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ECOLOGY OF THE INTERSTITIAL FAUNA INHABITING THE SANDY BEACHES OF WALTAIR COAST

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INTRODUCTION

INTERSTITIAL fauna constituting the group of microscopic metazoa, inhabiting the intertidal sandy beaches of fresh and salt waters, have received considerable attention during recent years in some parts of the world. Investigations on the freshwater beaches have been carried out in Poland, Hungary, Germany and United States and that of marine beaches in United States, St. Lawrence River Estuary in Canada, Great Britain, France, Germany, Norway, Sweden, Madagascar, Western Australia, India and the Mediterranean environs. Most of the accounts on the subject are taxonomic in nature except those of Wiszniewski (1934) from Poland and Pennak (1940, 1950) from United States which are chiefly ecological.

No attempt seems to have been made to study in detail, the interstitial fauna as such in the sandy beaches of Indian coast. There are a few reports of isolated groups of the sand-dwelling microscopic metazoa by a few workers. Aiyar and Alikunhi (1944) reported some of the archiannelids of the Madras coast. Gnanamuthu (1954) reported two new species of sand-dwelling isopods from the Madras coast. Krishnaswamy (1957) gave the systematic account of the sand-dwelling copepods of Madras coast, with a brief note on their ecology. The present investigation was undertaken to make a preliminary survey of the interstitial fauna inhabiting the sandy beaches of Waltair coast.

MATERIAL AND METHODS

Three stations, presenting different ecological conditions with reference to the slope of the beach, nature of the substratum, exposure to wave action etc. were selected to study the distribution of the fauna in relation to the environmental conditions (Fig. 1). All the observations were carried out during low tide when the intertidal sandy beach was accessible for proper investigation. It was found difficult to make comparable field observations from day to day, due to rapid changes in the configuration of the beach.

For quantitative study, following the method of Pennak (1940), a brass tube having an internal cross-sectional area of 15 cm^2. was thrust into the sand and carefully removed without disturbing the contained core of sand. The core of sand was cut into slices of 1 cm. thickness, each having a volume of 15 cc. The animals present in each 15 cc. sample were collected, sorted and counted. For studying the distribution of the species, different samples were taken from different intertidal and vertical levels along a single transect from the low water to the high water mark.

For the mechanical analysis of sand, samples were collected from different levels in the intertidal height, from the upper 10 cm. of the beach and the analysis was made with standard B.S.T. sieves. The amount of capillary water present at different levels of the beach was determined by weighing the wet sand samples

