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Ecology of Intertidal Meiofauna of the Kakinada Bay (Gautami-Godavari Estuarine System), East Coast of India

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The survey of intertidal meiofauna in the Kakinada Bay yielded 13 groups and 22 species of harpacticoid copepods (18 genera and 8 families). The meiofauna ranged between 302 and 5924 no.$(10cm^2)^{-1}$ with relatively high densities in a mangrove biotope. The distribution of meiofauna is discussed in relation to the prevailing environmental parameters. Spatially, high diversity in harpacticoid copepods was recorded in silt-free fine sand sediments, while seasonally the diversity was low during flood period. Two harpacticoid copepod communities, namely, (i) a mangrove, detritic, clayey-silt copepod assemblage characterized by *Pseudostenhelia secunda* and *Stenhelia* (*Delavalia*) *longifurca* and (ii) a coastal silt-free fine sand copepod assemblage characterized by *Amphiascoides* sp. and *Hastigerella* sp. have been identified.

There is paucity of information on the meiofauna in estuarine systems in India. The present paper gives the distribution of intertidal meiofauna of Kakinada Bay, east coast of India in relation to the prevailing environmental parameters.

Materials and Methods

Three stations in Kakinada Bay were selected for regular sampling of which one was at Chollangi (st 1) in a mangrove forest and the other 2 were situated south and north respectively to Kakinada canal at Etimoga (st 2) and Dummulpeta (st 3) (Fig. 1). Regular, monthly and replicate core samples (each 3.6 cm diam. and 20 cm long) for meiofauna were collected from 4 sampling points at each station during low water of springs along the mid littoral zone, covering a distance of 300 m, from February 1978 to January 1980. A 3rd core sample was taken separately in March, June and September for grain size analysis and estimation of organic matter in the sediment. Simultaneously data on salinity (Knudsen method), temperature, dissolved oxygen (Winkler method), grain size[1,2] and sediment organic matter[3] were also collected. Samples were passed through a set of 2 sieves (0.5 and 0.062 mm) to separate the meiofauna. The meiofauna were identified to group level and the group harpacticoid copepoda to species level. Mean values of 8 samples taken from the whole transect of 300 m long at any given station were given. Standard deviations were calculated for mean values and tests of significance performed. Pearson product moment correlation coefficients[4] were calculated to correlate mean animal densities with salinity and significance tests were performed. Margalef's[5] species diversity index was employed.

Results and Discussion

Environmental parameters—Monthly variations in temperature, salinity and dissolved oxygen of surface and interstitial waters are given in Table 1. Surface water temperature ranged from 25.2°C (August 1978 at st 1) to 35.4°C (September 1978 at st 3); interstitial water temperature from 24.3°C (December 1979 at st 1) to 33°C (April 1978 at sts 1, 2 and 3). Comparatively salinity values, both for surface and interstitial water, were low at st 1 and high at st 3. This may be because of their location. The influence

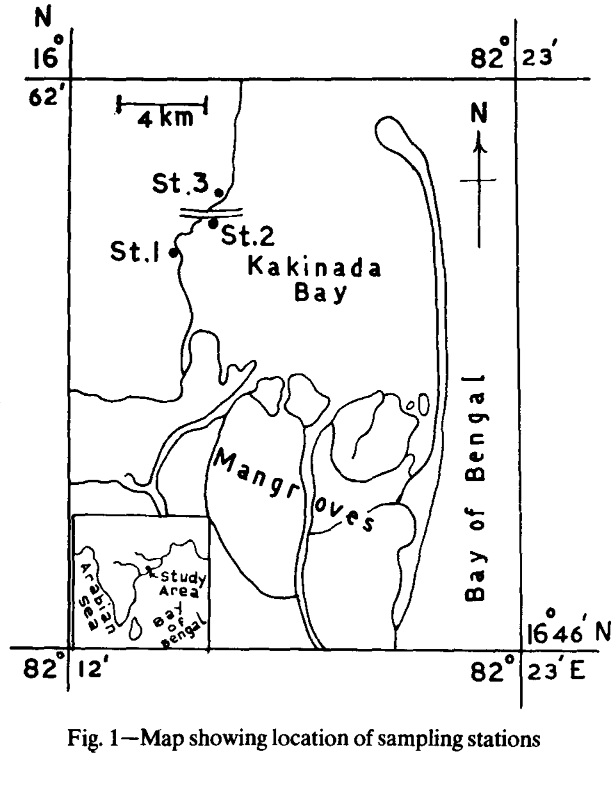

Fig. 1—Map showing location of sampling stations

Table 1—Monthly Averages of Temperature (°C), Salinity ($\times 10^{-3}$) and Dissolved Oxygen ($ml.l^{-1}$) at Sts 1 to 3 for Surface and Interstitial Waters

