Study of intertidal distribution of *Cerithium scabridum*, Philippi, 1848 (Mollusca, Gastropoda) along the coastal Saurashtra, Gujarat, India

Jigneshkumar N. Trivedi and Kauresh D. Vachhrajani*

Marine Biodiversity and Ecology Lab, Department of Zoology, Faculty of Science,
The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India
*corresponding Author: kauresh@gmail.com

Abstract : Intertidal distribution of *Cerithium scabridum* was studied on rocky Intertidal areas at Sutrapada (SP), Dhamlej (DH) and Kodinar (KO) along the coastal Saurashtra, Gujarat, India. Total 10 Line transect intercepted with 0.25 m^2 quadrate were laid perpendicular to the shore line at each study site every month (December, 2011 to December, 2012). Total 6 quadrates (0.25 m^2) were laid randomly per line transect from upper to lower intertidal mark for the quantification of the species. Maximum abundance of the *C. Scabridum* was observed in upper intertidal zone of all the study sites. Ecological attributes like abundance, density and frequency of occurrence of species were also calculated and they exhibited significant spatio-temporal variations at different study sites. Seasonal variability of sea water parameters like sea water temperature, salinity and pH were also studied and correlated with ecological attributes of species. Sea water temperature showed significant correlation with mean seasonal abundance of the species at all the study sites (SP: R^2=0.77, P<0.05, DH: R^2=0.91, P<0.05, KO: R^2=0.78, P<0.05). In the present study, It was observed that seasonal changes in abiotic factors and chemical properties of sea water has prominent effect on the intertidal distribution of the species.

Key words **:** *Cerithium scabridum,* Intertidal zone, Saurshtra coast, Seasonal abundance.

Introduction

The coastal marine ecosystem supports variety of habitats that consequently support high species diversity. In coastal areas, the intertidal zone is considered as most diverse and productive because with in the area of few meters various kinds of flora and fauna are observed (Underwood, 2000). The intertidal zone has been studied extensively for its biodiversity in last two-three decades (Little and Kitching, 1996). Vertical zonation is the most important process or phenomena observed on the rocky intertidal area in which from upper to lower intertidal area, different bands or zones containing different biodiversity are observed (Stephenson and Stephenson, 1949; Bandel and Wedler, 1987; Ellis, 2003). The variation in the distribution and abundance of organisms in different zones of intertidal zone has provided basis for so many ecological experiments and such complex patterns of variation have been studied well specially for the organisms of rocky intertidal area (Archambault and Bourget 1996; Blanchard and Bourget 1999; Trivedi et al., 2012). Intertidal distribution pattern, population structure and seasonal variation in abundance have been studied extensively to know the various ecological processes (Raffaelli and Hughes, 1978; Myers and McGrath, 1993). Intertidal distribution pattern and abundance variation related to different season have been studied for many molluscan species (Chapman, 1994; Olabarria and Chapman, 2001; Sagarin and Gaines, 2002). Molluscan shells have been found important for various commercial purposes like poultry food, medicines, industrial raw material, fisheries, handicrafts and interior decoration.

Gujarat has approximately 1650 km long coastline and the total coastal area covered by different kinds of marine habitats include 29 % of muddy flats followed by 28 % of sandy beaches, 22 % of marshy coast, and 21 % of rocky coast. The intertidal area of Saurashtra coast is narrow in width and rocky in nature, which is made of milliolite lime stones (Vaghela, 2010). Saurashtra coast is very diverse in case of marine biota and studies on distribution and diversity of marine invertebrates have been carried out by different organizations and researchers (Raghunathan, et al., 2004; Mishra and Kundu, 2005; Joshi, 2010; Vaghela, 2010). The gastropod fauna of Gujarat have been studied well and total 188 species were identified (Apte, 1998). The commercially important gastropods are harvested extensively from various marine areas of India and their population is declining at alarming rate. So for the conservation of the gastropod species, studies are required to carve the real picture of the population status of various species (Apte, 1998). Few studies have been done on the intertidal distribution of gastropod species along the coastal region of Saurashtra, Gujarat (Mishra and Kundu, 2005; Gohil and Kundu, 2013). The main aim of the present investigation was to study the spatio-temporal distribution of *Cerithium scabridum* with relation to various abiotic factors.

