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ICHTHYOFAUNA OF THE INTERTIDAL REEF FLATS OF MINICOY ATOLL, LAKSHADWEEP : AN ANALYSIS OF ITS STRUCTURE, RELATIVE ABUNDANCE AND FOOD*

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Abstract

Long term observations, based on day samplings and analysis at Minicoy atoll in Lakshadweep have yielded substantial information on the structure, composition, relative numerical and biomass abundance as well as food of the ichthyofauna inhabiting the windward and leeward sides of the atoll. The leeward reef flat has a greater fish biomass compared to the windward reef lat, the average total weight per one hour sampling with a cast net being 3839.4 gm and 1179.4 gm respectively. The difference in the surface morphology between the windward and leeward sides is found to influence the fish biomass. The leeward side at Minicoy is strewn with loose boulders with profuse algal growth and associated invertebrates, while the windward reef flat is mostly flat and cemented and there are very few loose coral boulders. The loose boulders harbour ample plant and animal food to the fishes as well as dwelling crevices on the leeward side. The extensive sea grass beds along the lagoon shore may also serve as excellent forage ground for lagoon fishes and lagoon reef fishes in the leeward side.

Out of the 21 families and 190 species of resident and migratory fishes hitherto recorded from the reefs of Minicoy, 60 species belonging to 17 families are commonly found in the present samples. Very little qualitative difference in the faunal compoition was observed between the windward and leeward sides. The percentage of incidence of different species in the samples varied from 6 to 100%. Bulk of the species occurring belong to families Acanthuridae, Holocentridae, Pomacentridae, Serranidae, Chaetodontidae, Kuhlidae, Labridae and Callyodontidae. *Acanthurus triostegus triostegus*. is the richest forming 49% of the total catch. Others in the order of abundance of biomass include *Epinephelus hexagonatus* (9.6%), *Holocentrus lacteoguttatus* (8.7%), *Abudefduf glaucus* (5.1%), *Epinephelus caeruleopunctatus* (4.1%), *Acanthurus lineatus* (3.6%), *Epinephelus merra* (2.9%), *Abudefduf cingulum* (2.2%), *A. septemfasciatus* (1.8%), *A. zonatus* (1.1%), *A. sordidus* (1.0%) and the rest minor components.

About 60% of the reef flat fishes are carnivorous feeding on benthic invertebrates associated with dead and live coral boulders which include alphids, young crabs, ascidians, bryozoans and gammarid amphipods ; 30% omnivorous and the rest 10% herbivorous. Strictly plankto-phagous forms are not found — a conspicuous contrast to lagoon fishes.

The present study also indicates a more or less stable state in the ichthyofaunal assemblage of Minicoy reef flats as judged from the earlier literature and present samplings. In general when large areas are sampled over a long span of time, stability is the norm. But sampling at short intervals on a restricted area displays diversity due to migration or recruitment in reef fish fauna.

Introduction

The Intertidal reef flat which consists of a homogeneous area of coral rubble covered

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with encrusting algae which gets periodically exposed during the tidal cycle offers a peculiar type of ecosystem for a variety of resident reef fishes consisting mainly of browsers and crevice dwellers. The ecological aspects and biology of reef fishes have received a lot of attention from workers all over the world in the last three decades and the comparatively recent works and reviews are presented by Talbot and Goldman (1972). Viven (1973, 1977), Ehrlich (1975), Goldman and Talbot (1976), Sale (1978, 1979, 1980), Sale *et al.* (1980), Bohnsack (1983) and Sale *et al.* (1984). These works have thrown much light on the community structure, reproductive biology, patterns of recruitment, mechanisms of co-existence and trophic relationships of the reef fish communities. The fisheries potential of coral reefs was investigated by various authors (Stevenson and Marshall, 1974 ; Munro, 1983). Since the coral reefs function as recycling, closed ecological systems it is controversial whether the reef fishery resources could be sustained under substantial harvesting pressure. A knowledge of the abundance and species diversity of reef fishery resources, their trophic relationships, harvest statistics and population estimates are essential prerequisites for the proper management of reef fishery resources.

