Results

Chapter 1: Intertidal Zonation and Faunal Community Structure

Introduction

The coastal environments are considered as biodiversity hot spots, especially the intertidal zone because in few meter area only, tremendous variety of flora and fauna could be observed (Underwood, 2000). The intertidal zone and its faunal and floral community have been studied intensively in last three to four decades. Organisms dwelling in intertidal zone are often grouped in specific pattern which are caused by different kinds of physical and biotic factors. The intertidal or coastal environments are highly variable in terms of time and space as compared to the pelagic environment and, therefore, intensive sampling is needed to find out the controlling variables of species distribution. The effects of different environmental factors on ecological processes and variations in distribution, abundance and size structure of population have been studied extensively in ecology (Myers and McGrath, 1993).

Vertical zonation is the most important process or phenomena observed on the rocky intertidal area where different bands or zones containing different biodiversity are observed from upper to lower intertidal area (Stephenson and Stephenson, 1972; Ellis, 2003). These patterns are very complex to understand because numerous biotic and abiotic factors act at different spatial and temporal scale. The variation in the distribution and abundance of organisms in different zones of intertidal area has provided basis for ecological experiments and such complex patterns of variation have been studied well in different faunal communities. In the intertidal zone, different assemblages of macro faunal community occupy different areas at different levels. Each species present in the assemblage shows preference to particular zone where abiotic and biotic conditions are more favorable for the survival of the species (Stephenson and Stephenson, 1972). Above and below this particular zone, the species cannot survive because of two major reasons; first the physical conditions are not preferable for the species and second the species has to compete with the other native species of the zone for space and food.

Various abiotic and biotic factors act at various levels which affects the distribution pattern of macro fauna in the intertidal zone. The breaking of waves at the shores transmits enormous amount of energy which affect the physiographic situation of the shore line. The energy of the waves directly affect the macro fauna living on the shore surface therefore, the surface inhabitants have to develop great strength of adhesion to overcome the effect of wave action (Newell, 1979). It is also studied and observed that different macro fauna occur in the great abundance in the area where wave action is less (Newell, 1979). Saurashtra coastline (India) is characterized by its rocky, sandy and muddy intertidal zones harboring rich and varied diversity of flora and fauna. The substratum is mainly formed of miliolite and laterite rocks providing altogether a different habitat to the intertidal population (Sarvaiya, 1977). The upper intertidal area of Saurashtra coast is characterized by sandy shore followed by rocky substratum in mid and lower intertidal area.

Sandy shore lines are one of the most extensive intertidal ecosystems distributed in temperate and tropical coastlines. Despite of having barren appearance the sandy shores supports various kinds of marine flora and fauna and many of the sandy shores are considered as highly productive littoral localities. Numerous studies were conducted all over the world to study the zonation pattern of macro fauna on sandy beaches. Often the zone patterns are named after the dominant species residing in that particular zone. Xu et al., (1992) have studied the sandy beach of Hainan Island, China and observed that there were three main zones: a gammaridean zone, dominated by the amphipod, *Talorchestia brito*; an isopod zone, dominated by *Excirolana japonica*; and a clam-gastropod zone, dominated by *Gomphina aequilatera* and *Umbonium vestiarium*. The study showed that tides, substratum type, salinity and wave action were the main factors controlling vertical distribution of benthic fauna.

The intertidal areas of rocky shores are mostly dominated by mollusks. The mollusks showed variation in the distribution pattern from high to low water mark and they are dominant in certain zones of the rocky shores. Amongst these mollusks, the gastropods are typical inhabitant of rocky shores at the intertidal level and as such they are subjected to extreme environmental conditions. This situation allowed one to correlate, in the field, the distribution, the frequency, variations in abundance and biomass, growth, mortality, reproductive periods and existence of phenotypes in different populations of gastropods with relation to contrasting and changing environmental conditions (Bacci and Sella, 1970).

The lower zones of intertidal area are mostly dominated by the tide pools which remain filled with the water during low tide. These tide pools creates unique kind of habitat which is inhabited by several faunal groups like zoanthids. Zoanthids are generally found as prominent animal community in the reef areas where corals are not found extensively (Cooke, 1976; Sebens, 1982). Although zoanthids occurs in high densities in the intertidal zone the taxonomy and ecology are not studied in details (Reimer et al., 2006). The intertidal areas of Saurashtra coast is dominated by species belonging to the genus *Zoanthus* and *Palythoa* (Pandya and Mankodi, 2013).

The intertidal area of the Saurashtra coast is studied for the diversity and distribution of various fauna but so far no study has been carried out regarding the zonation pattern of the intertidal area. The present study aims to establish the intertidal zonation pattern based on the dominant animal community inhabiting the intertidal area. The study also investigates the effect of various abiotic factors of sea water and sediment on the distribution pattern of dominant fauna.

Materials and methods

In present study, the intertidal area was divided into three traditional zones as upper, middle and lower intertidal zones, the size of each zone varied among the study sites with tidal variations. The upper intertidal zone is made up of sandy shire at all the study sites. In the present study only dominant fauna residing in different zones of the intertidal area were identified based on their density and quantified for different seasons. The fauna residing in the sandy shore was quantified using quadrate sampling method (1 m^2) in which total 50 random quadrate were laid monthly at each site. The mid and lower intertidal zone which is made up of rocky shore was surveyed using line transect method intercepted by 0.25 m^2 quadrate. A total 10 line transects were laid randomly perpendicular to the shore line covering all three zones monthly at each study sites. For the survey of zoanthids which are occurring in high densities in the study area colony count using belt transect method is the most appropriate method used for the sampling (Irei et al., 2011) but in the present study area, the size of the colonies of all the species observed at each study sites were very large (10m × 10m or more) so the colony count could not be adopted for sampling. Therefore, instead of colony count, polyp count method was adopted using 0.25 m^2 quadrate (Raghunathan et al., 2004).

The abiotic parameters of sediment (pH, Salinity and Surface temperature) and sea water (pH, Salinity and Surface temperature) were also quantified monthly using calibrated instruments. Each study site was sampled monthly for different kinds of ecological attributes like abundance, density and frequency of occurrence of the species. The monthly data was complied for different seasons viz. summer (March to June), monsoon (July to October) and winter (November to February). Monthly data was recorded for three different abiotic factors. Amongst the different ecological attributes studied, abundance and density of the species are used to show the richness and evenness of the species while percentage frequency is used to show the occurrence of different species with relation to the community.

All the species studied here exhibited patchy distribution pattern, therefore, density of species may not give appropriate picture of species richness as well as distribution. Hence, the abundance of the species is used to define the distribution pattern of the species. The data was analyzed using two way ANOVA without replication to know the spatial and temporal differences between four sites and between three seasons. The kite diagram was plotted to know the intertidal distribution of the species. Regression and correlation coefficient tests were applied to assess the influence of abiotic factors on the population abundance of the species.

Results

Abiotic parameters of seawater

The mean sea water temperature varied between different stations. The maximum temperature was observed at Dahamlej in summer season while minimum temperature was observed at Veraval in winter. The mean sea water pH did not fluctuate between different stations in different seasons. Maximum pH was observed at Kodinar during monsoon, while minimum pH was recorded at Dhamlej in monsoon. The mean sea water salinity varied between different stations in different seasons. At Veraval the mean sea water salinity varied between in summer to in monsoon, possibly due to the addition of fresh water in sea water during monsoon (Table 3).

	Veraval	**Sutrapada**	**Dhamlej**	**Kodinar**
Seawater temp. (°C)				
Winter	27.53 ± 1.70	28.46 ± 0.78	30.8 ± 0.92	29.76 ± 1.59
Summer	33.2 ± 1.70	30.42 ± 0.55	32.45 ± 1.62	32.27 ± 1.68
Monsoon	31.1 ± 0.95	29.15 ± 0.55	28.7 ± 1.41	30.75 ± 1.06
Sea water pH				
Winter	8.12 ± 0.06	8.27 ± 0.29	8.06 ± 0.09	8.18 ± 0.07
Summer	8.26 ± 0.19	8.12 ± 0.17	8.34 ± 0.19	8.27 ± 0.19
Monsoon	8.17 ± 0.23	8.14 ± 0.10	7.77 ± 0.26	8.36 ± 0.29
Salinity				
Winter	39.7 ± 1.53	36.62 ± 1.09	37.66 ± 1.60	37.63 ± 1.38
Summer	37.63 ± 1.38	39.42 ± 1.78	38.32 ± 1.57	39.63 ± 1.38
Monsoon	30.1 ± 1.80	32.25 ± 0.34	33.7 ± 0.97	30.1 ± 1.80

Table 3: Seasonal variation in the mean values of different abiotic factors of sea water at different stations

Abiotic parameters of sediment

The mean sediment temperature varied between different seasons but it did not vary much between different sites. Kodinar site showed high variation in the sediment temperature in which maximum sediment temperature was recorded in summer while minimum sediment temperature was recorded in monsoon. Same kind of pattern in seasonal sediment temperature variation was observed at rest of the three study sites. The sediment pH varied in different seasons but did not vary much between different study sites. Highest sediment pH was recorded in summer at all the study sites while minimum pH was recorded in monsoon. The sediment salinity was recorded very high in summer at Dhamlej while minimum salinity was recorded Sutrapada in monsoon (Table 4).

	Veraval	Sutrapada	Dhamlej	Kodinar
Sediment temp.(°C)				
Winter	29.33±0.45	28.46±0.83	28.60±0.72	28.00±0.81
Summer	33.35±1.04	33.60±1.08	33.62±0.65	33.66±1.15
Monsoon	31.10±1.13	29.70±0.56	30.3±0.84	29.6±0.98
Sediment pH				
Winter	7.76±0.15	8.05±0.15	7.96±0.05	8.06±0.20
Summer	8.25±0.17	8.32±0.22	8.32±0.09	8.35±0.17
Monsoon	7.50±0.14	7.50±0.15	7.75±0.21	7.55±0.35
Sediment salinity				
Winter	38.66±0.57	37.09±1.07	39.75±1.08	36.66±2.08
Summer	39.75±1.07	39.00±0.81	40.00±1.82	38.75±1.5
Monsoon	35.00±1.41	32.5±0.70	34.0±1.41	32.5±0.85

Table 4: Seasonal variation in the mean values of different abiotic factors of sediment at different stations

Intertidal zonation pattern

In the present study, specific pattern has been observed in the distribution pattern of intertidal benthic fauna. The results of the quadrate data have presented a specific pattern of zonation at all the study sites. The intertidal zone of all the study sites is more or less same in terms of geo morphology in which the upper intertidal area is made up of sandy shore while the mid and lower intertidal area is made up of rocky shore. In the present study the dominant faunal species occurring in the intertidal zone of each study site was quantified and the different zones were named after dominant faunal species or group. In the present study the exposure or width of the intertidal zone varied between different study sites in which maximum exposure was observed Dhamlej (140 meters) followed by Sutrapada (130 meters), Kodinar (125 meters) and Veraval (55 meters). The average exposure observed at all the study site was 120 meters except Veraval where average exposure was 50 meters.