Month	Surface Water									Interstitial Water								
	Temperature			Salinity			Oxygen			Temperature			Salinity			Oxygen		
	St 1	St 2	St 3	St 1	St 2	St 3	St 1	St 2	St 3	St 1	St 2	St 3	St 1	St 2	St 3	St 1	St 2	St 3
1978																		
Feb.	32.8	33.5	33.0	27.6	28.1	28.1	4.00	4.22	4.33	28.0	30.7	32.6	17.7	25.9	31.7	1.99	2.57	2.50
March	30.7	31.1	34.8	30.0	30.8	30.8	3.98	4.10	4.61	29.7	29.6	30.8	18.0	26.6	32.1	1.95	2.46	2.48
April	32.6	33.5	34.1	31.6	32.5	33.1	4.32	4.62	4.20	33.0	33.0	33.0	30.5	32.9	33.4	2.01	2.09	2.53
May	32.0	31.8	31.1	36.8	36.6	37.7	4.77	5.22	4.78	36.6	31.7	29.3	38.7	37.1	38.7	1.89	2.14	2.96
June	27.6	28.7	30.6	28.9	29.2	33.1	4.61	4.98	4.70	31.4	28.4	29.2	29.7	30.2	30.6	2.05	2.34	2.68
July	29.1	29.4	28.5	30.4	30.6	32.0	4.70	5.00	4.83	36.5	29.0	28.9	15.3	31.6	36.4	2.09	2.52	2.71
Aug.	25.2	25.6	27.1	20.2	29.2	24.1	4.77	5.12	5.16	32.7	25.6	27.6	10.5	28.6	29.8	2.47	2.42	2.76
Sept.	31.0	31.5	35.4	26.5	27.7	26.8	4.62	4.98	5.06	35.1	28.8	30.5	17.4	28.7	31.8	2.54	2.56	3.59
Oct.	31.4	31.9	35.0	16.0	15.8	19.9	4.50	4.77	5.12	31.7	29.3	30.7	15.2	19.7	21.7	2.23	2.57	2.70
Nov.	32.9	33.6	32.9	12.2	22.0	28.4	4.34	4.52	4.68	33.5	29.7	30.0	9.9	22.0	27.1	2.25	2.54	2.66
Dec.	26.4	26.5	27.2	22.9	23.8	25.9	4.39	4.59	4.93	29.4	25.2	25.8	19.5	24.7	26.1	2.20	2.21	2.88
1979																		
Jan.	28.8	29.0	28.8	19.5	22.7	27.7	3.92	4.03	4.31	27.0	25.4	25.6	13.1	22.6	28.5	1.91	2.23	2.46
Feb.	32.5	33.0	30.4	24.4	24.9	25.6	4.10	4.59	4.70	34.4	29.2	27.8	10.0	23.2	30.0	2.18	2.50	2.74
March	31.6	32.0	32.5	30.5	31.9	39.4	4.02	4.42	4.59	25.8	29.8	30.6	19.7	31.7	41.5	2.02	2.27	2.46
April	34.0	34.5	33.6	35.5	38.3	38.7	4.21	4.31	4.48	28.1	32.6	32.1	32.9	36.0	41.8	2.04	2.16	2.54
May	31.1	32.5	31.5	32.2	32.6	32.6	4.92	5.10	5.10	32.5	31.3	31.1	28.2	35.3	36.3	2.06	2.68	2.94
June	30.5	32.2	34.5	35.8	36.2	36.2	4.62	4.70	5.04	29.3	31.6	32.2	37.7	39.1	40.8	2.20	2.41	2.87
July	31.0	31.5	29.0	36.2	37.9	39.0	4.88	5.10	5.43	27.3	29.2	28.1	27.5	38.4	43.7	2.31	2.94	3.31
Aug.	27.2	27.5	29.1	25.5	33.3	38.3	4.96	5.26	5.77	31.6	29.7	29.2	18.3	35.4	42.1	3.04	3.45	3.55
Sept.	33.6	34.2	31.5	20.5	24.4	34.4	5.10	5.15	5.88	30.4	32.8	30.8	10.6	29.1	35.1	2.98	2.99	3.21
Oct.	34.5	34.5	34.8	19.5	23.3	26.9	4.98	5.04	5.43	29.2	32.0	31.0	9.0	26.3	30.7	2.22	2.87	3.54
Nov.	27.6	28.0	30.5	10.4	11.7	27.3	4.47	4.59	4.82	26.5	28.5	29.1	6.6	16.6	24.6	2.41	2.49	2.81
Dec.	28.2	28.5	26.0	7.5	7.4	20.8	4.40	4.65	4.98	24.3	27.6	24.4	4.7	14.9	18.2	2.37	2.56	3.00
1980 Jan.	30.3	30.5	27.0	21.4	22.2	29.0	4.32	4.14	4.37	25.2	27.3	25.6	12.2	21.7	30.3	2.15	2.12	2.41
Mean	30.5	31.1	31.2	25.1	27.2	30.7	4.50	4.70	4.90	30.4	29.5	29.8	18.9	28.3	32.6	2.20	2.50	2.80

