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Quantitative Study of Molluscan Diversity at Disturbed and Non-Disturbed Site along the Sikka Coast, Jamnagar, Gujarat, India

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ABSTRACT
Habitat destruction and biodiversity loss due to the port, harbor and jetty development are consistent in the Gulf of Kachchh (GoK). The present paper highlights the quantitative analysis of molluscan fauna at two sites divided by GSFC jetty. GoK inundates tide from the west (mouth of GoK) hence left side of the GSFC jetty road (called Vador site 1) received a high siltation load and the right side of the GSFC jetty road (called GSFC jetty site 2) got shelter due to GSFC jetty. We have done quadrate sampling for molluscan fauna during the monsoon and winter season of 2018 at the sites and calculated abundance, density, frequency, and biodiversity indices. A total of 50 quadrates were laid at both sites, for each quadrate mollusc species were identified and quantified. A total of 21 mollusc species were identified from both sites. A varying abundance of different species from 130.76 of *Cerithedea cingulata* to 1.0 of *Paphia rotundata* was recorded at site 1. This phenomenon of difference is the same for density and frequency among the species recorded at site 1. Whereas there are not many differences in abundance, density, and frequency among the different species of site 2. Though taxa and individual number numbers of molluscan fauna is higher at site 1, diversity indices suggest that site 2 is better than site 1. Our results suggest that a heavy load of siltation at site 1 alters the substratum and microhabitat level and hence Shannon index, Evenness index, and Margalef index are lower at site 1 compared to site 2.
Keywords : Intertidal, Marine Fauna, Pollution, Degradation, Habitat

Introduction:

The coastal marine ecosystem supports a variety of habitats that consequently support high species diversity. In coastal areas, the intertidal zone is considered as most diverse and productive because within the area of a few meters various kinds of flora and fauna are observed (Underwood, 2000).). For its biodiversity, the intertidal zone has been extensively studied (Little and Kitching, 1996). In the intertidal zone measures of species richness, density and abundance are dependent on the difference between spatial patterns of mobile and sessile taxa (Davidson et al., 2004). Molluscs are dominating animal groups in terms of the diversity in the intertidal areas, and due to their ecological adaptation they are found in nearly every habitat; from deepest ocean trenches to the intertidal zone, land, and freshwater where they cover a wide range of habitats. Due to easy accessibility, intertidal zones always remain highly sampled than any other ambiance. (Vaghela & Kundu, 2011; Khade & Mane, 2012).

Factors or anthropogenic activities that affect the natural habitats of coastal molluscan populations are mainly overexploitation, urbanization of coastal areas, pollution, conversion of natural areas, industrialization, and development of public facilities (Ahmed, 1997). However, estuaries and coastal zone are used for a variety of purposes because of their socioeconomic and ecological significance and these activities are subject to increasing pressure and anthropogenic impact on coastal habitats, which in turn results in environmental stress and public health issues. From the research point of view, factors controlling the biodiversity of an area and their functions are mainly in focus (Tilman, 2000). Comparable and meaningful measures of biodiversity are needed to grow awareness related to biodiversity issues to take these into a sharp focus (McCann, 2000).

Gujarat has approximately 1650 km long coastline and the total coastal area is covered by different kinds of marine habitats including 29 % muddy flats followed by 28 % of sandy beaches, 22 % of marshy coast, and 21 % of rocky shores (Vadher et al., 2014). With the ever-increasing industries and infrastructure in the coastal area of Gujarat, Biodiversity is under tremendous pressure. The Gulf of Kachchh is the prime location for industrial development with the set up of two big petroleum refineries in the southern part of the Gulf of Kachchh. With increasing ship traffic and harbor and jetties development, intertidal diversity is under threat. Being placed in the middle of the southern Gulf of Kachchh, Offshore Sikka conferred with many development plans including GSFC jetty and Reliance Jetty. Being funnel-shaped Gulf received amplification of tides towards the east (Vethamony & Babu, 2010). The Mouth of GoK is towards the west side and hence the south ~~west~~ side of GSFC jetty received a heavy load of siltation while the north ~~east~~ side of the jetty got shelter from the current and siltation load. As being towards the safe side, the North ~~east~~ side of GSFC jetty remains an undisturbed site while the sourth ~~west~~ side of the jetty (Vador Site) acquiring disturbance of siltation loads. The present paper investigates the intertidal mollusc abundance, density, and frequency at the Sikka coast. To understand the effect of increasing infrastructure two sites were selected on either side of GSFC jetty as the west side of GSFC jetty, site 1 Vador, receives heavy siltation load.

