Mussel reefs in sub-littoral zone-An important habitat for infaunal and ichthyofaunal diversity

Viswambharan D.[1]*; Sasikumar G.[2]; Rohit P.[3]

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Abstract

A Sub-littoral mussel reefs harbours rich and diverse invertebrate communities. They utilize the reef complex as their habitat, rich feeding substrate and also as refuge from predation. Though the invertebrate diversity of the reefs is available, reports pertaining to their relation to dietary habit of reef fishes are lacking. A study was taken up at the sub-littoral mussel reefs occurring off Someshwara Coast (12^0 47' 19" N 74^0 51' 05"E) in Karnataka (eastern Arabian Sea) to ascertain the diversity reef as well as the fish fauna of the region. The invertebrate community of the reef was collected by quadrant sampling method. The details on fish fauna of the reefs were collected by visual census and also by using semi-structured interviews with local fishers. Detailed study was carried out to find the dietary relationship of the ichthyofauna with the diverse organism associated with the sub littoral mussel beds. Apart from barnacles and mussels, the invertebrate community was dominated by polychaetes followed by amphipods and crablets. The major ichthyofaunal diversity includes fishes of the family Leiognathidae, Lutjanidae, Siganidae, Sciaenidae, Epinephelidae, Carangidae, Ariidae, Haemulidae, Cynoglossidae, and others. The information pertaining to the dietary habits of the fish assemblages were compared with the in-faunal and ichthyofaunal diversity of the reefs to bring out the importance of mussel bed habitat.

Keywords: Mussel bed, Invertebrate diversity, Dietary habits, Ichthyofaunal diversity.

1- Marine Biodiversity Division, Mangalore Research Centre of ICAR-CMFRI, PB No: 244, Hoige Bazar, Mangalore 575 001

2- Molluscan Fisheries Division, Mangalore Research Centre of ICAR-CMFRI, PB No: 244, Hoige Bazar, Mangalore 575 001

3- Pelagic Fisheries Division, Mangalore Research Centre of ICAR-CMFRI, PB No: 244, Hoige Bazar, Mangalore 575 001

Corresponding author's Email: divyaarinu@gmail.com

Introduction

Mussels are widely distributed in the rocky coast of tropical and temperate waters. They are attached to the hard substratum with their byssus threads, forming extensive mats on the intertidal and subtidal zones (Lee, 1985). Such microhabitats are considered as one of the world's most diverse ecosystems (Suchanek 1992). Since they are rich in organic matter derived from attached algae as well as detritus trapped by the byssus, it forms an important feeding, breeding and efficient anti-predatory structure for a wide variety of invertebrate as well as vertebrate taxa (Hooper *et al*., 2005; Suchanek, 1979). The higher structural complexity of mussel bed reduces the food capturing efficiency of predators (Scharf *et al*., 2006). This complex structure also act as a trap for many zoobenthos as these refugees become prey for potential predators due to saturation of prey in the available shelter (Czarnecka *et al*., 2014). Though, the diversity of the mussel beds are documented, (Thippeswamy, 1990; Hemachandra and Thippeswamy, 2009) studies detailing the infaunal relationship with dietary habits of reef fishes are lacking. Hence a study was undertaken to understand the seasonal variation in mussel bed in-faunal and icthiyofaunal diversity of the mussel bed. Analysis was conducted to find the relationship between the mussel bed in-faunal communities and their contribution to the dietary requirement of fishes, having commercial importance.

Methodology

a) *Location of the study:* The intertidal and sub-tidal coastal waters off Karnataka are important beds for the green mussel. The sub-littoral mussel reefs off Someshwara Coast (12^0 47' 19" N 74^0 51' 05"E) in Karnataka (eastern Arabian Sea) along the south-west coast of India (Fig. 1) was selected for the study.

b) *Collection and data analysis of invertebrate community of reef*: The invertebrate community of the reef was collected by quadrant sampling method. The quadrant of 15x15 cm was used and the portion of the mussel bed was chiselled out carefully without disturbing the associate organisms. The monthly samples were collected from 3 sites of the reef from August 2016 to July 2017. The invertebrate communities found in the mussel bed were identified and grouped into major taxa and ranked based on their abundance in the reef. The monthly data were grouped into pre-monsoon (February to May), monsoon (June, July) and post-monsoon (August to January) for seasonal analysis. Seasonal variation in the floral and faunal diversity of mussel bed was assessed using ANOVA.

