
Symphyllia	0	1.69	1.69	0	1.69	0
Favia	0	1.69	1.69	0	1.69	0
Favites	3.39	3.39	3.39	3.39	3.39	1.695
Goniastrea	1.695	3.39	3.39	0	1.69	0
Platygyra	5.085	1.69	1.69	0	1.69	1.695
Leptoria	0	0	0	3.39	0	1.695
Leptastrea	1.695	0	3.39	0	1.69	0
Montastrea	0	3.39	1.69	0	1.69	1.695
Echinopora	0	1.69	0	0	0	1.695
Porities	27.12	20.3	37.3	47.46	39	42.37
Goniopora	11.86	8.47	3.39	5.085	3.39	6.78

KOSWARI ISLAND

Koswari Island is an elongated one with a sharp corner in the northwest side. It has a low and narrow sandy coast with coral rubbles Coastal dunes are seen inside the island, which extend to a maximum height of 1m from the mean sea level. Most part of the island cover is occupied by shrubs. At the centre of the island, there is a small ditch seen, which gets filled with water during the high tide. Fringing type reef is observed in this island and an area cover is small. The reef rim topography is comparatively low and inclined to the wave direction. Here also erosion is common along the windward side and accretion is seen on the leeward side.

Reef developments are extensive on the southwest, south and southeast directions of the island. The results of LIT studies show that the Koswari Island has an average 36.88 % of live coral cover, 8.13% of dead coral, 10.63% of algae, 9.38% soft coral, 3.75% sponges 28.75% of abiotic and 6.25% of others (Table 2). Live coral covers are seen in the southwest, south and southeast direction of the island. The live coral cover of this island is considered as 'poor' and the order of dominance of live coral categories and their

percentage are *Porites* > *Acropora* > *Goniopora* > *Pocillopora* > *Pavano* > *Turbinaria* > *Goniastrea* > *Cyphastrea* > *Platygyra* and others (Table 3). Among the live coral categories, *Porites* and *Acropora* are dominant species noted in the present survey. Illegal mining of corals for last two decades have brought deleterious effect on the corals and are responsible for decrease of coral diversity. The percentage of rubble that covered this island was 2.5 % and abiotics was 28.75 % (Table 2).

KARIYACHALLI ISLAND

Kariyachalli Island is nearly ellipsoidal in shape with sharp corner at the northwest side. The coast is low and narrow consisting of sand and coral rubble. Coral rubbles are mainly seen along the southern coast of the island. Small scale sand dunes are seen inside the island and they are mostly covered with shrubs. Topographically the height of the island is 1 meter above the mean sea level. A small ditch is seen on the eastern side of the island, which is filled with water during the high tide. Coral reef type observed around this island is fringing reef. Erosion is seen on the windward (southeast) side and accretion is seen on the leeward side (northwest). This island is partly sheltered by Vilanguchalli reef as they are close to each other.

Reef developments are extensive on the southwest direction of the island. The results of LIT studies evidently show that Kariyachalli Island had an average of 40.63 % of live corals, 8.75 % of dead coral 8.13 % of algae, 6.25 % of soft corals, 4.38 % of sponges, 21.88 % of abiotic and 6.88 % of others (Table 2). The live coral cover of this island is considered as 'fair' and the order of dominance of live coral categories are *Porites*> *Acropora* > *Goniopora* > *Pocillopora* > *Leptastrea* > *Euphyllia* > *Pavano* > *Platygyra* and others (Table 3). These islands contain higher percentage of live coral when compared with the other islands of Thoothukudi group. Among the live coral categories *Porites and Acropora* are dominant. The percentage of rubble cover of this island was 3.13 % and abiotics was 21.88 % (Table 2). The dead coral with algae are found as a rim along the shoreline. The sub-tidal zones have many corals represented by certain branching forms of *Acropora* sp. and *Montipora* sp, massive corals such as *Favia* sp, *Favites* sp, *Hydnophora* sp, *Platygyra* sp, *Goniastrea* sp and *Goniopora* sp (Table 3). Sea grass beds are seen outside the coral reef along southern side of the island. The sea grass, *Thalassia* sp is a common species in this island followed by this the sparse distribution of *Halimeda sp*. also observed. Better diversity of the coral species was recorded in this Island, when compared to the other Thoothukudi group Islands.

VEMBAR GROUP OF ISLANDS

The Vembar group of islands is arranged more or less in the same latitude as the earlier mentioned Islands. The reef seen in these islands are fringing type and they are mainly seen in the windward direction and protect the island from direct wave action. The reef crest acts as a wave breaker leading to the deposition of the sediments. Of the three islands, Nallathanni is the biggest one but has poor live coral coverage.