Materials and Methods:

Study area:

The Gulf of Kachchh is situated in the state of Gujarat, the western part of India. The Region is an arid peninsula, the mouth of the Gulf is a shallow water basin about 60 m deep then sloping up to a depth of fewer than 20 m at the head, visited by 'mixed semidiurnal' tides it experiences two high tides and two low tides of variable ranges every day. The southern shores of the Gulf of Kachchh in Jamnagar district are demarcated as the Marine National Park and Sanctuary. The annual rainfall in this area is less than 75 cm with maximum precipitation in July-August. As there are no major river openings, land runoff is minimal. The relative humidity is highest in August (82%) and lowest in December-January (60%). The mean spring tidal influx extends from the mouth to the closed end of the Gulf and it has a range between 2.1 m and 6.2 m (Shukla & Bhatt, 2011). The mean spring tidal range increases from mouth to head 3.06 m at Okha, 4.67 m at Sikka, 5.82 m at Kandla, and 6.43 m at Navlakhi (Vethamony & Babu, 2010). The funnel shape of the Gulf, coastal configuration and orientation of the coast are the reasons for the amplification of tides. The current study focused on the intertidal area of Vador (Site 1) near GSFC Jetty area (Site 2), Sikka, located at the middle of the southern part of the Gulf of Kachchh.

Site 1: Vador area of Sikka coast (Latitude: 22.44284, Longitude: 69.83196) (Figure 1). This site is located in the middle of the southern belt of GoK. The sandy beach partially covered with mud flats and mangrove vegetation and narrow creek was prominent in width 1 – 2 m. Water remains in the area even during low tide due to the slope and networks of small creeks. This site is on the left side of GSFC jetty road so it receives heavy load of silt along with the water current during the high tide hence we consider this site as a disturbed site.

Site 2: GSFC Jetty area of Sikka coast (Latitude: 22.46904, Longitude: 69.80616) (Figure 1). This site area is situated at the right side of GSFC jetty road, Sikka. The site consists of live coral reef with sandy and muddy patches followed by mangrove forests (Gadhavi et al., 2014). This site is east of GSFC Jetty so load of silt is halt by jetty at other side during high tide and hence site got shelters during high tide and hence we consider this site as undisturbed site.

Methodology:

The study has been carried out from July 2018 to December 2018 for six months. For qualitative analysis of molluscs in the intertidal area of study sites, line transect and quadrate sampling were done (Grieg – Smith, 1983). Quadrates of 1m² were laid from the high tide line to the low tide line i.e. perpendicular to the shoreline. Quadrates frequency was determined based on the total length of the intertidal area along the sampling site. Sampling used to be started with the start of the low tide and an attempt was made to finish sites within the stipulated duration of about 2-3 hours. The population of Molluscan fauna was surveyed using a line transect intercepted with a 1 m^2 quadrate. A total of 5 line transects of 50 m each were laid randomly perpendicular to the shoreline and 5 quadrates (at an interval of 10 m) were laid randomly on each transect at each site. A total of 10 line transects and 50 quadrates were laid during the study period.

For each Quadrate, Molluscs occupied with Gastropods and Bivalves were photographed and counted on field. All the specimens have been identified with standard references (Abott, 1954; Apte, 1998; Apte, 2012) and a checklist of molluscan species has been made. Data collected by quadrate sampling are summed up for data analysis; density, frequency, diversity, richness, evenness, and dominance were calculated by PAST software (Hammer et al., 2001). Formulas of all calculated indices are given below:

Abundance: Total number of individuals recorded/Total number of quadrate where the individuals occurred.

Density: Total number of individuals recorded from the quadrate/ Total number of quadrate studied.