of freshwater is more at st 1, as it is situated near to the freshwater source of Kakinada Bay and an irrigation canal (Chollangi canal) enters Kakinada Bay at st 1. The marine water influence is more at st 3, as it is situated on an open coast. Values of dissolved oxygen of interstitial water were low during summer months (February to June); from July they gradually increased and reached peak levels in August/September and decreased to low level in November and continued up to January. Dissolved oxygen values of interstitial water were low at st 1, which may be attributed to the decomposing mangrove foliage observed at this station.

Sediments of sts 2 and 3 were moderate (sorting = 0.6505) and well (sorting = 0.4994) sorted respectively. Fine sand was the principal component at st 3, while silt was the major constituent at st 1 (Table 2). Seasonal variations in percentages of silt and clay at st 1 and sand and silt at st 3 were not significant. Fine sand dominated the sediment in all seasons followed by silt and clay at st 2. The sand grain size did not fluctuate very widely either seasonally or spatially at sts 2 and 3. The mean grain size was 0.14 mm for both these stations. Sedimentary organic matter ranged from 0.57% (September 1979 at st 3) to 2.37% (March 1978 at st 1). No significant and consistent seasonal variations in sedimentary organic matter were observed at sts 1 and 2. At st 3, the organic matter, from its relatively high values in March, decreased gradually and registered low values in September. In general, the sedimentary organic matter values were low at st 3 and high at st 1. Probably the decomposing mangrove foliage contributed to the high percentage of organic matter at st 1 (Table 2).

The stations located in Kakinada Bay experi-

Table 2—Sediment Parameters of Stations 1-3

Month	Sand (%)	Silt (%)	Clay (%)	Median grain size (mm)	Organic matter (%)
		St 1[a]			
1978					
March	0	97.5	2.5	—	2.37
June	0	97.0	3.0	—	2.10
Sept.	0	94.5	5.5	—	1.89
1979					
March	0	97.4	2.6	—	2.23
June	0	98.0	2.0	—	2.17
Sept.	0	97.1	2.9	—	2.30
Mean	0	96.9	3.1	—	2.17
		St 2[b]			
1978					
March	71.2	25.5	3.3	0.13	1.15
June	62.4	34.3	3.3	0.14	0.68
Sept.	79.8	16.9	3.3	0.15	1.33
1979					
March	74.4	17.5	8.1	0.15	1.02
June	74.1	16.3	9.6	0.13	1.31
Sept.	53.6	38.0	8.4	0.14	0.84
Mean	69.2	24.8	6.0	0.14	1.05
		St 3[c]			
1978					
March	97.9	2.1	0	0.13	0.81
June	98.6	1.4	0	0.15	0.75
Sept.	97.0	3.0	0	0.15	0.63
1979					
March	96.7	3.3	0	0.15	0.79
June	96.4	3.6	0	0.14	0.66
Sept.	97.2	2.8	0	0.14	0.57
Mean	97.3	2.7	0	0.14	0.70

Sediment type: [a]-Clayey silt with mangrove foliage; [b]-fine sand with mud; and [c]-silt-free fine sand

enced the dilution effect due to freshwater influx slightly later than in the main part of the estuary. The estuary presents 3 very different environments with reference to the hydrographic conditions, which in their turn affect the biological characteristics. The duration of the 3 periods in Kakinada Bay is: summer period from February to September, flood period in October-November and post-flood period in December-January.

Meiofauna—They comprised 13 groups (Nematoda, harpacticoid copepoda, Ostracoda, Kinorhyncha, Turbellaria, Mollusca, Polychaeta, Halacarina, Oligochaeta, Tardigrada, crustacean larvae, insect larvae and Amphipoda) and 22 species of harpacticoid copepods belonging to 18 genera and 8 families. Seasonal variations of meiofauna and important harpacticoid copepods of sts 1-3 are given in Figs 2-4 respectively. Values of correlation coefficient (r) and significant tests (t) of meiofauna and diversity index values of harpacticoid copepods are presented in Table 3.