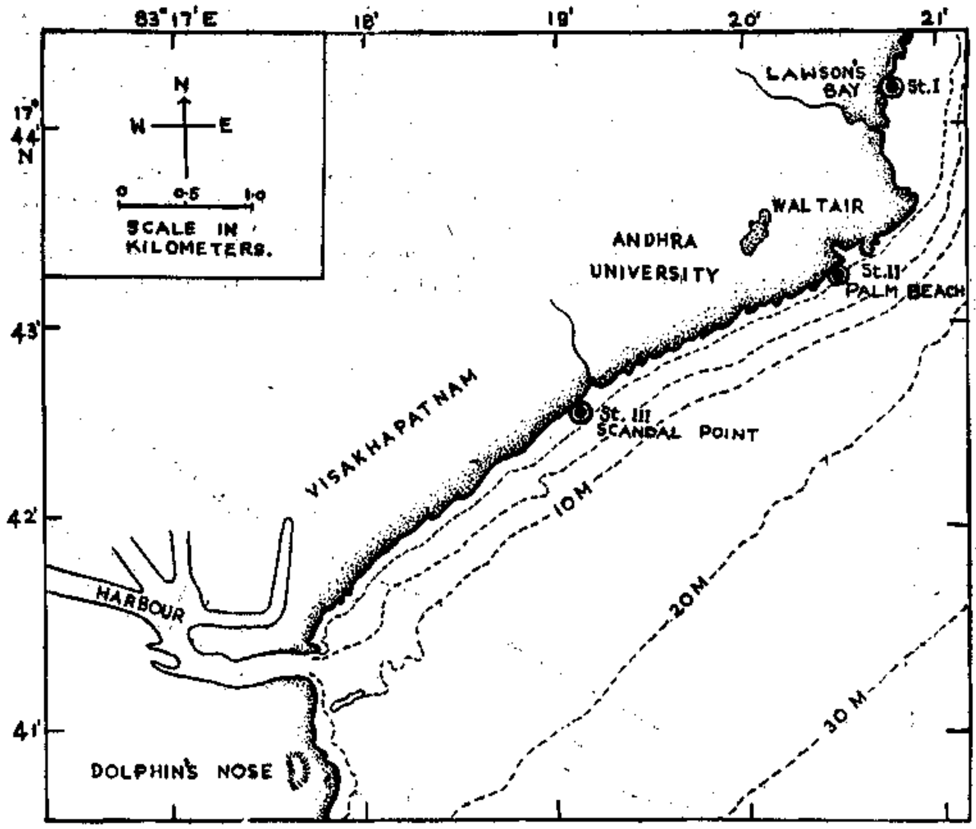

Fig. 1. Map showing Waltair coast with the three localities investigated.

and reweighing after allowing them to complete dryness. Temperature of the surface water was read in knee-deep water with a sensitive centigrade thermometer. The temperature of the sand was recorded by inserting the thermometer into the sand to the required depth. For chemical analysis, sea water samples were collected at the knee-deep water. Interstitial waters for this purpose were drawn with the suction flask arrangement as followed by Pennak (1940) from a depth of 15 cm. from the middle beach. The chemical analyses were carried out as soon as possible and in any case not later than half an hour after the collection of the samples. In estimating salinity, the samples were titrated against silver nitrate and Knudsen's tables were used in the calculations. Winkler's method was used in determining the amount of oxygen content dissolved in the water samples. Interstitial waters for the estimation of oxygen content, were collected avoiding the admixture of air bubbles during suction and the impure samples were discarded. Hydrogen ion determinations were made with the help of a Hellige comparator, using cresol red as the indicator. The hydrographical conditions were studied only at Station II where there was no influx of fresh-water in the vicinity of the station.

Physico-chemical Conditions of the Sandy Beach

Tides and Waves. The effect of tide on the beach is of utmost importance since it marks the boundaries of the intertidal zone while the wave action controls the physical factors of the sandy beach, such as its slope and the size of the sand grains. Thus in Station II where the wave action was severe, the slope of the beach was high with a narrow intertidal belt, mainly composed of coarse and medium sand. In Station III the wave action was small and consequently the slope was low with a wide intertidal belt, mainly composed of fine sand.

Beach Slope. Mean values of beach slope of the three stations are diagrammatically shown in Fig. 2. The slope controlled the width of the intertidal zone, the relation between them being inversely proportional. Marked variations in the slope of these beaches were mainly brought about by the mechanical action of the waves on the beach and the slope was directly proportional to the intensity of wave action.

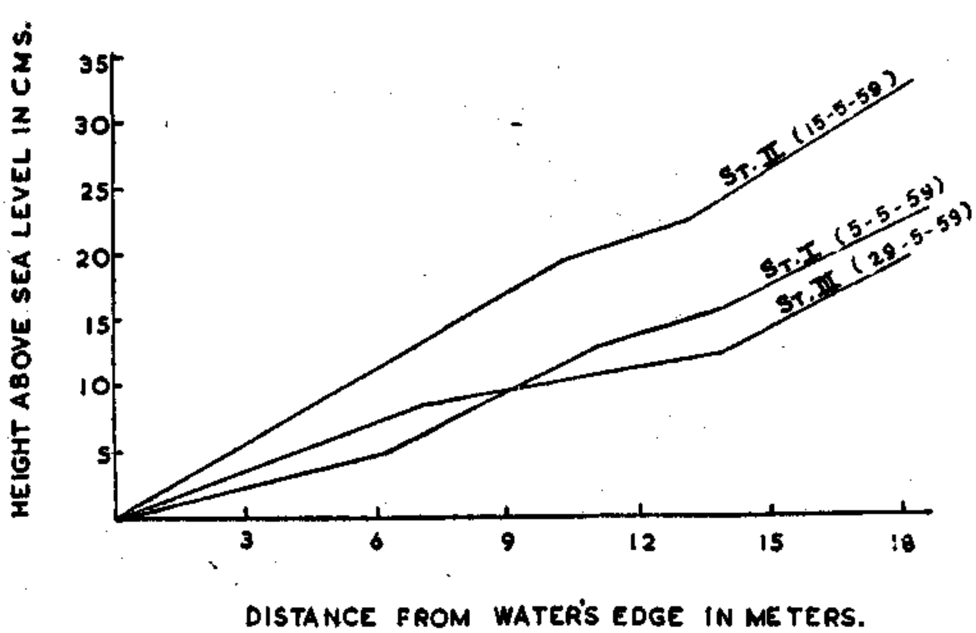

Fig. 2. Slope at the three stations.