Frequency (%): Number of quadrate where the species occurred X 100/ Total number of quadrate where the individual occurred.

Margalef's Diversity Index: Dmg = (S-1) /ln N. Where, N= the total number of individuals in the sample; S= the number of species recorded; Ln= natural logarithm.

Shannon's Diversity Index: H= Σ pi*ln pi. Where, Pi= S/N; S= number of individuals of one species; N= Total number of all individual in the sample or number of individuals (of all species); Ln= natural logarithm.

Pielou's Evenness Index: E = H/lnS. Where, H= Shannon's-Wiener Diversity Index; S= Total number of species in the sample.

Berger-Parker Dominance Index: D = N max/S. Where, N max = the number of individual of most abundant species; S = Total number of observed species.

Results:

During the present study, by using randomly placed quadrate sampling technique, collectively a total of (21) molluscan species were recorded from quadrates laid at both sites (Table 1). A total of 14 species were recorded from quadrates laid at Vador whereas 11 species were recorded from quadrates recorded at GSFC jetty (Table 1).

A varying abundance of different species was found over the study period at Site 1. The highest value of average abundance was calculated (130.76) for *Cerithedea cingulata* followed by *Nassarius sp.* (9.63) whereas the lowest value of average abundance for *Bullia sp.* (1.00), *Dosinia sp.* (1.00), *Trochus tentorium* (1.00), *Trochus radiates* (1.00), *Paphia rotundata* (1.00) (Table 2).

Moreover, the average highest molluscan species density at site 1 was shown by *Cerithedea cingulata* (130.76 no / m²) followed by *Trochus maculatus* (3.24 no / m²). The average lowest molluscan species density at site 1 was shown by *Trochus tentorium* (0.04 no / m²) and by *Paphia rotundata* (0.04 no / m²) (Table 2).

Moreover, the average highest molluscan species frequency at site 1 was shown by *Cerithedea cingulata* (100 %) followed by *Trochus maculatus* (60 %). The average lowest molluscan species density at site 1 was shown by *Trochus tentorium* (4 %) and by *Paphia rotundat*a (4 %) (Table 2).

A varying abundance of different species was found over the study period at Site 2. The highest value of average abundance was calculated (3.10 no / m²) for *Dosinia sp.* followed by *Nassarius sp.* (2.57 no / m²) whereas the lowest value of average abundance for *Palmadusa contaminata* (1.00 no / m²) (Table 3).

Moreover, the average highest molluscan species density at site 1 was shown by *Dosinia sp.* (2.48 no / m²) followed by *Spisula sp.* (1.12 no / m²). The average lowest molluscan species density at site 1 was shown by *Palmadusa contaminata* (0.04 no / m²) and by *Dosinia rustica* (0.04 no / m²) (Table 3).

Moreover, the average highest molluscan species frequency at site 1 was shown by *Dosinia sp.* (80 %) followed by *Spisula sp.* (60 %). The average lowest molluscan species density at site 1 was shown by *Palmadusa contaminata* (4 %) and by *Dosinia rustica* (4 %) (Table 3).

A total of 3558 no individuals were recorded from 25 quadrates laid at site 1 whereas a total of 186 no individuals were recorded from 25 quadrates laid at site 2. Shannon_H diversity is recorded as high at site 2 (2.017) compared to site 1 (0.4431). Evenness_e^H/S is also recorded high at site (2 0.6831) compared to site 1 (0.1113). Margalef indices are also recorded as high at the site (1.914) compared to site 1 (1.59). Whereas Berger-Parker indices are recorded highest at site 1 (0.9188) compared to site 2 (0.3333).

Discussion:

During the present study, efforts have been made to analyze molluscan fauna found along the Vador and GSFC jetty, in addition to abundance, density, frequency, dominance, etc. that were calculated to establish a baseline study, by using quadrate analysis techniques, which can assist in future detailed studies and resource management of the area. During the present study, by using a randomly placed quadrate sampling technique collectively, a total of 21 molluscan species were found and identified for the first time from both sites. While only 5 species were found common in both stations.

