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SPECIES COMPOSITION AND DISTRIBUTION OF ZOOPLANKTON IN THE LOWER CROSS RIVER ESTUARY

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ABSTRACT

Species composition, spatial distribution, abundance and diversity of zooplankton in the Cross River estuary were investigated over a period of 24 months. A total of 61 taxa belonging to eleven phyla were identified. Copepoda was the most abundant, with 17 taxa followed by the Cladocera with 11 taxa. Overall contribution of crustaceans to the total zooplankton population was 74.16%, while Chaetognaths and Cnidarians contributed 6.3% and 6.1% respectively. Densities ranged from 40 organisms/l to 1,660 organisms/l. Copepod presence was high in all the sampling zones but more in the lower reaches of the estuary. Cladocerans, Ciliates and Rotifers were more important in the upper reaches of the estuary, whereas the Cnidarians and Chaetognaths were absent upstream but highly abundant in the downstream reaches. Zooplankton composition showed significant spatial variation ($p < 0.05$) in taxa occurrence and density across the sampling zones. Copepods had the highest dominance value of 0.73, followed by Cladocera with 0.51. Jaccard's coefficient of similarity of species revealed dissimilarity between the upper reach stations and the lower reaches. Taxa richness was highest in the lower reach station 6 with a value of 6.79. A general trend of increase in species diversity and richness from upstream to downstream was observed. Inter-and intra-specific relationship revealed highly significant positive correlation ($p < 0.01$) between Cnidarians and Copepods ($r = 0.896$), Cladocerans ($r – 0.841$) and between chaetognaths and Copepods ($r = 0.725$, $P < 0.05$) and Cladocerans ($r = 0.451$, $P < 0.05$). Paucity of zooplankton in terms of occurrence and abundance at certain sampling locations of higher proximity to household and industrial effluent sources is indicative of anthropogenic perturbations.

Keywords: Zooplankton, abundance, distribution, diversity, estuary

INTRODUCTION

Zooplankton occupy an important trophic niche in the aquatic ecosystem, as they constitute the most important link in energy transfer between phytoplankton and higher aquatic fauna (Hickman *et al*, 2001; Iloba, 2002). Whilst they exert tremendous grazing pressure on the phytoplankton, they constitute an invaluable source of protein, amino acids, lipids, fatty acids, minerals and enzymes and are therefore an inexpensive ingredient to replace fish meal for cultured fish (Kibria *et al*, 1997; Ovie and Eyo, 1994; Fernando, 1994). Also, zooplankton importance has been underscored in their use as biological indicators of aquatic environmental perturbation (Rutherford *et al*, 1999; Soberan *et al*, 2000; King and Jonathan, 2003; Abowei and Sikoki, 2005). Studies on zooplankton have been carried out extensively in other waters in Nigeria (Oronsaye, 1993; Ovie, 1993; Oronsaye and Egborge, 1996) but there is very little documented information on zooplankton in the Cross River. Earlier reports of zooplankton in this area were not detailed. The paucity of data on zooplankton in this area has necessitated this study.

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MATERIALS AND METHODS

STUDY AREA

The Cross River estuary lies between longitudes 8°00'E and 8°40'E and between latitudes 4°30'N and 5°15'N of the equator. The river system is formed by a number of tributaries among which are Calabar River, Great Kwa River and Akpa Yafe River, with extensive flood plains and wetlands to empty into the estuary (Fig. 1). The river system, with an estimated area of 54,000km2, out of which 39,000km2 lies in Nigeria (Moses 1979) is one of the richest fisheries zones in Nigeria producing 8,000 tonnes of fish and 20,000 tones of shrimps annually (Moses 2000). Moses (2000) further noted that the estuary constitutes one of the richest sources of shrimp fisheries in Nigeria yielding the best quality shrimps. The high level of fish production from this estuary is a direct function of the high level of food resources for fish expressed in abundance of planktonic food organisms.

