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Coral fish diversity in Netrani waters off Murudeshwar Karnataka, south India

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ABSTRACT

Fish diversity associated with coral reef patches around Netrani Island, in Karnataka (south India) was investigated by visual census method. Sampling was done in four sites around the Island. A total of 69 species belonging to 39 genera, 19 families and 3 orders were recorded in the transect in four sites. When comparing the abundance, the fishes of Balistidae family dominated in all the four sites (22 %) followed by Pomacentridae (12.5 %), Caesionidae (9.7 %), Labridae (7.8 %), Acanthuridae (7.3 %), Haemulidae (6.7 %) and Scaridae (6.1 %). In line with the abundance and number, Shannon diversity indices (H') were 2.8 in site 1; 2.6 in site 3; 2.3 in site 4 and 2.2 in site 1. The evenness (J') of species distribution was more in site 2 (0.9), followed by site 3 (0.8); site 4 (0.7) and site 1 (0.7). The Bray-Curtis similarity was in the range of 69.98 to 79.50. The dendrogram plotted showed that site 2 and 3 form a group with similarity of 79.50, to which site 1 and site 4 got linked. There was no significant difference in the hydrographic parameters of the surface and bottom waters in four sites and also between different sites. The study revealed high coral fish density in the area indicating the need for adopting conservation measures.

Keywords: Abundance, Diversity, Indices, Netrani, Reef fish

Introduction

Habitat structure plays an important role in structuring animal communities and a heterogeneous environment often enhances diversity and population abundance of the species (Turner *et al.*, 2001). Coral reef habitat is a complex ecosystem providing shelter to many animals including nudibranchs, molluscs, sponges, fishes and other marine vertebrates. Reef fishes are the most diverse element in the reef fauna and because of their wider ecological significance, some families of reef fish present valuable groups for monitoring the health of reefs and for investigating factors underlying the high species diversity characteristics of reef ecosystems. Some fishes such as species of butterfly fish (Family: Chaetodontidae) have been proposed as useful indicator species of reef development as well as health (Reese, 1981; Ohman *et al.*, 1998). Our resources in the reefs are fast dwindling and hence the study of diversity in the coral reef ecosystem is of great significance in order to assess the changes over the period of time. The strength of association between organisms and their habitat can provide an indication of the level of habitat change (Jones and Andrew, 1993) and an array of studies have documented positive relationships between fish abundance as well as diversity and coral cover (Bell and Galzin,1984; Findley and Findley, 1985; Hart *et al.*, 1996). Studies on the most diverse element *i.e.*, fish species in the coral reef ecosystem help to understand the present status and the changes taking place over a period of time.

The uninhabited Netrani Island (14°01' 667" N and 74°31'667" E) is located off the coast in Murudeshwar, Karnataka, of southern India. Around this Island, patchy coral reefs are observed with diverse fauna and flora and an inventory of the same was made recently (Zacharia *et al.*, 2008). This site has international acclamation as a recreational diving site. Which is also used as a target for shooting and shelling practice by Indian Navy and therefore degraded coral patches were noticed (Zacharia *et al.*, 2008). In the present scenario of changing environmental conditions and the threat to these patchy reefs around the Netrani Island, a study was initiated to assess the fish diversity of the area. Knowledge of the current status of fish communities coupled with long term monitoring is

essential for formulating future management strategies. The findings from the present study would form a baseline for future monitoring of the site for impact from human interferences.

Materials and methods

Study area

Netrani Island (14°01' 667" N and 74°31'667" E) is located 19 kms (10 nautical miles) from the coast of Murudeshwar. The island is uninhabited and is not easily accessible due to sharp stones around the Island. Four sites were selected randomly around the island for the underwater visual census (UVC). First site was in the western side of the island (14°00'84" N and 74°19'59" E), second site was on the northern side (14°00'72" N and 74°19'47" E), third site on the eastern side (14°01'18" N and 74°19'65" E) and fourth site on southern side (14°00'96" N and 74° 19'81" E) (Fig. 1). The survey was conducted during post-monsoon period in October 2007 and pre-monsoon period in April 2008.