Grain size. The relative amounts of different sized sand grains were determined by running the dried sand samples through a series of standard B.S.T. sieves with different meshes and weighing the sand retained by each sieve. This gave the percentage of each grade of sand present in the total weight of the sand and formed a record of the nature of the sand sample. The results are indicated in Table I and it was found that most of the intertidal sands of this coast fall under the category of medium sand, passing through a sieve of 0.5 mm. In all cases it was found that a higher percentage of the coarse grains were present at the low water level and the fine grains at the high water level; the size of the sand particles decreasing from low tide mark to the high tide mark.

TABLE I

Percentage composition of the sand grains of the various diameters at the three stations

Size of the mesh in mm.	Above 0.74	0.74-0.38	0.38-0.25	0.25-0.19	0.19-0.15	0.15-0.12	0.12-0.11	0.11 below
Station I :								
H.W.M. ..	0.02	18.67	9.15	26.93	8.27	21.64	9.12	5.30
M.W.M.	0.30	37.46	16.38	19.50	6.42	10.34	7.20	0.76
L.W.M. ..	2.40	39.80	20.96	9.20	10.02	9.10	6.80	4.16
Station II :								
H.W.M. ..	2.10	20.30	22.46	16.60	13.80	14.10	8.08	3.16
M.W.M.	4.82	25.90	23.10	18.80	10.96	9.25	5.10	1.38
L.W.M.	20.40	63.96	6.85	4.41	1.00	2.46	0.10	1.08
Station III :								
H.W.M.	0.50	6.40	12.20	20.16	28.46	16.38	11.70	3.40
M.W.M. ..	1.00	29.80	20.96	23.08	12.30	6.10	3.60	2.80
L.W.M. ..	3.10	36.97	13.78	20.16	10.96	9.03	3.80	2.18

H.W.M. : High water mark ; M.W.M. : Mid water mark ; L.W.M. : Low water mark.

Grade and pore-space. The grade of the sand is known to influence the quantity of capillary water it holds as well as the interstitial spaces in which the psammolittoral organisms move about. Following the method of Bruce (1928), sand samples of different grades were analysed and the rough measurements are shown in Table II. However, the larger particles of sand appeared to occupy slightly larger interstitial spaces as compared to the fine grains. Despite the minor variations in interstitial space in sands of different grades, the pore space appeared to be uniform varying between 37% to 41%. The interstitial volume of the heterogeneous beach sand occupied only 30%, as the smaller particles fill up the space between the larger particles.

TABLE II

Interstitial space in sands of different grade

Size of the sand in mm.	Percentage of interstitial space	Mean
0.75 - 0.50	41	
0.50 - 0.30	40	
0.30 - 0.25	39	
		39%
0.25 - 0.20	38	
0.20 - 0.18	39	
0.18 - 0.15	37	

Capillary Water. The amount of capillary water held by sand at various intertidal and vertical levels of the beach depended on the distance from the water's edge as well as the depth from which the sample was taken. The mean percentage of saturation at different levels of the beach is shown in Table III. The percentage of capillary water in the sand fell with distance from the water's edge and increased with depth with the exception at the zero water mark. Variations in the distribution of water content at different levels of the beach were mainly due to the differences in beach slope, as the slope controls the width of the wet sand along a beach.

TABLE III

Mean percentage of saturation in sands at various intertidal and vertical levels of the beach

Depth in cms.	Distance from water's edge in meters.							
	0	3	6	9	12	15	18	21
5	100	84	76	70	48	27	19	11
10	100	89	78	76	50	32	24	14
15	100	94	86	78	61	43	33	17
20	100	100	95	80	69	55	38	24
25	100	100	100	98	80	62	46	31

Temperature. The temperature of the air, sea water and that of sand, taken at different levels of the intertidal beach (A, B and C) and at depths of 2.5 cm. and 15 cm. are given in Table IV. The temperature records of the intertidal sand have

TABLE IV

Temperature of air, sea water and sand at Palm Beach for the year 1958-'59
(A, B and C denote the distance from water's edge 5, 10 and 15 meters respectively.)