St 1: Mean total number of animals [nos. $(10cm)^{-2}$] ranged from 491 (September 1979) to 5924 (October 1978) and averaged 2130. At st 1 the meiofauna registered 2 peaks of abundance, one in October 1978 and the other in April 1978 (Fig. 2). The seasonal pattern of abundance showed irregular fluctuations from February to September. From the lowest abundance of September, the meiofauna gradually increased in density (Fig. 2). The observed seasonal variations in total meiofauna were significant (P= 0.05) except for those observed in February, July, December 1979 and January 1980. Nematoda was the most dominant (88.2%) group and governed the trend of seasonal fluctuations of the total meiofauna with maximum density [$4850.(10cm^2)^{-1}$] recorded in October 1978. Ostracods, ranking second in abundance, were found at peak abundance in February 1978 [$790.(10cm^2)^{-1}$]. However, during 1979-80, their density was relatively very low. Harpacticoid copepods comprised 5.3% of total meiofauna. Eleven species belonging to 9 genera and 6

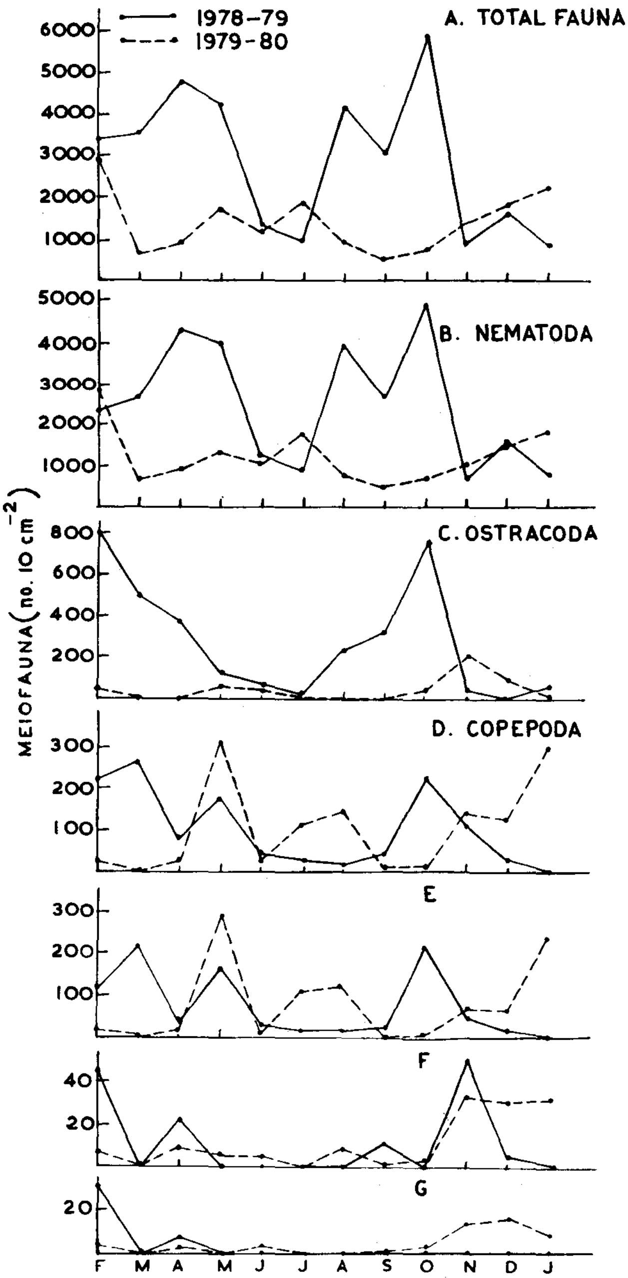

Fig. 2—Seasonal variation of meiofauna (A-D) and dominant harpacticoid copepods E-*Pseudostenhelia secunda*, F-*Stenhelia* (*Delavalia*) *longifurca* G-*Halectinosoma curticorne*, at station 1