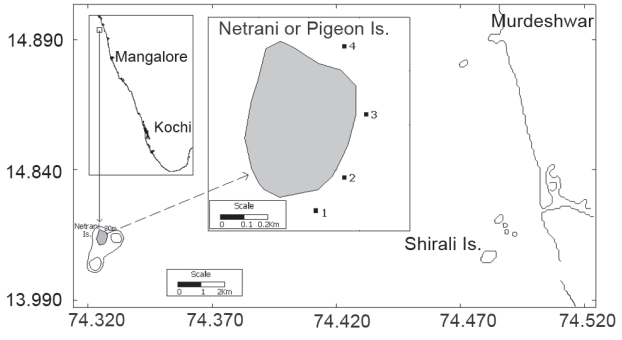

Fig. 1. Map showing study area

Sampling procedure

Underwater visual census

Non-cryptic, diurnally active coral fishes, abundance estimates were done using underwater visual census (UVC) technique of belt transect by SCUBA diving (Brock, 1954). This is a non-destructive technique for estimating fish populations that enables the researchers to select specific species and is relatively rapid and inexpensive (Fowler, 1987; Bellwood and Alcala, 1988). Despite the potential disadvantages of variations in duration of swimming speed, species identification and transect width, UVC are the most practical and extensively used technique to study coral reef fishes (Nagelkerken *et al.*, 2000). For the present study, the selected transect dimensions were 30 m length by 5 m from each side of the transect line (30 x 10 m). A total of 9 transects were done in all the sites. The fish observer swam slowly along the transect of each site to identify and count the fishes located within an area of 300 m^2 by visual estimates following Hodgson and Waddell (1997) and English *et al*. (1997). In each site, transects were done 50 m apart so that fishes were not resampled. Replicates in each sites were conducted on the same day to minimise the error in sampling. Range of visibility in all locations was relatively homogenous with good clarity and therefore it did not interfere with visual recording of fish density. Fishes were identified to species level following Fischer and Bianchi (1984), Smith and Heemstra (1986), Rao *et al.*, (2000), Carpenter and Niem (2001) and Froese and Pauly (2006). The duration of survey at each site was about 75 min. Fish density was calculated as the total number of individuals per species divided by the total area surveyed and expressed per 100 m^2, while relative abundance (%) was calculated as the proportion of all individuals of each species divided by total number of individuals (Anguilar-Perera and Appeldoorn, 2008). All species were grouped into families; density was estimated as stated above and the results were given for each fish family in the area.

Hydrographical, chemical and sediment variables

Since this is the first study of its kind in the area, baseline information on hydrographical, chemical and sediment parameters in the patchy coral reefs around the Island is essential for future comparisons. Water samples were collected from surface as well as bottom at each location and the depth of the area was taken. *In situ* measurements were taken for temperature and depth. For collection of bottom water sample, Nansen reversing bottle sampler was used. The hydrogen ion concentration (pH) was measured using an Elico model LI-120 pH meter. Dissolved oxygen was measured using Winkler's method (Strickland and Parson, 1972). Salinity was estimated by Mohr's titration method (Strickland and Parsons, 1972). Nutrients *viz.,* nitrate, nitrite, phosphate and silicate, in the samples were analysed colorimetrically based on the method by Parsons *et al.* (1984). Organic carbon in the sediment was determined with fair accuracy by the method described by Jhingran *et al.* (1988), which was proposed by El- Wakeel and Riley (1957).

Data analysis

Fish density and diversity were estimated in the four sites. To analyse the difference of diversity between the four sites, Shannon-Weiner diversity index (H') and Pielou's Eveness index (J') for evenness were calculated (Ludwig and Reynolds, 1988). To compare the biodiversity between the areas, dominance plot was

drawn by ranking the species in decreasing order of abundance. The similarity in species composition based on the species and abundance was studied by calculating the Bray-Curtis coefficient (Cluster analysis) (Bray and Curtis, 1957). The data were square root transformed before the analysis for diversity indices, similarity and cluster analysis. All analyses including fish diversity structure was analysed by multivariate statistical techniques using the PRIMER V software package (Clarke and Warwick, 2001).