The quadrate data revealed that the upper intertidal zone is dominated by brachyuran crab species *Ocypode ceratophthalma* at all the study sites. The distribution of the species was observed only in the upper intertidal zone which has an average width of 20 meters at all the study sites. Due to the high abundance of *Ocypode ceratophthalma* in the upper intertidal zone, the zone is denoted` as *Ocypode ceratophthalma* zone. The mid intertidal zone was dominated by different gastropod species. The distribution of the gastropod varied from mid to lower intertidal zone at all the study sites. The maximum abundance of the gastropod species was observed in the mid intertidal zone while the abundance decreased in the lower intertidal zone. As the mid intertidal zone is dominated by gastropod species it was denoted as gastropod zone. The lower intertidal zone of all the study sites was covered by different sizes of tide pools which remain filled with the water during low tide. These tide pools are dominantly inhibited by different species of zoanthids. The distribution of the zoanthid species was observed from mid to lower intertidal zone in which maximum abundance was observed in the lower intertidal zone. Due to the occurrence of zoanthid species in high abundance in the lower intertidal zone, the zone is denoted as zoanthid zone (Fig. 8).

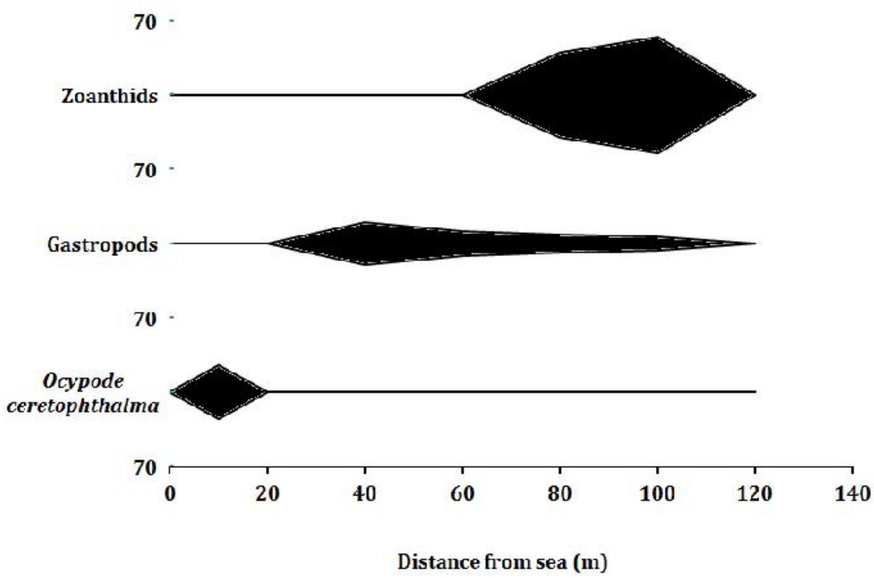

Figure 8: Intertidal zonation pattern based on dominant animal community.

The dominant species occurring in the each zone have been quantified monthly to know their seasonal distribution pattern at each study site in different seasons. The seasonal abundance of each dominant species was also correlated with various abiotic parameters of sea water and temperature to know their effect on the distribution of the species in different intertidal zones.

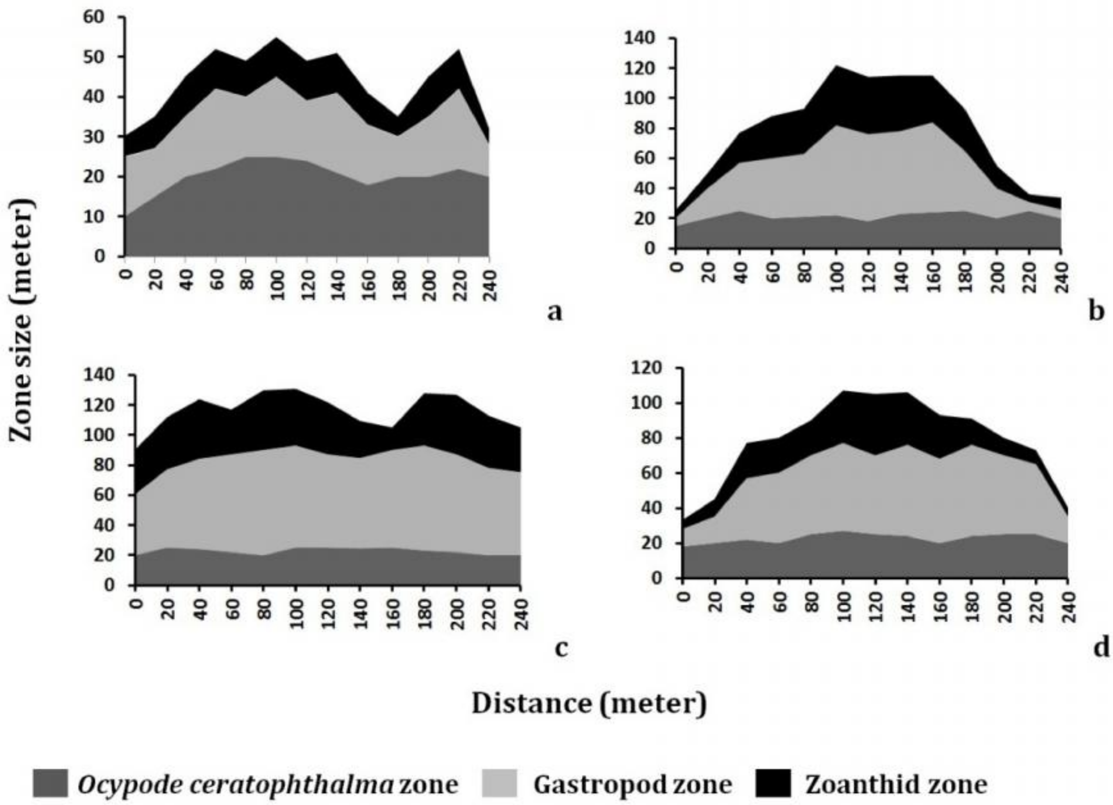

Figure 9: Size variation of different zones at different study sites. a: Veraval, b: Sutrapada, c: Dhamlej, d: Kodinar

***Ocypode ceratophthalma* zone**

Brachyuran crab species *Ocypode ceratophthalma* is a common inhabitant of the tropical sandy beaches where it occurs in a high abundance. The species is burrowing nature and exhibits various kinds of behavioral patterns in burrowing. In the present study the species showed specific pattern in the distribution in upper intertidal zone of each study sites. The exposure or width of the *Ocypode ceratophthalma* zone varied between different study sites. The width of the zone was affected by the geomorphology of the shore type at each site. The width of the zone varied from 10 meters to 25 meters with an average width of 20 meters at each study site (Fig. 9). The high abundance of the burrow was recorded near the water line but the burrow number decreased towards the upper part of the sandy shore at each study site (Fig. 10). Opposit pattern was observed for the burrow diameter in which burrow with less diameter were recorded near the water line while burrow with large diameter were distributed near the upper part of the sandy shore at each site (Fig. 11).

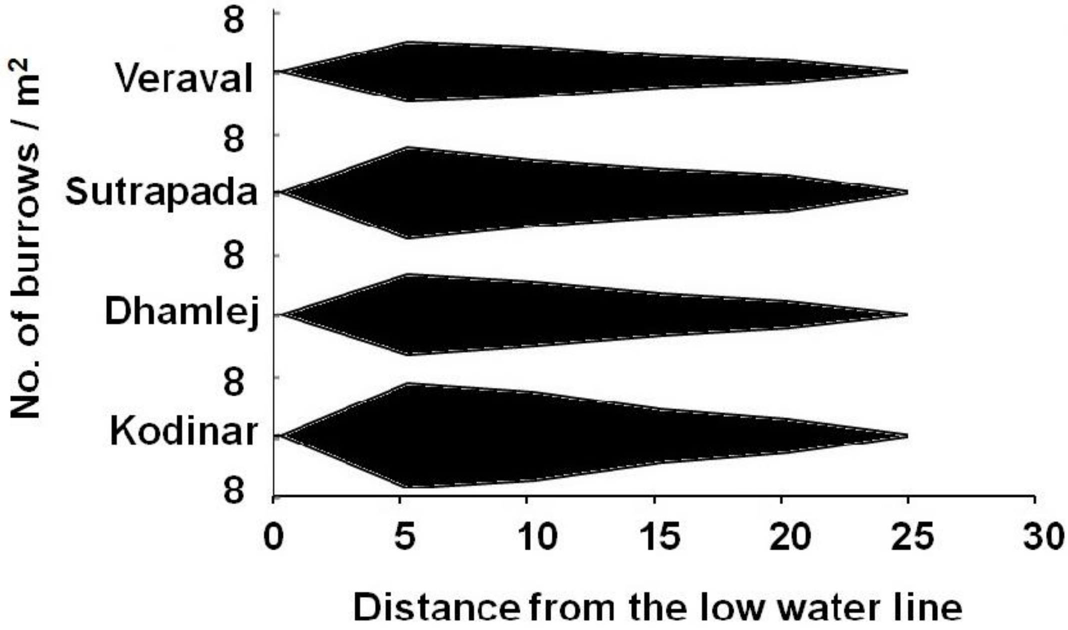

Figure 10: Variation in burrow numbers of *O. ceratophthalma* on sandy zone at different study sites.

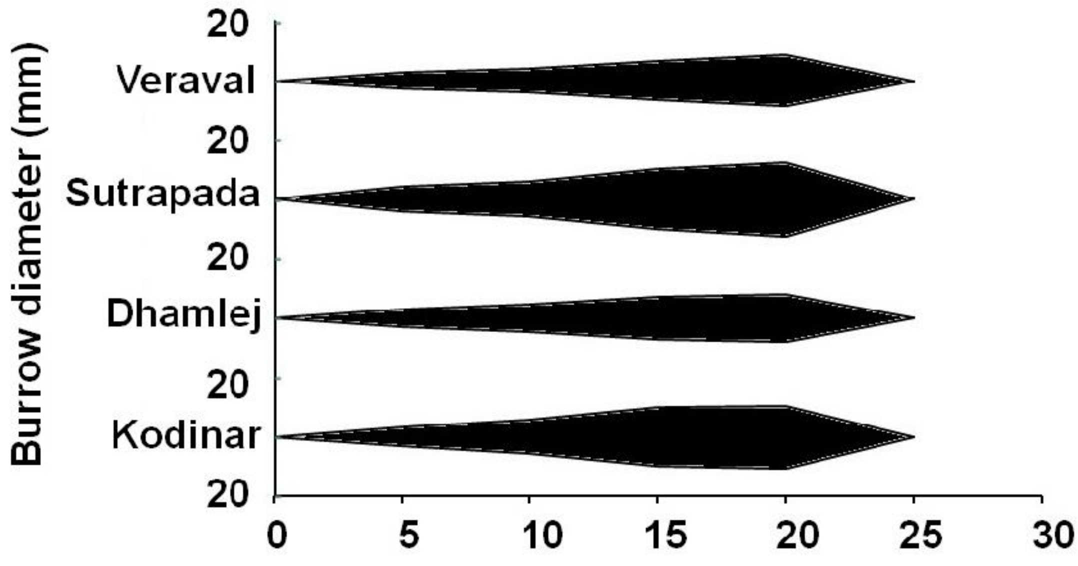

Figure 11: Variation in burrow diameter of *O. ceratophthalma* on sandy zone at different study sites.