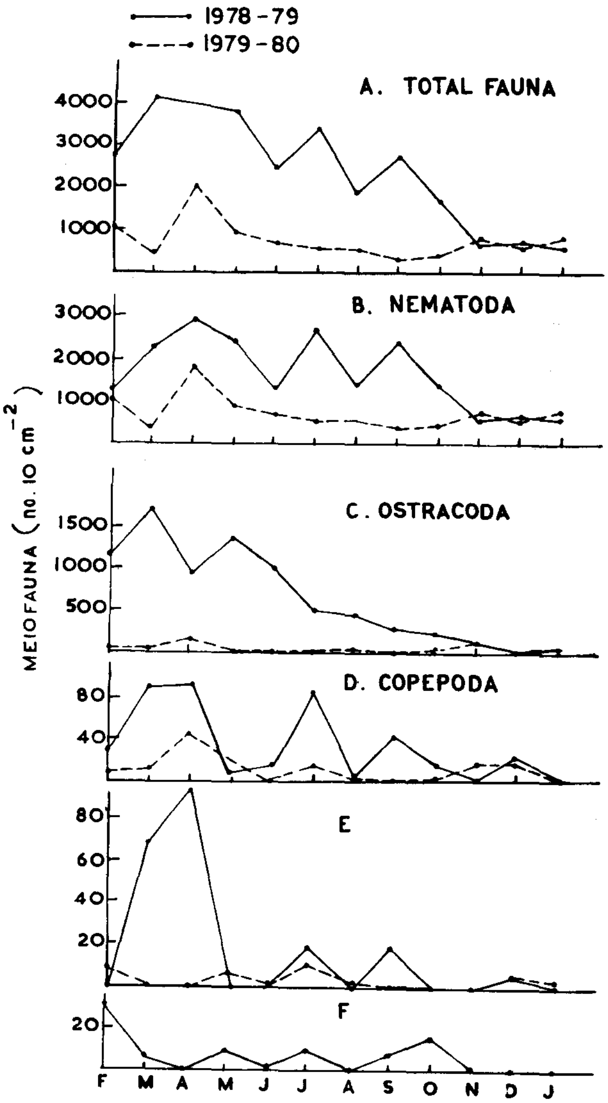

Fig. 3—Seasonal variation of meiofauna (A-D) and dominant harpacticoid copepods E-*Sunaristes* sp, F-*Laophontopsis secunda* at station 2

families were recorded. *Pseudostenhelia secunda* was the most abundant (78.4%) in copepods. The copepod seasonal fluctuations showed that in both years peaks of abundance alternated with a sharp fall of density. Kinorhynchs occurred mostly during February-April and again in September-November; comprising 0.3% of the total meiofauna. Polychaetes, turbellarians and larval forms sporadically appeared in the samples during February-May and constituted 1% of the total meiofauna.

St 2: Mean total number [nos.(10cm)$^{-2}$] of animals ranged from 302 (September 1979) to 4199 (March 1978) and averaged 1599. In 1978-79, the meiofauna was at a high level of abundance during most of the summer (February-September) except in June, when there was a sudden but slight decrease in the abundance. The density of total meiofauna was relatively low during 1979-80 (Fig. 3). The observed seasonal variations in total meiofauna were significant (P= 0.05) except for those observed in August, October 1978 and April 1979. Nematodes were again the dominant forms comprising 83.3% of the total meiofauna. The trend of seasonal abundance of nematodes closely followed that of total meiofauna. Maximum density [2928.(10cm^2)$^{-1}$] was recorded in April 1978. Ostracods, ranking second in order of abundance constituted an important group, comprising as much as 13.6% of the total meiofauna. They were recorded in highest percentage of

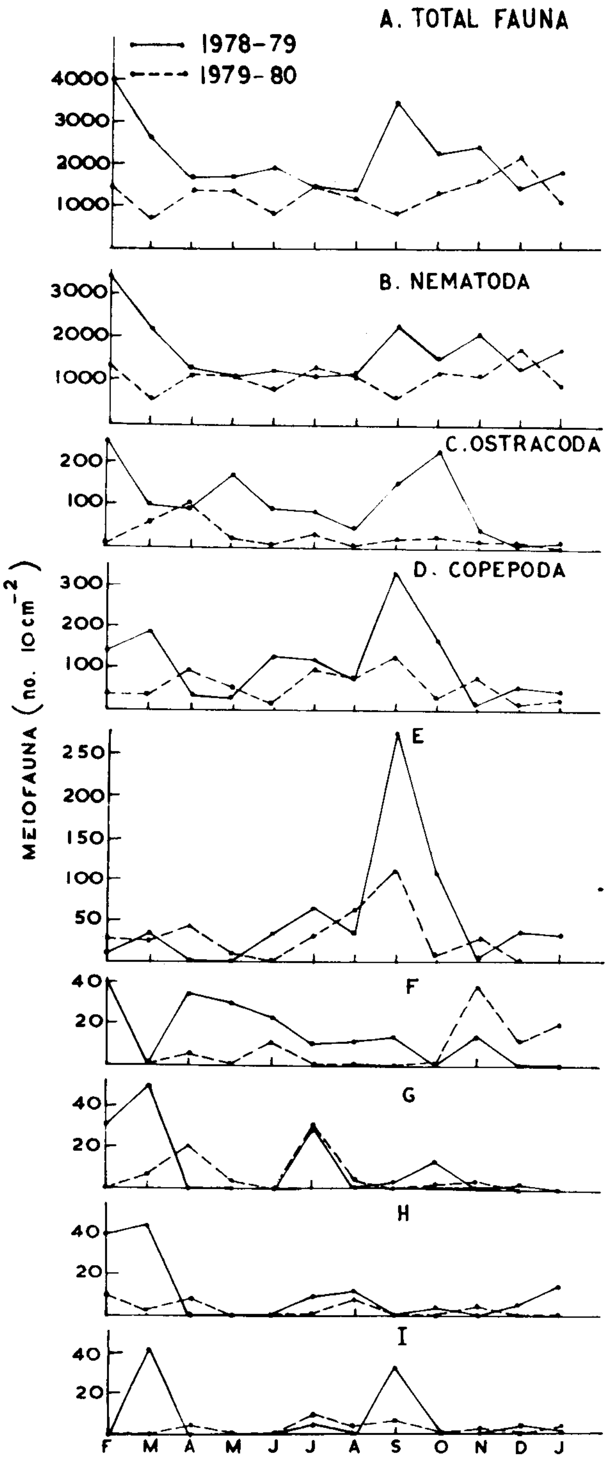

Fig. 4—Seasonal variation of meiofauna (A-D) and dominant harpacticoid copepods E-*Amphiascoides* sp, F-*Hastigerella* sp, G-*Halectinosoma curticorne*, H-*Laophontopsis secunda*, I-*Tachidius discipes* at station 3

