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Advances in Applied Science Research, 2013, 4(4):224-231

ISSN: 0976-8610
CODEN (USA): AASRFC

Diversity and spatial distribution of zooplankton in the intertidal regions of Calabar River, Cross River State, Nigeria

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ABSTRACT

Studies on the diversity and spatial distribution of zooplankton in the intertidal regions of Calabar River in Adiabo River System were carried out for three months (September to November, 2012). A total of 28 species of zooplankton belonging to 23 genera and 9 taxonomic groups were identified. The most abundant zooplankton group at all stations was Calanoida (with 20 individuals at station 1, 32 at station 2, 30 at station 3 and 30 at station 4), thus constituted 48.2% of the zooplankton community observed in this study. Overall contribution of Cladocera was 14.71%, Chaetognatha 12.7%, Decapoda 9.64%, Lamellibranch 2.54%, Mysidae 4.06%, Rotifera and Salps contributed 3.04% respectively. Echinodermata was the least zooplankton group with 1 individual (1.02%). Species richness, diversity and evenness were assessed. Margalef index (R) varied between 6.377 and 7.256 indicating a slight variation in richness in all stations. Shannon-Weaver (H) ranged between 1.241 and 1.383 and Equitability between 0.376 and 0.420 showing that the species were evenly distributed in all stations sampled. The population of Zooplankton was generally high in the river system during the study period. This study provides vital details on zooplankton distribution and abundance along the intertidal regions of Calabar River, Nigeria which may unravel the information on the energy turnover of the river ecosystem. It will also serve as useful tool for further ecological assessment and monitoring of the river ecosystem.

Keywords: Zooplankton, Spatial Distribution, Diversity, Intertidal Region, Adiabo River System.

INTRODUCTION

Zooplankton are ecologically important groups of aquatic organisms that occupy a wide range of habitats. A large number of non-insect animal species live in the ocean and have planktonic life stages [Davis *et al* 1996]. Major constituents of zooplankton community include Copepods, Chaetognaths, Amphipods, Euphausiids, Pteropods, holoplankton, as well as larval stages of meroplankton. Plankton studies involve analysis of physico-chemical parameters which reflects the biotic status of the ecosystem [Mulani *et al* 2009]. Zooplankton are one of the most important biotic components which influence the functionality of an aquatic ecosystem such as energy flow, food chain, food web and cycling of matter [Murugan *et al* 1998, Dadhick and Sexena, 1999, Sinha and Islam, 2002, Park and Shin, 2007, Iloba, 2002, Aoyagui and Bonecker, 2004]. Copepods are known to be the major link between phytoplankton and first level carnivores while arrow worms are the common carnivores in zooplankton [Prasad, 2000; Tse *et al.,* 2007].

Ahmad [1996] and Contreras *et al* [2009] notes that zooplankton is a well-suited tool for understanding water pollution status. Also zooplankton has been underlined as bioindicators of aquatic environmental perturbation [Rutherford *et al* 1999, Soberan *et al* 2000, King and Jonathan, 2003, Abowei and Sikoko, 2005].

Most species of zooplankton are Cosmopolitan in distribution [Mukhergee, 1997]. The distribution of zooplankton depends on certain factors such as physical and chemical parameters, climatic conditions and vegetation cover [Neves *et al* 2003, Rocha *et al* 1999]. Zooplankton mostly grazes on phytoplankton and for this they are most abundant in shallow areas where primary productivity is high due to high availability of light [Lalli and Parson,

1999]. Zooplankton distribution is also related to their ability to adapt to the prevailing factors in the environments [Marcus, 2004, Tse *et al* 2007].

The purpose of this paper is to carry out a survey and also produce a baseline data on diversity and spatial distribution of zooplankton of Calabar River in Adiabo river system with the aim to determine the species composition, diversity and spatial distribution of zooplankton in the intertidal regions of the River.

MATERIALS AND METHODS

Description of the study area

Calabar River is located approximately at latitude $5^{o}30^{1}$N and Longitude $8^{o}18^{1}$E southeast of Nigeria. The climate in the area is characterized by a long wet season from April to October and a dry season from November to March; mean annual rainfall is about 2000mm [Akpan and Offem 1993]. Vegetation in this area is basically rain forest close to mangrove belt. Mangrove species such as *Rhizophora cemosa, Avecinia africana* are present. *Nypa fruticans* is the main Nypa palm. Pandamus species is the mix forest of the area [Holzlohner *et al* 2002]. Activities of the people living in the study area include fishing and sand minning.

