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Do Artificial Coastal Boulders Enhance Intertidal Bio-Diversity? - A Field Based Pragmatic Analysis With Particular Reference To Pondicherry Coastal Zone.

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Abstract: *Artificial structures such as pier, pilings, floating pantoons, breakwaters made of boulders and seawall are becoming common features of landscape in shallow coastal waters. Present case study is focused on the distribution and abundance of fauna and flora growing along the vertical range in the artificially deployed boulders in the pondichery coast. A clear zonation pattern in the flora and faunal distribution has been noticed. Totally 23 species representing 21 genera are recorded. It is also noticed Ligia sp. is found only in the high tide zone. Shannon index was calculated for each zone where low tide zone showed higher diversity and abundance than the other two zones. Interestingly, the transboundary nature of foraging crabs have been observed moving between low tide and mid tide. The distribution pattern is discussed refereeing to the previous reports.The artificial boulders could support higher biodiversity as well as abundance, though not at par with naturally occurrying rocky shore, but could support a variety of flora and fauna and thereby, the artificial structures render significant ecological services to the coastal marine environment in terms providing new micro-climate and ecological niches in addition to the purpose for which it is deployed on the coast.*
Keywords: *coastal zone-artificial boulders-fauna-flora-species diversity-diversity index*

I. Introduction

Many man-made noval structures in intertidal and sub tidal habitats, e.g. piers, pilings, ports and jetties, pontoons, etc. (Walker, 1988; Glasby and Connell, 1999) created new habitats in the coastal areas. Compared to terrestrial systems, there has, however, been relatively little research on the importance of these structures in view of creation new habitat and biodiversity. Studies on faunal assemblage in various artificial coastal structures are very much limited. Work done at Severns estuary by Mettam(1994), Portuguese coast by D.B. et.al.,(2002), Northern shores of Hong Kong by Kathryn et.al.,(2001), Northwest coast of Portugal by Araujo et.al.,(2005), and recently from Isla cies, Northwest of spain by Jesus et.al.,(2011) are the few studies carried out so far .Realising the paucity of detailed scientific information on the importance of coastal artificial structure in term of new habitat & additional assemblage of fauna and thereby widening the spectrum of intertidal biodiversity, presently an attempt has been made to examine whether these man-made intertidal structure enhance intertidal biodiversity by transforming the boulders in to habitable environment and support floral and faunal community.

Description Of The Study Area

The union territory of Pondicherry is located on the East Coast of South India facing bay of Bengal at latitude of 11‘56’N and longitude of 79‘50’E.Due to its graphical location along the Bay of Bengal. It experiences an average of 2 to 3 cyclones annually. The normal wave climate in Bay of Bengal is mild(with significant wave height varies from 1.0m to 1.5m and peak period varies from 7.0 sec to 9.0 sec. To protect the shoreline erosion and to minimize the wave action at the entrance of the fishing harbour, Pondicherry government has built wave breakers using boulders of size 0.50 tons to 1.50 for a total length of about 6 to 7km in many places along Pondicherry coastal line. The study area i.e. these artificial coastal structures created for the said purpose on the southern part of the Pondicherry town (fig 1 &2).

Fig.1 Satellite view of study area **Fig.2** close up Ground view of study area

II. Methodology

Samplings were done at low tide for 3 different days. Algal species were collected for their identification after recording their distribution pattern and taking photographs. As there is no plain surface area, 25cm² wire frame quadrates were used to carry out sampling adopting the random placement technique. While recording the fauna in each quadrate we simply counted the number of individuals present of each species and the noted down the space occupied by the seaweeds (in percentage) species wise present in each quadrate. The faunal density using Shannon-Weaver diversity index. Shannon index (H`) is:

$H` = -\sum (n_1/N)\ln(n_1/N)$

Where,N=the total number of individuals ; ni=the number of individuals in the 'ith' species.