The study area was delineated into six sampling stations, located progressively over a salinity gradient, ranging from freshwater with less than 0.5°/₀₀ (sampling zone A, stations 1 and 2) through brackish water with about 12°/₀₀ (sampling zone B, stations 3 and 4) to marine environment with up to 21°/₀₀ (sampling zone C; stations 5 and 6).

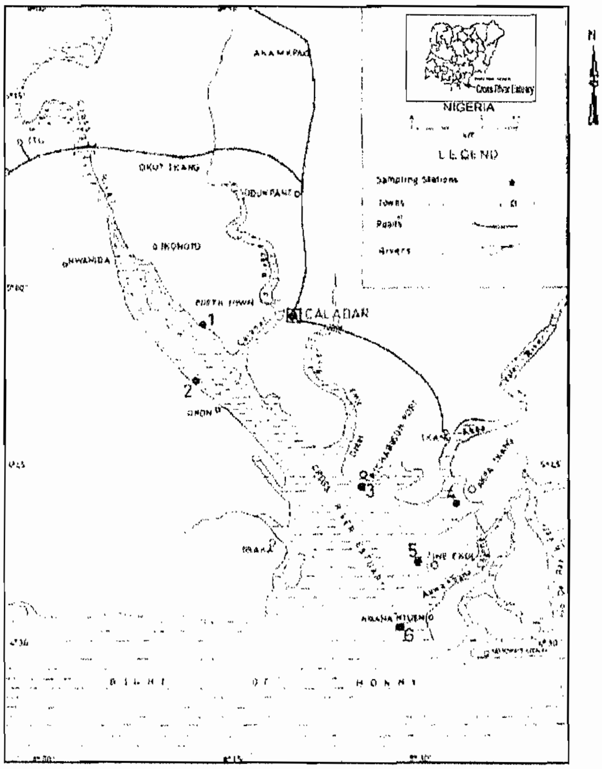

Fig. 1: Map of Lower Cross River Estuary Showing Sampling Stations

Monthly samples were collected from the six (6) stations over a period of 24 months (March 1998 to February 2000). Trawl samples were collected from each station using a towing plankton net attached to a slow moving boat and fixed immediately with 4% hexamine buffered formalin to preserve the organisms.

Identification was done both by gross visual examination on the plankton net and microscopic examination of sedimented samples. Enumeration and microscopic identification were performed using a Zeis inverted microscope at x 200 x 400 and x 1000 magnification. Identification guides used were those provided by Newell and Newell (1977), Maosen (1978), Kasturirangan (1983), APHA (1985) and Badejo (1998).

Determination of zooplankton biomass by biovolume was done by using the sample configuration that best fits the shape of the organism being measured, such as sphere, cone or cylinder. An average measurement was taken from 20 individuals of each species of a particular sample. The total biovolume of each species was calculated by multiplying the average cell volume in cubic micrometers by the number per litre.

Total Biovolume was computed as:-

$$V_t \sum_{i=1}^{n} (N_i \times V_i)$$

Where:
V_t = Total plankton cell volume (mm^3/L),
N_i = Number of organisms of the i^{th} species/L,
V_i = Average volume of cells of i^{th} Species (mm^3/L)

A two-way analysis of variance (ANOVA) was used to compare the spatial distribution of the zooplankton at the six sampling stations. Pearson's correlation coefficient was also used to evaluate spatial and temporal relationships among the species across the sampling stations. The Shanon-Weiner's Diversity index was used to calculate species diversity at the stations. Dominance was calculated using Simpson's Dominance Index. The Margalef index was used to statistically compute the taxa richness across the stations while the Jaccard's coefficient of similarity was used to compute species similarity between the stations.