Date	Time	Climate	Air	Sea water	Temperature in 0°C.					
					A		B		C	
					2.5 cms. Below	15 cms. Below	2.5 cms. Below	15 cms. Below	2.5 cms. Below	15 cms. Below
13-10-58	14.30	Sunny	32.8	28.2	29.5	28.2	31.3	28.6	33.8	29.3
27-10-58	14.00	Cloudy	30.1	27.3	28.1	27.9	28.2	30.2	30.2	29.7
17-11-58	18.30	Sunny	30.0	28.1	28.3	28.3	29.7	29.9	30.2	30.8
28-11-58	15.00	Cloudy	30.3	27.2	27.9	27.3	29.1	28.0	31.9	30.4
2-12-58	6.00	Sunny	30.2	26.4	26.8	27.6	27.0	28.3	29.2	30.3
25-12-58	13.00	Cloudy	28.5	26.3	27.1	26.8	27.4	27.0	29.5	28.7
2-1-59	6.30	Sunny	29.5	25.8	27.0	27.6	27.8	28.9	29.5	30.8
23-1-59	13.30	Cloudy	28.1	24.8	26.7	25.2	27.0	26.8	28.4	28.2
13-2-59	17.30	Cloudy	28.3	26.9	26.9	27.3	27.0	27.6	29.0	29.8
20-2-59	12.00	Sunny	31.8	28.0	29.3	28.0	31.8	29.4	33.2	30.1
9-3-59	14.30	Cloudy	28.0	27.4	27.4	27.2	29.1	28.8	29.2	28.9
16-3-59	17.30	Sunny	29.7	26.4	27.3	28.7	27.7	29.1	28.0	30.3
11-4-59	14.00	Sunny	31.8	26.9	28.1	27.2	30.9	29.0	33.8	30.2
20-4-59	12.00	Sunny	32.2	27.6	28.0	27.6	29.8	29.1	34.1	30.3
5-5-59	13.00	Sunny	33.0	28.8	30.8	28.6	33.5	29.3	35.5	30.2
14-5-59	6.00	Sunny	31.6	27.8	28.0	28.4	28.3	29.2	30.4	31.9
27-5-59	6.00	Sunny	32.3	27.4	27.5	28.1	29.7	30.9	31.3	32.6
4-6-59	13.30	Sunny	34.8	29.4	31.9	30.3	34.1	32.0	36.8	32.6
26-6-59	6.00	Sunny	32.4	28.3	28.7	29.4	30.0	31.2	31.6	32.8
12-7-59	18.00	Sunny	27.8	28.8	28.8	28.8	29.1	29.4	30.3	31.8
27-7-59	6.30	Cloudy	29.6	27.8	28.0	28.6	29.5	30.8	30.1	31.4
8-8-59	18.00	Sunny	27.8	26.8	27.1	27.3	28.2	28.7	29.8	30.7
15-8-59	12.00	Sunny	32.3	27.8	29.1	27.8	30.3	29.1	32.8	30.8
26-8-59	6.00	Cloudy	30.1	27.6	27.6	27.8	28.1	28.8	29.3	30.7

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shown an increase from low water level to high water level. This was especially true in summer months when the difference was as much as 4°C to 6°C. The temperature of the sand was also found to decrease with depth and the difference was pronounced in summer months when it was 3°C to 5°C between the surface sand at 2.5 cm. depth and that at 15 cm. below the surface. But towards the evening before sunset and early morning before sunrise, this gradient was reversed as the surface sand gets cooled by the atmospheric air while the deeper sand still retains the higher temperature. This vertical difference in temperature between surface and subsurface levels of the beach sand, increased from the low water level to the high water level. Higher temperatures of the sand were recorded on sunny days when the beach was subjected to bright sunshine rather than on cloudy days and hence the insolation of the sun was considered as an important factor in controlling the temperature of the sand. The maximum temperature is attained by the sand at about 2.00 p.m. and the minimum at dawn.