The lagoons and adjacent reef areas of Lakshadweep group of islands lying between 08°00′ and 12°30′N and 71°00′ and 74°00′E offer a rich and varied coral reef ichthyofauna. Balan (1958) made a qualitative study of the fish fauna of Agatti, Kavaratti, Amini and Kadmat and recorded 80 species of fishes belonging to 65 genera from these islands. During sixties and seventies Dr. S. Jones and his co-worker M. Kumaran in a series of papers elucidated the coral reef fish fauna of Lakshadweep which culminated in the publication of their book in 1980 entitled '*Fishes of Laccadive Archipelago.*' Later studies on coral reef fishes from Lakshadweep were by Pillai *et al.* (1984 b, 1985). Madan Mohan *et al.* (1986), Kumaran and Gopakumar (1986) and Gopakumar *et al.* (1988). However, comprehensive studies on the icthyofauna in relation to the various habitats of the coral reefs in Lakshadweep is still lacking. The present study was undertaken with a view to analysing the structure and composition of the fish fauna inhabiting the intertidal reef flats of Minicoy Atoll.

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Material and Methods

The samples were collected at low tides during day time. A small cast net with a mesh size of 20 mm was used to cover the loose boulders and the fishes hiding beneath were collected by tilting the boulders and driving them into the net. The operations were carried out for one hour by quickly moving from one boulder to another along the length and width of the reef flat. However the number of castings of the net varied in each sampling and many were abortive having no fish under the boulders. The entire accessible intertidal, windward and leeward reef flat was covered during the many samplings carried out. A total of 9 sampling (9 hours) was done during December 82 to March 1983 on the windward side and 7 (7 hrs) on the leeward side. Total weight of the fishes, species composition, species wise weight of fishes and number were recorded during each sampling. The gut was analysed to determine the food habit. The eels, though form a common inhabitant of the reef flat, were not represented in the collections and as such they are not considered in this work.

Results

The biomass of fishes from the leeward and windward sides of Minicoy atoll during each sampling was as follows :

No. of sampling		Leeward (gm)	Windward (gm)
1	..	3161.0	2440.0
2	..	7494.5	1439.5
3	..	4841.5	1002.5
4	..	1509.0	1355.0
5	..	4252.0	914.0
6	..	2999.0	714.5
7	..	2619.0	1210.5
8	..	—	457.0
9	..	—	1082.0
Total	..	26876.0	10615.0
Average	..	3839.4	1179.4

The leeward reef flat was found to have a greater fish biomass than the windward reef flat. The average total weight of a sample was 3,839.4 gm for the leeward reef flat and 1,179.4 gm for the windward reef flat.

Majority of the fishes on the reef flats were quite small. The weight range of individual species was from 2.7 gm to 136.6 gm. Weight frequency of reef flat fishes expressed as percentage of total number and total weight are given in Fig. 1 a and 1 b respectively. It is seen that fish in the weight range 30-39 gm followed by those in 0-9 gm constituted 42.2% and 30.1% respectively in the percentage of total number of fish caught. Fish in the weight range 30-39 gm followed by those in 10-19 gm constituted 54.9% and 12.4% respectively in the percentage of total weight of fish caught.

Species diversity : The ichthyofauna of the reef flats were characterised by their richness of species. Out of 21 families and 190 species of resident and migratory fishes recorded from the different reef habitats at Minicoy (Jones and Kumaran, 1980), 60 species belonging to 17 families were obtained in the present study from the reef flats. The specieswise percentage in the total number of fish collected, their percentage in the total weight and percentage of incidence in the samples is given in Table 1. The number of species contributing to each family and the percentage of biomass contribution of different families were as follows :

Family		No. of species	% of biomass contribution
Acanthuridae	..	6	54.7
Serranidae	..	5	17.0
Holocentridae	..	1	8.7
Pomacentridae	..	10	12.4
Labridae	..	14	3.5
Chaetodontidae	..	4	1.1
Kuhlidae	..	1	0.2
Callyodontidae	..	2	0.6
Blennidae	..	5	0.6
Cirrhitidae	..	1	0.1
Mullidae	..	3	0.3
Apogonidae	..	1	0.1
Lutjanidae	..	2	0.2
Plesiopidae	..	1	0.1
Synodontidae	..	1	0.1
Lethrinidae	..	1	0.1
Balistidae	..	2	0.2

It is seen that the maximum species diversity is exhibited by Labridae followed by Pomacentridae Acanthuridae, Serranidae and Blennidae. The maximum biomass contribution was by Acanthuridae followed by Serranidae, Pomacentridae, Holocentridae, Labridae and Chaetodontidae.

