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Biodiversity and community structure of coral reefs around Krusadai Island, Gulf of Mannar, India

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ABSTRACT

This paper gives the results of the surveys conducted in the Krusadai Reef for the assessment of the coral cover and biodiversity during March-May 2005, following the Line Intercept Transect Method. A total of 35 hard coral species were recorded in this reef. The total live, dead and bleached coral cover for the reef as a whole was estimated as 54.9, 18.7 and 15.4% respectively and the remaining part was covered with soft corals, sponges, seagrasses, sand and rubble. Dead coral cover was dominated by porites. Further, relative abundance values were derived for each species and they were assigned the status dominant/ abundant/ common/ uncommon/ rare. Although, no species was assigned "dominant" status, *Acropora formosa* belonged to the category "abundant" and all other species were either of "common" or "uncommon" status only. Fisher α and Shannon diversity indices were highest (3.68 and 2.14 respectively) in 8th site. Pielou's evenness was highest in 7th site. SIMPER analysis revealed that *Acropora formosa* (33.95%) along with *Acropora humilis* (15.85%), *Porites mannarensis* (12.97%) and *Montipora digitata* (12.07%) were responsible for dissimilarity among various sites in the island. The average similarity in species composition was 20.5%.

Introduction

Coral reefs, the most diverse and complex of all ecosystems, which are also among the most economically valuable to humankind are being heavily exploited (Spalding *et al*., 2001). Almost three-quarters of the world's coral reefs are thought to be deteriorating as consequence of environmental stress (Mumby *et al*., 2001). It is predicted that coral reefs will suffer mounting stress associated with a global increase in atmospheric carbon-di-oxide over the coming decades and from local disturbances such as overfishing and disease.

The reefs of the Gulf of Mannar Biosphere Reserve and Palk Bay are the only major coral formations along the mainland coast of India. A discontinuous barrier termed Mannar Barrier extends over a distance of 140 Km from Tuticorin to Pamban in the Gulf of Mannar. The Mannar Barrier possesses a chain of 21 islands all along its length with fringing reefs around them. The coral fauna and geomorphology of the Gulf of Mannar reef system has been described in detail by Stoddart (1973). Kumaraguru *et al*. (2005) studied the impact of tsunami of 26 December 2004 on the coral reef environment of Gulf of Mannar. But information regarding the biodiversity profile, species status etc. is not available which makes comparisons very difficult. The Department of Ocean Development (DOD) and Space Application Centre (SAC), Ahmedabad (1997) have produced coral reef maps of India, but no comprehensive study has yet examined in detail the community structure and spatial patterns in biodiversity of stony corals across reef flats of this ecosystem. The study was aimed to describe the species diversity, richness, stony coral cover (live and dead), similarities within group and the spatial patterns of ecological communities in the fringing reef of Krusadai Island, the "Paradise of Marine Biologist".

Materials and methods

Krusadai Island is a part of fringing reefs of the 21 islands of Gulf of Mannar which extends from Tuticorin to Rameswaram. Krusadai Island lies at the eastern end of the island chain ($9^0$15'N; $79^0$12'E) with an area of 0.74 km^2 (Fig.1). The eastern part of the north shore of this island is sandy. The western part of the north shore is muddy and fringed with mangroves. Off the east coast of the island is Galaxea Reef, which is exposed at low tide and slopes steeply into the sea. There is a shallow lagoon on the southern side of Krusadai Island.

Life – form Line Intercept Transect method was adopted for the survey (English *et al.*, 1994). Though all conspicuous benthic lifeforms underlying the transect lines were monitored, since cover by organisms other than corals (ie., macroalgae, soft corals, coralline algae and sponges) constituted only less than 1% of total cover, reference is made only to scleractinian corals in this paper. The transects, placed randomly on the reefs, ran parallel to

