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# ROCKY SHORE: A NOVEL VISIONARY LOCATION FOR PHYTAL ANIMALS ASSOCIATION WITH SEAWEEDS, MAJALI, WEST COAST OF INDIA

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## ABSTRACT
Majali intertidal shorelines are complex in nature with presence of cervices, pools, rocky platforms, rocky gravel beds with sandy pools which decides the different habitats. It gives an overview about the type of biota thriving ,problems ,adaptations and the importance of it in the marine environment. Life on rocky shores is dominated by need to deal with high wave front, regular exposure to sun, interaction between physical stressors and biological pressure applied by voracious grazers at inter tidal zone.In this study algal association were mapped along vertical zonation in mid littorial and littorial zones influenced by tidal undulation causing disturbance in abundance and distribution of faunal and floral communities. For assessment of species evenness two indices Margalef's richness index (1.50-0.96) and Pielou's evenness index (0.65to0.80) were calculated. To study diversity indices for rarity or commonness of species Shannon -Weiner diversity index was caculated ,its range for habitat rocky pools and rocky boulders showed highest diversity index of 1.85 compared to rocky gravel bed and sandy pools with least diversity index 1.27.To understand the similarities index Bray's Curtis similarity index was calculated ,ranged from23.34%to37.63%.showing equal clusters for rocky pools and rocky platforms and separate cluster of sandy shore, showing similarities in species occupying same morphology habitat. Human interference or human trafficking in rocky intertidal regions leads to anthropogenic activities which in turn creates a havoc for the abundancy of species and migration of species or patchiness in intertidal zones. The study emphasis on the need of urge amongst the youth of nation, research scholars and authors to investigate for more and preserve the heritage diversity ,hence aid in restoration and its conservation, serves as alive museum for upcoming studies.

***Keywords:*** *Rocky Shore, Intertidal Zonation, Diversity, Flora and Fauna*

## INTRODUCTION
Rocky shores are biologically richer environments and termed as "natural laboratories" for studying inter tidal ecology concerned to number and variety in flora and faunal species attributing for higher diversity existing in larger number of ecological niches. Several authors' studies accounted detailed structure of intertidal diversity (Colman, 1933; Fischer-Piette, 1936; and Hatton, 1932).
Rocky shore supporting enormous amount of unusual flora and fauna are nursery grounds for fishes and feeding grounds for birds along with associated algal beds forming conspicuous biotopes in marine environment, they help too in stabilizing and retention of inshore sediments. Faunal association with algal species are mainly due to fulfillment of their necessity requirements regarding food, breeding habitat, protection of juveniles against prey and tidal amplitude, undulating wave action, richer dissolved oxygen and protection against predators amongst species (Denny and Gaines, 2007) and aid in study of abundance and distribution of faunal communities in association with seaweeds (Connell, 1972; Paine, 1966). Macroalgal beds provides protection and shelter as well as foraging location for invertebrates which predates on associated epifauna (Chapman, 1955; Southward, 1958; Sloane *et al.,* 1961; Moore, 1971; Sarma, 1974). Many faunal species inhabitating algal species depend on plants for food (Thirumaran, 2008).

Living conditions on rocky shore is determined by the undulating tidal currents and the exposure to temperature, rainfall, predation, competition with other forms for space both for flora and faunal communities. Marine algal beds harbor rich productive area and support good heavy congregation of sessile epifauna, macro fauna, herbivores , other sedentary and mobile mesograzers (Amphipods, Isopods) called as phytal animals (Kenji, 1975) which includes invertebrates like bryozoans, gastropods, polychaetes, small crustaceans, ascidians, hydroids, sponges growing on adhesive substratum (Fletcher and Day,1983; Edgar, 2004). Zonation in intertidal area is a universal feature depending upon the steepness of shore, tidal amplitude,temperature,competition and other factors causing inshift in faunal mobility from one zone to other,in turn forming a band of distinctive faunal communities visible as zones .Depending on tidal amplitude and its undulating pattern following zones are classified as Spray zone,High tide zone(upper Mid littorial zone), middle tide zone (lower Mid littoral zone), and low tide zone(lower littoral zone) where each zone contains unique distribution and congregations of floral and faunal communities adapted to live in distinctive zones.