Materials and Methods

The study was conducted at three different sites of coastal area of Saurashtra, Viz. (1) Sutrapada (20^0 49' 53" N, 70^0 29' 17" E), (2) Dhamlej (20^0 46' 29" N, 70^0 36' 19" E) and (3) Kodinar (20^0 45' 29" N, 70^0 39' 39" E) (Fig. 1). The intertidal area is mostly rocky in nature with upper portion made up of sandy shore. The exposure area or width of the intertidal zone varies from 60 meters to 150 meters. The width of the

intertidal zone also varies with the tide cycle. Evident zonation pattern in intertidal area was observed at all the study sites (Trivedi and Vachhrajani, 2012).

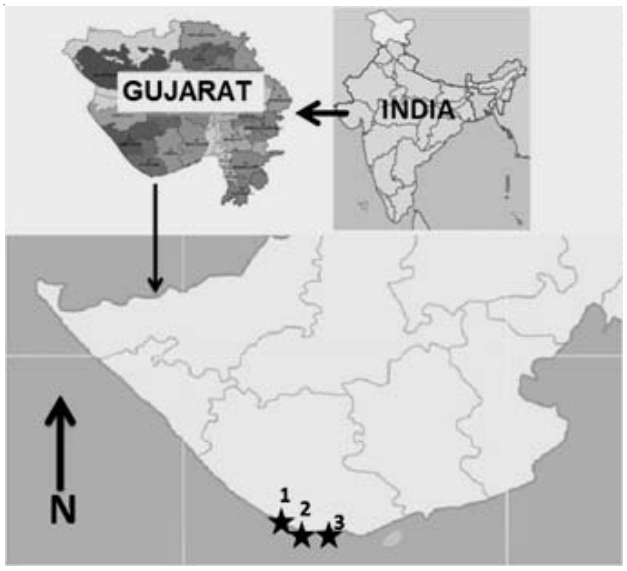

Fig. 1 Map of study area (1) Sutrapada (2) Dhamlej (3) odinar

In the present study, the intertidal area was divided into three zones including upper, middle and lower intertidal zone. The population of *Cerithium scabridum* was surveyed using line transect intercepted with 0.25 m^2 quadrate. Total 10 line transects were laid randomly perpendicular to the shore line covering all three zones and three quadrates (one quadrate per zone) were laid randomly on each transect. Among the abiotic factors, surface water temperature, pH and salinity were recorded using digital 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. winter (November to February), summer (March to June) and monsoon (July to October). Monthly data was also recorded for three different abiotic factors. In statistical analysis of the data two way ANOVA without replication was applied 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 and Discussion

The mean seawater temperature varied between different stations. The maximum temperature was observed at Dahamlej (32.45 ± 1.62) in summer season while minimum temperature was observed at Sutrapada (28.46 ± 0.78) in winter season. The mean sea water pH did not fluctuate between different stations in different seasons. Maximum pH 8.36 was observed at Kodinar during monsoon season while minimum pH 7.77 was recorded at Dhamlej in monsoon. The mean sea water salinity varied between different stations in different seasons. At Kodinar the mean sea water salinity varied between 39.63% in summer to 30.1% in monsoon, possibly due to the addition of fresh water in sea water during monsoon (Table. 1).

Table 1. Seasonal variation in the mean values of different abiotic factors at different stations

	Sutrapada	Dhamlej	Kodinar
Sea water temp.(^{0}C)			
Winter	28.46 ± 0.78	30.8 ± 0.92	29.76 ± 1.59
Summer	30.42 ± 0.55	32.45 ± 1.62	32.27 ± 1.68
Monsoon	29.15 ± 0.55	28.7 ± 1.41	30.75 ± 1.06
Sea water pH			
Winter	8.27 ± 0.29	8.06 ± 0.09	8.18 ± 0.07
Summer	8.12 ± 0.17	8.34 ± 0.19	8.27 ± 0.19
Monsoon	8.14 ± 0.10	7.77 ± 0.26	8.36 ± 0.29
Salinity			
Winter	36.62 ± 1.09	37.66 ± 1.60	37.63 ± 1.38
Summer	39.42 ± 1.78	38.32 ± 1.57	39.63 ± 1.38
Monsoon	32.25 ± 0.34	33.7 ± 0.97	30.1 ± 1.80