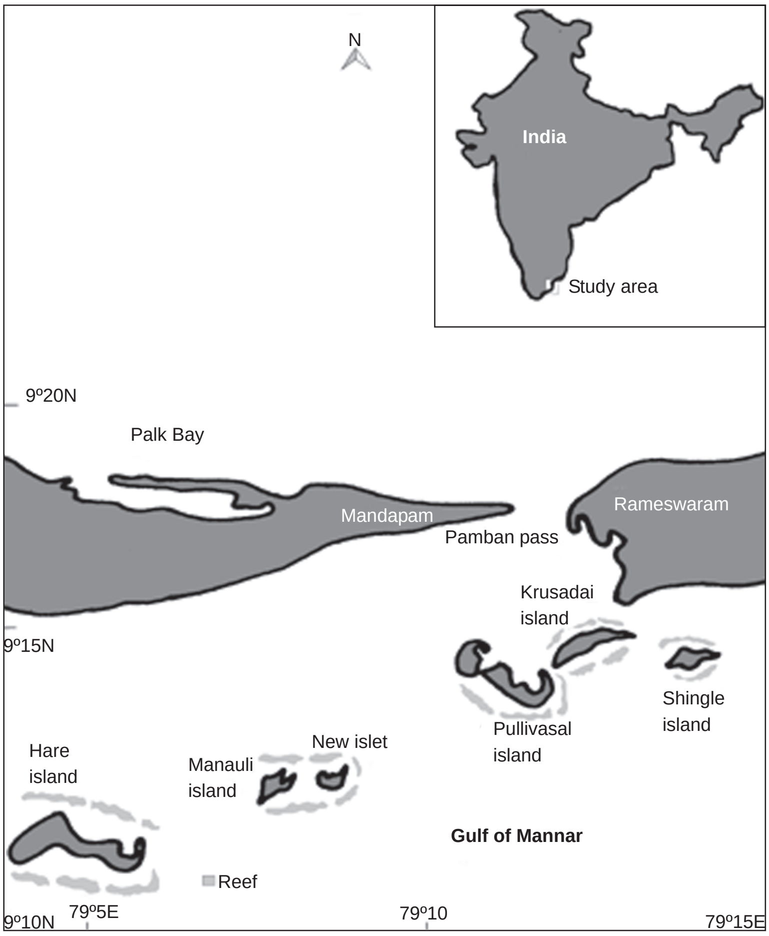

Fig. 1. Location of the study site

shore of the island at each side and to each other at fixed intervals of 2m depth.

A total of 10 transects of 20m each were undertaken at stations S 1 to S 10 around the Island covering both southern as well as northern sides. All hard corals intercepted by the transect were recorded and their maximal projected length were measured. An individual colony of a hard coral was defined as any colony growing independently of its neighbours (Loya, 1972). The colonies were sampled and identified following Pillai (1967a, b, c;1973; 1986); Veron (1986; 2000); Wallace (1999) and Venkataraman *et al.* (2003).

The relative abundance (RA) of each species was calculated according to the contribution to living cover (Rilov and Benayahu, 1998):

$$RA = \frac{Pi}{P\ total} \times 100$$

Pi = pooled living coverage of the i^{th} species from all transects at a given site.

P total = pooled total living coverage of all species in all transects at a given site.

The resulting values were transformed into abundance categories (%): not recorded (RA=0), rare (0<RA<0.1), uncommon (RA=0.1-1), common (RA=1-10), abundant (RA=10-20), dominant (RA>20).

The diversity of corals was calculated following the Shannon-Wiener index (H'(log e)) (Clarke and Warwick, 2001). Species richness was calculated following the Margalef index (d) and the evenness (J') was computed using the formula of Pielou.

K-dominance curves (Lambshead *et al.*, 1983) present the different species ranked in order of dominance according to their contribution to living coverage on the x-axis (logarithmic scale) with percentage dominance on the y-axis (cumulative scale). The starting point of the curve and its inclination are indicative of the diversity profile of the community; for example, a steep slope with high starting point reflects low diversity. K-dominance curve was constructed on the data sets.

Coral Mortality Index (Gomez *et al.*, 1994) for each site was calculated as the ratio of standing dead coral cover to total cover of both live and dead corals.

$$MI = \frac{\text{Dead corals}}{(\text{Live corals} + \text{Dead corals})}$$, where MI is the mortality index.

If MI > 0.33, the mortality index is considered to be high and the reef is classified as sick.

Results and discussion

The reefs of Krusadai Island showed an average live coral cover of 54.9%. A total of 35 species of hard corals were found on the transects (Table 1). An average bleached coral cover of 15.3% and dead coral cover of 18.7% was recorded from the reefs (Table 2). Average Mortality Index for the reef was 0.22. Dominance by a single species was lacking. *Acropora formosa* belonged to the category "abundant" with the highest relative abundance percentage of 15.4 (Table 1). Shannon diversity index was highest (2.13) at station S8. Pielou's evenness was highest at S7. SIMPER analysis (Table 4) showed that *Acropora formosa* (33.95%) along with *Acropora humilis* (15.85%), *Porites mannarensis* (12.97%) and *Montipora digitata* (12.07%) were most responsible for within – group dissimilarity among the island reefs (Table 4). The average similarity in species composition was 20.5%. K – dominance curve confirmed high diversity of the reef with its gentle slope and low starting point (Fig. 2).