TABLE V

Salinity of the Palm Beach waters during the sunny days for the year 1958-'59

Date	Sea water S°/₀₀	Interstitial water S°/₀₀	Difference S°/₀₀
13-10-58	28.64	29.03	0.39
10-11-58	30.61	30.79	0.18
17-11-58	29.24	30.06	0.82
3-12-58	31.49	31.52	0.03
4-1-59	31.16	31.28	0.12
3-2-59	31.48	32.06	0.58
27-2-59	31.26	31.54	0.28
15-3-59	33.26	33.38	0.12
25-3-59	32.64	32.96	0.32
2-4-59	32.95	32.82	0.87
20-4-59	33.95	34.07	0.12
5-5-59	34.31	34.86	0.55
29-5-59	33.86	34.21	0.35
4-6-59	34.13	34.78	0.65
28-6-59	33.64	34.02	0.38
12-7-59	33.17	33.85	0.68
8-8-59	33.96	34.06	0.10
4-9-59	33.42	33.95	0.53
16-9-59	33.78	34.04	0.26

Salinity. It has been found from the values obtained that under normal conditions the salinity of the interstitial water does not vary much from that of the adjacent sea water. But on hot sunny days the salinity of the interstitial water was found to be slightly higher than that of the adjacent sea water. This difference appeared to be more pronounced at midday time when the beach was subjected to the severity of sunshine as compared to the morning and evening periods. Hence, it was assumed to be due to the evaporation of the capillary water at the surface. Even then the difference between the two waters was found to be less than 1 part per thousand (Table V). But during periods of heavy rainfall, a considerable difference in salinity between sea water and interstitial water has been found to exist; the salinity of the interstitial water being less than that of the adjacent sea water by 2-3 parts per thousand or more depending on the intensity of the rain (Table VI).

TABLE VI

Salinity of the Palm Beach waters during the rainy days for the year 1958-'59

Date	Sea water S°/oo	Interstitial water S°/oo	Difference S°/oo
5-10-58	28.16	26.42	1.74
27-10-58	26.37	24.58	1.79
28-11-58	25.90	22.18	3.72
12-12-58	25.28	24.96	0.32
25-12-58	28.70	26.25	2.45
23-1-59	30.85	27.92	2.93
13-2-59	31.11	29.78	1.33
9-3-59	32.19	32.02	0.17
5-7-59	32.96	30.14	2.82
17-7-59	32.18	29.02	3.16
29-7-59	32.85	30.27	2.58
15-8-59	31.62	30.04	1.58
24-9-59	32.96	32.08	0.88

TABLE VII

Oxygen content of the Palm Beach waters during the sunny days for the year 1958-'59

Date	Sea water ml/L.	Interstitial water ml/L.	Difference ml/L.
27-10-58	4.23	4.08	0.15
20-11-58	4.01	3.67	0.34
3-12-58	4.27	3.73	0.54
4-1-59	4.02	3.75	0.27
3-2-59	4.16	3.78	0.38
20-2-59	4.10	3.90	0.20
25-3-59	3.65	3.20	0.45
20-4-59	4.63	4.17	0.46
2-5-59	3.98	3.87	0.11
15-5-59	4.51	4.20	0.31
4-6-59	2.47	4.22	0.05
28-7-59	4.83	4.42	0.41
8-8-59	3.92	3.46	0.46
15-8-59	3.88	3.54	0.34
26-9-59	4.37	4.18	0.19

Dissolved Oxygen. The values obtained are shown in Table VII which indicate the presence of low concentrations of oxygen in interstitial water as compared with that of the adjacent sea water. On rainy days the oxygen concentration of interstitial water was higher than that of the adjacent sea water which was due to the seeping of rain waters (Table VIII). The low concentrations of oxygen in interstitial waters during normal periods was attributed to the rapid oxygen utilization by the psammobionts and the wave action appeared to be an important factor in replenishing the oxygen content of the interstitial water.

TABLE VIII

Oxygen content of the Palm Beach waters during the rainy days for the year 1958-'59

Date	Sea water ml/L.	Interstitial water ml/L.	Difference ml/L.
27-10-58	4.21	4.55	0.34
10-11-58	4.12	4.38	0.26
28-11-58	4.08	4.67	0.79
12-12-58	4.96	5.02	0.66
23-1-59	4.08	4.31	0.23
9-3-59	3.94	4.26	0.32
4-7-59	4.47	5.17	0.70
17-7-59	5.14	5.94	0.80
24-8-59	3.96	4.72	0.76
16-9-59	4.46	4.82	0.36

Hydrogen ion concentration. The pH of the capillary water was found to be slightly less than that of the adjacent sea water (Table IX). This low concentration of hydrogen in interstitial waters is assumed to be due to the presence of low concentrations of oxygen and higher concentrations of carbon dioxide.