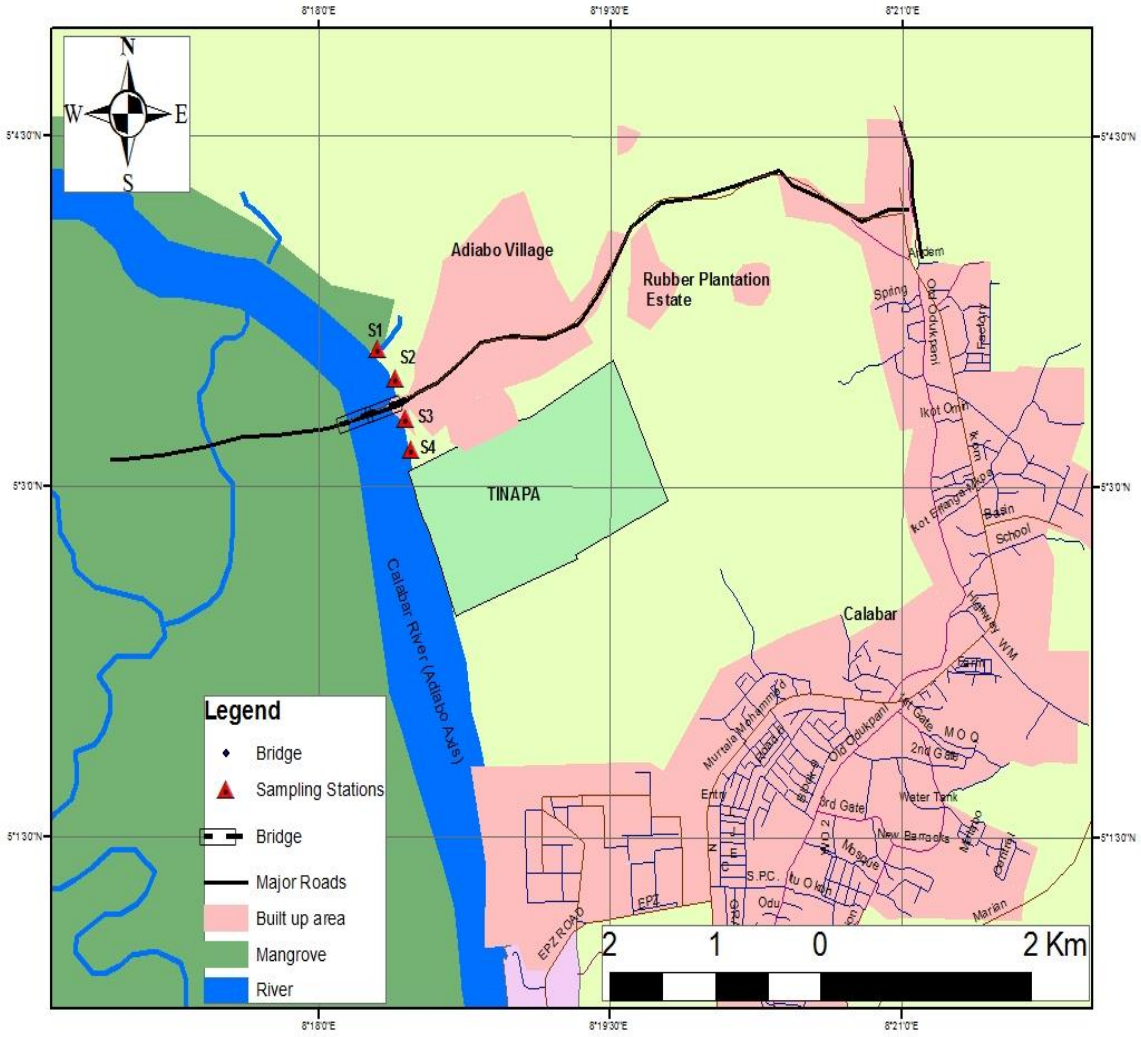

Figure 1: Map of Calabar River Showing Sample Locations (1-4)

