

A quantitative analysis of fine scale distribution of intertidal meiofauna in response to food resources

Z A Ansari & M U Gauns

National Institute of Oceanography, Dona Paula, Goa 403 004, India

Received 27 July 1995; revised 25 March 1996

Fine scale vertical and spatial distribution of meiofauna in relation to food abundance was studied in the intertidal sediment at Dias beach. The major abiotic factors showed significant changes and progressive fine scale decrease in vertical distribution, with increasing depth in the sediments. Meiofauna were concentrated more in the 4-6 mm and decreased progressively in the deeper layer. The density of meiofauna was high at mid tide level. Nematodes, turbillarians and harpacticoids were the taxa recorded. Spatially, meiofauna showed patchy dispersion, related to the availability of food and predation.

The metazoan meiofauna live in the intertidal spaces between the sand grains. Their importance in the benthic productivity is more than what their smaller size and biomass indicate¹. Mesoscale vertical and spatial distribution of meiofauna were reported in detail². Microscale distribution has been studied only in limited cases³. In all these studies meiofauna were noted for their patchy distribution but the causes of dispersion are not clearly understood. The present study was designed to test microscale distribution of meiofauna on a sandy beach and to examine whether patchy food distribution can influence the dispersion pattern of meiofauna spatially.

Materials and Methods

For the present study a sampler was fabricated (Fig. 1) from a micrometer screw and the barrel of a 20 ml disposable plastic syringe, as used by Joint *et al.*³. The barrel has a diameter of 2 cm. Between October and November 1994, on five sampling dates, samples of meiofauna were collected from low tide, mid tide and high tide levels at Dias beach Goa. On each sampling dates triplicate samples were collected from each tidal level and a total of 45 samples were analysed for the present study. Sediment cores of 20 mm length were taken by pushing the tube into the sediment. The sediment extruded was sectioned into 2 mm slice with the

help of a thin glass slide. Each 2 mm slice was then preserved in 1:500 Rose Bengal-formalin seawater solution. Samples for spatial distribution were collected separately using cores of sizes of 0.48, 0.78, 1.76, and 3.14 cm² core area. Samples for chlorophyll-*a*, phytoplankton, organic carbon and interstitial water were also collected simultaneously. The redox potential (*Eh*) was measured with the help of a Platinum electrode attached to pH meter.

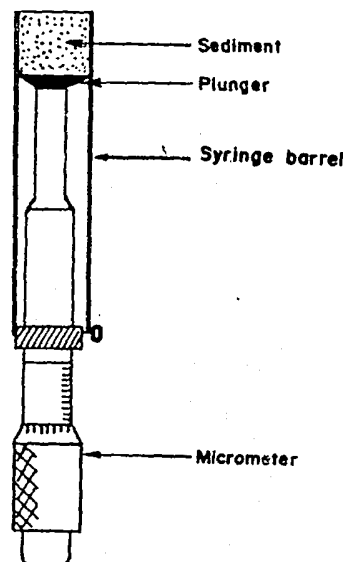


Fig. 1—Core used in the present study

Meiofauna was extracted by sieving on a screen of 0.045 mm mesh size. All animals were counted under high power binocular microscope and their total density calculated. Chlorophyll-*a* was analysed by the method of Lorenzen⁴. Phytoplankton cells were counted under microscope. Interstitial water was calculated by subtracted the wet weight from dry weight of sediments and organic carbon estimated⁵.

The analysis of variance was performed on the raw data to study the changes in meiofaunal density at different tidal levels at different core depths. Green's⁶ index of dispersion was used to study the patchiness and aggregation. The value of Green's index between 0 and +0.2 were considered slightly aggregated, +0.2 and +0.4 moderately and +0.4 and 1.0 strongly aggregated.

Results

The quantitative analysis of the sample collected by the sampler is given in Table 1. The weight of each section is not significantly different within or between cores (ANOVA, $F=1.82$). It was possible to obtain reproducible sections unless large pieces of molluscan shells were present in which case the core had to be discarded. Therefore the samples collected by this method were considered satisfactory.

The Dias beach has a gradual slope and together with fine heterogenous sediment has poor drainage⁸. The physico-chemical properties of the area undergo distinct seasonal variations. The sediment consisted of moderately sorted fine sand with

varying proportions of silt and clay at the three tide levels (Table 2). Sand fraction was more than 50%. Mean temperature was in the range of 28.2 and 31.2° and salinity of the interstitial water was high ($31.08-33.22 \times 10^{-3}$). The pH of the sediment was above 7.