UPPUTHANNI ISLAND

Upputhanni Island is second largest Island in the Vembar group. The northwest and northeast sides of this Island have a low and broad sandy coast, while the southwest and southeast is low and narrow sandy coast with coral rubbles.

Small scale sand dunes are seen inside the island. Some places of the island area are covered with shrubs. Topographically the height of the island is 1 meter above the mean sea level. A large trench is seen on the southern side of the island, which is filled with water during the high tide. Coral reefs observed around this island are of the fringing reef type. These reefs protect this Island from direct wave action.

Reef developments are extensive on the southeast to southwest direction of the island. The results of line intercept transect studies show that Upputhanni Island has 41.88 % live coral cover, 9.38 % dead coral, 3.13 % rubble, 8.75 % algae, 10 % soft corals, 3.75 % sponges, 16.88 % abiotic content and 6.25 % other content (Table 2). The live coral cover of this island is considered as 'fair' and the order of dominance of life form categories are *Porities* > *Acropora* > *Pocillopora* > *Goniopora* > *Favites* > *Leptoria* > *Pavano* and others (Table 3). The life form has many corals represented by certain non-branching forms of *Porites* sp, *Favia* sp., and *Goniastea* sp., and branching form of *Acropora* sp. and *Montipora* sp. Most of the dead coral boulders are covered with macro algal assemblages in the northeastern direction with *Sargassum gracillaria* sp., *Caulerpa* sp., and *Padina* sp. dominating the reef crest area.

PULIVINICHALLI ISLAND

Pulivinichalli Island is elongated in structure having a low and narrow sandy coast. Coral rubble is seen on the south and southeast coast of the island. Sand dunes of 0.5 meters height are seen in the central part of this island. Shrubs are low in number. Fringing reefs are observed off this island and the area covered by the reef is small. The dead coral cover seen on the southeast to northeast direction protects the island from direct wave action.

Reef developments are extensive on the southwest and southern direction of the island. The results of LIT studies show an average of 50.63 % live coral, 8.13 % dead coral with algae, 8.13 % algae, 3.75 % rubble, 8.75 % soft coral, 5.63 % sponges, 10.63 % abiotic matter and 4.38 % other matter (Table 2). Among the live coral categories observed, branching *Acropora* is the dominant one. Most of the live corals are present in the southeast to southwest direction of this island. The shallow reef was once dominated by *Acropora* sp (Table 3). But slowly this species was replaced by *Porites* sp. The shoreward subtidal slope area, lower subtidal zones have *Porites* and branching *Acropora.*. The subtidal zones have many corals represented by *Acropora* sp., *Montipora* sp., *Favia* sp., *Platygyra* sp., *Galaxea* sp., *Pocillopora* sp., and *Goniastrea* sp. (Table 3). The reef crest often gets exposed during low tide. Better diversity of the coral species were recorded in this Island, when compared to the Vembar group of Islands.

NALLATHANNI ISLAND

Geomorphologically, Nallathanni is the biggest island in the Vembar group having a straight coastline on the northwest and northeast sides, while the other sides have an irregular coastline. The coast is low and narrow consisting of sand and coral rubble. Coral rubble are seen along the southwest, southeast and northeast coast of the island. Sand dunes are seen in the inner region of the island, which are covered by vegetation. On the western side, dunes with a height of 8 metres were observed. Topographically the height of the island is 1.5 meters above the mean sea level. Fringing reef type is observed off this island upto a depth of 3 meters. The fringing reef along the windward side of the island protects the island from direct wave action. Reef development is extensive along the southern direction of the island. The results of LIT studies show that Nallathanni Island has an average of 46.75 % live coral cover, 10.75 % dead coral, 6.25 % rubble, 6.88 % algae, 10 % soft coral, 5 % sponges, 11.25 % abiotic matter and 3.13 % of other matter (Table 2). The live coral cover of this island is considered 'poor'. Among the live coral categories observed, the order of dominance was *Porities* > *Acropora* > *Goniopora* > *Pocillopora* > *Galaxea* > *Turbinaria* and others (Table 3). The northeast and southeast directions of the island have dead coral with algae at the subtidal zone. Very few species like *Porites* sp. and *Acropora* were seen in this island in the subtidal zone along the southern direction.

Species diversity index studies were conducted for all the islands in the Thoothukudi and Vembar groups, Gulf of Mannar. Maximum richness was observed in Pulivinichalli Island (4.32) of the Vembar group and minimum in Van Island (3.43) of the Thoothukudi group. Higher diversity was observed in Koswari Island (2.34) of the Thoothukudi group and minimum was in Upputhanni Island (1.92) of the Vembar group. Species Hill's number was highest in Koswari Island (10.42) of the Thoothukudi group and the lowest in Upputhanni Island (6.80) of the Vembar group. Species evenness was maximum in Van Island (0.83) and minimum in Upputhanni Island (0.71) (Table 4).

