

# 28. Intertidal Benthic Community Ecology of Sand-dwelling Macroinvertebrates of Goa Beaches

*Sadananda Harkantra and Arun Parulekar*

Studies on the intertidal ecology of two sandy beaches of Goa along the western coast of India revealed the presence of 47 species of macroinvertebrates belonging to 32 families. The open beach at Candolim, characterized by coarse sand-grain size, is relatively unstable, less productive, and supports a poor benthic fauna. In contrast, an estuarine beach at Siridao, having fine sand-grain size, is comparatively stable, more productive, and exhibits a rich fauna. This indicates the richness of benthic life in an estuarine environment. The heterogeneity and seasonality of the faunal community structure at these two beaches are mainly attributed to the interaction of abiotic and biotic factors. Different species showed distinct zonal patterns of distribution from high to low tide levels with species richness highest at low tide.

## INTRODUCTION

A review of the literature on the intertidal macrofauna along the Goa coast (Dwivedi et al. 1973, McLusky et al. 1975, Nair 1978) revealed a paucity of information on taxonomy and community ecology. The few studies conducted pertaining to Goa beaches by Parulekar (1972) and Menon et al. (1967) dealt with the polychaetes and pelycepoda, respectively. Therefore, an investigation was undertaken to study the distribution and taxonomy of macroinvertebrates inhabiting two beaches of Goa in relation to a number of environmental parameters. The study area included an open sea sandy beach at Candolim (15°31'40"N, 73°45'58"E) and an estuarine sandy beach at Siridao (15°45'58"N, 73°51'00"E) (figure 1).

## MATERIAL AND METHODS

Macrofauna sampling and environmental parameters were monitored

over a period of 16 months (February 1981 to May 1982) by following the methods of Ansell et al. (1972), McLusky et al. (1975), Wafar et al. (1980) and Verlencar (1982). Because of intertidal considerations, monthly sampling was done at 10 m intervals at both beaches. The macrofauna were initially treated with 5 percent rose-bengal sea formalin and the assorted fauna preserved in 5 percent formalin for further taxonomic investigations. Organisms, as far as possible, were identified to the species level.

#### DESCRIPTION OF STUDY AREA

Candolim— an open sea beach— is located in the northern half of Goa, whereas, Siridao— an estuarine beach— is situated about 2 km upstream from the mouth of the Zuari estuary (figure 1).

The tides are of a semidiurnal mixed nature with an amplitude of 2.25 m; accordingly, the beach expanse, on an average, is 40 to 50 m. The currents are clockwise during November-April, transitional in October, and anticlockwise from May-September. The winds are variable with speeds up to 30 km/hour or more in June-August in comparison to 13-17 km/hour in the remaining months of the year. The sea is generally calm, except in the rainy season (June-September) when it can become

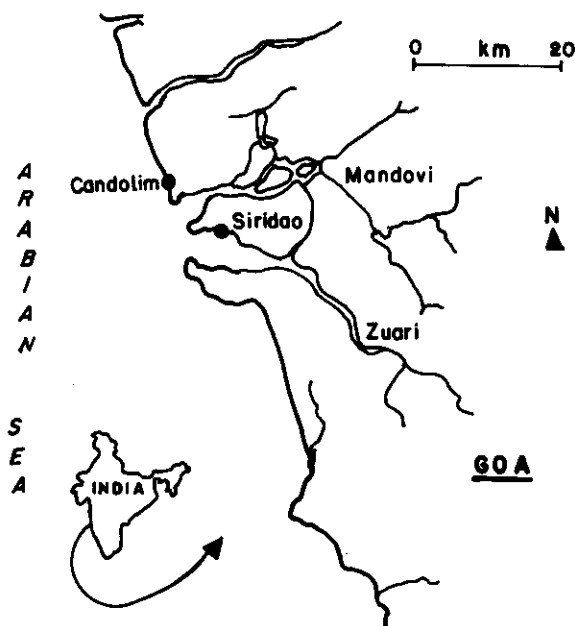


Figure 1. Goa, India. Map showing position of Candolim and Siridao beaches.

choppy. The surf is moderately high with an appreciable quantum of spray. Goa has a typical monsoon-type tropical climate. The annual average rainfall is 3,000 mm with a maximum during the summer southwest monsoon (June-September). Atmospheric temperature varies from 28°C (December) to 33°C (May) with a relative humidity between 70 percent (April) and 90 percent (July-August).

