

Dynamics of intertidal meiofaunal benthos in a tropical mangrove swamp, southeastern Nigeria

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ABSTRACT

Changes in densities of meiofaunal nematodes and copepods during the period from December 2006 to September 2007 are described for seven locations in the Cross River estuary. There were no consistent patterns of change in either the number of species of copepod or the genus. Large fluctuations in total numbers of nematodes were prevalent at the various sampling locations throughout the year. The population density of most species changed during the year, but these could not be related to the seasons. Rather, it is speculated that non-seasonal environmental factors are of greater significance. The densities of a few species remained constant all through the year. Total density was strongly related to tidal height and mangrove litters, with highest densities at low water levels.

INTRODUCTION

The meiofauna are generally the most abundant metazoans in marine sediments and therefore are of considerable interest to marine biologists. (Gerlach, 1977; Lee et al., 1977; Dye, 1983; Frauenheim et al., 1999; Rees et al., 1999; Callaway et al., 2002; Schratzberger et al., 2006). Their importance is particularly marked in the littoral marine habitats where they become proportionately more abundant with sediment type. Assessment of their ecological role has been impeded by the taxonomic intractability of meiofauna, but groupings on the basis of buccal morphology (e.g. Nematodes), tail morphologies and locomotory patterns have proven to be useful tools. Although this area of marine biology is relatively neglected, importance of meiofauna to trophic dynamics and nutrient recycling in estuarine ecosystems is recently increasingly emphasized (Warwick and Price, 1979; Platt and Warwick, 1980).

Spatial and temporal heterogeneity are common in meiofauna distribution. In shallow littoral water studies, these variabilities have been attributed to biotic factors such as the presence of decaying organisms (Gerlach, 1977) and food preferences (Lee et al., 1977) as well as to abiotic factors such as temperature (Tietjen and Lee, 1977) and sediment granulometry (Schratzberger et al., 2006).

In this paper, the temporal changes in species densities, faunal composition and total density of the major taxonomic groups of meiofauna are considered for the Calabar River estuary, off the Gulf of Guinea. The knowledge of the dynamics of meiofauna could be of great advantage in a regional mangrove conservation programme.

MATERIALS AND METHODS

Study environment

The sampling sites were all within the Cross River estuary on the southeastern coast of Nigeria (Fig. 1). The estuary lies between latitudes 4.00' and 8.00'N and longitudes 7°20' and 10°00'E. It discharges into the Gulf of Guinea in Southeastern Nigeria but takes its origin from the Cameroun Mountains. Major tributaries include rivers, Calabar, Akpayafe, Mbo and great Kwa Rivers all of which drain through the tropical rainforest belt, consisting of thick rain forest to the North and the freshwater and mangrove swamps to the south. It is the largest estuary in Africa. The area is characterized by two seasons, wet season (April –October) and the dry season (November-March). During December-January, the climate is characterized by cold dry and dusty conditions brought about by the North East Trade Winds blowing across the Sahara Desert. The South West Trade Winds dominate the wet season. Annual rainfall averages 4021mm. The average temperature is 28°C and relative humidity is 80%.

The sampling sites were identified by numbers and corresponded to those of earlier benthic studies in the area.

Each site was sampled within an interval of 2 days during the period from 10th December, 2006 and September 2007, using methods described by Hodda and Nicholas, (1985).

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In November, samples were taken with a sharpened perspex cylinder (4.9cm² surface area). At all other times, samples were taken with a steel corer (25cm² surface area) and bisected from top to bottom to give a surface area of 12.5cm² before further processing. Samples were taken in a row, with edges 1cm apart and 5cm from the row taken in earlier studies. All samples were taken to a depth of about 8cm during low tide, placed in plastic container and fixed in 5% formaldehyde in 63µm filtered seawater. The fauna was extracted from the mud by a combination of sedimentation, sieving and centrifugation (Hodda and Nichola, 1985). A sub-sample of the first 100 nematodes in the dish containing the extracted fauna in addition to any other animals in the same portion of the dish, was identified: density was calculated by extrapolating the number in this measured fraction to the whole sample, which was of known volume. The sub-sample was mounted in glycerol in microscope slides for identification and counting. Counts were compared from sub-samples of three sizes with total counts of samples from 4 different sites in the estuary and estimates of density found to be generally within 20th of the actual density.