III. Result

Faunal distribution in Low tide zone along tidal gradient

Totally 23 faunal species and four seaweed species have been recorded in the low tide zone representing nine groups of species (Table 1). Seaweeds which are dominated in the low tide are *Ulva lactuca and Chaetomorpha media* (chlorophytes), *Halymedia doressi (*Rhodophyte)and *Grateloupia lithophilia* (Phaeophytes).The faunal species dominated in the low tide zone are *Perna viridis*, *Saccostrea cuculata(bivalves) and Thais rudolphi,* (Gastropods) along with mosaic distribution of *Balanus Amphitrite and Cthamalus* .(Fig,4&5). The species which are present least in number are Gobid fish, *Cyprea arabica, Siphenculids.* Eighteen species are recorded in the mid tidal zone (table1). However, species like *Perna viridis, Crabs, Thais rudolphi* are also found to be sighted in low tide zone . The species which are dominant in the mid zone are *Cellona radiate and Littorina undulata (gastropod), Saccostrea cuculata (bivalve).* The species which are present in least numbers in the mid zone are *Thais rudolphi and, Perna viridis.* Seven species are recorded in the high tide zone (Table). The dominant species in the high tidal zone are *Turbo bruneus, Neritina sp and Ligia (insect*). The least number of species recorded in the high tidal zone are *Acaemia sp., Littorina undulata, Clypidina notatum* . It is also observed that among the ten gastropod species, four species viz.*Cellana radiata, Clypedina notatum ,Acmaea sp* and *Acanthopleura spinosa* are found to be present in almost all the tidal zones but their abundance get reduced towards high tide zone(Fig.3).

Restricted Distribution

The faunal species present only in the low tidal zone are *Heteroneries, Siphenculids and Gobid fish, and macroalgae viz. Halymenia doresii., Grateloupia lithophilia.,and Ulva lactuca* .18 faunal species are present in both the mid & low tidal zone level ; among them *Crabs, Cellona radiata, clypidina notatum, Acemia sp., Perna viridis, Saccostrea cuculata, Thais rudolphi, chaetomorpha media* are dominants . *As far as high tide zone is concerned, Ligia,* characteristic member of the high tide zone insect, is found to be present in the high tide zone where as other members of this zone are available in other two zones.

Fig .3 Distribution of fauna and flora along tidal gradient

	Low tidal	*Mid zone*	*High zone*
Seaweed			
Ulva fasciata	√		
Chaetomorpha	√	√	
ymedia doressi	√		
Grateloupea lithophila	√		
Insect-Ligia			√
Heteronereis	√		
Siphenculid	√		
Crabs			
Metapograpsus	√	√	
Grapsus strigosus	√	√	
Thalamita creneata	√	√	
Nanosesarma sp	√	√	
Dotilla sp	√	√	
Barnacles			
Balanus Amphitrite	√	√	
Megabalanus tintinabulum	√	√	
Cthamalus malayensis	√	√	
Gastropod			
Cellana radiate	√	√	√
Clypedina notatum	√	√	√
Acmaea sp	√	√	√
Acanthopleura spinosa	√	√	√
Cyprea Arabica	√	√	
Thais rudolphi	√	√	

Babylonia spirata	√	√	
Neritina sp		√	√
Nucella		√	√
Turbo bruneus		√	√
Bivalves			
Perna viridis	√	√	
Saccostrea cuculata	√	√	
Fish			
Gobid	√		

Fig.4 Vertical profile of the tidal zones

Fig.5 Seaweed distribution in low tide

Table 1 Faunal Density along tidal gradient

Name of Species		**Density(no./m²)***	
	Low tide	Mid tide	High tide
Balanus amphritite	7.2	0	0
Megabalanus tintinnabulum	2.0	0	0
Cthamalus malayensis	38.8	38.8	0
Heteroneries sp	6.0	0	0
Siphenculid	2.8	0	0
Grapsus strigosus	4.0	2.8	0
Thalamita crenata	4.0	4.0	0
Metopograpsus sp.	4.0	6.0	0
Nanosesarma sp.	4.0	6.0	0
Dotilla sp.	4.0	2.0	0
Cellona radiate	6.8	6.0	0
Acanthopluera spinosa	1.2.8	0	0
Cyprea arabica	4.0	0	0
Thais rudolphi	16.0	2.0	0
Babylonia spirata	4.0	5.2	0
Perna viridis	12.0	3.2	0
Saccostrea cuculata	6.8	7.2	0
Gobid(fish)	2.4	0	0
Clypidina notate	0	5.2	3.2
Littorina undulate	0	10.0	2.8
Neritina sp.	0	6.0	10.0
Nucella sp.	0	5.2	4.0
Turbo bruneus	0	8.0	5.2
Ligia(insect)	0	0	2.8
Acaemia sp.	0	0	1.2