abundance at this station; contributing in some months (February, March and June 1978) more than 40% to the total meiofauna. They were present in large numbers in summer from February to July and in low abundance during the remaining period of the survey. The harpacticoid copepods averaged 1.3% of the total meiofauna and never reached 4%. Thirteen species were recorded belonging to 12 genera and 8 families. *Sunaristes* sp. was the most abundant (43.4%) in copepods. The total copepod stock showed large scale fluctuations with peak periods of abundance alternated with periods of very low abundance. In general, the higher levels of abundance were relatively more during March to July than those observed from August to February. The copepod fauna registered its peak abundance [94.(10cm^2)$^{-1}$] in April 1978. Polychaetes, kinorhynchs and molluscan juveniles although recorded in most of the samples in a year, occurred in very small numbers constituting 1% of total meiofauna.

St 3: Mean total number [nos.(10cm^2)$^{-1}$] of animals ranged from 680 (March 1979) to 4095 (February 1978) and averaged 1766. The seasonal abundance of the meiofauna showed that the fauna occurred at a relatively high level of abundance throughout the year, with small scale fluctuations in numbers (Fig. 4) and these variations were significant ($P = 0.05$) in February, March, September 1978; March, June and September 1979. Nematodes were again the most dominant (81%) forms. Their seasonal fluctuations in abundance closely followed that of total meiofauna. Overall the copepods averaged 4.7% of the total meiofauna, ranking second in order of abundance. Sixteen species were recorded belonging to 14 genera and 7 families. *Amphiascoides* sp. was the most dominant (48.5%) in copepods. Seasonally the abundance of copepoda showed large scale fluctuations, with alternating periods of rise and fall in density. In general, their density was relatively low during 1979-80. Turbellarians (3.8%), ostracods (3.5%) and tardigrades (3.6%), more or less, equally contributed in their percentage abundance to the total meiofauna. Tardigrades were observed in highest percentage abundance only at this station during the present survey and they constituted 23% of the total meiofauna collected in May 1978. Ostracods registered a major peak of abundance [248.(10cm^2)$^{-1}$] in February 1978. An increase in density was noticed in October, May 1978 and in April 1979. During the remaining period, they were relatively at a low level of abundance. Turbellarians were collected abundantly from September to December in both years and in January 1980.

The harpacticoid copepods [*Halectinosoma curticorne, Tachidius discipes, Stenhelia* (*Delavalia*) *longifurca, S.* (*D.*) *madrasensis, Pseudostenhelia secunda, Nitocra spinipes, Enhydrosoma buccholtzi* and *Nannopus palustris*] exhibited a decrease in density in low saline waters; and many species totally disappeared during flood period. However, correlation between salinity and meiofauna density revealed

Table 3—Values of Correlation Coefficients (*r*) and Significance Tests (*t*) of Meiofauna and Diversity Index Values of Harpacticoid Copepods at Stations 1-3