Analysis

Correlation coefficients between estimated and real densities were determined using least-squares method. Due to the large proportion of zeros in many of the samples, the non-parametric Kruskal-Wallis one-way-analysis of variance was applied to compare estimated and real faunal densities. Rank correlation coefficients were also used for the same reason.

RESULTS

Eighteen genera of mangrove swamp meiofaunal, benthic taxa comprising 14 nematode, 2 genera of copepod, 1 of Kinorhynch and 1 gastrotrich were obtained during the study. Nematodes dominated all samples from every site and every sampling time, comprising 80 – 100% of the individual animals within the replicate cores (\bar{X} =98.5%). Harpacticoid copepods were the next most abundant taxa (0–29%). Oligochaetes, polychaetes, rhabdocoel platyhelminths and larvae of dipteran families were also obtained in small numbers. The densities of the most common nematodes and copepods over the seasons, are listed in Table 2. The densities of most nematode species were very variable. For example, the density of *Spirinia sp* was highest in the rainy months of June-September and lowest in the dry season. *Ethmolaimus sp* was found at maximum densities at sites 5 and 6 during the dry

season and lower at other sites it was generally low during the rainy season. Density of a few species varies little at each site throughout the year; however, density differed among the sites: *Paracytholaimus sp* and *Metadesmolaimus* were examples. Only a few had concordant patterns of density over the year at all the sites at which species were found. *Ptycholaimus sp* always had the highest density in the rainy season (June- July- September), at five of the six stations (sites) at which it was found. *Terschellingia sp* and *Spirinia sp* both reached maximum density in rainy season at most of the sites where they were found. Some species had very highly statistically significant changes in density over the year at some sites. *Paradontophora sp* and *Oxystomina sp* were species in this group.

The copepods also demonstrated high variability in mean density spatially and temporally. *Mesochra sp* was the only copepod species with a consistent pattern of density over the year at all sites.