The abundance of *Ocypode ceratophthalma* showed variation between different seasons and different sites. Maximum abundance of the species was recorded at Kodinar followed by Sutrapada, Dhamlej and Veraval in monsoon while in case of summer and winter the abundance remained more or less same at all the study sites (Fig. 12b). The result of ANOVA showed significant variation for the mean values of the seasonal abundance (ANOVA df: 42.88, $p < 0.001$) of the species. Significant variation was also observed between mean values station specific abundance (ANOVA df: 5.86, $p < 0.5$) of the species (Table 5)

The density of *Ocypode ceratophthalma* showed variation between different seasons and different sites. Maximum abundance of the species was recorded at Kodinar followed by Sutrapada, Dhamlej and Veraval in monsoon while in case of summer and winter the density remained more or less same at all the study sites (Fig. 12a). The result of ANOVA showed significant variation for the mean values of the seasonal density (ANOVA df: 29.63, $p < 0.001$) of the species. Significant variation was also observed between mean values station specific abundance (ANOVA df: 6.29, $p < 0.5$) of the species (Table 5)

The frequency of occurrence of *Ocypode ceratophthalma* showed variation between different seasons and different sites. Maximum abundance of the species was recorded at Kodinar followed by Sutrapada, Dhamlej and Veraval in monsoon while in case of summer and winter the density remained more or less same at all the study sites (Fig. 12c). The result of ANOVA showed significant variation for the mean values of the seasonal density (ANOVA df: 20.86, $p < 0.001$) of the species. Significant variation was also observed between mean values station specific abundance (ANOVA df: 7.49, $p < 0.01$) of the species (Table 6)

Regression analysis between sediment temperature and burrow abundance of the *O. ceratophthalma* did not show significant correlation at all the study sites that show that sediment temperature is not a prime factor which affects the distribution of the species. Sediment salinity also did not show significant correlation with the abundance of the species for different study sites except Kodinar. Sediment pH showed significant correlation with the abundance of the species at Sutrapada and Kodinar but significant correlation was not observed at Veraval and Dhamlej (Table 6).

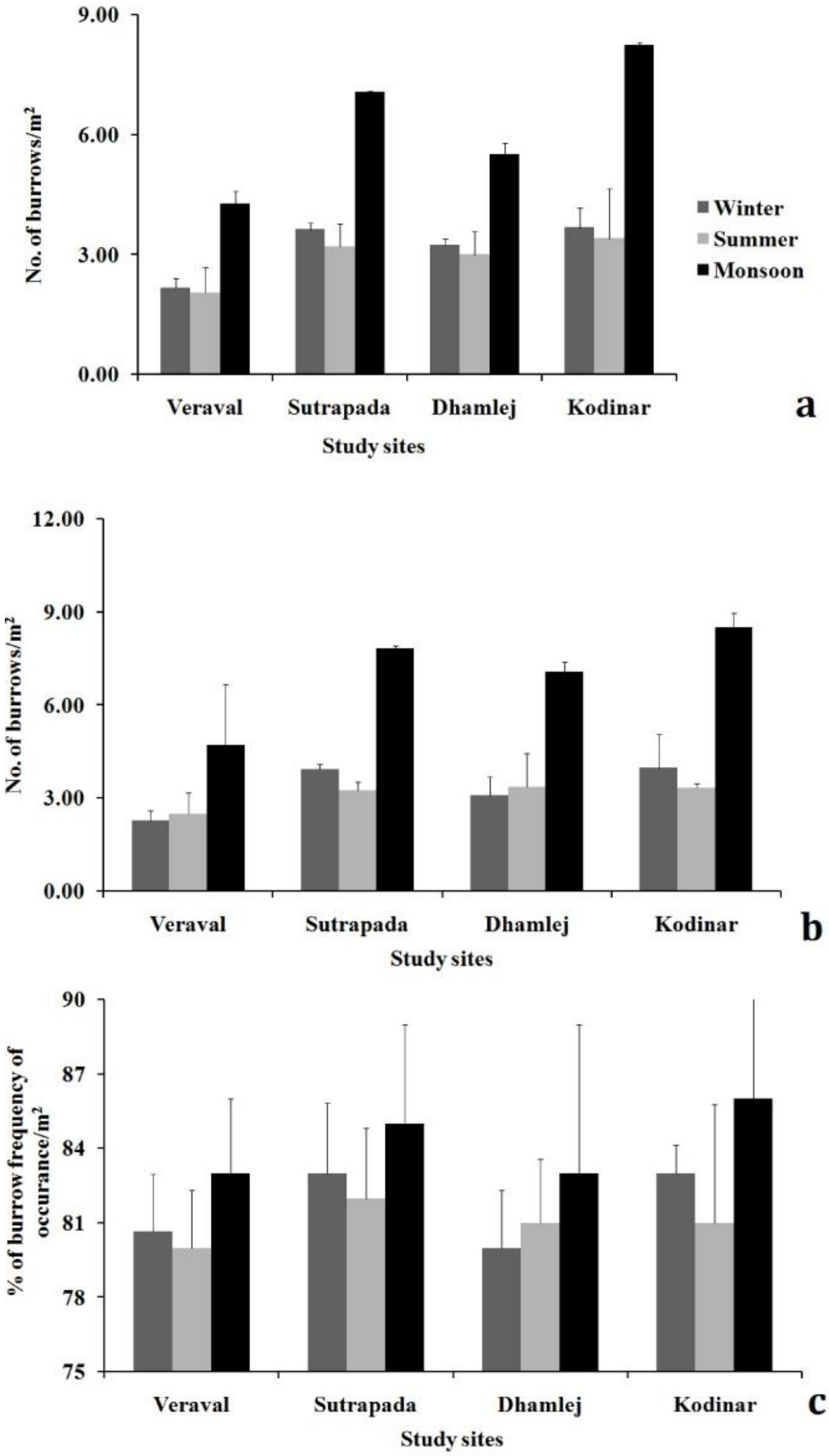

Figure 12: Seasonal variation in eco attributes of *O. ceratophthalma* at different study sites.(a) Density (b) Abundance (c) Frequency of occurrence.

Source of Variation	Density	Abundance	Perc. Frequence
Station	6.29|*	5.86*	7.49**
Season	29.63***	42.88***	20.86***

Table 5: Results of the Two – way ANOVA without replication analysis of the mean seasonal density, abundance and frequency values of *O. ceratophthalma* burrows sampled at three different sites (* p < 0.05, ** p < 0.01, *** p < 0.001).

Sediment Temperature	**Equation**	**R^2**
Veraval	y=0.0498X+1.34	0.007
Sutrapada	y=-0.3221X+14.49	0.19
Dhamlej	y=-0.0794X+6.57	0.011
Kodinar	y=0.1434X+3.98	0.03
Sediment Salinity		
Veraval	y=0.0453X+2.68	0.116
Sutrapada	y=0.1797X+3.60	0.065
Dhamlej	y=-0.4411X+21.0	0.482
Kodinar	y=-0.5807X+25.99	0.5624**
Sediment pH		
Veraval	y=--1.8861X+17.85	0.394
Sutrapada	y=-4.504X+40.79	0.764***
Dhamlej	y=4.1207X+37.38	0.361
Kodinar	y=-4.4688X+40.79	0.566**

Table 6: Results of the regression analysis between mean seasonal abundance of *O. ceratophthalma* and mean sediment temperature, salinity and pH (** p < 0.01; *** p < 0.001).

Gastropod zone

The second zone which contain rocky shore habitat was dominantly inhabited by gastropod species (Fig. 9). Out of different gastropod species identified in the gastropod zone, five species of gastropods which includes *Turbo intercostalis* Menke, 1846, *Lunella coronata* (Gmelin, 1791), *Astrea stellata* (Gmelin, 1791), *Cerithium scabridum* Philippi, 1848 and *Cerithedia cingulata* (Gmelin, 1791) were reported as a dominant species occurring in the gastropod zone of all the study sites. The gastropod species were not observed in the sandy shore zone.

In the present study, *Cerithium scabridum* was observed as most abundant species followed by *Lunella coronata, Astrea stellata, Turbo intercoastalis* and *Cerithideopsilla cingulata* at all the study sites. *Cerithedia cingulata* was occurring in high abundance in the upper part of the gastropod zone while rest of species showed more or less even distribution on remaining zones of intertidal area of all the study sites. (Fig. 13).

The maximum abundance and density *Cerithium scabridum* was observed very high during the summer season while it showed declining trend during winter and monsoon at all the study sites (Fig. 15d, 14d). Maximum density and abundance of the species was observed at Veraval and Dhamlej respectively (Fig. 15d, 14d). The frequency of occurrence of the species was more or less similar at all the study sites during different seasons (Fig. 16d) and is mostly observed in small to large congregations. The results of ANOVA showed significant variation between the mean values of density (ANOVA df: 30.89, $p<0.01$) and abundance (ANOVA df: 34.23, $p<0.01$) of the species for different seasons while the mean values of frequency of occurrence (ANOVA df: 14.76, $p<0.01$) showed significant variation for different stations (Table 7).

In the present study, maximum abundance of *Lunella coronata* was observed on the upper intertidal zone while in mid and lower intertidal zone the abundance of the species showed declining trend (Fig. 13). The abundance and density of the species was observed high during summer season while it showed declining trend during monsoon and winter season at all the study sites (Fig. 15b, 14b). Maximum density and abundance of the species were recorded high at Veraval as compare to other sites (Fig. 15b, 14b). The frequency of occurrence of the species showed variation between different sites in which maximum frequency of occurrence was recorded in summer followed by monsoon and winter which indicated the patch mode of distribution of the species during different seasons (Fig 16b).