Meiofauna	Study period		Summer		Flood period		Post-flood period	
	r	*t*	*r*	*t*	*r*	*t*	*r*	*t*
Station 1								
Total meiofauna	0.1216	0.6	0.0226	0.1	0.8847	3.8	−0.1456	0.3
Nematoda	0.1579	0.8	0.0430	0.2	0.8966	4.0	0.0500	0.1
Copepoda	0.0430	0.2	0.1678	0.6	0.6057	1.5	−0.3168	0.7
Ostracoda	−0.0518	0.2	−0.1516	0.6	0.8238	2.9	−0.8373	3.1
Kinorhyncha	−0.3404	1.7	−0.4291	1.8	0.9085*	4.3	0.0873	0.2
Pseudostenhelia secunda	0.1279	0.6	0.0118	0.0	−0.5514	1.3	−0.6352	1.6
Stenhelia (Delavalia) longifurca	−0.3195	1.6	0.2186	0.8	0.8085	2.7	−0.2074	0.4
Diversity Index value	2.9		2.2		1.1		3.0	
Station 2								
Total meiofauna	0.2197	1.1	−0.1801	0.7	−0.6094	1.1	0.4239	0.7
Nematoda	0.2459	1.2	−0.0911	0.3	−0.5952	1.0	0.4204	0.7
Copepoda	0.1359	0.6	−0.2245	0.9	−0.9468	4.2	0.0628	0.1
Ostracoda	0.1362	0.7	−0.2455	0.9	−0.5676	1.0	−0.2330	0.3
Sunaristes sp	0.1173	0.6	−0.1362	0.5	0.0	0.0	−0.3105	0.5
Laophontopsis secunda	−0.2673	1.3	−0.4111	1.7	−0.5243	0.9	0.0	0.0
Diversity index value	4.4		4.1		2.0		4.2	
Station 3								
Total meiofauna	−0.3627	1.8	−0.5230*	2.3	−0.4762	0.8	−0.6772	1.3
Nematoda	−0.3523	1.8	−0.4978	2.1	−0.0422	0.1	−0.5056	0.8
Copepoda	−0.0270	0.1	−0.4232	1.7	−0.7939	1.8	0.3021	0.4
Ostracoda	−0.0552	0.3	−0.2524	1.0	−0.6624	1.3	−0.4677	0.7
Turbellaria	−0.4621*	2.4	−0.1399	0.5	−0.5984	1.1	−0.6685	1.3
Tardigrada	0.0355	0.2	−0.3136	1.2	−0.4423	0.7	0.7131	1.4
Amphiascoides sp	−0.0106	0.1	−0.2504	1.0	−0.8802	2.0	0.2289	0.3
Hastigerella sp	−0.1537	0.7	−0.3696	1.5	−0.1531	0.2	0.2331	0.3
Halectinosoma curticorne	0.2158	1.0	0.1371	0.5	0.0132	0.0	−0.7000	1.9
Laophontopsis secunda	−0.1691	0.8	−0.4948	2.1	0.9990*	15.6	0.7540	1.6
Diversity index value	4.6		2.8		2.8		5.5	
Table *t* value (p = 0.05)		2.1		2.2		4.3		4.3

*Significant correlation at p = 0.05

weak positive and inverse correlations (Table 3). An analysis of diversity of copepod fauna indicated the existence of a correlation between salinity and diversity; the diversity of copepods decreased at all stations during flood period and high diversity indices were found during post-flood and/or summer periods (Table 3).

The clayey-silt sediment of st 1 with decomposing mangrove foliage supported high population densities of meiofauna. The fine sand/mud sediments with large amounts of detritus are known to support rich meiofaunal densities[6,7]. The clayey-silt sediments of st 1 also registered highest mean density [102.$(10cm^2)^{-1}$] of harpacticoid copepods. A further analysis of species composition and abundance reveals that a single species *Pseudostenhelia secunda* was responsible for the high abundance and it contributed as much as 78% to the total copepod stock at st 1, while at other stations its contribution was less.

All the 3 known species of the genus *Pseudostenhelia* (*P.prima*, *P.secunda* and *P.wellsi*) were recorded from similar biotopes (intertidal muds of detrital origin). In the present study numerous males and females of *P.secunda* were collected at st 1. Although it has an ubiquitous distribution occurring at all stations in the estuarine system, it was recorded in maximum abundance at st 1 and in minimum abundance in the fine sands of st 3, where the silt content was very less. The dominance of this species in the harpacticoid copepod community in the clayey silt sediments of st 1 indicates its preference toward such substrata.

At st 3, where fine sands constituted the sediment, the harpacticoid copepod fauna was made up by an assemblage of interstitial dwellers like *Amphiascoides* sp., *Hastigerella* sp., *Halectinosoma curticorne*, *Laophontopsis secunda*, *Halectinosoma gothiceps*, *Tachidius discipes*, *Robertsonia propinqua* and *Sunaristes* sp. These interstitial harpacticoid copepods contributed as much as 99% to the copepod community. The copepod fauna of st 3 represents a typical collection of sandy shore fauna and predominated by typical sand dwellers like *Amphiascoides* sp. and *Hastigerella* sp. constituting as much as 70% of the total copepod stock. These 2 forms were, however, not recorded from other stations, where the sediment is dominated by silt mixed with fine sand or silt and clay. They are mostly present in fine sands, which are relatively free from silt and clay. It is evident from the above observations that the sediments with similar particles in their composition (i.e. silt dominated sediment of st 1 and fine sand dominated sediment of st 3, unlike the sediment of st 2 with an admixture of particles of fine sand, silt and clay) supported high densities of harpacticoid copepods with 1 or 2 species dominating in the copepod community.