Results and discussion

A total of 66 species belonging to 39 genera, 19 families and 3 orders were recorded along the transect in four sites of Netrani waters (Table 1). When comparing the abundance, the fishes of Balistidae family dominated in all the four sites (22 %) followed by Pomacentridae (12.5 %), Caesionidae (9.7 %), Labridae (7.8 %), Acanthuridae (7.3 %), Haemulidae (6.7 %) and Scaridae (6.1 %) (Fig. 2). The other major groups which contributed to the fish species are Siganidae (4.2%), Chaetodontidae (3.2 %), Lutjanidae (2.9 %), Gobiidae (2.8 %), Pomacanthidae (2.6 %) and Zanclidae (2.5 %). Minor groups consisted of Carangidae (1.8 %), Serranidae (1.8 %), Holocentridae (1.5 %), Synodontidae (1.1%), Muraenidae (1.0 %), Mullidae (0.9 %), and Tetraodontidae (0.8 %). The fish density was calculated per 100 m^2 and it was grouped into families. The density of fishes belonging to Balistidae was high in all the sites, except site 4 which was on the southern side of the Island, where Pomacentridae family dominated (Table 2).

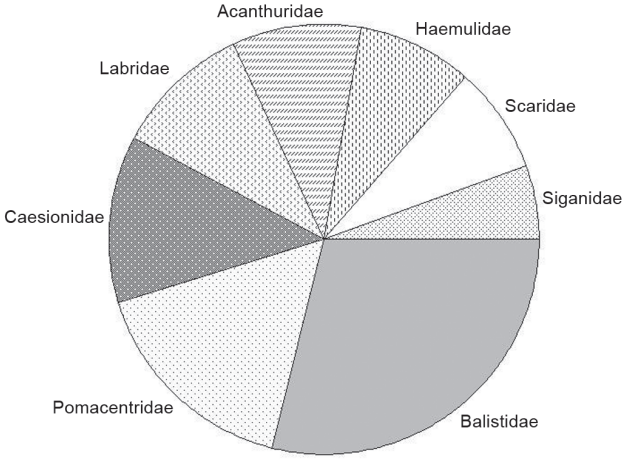

Fig 2. Major families contributing to fish abundance (%) at Netrani 2007-2008

Table 1. Finfishes recorded in the UV Transect at Netrani 2007-08

Species	Family	Order
Odonus niger	Balistidae	Tetradontiformes
Caesio teres	Caesionidae	Perciformes
Sufflamen fraenatum	Caesionidae	Perciformes
Sargocentron rubrum	Holocentridae	Perciformes
Siganus javus	Siganidae	Perciformes
Lutjanus argentemaculatus	Lutjanidae	Perciformes
Lutjanus bohar	Lutjanidae	Perciformes
Lutjanus fulvus	Lutjanidae	Perciformes
Lutjanus lemniscatus	Lutjanidae	Perciformes
Lutjanus rivulatus	Lutjanidae	Perciformes
Cetoscarus bicolor	Scaridae	Perciformes
Chlorurus bleekeri	Scaridae	Perciformes
Chlorurus troschelii	Scaridae	Perciformes
Scarus globiceps	Scaridae	Perciformes
Scarus hoefleri	Scaridae	Perciformes
Abudefduf sordidus	Pomacentridae	Perciformes
Amphiprion perideraion	Pomacentridae	Perciformes
Dascyllus trimaculatus	Pomacentridae	Perciformes
Pomacentrus coelestis	Pomacentridae	Perciformes
Pomacentrus philippinus	Pomacentridae	Perciformes
Apogon aureus	Pomacentridae	Perciformes
Heniochus diphreutes	Chaetodontidae	Perciformes
Heniochus monocerrus	Chaetodontidae	Perciformes
Chaetodon auriga	Chaetodontidae	Perciformes
Chaetodon collare	Chaetodontidae	Perciformes
Chaetodon decussatus	Chaetodontidae	Perciformes
Chaetodon dolosus	Chaetodontidae	Perciformes
Chaetodon plebeius	Chaetodontidae	Perciformes
Gymnothroax eurostus	Muraenidae	Anguilliformes
Gymnothroax favagineus	Muraenidae	Anguilliformes
Gymnothroax flavimarginatus	Muraenidae	Anguilliformes
Gymnothroax javanicus	Muraenidae	Anguilliformes
Gymnothroax thyrsoideus	Muraenidae	Anguilliformes
Dendrochirus zebra	Scorpaenidae	Perciformes
Pterois antennata	Scorpaenidae	Perciformes
Pterois volitans	Scorpaenidae	Perciformes
Scorpaenopsis gibbosa	Scorpaenidae	Perciformes
Zanclus cornutus	Zanclidae	Perciformes
Parupeneus indicus	Mullidae	Perciformes
Acanthurus xanthopterus	Acanthuridae	Perciformes
Zebrasoma desjardinii	Acanthuridae	Perciformes
Pomacanthus striatus	Pomacanthidae	Perciformes
Apolemichthys kingi	Pomacanthidae	Perciformes
Cheilinus undulatus	Labridae	Perciformes
Coris aygula	Labridae	Perciformes
Coris formosa	Labridae	Perciformes
Labroides dimidiatus	Labridae	Perciformes
Cheilinus undulatus	Labridae	Perciformes
Coris aygula	Labridae	Perciformes
Coris formosa	Labridae	Perciformes
Labroides dimidiatus	Labridae	Perciformes
Thalassoma lunare	Labridae	Perciformes
Cephalopholis formosa	Serranidae	Perciformes
Ephinephelus coeruleopunctatus	Serranidae	Perciformes
Ephinephelus flavocaeruleus	Serranidae	Perciformes

