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Diversity of coral reef fishes in Cuddalore waters, south-east coast of India

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ABSTRACT

The present study was undertaken to obtain basic information on the diversity and species richness of coral reef fishes in Cuddalore waters. Based on collections made for a period of one year, the study has brought to light the occurrence of 25 species of colourful fishes belonging to 16 families. Among the 25 species, *Upeneus vittatus* was found to be the most dominant species (27.5%). The values of Shannon diversity ($\log_2$) index, Margalef richness, Simpson richness and Pielou's evenness during the four seasons covered, varied from 3.3 to 3.9; 2.2 to 3.0; 0.8 to 0.9 and 0.8 to 0.84 respectively. The maximum diversity and richness were recorded during the pre-monsoon season and the lowest during the monsoon season. However, these conventional indices could not effectively bring out the differences in diversity between the seasons as the values ranged narrowly. The recently introduced taxonomic diversity index which ranged from 83.7 to 76.0 was found to be effective. But the difference between summer (76.8) and monsoon (76.0) seasons with 19 and 15 species respectively was not distinct. The variation in taxonomic distinctness index (range: 298.9-131.6) and total phylogenetic diversity index (range: 2033.3-1166. 7) effectively brought out the differences between the seasons underscoring the advantage of using these diversity indices for biodiversity assessment. Further, the present study underlines the need for making a detailed investigation on the biodiversity of fishes occurring in the reef patches reported off Cuddalore, Parangipettai and Pondicherry making use of visual census method.

Introduction

The world conservation strategy (IUCN/UNEP/WWF, 1980) identifies coral reefs as one of the “essential ecological processors and life support systems” necessary for food production, health and other aspects of human survival and sustainable development. The marine fishes reach their greatest diversity in the coral reef ecosystem. Studies on their species composition, species richness and diversity will go a long way in evolving suitable strategies for the protection and management of such species rich areas. Besides this, it is also useful for marine aquarium trade. Though a lot of information is available on the coral reef fishes of the Gulf of Mannar in Tamil Nadu (Muralitharan, 1999), information about the diversity of such fishes in the Coromandel coast in Tamil Nadu is very meager. The present study was undertaken to gather information on the diversity of coral reef fishes in the Cuddalore coast where coral patches are reported to occur (Reef Base, 2000).

Materials and methods

The fishes having ornamental value occurring in Cuddalore coastal waters (Lat.11°42’N: Long.79°46’E) were collected from the trawl catches for a period of one year from January to December 2004 covering the four seasons: post-monsoon (January-March), summer (April-June), pre-monsoon (July-September) and monsoon (October-December). The fishes were preserved in 10% neutralised formalin. Later, the specimens were examined in detail and identified following Day (1878), de Beaufort and Chapman (1951), Munro (1955), Fischer and Bianchi (1984), Ramaiyan *et al*. (1987) and Mohsin and Ambak (1996). The diversity of fishes was calculated following the Shannon - Wiener index. Species richness (S) was calculated following the Margalef index (d) and Simpson index.

The newly introduced diversity indices such as taxonomic diversity (Δ), average taxonomic distinctness (Δ^+), variation in taxonomic distinctness (Λ^+) and total phylogenetic diversity were calculated following Clark and Warwick (2001). To compare the biodiversity between the four seasons, dominance plot was drawn. The similarity in species composition was studied by calculating the Bray – Curtis coefficient (Clarke, 1999). In the cluster analysis, hierarchical agglomerative clustering was used. In the non-metric multidimensional scaling (MDS), the Bray-Curtis similarity was used to construct a map. The goodness of fit of the MDS was found out by calculating the stress value (Clarke and Warwick, 2001). The Δ^+ and Λ^+ values were used for plotting the 95% funnel and ellipse plots. All the diversity indices and other calculations were done using the PRIMER package developed by the Plymouth Marine Laboratory, UK.

