5

Diversity of coral reef fishes

S. Jasmine, Rani Mary George, M. K. Anil and H. Jose Kingsly

Abstract

Reef fish diversity associated with coral reef patches around eleven sites from Enayam to Thirumullavaram, along the south-west coast of India, was investigated by Underwater Visual Census Method. Sampling was done in all the sites and a total of 70 species belonging to 48 genera, 31 families and 3 orders were recorded in the transect from these sites. In cumulative abundance, the family Pomacentridae dominated with 49% followed by Lutjanidae (9%), Siganidae (7.4%), Chaetodontidae (6.1%), Ballistidae (5.85%), Labridae (4.5%), Acanthuridae (3.3%), Scaridae (2.7%), Caesionidae (2%) and Carangidae (1%). In line with the abundance and number, Shannon diversity indices (H') were maximum in Muttom (3.59), followed by Enayam (3.26) and Varkala (3.12) during the post-monsoon season. During pre-monsoon, almost all sites were having high H' values ranging from 2.38 to 3.95, except three centres. The evenness (J') of species distribution was more in site Enayam (0.91) during pre-monsoon and in post-monsoon. Odayam recorded the highest value of J'(0.99). The Bray-Curtis similarity was in the range of 4.47 to 55.17 during the pre-monsoon and from 6.8 to 62.77 in the post-monsoon period. The dendrogram plotted for the pre-monsoon period shows that Enayam and Adimalathura formed a group with maximum similarity of 55.18, to which Muttom got linked and in post-monsoon, Muttom and Enayam formed a group with maximum similarity of 65.62, to which Vizhinjam and Adimalathura got linked. There was no significant difference in the hydrographic parameters of the surface waters in the study stations. The study revealed high coral fish density in the area indicating the need for adopting appropriate conservation measures to prevent depletion of this resource which would affect the health of the reef system.

Keywords: *Coral reef, Diversity, Fishes, South-west coast of India*

Introduction

Coral reef fish communities, which are among the richest animal communities in nature, are established in heterogeneous and patchy environment. Reef fishes are the most diverse elements in the reef fauna and, because of their wider ecological significance, some families of reef fish present valuable groups for monitoring the health of the reefs and for investigating factors underlying the high species diversity characteristics of reef ecosystems.

India is endowed with a vast resource potential of marine ornamental fishes distributed in the coral reefs and rocky coasts with patchy coral growth and sea grass beds. Our resources in the reefs are fast dwindling and hence the study of diversity in the coral reef ecosystem is of great significance to assess the changes over a period of time. In spite of the vast areas of distribution of these fishes in our waters, knowledge of their taxonomy, availability, seasonal abundance and stock sizes are limited. Previous studies revealed that the coast from Muttom to Vizhinjam, and Varkala to Thirumullavaram in the south-west coast of India is rich in marine ornamentals due to their rocky habitat. The Vizhinjam, Enayam and Thirumullavaram areas are unique with patchy coral growth and stable water quality. Vizhinjam alone harbours more than 150 species of marine ornamental fish species (Anil *et al*., 2010). 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 relationship between fish abundance, 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 present study deals with the underwater visual census (UVC) carried out along this coast for the availability and abundance of coral reef fishes.

Materials and methods

Study area

Along the south-west coast of India, a total of 11 sites (Fig.1) having patchy coral growth or rocky habitat were selected for Underwater Visual Census (UVC). The sites selected were Muttom (08°07'093'' N and 077°16'900'' E), Enayam (08°12'818'' N and 077°10'860'' E), Adimalathura (08°21'267'' N and 77°00'520'' E), Vizhinjam (08°22'527'' N and 07°659'454'' E), Eravipuram (8°51'.238''N & 76°36'497''E), Paravoor (08°48'393'' N and 076°38'795'' E), Odayam (08°44' 378'' N and 076°41'884'' E), Varkala (08°44'157'' N and 076°41'966'' E), Thangassery (08°52'425'' N and 076°34'700'' E), Thirumullavaram

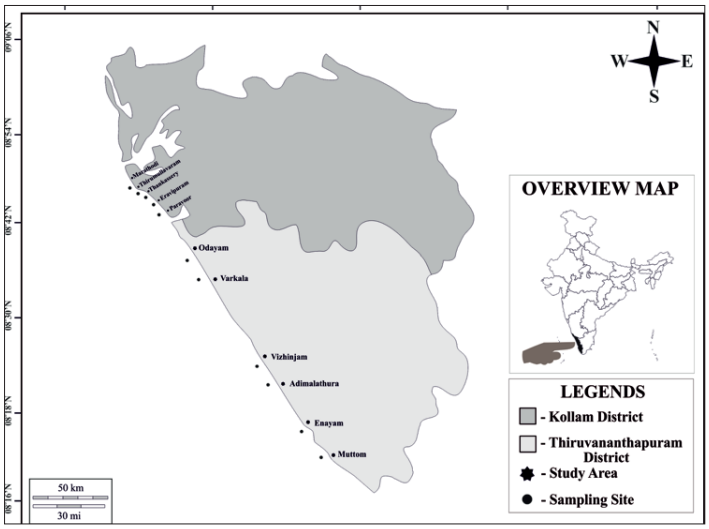


Fig.1. Map showing study area

(08°07'093'' N and 077°16'900'' E) and Marathodi (08°54'075'' N and 076°32'684'' E). The survey was conducted during the post-monsoon period in January 2009 and the pre-monsoon period in April 2010.