Epinephelus merra	Serranidae	Perciformes
Epinephelus tauvina	Serranidae	Perciformes
Amblyeleotris periophthalma	Gobiidae	Perciformes
Amblyeleotris triguttata	Gobiidae	Perciformes
Amblyeleotris wheeleri	Gobiidae	Perciformes
Elacatinus genie	Gobiidae	Perciformes
Valenciennea sexguttata	Gobiidae	Perciformes
Plectorhinchus chubbi	Haemulidae	Perciformes
Plectorhinchus vittatus	Haemulidae	Perciformes
Carangoides chrysophrys.	Carangidae	Perciformes

Table 2. Fish density per 100 m^2 at four sites in Nethrani

Family	Site 1	Site 2	Site 3	Site 4
Balistidae	10000	1080	3333	240
Caesionidae	2667	540	800	2400
Pomacentridae	2000	810	667	4800
Acanthuridae	800	432	733	2880
Haemulidae	267	108	3800	288
Labridae	800	594	1311	2496
Scaridae	2667	540	667	144
Siganidae	667	378	333	1440
Lutjanidae	667	648	400	240
Gobiidae	333	216	800	480
Pomacanthidae	800	378	400	144
Zanclidae	1000	216	267	144
Carangidae	200	216	400	384
Serranidae	67	162	800	144
Holocentridae	267	162	400	144
Synodontidae	67	108	200	384
Chaetodontidae	867	432	533	288
Muraenidae	67	108	400	96
Mullidae	133	108	133	192
Tetraodontidae	200	54	200	96
Scorpaenidae	133	162	67	144

The diversity indices were calculated for the four sites. In line with the abundance and number, Shannon diversity indices (H') obtained were 2.8 in site 2, 2.6 in site 3, 2.3 in site 4 and 2.2 in site 1. The evenness (J') of species distribution was more in site 2 (0.9), followed by site 3 (0.8), site 4 and site 1 (0.7). The details of the indices calculated is given in Table 3. The cumulative curve expressed as the percentage of abundance in the sample, referred to as dominance plot (Fig. 2) shows that curve for site 2, which lie on the lower side, extended further and rise slowly due to high density of species. As the percentage contribution of each species is added, the curve extends horizontally before reaching the cumulative 100%. This plot shows that density of fish species is high in site 2 *i.e.*, on the northern side of the island. The similarity in the species composition and abundance among the four sites studied by Bray-Curtis coefficient (Cluster analysis) resolved the sites to three clusters in the range of 69.98 to 79.50 (Table 4).