Results and discussion

As many as 25 species of coral reef fishes belonging to 16 families were identified (Table 1). One hundred and twenty one coral reef fishes have been reported to occur in the reef slope of the Kavaratti atoll of Lakshadweep (Vijay Anand and Pillai, 2002) and 65 species have been recorded from the seagrass bed of the same atoll (Vijay Anand and Pillai, 2007). In the present study, only 25 species were found to occur as the reefs in Cuddalore are reported to be only patchy in nature (Reef Base, 2000). Family Lutjanidae and Mullidae were represented by 4 and 3 species respectively. Families Haemulidae, Chaetodontidae, Labridae and Ephippidae were represented by 2 species each. Carangidae, Scorpaenidae, Zanclidae, Diploprionidae, Serranidae, Siganidae, Scatophagidae, Pomacentridae,

Table 1. List of fishes having ornamental value collected from Cuddalore waters

Species	Mon[1]	Post[2]	Sum[3]	Pre[4]
Serranidae				
Epinephelus caeruleopunctatus	12	0	28	58
Diploprionidae				
Diploprion bifasciatum	0	25	0	77
Carangidae				
Carangoides equula	43	110	84	222
Mullidae				
Parupeneus indicus	13	31	23	26
Upeneus tragula	124	214	184	378
U. vittatus	123	578	467	785
Lutjanidae				
Lutjanus fulviflammus	97	312	217	352
L. lunulatus	23	53	41	74
L. kasmira	14	47	33	77
L. fulvus	16	53	47	84
Haemulidae				
Plectorhinchus orientalis	11	28	25	73
Pomadasys kaakan	12	70	64	75
Teraponidae				
Terapon jarbua	12	54	34	85
Ephippidae				
Platex teira	0	24	22	66
P. pinnatus	0	0	0	43
Scatophagidae				
Scatophagus argus	23	62	45	89
Chaetodontidae				
Heniochus acuminatus	0	24	0	44
Chaetodon vagabundus	0	55	27	75
Pomacanthidae				
Pomacanthus semicirculatus	0	0	0	1
Pomacentridae				
Abudefduf sexfasciatus	0	46	21	72
Labridae				
Xyrichthys bimaculatus	16	41	28	91
Hologymnosus doliatus	0	3	0	53
Zanclidae				
Zanclus cornutus	0	28	0	75
Siganidae				
Siganus javus	20	48	38	84
Scorpaenidae				
Pterois volitans	0	43	26	68

([1]-Monsoon:[2]-Post-monsoon:[3]-Summer:[4]Pre-monsoon)

Teraponidae and Pomancanthidae were represented by one species each. Among the major 10 families of coral reef fishes (Pomacentridae, Labridae, Chaetodontidae, Apogonidae, Serranidae, Scaridae, Acanthuridae, Blennidae and Gobiidae) mentioned by Allen and Steene (1994), four families (Pomacentridae, Chaetodontidae, Pomacanthidae and Serranidae) were represented in Cuddalore waters. In the reef slope of the Kavarathi atoll, Lakshadweep, Labridae, Chaetodontidae, Balistidae, Pomacentridae and Acanthuridae were found to be the most speciose families (Vijay Anand and Pillai, 2002). In the seagrass beds of the above island, Labridae, Chaetontontidae, Acanthuridae and Mullidae were found to be the most speciose families (Vijay Anand and Pillai, 2007). However, in the present study only Lutjanidae was represented by 4 species. All the other families were represented by 1 or 2 species only.

Among the 25 species recorded in the present study, *Upeneus vittatus* was the dominant species comprising 27.5%. The second dominant species was *Lutjanus fulviflammus* with a percentage contribution of 13.8 followed by *U. tragula,* which constituted 12.7%.

The number of species collected during different seasons varied from 15 during monsoon to 25 during pre-monsoon. The order of species richness was: pre-monsoon > post-monsoon > summer > monsoon. In line with the above trend, the number of fishes collected during different seasons varied from 559 during monsoon to 3127 during pre-monsoon (Table 2). This variation may be due to less fishing activity during the monsoon season. The order of abundance was same as that of species richness.