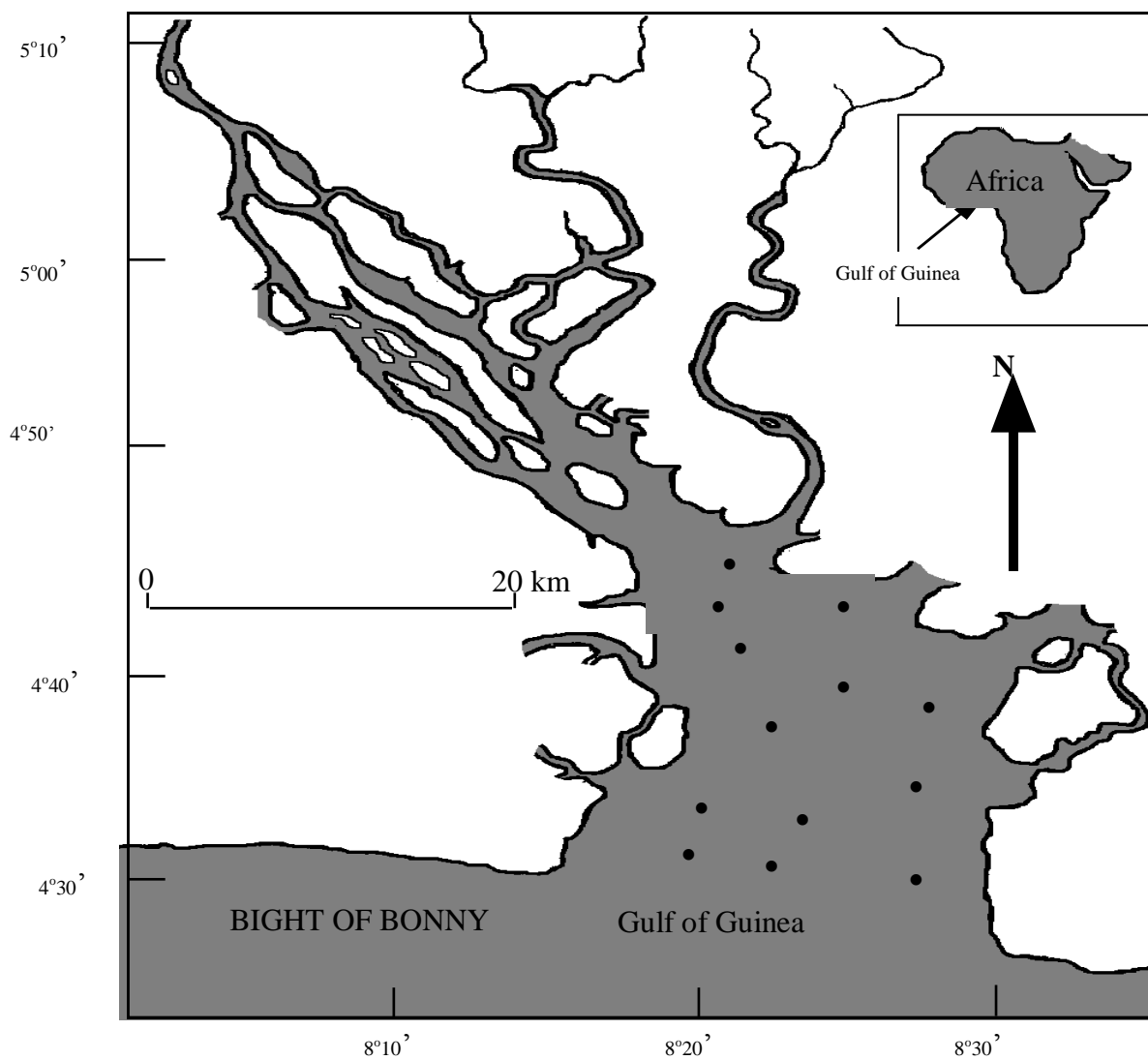


Fig. 1. Cross River estuary showing the sampling stations on the southeastern coast of Nigeria

Table 1. Environmental parameters at sampling stations in Cross River estuary

station	Distance from low tide mark (m)	Height above datum (m)	Density of mangroves roots.	Median grain size (μm)	Mud consistency	Conductivity October				Surface water	P ^H October			
						2cm	5cm	10	15		2cm	5cm	10cm	15cm
1	2	0.0	Very few	20	Very soft	+50	-108	-140	-180	7.8	6.6	7.3	7.2	7.1
2	50	0.3	Dense	28	Soft	-280	-291	-310	-261	6.9	6.6	6.4	6.4	6.6
3	45	0.3	Dense	4	Soft	-330	-226	-316	-326	6.8	7.0	6.9	6.9	7.0
4	5	0.5	Dense	35	Hard	-201	-186	-188	ND	8.2	7.5	6.9	6.2	
5	25	1.2	Sparse	200	Hard	-60	-108	-136	-160	ND	7.8	6.6	7.8	6.5
6	30	0.4	Absent	45	Soft	-150	-177	-215	-271	8.3	7.9	7.5	7.6	7.5
7	25	1.3	Moderate	12	Firm	-48	-96	-126	-134	ND	7.8	7.2	6.5	6.0

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Table 2. Density of most abundant meiobenthic genera