Collection and data analysis of reef fish assemblages: The data pertaining to the ichthyofaunal assemblages of reefs were collected using visual census. The under-water census was performed once in each season.

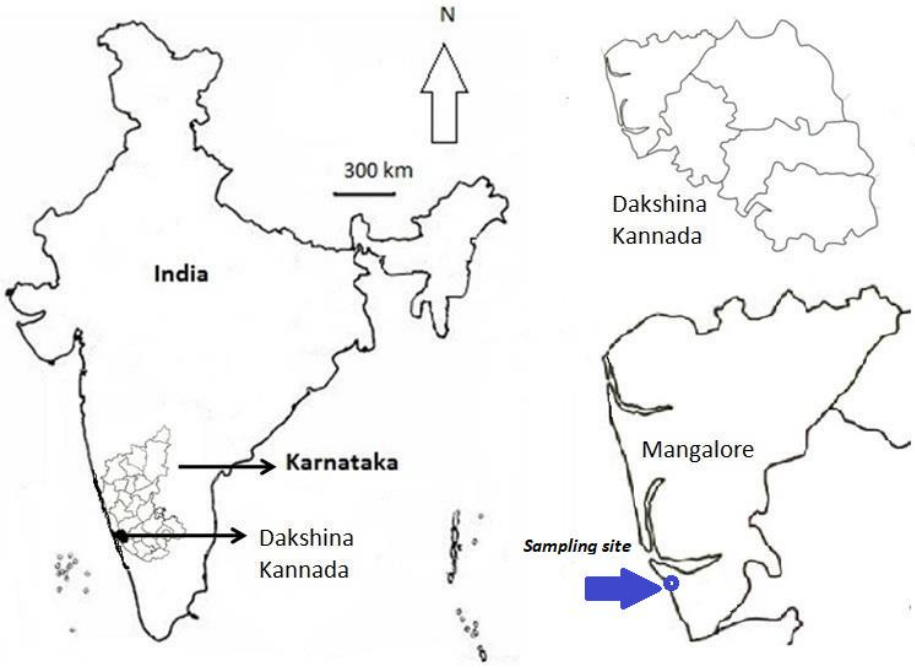


Figure 1: Map showing the sampling site.

This was supplemented with information on fish diversity collected using semi-structured interviews with the local/mussel fishers operating set gillnets, trammel net and cast net. Dietary habit of the fish was taken from secondary sources. Ichthyofaunal assemblages were ranked based on their major food items and dependence on the mussel reef. Spearman's rank correlation between the dietary organisms and reef's communities were calculated to assess the relationship between them. The fish assemblages were grouped based on their seasonality of occurrence and relative abundance in each season.

Results

Invertebrate communities of reef:

A total of 37 species of invertebrates and seaweeds were obtained from the mussel reefs. This comprised of12 major classes such as, Class Ulvophyceae, Florideophyceae, Turbellaria, Polychaeta, Maxillopoda, Malacostraca, Pycnogonida, Polyplacophora, Gastropoda, Bivalvia, Ophiuroidea and Echinoidea. The overall diversity of the in-faunal communities of the reef (excluding green mussel) indicated the dominance of polychaetes followed by malacostracans (amphipods and crabs) (Fig. 2). The seaweeds were represented mainly by 7 species belonging to the class Ulvophyceae and Florideophyceae. The class Polychaeta was represented by 17 species of which two genera, Nereis and Perinereis dominated. The class Malacostraca was represented mainly by 6 species which includes crabs and amphipods.