The sedimentary pigment (chl-*a*) was in the range of 0.17-0.34, 0.70-1.08 and 0.72-1.19 $\mu\text{g/g}$ in 3 tide levels respectively (Table 3). Highest values were recorded in the 2-6 mm and decreased with increasing depth in the sediment. The organic carbon levels were in the range of 1.11-1.80 mg C/g sediment. The redox potential of the sediment indicated oxygenated conditions as most of the values were above +100. There was a progressive decrease in the values with increasing depth in the sediment. This was accompanied by a decrease in the interstitial water content.

Vertical distribution of algae in the sediment is given in Table 4. The phytoplankton was dominated by diatoms such as *Navicula* sp., *Skeletonema* sp. and *Nitzschia* sp. followed by blue-green algae. At mid tide and low tide due to frequently flooding and water table movement algal cells were recorded in the deeper layer of the sediment. However, the cell concentration was more in the upper layer.

Among the meiofauna nematodes, turbillarians and harpacticoid copepod are the most dominant groups. The actual counts recorded at each tidal level and in different sections of the core are given in Table 5. Total density was high in the 0-8 mm, the highest being in the section recorded poor density at high tide and mid tide, probably because of desiccation and the downward movement of fauna. Below 8-10 mm the faunal density decreased progressively with increasing depth in the sediment. Total number of individuals recorded in the 20 mm long core was 254, 337 and 264 at high, mid and low tide respectively. The lowest density was recorded both at the top and bottom of the core.

Nematoda—Broadly speaking the nematodes were the most consistent group and were dominated by deposit feeders and epigrowth feeders. The most abundant species of nematodes belong to families desmodaridae, comesomatidae and chromadoridae. There was an overlapping of feeding types with a

Table 1—Wet weight (g) of core sediment in each 2 mm section at high tide, mid tide and low tide

Section (mm)	Wet wt. (g)		
	High tide	Mid tide	Low tide
0-2	1.003	1.012	1.013
2-4	1.007	1.008	1.011
4-6	1.005	1.011	1.013
6-8	1.003	1.013	1.015
8-10	1.006	1.015	1.016
10-12	1.010	1.013	1.011
12-14	1.006	1.011	1.013
14-16	1.004	1.014	1.012
16-18	1.002	1.012	1.014
18-20	1.003	1.011	1.015

Table 2—Granulometric properties of the intertidal sediment at Dias beach

Tidal level	Sediment properties				Temp. (°C)	Sal. ($\times 10^{-3}$)	pH
	Mean size (mm)	Sand (%)	Silt-clay (%)	Sorting (ϕ)			
High tide	0.14	66.7	33.3	0.95	28.2	33.2	7.5
Mid tide	0.09	53.2	46.8	1.28	31.1	32.3	7.8
Low tide	0.07	52.7	47.3	1.57	31.2	31.1	7.6

Table 3—Chemical properties of the sediment at Dias beach

Depth (mm)	Chl- <i>a</i> ($\mu\text{g/l}$)	Org C (mgC/g)	Eh (mv)	Interstitial water (%)
High tide				
0-2	0.25	1.31	+150	42
2-4	0.28	1.31	+146	44
4-6	0.34	1.30	+142	44
6-8	0.26	1.28	+140	43
8-10	0.22	1.27	+137	41
10-12	0.21	1.27	+135	40
12-14	0.17	1.26	+130	37
14-16	0.14	1.22	+134	36
16-18	0.09	1.16	+126	34
18-20	0.09	1.11	+122	30
Mid tide				
0-2	0.90	1.80	+134	39
2-4	1.02	1.76	+130	41
4-6	1.08	1.79	+128	39
6-8	1.03	1.74	+121	37
8-10	0.99	1.70	+118	36
10-12	0.95	1.76	+115	36
12-14	0.81	1.65	+115	33
14-16	0.73	1.60	+114	33
16-18	0.70	1.61	+111	32
18-20	0.61	1.44	+102	32
Low tide				
0-2	1.08	1.71	+119	38
2-4	1.15	1.69	+119	38
4-6	1.09	1.66	+115	37
6-8	1.12	1.56	+115	38
8-10	1.07	1.62	+113	36
10-12	1.03	1.62	+108	35
12-14	1.01	1.60	+110	35
14-16	0.88	1.55	+105	34
16-18	0.80	1.54	+104	32
18-20	0.72	1.48	+101	31

Table 4—Vertical distribution (percentage) of microalgae at Dias beach

Core depth (mm)	Microalgae abundance (%)		
	High tide	Mid tide	Low tide
0-2	10	12	16
2-4	24	23	18
4-6	30	26	23
6-8	16	16	12
8-10	6	11	10
10-12	5	8	9
12-14	5	6	5
14-16	2	4	3
16-18	2	2	2
18-20	0	2	2

was high in 4-8 mm and decreased with increasing depth (Fig. 2). The percentage concentration of nematoda was 40.5, 42.0 and 45.0 and at high tide, mid tide, and low tide, respectively.