Genus	Station No	Density (No.cm ⁻²) x 10 ³				Level of significance
		2006		2007		
		Nov.	Mar.	June	Sept.	
Nematode	2	5.2	-	-	-	*
<i>Chromadorina</i> sp	5	38.6	0.8	-	-	ns
	6	-	1.9	46.2	-	*
<i>Dichromadora</i> sp	7	-	-	420	261.2	**
	2	-	-	6.8	15.5	**
	3	-	2.8	3.6	68.2	**
	1	15.8	-	186.1	-	**
	5	-	-	18.4	-	**
	6	201.0	-	1.2	-	**
<i>Ptycholaimellus</i>	7	7.5	70.1	113.1	85.8	*
Sp.	2	125.6	26.8	630.6	501.3	*
	3	9.5	1.5	12.9	11.6	n.s
	4	3.2	-	0.4	0.8	n.s
	1	95.3	13.5	350.1	138.6	*
	6	40.1	-	-	-	*
<i>Ethmolaimus</i> sp	7	1.3	-	-	-	**
	2	-	-	1.5	-	n.s
	3	27.8	05.1	18.6	-	n.s
	4	0.9	0.4	1.5	2.6	*
	6	2066.9	188.6	1.3	56.5	**
	1	4801.6	156.8	-	-	**
<i>Paracyatholaimus</i>	7	26.0	36.5	11.7	28.9	n.s
	2	135.2	72.8	200.6	56.8	n.s
	1	12.2	86.5	58.8	13.6	n.s
	4	1.6	6.7	-	0.8	n.s
	5	-	-	-	-	-
	3	62.0	-	-	1.2	**
	6	-	0.9	3.9	-	n.s
<i>Spirinia</i> sp	1	1.8	125.3	283.6	186.3	**
	3	23.6	10.9	86.3	92.1	*
	4	189.2	96.5	130.5	521.9	**
	6	1.2	0.8	-	0.6	n.s
	7	1.2	-	112.6	132.1	n.s
<i>Leptolaimus</i> sp	3	0.8	13.2	-	-	*
	5	-	-	-	-	n.s
	2	0.6	0.9	-	-	*
	1	2.1	25.6	4.8	-	*
<i>Diplolaimella</i>	6	6.8	10.0	-	-	*
	1	1.2	13.6	-	6.5	**
	8	-	2.8	-	-	n.s
	3	196.8	-	-	1.3	*
	2	43.6	1.2	26.8	5.6	*
<i>Monhystera</i> sp	2	1.3	12.4	188.2	156.5	*
	3	-	23.5	38.8	-	**
	5	-	4.6	3.4	-	**
	1	20.6	180.1	28.5	13.0	n.s
	6	5621.2	-	-	-	**
<i>Metadesmolaimus</i>	2	-	8.2	-	1.7	n.s
sp	3	-	-	-	12.1	n.s
	6	25.6	10.5	9.2	-	**
<i>Sphaerolaimus</i> sp	3	4.5	23.6	-	-	**
	4	2.4	-	1.8	-	n.s.
	2	2.8	0.8	2.1	-	**

	6	162.3	120	258.5	7.3	**
<i>Oxystomina</i> sp	3	26.8	-	-	-	**
	4	-	-	7.4	-	n.s
	5	3.1	-	19.7	6.3	*8
	2	-	19.1	3.5	-	n.s
<i>Terschellingia</i> sp	3	7.0	125.6	62.7	58.6	*
	4	190.6	150.1	2516.9	1362.1	**
	6	4.8	6.8	13.1	15.8	n.s
	5	4.5	1.2	1.7	0.6	n.s
	2	30.6	15.5	-	28.1	*
<i>Paradontophora</i>	3	11.8	98.6	25.2	62.1	n.s
sp	2	262.1	76.1	0.8	68.5	**
	4	5.6	-	1.5	-	**
	6	321.3	145.6	467.6	45.2	**
Copepoda						
<i>Canthocamptus</i>	2	12.1	0.3	0.4	1.1	
sp	4	-	-	8.5	0.6	
	6	7.0	18.6	-	50.1	
	5	-	5.2	-	-	
	7	1.1	-	3.1	-	
<i>Mesochra</i> sp	2	6.2	12.8	21.1	63.1	*
	4	1.2	1.1	5.6	-	*
	6	-	2.1	-	8.1	*
<i>Unidentified</i> sp	2	0.6	8.3	-	-	*
Kinorhynchia & Gastrotricha	3	18.2	4.5	-	12.1	*
	4	25.7	15.1	-	3.6	*
	6	5.6	-	-	2.8	n.s
	5	28.5	-	-	-	*

*= significant ** = more significant

ns= not significant

The density of all the species (nematodes , copepods) at the individual sites showed no overall trends temporally (Kendall Coefficient of concordance: $W = 0.17$, $P > 0.1$, d.f. = 3 for each taxon).

Despite considerable differences in the total density of nematodes in replicate samples, there were statistically significant difference over the different season at every site and also between the different sides within each sampling season (Table 2).