Cerithium scabridum belonging family certhiidae is one of the common gastropod of rocky intertidal area. The species has got high spired shell that is three time as long as wide. The species has got 9- 10 whorls. The species is brownish in color with contrasting pattern of brown and white mottles on the cord. The distribution of the species is wide spread ranging from red sea to western and southern Indian Ocean (Houbrick, 1992). In the present study the maximum abundance of the species was observed in the upper intertidal zone as compare to other zones of intertidal area. Maximum abundance of the species was observed at the upper intertidal area of Dhamlej followed by Sutrapada and Kodinar (Fig. 2).

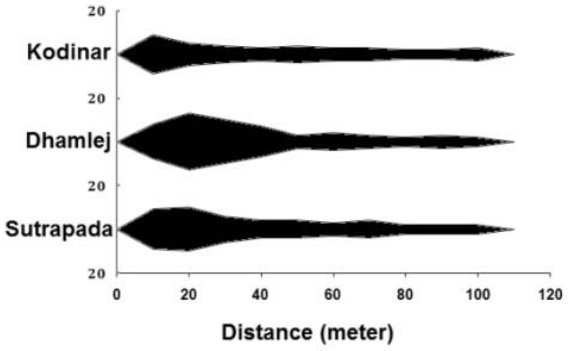

Fig. 2 Intertidal distribution of *Cerithium scabridum*

The abundance of the *Cerithium scabridum* showed fluctuations in different season between different stations. maximum abundance of the species was observed at Dhamlej (7.7±5.89) followed Sutrapada (6.69±5.85) and Kodinar (4.8±4.99) in summer season while in case of winter and monsoon season the abundance was more or less same at all the study sites (Fig.3). The result of ANOVA showed significant variation for the mean values of the seasonal abundance of the species but significant variation was not observed between station specific abundance of the species (Table 2).

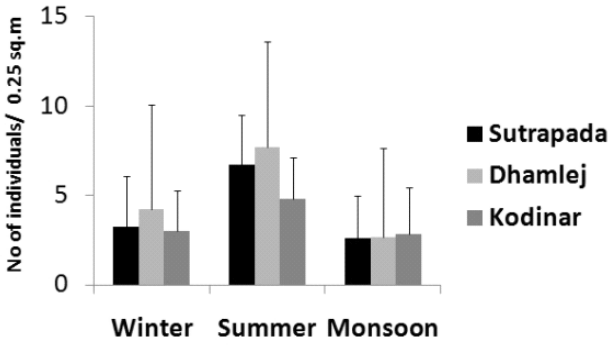

Fig. 3 Seasonal mean variation in abundance of *Cerithium scabridum* at different study sites

The Density values of the *C. scabridum* showed similar trend like abundance. The density of the species was observed low as compare to abundance of the species. Maximum abundance of the species was observed at Dhamlej (3.08±5.87) followed by Sutrapada (2.78±5.84) and Kodinar (1.23±2.59) in summer season while in case of winter and monsoon the density of the species observed more or less same (Fig. 4). The result of ANOVA showed significant variation for the mean values of the seasonal abundance of the species but significant variation was not observed between station specific abundance of the species (Table 2)

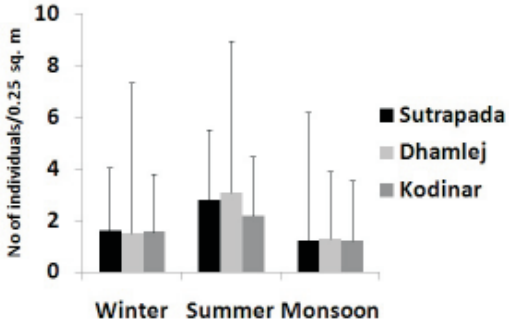

Fig. 4 Seasonal mean variation in density of *Cerithium scabridum* at different study sites