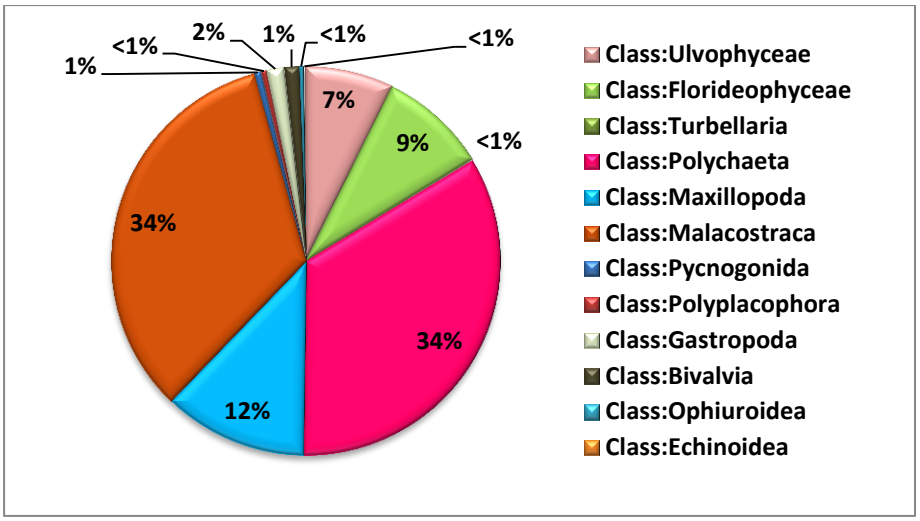


Figure 2: Pie-diagram showing the over-all diversity of invertebrate communities in mussel bed.

The class Gastropoda and Bivalvia were represented by three species each. The class Turbellaria, Pycnogonida, Polyplacophora, Ophiuroidea and Echinoidea were represented predominantly by single species (Table 1).

Out of the 12 infaunal taxa, four showed seasonal variation (Table 1 and Fig. 3). Seaweeds, barnacles and gastropods showed significant seasonal variance while polychaetes, amphipods, crabs, bivalves and other groups were not affected by the changes. Seaweeds and Gastropods were found abundantly during the monsoon and post-monsoon, while they were sparsely distributed during the pre-monsoon period but the barnacles followed a reverse trend. During the pre-monsoon and late post-monsoon period, the reefs were infested with barnacles while during the monsoon and early post-monsoon they were totally absent. The significant seasonal variance in the above communities might be due to drastic changes in salinity, nutrient, wave action and other physical/ environmental parameter (Druehll and Green, 1982; Starczak *et al.*, 2011) during different seasons.

Ichthyofaunal assemblages of reefs: The ichthyofaunal diversity of the mussel reef was contributed by 76 species of which 65 depend on the mussel reef complex for their dietary requirements (Table 2). The rest 11 species were visitors which relay on the reef for needs other than the dietary requirements. This group mostly included shoaling planktivorous fishes like Indian Mackerel, white sardine and mullets .The major ichthyofaunal diversity includes fishes of the family Leiognathidae, Lutjanidae, Siganidae, Sciaenidae, Epinephelidae, Carangidae, Ariidae, Haemulidae, Cynoglossidae, and others. The relationship between the infaunal communities and their importance in fish diet is given in the Table 3.

Table 1: Major species found in the reef along with their taxonomic hierarchy and density per squaremeter.

Sl no	Phylum	Sub-Phylum	Class	Species (major)	Numbers per m^2
1	Rhodophyta		Florideophyceae	*Centroceras clavulatum; Gigartina acicularis; Gracilaria corticata; Gelidium sp*	996*
2	Chlorophyta		Ulvophyceae	*Ulva fasciata; Ulva sp; Chaetomorpha antennina*	1266*
3	Platyhelminthes		Turbellaria	*Pericelis sp*	15
4	Annelida		Polychaeta	*Neries sp, Paraneries sp*	2136
5	Arthropoda	Crustacea	Maxillopoda	*Balanus sp.*	1621*
			Malacostraca	*Eriphia sebana, Ozius rugulosus, Medaeus granulosus, Hyperia sp. Caprella sp.*	1970
		Chelicerata	Pycnogonida	Species unidentified	76
6	Mollusca		Bivalvia	*Perna viridis, Paphia malabarica, Meretrix sp*	8295
			Polyplacophora	*Ischnochiton sp*	61*
			Gastropoda	*Patella sp; Bithynia tentaculata; Littorina sp; Cymatium sp*	196*
7	Echinodermata		Ophiuroidea	*Ophiophragmus sp.*	45
			Echinoidea	*Sterechinus sp*	30

* *P-value* (<0.01) groups showing significant seasonal variance.