In the present investigation, the reefs of Krusadai Island recorded an average live coral cover percentage of 54.9%. In Southeast Asia, reefs are evaluated according to a linear scale of coral cover (Gomez and Yap, 1988), such

TABLE 1: *Total percentage coral cover of each species, their life form categories and status according to relative abundance*

Species	% cover	Life form categories	Relative abundance	Species status
Acropora cytherea	0.2	Branching	0.36	U
A. divaricata	0.3	-do-	0.6	U
A. intermedia	4.3	-do-	7.82	C
A. formosa	8.5	-do-	15.4	A
A. humilis	4.3	-do-	7.89	C
A. digitifera	1.2	-do-	2.12	C
A. valenciennesi	1.7	-do-	3.02	C
A. hemprichii	2.9	-do-	5.27	C
A. retusa	0.7	-do-	1.27	C
A. haimei	1.8	-do-	3.27	C
A. lamarcki	3.1	-do-	5.64	C
A. secale	0.8	-do-	1.47	C
A. hyacinthus	0.3	-do-	0.54	U
A. samoensis	0.1	-do-	0.36	U
A. nasuta	0.3	-do-	0.54	U
Montipora digitata	5.1	Digitate	9.31	C
M. venosa	0.3	-do-	0.54	U
M. verrucosa	0.7	Digitate	1.27	C
M. tuberculosa	0.9	Foliose	1.63	C
M. aequituberculata	1.4	-do-	2.54	C
M. foliosa	2.6	-do-	4.73	C
M. peltiformis	1.2	-do-	2.18	C
Pocillopora damicornis	0.6	Branching	1.11	C
Pavona divaricata	0.2	Massive	0.36	U
P. decussata	0.4	-do-	0.72	U
Merulina ampliata	0.3	-do-	0.55	U
Favia favus	1.2	-do-	2.18	C
Hydnophora exesa	1.1	-do-	2.0	C
Platygyra lamellina	0.7	-do-	1.27	C
Cyphastrea microphthalma	0.6	-do-	1.09	C
Polycyathus verrilli	0.3	Digitate	0.54	U
P. mannarensis	4.5	Massive	8.19	C
P. compressa	0.2	-do-	0.4	U
P. solida	0.9	-do-	1.63	C
P. lutea	1.1	-do-	2.0	C

A=abundant, C= Common, U=Uncommon

that only those reefs with >75% live coral cover are considered to be in "excellent" condition. Reefs with 50-75% live coral cover are considered to be in "good" condition ; with 25 – 50% live coral cover in "fair" condition; and those with <25% live coral cover, in "poor" condition. According to this classification, the Krusadai Island reefs fall under the category "good". Disturbance, competition and stress are the primary factors controlling diversity and abundance of plants and animals in natural communities (Houston, 1994). Edinger and

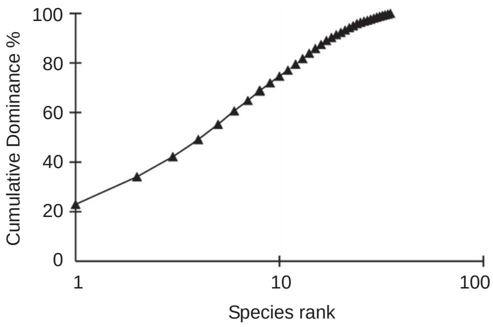

Fig. 2. K- dominance plot for Krusadai Island

TABLE 2: *Krusadai reef – percentage of bleached and dead coral cover*

Groups	Mean % bleached coral cover	Mean % dead coral cover
Porites	5.0	14.8
Acroporids	5.4	2.89
Faviids	4.9	0.3
Montiporids	-	0.7
Pocilloporids	-	0
Total	15.3	18.7

TABLE 3: *Diversity indices for 10 sites*

Sites	S	N	J'	H'(log e)	1-Lambda'
S1	8	37	0.81	1.70	0.77
S2	9	100	0.85	1.89	0.83
S3	1	100	-	0	0
S4	5	99	0.86	1.39	0.73
S5	4	60	0.89	1.24	0.69
S6	9	97	0.90	1.97	0.86
S7	7	51	0.93	1.81	0.84
S8	12	92	0.86	2.14	0.86
S9	10	58	0.77	1.76	0.79
S10	7	46	0.82	1.59	0.75

S = Total species, N = Total individuals, d = Margalef species richness,
J' = Evenness, H' = Shannon diversity, 1-Lambda = Simpson diversity.