TABLE IX

pH values of Palm Beach waters during the period July-September, 1959

Date	Sea water	Interstitial water	Difference
3-7-59	8.2	8.0	0.2
10-7-59	8.1	8.0	0.1
18-7-59	8.0	7.8	0.2
24-7-59	8.1	8.0	0.1
4-8-59	8.2	7.9	0.3
14-8-59	8.0	7.7	0.3
20-8-59	8.2	8.0	0.2
27-8-59	8.1	8.0	0.1
4-9-59	7.9	7.8	0.1
12-9-59	8.7	8.6	0.1
22-9-59	8.6	8.4	0.2
28-9-59	8.5	8.4	0.1

Organic matter. An attempt has been made to determine the amount of particulate organic matter of the intertidal sands by the 'loss of weight on ignition' method. In general it was observed that the percentage of organic carbon was very low which might be due to the wave washed nature of the beach, that prevents the successful settlement of organic detritus.

GENERAL ECOLOGY OF THE INTERSTITIAL FAUNA

These organisms have shown different structural modifications to suit the needs of this environment. The majority are small in size, elongate and vermiform in outline, transparent in colour, without eyes but with well developed special sense and adhesive structures. Their response to light is negatively phototactic. Several species exhibit gregarious habit and this appears to be maintained with the help of the sensory structures. The different groups of animals exhibit their own methods of locomotion. The majority of these organisms achieved varying degrees of adaptability and are able to withstand a fairly wide range of environmental variation. In feeding habits, they are represented by herbivores, carnivores, omnivores and detritus feeders. Bacteria, Protozoa, Diatoms and organic detritus appeared to constitute the chief diet of these organisms. The majority appeared to breed during the summer months of the year. The density-size relationship of the fauna is seen and the small forms exist in huge numbers while the larger species are represented by small numbers.

Effects of physico-chemical factors on the fauna

Tide. In addition to the maintenance and restoration of marine conditions in this habitat, the effect of tide is partly important in determining the width of the inhabitable intertidal zone and thus influences the intertidal distribution of the microscopic metazoa.

Wave action. The mechanical influence of wave action did not appear to disturb the zonation of the fauna but heavy wave action appeared to alter their distribution pattern by washing many of these organisms into the sea. This was indicated by the considerable decrease in the number of these organisms in the sand samples that were analysed following the periods of high wave action.

Beach slope. The beach slope controls the width of the inhabitable intertidal zone and influences the intertidal distribution of these organisms. Thus when the gradient is high, the beach is narrow with the horizontal distribution of the species very much condensed. On the other hand when the gradient is low, the intertidal zone is wide followed by the increase in the intertidal distribution of the species.

Grain size. The effect of grain size on the microscopic metazoa of the beach appeared to be significant. The larger forms were generally found in coarse sand and the smaller ones in fine sand. The nematodes with numerous long bristles were generally found to inhabit a coarse grade of sand while the forms with small and vestigial bristles inhabit the fine sand. Similarly kinorhynchs, annelids, isopods and larger copepods were collected from sand of a coarse texture. Life was also found to be poor or scarce in sands of fine grade and this may be due to the absence of adequate interstitial space between the sand grains and as such the absence of a congenial environment for the movement of these organisms.

Capillary Water and its action. Optimum conditions of saturation were found to be favourable to these interstitial forms since the animals collected were few in substrates with a low or a high degree of saturation. The evaporation of the capillary water from the surface of the sand is of utmost importance for it results in the cooling of the sand and preventing the rise of temperature that would prove detrimental to the life of these organisms.

Temperature. When the beach is uncovered at low tide and subjected to sunshine, though an increase in temperature can be expected, the presence of capillary water and its evaporation was considered to keep down the temperature of the sand to a tolerable degree for the organisms. Higher temperatures were recorded at high tide level due to the presence of dry sand and the psammolittoral organisms were scarce at that level and the few forms that occur there were found to inhabit deeper layers of the sand which ensure adequate moisture and optimum temperature.

Salinity. The minor fluctuations in the salinity of interstitial waters had no influence on the life of these organisms. But during heavy rains, the interstitial waters were considerably diluted and the collections made following heavy rains have revealed noticeable reduction in numbers, probably showing the deleterious effects caused by the fluctuations in salinity.

Other factors like pH, dissolved oxygen and particulate organic matter, did not appear to have any constant relationship to either numbers or distribution of these organisms.