The present area, Majali Rocky shore experiences and reflects similar zonational pattern depending on the abiotic parameters. Common inhabitants of spray zone are branacles and periwinkles, Mid tidal zone experiencing ebb and flood of tide, which is turbulent area uncovered twice a day includes sponges, hydrozoans, sea anemones, isopods, mussels, perna viridis, gastropods, echinoderms and macro algae, flora found attached to rocks, hidden in cervices and flora and fauna in tidal pools. Lower tidal zone are dominated by macro algae, sea cucumber, Algal grazers like limpets, sea urchin, top shells chiton, crabs, detritus feeders (Tikander *et al.,* 1986). Either accidentally or intentionally anthropogenic activities, pollution, invasive species, intertidal zone harvest for food ,collection of bait (molluscans), domestic sewage, oil spills from load bearing cargo ships affects rocky shores. One such situation aroused near Mumbai bay in month of August 2010, due to mishap handling caused drifted tarballs along the intertidal area driven by wind and currents, resulted in sustenance of tar balls debris for as long as 10 years creating low ecological niche in particular area of the Majali coast.

As very meager information is available from west coast of India ,this study emphasizes rocky shore intertidal zone as a hotspot for algal association due to increase in treat as consequence of human anthropogenic activities (oil spilling and Human interference).The intertidal stretch of rocky and sandy shore of Majali provides good educational resource for research of algal association in different ecological niche and the urge to study the algal association in future succession.

## MATERIALS AND METHODS

Rocky shore showed rich diversity in algal association which is not explored and documented from Majali coast.

### *Description of study area*

Majali coast located at northern sector of Karwar, within grid of (Lat: $14^{o}53'54.42"$N, Long:$74^{o}05'45.65"$ E ) and ( Lat: $14^{o}53''58.38''$N Long: $74^{o}05''30.56"$E) (Figure 1) topographically with gentle slope gradient and vigorous wave action but still harboring richer flora and faunal communities.

### *Climatic and Hydrological condition*

The present study was carried out for a period of six months from Feb 2018 to July 2018, the coast experienced torrential rain in June and July due to South West Monsoon creating less saline conditions with turbulent sea behavior Tidal amplitude(2.37m to 2.18m) by referring Tidal chart of West coast of India,were as Feb to May conditions petrified with harsh air temperature measured using Thermometer ($24\text{-}31^{0}$C) leading to desiccation in species. Salinity ranged from 33 to 10 ppt measured using refractometer(Feb to July). Dissolved oxygen measured by hand held DO meter (HACH) was 5.0 to 6.1mg/ml.

***Methodology***

Quadrant surveying of the seaweeds and algal associated faunal species were done using $1m^2$ quadrant during the period of six months from Feb 2018 to July 2018 .Sampling was done along the lower littorial and Mid littorial zone of intertidal area. The quadrant was placed randomly in three separate habitats within shore zones.The faunal algal associated species and macro algae were recorded. All collected samples were stored in 4% formalin to identify its morphological features. These were identified by referring (Naik and Shivakumar, 2012) and WORMS Website).

***Algal and faunal Diversity Profile***

For easy calculation and show inter dependency of algal association three habitats were demarcated as per the vertical zonation (Naik and Shivakumar, 2012). In present study for analysis statistical application PAST software was used for Diversity assessment of faunal assemblages in habitat with algae (Phytal animals) for species richness and species evenness ,Shannon diversity indices and Brays Curtis similarity indices were followed which reveals relativeness in species with algal variation.


**Figure 1: Location of the study area Majali Rocky Shore Karwar, West Coast of India.**

## RESULTS AND DISCUSSION

### *Faunal species composition*

The autecology of the faunal species is determined by abiotic factors of the intertidal region aiming at occurrence and distribution with in given area of sheltered condition. The examination of Phytal fauna of Majali rocky shore revealed the presence of algal associated fauna of following six group were recorded 1.Coelenterata2.Annelidans3.Arthropoda4.Molluscans 5.Echinodermata 6. Pisces. Twenty five species of macrofauna were recorded from Majali coast. Among the Twenty five species, Molluscans were found to largest component in collection with eight families and 11 species. Next dominant group emerged is Arthropoda with six family and 8 species in order of abundance associated with algal species. Other groups were in equal accordance to least order of abundance (Table1&2). Most polychaetas (sessile and mobile) were found in sandy shore and rocky boulders where as gastropods most abundant at Mid littorial zone on Rocky boulders.