The percentage of species in the total number of fishes collected ranged from 0.1 to 37.8%. The most abundant species in the total number was *Acanthurus triostegus triostegus* (37.8%) followed by *Abudefduf glaucus* (16.3%), *Holocentrus lacteoguttatus* (12.8%), *Abudefduf cingu-*

lum (5.7%), *Acanthurus lineatus* (2.9%), *Epinephelus hexagonatus* (2.8%), *E. caeruleopunctatus* (2.2%), *Abudefduf zonatus* (2.2%), *A. xanthozonus* (1.9%), *A. septemfasciatus* (1.3%), and *Epinephelus melanostigma* (1.1%). The percentage of species in the total weight of fishes collected ranged from 0.1 to 49.0%. The dominant species by weight of the total fish caught were *Acanthurus triostegus triostegus* (49.0%), *Epinephelus hexagonatus* (9.6%), *Holocentrus lacteoguttatus* (8.7%), *Abudefduf glaucus* (5.1%), (*Epinephelus caeruleopunctatus* (4.1%), *Acanthurus lineatus* (3.6%), *Epinephelus merra* (2.9%), *Abudefduf cingulum* (2.2%), *A. septemfascilatus* (1.8%), *A. zonatus* (1.1%) and *A. sordidus* (1.0%). The percentage of incidence of the various species in the samples ranged from 6.2 to 100%. The dominant species in terms of percentage of incidence were *Acanthurus triostegus triostegus* (100%), *Holocentrus lacteoguttatus* (81.2%), *Abudefduf glaucus* (81.2%), *Acanthurus lineatus* (62.5%) and *Abudefduf cingulum* (68.7%).

Food and feeding habits : Out of 34 species analysed for food and feeding habits, 20 species were carnivores, 10 omnivores and 4 herbivores (Fig. 1 c). The results of food analyses of the fishes are given in Table 2. The bulk of the species in the reef flats were carnivores belonging to families Serranidae, Holocentridae, Lutjanidae, Labridae, Kuhlidae, Mullidae and Apogonidae. The most common food items of them were benthic invertebrates associated with dead and live coral boulders which include alphids, young crabs, ascidians and gammarid amphipods. The omnivores belong to families pomacentridae and chaetodontidae. The herbivores were represented by members of Acanthuridae which fed mainly on filamentous

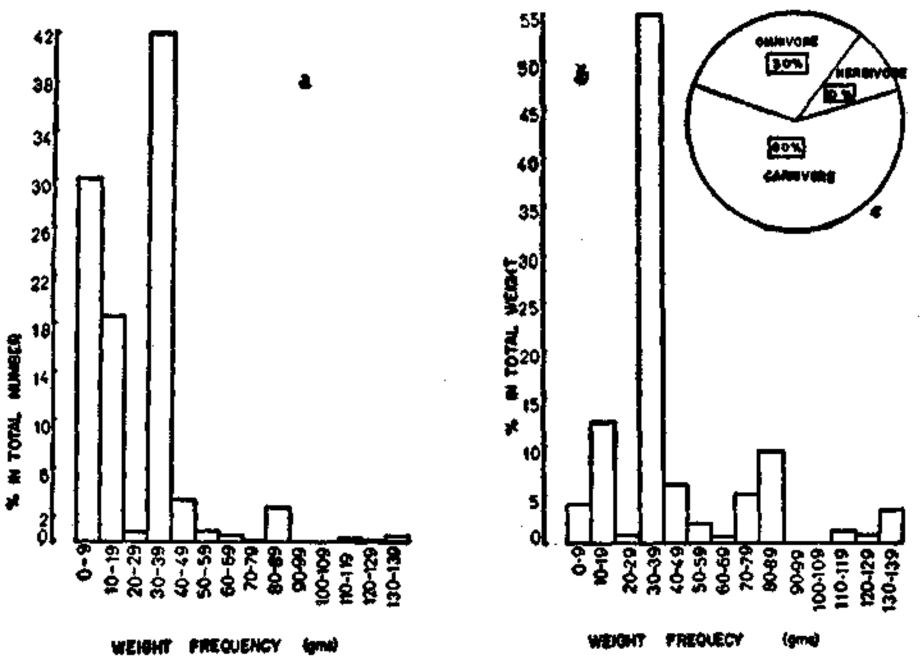

Fig. 1. Weight frequency of reef flat fishes from Minicoy expressed as percentage of: a. total number and b. total weight and c. percentage composition of the different feeding types of reef flat fishes from Minicoy.