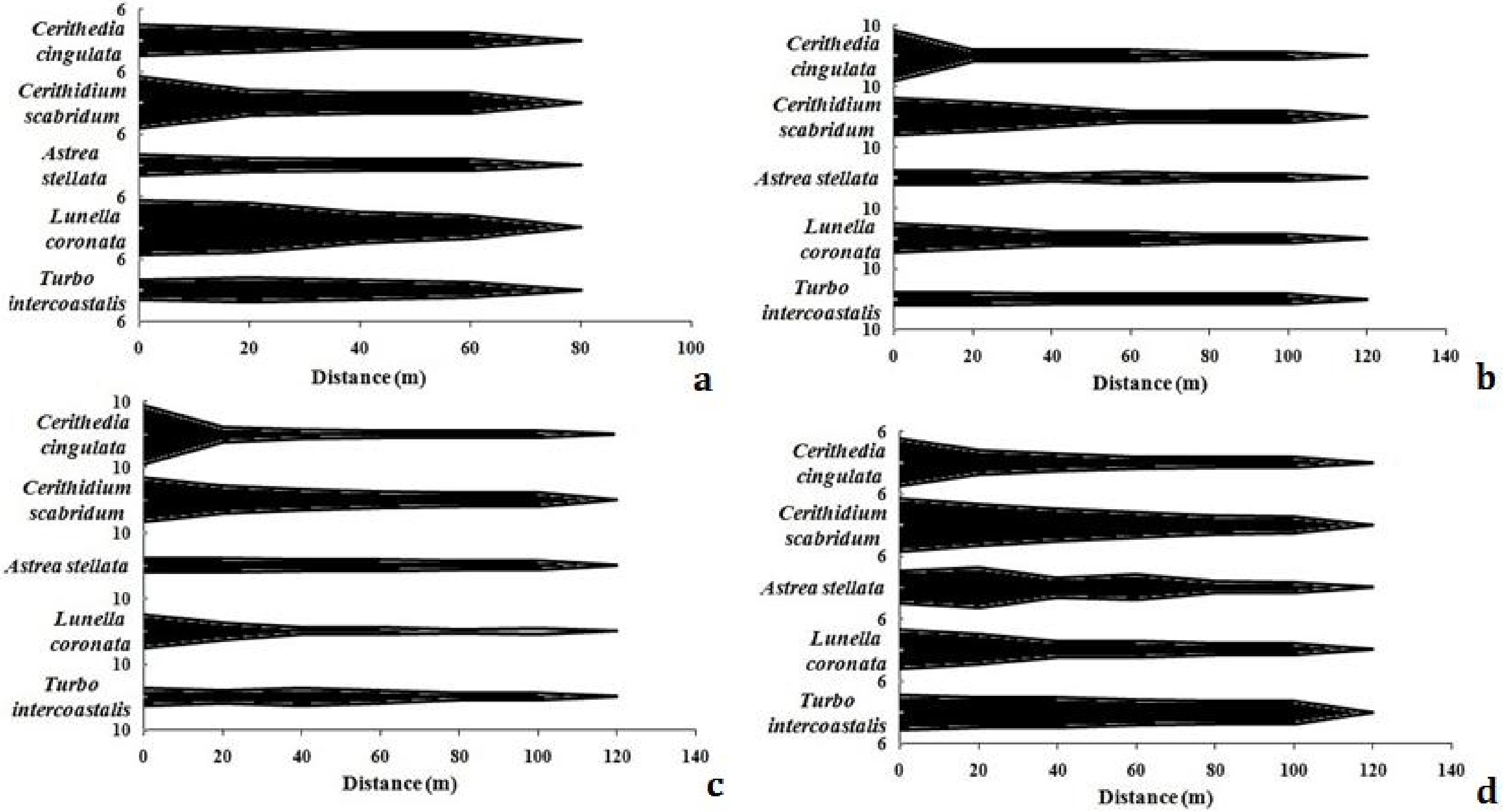

Figure 13: Intertidal distribution of gastropod species. a. Veraval, b. Sutrapada, C. Dhamlej, d. Kodinar.

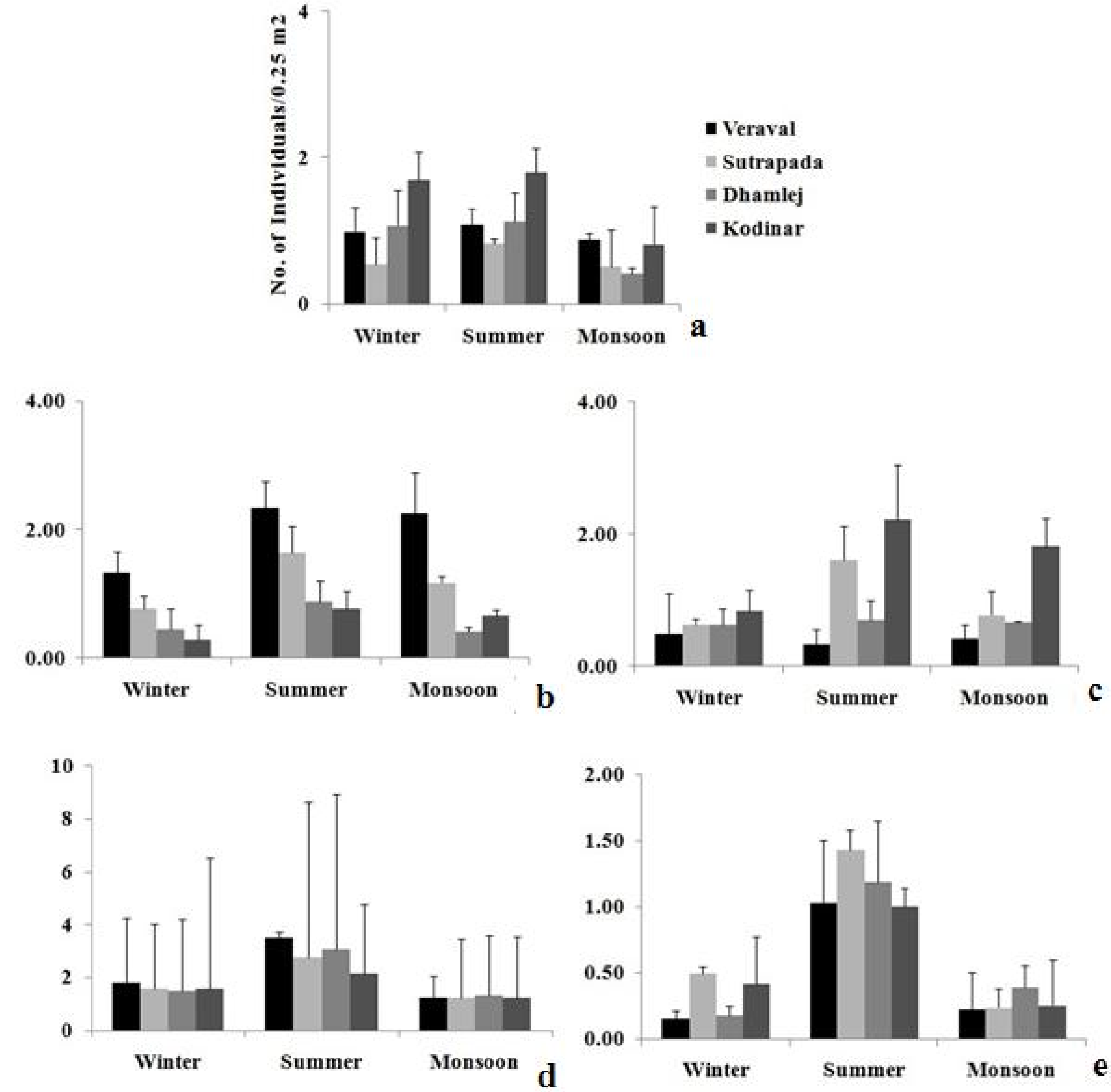

Figure 14: Seasonal variation in mean density (± SD) of gastropod species at different study sites. (a) *Turbo intercoastalis*(b) *Lunella coronata* (c) *Astrea stellata* (d) *Cerithium scabridum* (d) *Cerithedia cingulata*

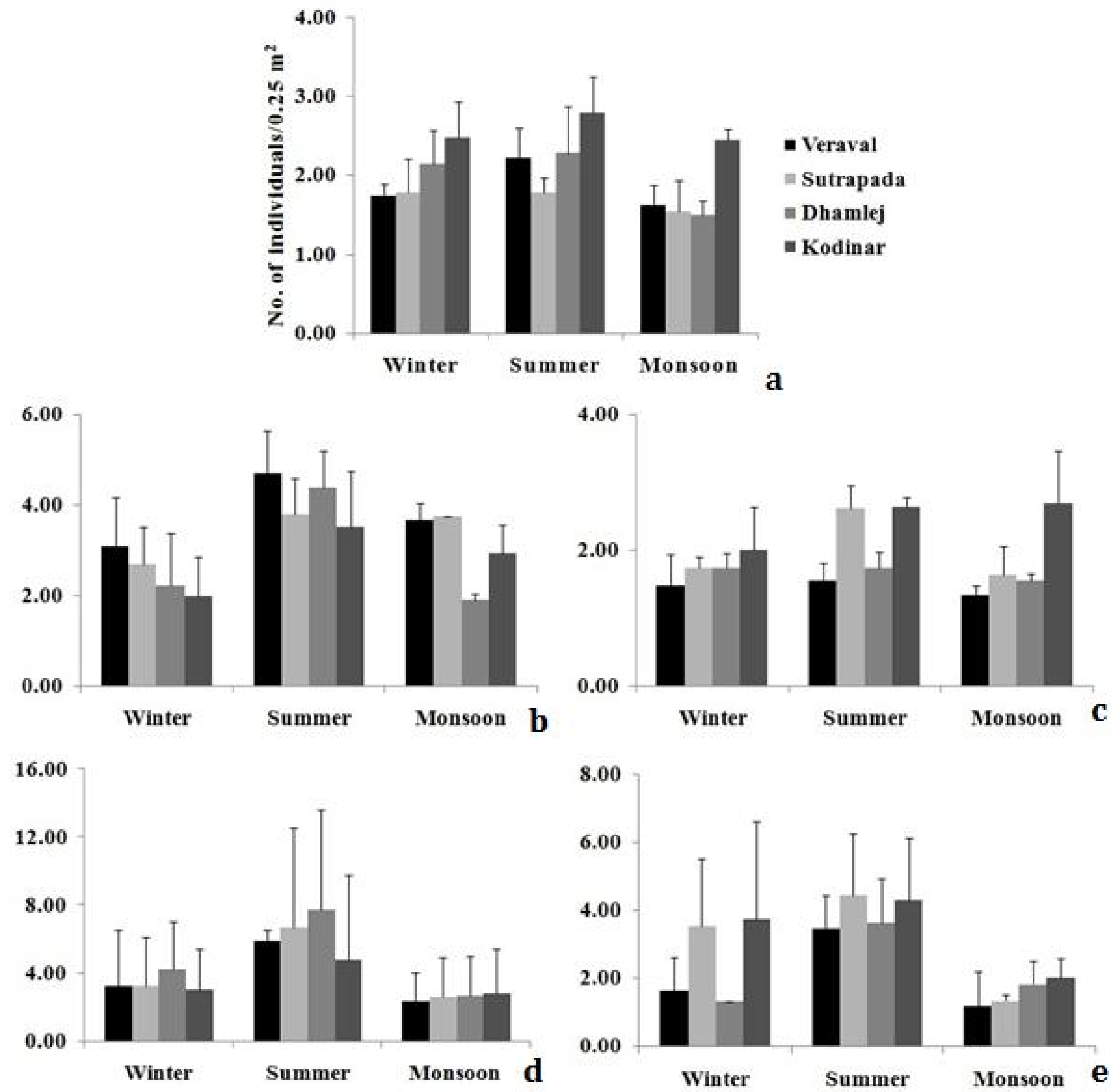

Figure 15: Seasonal variation in mean abundance (± SD) of gastropod species at different study sites. (a) *Turbo intercoastalis* (b) *Lunella coronata* (c) *Astrea stellata* (d) *Cerithium scabridum* (d) *Cerithedia cingulata*