*** average values of 3 sets of 6 quadrate data collected during field survey**

Table 2. Faunal Diversity Indices

		Density No/ m²	
	Low tide	Mid tide	High tide
No.of.species	21	18	7
Dominance_D	0.108	0.12	0.2
Shannon_H	2.665	2.557	1.77

Table 3. Density, Abundance, Frequency of seaweeds at different tidal zones

Name of seaweeds	**Density(gm/m²)**	**Abundance%**	**Frequency %**
Low tide			
Ulva lactuca	18.3	22	83.33
Chaetomorpha media	15	18	83.33
Halymenia doresii	10	20	50
Grateloupia lithophilia	10	15	66.67
Mid tide			
Chaetomorpha media	8.33	12.5	66.67
High tide *Nil*	-	-	-

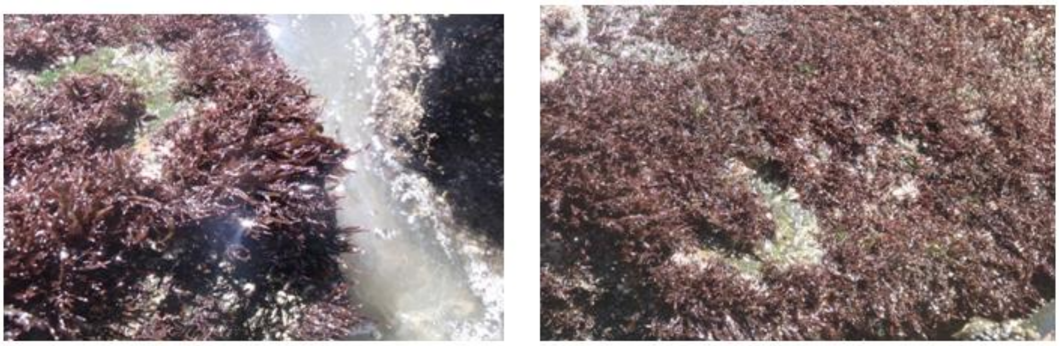

Fig. 6 Red algae growing at low tide

Fig.7 Distribution of fauna and flora – Mid tide

Artificial structures, such as pier pilings, floating pontoons, breakwaters and seawalls are becoming common features of landscape in shallow coastal waters of urbanised areas, in some areas, even replacing considerable portions of natural habitats (Chapman et al., 2002). Compared to terrestrial ecosystems, there has been relatively little research on the importance of these structures to marine/estuarine habitats. Nevertheless, faunal assemblages on artificial structures, such as wooden pilings, concrete walls and fiberglass pontoons have been shown to differ from those found on natural rocky reefs (Osman, 1977; Anderson and Underwood, 1994; Connell, 2000; Glasby, 2000). Similar pattern of faunal and floral distribution has been observed in the present study. The study has been done in the artificial structure created near the fishing harbor entrance is found to support a variety of taxa belonging to fauna & macro algal flora. The macroalgae cover is higher in low tide level in study area shared by four types of seaweeds/macroalgae (Table 3 & Fig.6&7). Similar observations on erect, frondose algae having higher cover along low tide level in the south Pacific was also reported byt Cortés & Jímenez (1996). Crabs are quite obvious both in low and mid tide zones mostly noticed roaming amoung green algae Ulva fasciata and Chaetomorpha media (Fig 6). Among the crab recorded, most of them are found to be transboundary between low tide and mid tide zone (Fig5). Similar observations are also made by Kennish (1997) and Vinueza et al., (2006) relating to Graspus sp. As reported by Parlekar (1981/1972) few members of gastropods and decapods are recorded both in the upper low tide and lower mid tide zone indicating their tansboundary nature. It is presumed that such a transboundary behaviour of these intertidal members may be for the purpose of foraging influenced by the tidal cycle of the given region. The sedentary crustacean species of Barnacles viz. Balanus and *Megabalanus* are seen only in the low tide region. The population of *Balanus amphitrite* is sparse and occurs on vertical substrata, with patchy distribution along low water tide levels competing with Cthamalus malayensis ,another type of acorn barnacle . It is also noticed that the abundance and density of Cthamalus in the upper zones of low tide out numbered the Balanus population totally making inconspicouos in the mid tidal zone (Table).Similar observation was also made by Parlekar (1981) in the malvy rocky shores(Parlekar 1972). The snail *Littorina littorea* was distributed in almost all the three tidal zones but its distribution is found to be uneven in each tidal zone showing a decreasing trend towards high tide zone . Such distribution pattern has been observed in Malvan rocky habitat also. The percentage level of Oyster, *Saccostrea cuculata one of the mosaic type of* community is higher in low-mid region.. Similar pattern has also been observed by Fischer (1981) where the epilithic clams *Saccostrea cuculata*, and the colonies of the polychaete *Phragmatopoma attenuata* form bands with moderate to high cover in the low and mid tide zone. Chitons commonly called as limpet (gastropod) ,are more dominant herbivores on tropical than temperate shores. One of the reasons for their success on tropical shores may be a function of their body plan which allows them to exploit refuges unavailable to hard, fixed-shelled molluscs and therefore escape stressful conditions (Kathryn, et al., 2000). The patella species *Acanthopleura japonica* described by (Boyden et al., 1977) has a flexible series of hard plates which allow to retreat into smaller refuges than species with fixed, it rounded or conical shells and also to mould their bodies to the substrate contours (Fig 5).

Concludingly, it is understood that the overall faunal density as shown in the table 1 is high in the low tide zone and the trend decreased on its vertical gradients recording least for high tide zone. Moreover, Shannon index is also confirm these observation that the low tide index is 2.665 and decreased to 2.567 for the mid tide and very low for the high tide. (Table 2). Similarly the index for the seaweed is also high in the low tide(Table 3). Ulva fascinated is more denser at low tide zone with 75.8g/m2 with a frequency occurrence of 83.33 . Higher number of taxa (23 species) have been recorded in the low tide zones as indicated iln the Fig 3. In fact, mosaics of organisms are an obvious feature of intertidal habitats, mainly at low levels on the shore (Menge et al., 1993). Similar report on tendency for shifting upwards the distribution of organisms with increasing wave exposure is well documented (Underwood, 1981). In high tide zone the species distribution is decreased due to dessication consequently recording only 7 species in including Ligia, one of the successful insects inhabiting in this temperature influenced tidal zone. As reported by Parlekar (1981) insects like Ligia are adopted for dessication. Physiological tolerances to water loss and desiccation stress are positively related to species zonation (Britton & McMahon, 1986) . Moreover, there was high variability in the zonation patterns of fauna on boulders and cliffs around the study area (Table). Causes underlying the distribution patterns of organisms in intertidal rocky systems have been approached by many authors. Examples include, height above chart datum (Schonbeck and Norton, 1978; Underwood, 1978; Bockelmann et al. 2002),the role of competition (Schonbeck and Norton, 1980; and gradient of wave exposure (Underwood,1981; Menge et al., 1993). Besides, food availability and tidal water flash liked with insulation, ability of the individual species against insolation ,complexity of the substratum and physical stability of the boulders in the habitat might be the operating factors in the zonation pattern in rocky shore environment. All these factors might have been in one way or other influenced the faunal distribution in the artificially formed rocky habitat in the present study. However it is also true that in the present study area, these artificial boulders could not support much species diversity as well as abundance when compared to naturally rockyshore faunal assemblege, as the complexity of the habitat (artificial boulders) is not high similar to those natural. Nonetheless, the present study has brought to light that even the artificially placed boulder to serve for wave protection purpose, these boulders also contribute significant ecological services to the coastal intertidal biodiversity thro the transformation of mere mountain pieces into a habitable substratum bestowed with a variety of ecological niches condusive for a variety of marine fauna and flora.

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