TABLE 1. *Specieswise percentage in the total number, percentage in the total weight and percentage of incidence of reef flat fishes of Minicoy*

Family/Species	% in total number	% in total weight	% of incidence
(1)	(2)	(3)	(4)
ACANTHURIDAE			
Acanthurus triostegus triostegus	37.8	49.0	100.0
A. lineatus	2.9	3.6	62.5
A. leucosternon	0.6	0.4	19.0
Ctenochaetus strigosus	0.2	0.4	6.2
Naso lituratus	0.1	0.7	6.2
N. unicornis	0.1	0.6	6.2
SERRANIDAE			
Epinephelus hexagonatus	2.8	9.6	37.5
E. merra	0.5	2.9	37.7
E. caeruleopunctatus	2.2	4.1	43.7
E. melanostigma	1.1	0.3	6.2
Cephalopholis argus	0.2	0.1	18.7
HOLOCENTRIDAE			
Holocentrus lacteoguttatus	12.8	8.7	81.2
POMACENTRIDAE			
Abudefduf glaucus	16.3	5.1	81.2
A. cingulum	5.7	2.2	68.7
A. zonatus	2.2	1.1	31.2
A. xanthozonus	1.9	0.3	31.2
A. septemfasciatus	1.3	1.8	37.5
A. bengalensis	0.8	0.6	31.2
A. biocellatus	0.5	0.1	25.0
A. sordidus	0.4	1.0	31.2
A. sexatilis	0.2	0.1	6.2
A. sexfasciatus	0.2	0.1	12.5
CHAETODONTIDAE			
Chaetodon auriga	0.3	0.7	25.0
C. lunula	0.1	0.1	12.5
C. citrinellus	0.1	0.1	6.2
C. collaris	0.3	0.2	6.2
LABRIDAE			
Thalassoma purpurea	0.2	0.5	6.2
T. janseni	0.5	0.1	25.0
T. hardwicki	0.1	0.2	12.5
T. umbrostigma	0.3	0.4	25.0
T. quinquevittata	0.1	0.1	6.2
Halichoeres centriquadrus	0.1	0.2	12.5
H. kawarin	0.1	0.1	6.2
H. marginatus	0.1	0.1	6.2
H. scapularis	0.1	0.1	6.2
H. notopsis	0.1	0.1	6.2
Cheilinus diagramma	0.1	0.6	12.5
C. trilobatus	0.4	0.6	18.7
Stethojulis axillaris	0.7	0.3	25.0
S. phekadopleura	0.3	0.1	12.5
KUHLIDAE			
Kuhlia taeniura	0.4	0.2	6.2
CALLYODONTIDAE			
Callyodon sexvittatus	2.7	0.5	18.7
C. bataviensis	0.1	0.1	6.2
BLENNIDAE			
Istiblennius edentulus	0.2	0.2	25.0
I. periophthalmus	0.1	0.1	6.2
I. lineatus	0.1	0.1	6.2
Entomacrodus vermiculatus	0.1	0.1	12.5
Omobranchus elongatus	0.1	0.1	6.2
CIRRHITIDAE			
Cirrhitus pinnulatus	0.2	0.1	6.2
MULLIDAE			
Parupeneus bifasciatus	0.2	0.1	18.7
P. barberinus	0.1	0.1	6.2
P. macronema	0.1	0.1	6.2
APOGONIDAE			
Ostorhynchus novemfasciatus	0.1	0.1	6.2
LUTJANIDAE			
Lutjanus fulviflamma	0.1	0.1	6.2
L. russelli	0.1	0.1	6.2
PLESIOPIDAE			
Plesiops cueruleolineatus	0.1	0.1	6.2
SYNODONTIDAE			
Synodon variegatus	0.1	0.1	6.2
LETHRINIDAE			
Lethrinella miniatus	0.1	0.1	6.2
BALISTIDAE			
Rhinecanthus aculeatus	0.1	0.1	6.2
Balistopus undulatus	0.1	0.1	6.2

and coralline algae. Strictly Planktophagus forms were not found.