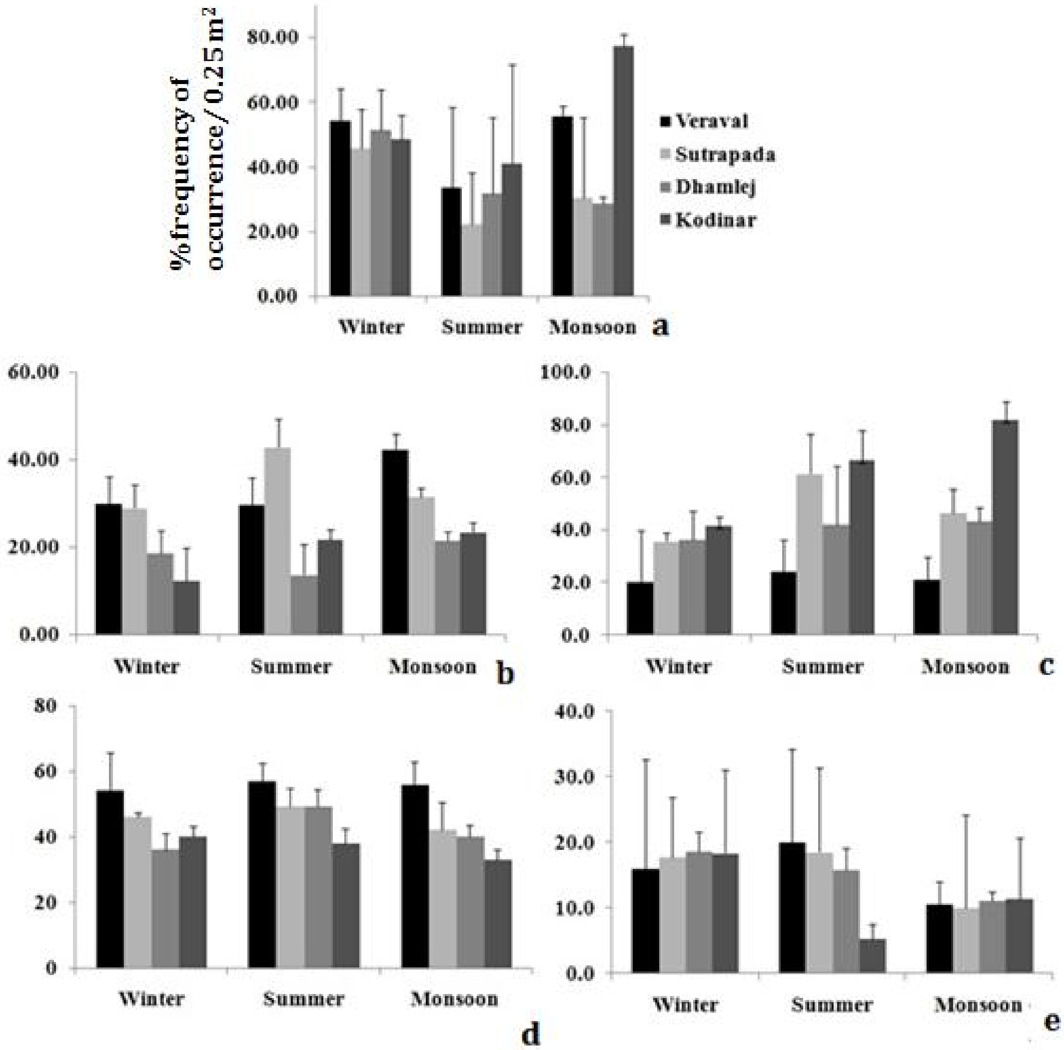

Figure 16: Seasonal variation in mean frequency of occurrence (± SD) of gastropod species at different study sites. (a) *Turbo intercoastalis*(b) *Lunella coronata* (c) *Astrea stellata* (d) *Cerithium scabridum* (d) *Cerithedia cingulata*

The results of ANOVA showed significant variation between the mean values of density (ANOVA df: 8.71, $p<0.01$) and abundance (ANOVA df: 9.84, $p<0.01$) and frequency of occurrence (ANOVA df: 1.51, $p<0.05$) of the species for different seasons while the mean values of density (ANOVA df: 23.95, $p<0.01$) and frequency of occurrence (ANOVA df: 6.96, $p<0.05$) showed significant variation for different stations (Table 7).

Astrea stellata is another commonly observed turbinid species along the intertidal region of Saurashtra coast of Gujarat state. In the present study, the species showed even distribution pattern in all the three zones of all the study sites except Kodinar (Fig. 13). At Kodinar, Maximum abundance of the species is observed at upper and middle intertidal zone of intertidal area. Maximum density and abundance of the species were recorded in summer followed by monsoon and winter (Fig 14c, 15c). Maximum density and abundance of the species was recorded at Kodinar as compare to other site (Fig 14c, 15c). The frequency of occurrence of the species showed more or less fluctuation at different sites in different seasons (Fig. 16c). The results of ANOVA showed no significant variation between the mean values of density, abundance and frequency of occurrence of the species for different seasons but the mean values of density (ANOVA df: 5.22, $p<0.05$), abundance (ANOVA df: 5.88, $p<0.05$) and frequency of occurrence (ANOVA df: 8.92, $p<0.01$) showed significant variation for different stations for the species (Table 7).

Turbo intercoastalis showed more or less even distribution in different zones of intertidal area of all the study sites (Fig. 13). The abundance of the species was observed slightly high in the different zones of intertidal region of Kodinar (Fig. 13). The density of the species was observed more or less same during summer and winter while it showed drastic decline during monsoon season while the abundance of the species did not varied much during different seasons (Fig. 14a, 15a). Maximum density and abundance of the species was recorded at Kodinar (Fig. 14a, 15a) as compared to other sites. The frequency of occurrence of the species showed more or less fluctuation at different sites in different seasons because patch distribution of the species (Fig. 16a). Amongst all the ecological attributes studied only mean values of density showed significant variation for different seasons (ANOVA df: 5.94, $p<0.05$) and station (ANOVA df: 6.18, $p<0.05$) (Table 7).

Amongst the five species of gastropods studied in the present study *Cerithedea cingulata* showed lowest values for all the parameters studied. Maximum abundance of the species was observed in the upper intertidal zone of all the study sites (Fig. 13) Maximum density and abundance of the species were recorded in summer while major decline was recorded during winter and monsoon (Fig. 14e, 15e). The values of abundance of the species were recorded very high as compare to density (Fig. 14e, 15e) at all the study sites. Maximum density and abundance of the species was recorded at Sutrapada (Fig. 14e, 15e) as compare to other sites. The frequency of occurrence of the species showed more or less fluctuation at during summer and monsoon but showed decline during monsoon (Fig. 16e). Amongst all the ecological attributes studied only mean values of density (ANOVA df: 49.67, $p<0.01$) and abundance (ANOVA df: 13.77, $p<0.01$) showed significant variation for different seasons while no significance was recorded for any parameter for different stations (Table 7).

The abundance of *C. scabridum* and *L. coronata* showed significantly strong correlation with sea water temperature at all the study sites except Veraval. The abundance of *A. stellata* showed significant correlation with sea water temperature at Sutrapada only. *C. cingulata* and *T. intercoastalis* didn't show significant correlation with sea water temperature at any study site. In case of sea water pH, abundance of *L. coronata* showed significant strong correlation at Veraval and Sutrapada. Abundance of *A. stellata* and *C. scabridum* showed significant strong correlation with sea water pH at Kodinar and Veraval respectively. Abundance of *C. cingulata* showed significant strong correlation with sea water pH at all the sites except Sutrapada. Abundance of *T. intercoastalis* didn't show significant correlation with sea water pH at any study site. In case of sea water salinity, abundance *C. scabridum* showed significant strong correlation at Dhamlej. Abundance of *C. cingulata* also showed significant strong correlation with sea water salinity at Sutrapada and Kodinar. Abundance of gastropod species like *T. intercoastalis,L. coronate* and *A. stellata*didn't show significant correlation with sea water salinity at any study site (Table 8).

Species	Source of Variation	Density	Abundance	Freq. of occurrence
T. intercoastalis	Season	5.94	3.2	2.65
	Stations	6.18	41.59	2.24
L.coronata	Season	8.71**	9.84**	1.51*
	Stations	23.99**	2.66	6.96*
A. stellata	Season	2.04	1.9	2.95
	Stations	5.22*	5.88*	8.92**
C. scabridum	Season	30.89**	34.23**	2.66
	Stations	1.43	2.2	14.76**
C. cingulata	Season	49.67**	13.77**	2.71
	Stations	1.63	2.85	0.56

Table 7: Results of the Two way ANOVA without replication seasonal density, abundance and frequency of occurrence values of different gastropod species studied at different sites (* $p<0.05$; ** $p<0.01$)

	Veraval		Sutrapada		Dhamlej		Kodinar	
	Regrassion equation	**R2**	**Regrassion equation**	**R2**	**Regrassion equation**	**R2**	**Regrassion equation**	**R2**
Sea water Temp.								
T. intercoastalis	y = 0.070x - 0.26	0.28	y = 0.028x + 0.87	0.03	y = 0.211x - 4.52	0.91	y = 0.136x - 1.66	0.79
L. coronata	y = 0.300x - 5.27	0.8	y = 0.502x - 11.31	**0.64***	y = 0.633x - 16.57	**0.78***	y = 0.591x - 15.47	**0.93***
A.stellata	y = 0.025x + 2.20	0.31	y = 0.490x - 12.39	**0.81***	y = 0.054x + 0.01	0.77	y = 0.226x - 4.55	0.57
C. scabridum	y = 0.374x - 7.51	0.23	y = 1.935x - 52.59	**0.77***	y = 1.319x - 35.59	**0.91***	y = 0.765x - 20.13	**0.78***
C. cingulata	y = 0.262x - 5.86	0.28	y = 0.714x - 17.87	0.19	y = 0.444x - 11.36	0.47	y = 0.330x - 6.86	0.12
Sea water pH								
T. intercoastalis	y = 3.861x - 29.73	0.72	y = 0.632x - 3.47	0.13	y = 1.216x - 7.97	0.05	y = 0.138x + 3.71	0.04
L. coronata	y = 11.520x - 90.46	**0.99****	y = 7.591x + 65.48	**0.99****	y = 8.361x + 71.20	0.25	y = 5.222x - 40.38	0.37
A.stellata	y = 0.685x - 4.16	0.19	y = 3.480x + 30.45	0.27	y = 0.597x - 3.21	0.17	y = 3.777x - 28.80	**0.80***
C. scabridum	y = 21.85x - 175	**0.67****	y = 12.95x + 11.0	0.23	y = 10.66x + 92.06	0.11	y = 0.944x + 11.35	0.06
C. cingulata	y = 14.42x - 115.9	**0.73****	y = 2.113x - 14.17	0.01	y = 11.25x + 94.30	**0.57***	y = 9.430x + 81.34	**0.52****
Seawater Salinity								
T. intercoastalis	y = 0.030x + 0.75	0.23	y = 0.036x + 0.37	0.87	y = 0.166x - 4.11	0.69	y = 0.027x + 1.59	0.5
L. coronata	y = 0.007x + 4.07	0.02	y = 0.011x + 3.82	0.04	y = 0.373x - 10.82	0.48	y = 0.010x + 2.42	0.04
A.stellata	y = 0.018x + 0.76	0.76	y = 0.127x - 2.60	0.72	y = 0.045x + 0.01	0.97	y = 0.028x + 3.46	0.14
C. scabridum	y = 0.198x - 3.29	0.28	y = 0.530x - 14.96	0.76	y = 0.848x - 26.16	**0.67***	y = 0.156x - 2.04	0.51
C. cingulata	y = 0.114x + 1.99	0.23	y = 0.439x - 12.74	**0.98****	y = 0.206x - 5.29	0.18	y = 0.233x - 5.02	**0.99****

Table 8: Results of the regression analysis between mean seasonal abundance of different gastropod species studied and mean sea water salinity, temperature and pH recorded at different study sites

Zoanthid zone

In the present study total three different species of zoanthids *viz.Palythoa mutuki, Palythoa tuberculosa* and Z*oanthus* sp. (Fig. 17) were observed occurring in the lower intertidal zone of the study sites. Specific kind of habitat preference and distribution pattern was observed for all the zoanthid species. At all study sites, it was observed that all the species have mostly confined to the lower intertidal zone due to the presence of deep and large tide pool as well as due to the presence of water during low tide (Fig. 9). In lower intertidal zone of Sutrapada, Dhamlej, and Kodinar maximum abundance of *P. mutuki* and *P. tuberculosa* were observed in upper part of lower intertidal zone while Z*oanthus* sp. was observed abundant in lower part of lower intertidal zone (Fig. 18). At Veraval, both *P. mutuki* and Z*oanthus* sp. were observed abundant in lower intertidal zone while the distribution of *P. tuberculosa* was not observed in intertidal zone (Fig. 18).