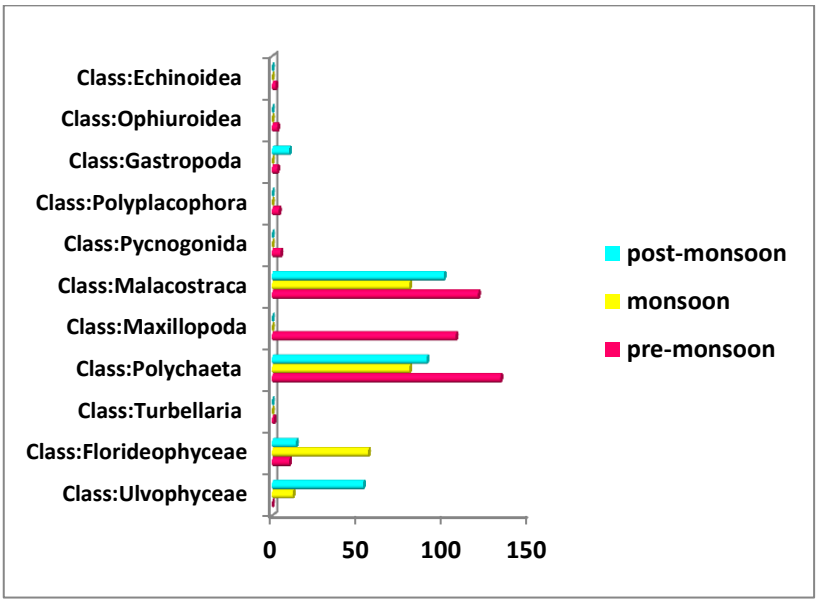
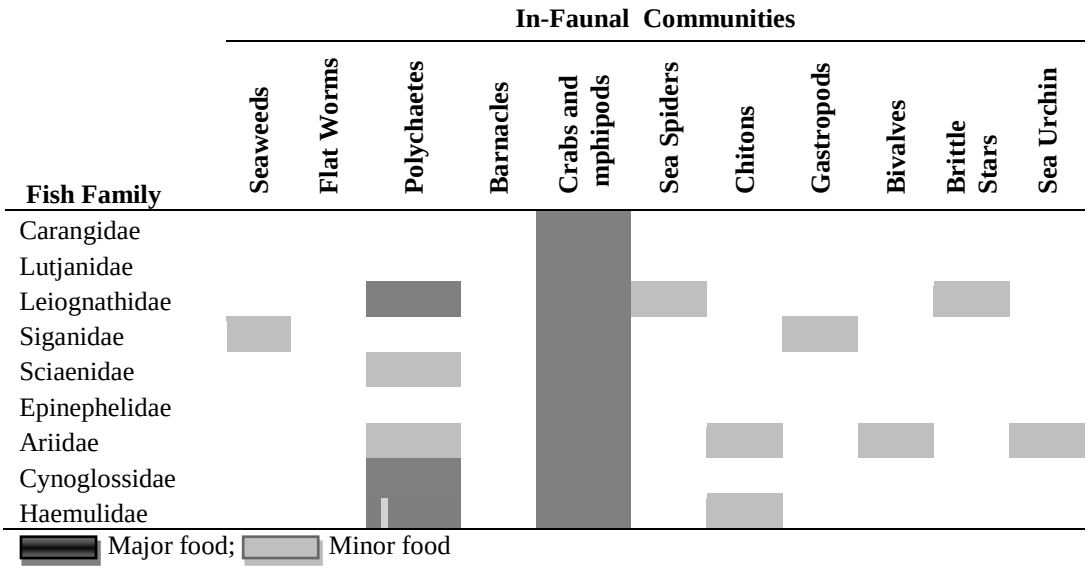


Figure 3: Illustration of seasonal variation in the in-faunal communities of mussel bed.