## RESULTS AND DISCUSSION

Table 1 shows the environmental characteristics of both beaches during the study period. It is clear that Siridao beach—characterized by low salinity and a relatively stable beach gradient with fine sand-grain size—is the more productive. In contrast, the Candolim beach—characterized by coarse sand-grain size—is geomorphologically most unstable and relatively less productive. It is known that in tropical waters estuarine regions are more productive due to their high nutrient content resulting from land drainage and in situ regeneration of organic matter (Verlencar 1982). It is also quite obvious that an open sea beach is more unstable as it is more directly exposed to heavy wave action and currents than an estuarine-protected beach. Surf-water oxygen values were of higher magnitude at both beaches showing good mixing of surf water. However, the interstitial water oxygen values of Siridao beach were lower mainly due to fine grain size and the abundance of buried detritus. Similar low oxygen values were observed in a comparable biotope of a Swedish beach (Jansson 1968).

The macroinvertebrate fauna that inhabit the two beaches studied are listed in table 2. Out of a total 47 species belonging to 32 families, 34 were found at Siridao beach and 27 at Candolim beach. This clearly indicates a rich benthic fauna in an estuarine beach. Such a richness was also reported by Gauld and Bhuchanan (1956), McIntyre (1965), and Parulekar (1978). Percent occurrence of species was calculated on the basis of presence and absence records. The magnitude of occurrence and pattern of horizontal distribution are summarized in table 2.

It is clear from table 2 that the spionidae, *Nerine cirratulus*, showed the highest frequency of occurrence followed by *Glycera alba*, *Donax faba*, *Pisionodense indica*, and *Pontherpinia unirostrata*. A similar type of distribution and abundance of intertidal fauna was also observed by McIntyre (1965), Ansell et al. (1972), Philip (1974), McLusky et al. (1975) and Nair (1978). *Lineus* sp., *Nereis* sp., and *Eurydice peraticis* were of common occurrence. The presence of some pelagic organisms such as the amphipods *P. unirostrata*, and *Perioculodes* sp., and the mysid *Gastrosaccus simulans* can be explained by strandings during ebb tide. *N. cirratulus*, *G. alba*, *P. indica*, and *Donax* sp.

Table 1. Environmental parameters.

S.N.*	Condolim Beach			Siridao Beach		
	Range	$\bar{X}$	SD	Range	$\bar{X}$	SD
1.	24.7-30.5	28.03	1.46	25.0-30.5	28.41	1.50
2.	25.2-35.8	31.04	3.93	24.9-33.2	29.32	3.40
3.	6.10-35.68	28.75	9.35	3.40-33.65	26.22	10.59
4.	5.00-35.98	28.96	10.24	0.50-33.98	25.79	12.02
5.	2.46-4.98	4.32	0.64	3.20-5.28	4.28	0.58
6.	1.07-4.30	2.97	0.95	0.80-4.50	2.27	1.29
7.	0.76-5.65	2.80	1.35	0.54-9.75	3.69	2.58
8.	0.54-4.28	1.85	1.14	0.83-5.12	2.51	1.41
9.	0.32-1.20	0.69	0.27	0.96-1.66	1.39	0.24
10.	0.01-0.11	0.06	0.03	0.01-0.08	0.06	0.02
11.	0.64-2.12	1.64	0.45	2.03-2.29	2.54	0.28

\*1, 2: Surf-water and high tide sand, temperature ( $^{\circ}\text{C}$ ); 3, 4: surf and interstitial water salinity (ppt); 5, 6: surf and interstitial water oxygen (ml/l); 7: surf-water chlorophyll *a* ( $\text{mg}/\text{m}^3$ ); 8: surf-water particulate organic carbon ( $\mu\text{g}/\text{l}$ ); 9: mean sand organic carbon ( $\mu\text{g}/\text{g}$ ); 10: slope; 11: mean sand grain size ( $\phi$ ).

Table 2. Faunal list showing abundance and distribution.