Harpacticoid copepods, in their spatial distribution are associatd with certain sediment types and can be regarded as 'indicators' of those sediment biotopes. The present investigation provides examples to substantiate the fact that the copepods indicate the nature of substratum. *Pseudostenhelia* indicated the occurrence of clayey silt sediments enriched with detritus. *Amphiascoides* and *Hastigerella* indicated the preference of silt-free fine sand sediments. Besides individual species, a community of species can indicate the sediment biotopes[8,9]. In the present investigation, the harpactocoids *Pseudostenhelia secunda, Stenhelia (Delavalia) longifurca, S. (D) madrasensis, Halectinosoma curticorne, Nannopus palustris, Nitocra spinipes* and *Enhydrosoma buccholtzi* preferred clayey silt sediments enriched with detritus. The *Amphiascoides* sp., *Hastigerella* sp., *Laophontopsis secunda, Halectinosoma gothiceps* and *Tachidius discipes* were found ubiquitously in the silt-free fine sand sediments. The following harpacticoid copepod assemblages were recognized based on salinity and sediment distribution in the estuarine system:

i. A mangrove, detritic, clayey silt assemblage characterized by *Pseudostenhelia secunda* and *Stenhelia (Delavalia) longifurca*

ii. A coastal, silt-free fine sand assemblage characterized by *Amphiascoides* sp. and *Hastigerella* sp.

Ostracods showed a relationship between their abundance and nature of sediment. High densities of ostracods were found in the muddy sands of st 2, while they were present in low numbers in the relatively silt-free fine sands of st 3. Wieser[7] and McIntyre[10] observed high densities of ostracods in fine sand-silt sediments in their subtidal studies.

Kinorhynchs were found at sts 1 and 2 and were absent at st 3, where the sand fraction dominates the sediment composition. They were common at st 1, where the sediments composed of silt and clay with decomposing mangrove foliage. The great majority of kinorhynch taxa associate with subtidal sediments particularly soft sediments - mud or mud mixed with sand - with a relatively high organic content[11]. Kinorhynch populations were recorded[12–15] in the muddy or in the fine sandy sediments. However, Rao and Ganapati[16] observed kinorhynchs also in medium sand and coarse sand sediments along Waltair coast.

High densities of tardigrades [66.$(10cm^2)^{-1}$] were observed in the relatively silt-free fine sands of st 3 and were rarely represented at st 2. Probably the sandy sediments or sand dominated muddy sand

Table 4—Comparison of Meiofauna Densities (no.$10cm^{-2}$) of Intertidal Estuarine Habitats

Locality	Nature of substrarum	Copepoda			Nematoda			Total meiofauna		
		Min	Max	Av	Min	Max	Av	Min	Max	Av
Blyth estuary (UK)										
i. Middle reaches	Mud	—	—	—	808	1848	—	—	—	—
ii. Upper reaches	Mud	—	—	—	203	799	—	—	—	—
Southampton (UK)	Mud	81	1021	—	—	—	—	—	—	—
Salt marsh, Mass. (USA)	Mud	—	—	—	1440	2130	1830	—	—	—
Salt mash, Georgia (USA)	Mud	—	—	—	260	12400	5940	—	—	—
Salt marsh, North Inlet Estuary (USA)	Mud	1	192	76	50	950	—	175	1000	—
Vellar estuary (India)	Fine sand	5	422	180	307	3240	2232	420	3815	2625
Pitchavaram mangroves (India)	Mud	—	—	—	205	2782	—	—	—	—
Present study- St 1	Clayey silt + mangrove foliage	8	309	102	483	4850	1843	491	5924	2130
St 2	Fine sand + Mud	2	94	23	295	2928	1198	302	4149	1599
St 3	Fine sand	14	331	83	544	3425	1416	680	4095	1766

sediments are more congenial for colonization by tardigrades. Rao and Ganapati[16] recorded tardigrades in medium sands near mid water level at Waltair coast. Very tight packing of sediment particles and clogging of interstices by fine elements are unfavourable to the existence of tardigrades[17].

Particulate organic matter is abundant in the estuarine systems. It serves as a food source for many meiobenthic organisms[18]. It has been well established that the meiofauna aid in decomposition[19] and play an important role in recycling of nutrients at a lower trophic level[18,20]. The occurrence of high percentage of organic matter at st 1, which is located in the mangrove biotope, may probably be responsible for the existence of high densities of meiofauna at st 1 during the present survey.

An attempt has been made in the present study to compare the densities of meiofauna of Kakinada Bay with the densities of meiofauna reported for other intertidal estuarine habitats (Table 4). The densities of total meiofauna and nematoda at st 3 are comparable with the densities reported for fine sand habitats in Vellar estuary[12]. The total meiofauna density of st 1, located in the mangrove habitat, was higher than the density recorded for high marsh habitat in North Inlet estuary[21]. The nematode densities recorded at st 1 were higher than the densities recorded in muddy sediments[22–24] and lower than the densities reported for Georgia salt marsh[25]. The copepod densities recorded at st 1 were higher than the densities reported for high marsh habitat in North Inlet estuary[21] and lower than the densities reported for muddy sediments of Southampton[26]. However the copepod densities recorded at st 3, composed of fine sands were lower than the densities reported for fine sand habitat of Vellar estuary[12].

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