Underwater visual census

Reef fish assemblages are difficult to sample because of the diversity and mobility of the fauna and the variety of microhabitats within the complex reef distribution (Russel *et .al.*, 1978). Non-cryptic, diurnally active coral fish abundance estimates were done using Underwater Visual Census (UVC) technique by scuba diving (Brock, 1954). This is a non-destructive technique for estimating fish populations that enables researchers to select specific species and is relatively fast and inexpensive (Fowler, 1987; Bellwood and Alcala, 1988). Despite the potential disadvantages of variations in swimming speed, species identification and transect width, UVC is 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 5 m). A total of 3 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). At each station, the first site was on the western side, the second site on the northern side, the third on the eastern side and the fourth on the southern side. At each site, transects were done 50 m apart so that fishes were not resampled. Replicates in each site were conducted on the same day to minimise error in sampling. The range of visibility in all locations was relatively similar with good clarity and therefore, it did

not interfere with visual recording of fish density. Fishes were identified to species level following Smith and Heemstra (1986), Rao *et al.* (2000) and the FAO identification manual. The duration of survey at each site was about 75 min. The relative abundance (%) was calculated as the proportion of all individuals of each species divided by the total number of individuals (Sujitha *et al*., 2011). All species were grouped into families and the results were given for each fish family in the area.

Hydrographic variables

The hydrographic parameters in the patchy coral reefs along the coast were studied. Water samples were collected from the surface at each location and the depth of the area was noted. *In situ* measurements were taken for temperature and depth. 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 Parsons, 1972). Salinity was estimated by Mohr's titration method (Strickland and Parsons, 1972) and turbidity was measured using portable Nephelometer.

Data analysis

The fish density and diversity were estimated in eleven sites. To analyse the diversity between the sites, the Shannon-Weiner diversity index (H') and for evenness, Pielou's Evenness index (J') were employed (Ludwig and Reynolds, 1988). To compare the biodiversity between the areas, dominance plot was drawn by ranking the species in the 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). All analyses, including the fish diversity structure, were conducted by multivariate statistical techniques using the PRIMER v5 software package (Clarke and Warwick, 2001).

Results and discussion

The fish assemblage along the rocky shores of the surveyed areas revealed a rich diversity of coral reef fishes. Rare species, such as bramble shark, were also recorded, but no new records to Indian waters were observed during the survey. The reef fishes are diverse and abundant and surveys have revealed the existence of patchy reefs around these sites, which comprised mainly of corals of the family Pocilloporidae. The plausible reason for high fish density around these reefs could be that coral reefs offer greater structural complexity and shelter. Further, pomacentrid species was the most dominant group in the area and most pomacentrid species are strongly site attached and have only small territories or home ranges.

A total of 70 fish species belonging to 48 genera, 31 families and 3 orders were recorded in the transect in these sites (Table 1). During the

pre-monsoon season, fishes of the family Pomacentridae dominated (49%), followed by Lutjanidae (9%), Siganidae (7.4%), Chaetodontidae (6.1%), Balistidae (5.8%), Labridae (4.5%), Acanthuridae (3.3%), Scaridae (2.7%), Caesionidae (2%) and Carangidae (1%) (Fig 2i). During post-monsoon also, fishes of the family Pomacentridae dominated (64%), followed by Chaetodontidae (8.7%), Lutjanidae (5.5%), Siganidae (4.5%), Balistidae (3.9%), Acanthuridae (3.2%), Scaridae (2.9%), Labridae (4.5%), and Carangidae (1.7%) (Fig 2ii). Minor groups such as Apogonidae, Gobiidae, Haemulidae, Holocentridae, Pempheridae, Pomacanthidae, Muraenidae, Mullidae, Ostraciidae, Scolopsidae, Serranidae, Synodontidae, Tetraodontidae and Zanclidae also contributed to the total coral fish fauna in the study area (Fig 2i & ii).

The number of species and their abundance vary between regions on the basis of the type and extent of the substratum and the physical environment (Venkataramani and Jayakumar, 2010). From the present study on the coral fishes, it is evident that Enayam-Vizhinjam and Varkala-Thirumullavaram waters have a good coral/sponge cover with high fish density. Among the stations surveyed, Enayam, Vizhinjam, Varkala and Thirumullavarm recorded the highest species diversity followed by Muttom, Adimalathura, Eravipuram, Thangassery, Odayam, Paravoor and Marathodi. In each station, a particular species was found to be dominant such as *Pempheris oualensis* in Muttom, *Pomacentrus* spp. in Enayam and Vizhinjam, *Pterocaesio chrysosona* in Adimalathura, *Scatophagus argus* in Marathodi, *Lutjanus fulvus* in Eravipuram, the cleaner wrass *Labroides dimidatus* in Paravoor and *Scolopsis* spp. and *Neopomacentrus* spp. in Odayam. In Varkala, fishes belonging to the family Lutjanidae and Acanthuridae and in Thangassery, Siganids were more abundant.