All the quadrates of site 1 recorded *Cerithedea cingulata* with high average abundance (130.76), average density (130.76 / m²), and high average frequency (100 %). The rest all the molluscan species have low average abundance (< 10), low average density (< 4), and low average frequency (< 40 % except *Trochus maculatus* which has 60 %). This is the reason that Shannon_H index (0.4431) is low; Evenness (0.1113) is very low; Margalef index (1.59) is comparatively low while Berger-Parker index (0.9188) is high (Table 4).

Site 2 recorded uniform average abundance and average density among all the species while average frequency ranges from 4 % to 80 % (Table 3). This is the reason that Shannon_H index (2.017) is high; Evenness (0.6831) is also high; Margalef index (1.914) is comparatively high while Berger-Parker index (0.3333) is low (Table 4).

Many scientists have earlier described that undisturbed areas are usually characterized by high species richness and an abundance of benthic fauna, which also creates a complex of microhabitats available for other species. On the other hand, disturbed areas, suffer from reduced structural diversity and heterogeneity of the habitat and dominance of thick-shelled bivalves (Kaiser & Spencer, 1994). This phenomenon is found here also as Site 2 has a higher Shannon_H diversity index (2.017) which is an undisturbed site compared to Site 1 Vador where Shannon_H diversity index (0.4431) is lower which is a disturbed site. Evenness index (0.1113 at site 1 & 0.6831 at site 2) also suggest that site 2 is a good site where molluscan are evenly distributed compared to site 1. Margalef index also suggests that species richness is higher (1.914) at site 2 compared to site 1 (1.59). Increase in the value of the Berger –Parker index (0.9188 at site 1, 0.3333 at site 2) accompanies a decrease in diversity. So all biodiversity indices suggest that site 2 GSFC jetty is a comparatively good site compared to site 1 Vador. This result shows that a heavy load of siltation at site 1 Vador alters the microhabitats hence we found it is a disturbance in the substratum reflected with our study result.