Discussion

It is well understood that coral reef fishes have specialisations of form colour or behaviour that suit them for a particular way of life within that biotope and as a result of these specialisations they have precise habitat requirements. Such specialisations are interpreted as resource sharing mechanisms that allow many species to live together without direct competition for limited resources (Smith, 1977). The temperature variation of the habitat, the nature of wave action, the physical nature of the habitat which provide shelter to the fishes, their food requirements, etc. directly influence the resident ichthyofauna of a specific reef habitat (Talbot and Goldman, 1972). The leeward reef flat of Minicoy consists of three microhabitats *viz.* the outer reef flat exposed to waves and currents and colonised by scleractinian corals and encrusting calcareous algae and characterised by numerous crevices the boulder zone characterised by dead coral boulders which get completely exposed during spring low tides and the inner sheltered reef flat. The windward reef flat at Minicoy consists of only the outer reef flat habitat. The difference in the habitats offered by the windward and leeward flats was found to influence the fish biomass. The boulder zone of the leeward reef flat is strewn with loose boulders with profuse algal growth and associated invertebrates while the windward reef is mostly flat and cemented and there are very few coral boulders. (Pillai *et al.*, 1984 a). The loose boulders provide ample plant and animal food to the fishes as well as dwelling crevices on the leeward side. The extensive sea grass beds along the lagoon shore may also serve as excellent forage ground for lagoon fishes and lagoon reef fishes in the leeward side.

In general reef fish communities are more diverse when compared to those in other habitats. The richness of species in the reef habitat is exemplified by the total of 60 species collected from the habitat. Even though 10% of them could be considered as 'reef cosmopolitan' rest of them appear to be specific to the reef flats.

The small size of the fishes noted is one of the significant aspects of the habitat. About 80% of the fishes collected during the study were below 50 gm. The size of the fish is related to space utilisation. The three major aspects of space utilization are hunting and feeding grounds, shelter and reproductive activities. Almost all the activities of a fish such as how much food it requires, the size of the prey it consumes, the shelter it needs and the number of eggs it can produce, are determined by the size of the individuals present and reveal the integrated nature of the fish community (Smith, 1977).

The food supplies of a reef habitat also play a key role in delimiting species of fishes. Majority of the species were found to be carnivorous, but exhibit lot of overlap in the food items consumed. The absence of strictly planktophagus forms is a striking contrast to most of the lagoon fishes which are essentially plankton feeders. However Smith (1977) observed that space rather than food is the major limiting factor.

Sale (1980) stated that a region of more or less homogeneous habitat on a reef will contain an assemblage of fishes which will be drawn from a pool of species capable of occupying that habitat. In the present study except for a few species *viz. Acanthurus triostegus triostegus, Holocentrus lacteoguttatus, Acanthurus lineatus* and *Abudefduf cingulum*, none of the species can be considered as abundant in the reef flats as judged by their percentage contribution to the total weight, total number and percentage of incidence in the

TABLE 2. *Food and feeding habits of reef flat fishes of Minicoy*

Species		Major food items	Feeding habit
Acanthurus triostegus triostegus	..	filamentous and coralline algae.	Herbivore
A. lineatus	..	filamentous and coralline algae.	Herbivore
A. leucosternon	..	filamentous and coralline algae.	Herbivore
Ctenochaetus strigosus	..	filamentous and coralline algae.	Herbivore
Epinephelus hexagonatus	..	crabs, alphids, fishes.	Carnivore
E. merra	..	crabs, octopus, coral pieces.	Carnivore
E. caeruleopunctatus	..	crabs, fishes.	Carnivore
Cephalopholis argus	..	shrimps, crabs.	Carnivore
Holocentrus lacteoguttatus	..	crabs, prawns alphids.	Carnivore
Lutjanus fulviflamma	..	crabs, decapods, fishes.	Carnivore
L.russelli	..	crabs, fishes.	Carnivore
Thalassoma janseni	..	fish larvae, mysids, crabs.	Carnivore
T. hardwicki	..	crabs, bivalves.	Carnivore
T. umbrostigma	..	crabs, alphids.	Carnivore
T. purpurea	..	crabs, fish larvae.	Carnivore
T. quinquevittata	..	crabs, alphids.	Carnivore
Halichoeres centriquadrus	..	crabs, alphids.	Carnivore
H. scapularis	..	fishes, crabs, alphids.	Carnivore
H. kawarin	..	crabs, alphids.	Carnivore
Cheilinus diagramma	..	crabs, fishes.	Carnivore
C. trilobatus	..	crabs, alphids.	Carnivore
Kuhlia taeniura	..	alphids, crabs, fishes.	Carnivore
Parupeneus bifasciatus	..	prawns, crabs, amphipods.	Carnivore
Ostorhynchus novemfasciatus	..	copepods, amphipods, crabs.	Carnivore
Abudefduf glaucus	..	filamentous and coralline algae, copepods.	Omnivore
A. cingulum	..	filamentous and coralline algae, copepods, fish larvae, ascidians, foraminifera, hydroids.	Omnivore
A. zonatus	..	filamentous and coralline algae, crabs, copepods, amphipods.	Omnivore
A. septemfasciatus	..	filamentous and coralline algae, foraminifera, gastropods, ascidians, amphipods.	Omnivore
A. sordidus	..	filamentous and coralline algae, formainifera, gastropods, copepods, amphipods.	Omnivore
A. sexatilis	..	coralline algae, fish and crustacean larvae, ascidians, copepods, mysids, amphipods, foraminifera.	Omnivore
A. sexfasciatus	..	filamentous and coralline algae, copepods, amphipods.	Omnivore
Chaetodon auriga	..	filamentous algae, copepods, sea anemone, sand particles.	Omnivore
C. lunula	..	filamentous algae, anthozoans, polychaetes, sponges.	Omnivore
Istioblennis edentulus	..	filamentous and coralline algae, crabs, foraminifera, calcareous particles.	Omnivore