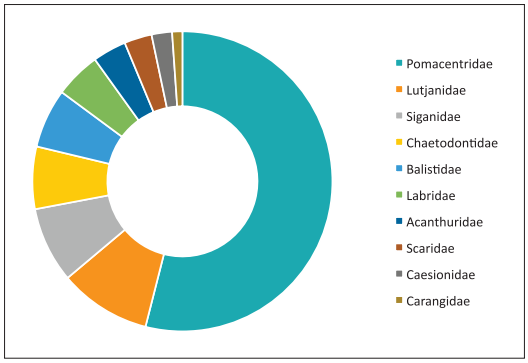


Fig. 2(i). Major families contributing to reef fish abundance (%) in the surveyed sites during pre-monsoon

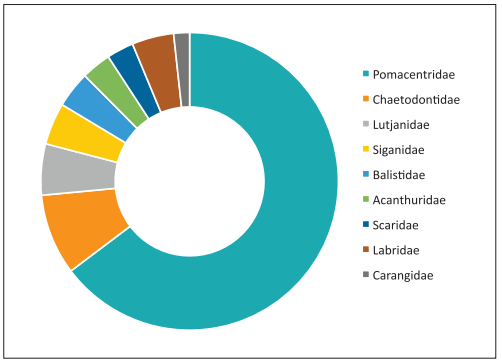


Fig. 2(ii). Major families contributing to reef fish abundance (%) in the surveyed sites during post-monsoon

Common ormanental fishes of the area

Table 1. Fin fishes recorded in the UV Transect at different study stations* along the southwest coast of India (relative abundance**)

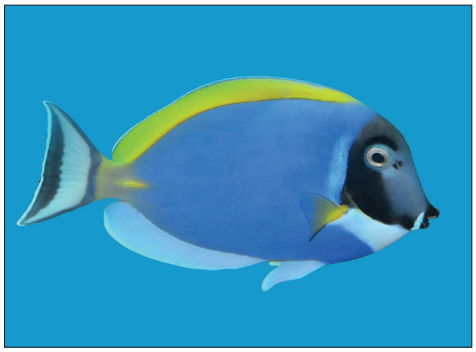
Species of Coral Fishes	Stations										
	MU	EN	AD	VZ	ER	PA	OD	VA	MA	THI	THA
AMBASSIDAE											
Ambassis sp.				A							
ACANTHURIDAE											
Acanthurus mata	R	A		R	R			C	R		C
Acanthurus triostegus										R	R
Acanthurus nigricauda											C
Acanthurus xanthopterus				R							
APOGONIDAE											
Apogon sp.				A			C				
Archamia fucata				A							
BALISTIDAE										R	R
Abalistes stellatus	R	C						R	R		A
Sufflamen fraenatus										R	
Odonus niger	C		C	C		C		C		R	A
CHAETODONTIDAE											
Chaetodon plebius		R								R	
Chaetodon vagabundus				R					R		
Chaetodon lunula				R							R
Chaetodon collare	C	C		A			C	C	C	A	A
Heniochus pleurotaenia		R		R	R						
CARANGIDAE											
Caranx sp.				C	R	C					
Scomberoides commersonnianus									R		
CAESIONIDAE											
Pterocaesio chrysozona	A		R		R						A
DIODONTIDAE											
Diodon liturosus	C	C									
Diodon histrix		C									
ECHINORHINIDAE											
Echinorhinus brucus	R										
GOBIIDAE											

Species of Coral Fishes	Stations										
	MU	EN	AD	VZ	ER	PA	OD	VA	MA	THI	THA
Bathygobius sp.				C							
HAEMULIDAE											
Plectorhinchus lineatus		R									
HEMISCYLLIDAE											
Chyloscyllium griseum							R	R			
HOLOCENTRIDAE											
Sargocentron rubrum	R								R	R	
Myripristis murdjan		R			R						
LABRIDAE											
Thalassoma lunare		R		C	R				R	R	C
Cheilineus diagrammus										R	
Bodianus neilli	R			R					R	R	R
Hemigymnus fasciatus											R
Labroides dimidatus		R				R		C	R		C
LUTJANIDAE											
Lutjanus lutjanus	R	C	A			C	C	A			C
Lutjanus fulvus	R	A		C		R		C	R	C	C
Lutjanus decussatus											R
Lutjanus argentimaculatus		C									
Lutjanus russellii			C					R			
Lutjanus vitta								R			
MUGILIDAE											
Valamugil sp.				A							
Liza sp.				C							
MULLIDAE											
Parupeneus indicus	C		R	C	R				R		C
MURAENIDAE											
Gymnothorax javanicus					R			R			
Gymnothorax favagineus								R		R	
OSTRACIIDAE											
Ostracion cubicus											R
PEMPHERIDAE											
Pempheris oualensis		C						R			
POMACANTHIDAE											
Pomacanthus annularis				R							R