**Table 1: Faunal Diversity and Richness as related to shore height at Majali Rocky Shore**

| | | |
|---|---|---|
| **Phylum : Coelenterata** | **Phylum : Arthropoda** | **Phylum : Mollusca** |
| **Family : Epizoantidae** | **Family : Alphidae** | **Family : Cerithidae** |
| *Epizoanthus elongatum* | *Alpheus spp* | *Cerithium morus* |
| **Family : Actiniidae** | | *Cerithium citrinum* |
| *Bunodosoma goansis* | **Family : Portunidae** | **Family : Fissurellidae** |
| **Phylum : Annelida** | *Portunus pelagicus* | *Clypidina natata* |
| **Family : Spionidae** | *Charybdis cruciata* | **Family : Mytilidae** |
| *Sabellaria sp.* | | *Perna viridis* |
| | **Phylum : Mollusca** | **Family : Ostreidae** |
| **Phylum : Arthropoda** | **Family : Turritellidae** | *Crassostrea spp* |
| **Family : Amphipoda** | *Turritella duplicata* | |
| *Ampelisca sp.* | *Turritella fultoni* | **Phyum : Echinodermata** |
| **Family : Corphiidae** | **Family : Buccinidae** | **Family : Phyllophoridae** |
| *Apocorophium sp.* | *Babylonia spirata* | *Holothuria atra* |
| **Family : Porcellanidae** | | **Family : Temnopleuridae** |
| *Petrolisthes boscii* | **Family : Bursidae** | *Temnopleurus toreumaticus* |
| **Phylum : Arthropoda** | *Bursa spinosa* | **Phylum : Chordata** |
| **Family : Diogenidae** | **Family : Cypraeidae** | **Class Pisces** |
| *Clibanarius aequabilis* | *Cyprea Arabica* | **Family : Theraponidae** |
| *Troglopagurus mallaarensis* | *Cyprea pallidula* | *Therapon jarbua* |

### *Floral species composition*

Only generalized observation of most dominant species in three habitat and the floral species composition encountered in three types of algal phylum that is Chlorophyta, Phaeophyta and Rhadophyta were recorded. The three phylum representing 10 families and 20 number of species. Among which Chlorophyta depicts 3 families and 9 species, Phaeophyta 2 families and 5 species and Rhadophyta 5 families and 6 species.

**Table 2: Seaweed Diversity and Richness as related to shore height at Majali Rocky Shore**

| Lower littorial zone<br>Submerged rocky platforms and Sandy shore | Lower littorial zone<br>Rocky gravel bed and sandy pools | Lower Mid littorial zone<br>Rocky boulders and pools |
|---|---|---|
| **Family *:* Sargassaceae** | **Family : Gracilariaceae** | **Family : Cladophoraceae** |
| *Sargassum ilicifolium* | *Gracillaria gracilis* | *Chaetomorpha antennina* |
| *Sargassum polycystum* | **Family : Cladophoraceae** | *Cladophora vagabunda* |
| | *Cladophora rupestris* | *Cladophora serecia* |
| **Family : Dictyotaceae** | *Cladophora serecia* | *Cladophora rupestris* |
| *Dictyota dichotoma* | Red algae | **Family : Gracilariaceae** |
| *Padina tetrastomatica* | calcareous encrusters | *Gracillaria corticata* |
| *Spatoglossum asperum* | | **Family : Ulvaceae** |
| | **Family : Hypneaceae** | *Ulva clathrata* |
| **Family : Cladophoraceae** | *Hypnea valentine* | *Ulva intestinalis* |
| *Chaetomorpha linum* | **Family : Sargassaceae** | *Ulva compressa* |
| **Family:Halymeniaceae** | *Sargassum ilicifolium* | **Family : Caulerpaceae** |
| *Grateloupia lithophila* | *Sargassum polycystum* | *Caulerpa taxifolia* |
| | | **Family:Rhodomelaceae** |
| | | *Acanthophora muscoides* |
| | | *Acanthophora specifera* |

The zonation area of Majali is moderately sheltered rocky shore allows unique distribution of floral species with more hardy species in lower area which endures the force of breaking waves and reap benefit of competition. The Mid littoral zone along with breaking of waves have to endure periods of high temperatures and salinity gradient. The lower portion of shore receives constant wash off or uprootment by breaking waves, these species should battle with breaking waves with its strong hold fasts either on rocks or sandy substratum to keep them protectant from wash over. Sargassum and Padina species individuals are found attached to rocks with holdfast to fight breaking of waves and its congregation of species protect the faunal communities as sheltered grounds even with harsh environment disturb the species abundance ,distribution and migration to other ecological levels (Branoff *et al.,* 2009; Denny,1995; and Gaylord, 2000).