Quantitative Studies

The number of animals collected in a sample of 15 cc. of sand was found to depend on several factors such as the season, the weather, the intensity of wave action, the station, the width of the beach, the nature of the substrate, the spot of collection between the tide marks including the intertidal and vertical levels, etc. For example, the faunistic composition in 15 cc. of sand collected on 14-11-1958 at Station II from a depth of 10 cm. in the mid-tide level, consisted of 17 ciliates 7 flagellates, 15 turbellarians, 9 annelids, 12 copepods, 7 isopods, 11 gastrotrichs, 3 acarines and 2 kinorhynchs; which was an unbelievable concentration. And on the other extreme, a collection made on 3-12-1958 at the same spot had none of these organisms. Probably because of the gregarious habit of some of these psammophilous organisms, the variety of animals found in 15 cc. of sand sample is also variable. Thus in some samples analysed, the faunistic composition was mainly found to consist of a large number of individuals of a single species while in others a variety of different organisms were found. As has been pointed out by Pennak (1950) no satisfactory explanation could be suggested for these population irregularities.

Table X

Intertidal and vertical distribution of interstitial fauna in the three localities investigated. Numbers indicate averages of interstitial forms per 15 c.c. of sand sample

Station	Depth of sample in cms.	Distance from water's edge in meters							
		0	3	6	9	12	15	18	21
I	5	6	7	8	10	12	9	4	—
	10	4	18	28	15	20	13	8	—
	15	3	10	19	26	32	15	16	7
	20	3	8	12	16	21	27	21	9
	25	2	7	10	14	18	17	14	11
II	5	6	18	18	20	18	8	2	—
	10	16	28	26	30	32	10	6	2
	15	10	22	30	36	40	20	18	8
	20	4	10	25	30	30	31	20	10
	25	2	6	10	25	30	24	26	13
III	5	2	4	8	11	9	6	3	—
	10	1	6	12	16	18	10	8	—
	15	3	9	15	21	28	23	18	6
	20	2	6	10	16	22	26	20	11
	25	3	5	8	11	15	14	12	9

The average numbers of interstitial forms inhabiting the different intertidal and vertical levels of the beach, in the three localities investigated, are shown in Table X. The psammolittoral organisms were found to occur in abundance in the middle beach which is neither fully saturated nor too dry. On the other hand, as stated by Pennak (1940) the submerged sand near the water's edge which is fully saturated or the exposed sand at the high water mark which is completely dry, was found to be decidedly a less favourable environment for the existence of these organisms. Thus the general penetration of these forms tended to descend to greater depths as they proceed from the low water level towards the high water level, seeking optimum conditions of temperature and moisture.

Observations of the interstitial waters of this coast have revealed the presence of different groups of animals and among these groups, Crustacea, Nematoda, Turbellaria, Annelida, Gastrotricha and Acarina, in the order of their abundance, constitute the bulk of the interstitial fauna of this coast. All the other groups of animals are represented by small numbers.

The average numbers of the different groups of interstitial fauna inhabiting the different levels of the beach, are shown diagrammatically in Fig. 3. The occurrence and abundance of Protozoa has not yet been clearly understood and their distri-