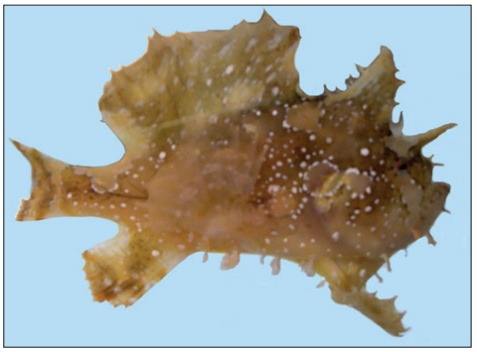
Species of Coral Fishes	Stations										
	MU	EN	AD	VZ	ER	PA	OD	VA	MA	THI	THA
Apolemichthys xanthotis		R									
POMACENTRIDAE											
Abudefduf bengalensis				C							A
Abudefduf sordidus				R							R
Abudefduf saxatilis		C		A					C	A	A
Pomacentrus caeruleus		a		A		C				A	
Pomacentrus pavo										C	
Neopomacentrus nemurus		A	C	A							A
Neopomacentrus violascens						A					C
Neopomacentrus filamentosus		A	A	A	A	A		A	A	A	A
Dascyllus trimaculatus				C						C	A
SERRANIDAE											
Epinephelus sp.	R			C		R	R			R	
Epinephelus malabaricus											
Cephalopholis argus								R		R	R
Cephalopholis sonnerati									R		
SCARIDAE											
Chlorurus sordidus		A		A					C		
SCATOPHAGIDAE											
Scatophagus argus									A		
SCOLOPSIDAE											
Scolopsis vosmeri									R		
SCORPAENIDAE											
Scorpaenes gibbosa	R		R								
SIGANIDAE											
Siganus javus	C	A	A	A	R			C			A
Siganus canaliculatus				C							
SYNODONTIDAE											
Synodus sp.					R						
TETRADONTIDAE											
Canthigaster solandri											R
Canthigaster sp.			R								
Arothron hispidus							R	R			
ZANCLIDAE											
Zanclus cornutus				R	R						R

* MU-Muttom, EN-Enayam, AD-Adimalathura, VZ-Vizhinjam, ER-Eravipuram, PA-Paravoor, OD-Odayam, VA-Varkala, MA-Marathodi, THI-Thirumullavaram, THA-Thangassery
** C- Common, A- Abundant, R-Rare

Photographs of common coral reef fishes recorded from the study area



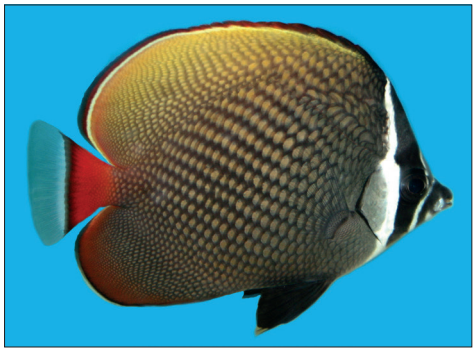
1. *Acanthurus leucosternon*



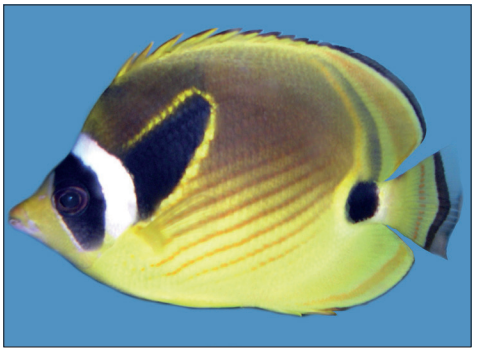
2.*Histrio histrio*

3. *Ostorhinchus aureus*

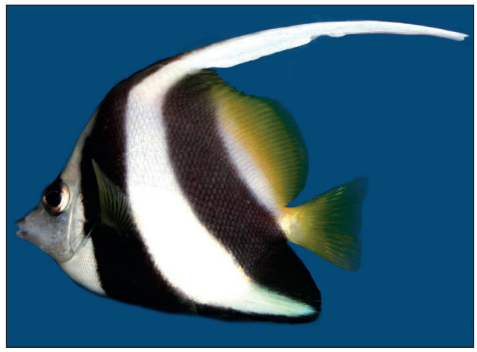
4. Odonus niger



5. *Chaetodon collare*



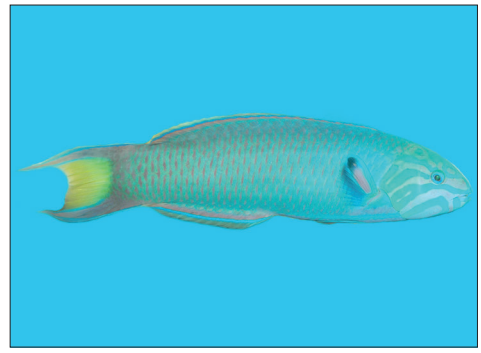
6. Chaetodon lunula



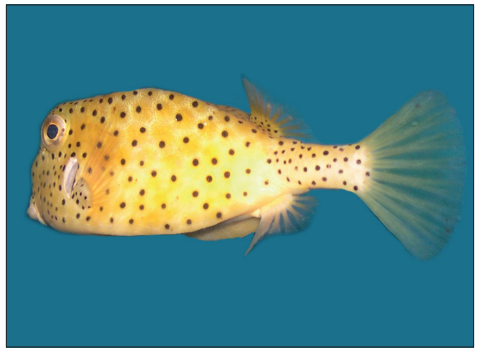
7. Heniochus acuminatus

8. Lophodiodon calori

9. Sargocentron rubrum



10. Thalassoma lunare



11. Ostracion cubicus

12 . Apolemichthys xanthurus

The diversity indices were calculated season-wise for the eleven sites (Table 2 & 3). During pre-monsoon, in line with the abundance and number, the Shannon diversity index (H') was high in Enayam and Muttom in the southern side and Thirumullavaram and Varkala in the northern side. The evenness (J') of species distribution was more in Enayam (0.9), followed by Muttom (0.87), Adimalathura (0.85) and Paravoor (0.85). The cumulative curve expressed as the percentage of abundance in the sample, referred to as dominance plot (Fig. 3) shows that the curve for Enayam, which lies on the lower side, extended further and rise slowly due to the 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 the density of fish species is high at Enayam.