Turbellarians—The numerical abundance of turbellarians showed high density at the surface than in the deeper layers (Fig. 2). The density was highest in the 4-10 mm at the three tidal level. The percentage contribution was 18.8, 19.7 and 19.1 at high tide, mid tide, and low tide, respectively.

Harpacticoida—The vertical distribution of copepods is shown in Fig. 2. The density was high in 2-8 mm section of the core and then decreased with increasing depth in the sediment. The density was maximum at mid tide. The most abundant species were *Stenhelia longifurca*, *Sunaristis* sp. and *Pseudostenhelia* sp. The vertical decrease in the number was significant. The percentage contribution was 14.6, 16.3 and 15.2 at high tide, mid tide and low tide, respectively.

tendency of epigrowth feeders to centres of distribution closer to the sand surface than either deposit feeders or carnivores. The nematode density

The spatial distribution of meiofauna is shown in Fig. 2. The mean total density increased with

Table 5—Actual meiofauna counts (no/cm²) at three tidal levels
[Values are means of triplicate core \pm SD]

Core depth (mm)	High tide	Mid tide	Low tide
0-2	12 \pm 7	18 \pm 6	10 \pm 4
2-4	35 \pm 11	42 \pm 12	37 \pm 8
4-6	48 \pm 19	76 \pm 18	53 \pm 13
6-8	47 \pm 12	62 \pm 12	44 \pm 9
8-10	32 \pm 7	40 \pm 9	31 \pm 7
10-12	25 \pm 6	30 \pm 8	25 \pm 4
12-14	19 \pm 8	24 \pm 6	22 \pm 4
14-16	15 \pm 6	20 \pm 5	18 \pm 3
16-18	11 \pm 4	13 \pm 6	12 \pm 3
18-20	10 \pm 3	12 \pm 3	12 \pm 4

Table 6—Green's index for major meiofaunal groups in different core sizes

Group	Core size			
	0.48 mm	0.78 mm	1.76 mm	3.14 mm
Nematoda	0.23	0.28	0.26	0.91
Turbellaria	0.18	0.21	0.37	0.17
Copepoda	0.25	0.33	0.41	0.12

increasing sampling size. The spatial dispersion was tested by Green's index (GI) and is given in Table 6. Nematodes have shown moderate aggregation at all the four scales. It is possible that individual nematode species were clumped. Copepods were patchy even at the smallest core size and showed strong aggregation at 1.76 cm² core area. The patch sizes were different for different taxa. The aggregation of copepods were stronger than in nematodes and turbellarians, probably because the nematodes and turbellarians were distributed more regularly in the entire length of the core.

Discussion

The density of metazoan meiofauna and the taxonomic groups recorded in the present study are similar to those reported from the same beach earlier⁸. This similarity provides ample evidence that the sampler used in this study is suitable for the study of fine scale distribution of intertidal fauna. Changes in the distribution of microalgae were also detectable by this method.