Sr. No.	Species	CD	CA	SR	SA	Distribution
1.	Family Lineidae					
1.*	<i>Lineus</i> sp.	+	CM	+	CM	HT, MT
2.*	<i>Cerebratulus</i> sp.	+	VR	+	VR	MT
	Family Pisionidae					
3.	<i>Pisionodense indica</i> Aiyar and Aikunhi	+	VC	-	-	LT
4.*	<i>Pisone</i> sp.	+	VR	-	-	LT
	Family Syllidae					
5.	<i>Syllis</i> sp.	+	VR	-	-	MT
	Family Nereidae					
6.	<i>Nereis</i> sp.	+	CM	+	CM	MT, LT
	Family Lumbrineridae					
7.*	<i>Lumbriconereis sphaerocephala</i> Scharda	-	-	+	VR	LT
	Family Nephthydidae					
8.*	<i>Nephtys dussumeri</i> Valenciennes	-	-	+	VR	LT
	Family Onuphidae					
9.	<i>Diopatra neopolitina</i> Delle Chiaje					
	Family Glyceridae					
10.	<i>Glycera alba</i> Rathke	+	VC	+	VC	HT, MT, LT
	Family Orbiniidae					
11.*	<i>Scoloplos marsuipialis</i> Southern	-	VC	+	RR	LT
	Family Spionidae					
12.*	<i>Nerine cirratulus</i> Delle Chiaje	-	-	+	AD	MT, HT
13.	<i>Prionospio pinnata</i> Ehler	-	-	+	RR	LT
14.	<i>Polydora</i> sp.	+	RR	-	-	LT
	Family Maldanidae					
15.*	<i>Glymere (Euchymene)</i> annadale Southern	-	-	+	VR	LT
	Family Spaeromidae					
16.	<i>Sphaeroma walkeri</i> Stebbing	+	VR	+	VR	HT
	Family Cirolidae					
17.	<i>Eurydice peraticis</i> Jones	+	VC	+	VR	MT
	Family Anthuridae					
18.*	<i>Cyathura</i> sp.	+	VR	+	VR	LT
	Family Phoxocephalidae					
19.*	<i>Pontharoinia unirostrata</i> Giles	+	VC	-	-	HT, MT, LT
20.*	<i>Parhyalella natalensis</i> (Stebbing)	+	RR	-	-	MT, LT
21.*	<i>Pericolodes</i> sp.	+	CM	-	-	MT, LT
	Family Talitridae					
22.*	<i>Talorchestia spinipalm</i> (Dana)	+	VR	-	-	HT
23.	<i>Talorchestia</i> sp.	-	-	+	VR	HT
	Family Harpacticoida					
24.*	<i>Scotollana</i> sp.	-	-	+	VC	HT, MT
	Family Mysidae					
25.	<i>Gastrosaccus simulans</i> W.T. Tattersalt	+	VC	+	VC	HT, MT, LT
	Family Alpheidae					
26.	<i>Alpheus malabarica</i> Fabricius	+	VR	-	-	MT, LT
	Family Dioginidae					

Table 2 (continued)

27.*	<i>Diogene affinis</i> Henderson	+	VR	+	VR	LT
28.*	<i>Diogene avarus</i> Heller	-	-	+	VR	LT
29.*	<i>Diogene violaceus</i> Henderson	-	-	+	VR	LT
30.*	<i>Diogene planimanus</i> Henderson	-	-	+	VR	LT
31.	<i>Emerita holthuisi</i> (Sankoli)	+	RR	+	VR	MT, LT
	Family Calappidae					
32.	<i>Matuta lunaris</i> (Forsk.)	+	VR	+	VR	LT
	Family Leucosinae					
33.	<i>Philyra globosa</i> Fabricius	+	VR	-	-	LT
	Family Ocypodidae					
34.	<i>Ocypode ceratophthalma</i> Milne Edwards	+	RR	+	RR	HT
35.*	<i>Dotilla mycteroides</i> Milne Edwards	-	-	+	RR	MT
	Family Neptunidae					
36.	<i>Portunus sanguinolentus</i> (Herbst)	-	-	+	VR	LT
	Family Veneridae					
37.	<i>Paphia textile</i> (Gmelin)	+	VR	+	VR	LT
38.*	<i>Gafrarium pectinatum</i>	+	VR	+	VR	LT
39.	<i>Cardium flavum</i> Linne	-	-	+	VR	LT
40.	<i>Mactra cuneatus</i> Chemnitz	+	VR	-	-	LT
	Family Donacidae					
41.	<i>Donax incarnatus</i> Chemnitz	+	VR	-	-	MT, LT
42.*	<i>Donax faba</i> Gmelin	-	-	+	VC	MT, LT
	Family Solenidae					
43.	<i>Solen truncatus</i> (Sowerby)	-	-	+	VR	LT
	Family Arcidae					
44.	<i>Arca granosa</i> Lamarck	-	-	+	VR	LT
	Family Anomiidae					
45.	<i>Placent placent</i> Linne	-	-	+	VR	LT
	Family Nassidae					
46.	<i>Nassa hepatica</i> (Montagu)	-	-	+	VR	LT
	Family Olividae					
47.	<i>Oliva gibbosa</i> (Born)	+	VR	-	-	LT