The frequency of occurrence values of the *C. scabridum* also showed similar trend like abundance. The values of the frequency of occurrence of the species were observed very high as compare to density and abundance of the species because the species lives in the congregation and the distribution of the species was observed very patchy at all the study sites. Maximum frequency of occurrence of the species was observed at Dhamlej (49±5.27) and Sutrapda (49±5.67) followed by Kodinar (38±4.56) in summer season while in monsoon season little increase in frequency of occurrence of the species was observed at Dhamlej (Fig.5). The result of ANOVA showed significant variation for the mean values of the seasonal abundance and station specific abundance of the species (Table 2).

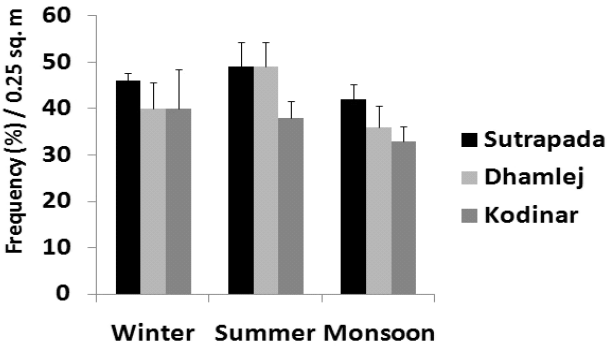

Fig. 5 Seasonal mean variation in freq. of occurrence (%) of *Cerithium scabridum* at different study sites

Table 2. Results of the Two – way ANOVA without replication analysis of the mean seasonal density, abundance and frequency values of *C. scabridum* sampled at three different sites (* p < 0.05; ** p < 0.01).

	source of variation	Density	Abundance	Freq. of occurrence
C. scabridum	stations	1	1.97	**3.57****
	seasons	**23.28****	**17.51****	**2.41***

In the present study it was observed that abundance of the species was recorded maximum in the upper intertidal area as compared to other zones because Cerithium species prefers tide pools to live that are present in the intertidal area (Houbrick, 1992; Gohil and Kundu; 2011). The rocky intertidal area of Saurashtra coast is mostly covered by tide pools that provides excellent habitat for gastropod species (Vaghela, 2010). Gohil and Kundu, 2013 have conducted study on population structure of *Cerithidum caeruleum* and observed that the maximum abundance of the species was observed at upper and middle intertidal zone where tide pools are available.

Table 3. Results of the regression and correlation coefficient analysis between mean seasonal abundance of *C. scabridum* and mean sea water temperature, salinity and pH (* p < 0.05; ** p < 0.01).

	Equation	R^2 value
Temperature		
Sutrapada	y=1.93x-52.59	**0.77***
Dhamlej	y=1.31x-35.59	**0.91***
Kodinar	y=0.76x-20.13	**0.78***
Salinity		
Sutrapada	y=0.53x-14.96	0.76
Dhamlej	y=0.84x-26.16	**0.67***
Kodinar	y=0.15x-2.04	0.51
pH		
Sutrapada	y=- 12.95x+110.0	0.23
Dhamlej	y= 8.83x-66.36	**0.94****
Kodinar	y=- 0.94x+11.35	0.006

The values of seasonal and site wise frequency of occurrence of the species were observed high as compare to seasonal and site wise abundance and density of the species that shows that the species is slightly colonial in nature. Gohil and Kundu, 2011 have conducted study on ecological status of *Rhinoclavis sinensis* at the intertidal zone of Dwarka and they noted same phenomena for density abundance and frequency of occurrence of the species. Maximum abundance and density of the species was observed at Dhamlej as compare to other sites. The intertidal area of the Dhamlej is flat in nature and also covered with small and large tide pools that remain filled with water during low tide that provides appropriate habitat for different macrobenthic species. 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). Regression and correlation analysis between sea water temperature and abundance of the *C. scabridum* showed significant correlation at all the study sites that show that sea water temperature plays an important role in the distribution of the species. Among all the study sites, significant correlation was observed between all the abiotic factors and abundance of the species at Dhamlej only which shows that the intertidal area of Dhamlej presents healthier habitat for *C. Scabridum* as compared to other sites (Table 3). The contamination of different pollutants into the sea water affects the quality of the sea water that on the other hand affects the distribution, density and abundance of the molluscan species (Bishop et al., 2002).