In respect to algal association in habitat,most dominant species were found on rocky boulders and in rocky pools which harbours algal species *like Acanthophora muscoides, Ulva compressa, Ulva intestinalis, Cladophora rupestris and Gracilaria* (Table 2 ) were recorded from Lower littoral and lower mid littoral zones. Similar results were recorded in faunal organism associated with littoral and sub littoral marine algae listed by (Atkinson, 1969; Norton, 1971).

Phytal fauna of various species *Caulerpa taxofolia, Ulva fasciata,Sargassum spp* of Vishakpatnam were dealted by Sarma and Ganapati (1972). Few other authors gave valuable information with ecological status of fauna associated with Seaweeds but in scarce (Joseph and Mohan, 1978b; Yogamoorthi, 1982; Murali Krishna and Murthy, 1983).

In present study a close scrutiny of data collected revealed that Shannon -Weiner diversity index (Table 3) for habitat rocky pools and rocky boulders showed highest diversity index of 1.85 compared to rocky gravel bed and sandy pools with least diversity index 1.27 as seaweeds requires more flat substratum for attachment hence more abundance found on rocky boulders and rocky pools, the faunal species such as crabs crawl up the rocky pools for the process of ecdysis and seek protection from predators since the crab after ecdysis have soft body shell which is feed easily by predators .Mussels and gastropods seek

protection from desiccation, hiding and camouflaging with the environment amidst seaweeds congregating at particular rocky pools and rocky boulders. The algal faunal communities seek protection from irradiance and strong desiccation causing bleaching in seaweeds which are present in mid littorial zone (Scrosati and Dewreede, 1998). Bertness *et al.*, (2001) found similar observation in irregular pattern of gradience in diversity due to abiotic factors resulting in species congregation into patchiness with high population at particular zone.Rich algal beds of *Cladophora spp, Sargassum spp and Gracilaria spp* preserves sponge communities. The Bivalvia shells with retention of fine sediment deposition, aid in good substratum for the seaweeds to anchor them and holdfast against harsh wavefront. Barnacles and periwinkles in upper zone aid as a strong hardy substratum for *Chaetomorpha* species to grow and reproduce.

In Majali the gravel bed aided rich faunal species which includes amphipods, copepods, isopods, crabs and turritella with abundant floral species of *Cladohora, Sargassum* and *Dictyota* where as the rocky pools venture species of *Gracilaria spp, Hypne spp, Acanthophora spp* amidst juveniles of crabs, shrimps and of Terapon spp which serves as nursery grounds.

**Table 3: Univariate diversity indices of intertidal fauna recorded in Majali , Karwar, West coast of India**

| Diversity Indices | S | N | D | H | d | J |
|---|---|---|---|---|---|---|
| Submerged rocky platforms and Sandy shore | 5 | 62 | 0.3262 | 1.303 | 0.9692 | 0.8094 |
| Rocky Boulders and rocky pools | 10 | 392 | 0.2098 | 1.851 | 1.507 | 0.8037 |
| Rocky gravel bed and sandy pools | 7 | 166 | 0.4063 | 1.271 | 1.174 | 0.6534 |