+ = presence

- = absence

CD = Candolim beach

CA = abundance at Candolim beach

SR = Siridao beach

CS = abundance at Siridao beach

AD = abundant (&gt; 60%)

VD = very common (40-60%)

CM = common (20-40%)

RR = rare (10-20%)

VR = very rare (&lt;10%)

HT = high-tide level

MT = mid-tide level

LT = low-tide level

are the permanent dwellers, i.e., infaunal in habitat; the others are temporary or epifaunal in habitat. Epifaunal organisms are mostly migrants from the subtidal area or stranded fauna from pelagic waters.

Most of the fauna were absent during the southwest monsoon (June-September) and were replenished during the postmonsoon (October-January). Species richness and abundance increased from post- to premonsoon (February-May). There were distinct seasonal differences in the occurrence of particular species, number of species, and their abundance. These changes were also associated with variations in environmental parameters, mainly salinity, chlorophyll *a*, and beach slope (tables 1 and 2). Panikkar (1969) postulated the concept of partial or complete destruction of tropical fauna during the southwest monsoon followed by an annual repopulation of fauna in postmonsoon. Such a phenomenon is a characteristic feature of tropical estuarine and coastal biotopes (Parulekar et al. 1980, Harkantra and Parulekar 1982).

It is also clear from table 2 that certain species are restricted to a particular tide level. Accordingly, *Ocypoda ceratophthalma* and *Talorchestia spinipalm* were found only at high tide whereas *P. indica*, *Diopatra neopolitina*, and *Lumbriconereis sphaerocephala* were restricted to the low tide region. A few species, such as *G. alba*, were present all along the transect. The vertical distribution of intertidal organisms is a direct consequence of the amplitude and height of the tide on the shore (Doty 1946, Stephenson 1949). Species richness increased from high to low tide level. Such zonal patterns had also been reported previously (Bhat 1959, Seshappa 1966, Parulekar 1978).

A comparison of the presence and absence of fauna at both beaches showed a dissimilarity of 70.21 percent. This indicates the extent of faunal heterogeneity at these beaches. Candolim beach fauna are characterized by a *P. indica* community whereas that of Siridao beach by the *N. cirratulus* community. Heterogeneity in the faunal structure is also related to the magnitude of the differences in abiotic factors (tables 1 and 2). Such a difference in faunal structure is mainly attributed to the interaction of localized abiotic and biotic factors (Thorson 1966, Wildish 1977). A comparison of these fauna to those of other localities such as Malvan and Karwar (Parulekar 1978, 1981) showed a close similarity. In spite of these similarities, the intertidal Goa fauna are unique because of the presence of the window-pane oyster *Placenta placenta* and the harpacticoida, *Scotollana* sp. Some of the species (table 2—asterik) are reported for the first time from Goa beaches.

Our study on the intertidal fauna of sandy beaches of Goa reveals the richness and diversity of tropical marine intertidal fauna. Such a faunal richness affects the condusive interaction between biotic and abiotic factors. However, oil pollution due to tar ball deposition during the south west monsoon has been reported for both beaches (Dwivedi and Parulekar

1974). Therefore, it is imperative to monitor the environmental perturbations for the protection of the biota.