The total densities of nematodes and copepods at each site were statistically related to tide level throughout the year. So also, was the percentage abundance of nematodes (Table 3). Environmental factors of pollution by zinc, iron, ammonium ions, lead and phosphates or salinity were statistically related to the percentage abundance of both nematodes and copepods, as well as the absolute density of copepods.

Table 3. Spearman rank correlation coefficient of meiofaunal density and abundance with environmental factors

Environmental factor	Density		Spearman Rank Correlation Coefficient		Ratio of nematode to copepod
	Nematodes	Copepods	% Abundance Nematode	% Abundance Copepod	
Elevation above low tide mark	-0.489	-0.581*	-0.725*	-0.312	0.32
Distance from low water level	-0.351	-0.262	-0.129	-0.211	0.09
Median grain size	0.389	-0.178	0.019	-0.398	0.26
Heavy metal pollutants	-0.152	-0.532*	-0.481*	-0.451*	0.0
Salinity	-0.152	-0.532*	-0.481*	-0.451*	0.0

* = significant

Note: Heavy metal pollution and salinity had the same rank order of sites.

DISCUSSION

The dominance of nematodes over the entire year, with harpacticoid copepods second in abundance, is typical of littoral estuarine meiofauna elsewhere (Tietjen, 1969, Bell, 1979, Hodda and Nicholas, 1986, Heyl et al., 1992; Kunitzer et al., 1992; Heip and Craeymeersch 1995; Schartzberger et al., 2006; Ewa-Oboho in press). Most genera found in the Cross River system are also typical of similar littoral marine habitats elsewhere. Unlike in the Cross River, total density and species composition show fairly constant values in some estuarine littoral habitats in North America and some parts of Europe (Bell, 1979). Given the size of the differences in nematode density between sampling site and times, it is not surprising that these differences are statistically significant (Table 2). The copepod fauna was also quite variable both among sites and over the course of the year.

The patterns suggest that some seasonal environmental variables associated with or influenced by the mangroves seems to have the main effect on how the total density of nematodes changes over time. Generally, sites with similar changes in population have similar vegetation characteristics. Sites 5 and 6 with the highest density in dry season were mudflats with no mangrove vegetation. Sites 2 and 3 both with moderate mangrove vegetation do not have exactly parallel seasonal patterns but have generally, the most variable population densities of nematodes. Probably, the stagnant water pools, fallen mangrove leaves and P^h are very variable environmental factors. These factors may also change in different ways at different sites even in the same season. Mangrove leaves have been shown to affect the horizontal density of nematodes as a whole (Odum and Heald, 1972, Aller and Yingst, 1995). Thus, it is most probable that this factor may also affect density temporally.

Considerable changes in species composition at each site resulted from the diverse ways that different nematode species changes in density over the year. The season of maximum density of some species may be influenced by more factors in mangroves than in areas with less mangrove vegetation. Dry season temperatures in the Cross River estuarine mangrove may become “harsh” to some nematodes when the tide is out as the exposed mud and surface pools of water become too hot for survival.

Besides, high temperatures may cause extremes of salinity, which could decrease micro-algal production which serves as food sources for most nematodes species. In the moderate climatic condition the influences of local factors are emphasized by the large number of species that fluctuate in density in quite different ways at different sites. This may be in complete contrast to the situation elsewhere e.g. in the U.S.A. Species of *Spirinia* and *Longicyatholaimus* have a constant seasonal pattern at some estuarine in east coast of U.S.A. (Hopper and Meyers, 1967; Tietjen 1969). The species of *Spirinia* in Cross River had very substantial peaks in density during the different periods at sites at which it was found in large number (Table 2). The most striking difference between the two coasts is the presence of mangroves. Therefore, the variability of nematodes in this study is most probably associated with the presence of mangrove vegetation and/or the associated flora and fauna. Exactly which factors are involved is not clear. The relationship of nematode density to tidal elevation remains statistically significant over a year. This could represent a valid and vital trend in biomass. The decrease in the density of copepods and the abundance of both nematodes and copepods with salinity and heavy metal pollution may be related to either factor and suggest that nematode species densities may be affected by environmental factors that are variable in space and time.

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