The dendrogram plotted shows that site 2 and 3 formed a group with maximum similarity of 79.50, to which site 1 and site 4 got linked (Fig. 3). Hydrographic parameters recorded from the four sites are given in Table 5.The depth in the area ranged from 7.5 to 9 m with an average depth of 8.25 m. The mean temperature ranged from 27.6 to 29.5 °C, while the pH ranged from 8.03 to 8.21. All hydrographic parameters monitored are given in Table 5. Studies on the environmental characteristics of the marine environment is important in ecological research as it determines the distribution of species in a specific area and fluctuations of which results in changes in species composition. Studies have shown that change in water quality is detrimental for symbiotic zooxanthellae on corals which provide energy through photosynthesis to corals (Richmond, 1993) which would result in coral bleaching.

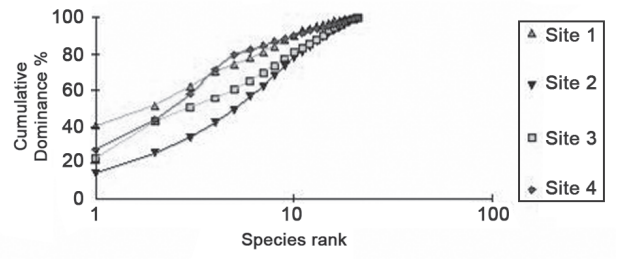

Fig. 3. Dominance plot for finfishes showing higher diversity in Site 2

Table 3. Diversity Indices for four sites at Netrani

Site No.	Species Richness (d)	Evenness (J')	Shannon H'(log)	Simpson (1-Lambda')
1	2	0.7	2.2	0.8
2	2.2	0.9	2.8	0.9
3	2.1	0.8	2.6	0.9
4	2	0.7	2.3	0.8

Table 4. Bray-Curtis Similarity for finfishes in four sites at Netrani

Site No.	1	2	3	4
1	0	0	0	0
2	76.15	0	0	0
3	75.49	79.5	0	0
4	71.11	72.97	69.98	0

The patchy reefs of Netrani are inhabited by numerous coral fishes and the site is of great ecological importance. The preliminary underwater video recording for creating an inventory of finfishes had recorded a total of 92 species belonging to 35 families in Netrani waters. Rare and endangered species like humphead wrasse *Cheilinus undulatus* and many new records to Indian waters were observed during the survey (Zacharia *et al.*, 2008). In the present study, 70 species belonging to 19 families were

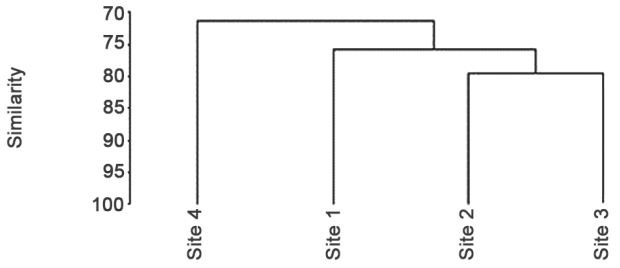

Fig. 4. Dendrogram of finfishes recorded at the four sites showing grouping of areas in Netrani

recorded. The reduction in the number of species doesn't mean that there is disappearance or extinction of species. It is because this survey was done using transect method and the species coming in the transect were only recorded. Considering the number of species recorded in the transect, largest group belonged to Labridae family, followed by Gobiidae and Chaetodontidae, but numerically dominant families included Balistidae and Pomacentridae. The reef fishes are diverse and abundant in the area. There exists a close relationship between the amount of reef present in the area and number of fish species occurring in that area (Mc Coy and Heck, 1976). As the diversity of the coral fishes is high, it could be assumed that there exists a good coral reef system in the area. Moreover, surveys in the area have also revealed the existence of patchy reefs around the Island, which comprised mainly of corals of the family Faviidae, Poritidae and Pocilloporidae. The fish species

Table 5. Hydrographic parameters recorded for Netrani waters (2007-08)