The density of *Palythoa mutuki* was recorded high as compare to other zoanthid species in lower intertidal zone of all the sites. The abundance of the species was much higher than its density at all the study sites. Maximum density and abundance of the species was observed at Dhamlej followed by Kodinar, Sutrapada and Veraval (Fig. 19a; 20a). The density and abundance was recorded high but it was declining during the monsoon and winter season (Fig. 19a; 20a). The species required specific kind of micro habitat for survival. Maximum density of the species was observed in the large tide pools filled with water. The lower intertidal area of Kodinar, Sutrapda and Dhamlej are mostly covered by large tide pool while small size tide pools were observed at Veraval. The frequency of occurrence of *P. mutuki* was observed increasing during winter and summer but it was observed declining during monsoon season (Fig. 21a). Amongst all the ecological attributes studied only mean values of frequency of occurrence showed significant variation for different seasons (ANOVA df: 9.06, $p<0.01$) as well as for different sites (ANOVA df: 17.05, $p<0.01$)(Table 9).

Palythoa tuberculosa was observed to be prominent species at lower intertidal zone at Dhamlej, Sutrapda and Kodinar but its distribution was not observed at Veraval (Fig. 18). The abundance of the species was observed very high then its density. Maximum density and abundance of the species was

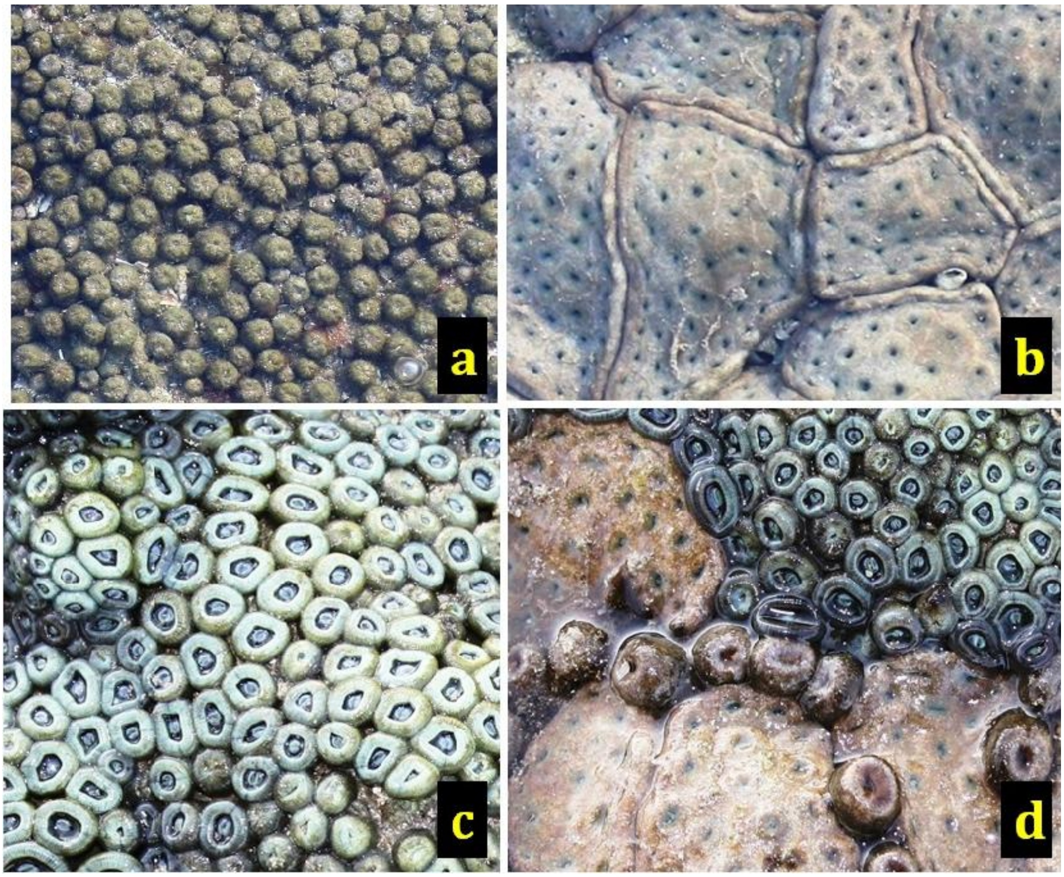

Figure 17: Zoanthid diversity of study area (a) *Palythoa mutuki* (Haddon & Shackeleton, 1891) (b) *Palythoa tuberculosa* (Esper 1805) (c) *Zoanthus* sp. (d) Mix colony of zoanthids

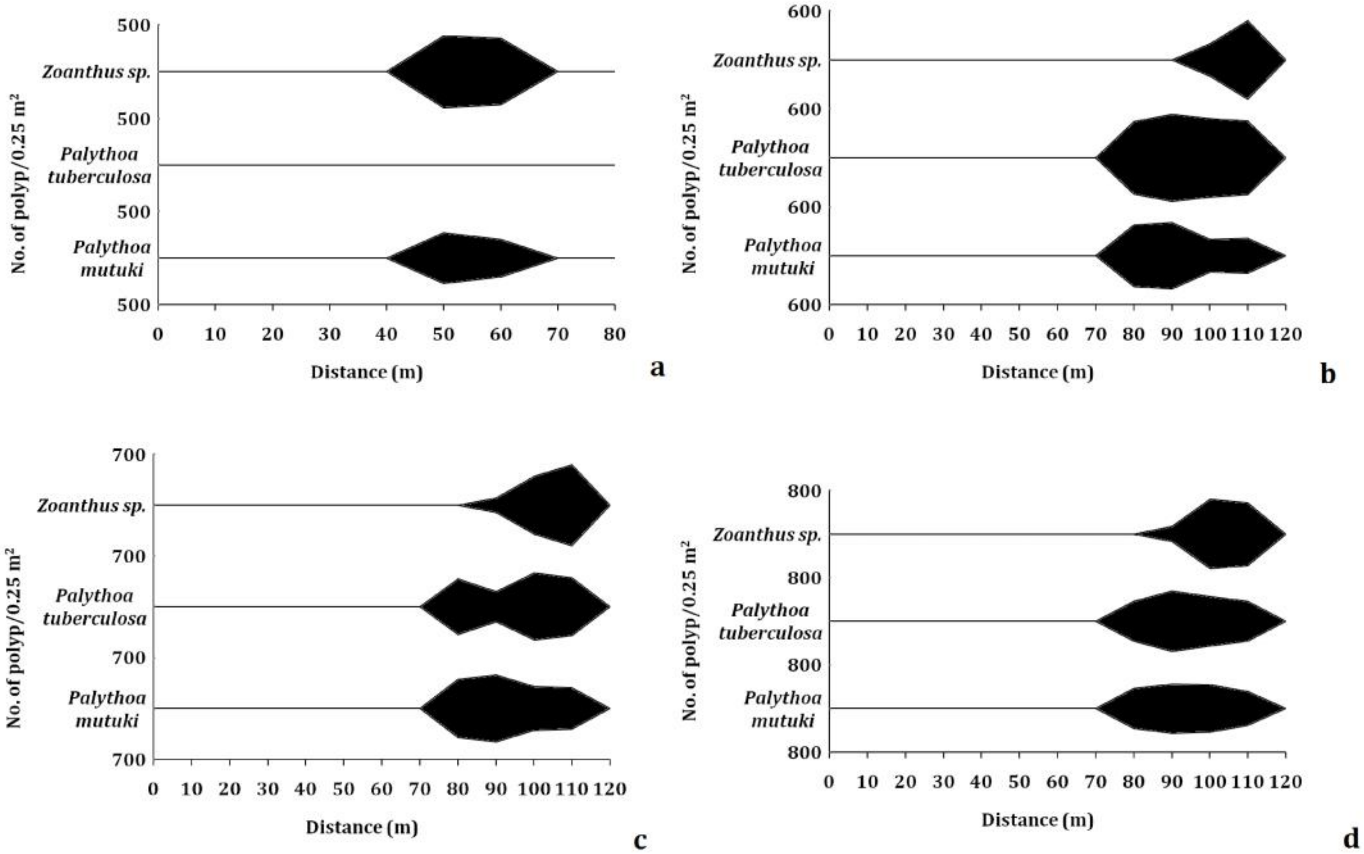

Figure 18: Intertidal distribution of zoanthid species. a. Veraval, b. Sutrapada, C. Dhamlej, d. Kodinar.

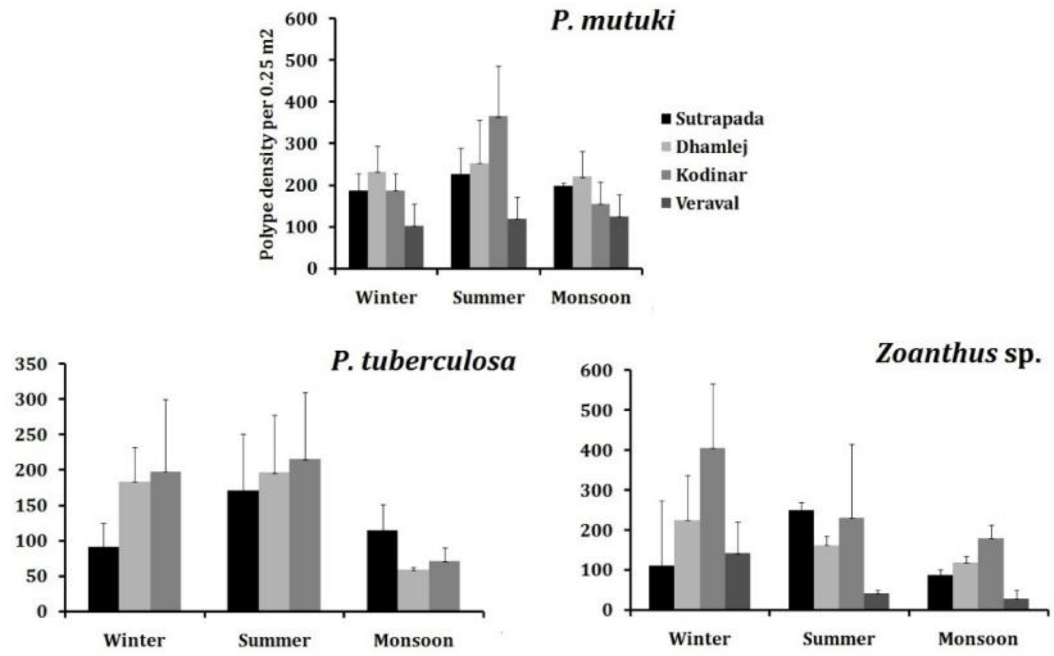

Figure 19: Seasonal mean variation in density of different zoanthid species of different study sites