Table 2: List of fish obtained in the underwater survey under each family.

Family	Species obtained
Leiognathidae	*Leiognathus brevirostris, Leiognathus daura, Leiognathus equulus Leiognathus lineolatus, Leiognathus splendens, Lethrinus nebulosus Gazza achlamys, Gazza minuta, Secutor insidiator, Secutor ruconius*
Carangidae	*Alectis indica, Alepes djedaba, Carangoides coeruleopinnatus,Caranx ignobilis, Scomberoides commersonnianus, Selar crumenophthalmus, Trachinotus blochii, Trachinotus mookale, Trachinoyus baillonii Gnathanodon speciosus*
Siganidae	*Siganus canaliculatus, Siganus vermiculatus*
Lutjanidae	*Lutjanus argentimaculatus , Lutjanus fulviflamma, Lutjanus kasmira Lutjanus rivulatus*
Sciaenidae	*Paranibea semiluctuosa, Otolithes cuvieri, Otolithes ruber, Johnius dussumieri , Johnius spp*
Epinephelidae	*Epinephelus chlorostigma, Epinephelus epistictus, Epinephelus longispinis*
Cynoglossidae	*Cynoglossus macrostomus, Cynoglossus sp*
Engraulidae	*Thyssa sp*
Pomacentridae	*Abudefduf septemfasciatus*
Sparidae	*Acanthopagrus berda*
Chanidae.	*Chanos chanos*
Drepaneidae	*Drepane punctata*
Gerreidae	*Gerres filamentosus*
Muraenidae	*Gymnothorax pseudothyrsoideus*
Kyphosidae	*Kyphosus cinerascens*
Lactariidae	*Lactarius lactarius*
Tetraodontidae	*Lagocephalus inermis*
Mugilidae	*Liza parsia, Mugil cephalus*
Lobotidae	*Lobotes surinamensis*
Monodactylidae	*Monodactylus argenteus*
Stromateidae	*Pampus argenteus*
Platycephalidae	*Platycephalus indicus*
Haemulidae	*Plectorhinchus diagrammus, Plectorhinchus gibbosus, Plectorhinchus schotaf, Pomadasys maculatus*
Paralichthyidae	*Pseudorhombus arsius*
Rhinobatidae	*Rhinobatos annandalei, Rhinobatos obtusus*
Scatophagidae	*Scatophagus argus*
Scombridae	*Rastrelliger kanagurta, Scomberomorus commerson*
Sphyrnidae	*Sphyrna zygaena*
Sillaginidae	*Sillago sihama*
Terapontidae	*Terapon jarbua*
Triacanthidae	*Triacanthus biaculeatus*
Portunidae	*Scylla serrata, Portunus pelagicus, Portunus sanguinolentus*
Dasyatidae	*Himantura gerrardi, Himantura uarnak*
Ariidae	*Arius subrostratus, Arius dussumieri, Arius thalassinus*
Clupeidae	*Escualosa thoracata*
Ambassidae	*Ambassis commersoni*

Table 3: The relationship between the infaunal communities and their importance in fish diet.



Among 65 depended species, 34 fish species have their major food items and 31 species have their minor food items in the infaunal diversity of the mussel bed, which clearly indicates its importance as feeding ground for them. Out of the 65 fishes which depend on reefs directly for feeding, 62 of them relay on malacostracans while 29 on polychaetes, 9 each on seaweeds and bivalves, 7 on gastropods, 2 each on sea-urchins and brittle stars, 2 on pycnogonids and 1 on polyplacophors.

In the current study, it was seen that the mussel reef provide nursery function to two commercially important fishes, seerfish (*Scomberomorus commerson*) and pomfret (*Pampus argenteus*). Since the occurrence of these fishes in the mussel ground during the post-monsoon phase was known to the fishers, specific nets were operated near the reef targeting them during the post monsoon phase.