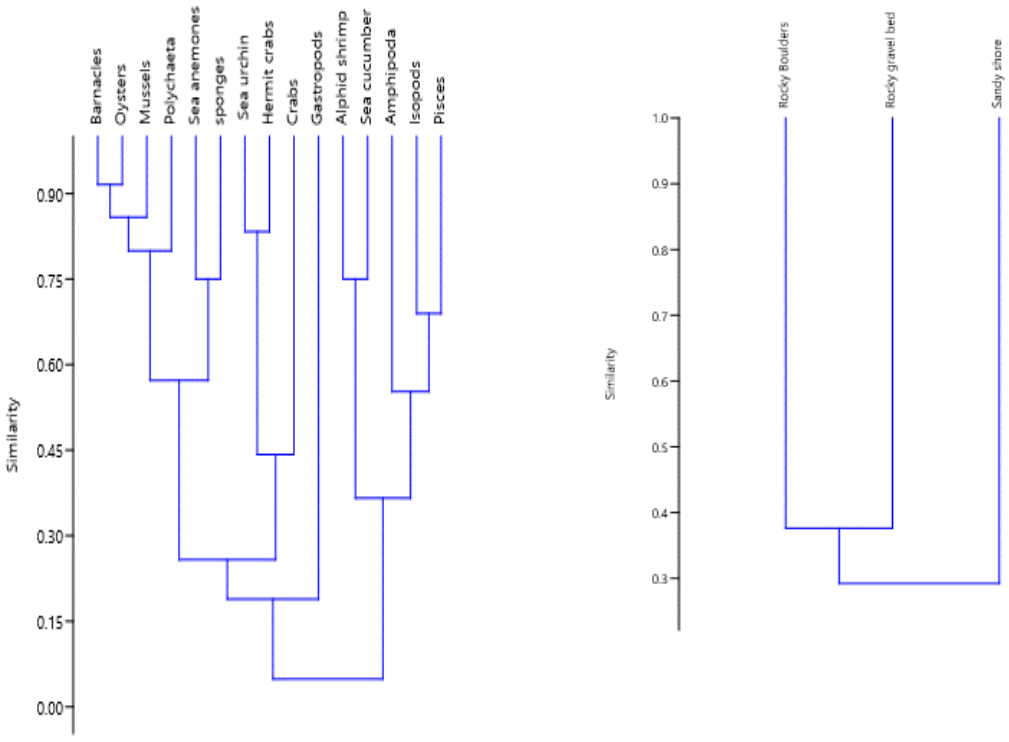


**Figure 2: Dendrogram of complete linkage of faunal diversity species wise (left) and habitat wise (right) of Inter tidal zone of Majali Rocky Shore**

Margalef's richness index (1.50-0.96) and Pielou's eveness index (0.65to0.80) indicated different level of ecological state of algal faunal association (Table 3). Habitat with rocky pools showed highest diverse

nature of faunal species but less dominant compared to sandy shore habitat were single or two taxa were dominated(Table 3).The similarities in species composition was in range of 23.34% to 37.63%, Bray's Curtis similarity index (Figure 2). The dendrogram clearly reveals the Habitat of rocky pools and boulders ,rocky gravel bed and sandy shore forms one cluster having similarities of species composition and less uniform in Habitat of submerged rocky and sandy shore.

It was observed that the green ephemeral algae of both filamentous and foliose forms bears good substratum for abyssal threads of *Perna viridis* in attachment and these forms are generally stress tolerant species (*Ulva spp)* with high reproductive capability and form algal mats or beds covering half of the coast where nutrient Such as nitrate, phosphate and nitrite are available excessive leads to pollution, hence serves as pollution indicators (Schramm,1999; Choi *et al.,* 2008). The absence of other species is due to the harsh environmental factors such as stressors in form of human traffic, pollution and also the steepness of slope of the shore.(Orfanidis *et al.,* 2003; Danwei *et al.,* 2006; Fatemi *et al.,* 2012).Increased forms of Ulva species (*Chaetomorpha antennina, Ulva intestinalis, Ulva clathrata, Centroceras* species give pavement for the Grazing grastropods to increase in number aggregate ,colonized at Mid littorial zone,over rating other species. Similar observation of abundant gastropods in Mid littorial zone recorded by (Babith and Subramanian, 2016).

## CONCLUSION

Rocky shore is the rich intertidal environment that includes rocky cliff, platforms, pools and boulders creating a complex scenario together with environmental parameters like temperature, Salinity, Dissolved oxygen and other nutrients. Organisms living in these zones should develop adaptation as evolutionary development to survive and reproduce. Oil spillage is creating severe disturbance to rocky shore habitat, shifting community composition to low profile algae and fewer organisms consequencing into displacing of species. Rocky shore serves as most productive area for algal mats to thrive and support good number of faunal communities. The benthic communities of intertidal habitats are shaped by especially undulating wave front.

Marine pollution should be identified and mitigation measures should be accomplished for sustainable management of the diversity. Rocky shore serves as a nursery grounds for invertebrate's young stages of their respective cycles or juveniles of respective species with in algal species and feeding grounds for the adult invertebrates. Hence Rocky shores should be preserved to facilitate acknowledgement of various interlinked flora and fauna species and ensure minimum human impacts from littering or disturbing the ecosystem in any excessive way.

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