	Post-Monsoon		Pre-Monsoon	
Sites	D.O (mg l^{-1}) Surface	D.O (mg l^{-1}) Bottom	D.O (mg l^{-1}) Surface	D.O (mg l^{-1}) Bottom
I	5.94	4.05	5.04	5.02
II	5.33	5.26	4.85	4.65
III	4.91	4.71	4.73	4.95
IV	5.32	3.88	5.03	4.78
Sites	Salinity (ppt) Surface	Salinity (ppt) Bottom	Salinity (ppt) Surface	Salinity (ppt) Bottom
I	35	32.8	34.3	34.5
II	35	30.7	34.4	34.4
III	31	35.1	34.3	34.4
IV	31.1	35.1	34.4	34.4
Sites	pH Surface	pH Bottom	pH Surface	pH Bottom
I	8.26	7.92	8.16	8.14
II	8.26	7.94	8.11	7.99
III	8	7.99	8.1	8.1
IV	8.08	8.01	8.11	8.1
Sites	Temp (°C) Surface	Temp (°C) Bottom	Temp (°C) Surface	Temp (°C) Bottom
I	27.8	28	27.5	28.5
II	29	27	30	29
III	29.5	29.5	29.5	29.2
IV	30	26	29	29.2
Sites	NO_2 Surface	NO_2 Bottom	NO_2 Surface	NO_2 Bottom
I	0	0.0003	0.044	0
II	0	0	0.69	0.133
III	0.0008	0	0.16	0.022
IV	0	0.002	0.022	0.089
Sites	PO_4 Surface	PO_4 Bottom	PO_4 Surface	PO_4 Bottom
I	0	0.25	0.25	0.2
II	0	0.2	0.2	0.3
III	0.05	0.5	0.35	0.25
IV	0	0.9	0.2	0.3
Sites	SiO_3 Surface	SiO_3 Bottom	SiO_3 Surface	SiO_3 Bottom
I	0	4.46	2.82	2.34
II	0	5.48	2.95	2.55
III	3.64	4.4	3.31	3.43
IV	0	5.48	2.44	2.62

NO_2, PO_4 and SiO_3 values in µg at l^{-1}

belonging to family Chaetodontidae which is generally used as bioindicators of health of the coral and habitat disturbances were also represented in good number on the reef. Cluster analysis on fish densities revealed distribution similarity between the eastern and northern side of the Island. Plausible reason for high fish density around the island could be that coral reefs offer greater structural complexity and availability of shelter (Roberts and Ormond, 1987). Pomacentrid species was the second dominant group in the area and most pomacentrid species strongly restrict themselves to specific site and have only small territories or home ranges (Sale, 1974; 1978; Fricke, 1975). Degradation of the site would hence adversely affect this group. Bell *et al*. (1985) has suggested that rich and abundant assemblages of fishes were found at sites rich in coral. Sano *et al*. (1984) in a series of experiments using living and dead branching corals reported that, overall, dead colonies support fewer individuals and species of resident fishes than do live colonies. From the present study on the coral fishes it is evident that Netrani waters have a good coral cover with high fish density. At present, our knowledge about the role of these species in the coral ecosystem is limited and it is difficult to predict the diversity loss due to degradation of the reef. However, it is clear that fishes are important to many processes on reefs such as control of algal populations, bioerosion and sediment production, nutrient cycling between adjacent habitats and control of populations of other important species such as echinoderms (Ormond *et al.*, 1991; Roberts, 1995). Ormond and Roberts (1999) suggested that functional complementarities of species in diverse reef systems can ameliorate the impacts of species loss. There is a rapid decline in coral reef ecosystem and about 10% of the coral reefs are already destroyed and 60 % are under threat globally due to various environmental and human interventions (Gray, 1997). Since uncertainties are there in the species interactions and loss of diversity in the reefs, the most effective course to adopt is conservation of the ecosystem.

Coral fishes are important to many processes occurring in the reef and loss would affect the health of the reef system. The present study revealed rich and varied diversity of coral fishes around the Island. Degradation of the reef habitat and overharvesting are leading to heavy losses in coral fish diversity around the globe and the study is a pioneering effort in this line which could form a baseline for further studies.

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