RESULTS AND DISCUSSION

A total of 66 species of zooplankton belonging to 11 phyla were identified including: Arthropoda, Rotifera, Ciliophora, Sarcomastigophora, Cnidaria, Ctenophora, Chaetognatha, Nematoda, Annelida, Mollusca and Vertebrata (Table 1). The Crustacean subclass Copepoda was the most abundant group with 17 taxa followed by the subclass Cladocera with 11 taxa. The Rotifers had 9 taxa, the Ciliates and Chaetognaths had 6 taxa and 5 taxa respectively while the other groups were poorly represented. Zooplankton densities ranged from 40 organisms/L to 1,660 organisms/L; overall contribution of Crustaceans to zooplankton population was 74.16% followed by chaetognaths, ciliates and cnidarians with 7.47%, 6.33% and 6.12% respectively. Copepod crustaceans showed the highest abundance, constituting 71.05% of total zooplankton population (Fig. 2).

TABLE 1: TAXONOMIC COMPOSITION AND SPATIAL DISTRIBUTION OF ZOOPLANKTON SPECIES IN CROSS RIVER ESTUARY

	Stations					
	1	2	3	4	5	6
1. PHYLUM ARTHROPODA						
Class Crustacea:						
Subclass Cladocera:						
Daphnia pulex	+	+	+	+	+	+
D. retrocurva	+	+	+	+	-	-
D. magna	+	+	+	+	+	+
D. galeata mendotae	+	+	+	+	+	+
D. longispina	+	+	+	+	+	+
D. hyalina	+	-	-	-	-	-
D. rosea	+	-	+	-	-	+
D. ambigua	-	+	+	+	+	+
Polyphemus intermedius	+	-	+	+	-	+
Leptodora sp.	+	-	+	+	-	-
Bosmina longirostris	+	-	-	+	+	+
Subclass Copepoda:						
Parapontella brevicornis	+	+	+	+	+	+
Calanus calanus	+	+	+	+	+	+
C. finmarchirus	+	+	+	+	+	+
Eucalanus elongatus	+	+	+	+	+	+
Limnocalanus macrurus	+	+	+	+	+	+
Pseudocalanus elongatus	+	+	+	+	+	+
Cyclopina longicornis	+	+	+	+	-	-
Cyclops strenuous	+	+	+	+	-	-
C. vicinus	+	+	+	-	-	-
Oithona nana	+	+	+	-	-	-
O. venusta	+	+	+	-	-	-
Diaptomus gracloides	+	+	+	+	+	+
D. siciloides	+	+	+	+	+	+
D. gracilis	+	+	+	+	+	+
Pseudodiaptomus hessei	+	+	+	+	+	+
Miracia efferata	+	+	+	+	+	+
Enterpira acutifrons	+	+	+	+	+	+
2. PHYLUM ROTIFERA						
Class Bdelloidea:						
Philodina sp	+	-	-	-	-	-
Class monogononta:						
Asplancha priodonta	+	+	-	-	-	-
A. girodi	+	+	-	-	-	-
Keratella cochlearis	+	-	+	-	-	-
Kellicottia longispina	+	-	-	-	-	-
Conochilus unicornis	-	+	-	-	-	-
Euchlanus sp.	+	-	-	-	-	-
Squatinella rustrum	+	-	-	-	-	-
Macrochaetus longipes	-	+	-	-	-	-
3. PHYLUM CILIOPHORA						
Class Ciliata:						
Strombilidium strobilus	+	+	-	+	-	-
S. conicum	+	+	-	-	+	+
Tintinnopsis lobancoi	+	+	+	-	-	-
T. campanula	+	-	-	+	-	+
Leprotintinnis pellucidus	+	-	+	-	+	-
Stensmella nivalis	+	+	-	-	+	+
4. PHYLUM SARCOMASTIGOPHORA						
Class lobosea:						
Arcella sp.	+	+	-	-	+	-
Difflugia limnetica	+	-	+	-	+	+
Class Zoomastigophorea						
Codisiga sp.	+	+	+	+	+	+
5. PHYLUM CHAETOGNATHA						
Sagitta elegans	-	-	-	+	+	+
S. enflata	-	-	+	-	+	+
S. setosa	-	-	-	+	+	+
S. zelesios	-	-	+	+	+	+
Flaccisagitta hexaptera	-	-	-	+	+	+
6. PHYLUM CNIDARIA						
Class hydrozoa:						
Obelia (medusa)	-	-	+	+	+	+
Physalia physalis	-	-	+	+	+	+
Class Schyphozoa:						
Aurelia aurita	-	-	+	+	+	+
Cyanea sp.	-	-	+	+	+	+
7. PHYLUM CTENOPHORA						
Class tentaculata:						
Pleurobrachia sp.	+	+	+	-	-	-
8. PHYLUM NEMATODA						
Class Enoplea:						
Enopleus brevis	+	+	-	-	-	-
9. PHYLUM ANNELIDA						
Class Polychaeta:						
Nereis diversicolor	-	-	-	-	+	+
Autolytus edwardsi	+	-	-	-	+	+
10. PHYLUM MOLLUSCA						
Veliger larvae	+	+	+	+	+	+
11. PHYLUM VERTEBRATA						
Class Osteichthyes						
Fish eggs and larvae	+	+	+	+	-	-