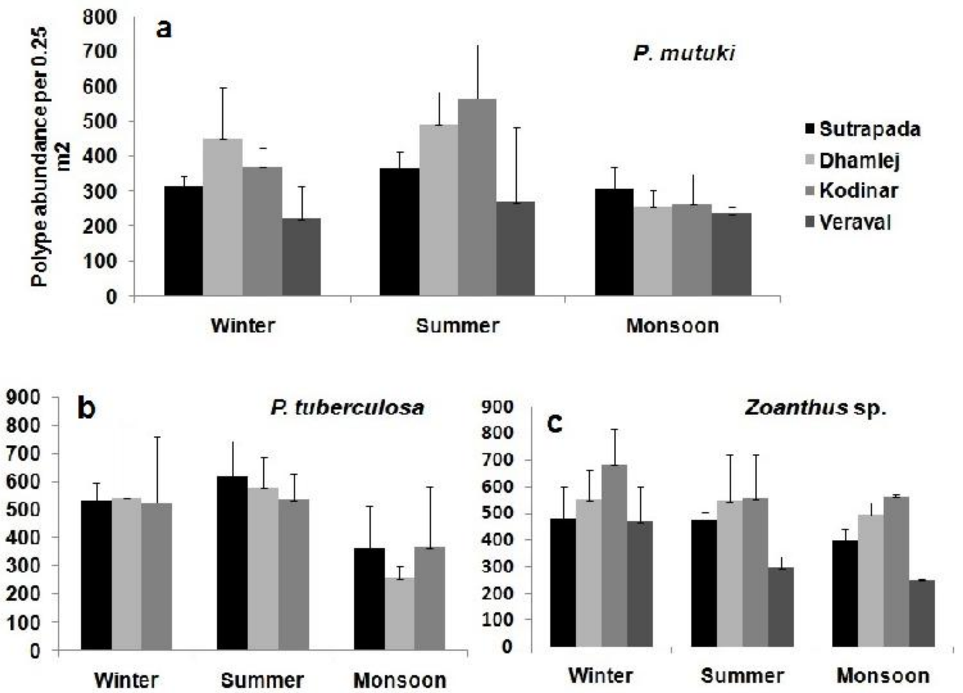

Figure 20: Seasonal mean variation in abundance of different zoanthid species of different study sites

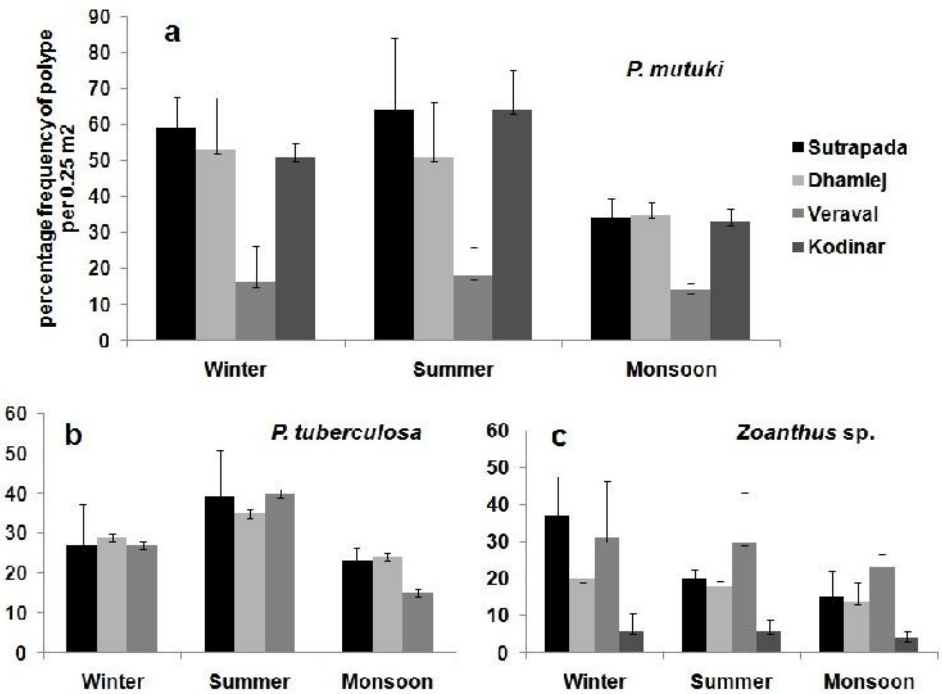

Figure 21: Seasonal mean variation in frequency of occurrence of different zoanthid species of different study sites

Species	Source of variation	Density	Abundance	Frequency
	Stations	3.63	3.02	**17.05****
P. mutuki	Seasons	2.11	4.32	**9.06****
	Stations	0.51	0.77	0.34
P. tuberculosa	Seasons	5.35	**25.61****	**16.35****
	Stations	4.26	**16.13****	**12.23****
Zoanthus sp	Seasons	2.83	**6.27***	3.74

Table 9: Results of the Two – way ANOVA without replication analysis of the mean seasonal density, abundance and frequency values of the three species of zoanthids sampled at four different sites (* $p < 0.05$; ** $p < 0.01$).

observed to be high at Kodinar followed by Dhamlej and Sutrapda (Fig. 19b; 20b). The density and abundance was recorded high during summer season while it was declining during other two seasons (Fig. 19b; 20b). Maximum density of the species was observed in shallow and large tide pools filled with water. The frequency of occurrence of P. tuberculosa was observed increasing during winter and summer but it was observed to be declining during monsoon season (Fig. 21b.). Amongst the ecological attributes studied, the mean values of all of these did not show significant variation between different sites. Mean values of ecological attributes like abundance (ANOVA df: 25.61, $p<0.01$) and frequency of occurrence (ANOVA df: 16.35, $p<0.01$) showed significant variation between different seasons (Table 9).

Zoanthus sp was observed in lowest part of lower intertidal area of all the sites. The abundance of the species was observed to be very high as compared to its density at all the study sites (Fig. 18). Maximum density and abundance of the species was observed to be high at Kodinar followed by at Sutrapda, Dhamlej and Veraval (Fig. 19c; 120c). The density and abundance was observed high in summer but it was declining during other two seasons. The species was mostly observed to be abundant near the lowest low tide line where water is available during low tide. The frequency of occurrence of *Zoanthus* Sp. was observed increasing during winter and summer but it was observed declining during monsoon season (Fig. 21c). Amongst all the ecological attributes studied, mean values of ecological attributes like abundance (ANOVA df: 16.13, $p<0.01$) and frequency of occurrence (ANOVA df: 12.23, $p<0.01$) showed significant variation between different stations. For different seasons, only the mean values of abundance showed significant difference (ANOVA df: 6.27, $p<0.05$) (Table 9).

The correlation study between abundance of different zoanthid species and different abiotic parameter. Sea water temperature and sea water salinity didn't showed significant correlation with the abundance of different zoanthid species at different study sites. The sea water pH showed certain effect on the abundance of the different zoanthid species at different study sites. Strong correlation was obtained between sea water pH and abundance of *P. mutuki* for Sutrapada site. The abundance of *P. tuberculosa* also showed strong correlation with sea water pH for Sutrapada and Dhamlej site. The abundance of *Zoanthid sp.* did not showed significant correlation with sea water pH for any site (Table 10).

	Sutrapada		Dhamlej		Kodinar		Veraval	
	Regression equation	**R2 value**	**Regression equation**	**R2 value**	**Regression equation**	**R2 value**	**Regression equation**	**R2 value**
Sea water Temp. (^{0}C)								
P. mutuki	y = 23.39x - 354.7	0.255	y = -1.425x + 468.9	0.002	y = 47.54x - 1045	0.221	y = 16.37x - 270.5	0.12
P. tuberculosa	y = 38.67x - 606.0	0.082	y = -19.75x + 1103.0	0.042	y = -17.34x + 1033	0.034		
Zoanthus sp.	y = -1.145x + 492.1	0.002	y = 4.811x + 424.3	0.004	y = 9.112x + 319	0.012	y = 28.47x - 518	0.427
Sea water Salinity								
P. mutuki	y = 6.539x + 94.76	0.187	y = 37.02x - 947.7	0.373	y = 28.47x - 616.4	0.463	y = 9.110x - 99.84	0.035
P. tuberculosa	y = 29.45x - 548.2	0.448	y = 37.35x - 890.8	0.153	y = 16.72x - 122.4	0.185		
Zoanthus sp.	y = 15.88x - 125.6	0.338	y = 15.64x - 7.336	0.046	y = 17.13x - 29.44	0.257	y = 28.69x - 693.1	0.402
Sea water pH								
P. mutuki	y = -325.2x + 2990	0.211	y = 325.9x - 2221	0.211	y = 41.16x + 93.17	0.001	y = 101.6x - 8102	**0.720****
P. tuberculosa	y = -165.88x + 1407	**0.648****	y = 557.7x - 4034	**0.573****	y = 50.38x + 910.6	0.002		
Zoanthus sp.	y = -462.5x + 4234	0.13	y = 381.9x - 2528	0.464	y = 77.51x - 38.22	0.006	y = 431.1x - 3174	0.147

Table 10: Results of the regression analysis between mean seasonal abundance of zoanthid species and mean sea water temperature, salinity and pH at different study sites (* $p < 0.05$; ** $p < 0.01$).

Discussion

For decades, the zonation pattern in various marine habitats has been subject of interest for many ecologists. The zonation pattern is studied to understand various ecological processes like predation, competition, larval settlement, food availability and desiccation. Tidal height and variations have been recorded as main contributing factors behind the zonation pattern of intertidal area. Tidal availability along with habitat complexity may influence the availability of suitable shelter which affects the survival and fitness of the organism in many ways. Availability of suitable habitat or shelter reduces the physiological stress of the animals. It also protect the animal from different kind of predators; like during the low tide the animals are more vulnerable to avian or terrestrial predator while during the high tide the animal is more vulnerable to fishes and other invertebrate predators (Stephenson and Stephenson, 1972; Ellis, 2003). Along with the availability of the shelter, the complex habitat provides greater quantity and variety of food as compared to the structurally simple habitats. The rocky intertidal area of Saurashtra coast is mostly covered by tide pools, rock crevices and small creeks in the lower zone while the upper part is made up of sandy shore which provides excellent habitat for gastropods, brachyuran crabs and zoanthid species (Vaghela, 2010). In the present study the prominent zonation pattern is recorded in which the upper intertidal zone is dominated by brachyuran crab *Ocypode ceretophthalma*, the mid intertidal zone is dominated by gastropod species and lower intertidal zone is dominated by zoanthid species.

Ghost crabs are the important part of the sandy shore ecosystem. They are the apex predator of the sandy shore macro fauna while on the other hand they provide important prey base for vertebrate animals. Ghost crab can be used as ecological indicator species to predict the effect of anthropogenic pressure on the sandy shore. Total burrow count and burrow diameter measurements can be used to estimate the density of the ghost crabs in the field when the sandy shore is less affected by the anthropogenic activities (Lucrezi et al., 2009). In the present study, the population size of *O. ceratophthalma* varied between different seasons and stations. Maximum density and abundance of the species was recorded from Kodinar followed by Sutrapada, Dhamlej and Veraval. The population of the species could be affected by the level of the anthropogenic pressure on the sandy shore because the sandy beach of the Veraval and Dhamlej are affected by high and moderate anthropogenic activities respectively while the amount of anthropogenic pressure on sandy shore of Sutrapada and Kodinar is comparatively less (Vaghela, 2010).

The density, abundance and frequency of occurrence of the species also varied between different seasons in which values of all the parameters were recorded high in monsoon season as compared to other seasons. In monsoon season, the species occurred in high numbers during the month of July and August. Strachan et al., (1999) had studied the ecology of *Ocypode cursor* and they also recoded similar kind of results and suggested that the time period of July and August is believed to be the juvenile recruitment of the species. The mean values of different ecological attributes varied significantly between different stations and seasons but the values of significance was recorded high for different seasons which showed that seasons have immense impact on the distribution pattern of the species.