The similarity in species composition and abundance among the stations studied by the Bray-Curtis coefficient (Cluster analysis) resolved the stations into ten clusters in the range of 4.47 to 55.18. The dendrogram plotted shows that Enayam and Adimalathura formed a group with the maximum similarity of 55.18, to which Muttom got linked (Fig. 3). It is interesting to note that Vizhinjam and Thangassery formed a cluster reinstating the similarity with the same habitat as these two stations have a rich, diverse fauna associated with the pocilloporid corals attached to the boulders and rocks of the enclosed bay.

During post-monsoon, the Shannon diversity index values (H') were high in Muttom and Enayam on the southern side and Varkala on the northern side. The evenness (J') of species distribution was more in Odayam (0.99) followed by Muttom (0.89), Enayam (0.85) and Marathodi (0.85). The details of the indices calculated are given in table 3. The dominance plot (Fig.3) shows that the curve for Muttom, Enayam and Varkala, which lie on the lower side, extended further and rise slowly due to high density of species. The similarity in the species composition and abundance among the stations studied by the Bray-Curtis coefficient (Cluster analysis) resolved the stations into ten clusters in the range of 6.96 to 65.62. The dendrogram plotted shows that Muttom and Enayam formed a group with the maximum similarity of 65.62, to which Vizhinjam and Adimalathura got linked. (Fig. 4). In the other cluster, Eravipuram and Paravoor formed a group with maximum similarity of 55.95 to which the other group Varkala and Thangassery with 48.63 got linked.

Table 2(i). Diversity Indices for sites during pre-monsoon

Stations	Species richness d	Evenness J'	Shannon diversity H'(log2)	Simpson 1-Lambda'
Muttom	3.46	0.87	3.62	0.89
Enayam	3.94	0.91	3.95	0.93
Adimalathura	3.43	0.85	3.56	0.89
Vizhinjam	2.77	0.77	3.30	0.86
Eravipuram	4.26	0.69	3.05	0.76
Paravoor	2.10	0.85	2.69	0.83
Odayam	2.67	0.64	2.38	0.73
Varkala	3.61	0.73	3.15	0.80
Marathodi	2.69	0.79	2.95	0.82
Thirumullavaram	4.41	0.83	3.52	0.89
Thangassery	2.97	0.70	3.05	0.82

Table 2(ii). Diversity Indices for sites during post-monsoon

Stations	Species richness d	Evenness J'	Shannon diversity H'(log2)	Simpson 1-Lambda'
Muttom	3.48	0.90	3.59	0.91
Enayam	2.79	0.86	3.26	0.88
Adimalathura	2.18	0.83	2.75	0.82
Vizhinjam	3.15	0.66	2.72	0.73
Eravipuram	0.90	0.76	1.52	0.60
Paravoor	1.64	0.77	2.15	0.70
Odayam	0.42	0.99	0.99	0.54
Varkala	2.59	0.82	3.12	0.85
Marathodi	2.73	0.85	2.83	0.83
Thirumullavaram	3.11	0.74	2.81	0.80
Thangassery	2.89	0.66	2.76	0.80