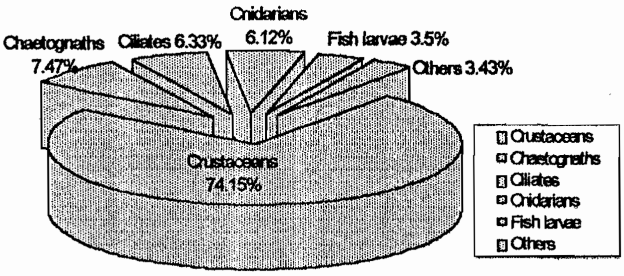

Fig. 2: Percentage Population of Zooplankton in Cross River Estuary

The spatial distribution of total zooplankton at the six sampling stations (Fig. 3) showed high Copepod presence in all the stations but they were more widespread in stations 5 and 6 which are closer to the sea. This corroborates the evidence of Oronsaye and Egborge (1996) that copepods have a preference for higher salinities. Analysis of variance showed significant variation ($p < 0.05$) in occurrence of copepods between sampling zone C (stations 5 and 6) and the upper reach stations 1 and 2 (sampling zone A). Variation in copepod presence between sampling zones A and B was however, not statistically significant ($p > 0.05$). The ciliates and cladocerans were more important in the upper reach stations (SZA) though they were present in all the stations; whereas, the Rotifers, Ctenophores and fish larvae were completely absent from the lower reach stations 5 and 6 (SZC). Rotifers have been reported to prefer freshwaters, (Ovie 1993; Iloba 2002) hence their higher abundance in the upper reach stations. The chaetognaths and cnidarians on the other hand, were completely absent from sampling zone A (stations 1 and 2) but were highly abundant towards the sea (SZC).