19 species. The Pielou's evenness (J') index which varies from 0 to 1 (Clarke and Warwick, 2001) was also observed to be on the higher side (0.8-0.84). The highest value was recorded during pre-monsoon season and the lowest during summer. All the above diversity indices varied narrowly.

The relatively higher values during the dry seasons (post-monsoon, summer and pre-monsoon) in Shannon, Margalef and Simpson indices, and comparatively lower values during the monsoon season could be attributed to the rainfall and the consequent sediment discharge. The inclement weather and cyclonic conditions prevented fishermen from venturing into the sea. The low values recorded during monsoon season may be attributed to less fishing activity resulting in collection of less number of coral fishes during this season.

The species diversity recorded in the reef slope of Kavaratti atoll was in the range of 3.32- 4.45 and in the seagrass bed of the above island was in the range of 2.49-3.14 (Vijay Anand and Pillai, 2002; 2007). The high diversity in the reef slope was attributed to availability of food resources. In the present study also, higher diversity was observed even though the number of species recorded was less which contributed to the higher evenness values (0.8-0.84) (Clarke, 1999).

The newly introduced diversity indices were used in the present study and the results are given in Table 2. In the present study, it could differentiate well the pre-monsoon (83.7) and post-monsoon (79.5) seasons from the monsoon season (76.0). However, the difference between monsoon (76.0) which had 15 species and summer (76.8) with 19 species was found to be very narrow. The variation in taxonomic distinctness index which stands for the variability and total phylogenetic diversity index which stands for the taxonomic breadth clearly differentiated the dry seasons from the monsoon season. In conformity with the fact that samples from biodiversity rich areas have more stability and less variation than others (Clarke and Warwick, 2001), the variation in taxonomic distinctness index was comparatively low during the dry seasons (post-monsoon-151.2; summer-190.4; pre-monsoon-131.6) compared to the monsoon season (298.9). The total phylogenetic diversity index also clearly differentiated the dry seasons (post-monsoon-1800; summer-1566.7; pre-monsoon-2033.3) from the monsoon season (1166. 7).

Table 2. Diversity of fishes having ornamental value collected from Cuddalore waters

Season	S	N	d	J'	H'(log2)	1-Lambda'	Delta	Delta+	Lambda+	sPhi+
Monsoon	15	559	2.213	0.833	3.257	0.858	76.042	94.603	298.916	1166.667
Post-monsoon	22	1949	2.772	0.802	3.578	0.862	79.462	97.258	151.213	1800
Summer	19	1454	2.471	0.801	3.402	0.846	76.784	96.686	190.448	1566.667
Pre-monsoon	25	3127	2.982	0.843	3.912	0.894	83.688	97.666	131.592	2033.333

The Shannon-Wiener diversity H' ($\log_2$) is very widely used for comparing diversity between various habitats (Clarke and Warwick, 2001), so also seasons. This was in the range of 3.3 - 3.9 with the maximum in pre-monsoon and the minimum in monsoon (Table 2). Shannon value of 3 is observed only in healthy and biodiversity rich areas (Clarke and Warwick, 2001). The higher Shannon index values observed during all the four seasons clearly showed the diverse nature of coral fishes in Cuddalore waters. The Margalef (d) species richness index which has the discriminating ability also showed higher values for all the four seasons (2.2-3.0). The Simpson species richness index for the monsoon season with 15 species (0.9) was found to be more than that during summer season (0.8) with 19 species.

In the dominance plot, the curve for the pre-monsoon was found to lie at the bottom vouching for the higher diversity (25 species) followed by post-monsoon (22 species) and summer (19 species). As lower diversity (15 species) was found during the monsoon season, the curve for this season was found at the top (Fig.1).

The pre-monsoon which showed the maximum diversity (Table 2) also had higher level of similarity (Table 3) when compared with post-monsoon (83.6) and summer (78.8%) and low similarity with monsoon (46.7%).