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Tables & Figures

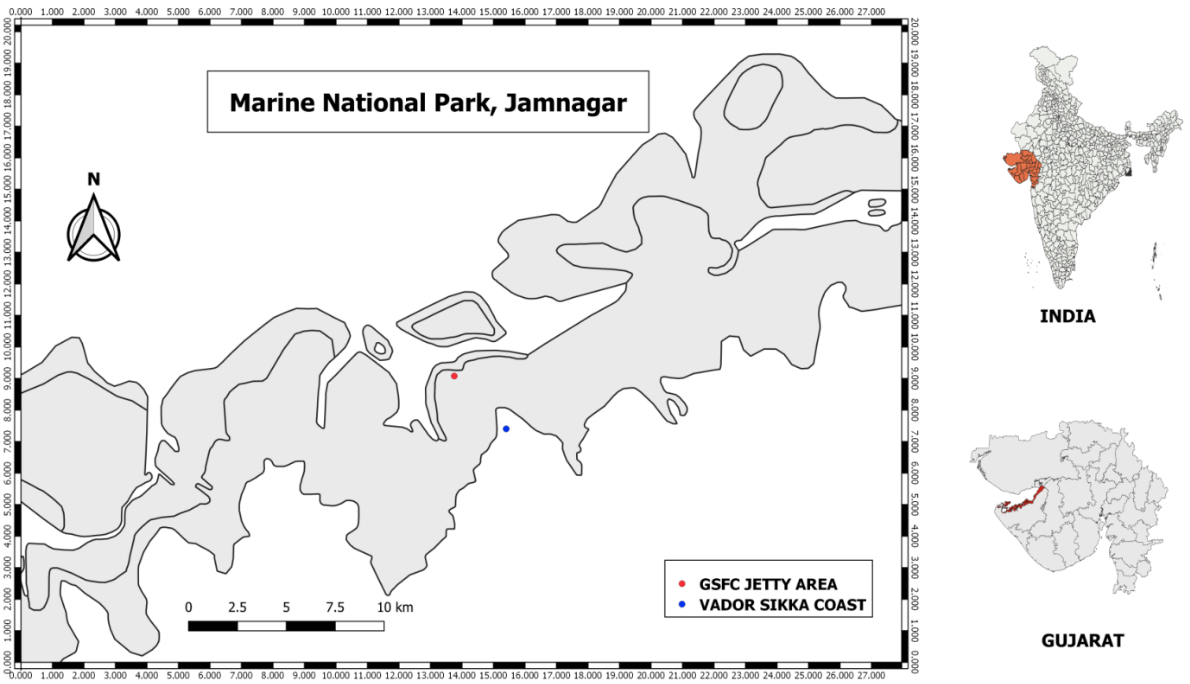

Figure 1: Vador and GSFC Site, Off shore Sikka

Table 1: List of Identified Molluscs species from the study sites

Sr.no.	Family	Sr.no.	Name of Species	Site1 Vador	Site2 GSFC Jetty
1	Potamididae	1	*Cerithidea cingulata*	+	+
2	Trochidae	2	*Trochus maculatus*	+	-
		3	*Trochus radiatus*	+	-
		4	*Trochus tentorium*	+	-
3	Volutidae	5	*Melo melo*	+	-
4	Veneridae	6	*Dosinea sp.*	+	+
		7	*Dosinea rustica*	-	+
		8	Paphia rotundata	+	-
		9	*Venus radiatus*	-	+
5	Cardiidae	10	*Vestucardium flavum flavum*	-	+
6	Mactridea	11	*Mactra tergida*	+	-
		12	*Spisula sp.*	+	+
7	Ergaliidae	13	*Ergalatux heptoganalis*	-	+
		14	*Mitrela blanda*	+	-
8	Nassariidae	15	*Nassarius sp.*	+	+
		16	*Turbo sp.*	-	+
9	Bullinea	17	*Bullia sp.*	+	-
10.	Ethellidea	18	*Ethalia carniolata*	+	-
11.	Cypraeidae	19	*Palmadusa contaminata*	-	+
12.	Tellinidae	20	*Tellina sp.*	-	+
13	Paradillium	21	*Paradillium petrulis*	+	-

Table 2. Molluscan species abundance, density and frequency along Vador (Site 1). Whereas A.A= Average Abundance; A.D= Average Density (specimen/m2) and A.F= Average Frequency.

Sr No	Species Name	A.A.	A.D.	A.F.
1	*Cerithedea cingulata*	130.76	130.76	100
2	*Melo Melo*	4.50	1.08	24
3	*Mitrella blanda*	1.44	0.52	36
4	*Paradilium petrulis*	3.00	0.84	28
5	*Trochus meculatus*	5.40	3.24	60
6	*Ethalia carneolata*	2.33	0.56	24

7	*Spisula sp.*	3.38	1.08	32
8	*Bullia sp*	1.00	0.08	8
9	*Nassarius sp.*	9.63	3.08	32
10	*Dosinia sp.*	1.00	0.12	12
11	*Trochus tentorium*	1.00	0.04	4
12	*Mectra tergida*	2.43	0.68	28
13	*Trochus radiatus*	1.00	0.2	20
14	*Paphia rotundata*	1.00	0.04	4

Table 3. Molluscan species abundance, density and frequency along GSFC Jetty (Site 2). Whereas A.A= Average Abundance; A.D= Average Density (specimen/m2) and A.F= Average Frequency.

Sr No	Species Name	A.A.	A.D.	A.F.
1	*Cerithedea cingulata*	1.29	0.36	28
2	*Spisula sp.*	1.87	1.12	60
3	*Nassarius sp.*	2.57	0.72	28
4	*Dosinia sp.*	3.10	2.48	80
5	*Palmadusa contaminata*	1.00	0.04	4
6	*Venus radiatus*	1.29	0.36	28
7	*Dosinia rustica*	1.00	0.04	4
8	*Ergalatax heptogonalis*	1.11	0.4	36
9	*Vasticardium flavum flavum*	1.23	0.64	52
10	*Telina sp.*	1.33	0.64	48
11	*Turbo sp.*	1.31	0.68	52

Table 4. Diversity Indices comparison between two sites

	Site 1	Site 2
Taxa_S	14	11
Individuals	3558	186
Shannon_H	0.4431	2.017
Evenness_e^H/S	0.1113	0.6831
Margalef	1.59	1.914
Berger-Parker	0.9188	0.3333