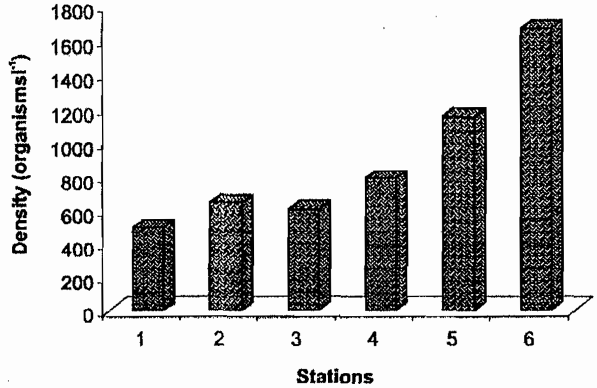

Fig. 3: Spatial distribution of Zooplankton in Cross River estuary

COMMUNITY STRUCTURE

Table 2 shows the indices of diversity, taxa richness and evenness of species distribution while Table 3 shows values of dominance of the zooplankton species. Copepods had the highest dominance value of 0.73, followed by cladocerans with of 0.51. Both Cnidarians and Chaetognaths had a dominance value of 0.30, while ciliates and Rotifers had 0.08 and 0.15 respectively. The other taxonomic groups (Ctenophores, Annelids and Nematodes) had very low dominance values and could therefore be regarded as rare species. Diversity and taxa richness showed a general trend of progressive increase from the upper reach stations (SZA) to the lower reach stations (SZC) (Table 3). This is probably attributed to introduction of more organisms into sampling zone C from the adjacent sea.

Jaccard's coefficient of similarity (Table 4) showed high degree of closeness between stations 1 and 2 (SZA) and between station 5 and 6 (SZC) but showed dissimilarity between SZA and SZC. This could be explained on the basis of salinity, as stations 1 and 2 are both freshwater stations and would therefore have similar plankter groups, whereas plankters in stations 5 and 6 would be mostly marine or euryhaline forms.

TABLE 2: INDICES VALUES OF GENERAL DIVERSITY, TAXA RICHNESS AND EVENNESS OF ZOOPLANKTON SPECIES IN THE CROSS RIVER ESTUARY

Index	Stations					
	1	2	3	4	5	6
Diversity H')	0.28	0.30	0.35	0.32	0.50	0.66
Taxa Richness	4.22	3.98	4.20	3.91	6.10	6.79
Evenness (E)	0.50	0.50	0.41	0.40	0.62	0.65

TABLE 3: INDEX OF DOMINANCE OF ZOOPLANKTON SPECIES IN THE CROSS RIVER ESTUARY

Index	Stations					
	1	2	3	4	5	6
Copepods	0.65	0.69	0.71	0.70	0.73	0.73
Ciliates	0.08	0.08	0.06	0.01	0.01	0.00
Cladocerans	0.51	0.51	0.33	0.28	0.09	0.06
Cnidarians	0.00	0.00	0.00	0.20	0.30	0.30
Chaetognaths	0.00	0.00	0.00	0.18	0.30	0.30
Rotifers	0.15	0.15	0.08	0.08	0.00	0.00
Fish larvae	0.22	0.22	0.22	0.11	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00

A significant positive correlation was observed between Cnidarians and Copepods ($r = 0.896$; $P < 0.01$), between Cnidarians and Cladocerans ($r = 0.841$; $P<0.01$), between Chaetognaths and Copepods ($r = 0.725$; $P < 0.05$) and between Chaetognaths and Cladocerans ($r = 0.451$; $P < 0.05$). The interactions between the various zooplankton groups is probably indicative of trophic relationships as well as natural regulation of numbers (Wetzel, 2001).

TABLE 4: INDEX OF SIMILARITY OF ZOOPLANKTON SPECIES BETWEEN THE SAMPLING STATIONS (JACCARD'S COEFFICIENT OF SIMILARITY)

Stations	1	2	3	4	5	6
1	-					
2	0.92	-				
3	0.75	0.81	-			
4	0.51	0.56	0.76	-		
5	0.36	0.33	0.49	0.62	-	
6	0.25	0.18	0.35	0.58	0.83	-

The observed broad spectrum of phyla represented in the zooplankton of the estuary is indicative of a rich content of aquatic biodiversity. Also, the generally high abundance and taxa richness observed is suggestive of high secondary productivity of the area, which corroborates the report of Moses (2000).

The rich ecological heritage of the Cross River estuary is however, being threatened by the current spate of environmental perturbation, principally from oil exploration activities in the near shore costal waters as well as other industrial and municipal effluents. The obvious consequence is a gross reduction in numbers and diversity of these primary consumers, resulting in altered food web, distortion of the energy transfer process and general ecological imbalance. A deliberate environmental management programme for the Cross River estuary is hereby recommended.

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