samples. Whether the community structure and relative abundance is stable or not is an aspect of controversy. Sale (1978) stated that similar species use same kinds of spaces and priority of recruitment appears to determine which species holds each site. Due to the patchy supply of living space, most reef fishes are sedentary as adults and produce frequent clutches of pelagic larvae over extended breeding seasons which enhances their chances of settling to suitable sites. Based on this strategy, Sale (1978) opined that reef fishes are preadapted for forming interspecific lotteries for living space if several species with similar requirements occur together. Studies by Russell *et al.* (1974, 1977), Kami and Ikehara (1976), Luckhurst and Luckhurst (1977), Talbot *et al.* (1978), Molles (1978), Sale *et al.* (1980), Donerty (1980), Williams and Sale (1981) and Sale (1984) showed that variability appeared to be a general phenomenon of fish recruitment on coral reefs everywhere. Sale *et al.* (1984) identified five possible causes of variation in recruitment: (*i*) the variable production of larvae (*ii*) the variability in the survivorship during larval life (*iii*) variability in the mortality following settlement (*iv*) the variable patterns in the force and direction of water currents and (*v*) the variability in the precise microhabitat requirements of different species. As summarised by Sale (1980) over a long term, the mixture of species successfully recruiting to a site should play a major role in determining the composition and relative abundance of the species present as residents although differential rates of mortality among resident species would mean that relative abundances among them would not be identical to those in the pool of arriving recruits. Chance colonisation as well as resource sharing mechanisms play significant roles in determining the community structure.

There exists two different theories of a reef fish community structure — the order hypothesis which emphasises stability constancy and similarity in community structure and the chaos hypothesis which emphasises variability differences and chance factors. Bohnsack (1983) stated that the key to the difference between these two schools lies in understanding species turn over which is the process of species extinction and recolonisation by the same or other species. He emphasised the importance of long term studies with short sampling intervals and reported that reef fish communities appeared to be maintained in dynamic equilibrium between immigration and extinction.

Jones and Kumaran (1980) reported 424 species of fishes from Minicoy alone, based on collection made during early sixties. The specific habitats of them are not mentioned. From the experience of the authors the probable reef flat fishes were separately listed from the above compilation and it is seen that there is no major change in the faunal elements. A sort of stability on the reef flat fish fauna is evident at Minicoy during the last two to two and a half decades. However, as pointed by Bohnsack (1983) the problem of order and chaos in the reef fish assemblage needs a compromise view. Our results indicate that when large areas are sampled over a long span of time stability is the norm, particularly when there is no catastrophic evnironmental change. For restricted habitats over short interval of time variation may be manifested.

The fisheries potential of reef flats is another aspect worth mentioning. Many reef flat fishes are valued as food fishes which are not exploited from Minicoy at present. It is felt that hook and line fishery, trap fishing and cast netting could be developed as a sustenance fishery in the island. However, large scale development of the reef fishery resources is restricted by the diversity of the species, the relative abundance of small fishes and the restrictions imposed on gear by the environment. Apart from food fishes, species belonging to several families such as Labridae, Acanthuridae and Pomacentridae are valued as ornamental fishes. Judicious exploitation of these fishes from the reef flats also deserve attention from fisheries developmental agencies in the island.

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