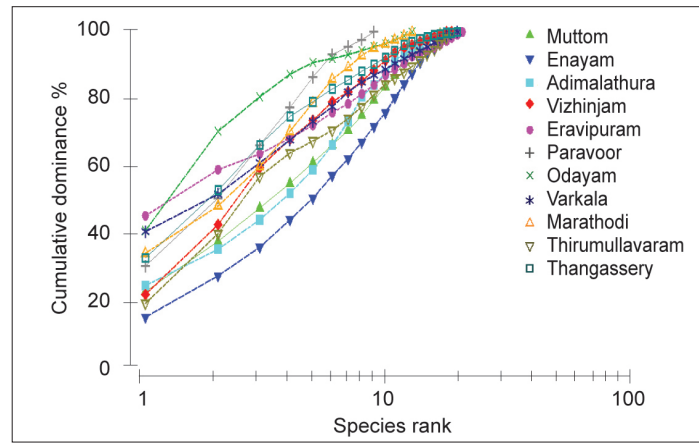


Fig. 3(i). Dominance plot for coral fishes during pre-monsoon

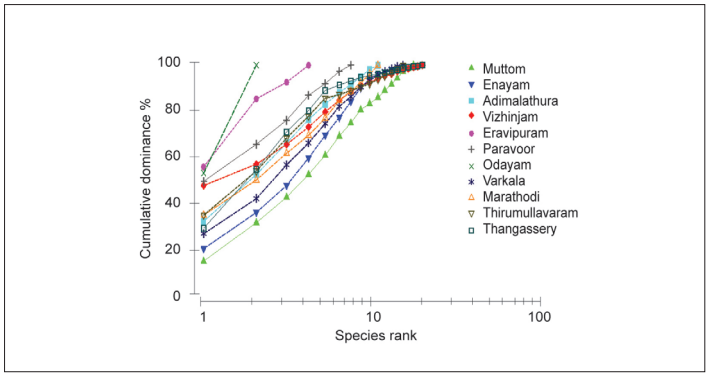


Fig. 3(ii). Dominance plot for coral fishes during post-monsoon

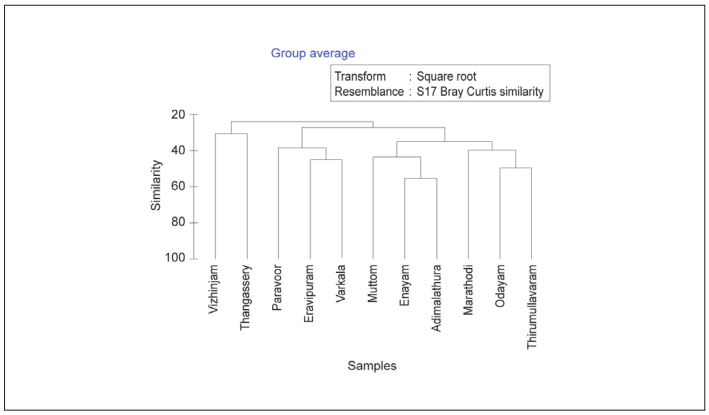


Fig. 4(i). Dendrogram of coral fishes recorded at the study sites during pre-monsoon

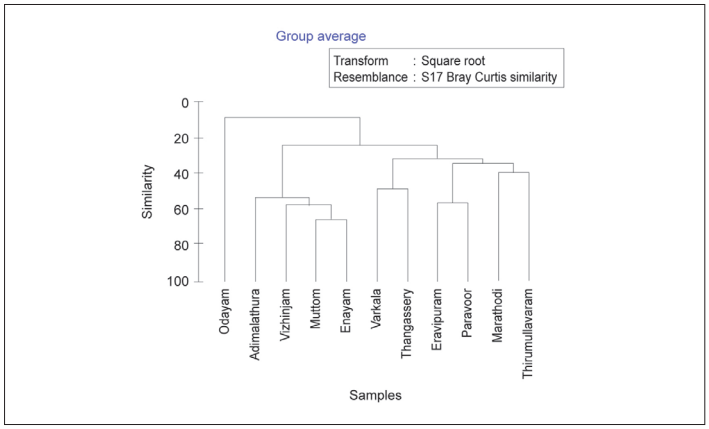


Fig. 4(ii). Dendrogram of coral fishes recorded at the study sites during post-monsoon

Table 3(i). Bray-Curtis Similarity for finfishes during pre-monsoon

Stations	MU	EN	AD	VZ	ER	PA	OD	VA	MA	THI	THA
MU	0	0	0	0	0	0	0	0	0	0	0
EN	49.64	0	0	0	0	0	0	0	0	0	0
AD	37.65	55.18	0	0	0	0	0	0	0	0	0
VZ	25.84	37.3	38.93	0	0	0	0	0	0	0	0
ER	36.31	41.98	46.89	26.91	0	0	0	0	0	0	0
PA	25.59	28.78	41.95	11.22	41.75	0	0	0	0	0	0
OD	36.17	38.73	28.13	26.63	28.44	4.472	0	0	0	0	0
VA	17.59	31.63	23.07	18.68	44.92	35.06	21.84	0	0	0	0
MA	21.14	44.95	26.88	24.27	28.67	18.46	37.32	29.7	0	0	0
THI	39.57	44.73	36.09	26.7	30.75	18.42	49.59	19.38	42.3	0	0
THA	28.04	20.9	29.9	30.44	26.73	24.58	10.74	25.22	14.9	14.42	0

Table 3(ii). Bray-Curtis Similarity for finfishes during post-monsoon

Stations	MU	EN	AD	VZ	ER	PA	OD	VA	MA	THI	THA
MU	0	0	0	0	0	0	0	0	0	0	0
EN	65.62		0	0	0	0	0	0	0	0	0
AD	62.77	50.79	0	0	0	0	0	0	0	0	0
VZ	55.52	59.45	46.31	0	0	0	0	0	0	0	0
ER	6.802	18.19	0	23.4	0	0	0	0	0	0	0
PA	24.97	30.36	16.98	35.89	55.95	0	0	0	0	0	0
OD	12.21	0	14.82	8.377	0	0	0	0	0	0	0
VA	27.91	16.11	14.14	36.33	27.42	39.65	9.97	0	0	0	0
MA	17.62	18.5	9.253	27.33	36.92	37.32	17.48	43.9	0	0	0
THI	34.62	39.23	41.11	39.01	23.05	39.81	15.04	28.67	39.29	0	0
THA	22.03	21.96	14.24	42.61	23.81	25.02	6.96	48.63	31.38	32.10	0

* MU-Muttom, EN-Enayam, AD-Adimalathura, VZ-Vizhinjam, ER-Eravipuram, PA-Paravoor, OD-Odayam, VA-Varkala, MA-Marathodi, THI-Thirumullavaram, THA-Thangassery

Studies on the environmental characteristics of the marine environment are important in ecological research as they determine the distribution of species in a specific area, fluctuations of which result in changes in species composition. Hydrographic parameters recorded from the study sites are given in table 4. There was not much variation in various parameters in the sites studied. The temperature variation can be due to different timings of the survey. The mean temperature ranged from 29 to 32.6°C, and from 30 to 33°C, while the pH ranged from 8.2 to 8.3 and 8.0 to 8.34 in pre-monsoon and post-monsoon, respectively. The turbidity between 0 and 3 ntu is considered as clear water and in our

survey during both the seasons, the sites presented very clear water, and the lowest turbidity values were recorded in Enayam. Studies have shown that change in water quality is detrimental to symbiotic zooxanthellae on corals which provide energy through photosynthesis to the corals (Richmond, 1993). In the patchy coral reefs of Enayam, Vizhinjam and Kollam, very low incidence of bleaching were observed, which indicated good water quality along the coast.