TABLE 4. Species diversity indexes between the stations during the study period (July 2007 to June 2008).

Station	Richness indices		Diversity indices		Hill's Number		Evenness	
	R1	R2	L	H'	N1	N2	E1	E2
Van	3.43	1.95	0.12	2.25	9.53	8.02	0.83	0.64
Koswari	3.85	2.29	0.12	2.34	10.42	8.57	0.85	0.65
Kariyachalli	3.83	2.11	0.19	2.09	8.05	5.31	0.74	0.47
Upputhanni	3.33	1.83	0.22	1.92	6.80	4.51	0.71	0.45
Pulivinichalli	4.32	2.22	0.16	2.19	8.96	6.07	0.73	0.45
Nallathanni	3.30	1.79	0.21	1.94	6.95	4.87	0.72	0.46

DISCUSSION

The reefs of thr Gulf of Mannar are being stressed by anthropogenic disturbances such as destructive fishing practices, domestic and industrial pollution, coral mining, coastal development activities such as salt pans, aquaculture practices and so on. The islands in Thoothukudi and Vembar groups has been hazardously damaged until few years back by coral mining, it affected the entire marine ecosystem (Pillai, 1973; Venkataramanujam *et al*., 1981). In the present study, the status of coral reef was assessed in all the study sites during the study period.

The present status of corals and reef organisms of the study sites are in the order of Pulivinichalli > Nallathanni > Upputhanni > Kariyachalli > Van > Koswari Islands. Among the islands, Pulivinichalli of the Vembar group exhibited the highest live coral cover (50.6 %), while Van (30.6 %) and Koswari (36.88 %) Islands of the Thoothukudi group exhibited the least coral cover. Generally *Porites* and *Acropora* species (12-28% and 10-21%) respectively dominated the reef ecosystem of the Thoothukudi and Vembar group of islands. More or less the relavant percentage of coral cover of the Gulf of Mannar islands was reported by Patterson Edward (2005). A higher percentage of *Porites* cover than the *Acropora* species indicated the high wave energy zone. The percentage of dead coral observed was also high in most of the study sites. The dead coral coverage observed in Van Island was 13.75 % and in Koswari Island it was 8.13 %. More or less the same trend was observed in other Islands also. This might be due to the settlement of fine sediments (silt and clay) on coral colonies (Gopinadhan Pillai *et al.,* 1979; Pandeya Anjali *et al.,* 1989; Ravindran *et al.,* 1999) and from anthropogenic input from industries like chemical factories, salt pans, fertilizer factories (Anon, 1997) and the thermal power station of Thoothukudi in the Gulf of Mannar region.

Among the two groups of islands studied in the present study, the Thoothukudi groups of islands were more affected especially the Van and Koswari Islands which were very close to the Thoothukudi coast. Their coral population and density was also thin (Table 2) when compared to other islands. By this observation, the study concluded that the fall in coral percentage and large amount of dead corals (Table 2) in the Thoothukudi group of islands might be due to indiscriminate discharge of effluents and waste into the shore by industries located near the shore of Thoothukudi. The future status of the coral islands is also alarming since several industries are going to be opened in Thoothukudi especially more then 4 new thermal power stations which are going to dump several thousand tons of coal ash in future. Pillai, (1971 a, b; 1972; 1973; 1975 and 1977) warned that the coral diversity and distribution would be severely affected by industrialisation and sedimentation in the coral reef environment of the Gulf of Mannar. In the present

study, hard corals had significant negative correlation with silt and clay (Suresh and Mathew, 1993).
In the present survey, a total of 103 species under 27 genera and 11 families have been identified from the study location (Table 1).

ACKNOWLEDGEMENT
Authors wish to thank Shri. Senbagamoorthy, Department of Forest, Ramnad District for the help they rendered for permission to survey the Islands. Authors also wish to express their sincere gratitude to the staff of Peoples Action for Development, NGO, Vembar especially to the Executive Director Mr. Rajendraprasad for the help in field surveys. I am grateful to Dr. K. Venkataraman, Director, ZSI, Kolkata and Dr. C. Ragunathan, the Officer In- charge, Zoological Survey of India, Port Blair, Andaman and Nicobar Island for giving me the necessary permission to do this research study. Due gratitude is also expressed to the Principal of Kamaraj college, Thoothukudi for the help they rendered.

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