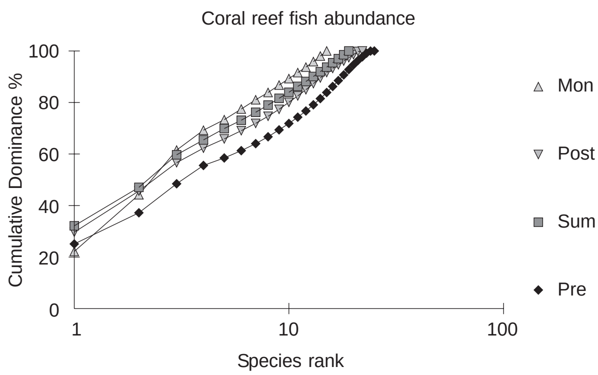

Fig. 1. Dominance plot for coral reef fishes recorded during various seasons in Cuddalore waters

Table 3. Similarity percentage of coral reef fishes collected from Cuddalore waters

Seasons	Monsoon	Post-monsoon	Summmer	Pre-monsoon
Monsoon				
Post-monsoon	60.141			
Summer	72.195	86.251		
Pre-monsoon	46.680	83.636	78.823	

The low similarity between pre-monsoon and monsoon seasons was due to the absence of *Pterois volitans, Heniochus acuminatus, Chaetodon vagabundus, Zanclus cornutus, Diploprion bifasciatum, Hologymnosus doliatus, Platex teira, P. pinnatus, Abudefduf sexfasciatus* and *Pomacanthus semicirculatus* during the monsoon season and variations in the abundance of other species between the two seasons.

In the dendrogram (Fig. 2), summer and post-monsoon formed a group at 87% similarity to which pre-monsoon season joined at 78%. The monsoon was linked to the above at 61% similarity. As this dendrogram showed monsoon next to pre-monsoon, MDS was done. In MDS (non-Multidimensional Scaling) plot, while post-monsoon, summer and pre-monsoon samples fell on the left side of the map, the monsoon due to its less similarity (more dissimilarity) with the other seasons in species composition fell on the right side. The stress value which was overlying

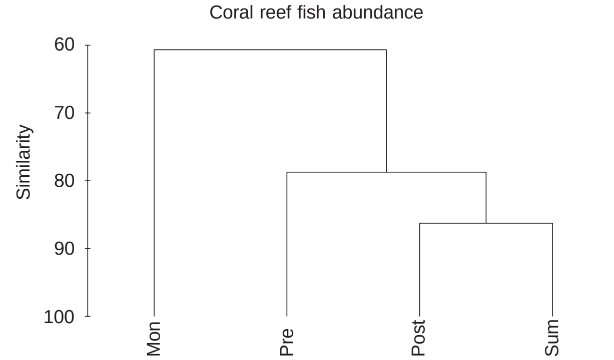

Fig. 2. Dendrogram showing similarity in species composition of fishes having ornamental value during various seasons in Cuddalore waters

on the MDS plot (0.0) showed an excellent ordination of the samples (Clarke and Warwick, 2001) collected during the various seasons (Fig. 3). The purpose of using this is to represent the samples collected as points in a map (low-dimensional space usually 2-d). Samples lying closer have more similarity in species composition and abundance.

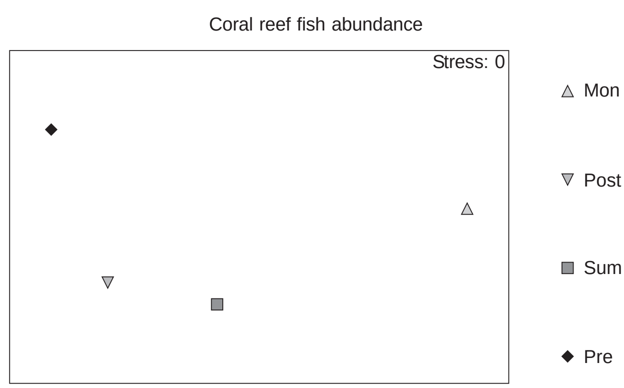

Fig. 3. MDS plot for coral reef fishes recorded during various seasons in Cuddalore waters