Table 4. Hydrographic parameters recorded at the study sites

Stations	Pre-monsoon					Post-monsoon				
	Temp (°C)	pH	Salinity (ppt)	D.O2 (mg/L)	Turbidity (ntu)	Temp (°C)	pH	Salinity (ppt)	D.O2 (mg/L)	Turbidity (ntu)
MU	32.2	8.25	34	4.41	1.24	33.0	8.20	34.5	4.04	1.07
EN	32.7	8.27	32	4.61	0.98	32.5	8.00	34.5	4.46	0.26
AD	30.1	8.27	34	4.30	2.98	30.2	8.34	34.0	4.24	1.93
VZ	32.2	8.24	32	4.41	2.14	30.5	8.10	34.0	4.86	1.67
ER	29.0	8.20	34	4.16	2.68	30.0	8.20	33.5	4.12	2.20
PA	29.2	8.22	34	3.98	2.46	31.5	8.30	34.0	4.20	1.89
OD	32.6	8.26	34	4.27	2.12	32.0	8.10	34.0	4.52	1.48
VA	32.6	8.25	34	4.53	1.89	32.0	8.15	34.5	4.48	1.27
MA	32.0	8.25	33	4.58	2.12	32.5	8.22	34.0	4.16	1.76
THI	32.0	8.23	32	4.54	1.78	32.5	8.12	34.0	4.22	1.69
THA	32.0	8.30	32	4.32	1.89	32.5	8.20	34.0	4.12	1.72

The patchy reefs along the south-west coast of India are inhabited by numerous coral fishes and the site is of great ecological importance due to its proximity to the Wadge Bank area, especially the southern belt. An earlier study (Anil *et al*., 2010) carried out for taking an inventory of the coral fishes along Vizhinjam, the prominent coral growing area along this coast, had recorded a total of 150 species belonging to 33 families. In the present study, 70 species belonging to 31 families were recorded. The reduction in the number of species does not indicate the disappearance or extinction of species. It is because the present survey was done using the visual census method and only the species coming in the transect were recorded. Considering the number of species recorded in the transect, the largest group of species belonged to the family Pomacentridae, followed by Lutjanide, Chaetodontidae and Labridae. In numerical abundance also, Pomacentridae dominated in most of the centres, followed by Chaetodontidae and Lutjanidae. A close relationship between the amount of reef present in the area and the number of fish species occurring in that area was observed (Mc Coy and Heck, 1976). As the diversity of coral fishes is high, it could be assumed that there exists a good coral /sponge reef system in the area. Moreover, surveys in the area have also revealed the existence of patchy reefs, especially in

Enayam, Vizhinjam, Thirumullavaram and Thangassery comprising mainly of corals of the family Pocilloporidae, Acroporidae (*Montipora*) and Poritidae. The other centres, such as Muttom, Adimalathura and Varkala, were having a good bed of sponges and seaweeds which give shelter to the fish fauna. The fish species belonging to the family Chaetodontidae, which is generally used as bioindicators of health of the coral and habitat disturbances, were also represented in good number in the reef areas. The plausible reason for the high fish density in the study area could be that coral/sponge beds offer greater structural complexity and availability of shelter (Roberts and Ormond, 1987). The Pomacentrid species was the 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) and degradation of the site would hence adversely affect this group.

At present, our knowledge about the role of coral fish 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 the reefs, such as control of algal populations, bio-erosion, sediment production, nutrient cycling between adjacent habitats and control of populations of other important species, such as echinoderms (Ormond *et al.*, 1991; Roberts, 1995). There is a rapid decline in the 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). As coral fishes are important to many processes occurring in the reef, their loss would affect the health of the reef system. The present study revealed rich and varied diversity of coral fishes along the coral/rocky shores along this part of south-west India.

References

Anil, M. K., Jasmine, S., Santhosh, B., Rani Mary George, Raju, B., Unnikrishnan, C. and Jose Kingsly, H. 2010. Availability of marine ornamental fishes along Vizhinjam coast, southern Kerala. In: Felix, S. (Ed.), *Technology and trade prospects for Ornamental Aquaculture in India.* Fisheries Research and Extension, Centre, Tamil Nadu Veterinary and Animal Sciences University, Chennai, p. 108-119.

Bell, J. D. and Galzin, R. 1984. Influence of live coral cover on coral-reef fish communities. *Mar. Ecol. Prog. Ser.*, 15 (3): 265-274.

Brock, V. F. 1954. A preliminary report on a method of estimating reef fish populations. *J. Wildl. Manage.*, 18: 299-308.

Bellwood, D. R. and Alcala, A. C. 1988. The effect of minimum length specification on visual estimates of density and biomass of coral reef fishes. *Coral Reef,* 7: 23-27.

Bray, J. R. and Curtis, J. T. 1957. An ordination of the upland forest communities of Southern Wisconsin. *Ecol. Monogr.*, 27: 325-349.

Clarke, K. R. and Warwick, R. M. 2001. *Change in marine communities: an approach to statistical analysis and interpretation,* 2nd edn. PRIMER-E, Plymouth.