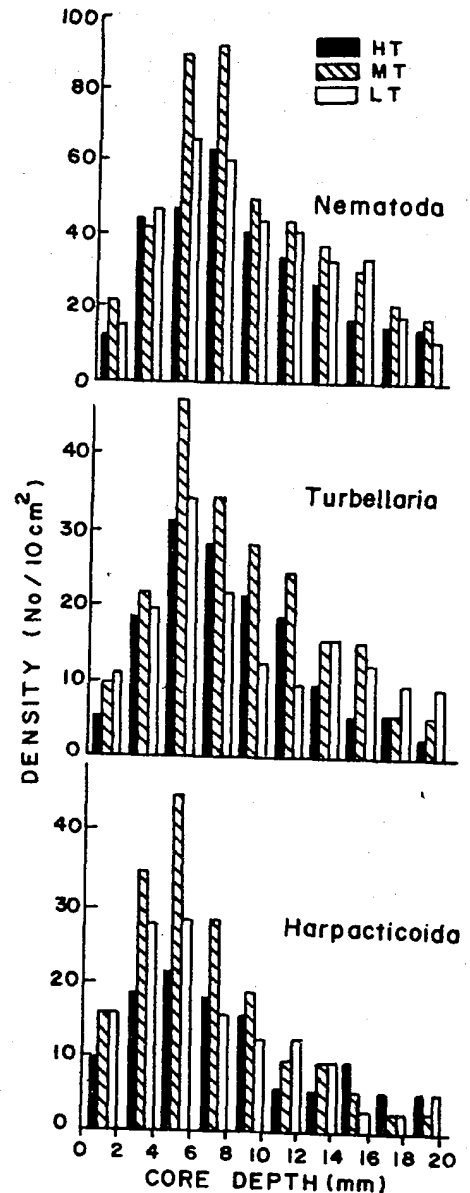


Fig. 2—Vertical distribution of major meiofaunal groups.

The density of different taxa showed variation in different sections of the core, which were in response to vertical gradient of physico-chemical and biological parameters. McLachlan⁹ observed strong vertical gradient in the sediment chemistry and meso-scale vertical distribution of intertidal meiofauna. The vertical distribution of meiofauna was positively correlated with vertical distribution

of chlorophyll-*a* and microphytoplankton. In similar studies positive correlation between meiofaunal group and their suspected microbial food has been reported¹⁰. It is however, suggested that microscale dispersion of intertidal meiofauna does not appear to be regulated by any single factor¹¹.

Meiofauna are sensitive to microhabitat changes and are able to select narrow areas within a relatively homogenous substrata¹². There is an indication that fine scale vertical stratification may play a role in allowing species with similar food requirement in the same locality³. This was true with nematode feeding types in the present study even though other groups also showed overlapping pattern.

This study has corroborated the earlier report that microscale patchiness exists in meiofauna¹⁰. Strong correlation between available food (phytoplankton and chlorophyll-*a*) and meiofaunal density suggest that food is one of the factor responsible for patchy distribution of meiofauna. Others have also proposed that patchy distribution of meiofauna may result from clumped food sources and/or selective predation². Although no direct species-specific interaction were indicated, competition can help aggregation of meiofauna at the fine scale spatial distribution^{13,14}. Differences in life style may also lead to different dispersion patterns. The nematodes for example, with slender body shape have great mobility and were moderately aggregated at fine scale. On the other hand copepods were strongly aggregated due to microhabitat specificity and their sensitiveness to oxygen tension in the deeper layer.

It may be concluded that the fine scale spatial and vertical distribution of meiofauna is the result of combination of physical factors and biological interaction on exposed sandy beaches. The availability of food seems to be a more deciding factor in the patchy dispersion and aggregation.

Acknowledgement

Authors are grateful to Dr. E. Desa, Director and Dr A H Parulekar, Head, Biological Oceanography Division for encouragement.

References

- 1 Gerlach S A, *Oecologia* (Berlin), 33 (1978) 55.
- 2 Coull B C & Bell S S, in *Ecological, processes in coastal and marine system*, edited by R J Livington (Plenum Publishing Corporation) 1979, 169.
- 3 Joint I R, Gee J M & Warwick R M, *Mar Biol*, 72 (1982) 157.
- 4 Lorenzen S, *Helg Veroff Inst Meeresf Bremerh*, 14 (1972) 305.
- 5 El-Wakeel S K & Riley J P, *J Cons Pern Int Explor Mer*, 22 (1956) 180.
- 6 Green R H, *Researchs Popul Ecol Kyoto Univ*, 8 (1966) 1.
- 7 Hummon W D, *Proc Eur Mar Biol Sym*, (1975) 495.
- 8 Rodrigues C L, *Community structure of intertidal fauna at Dona Paula beach (Goa, India)*, Ph.D. thesis, University of Poona, India, 1984.
- 9 McLachlan A, *Estuar Coast Mar Sci*, 7 (1978) 275.
- 10 Decho A W & Fleeger J W, *J Exp Mar Biol Ecol*, 118 (1988) 87.
- 11 Fleeger J W & Decho A W, *Stygologia*, 30 (1987) 35.
- 12 Coull B C, in *Estuarine microbial ecology*, edited by Harold Stevenson & R R Colwell, (University of South Carolina Press, Columbia) 1973, 499.
- 13 Wooden S A, *Ecology*, (1978) 274.
- 14 Findlay S E G, *Estuar Coast Shelf Sci*, 12 (1981) 471.