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#### LITERATURE CITED

- Ansell, A.D., P. Sivadas, B. Narayanan, V.N. Sankaranarayanan and A. Trevallion. 1972. The ecology of two sandy beaches in south India. I. Seasonal changes in physical and chemical factors and the macrofauna. *Mar. Biol.* 17: 38-62.
- Bhatt, Y.M. 1959. A Study of Intertidal Organisms of Bombay. Doctoral thesis. University of Bombay.
- Doty, M.S. 1946. Critical tide factors that are correlated with vertical distribution of marine algae and other organisms along the Pacific coast. *Ecology* 7: 325-328.
- Dwivedi, S.N. and A.H. Parulekar. 1974. Oil pollution along the Indian coastline. *Proc. Symp. and Workshop on Marine Pollution Monitoring (Petroleum)*, Gaithersburg, Maryland. *NBS Spl. Publ.* 409: 101-105.
- Gauld, D.T. and J.B. Bhuchanan. 1956. The fauna of sandy beaches in Gold coast. *Oikos*, 7: 293-310.
- Harkantra, S.N. and A.H. Parulekar. 1982. Ecology of benthic production in the coastal zone of Goa. *Mahasagar Bull. Nat. Inst. Oceanogr.* 14: 135-139.
- Jansson, B. 1968. Studies on the Ecology of Interstitial Fauna of Marine Sandy Beaches. Doctoral thesis, University of Stockholm.
- Menon, P.K.B., M.N. Sareen and K.K. Tandon. 1967. On the marine fauna of Goa: A preliminary survey. I. Mollusca—Pelecypoda. *Res. Bull. (NS) of the Punjab Univ.* 18: 315-320.
- McLusky D.S., S.A. Nair, A. Stirling and R. Bhargawa. 1975. The ecology of a central West Indian beach, with particular reference to *Donax incarnatus*. *Mar. Biol.* 30: 267-276.
- McIntyre, A.D. 1965. The meiofauna and macrofauna of some tropical beaches. *J. Zool. Lond.* 156: 377-392.
- Nair, Ayyappan. 1978. Production ecology of a tropical sandy beach at Benaulim, Goa. *Indian. J. Mar. Sci.* 7: 163-167.



- Parulekar, A.H. 1972. Polychaetes from Maharashtra and Goa. *J. Bombay Nat. Hist. Soc.* 68: 726-749.
- Parulekar, A.H. 1978. Studies on intertidal ecology of Anjidiv Island. *Proc. Indian Nat. Sci. Acad.* 39: 611-631.
- Parulekar, A.H., V.K. Dhargalkar and S.Y.S. Singbal. 1980. Benthic studies in Goa estuaries. III— Annual cycle of macrofaunal distribution, production and trophic relations. *Indian J. Mar. Sci.* 9: 189-200.
- Parulekar, A.H. 1981. Marine fauna of Malvan, Central west coast of India. *Mahasagar. Bull. Nat. Inst. Oceanogr.* 14: 33-44.
- Panikkar, N.K. 1969. New perspectives in estuarine biology. *Proc. First All Indian Estuarine Biol. Symp.* pp. 7.
- Phillip, K.P. 1974. The intertidal fauna of the sandy beaches of Cochin. *Proc. Symp. Mar. Intertidal Ecol. INSA Bull. No. 47:* 317-328.
- Stephenson, T.A. and A. Stephenson. 1979. The universal features of zonation between tide marks on rocky coast. *Ecology* 37: 289-305.
- Seshappa, G. 1966. Racial and speciation in the littoral region. *Proc. Sec. All India Cong. Zool. Pt. 2:* 323-331.
- Thorson, G. 1966. Some factors influencing the recruitment of marine benthic communities. *Neth. J. Sea. Res.* 3: 267-293.
- Verlencar, X.N. 1982. Nutrients and Organic Production in the Tropical Coastal Environment. Doctoral thesis. University of Bombay.
- Wafar, M.V.M., M.D. Rajagopal, Maria R. Menezes and Ann Stirling. 1980. Physicochemical features and energy input in three sandy beaches of the west coast of India. *Indian J. Mar. Sci.* 9: 25-30.
- Wildish, D.T. 1977. Factors controlling marine and estuarine sublittoral macrofauna. *Helgoander. Wiss. Meeresunters.* 30: 445-454.