In the present study it was observed that the number of burrow increase towards the upper part of the sandy shore away from the water line. Differences have been recorded in terms of burrow diameter in which the burrows with large diameter were recorded near upper part of the sandy shore while burrows with small diameter were recorded near the water line. Shuchman and Warbung (1978) and Strachan et al., (1999) also recorded similar findings where they generally noted high numbers of juvenile crabs closer to the sea, with the more adults were located at a greater distance from the sea. They commented that the variation in spatial distribution of adults and juveniles is most probably a function of physiological competence. The correlation study with sediment abiotic parameters and abundance of the species showed that sediment pH showed some impact on the abundance of the species.

All the species of genus *Ocypode* showed change in the area they occupy in a dynamic way with conditions of available space, temperature, etc at each geographic region (Shuchman and Warbung, 1978). Spatial variability has always been addressed in sandy beach ecology. Therefore, it is recommended that counting number of ghost crabs be included in ecological or morphological sand dunes survey, because dune modification will affect part of the habitat of these animals. Neves and Bemvenuti (2006) had suggested that the number of burrows is a rapid tool for impact verification at sandy beach and for use in environmental monitoring programs. In conclusion, the results of this study suggested that the present study area can provide suitable habitats for *O. ceratophthalma* population. *Ocypode ceratophthalma* does not seem to be much vulnerable to anthropogenic disturbances and environmental alteration at Saurashtra coast.

In the mid intertidal zone gastropods occurred in high densities. Out of different species of gastropods occurred in the mid intertidal zone, five species like *Turbo intercostalis*Menke, 1846, *Lunella coronata* (Gmelin, 1791), *Astrea stellata* (Gmelin, 1791), *Cerithium scabridum* Philippi, 1848 and*Cerithedia cingulata* (Gmelin, 1791) were reported as a dominant species occurring in the gastropod zone of all the study sites. Distribution and population structure of five different gastropod species showed variation between different study sites in different seasons. Population densities and abundance of different species like, *Certithium scabridum, Cerithedea cingulata* and *Lunella coronata* showed significant variation in different seasons. Amongst all the species studied *Cerithium scabridum* was found to be dominant at all the study sites because the species utilizes wide range of micro habitat (Houbrick, 1992; Gohil and Kundu, 2011).

Maximum density and abundance of *C. scabridum* was found at Veraval and Dahmlej because the intertidal areas of Veraval and Dhamlej have shallow tide pools with plenty of rock crevices which are the most favorable habitat of the species (Houbrick, 1992; Vaghela, 2010). *C. scabridum* was found to be distributed evenly in all the zones of intertidal area and being one of the most common gastropod species utilized by different carnivore species as a food while hermit crabs use the empty shells of the species as a shelter (Trivedi et al., 2013). The abundance of the species showed significantly strong correlation with sea water temperature at all the study sites except Veraval (Table 3) which showed that sea water temperature has pronounced effect on the distribution of *C. scabridum.* The maximum density and abundance of *L. coronata* was observed in summer season followed by winter and summer. Maximum abundance of the species was observed in the upper intertidal zone of all the study sites because the species is mostly found in rock crevices and shallow tide pools which remains filled with water during low tide. The mean values of all the ecological attributes of *L. coronata* population also showed significant variation for different seasons because being the upper intertidal dweller the species experiences the seasonal changes in the water quality (Mishra and Kundu, 2005).

However, the species abundance showed strong correlation with sea water temperature at all the study sites which imply that the change in the population of the species is highly influenced by sea water temperature. In case of *Astrea stellata* the mean values of different ecological attributes did not show significant variation for seasons but they showed significant variation for different stations. Maximum abundance and density of *Astrea stellata* was found at Kodinar as compared to other sites possibly because the species is gregarious in nature and mostly found in large to small congregations at the bottom of tide pools. Intertidal area of Kodinar is flat with large and deep tide pools which remain filled with water during low tide, a suitable habitat for *A. stellata.* The frequency of occurrence of the species was less at Veraval and Dhamlej because of the high level of anthropogenic pressure on the intertidal area at these two sites (Sarvaiya, 1977).

The sea water pH showed strong correlation with abundance of the species at Kodinar which implies that the tide pool water also played a key role in population growth of the species.*Turbo intercoastalis* belonging to family Turbinidae is amongst the most common gastropod species of intertidal zone of Saurashtra coast of Gujarat state (Apte, 1998; Trivedi et al., 2013). In the present study no significant variation is observed for mean values of different ecological attributes studied for the species. The abundance of species also didn't show any correlation with different abiotic parameters. The species showed even distribution in all the zones of intertidal area of all the study sites. Maximum density and abundance of the species were recorded at Kodinar as compared to other sites because at other sites the species is facing huge pressure of over fishing by local people for consumption (Sarvaiya, 1977). *Cerithedea cingulata* was restricted to upper intertidal zone because the species requires specific kind of micro habitat like rock crevices and small creek in where less water remain filled in during the low tide time. The mean values of density and abundance showed significant variation for different seasons which implies that seasonal variation has immense impact on the population structure of the species. The abundance of the species showed strong correlation with sea water salinity at Sutrapada and Kodinar which could be the possible reason behind selection of micro habitat like rock cervices by the species in which water doesn't get filled during low tide and salinity fluctuations in water will not affect the species.

Our earlier and present studies indicated that a biotic zonation was apparent on inter tidal area, besides physical zonation. The sub terrestrial region has prominent sand dunes at Sutrapada and Kodinar followed by at Dhamlej and least at Veraval coast. The Veraval coast was typically small with sudden and conspicuous down fall of the shore line leading the brief sub littoral region to deep infra littoral region. Therefore, here the maximum and minimum exposure limits were almost similar leading to least variation in the distribution profile of flora and fauna on inter tidal area. The physiographic gradations as well as variations in the size of tide polls at other three study sites were distinct and formed a typical zonation pattern on inter tidal area. Possibly, this lead to occurrence of variety of distinct micro habitats influencing the floral and faunal diversity and distribution in different zones of inter tidal area.

The zoanthids were the dominant species on the mid and lower inter tidal area. The zoanthids had patchy distribution in mid inter tidal zone while they cover almost entirely the lower inter tidal zone. We noted that the mollusca were abundantly distributed in the upper and middle inter tidal zone and were comparatively less in the lower inter tidal zone. We believe that possibly, the release of bioactive chemicals of zoanthids restrict and regulate the distribution of mollusca and other species in the lower inter tidal area. In the present study it is also observed that water quality, microhabitat type and availability and seasons have immense impact on the population structure of different gastropod species.

The species belonging to different genera like *Palythoa* and *Zoanthus* are very common in rocky intertidal area or coral reefs and have great influence on the local benthic fauna. Worldwide several studies have been carried out on the population dynamics and intertidal distribution of zoanthids (Acosta et al., 2005) but as far as the Indian subcontinent is concerned very few studies have been carried out on the population dynamics and ecology of zoanthids (Pandya and Mankodi, 2013). We observed that zaonthid species required specific kind of micro habitat for survival and growth. *P. mutuki* and *P. tuberculosa* were very common in Zone 3 of lower intertidal area where specific kind of micro habitats, like wide (2 to 5m) and deep (0.5 to 1m) tide pools, were available.

Irei et al., (2011) conducted study on distribution pattern of zoanthids at Okinava Island, Japan and have reported that density of different species of genera like *Palythoa* and *Zoanthus* were high in different kind of microhabitats like reef crest, reef slope and reef moat. Zoanthids use sand particles and detritus material present in the water column to make their structure (Reimer and Hickman, 2009). Due to different kind of industrial and mining work that are carried out along the coastal region of the study sites, the present study area is facing huge problem of sediment load which on the other hand help the zoanthid to grow their population. Except sediment, the geomorphology and physiographic characters like flatness of the intertidal area which reduces wave action and presence of wide and large tide pools that remain filled with the water during low tide also favor the growth of zoanthids.

In the present study, *P. mutuki* was observed as the dominant zoanthid species at all the study sites. The results of ANOVA test suggested that no significant variation was observed for the mean values of density and abundance of the species but significant variation was noted for the mean values of frequency of occurrence of the species for different study sites and different seasons (Table 4). Maximum density of the species was observed during summer as compared to other seasons which may be due to the maximum exposure observed during the months of summer. Maximum density and abundance of the species was observed at Kodinar, Dhamlej and Sutrapda because the rocky intertidal areas of these study sites are flat platform in shape and made up of large number of tide pools of different sizes and shapes. However, regression and correlation analysis between different abiotic factors and abundance of the species for different sites and seasons showed no significant results except for pH that showed moderately significant correlation with the abundance of the species in monsoon season at Veraval where pH value fluctuations were observed to be high in different seasons.

The distribution of *P. tuberculosa* was patchy at Kodinar, Dhamlej and Sutrapda in Zone 3 of lower intertidal area. As per the ANOVA results, non significant variation was observed for mean values of density, abundance and frequency of the species between different study sites but significant variation was observed for the mean values of abundance and frequency of the species between different seasons. This kind of phenomena was observed due to the discontinuous and patchy distribution of the species at different study sites and another possible reason could be that the species may be competing with *P. mutuki* for space (Pandya et al., 2012). Perez et al., (2005) have studied the structure of animal community associated with *Palythoa caribaeorum* and stated that the animal like barnacles compete with them for the space for their survival. However, regression and correlation analysis between different abiotic factors and abundance of the species for different sites and seasons showed no significant results except for pH that showed moderately significant correlation with the abundance of the species at Sutrapada and Kodinar. Distribution of the species was not observed at Veraval because *P. tuberculosa* requires wide and deep tide pools for survival that was not available at Veraval.

The distribution of Zoanthus sp. was observed mostly in zone 4 of lower intertidal area of different sites. Some time the colonies of *Zoanthus* sp. were observed coexisting with the colonies of *P. tuberculosa* and *P. mutuki* in the intertidal areas of the coastal Saurashtra (Pandya et al., 2012) but in this kind of mixed colonies *P. tuberculosa* was found as dominant species. Maximum density and abundance of the species was observed at Kodinar followed by Sutrapda, Dhamlej and Veraval because large colonies of the species were distributed in different patches of zone 4 of the lower intertidal area of the sites. The results of ANOVA revealed that significant variation was observed for the mean values of abundance of the species at different sites in different seasons. The results of ANOVA also showed significant variation for the mean values of frequency of occurrence at different stations. This kind of phenomena was observed due to the patchy distribution of the species and the fluctuations in the width of the exposure during different seasons. It was reported that different kinds of abiotic factors, seasons and geomorphology of the intertidal area have immense effect on the intertidal distribution of benthic fauna along the Saurashtra coast (Sarvaiya, 1977; Prasad and Mansuri, 1982; Mishra and Kundu, 2005). However, regression and correlation analysis between different abiotic factors and abundance of the *Zoanthus* sp for different sites and season showed non significant results.

The present study reports the distribution pattern of three different zoanthid species along the coastal Saurashtra, Gujarat. Significant variations were observed for different kinds of ecological attributes like density, abundance and frequency of occurrence for different zoanthid species. Different kinds of abiotic factors also play significant role in the spatio-temporal distribution of the zoanthid species. Amongst the three species studied, *P. mutuki* was observed to be dominant as compared to other zoanthid species in the study area and it was competing with other two species for the space. Long term monitoring on the distribution and population dynamics of zoanthid species is needed to find out its impact on the local benthic fauna.