Conclusion

Genus *Cerithium,* a microphagous herbivore, spans a broad variety of habitats, but the great majority lives intertidally or in shallow water. Most species have a planktotrophic larval stage and wide geographic distribution. The Indo-Pacific Marine Province supports 68 percent of all *Cerithium* species. Total 42 living species have been reported so far from the world under the genus (Houbrick, 1992). *Cerithium scabridum* is 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 species requires specific set of microhabitat and abiotic factors for survival and little alteration in microhabitat or abiotic factors may affect the population of the species.

Acknowledgments

The authors are thankful to Mr. Ravi Vasava, Mr. Vishal Panlhania and Mr. Kalpesh Gohel for technical help during field work. Trivedi J. N. is thankful to UGC- RFSMS fellowship for financial assistance during the study.

References

Apte, D. 1998. Book of Indian shells. Bombay Natural History Society, Mumbai, India. 115pp.

Archambault, P. and Bourget, E. (1996) Scales of coastal heterogeneity and benthic intertidal species richness, diversity and abundance. Marine Ecology Progress Series. 136: 126–132.

Bandel, K. and Wedler, E. (1987) Hydroid, amphineuran and gastropod zonation in the littoral of the Caribean Sea, Colombia. Senckenb. Marit. 19: 1-129.

Bishop, M. J., Underwood, A.J. and Archambault, P. (2002) Sewage and environmental impacts on rocky shores: necessity of identifying relevant spatial scales. Marine Ecology Progress Series. 236: 121–128.

Blanchard, D. and Bourget, E. (1999) Scales of coastal heterogeneity: Influence on intertidal community structure. Marine Ecology Progress Series. 179: 163–73.

Cecalupo, A., Buzzurro, G. and Mariani, M. (2008) Contributo alla conoscenza della malacofauna del Golfo di Gabes (Tunisia). Quaderni della civica stazione idrobiologica di Milano. 31: 1-268.

Chapman, M.G. (1994) Small- and broad-scale patterns of distribution of the upper-shore littorinid *Nodilittorina pyramidalis* in New South Wales. Australian Journal of Ecology. 19: 83–95.

Chapman, M.G. (2002) Patterns of spatial and temporal variation of macrofauna under boulders in a sheltered boulder field. Austral Ecology, 27: 211–228.

Crocetta, F., Renda, W. and Vazzana, A. (2009) Alien Mollusca along the Calabrian shores of the Messina Strait area and a review of their distribution in the Italian seas. Bollettino malacologico. 45: 15-30.

Ellis, D.V. (2003) Rocky shore intertidal zonation as a means of monitoring and assessing shoreline diversity recovery. Marine Pollution Bulletin. 46: 305-307.

Gofas, S. and Zenetos, A. (2003) Exotic molluscs in the Mediterranean basin: current status and perspectives. Oceanography and marine biology: an annual review. 41: 237-277.

Gohil, B. and Kundu, R. (2011) Ecological status of *Rhinoclavis sinensis* at Dwarka Coast, Gujarat (India). The Ecoscan. 5: 131-134.

Gohil, B. and Kundu, R. (2013) Ecological status of *Cerithidum caeruleum* at Dwarka coast, Gujarat, India. Indian Journal of Geo-Marine Sciences. 42(4): 481-486.

Houbrick, R.S. (1992) Monograph of the genus *Cerithium* Bruguière in the Indo-Pacific (Cerithiidae: Prosobranchia).Smithsonian contributions to Zoology. 510: 1-211.

Joshi, K. A. (2010) Spatial and temporal variations in population dynamics of few key rocky intertidal macrofauna at tourism influenced intertidal shoreline, PhD thesis, Saurashtra University, Gujarat, India.