Variability is more among the less diverse areas and less among the highly diverse areas. Variability can be compared through tests for taxonomic relatedness (Clarke and Warwick, 1999), which is helpful in checking the null hypothesis that a species list from one locality or time has the same taxonomic distinctness structure as the master list (of all species in that biogeographic region - Cuddalore waters). In the present study, the 95% funnel drawn for the variation in taxonomic distinctness (lambda plus) not only separated the seasons based on number of species collected, but also showed significant deviation during the monsoon season from the normal distribution (Fig. 4). Tests combining average taxonomic distinctness (delta plus) and variation in taxonomic distinctness involves plotting of the combination of these values by drawing the 95% probability contours (ellipse) which are advantageous in testing under

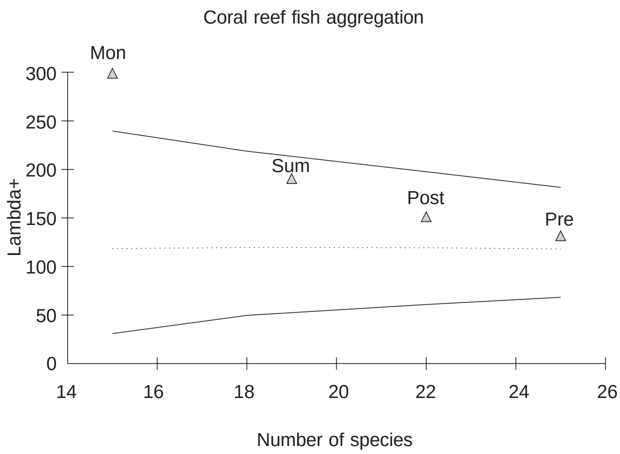

Fig. 4. 95% confidence funnel showing the deviation of lambda values of coral reef fishes recorded during monsoon season in Cuddalore waters

the usual null hypothesis of random sampling from the master species list and superimposing the real values (Clarke and Warwick, 1999). The ellipse plot also clearly showed the deviation in diversity during the monsoon season as it fell outside the 95% contour (Fig.5).

The present study clearly showed the advantage of using the newly introduced diversity indices as taxonomic diversity index, taxonomic distinctness index, variation in taxonomic distinctness index and phylogenetic diversity index in biodiversity studies (Clarke and Warwick, 1998) than the conventionally used diversity indices. As the new indices have not been used in India with respect to coral reef fishes, such results could not be compared and discussed with the results of the present study.

As all reef fishes cannot be collected by trawl nets, further detailed studies on reef fishes occurring in the Cuddalore waters have to be undertaken involving visual census method as done elsewhere (Vijay Anand and Pillai, 2002; 2007). Until that study is done, the results of the present study can be used as benchmark data in environmental impact assessment as Cuddalore is experiencing flurry of industrial activities with scope for further expansion in industrialization.

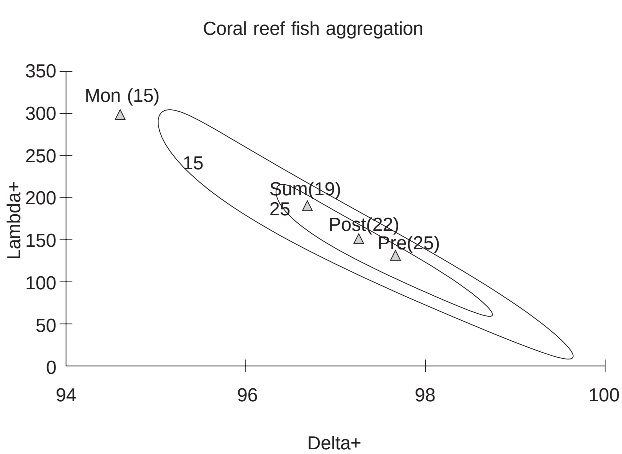

Fig. 5. The ellipse plot for combined distribution of lambda and delta values of coral reef fishes showing the deviation of monsoon season in Cuddalore waters

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