Risk (2000) defined *Acropora* corals as disturbance adapted "ruderals", due to their rapid growth and mechanical fragility. Branching non – *Acropora* corals and foliose corals, which grow and recruit more slowly than

TABLE 4: *Discriminating species in Krusadai Reefs*

Group Krusadai		
Average similarity : 20.58		
A. formosa	33.95	33.95
A. humilis	15.85	49.80
P. mannarensis	12.97	62.77
M. digitata	12.01	74.77
A. cytherea	6.56	81.33
A. intermedia	5.73	87.06
Acropora sp.	2.47	89.53
M. foliosa	1.61	91.14
A. hemprichii	1.43	92.57
A. haimei	1.35	93.92
A. secale	1.06	94.98
M. verrucosa	0.98	95.97

Species are listed in ascending order according to percentage contributions to dissimilarity

Acropora, are the competitive dominants, and they are defined as competition adapted. Massive and submassive corals, more tolerant to high sedimentation and/or eutrophication are defined as stress tolerators. In the present study, *A. formosa* belonged to the abundant category. All other corals belonged to either common or uncommon species status. Acroporids which are branching corals were more in number in this reef with 15 species. According to Hughes (1985), branching corals are type 2 corals which usually recruit in larger numbers and are more sensitive to disturbances and so they are better indicators of whole coral community state than corals that are more sustainable, like most of the massive corals which are type 1. The reefs of Krusadai Island with an average live coral cover of 54.9% can be considered as a healthy reef. A total of thirty five species of corals were recorded from the present study. There is evidence that for a given number of species, perturbed communities usually comprise a more limited taxonomic spread, whereas under less disturbed conditions the species present belong to a wider range of higher taxa which can be attributed to the species richness of this reef. Arthur (2000) reported a bleached coral cover of 89% in the Gulf of Mannar reefs with a bleaching related mortality of 23% due to the 1997 – 1998

El – Nino Southern Oscillation event, which elevated sea surface temperatures (SST's) of tropical oceans by more than 3^0 C. But in the present study, no comparisons could be made and conclusions drawn due to paucity of island-wise data.

In the present study, Shannon diversity, Simpson diversity and evenness values were moderately high. Likewise the K-dominance curve showed gentle slope and low starting point, indicating high diversity. According to Odum (1971) higher diversity means longer food chains and more cases of symbiosis (mutualism, parasitism, commensalism) and greater possibilities for negative feedback control which reduces oscillations and hence increases stability and species diversity. The average value of mortality index for the reef was found to be 0.22 which indicates fairly good condition of this reef (Gomez *et al*., 1994).

The indices of reef health considered in the present study ie., the live coral cover (low live coral cover: poor condition), diversity indices, reef condition (domination by branching corals), and mortality index (Mortality index, MI, <0.33) substantiate the healthy condition of this reef.

Coral reef ecosystems are very sensitive to external impacts both natural and manmade, which violate their homeostasis (Sorokin, 1992). The majority of damage to coral reefs around the world has been through direct anthropogenic stress (Grigg and Dollar, 1990). Being one of the most species rich habitats of the world, coral reefs are important in maintaining a vast biological diversity and genetic library for future generations (Moberg and Folke, 1999). According to Bryant *et al.* (1998), 57% of the world's coral reefs are potentially threatened by human activity such as coastal development, destructive fishing, overexploitation, marine pollution, runoff from deforestation and toxic discharge from industrial and agricultural chemicals. As global pressures on coral reefs and other ecosystems grow with increasing coastal populations, the need for careful monitoring, planning and management become essential (Knight *et al.*, 1997). Krusadai Island reefs are one among the healthy reefs of Gulf of Mannar which need to be protected from overexploitation and deterioration. According to Arthur (2000) southeast coast of India is densely populated and local communities depend heavily on marine resources. The relatively unaffected reefs of Krusadai may also get deteriorated if appropriate measures are not taken up at the right time.

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