Kelaher, B. P. and Cole V. J. (2005) Variation in abundance and size-structure of populations of the small chiton, *Acanthochitona retrojecta.* Journal of Molluscan Studies. 71: 145–151.

Lavie, B. and Nevo, E. (1986) Genetic diversity of marine Gastropods: contrasting strategies of *Cerithium rupestre* and *C. scabridum* in the Mediterranean Sea. Marine Ecology Progress Series. 28: 99-103.

Little, C. and Kitching, J. A. (1996) The Biology of Rocky Shores. Oxford University Press, New York, USA. 240 pp.

Misra, S. and Kundu, R. (2005) Seasonal variations in population dynamics of key intertidal mollusks at two contrasting locations. Aquatic Ecology. 39: 315-324.

Myers, A. A. and Mcgrath, D. (1993) Settlement and growth of the intertidal gastropod *Melarhaphe neritoides* on the south coast of Ireland. Journal of the Marine Biological Association of the United Kingdom. 73: 313–319.

Olabarria, C. and Chapman, M. G. (2001) Comparison of patterns of spatial variation of microgastropods between two contrasting intertidal habitats. Marine Ecology Progress Series. 220: 210–211.

Prasad, M. N. and Mansuri, A. P. (1982) Population density of the Limpet, *Cellana radiata* (Born) in polluted waters at Porbandar, West coast of India. Indian Journal of Marine Sciences. 11: 180–181.

Raffaelli, D. G. and Hughes, R. N. (1978) The effects of crevice size and availability on populations of *Littorina rudis* and *Littorina neritoides*. Journal of Animal Ecology. 47: 71–84.

Raghunathan, C., Sen Gupta, R., Wangikar, U. and Lakhmapurkar, J. (2004) A record of live corals along the Saurashtra coast of Gujarat, Arabian Sea. Current Science. 87(8): 1131-1138.

Sagarin, R. D. and Gaines, S. D. (2002) Geographical abundance distributions of coastal invertebrates: using one-dimensional ranges to test biogeographic hypotheses. Journal of Biogeography. 29: 985–997.

Sarvaiya, R.T. (1977) Studies on mollusca of Saurashtra Coasts-1. Fish Technology. 1: 27–32.

Sibaja-Cordero, J. A. and Cortes, J. (2008) Vertical zonation of rocky intertidal organisms in a seasonal upwelling area (Eastern Tropical Pacific), Costa Rica. Revista de biologia tropical. 56 (4): 91-104.

Stephenson, T. A. and. Stephenson, A. (1949) The universal features of zonation between tide-marks on rocky coast. Journal of Ecology. 37: 289-305.

Trivedi, J. N., Gadhavi, M. K and. Vachhrajani, K. D. (2012) Diversity and habitat preference of brachyuran crabs in Gulf of Kutch, Gujarat, India. Arthropods. 1(1):13-23.

Trivedi, J. N., Arya S. and Vachhrajani K. D. (2013) Gastropod shell utilization preferences of hermit crab *Clibanarius zebra* (dana, 1852) (diogenidae, anomura). Taprobanica. 5 (1): 12-18.

Turra, A. and Dendai, M. R. (2006) Microhabitat use by two rocky shore gastropods in an intertidal sandy substrate with rocky fragments. Brazilian Journal of Biology. 66(1): 351-355.

Underwood, A. J. (2000) Experimental ecology of rocky intertidal habitats: what are we learning? Journal of Experimental Marine Biology and Ecology. 250: 51–76.

Vaghela, A. (2010) Spatial and temporal variations in population dynamics of few key rocky intertidal macrofauna at anthropogenically influenced intertidal shoreline. Ph. D. Thesis, Saurashtra University, Gujarat, India.

Venkatesan, V, Kalidas, C, Zacharia, P.U. and Rajagopal, S. (2010) **Distribution of molluscan fauna in the Karangad estuarine mangroves, south east coast of India.** Advances in Environmental Sciences - International Journal of the Bioflux. 2 (2): 113-119.

Wallace, L. (1972) Some factors affecting vertical distribution and Resistance to desiccation in the limpet, *Acmaea testudinalis.* Biology Bulletin. 142: 186-193.