English, S., Wilkinson, C. and Baker, V. 1997. *Survey manual for tropical marine resources.* Australian Institute of Marine Science, Townsville, 390 pp.

Findley, J. S., and Findley, M. T. 1985. A search for pattern in butterfly fish communities. *Am. Natural.*, 126 (6): 800-816.

Fowler, A. J. 1987. The development of sampling strategies for population studies of coral reef fishes-A case study. *Coral Reef,* 6: 49-58.

Fricke, H. W. 1975. The role of behaviour in marine symbiotic animals. In: *Jennings, D. H. and Lee, D. L. (Eds.), Symbiosis: Symposia of the Society for Experimental Biology,* 29, Cambridge University Press Cambridge, p. 581-594.

Gray, J. S. 1997. Marine biodiversity: patterns, threats and conservations needs. *Rep. Stud. GESAMP,* 62: 24 pp.

Hart, A. M., Klumpp, D. W. and Russ, G. R. 1996. Response of herbivorous fishes to crown-of-thorns starfish *Acanthaster planci* outbreaks, II. Density and biomass of selected species of herbivorous fish and fish-habitat correlations. *Mar. Ecol. Prog. Ser.*, 132 (1-3): 21-30.

Hodgson, G. and Waddell, S. 1997. *International Reefcheck Core Method*. University of California, Los Angeles, USA.

Jones, G. P. and Andrew, N. L. 1993. Temperate reefs and the scope of seascape ecology. In: Battershill, C. N., Scheil, D. R., Jones, G. P., Creese, R. G., Mac Diarmid, A. B. (Eds.), Proceedings of the Second International Temperate Reef Symposium, 7-10 January 1992, Auckland, New Zealand NIWA, Marine Wellington, p. 63-76.

Ludwig, J. A. and Reynolds, J. F. 1988. *Statistical ecology.* Wiley, New York, 337 pp.

Mc Coy, E. D. and Heck, K. L. 1976. Biogeography of corals, sea-grasses and mangroves, an alternative to the centre of origin concept. *System. Zool.*, 25: 201-210.

Nagelkerken, I., Dorenbosch, M., Verberk W. C. E. P., Cocheret de la Morinière, E., van der Velde, G. 2000. Day-night shifts of fishes between shallow-water biotopes of a Caribbean Bay, with emphasis on the nocturnal feeding of Haemulidae and Lutjanidae. *Mar. Ecol. Prog. Ser.*, 194: 55-64.

Ormond, R. F. G., Brabury, R., Bainbridge, S., Fabricius, K., Keesing, J., De Vantier, L., Medley, P. and Steven, A. 1991. Test of a model of regulation of crown-of thorns starfish by fish predators, In: Bradbury, R. (Ed.), *Acanthaster and the coral reef a theoretical perspective*. Springer-Verlag, Berlin, p. 189-207.

Rao, D. V., Kamala Devi and Rajan, P. T. 2000. An account of Ichthyofauna of Andaman and Nicobar Islands, Bay of Bengal. *Rec. Zool. Surv. India*, Occ. Pap., 178: 1-434.

Richmond, R. H. 1993. Coral reefs: present problems and future concerns resulting from anthropogenic disturbance. *Am. Zool.*, 33: 524-536.

Roberts, C. M. 1995. Effects of fishing on coral reefs-A massive uncontrolled experiment with ecosystem structure. *Conserv. Biol.*, 9: 988-995.

Roberts, C. M. and Ormond, R. F. G. 1987. Habitat complexity and coral reef fish diversity abundance on Red Sea fringing reefs. *Mar. Ecol. Prog. Ser.*, 41: 1-8.

Russel, B. C., Anderson, G. R. V. and Talbot, F. H. 1978. Seasonality and recruitment of coral reef fishes. *Aust. J. Mar. Freshw. Res.*, 28:521-528.

Sale, P. F. 1974. Mechanism of co-existence in a guild of territorial fishes at Heron Island. In:. Cameron, A. M., Campbell, B. M., and Cribb, A. B. (Eds.). *Proceedings of the Second International Coral Reef Symposium,* The Great Barrier Reef Committee, Brisbane, 1: 193-206.

Sale, P. F. 1978. Coexistence of coral reef fishes-a lottery for living space. *Env. Biol. Fish.*, 3: 85-102.

Smith, M. M. and Heemstra, P. C. 1986. *Smith's sea fishes.* Springer-Verlag, Berlin, Heidelberg, New York, 1047 pp.

Sujitha Thomas, Miriam Paul Sreeram, Kakati, V. S., Mary. K. Manisseri and Rani Mary George. 2011. Coral fish diversity in Netrani waters off Murudeshwar, Karnataka, south India. *Indian J. Fish.*, 58 (1): 45-51.

Strickland, J. D. H. and Parsons, T. R. 1972. A manual of seawater analysis, *Bulletin of Fisheries Research. Board of Canada*, 2nd edn. 167: 310 pp.

Venkataramani, V. K. and Jayakumar, N. 2010. Breeding biology of marine ornamental fishes. In: *Souvenir of the International Seminar on Impact of ornamental fish breeding, farming and trade,* 13–15 February 2010, Department of Fisheries, Kerala, India, p.123 -131

Warren.E. Burgess, Herbert R. Axelrod and Raymond E. Hunziger 1993. *Dr. Burgess's Atlas of Marine Aquarium Fishes.* TFH Publications, 1023 pp.