Seasonal variation in the mussel bed floral communities also influenced the ichtyofaunal communities in the bed. It was observed that, the seaweed communities were observed profusely during the monsoon and post-monsoon phase. The seaweed feeding fishes like *Abudefduf septemfasciatus, Kyphosus cinerascens, Scatophagus argus, Siganus canaliculatus, Siganus vermiculatus* and *Terapon jarbua* were found to be occurring more during the same phase, which substantiates the role of mussel bed as a major feeding ground. Mussel eating ichtyofauna were also seen in the bed. Marine cat fishes, crabs and rays were the major mussel feeders. Apart from providing direct feeds to the organisms, it was also seen that some of the fishes observed in the mussel bed are ichthyophagi. Nearly 16% of the fishes visiting the mussel bed were found to be under this category. *Caranx ignobilis, Lobotes surinamensis, Lutjanus argentimaculatus, Lutjanus fulviflamma* and *Pomadasys maculatus* are few important among them.

Spearman's rank correlation between the dietary organisms and reef's communities gives a rank correlation coefficient of 0.89 (p<0.01). The high rank correlation coefficient implies a significant positive relationship between the in-faunal communities and fish diet which implies the importance of mussel reefs as nursery and feeding ground for natural fish stocks.

Discussion

In the earlier studies conducted in temperate waters, the mussel bed was found to be an excellent nursery ground for many commercially important fish species (Seitz *et al*., 2014). In the current study, nursery function was established as juveniles of few commercially important species were found in this bed. During our survey, it was seen that the juveniles of seerfish and white pomfret were obtained near the mussel beds during the post monsoon phase. These fishes were found to breed during the monsoon months in the coastal waters and juveniles were found in same area during post-monsoon phase. The gut content of juvenile pomfrets and seer fish is reported to have malacostracan crustaceans which were found in abundance in mussel beds (Kuthalingam, 1963; Kumaran, 1964; Siva *et al.*, 2016).

Most of the organisms in the mussel bed are not only feed by larger organisms but also by the other organisms which share the same habitat for shelter. The brittle star preys on a multiple of organisms including polychaetes, gastropods, bivalves, amphipods and mysids (Christensen, 1970); all of which is seen in the same mussel bed. Gastropod, Chiton and Echinoderm, sea urchin feeds on macro-algae like *Ulva sp*, *Ceramium* sp. (Jenkins, 1999; Scheibling and Antony, 2001) while amphipods form a minor diet for the green mussel (Kamermans, 1994). These clearly establish the fact that, mussel bed is important coastal habitat which directly or indirectly affects the marine coastal ecology health and is essential in the maintenance of coastal fishery. Hence it is important to conserve and protect this ecosystem.

During the present study, a total of 113 species including 37 species of seaweeds and in-faunal invertebrates and 76 fish species were observed at the mussel bed microhabitat at Someshwara. But the earlier study which was conducted nearly three decades back in the same site has reported 258 associated organisms (Thippeswamy, 1990), which is more than twice the currently reported value. Degradation has modified coastal habitats to the degree that they no longer fulfil nursery, feeding, or reproductive functions (Worm *et al.*, 2006). Mussel farming is a rapidly expanding mariculture enterprise along the Karnataka Coast which at present is entirely reliant on spat collected from natural/ wild mussel beds (Sasikumar *et al.*, 2016). Fishing of wild-spat from mussel beds in large quantities for

commercial farming operations has created resentment within the local fishermen groups. This is due to the possible physical damage of mussel beds by the wild-spat harvest from sub-tidal areas (Sasikumar *et al*., 2016).The scraping and chiseling activities related to mussel spat collection for farming, if undertaken haphazardly may damage the reef and therefore it should be undertaken with care.Such activities must be carried out with prudence considering sufficient interval for re-colonization. In certain areas, deployment of artificial spat collectors near mussel beds may be an alternative to collect spat during the spat settlement period of mussels. Such activities are proved successful and may be considered as an alternative for conserving the rich biodiversity of these reefs.

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