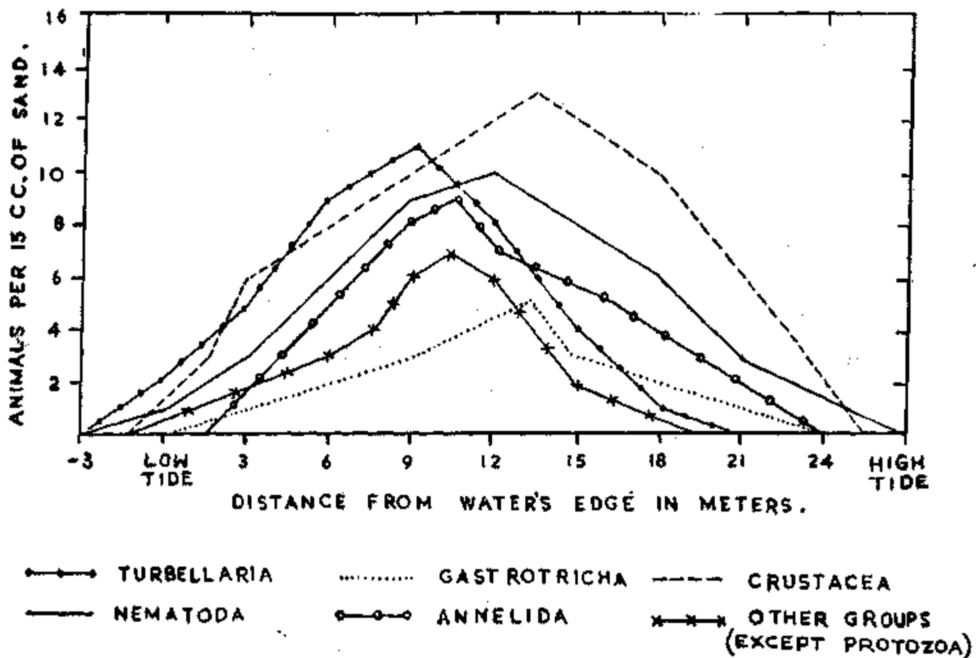

Fig. 3. Horizontal distribution of interstitial fauna in Palm Beach, Waltair, in April, 1959. Data for top 25 cms. of sand.

bution appeared quite sporadic. Species of Hydrozoa, Turbellaria, Nemertinea, Rotifera, Archiannelida, Polychaeta, Ostracoda, Halacaridae, and Nudibranchiata, were generally found to inhabit the top 20 cm. of sand between the low and mid-tide levels of the beach. Nematodes were practically collected at all the levels of the beach, the maximum concentrations usually occurring between depths of

10-20 cm. in the middle beach. Species of Gastrotricha, Kinorhyncha, and Isopoda occurred at the mid-tide level, preferably in the deep layers of sand and vertically they extend up to a depth of 70 cm. Oligochaetes were collected from different levels of the beach and their distribution appeared sporadic. Harpacticoid copepods were seen at all the depths of the intertidal beach, the majority restricting themselves to the mid-tide level. Several species of copepoda were found to occur at different intertidal and vertical levels of the beach showing conspicuous zonation. Tardigrades were found to inhabit between the mid and high-tide levels of the beach and in the deep layers of sand below a depth of 30 cm. The Diatoms, constituting one of the chief sources of food material between tide marks, were collected in small numbers in the superficial layers of the sand, in correlation with their photosynthetic activity. A few forms were also collected from the deeper layers of sand that were probably washed there by tides and waves.

The intertidal distribution of the species was greater in a wide beach than in a narrow beach. Slowly moving species were generally found to form distinct communities while mobile species appeared in a variety of places. Thus the horizontal distribution of interstitial fauna at the three localities along the length of the coast varied from locality to locality.

Life was recorded to a depth of 75 cm. towards the high water level of the beach and the small number of animals collected at these depths were chiefly cilates, nematodes, oligochaetes, gastrotrichs, tardigrades and crustaceans. The existence of the microscopic metazoa at these depths despite the low concentrations of oxygen, is probably correlated with their acclimatization to an anaerobic environment. The factors influencing the density and distributing of the fauna are still far from clear as several of them operate together to produce a combined effect ; but, however, food, temperature, moisture and the texture of the substrate, appeared to be the chief ones.

TABLE XI

Seasonal distribution of interstitial fauna at Palm Beach during the year 1958-'59

Date of Collection	Average number of animals per 15 cc. sand
27-10-58	8
17-11-58	9
25-12-58	7
23-1-59	8
20-2-59	12
16-3-59	10
11-4-59	16
27-5-59	21
26-6-59	24
12-7-59	31
15-8-59	18
8-9-59	11

Seasonal distribution. To study the seasonal distribution of interstitial fauna, series of samples were taken at Palm Beach from the mid-tide level where the majority of the organisms live. Samples were taken within 10 meters horizontal distance of each other. The average numbers of animals per 15 cc. sand were calculated (Table XI). Some of the species of interstitial fauna appeared to show periodicity in their occurrence but in general the majority were collected at the end of the summer season. The fluctuating salinity during rainy season may account for their sparsity during this period while the steady salinity conditions, rich phytoplankton bloom and the favourable temperature for the hatching of the eggs during the summer months, appear to be favourable for their growth and reproduction.

Summary

The present paper is a preliminary survey of the ecology of interstitial fauna inhabiting the sandy beaches of Waltair coast. The influence and fluctuations of the physico-chemical conditions of the beach were studied. The bionomics and the effects of the physico-chemical factors on the distribution and density of the fauna were observed. Quantitative studies, showing the number of the different groups of animals inhabiting different levels of the beach, have been made.

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