Sampling locations

Samples were collected from four different stations in the intertidal regions of the river. The choice of sampling locations of the river was based on the ecological settings, vegetations and human activities in the area. Station one

which formed the starting point where other locations began, is a place close to a narrow creek where a dredge is installed. The water has a very high transparency in this location. No farm lands are seen here. Station two is the narrow creek. It is covered by mangrove vegetations such as the *racemosa, Rhizophora, Nypa fruticaus* (nipa palm), which is used in roofing local houses. The river drains over a sandy substratum and contaminated with human waste during down pour which makes the water in this part of the river very dark with very low transparency. Station three is within the head bridge of the river. This is the landing site of fishermen canoes and where aquatic life like fishes, shrimps, crayfish etc are sold. The water in this part of the river is moderately transparent. No vegetation is found here. Station four is near slaughterhouse, where animals like cow, goat, etc are butchered. During rainy season, the wastes and dung are washed into the river. The water in this part of the river has a low transparency. The vegetation includes: aquatic macrophytes such as *Pomea aquatic, Lemna sp* (duck weed), *Utricularia sp, Nympaea sp* and *Pistia stratiotes* (Water lettuce).

Collection and preservation of samples

Zooplankton species were collected by filtering 60 litres of the water sample through 55µm plankton net at each station. The planktons were immediately fixed in a 5% formalin solution and transported to the Institute of Oceanography laboratory, University of Calabar, Nigeria, for analysis and identification. The samples were preserved in plastic samples bottles. Samples were collected monthly for three months, from September to November, 2012.

Analysis of zooplankton

In the laboratory, each sample fixed in 5% formalin solution was concentrated to 10mls to enable analysis using the drop count method described by Onyema *et al* [2007]. One drop at ten different times for each sample after adjusting to 10mls was studied at different magnification (x40, x100, x400) using a light microscope.

Identification of zooplankton species

Zooplankton species were identified and sorted into different taxonomical groups with the aid of appropriate identification schemes of Newell and Newell [1977] pictures of zooplankton species were also taken with the aid of Amcap Digital Microscope Camera.

Determination of species composition

Each species was grouped into their respective taxa in a tabular form. Pie chart and histogram were used to show percentage composition of each taxon and distribution of Zooplankton per station.

Determination of numerical and relative abundance

Numerical abundance of zooplankton species was determined by adding the number of zooplankton collected for the three months and divided by three to give the mean (numerical abundance) for each station. The mean value obtained was then used to calculate the relative abundance given by:

$$\% Ra = \frac{n}{N} \times 100 \quad (1)$$

Where;
n is the total number of the individual per species under consideration.
N is the total number of all individual per station

Diversity indices

In this study, three ecological statistics were used to obtain the estimation of species diversity, species richness and species evenness.

Margalefôs index (d): is a measure of species richness [Margalefôs, 1949] and is expressed as:

$$d = \frac{S - 1}{\ln N} \quad (2)$$

Where;
S is the number of species in samples.
N is the number of individuals in the samples.

Shannon and Weaverôs index (H): is a measure of species abundance and evenness [Shannon and Weaver, 1949] and is expressed as:

$$H = \sum \frac{Ni}{N} \log_2 \frac{Ni}{N} \quad (3)$$

Where;
N is the total number of individual in the sample
Ni is the total number of individuals of species *ith* in the sample

Species equitability or evenness (E) [Pielou, 1966] is determined by the equation:

$$E = \frac{H}{\ln S} \quad (4)$$

Where;
H is the Shannon and Weavers index.
S is the Number of species in samples.

RESULTS

Species abundance and composition of zooplankton species

Summary of the Species composition and abundance of the various zooplankton taxa encountered at the different sampling stations is presented in Table 1 while the illustration in Figure 2 shows the Percentage abundance of zooplankton groups along the intertidal regions of Calabar River in Adiabo River System. Twenty three genera were identified belonging to nine taxa from a total of 189 individuals collected from all the stations. Slaughter station accounted for the highest abundance (59) by number while the Sand mining station accounted for the lowest abundance (36) by number. The highest number of taxa (27) was also recorded in slaughter, Sand mining station and Obongôs palace while the lowest number (26) was recorded in dredge station. *Calanoida* have the highest percentage abundance 95 (48.2%) by number while *Echinodermata* have the least 1 (1.02%) by number. Though percentage abundance of *Calanoida* were high (2.30-20.8%) and also had the highest number of taxa (10), these include *Eurytemora hirundoides, Calanoide carinatus, Calanus finmarchicus, Eucalanus elongatus, Euchaeta marina, Paracalanus parvus, Temora longicornis, Pseudocalanus, Oithona halgolandica* and *Metridia lucens*. *Eucalanus elongatus* were not encountered in the Narrow creek dredge station.

Diversity indices of zooplankton in the intertidal regions of Calabar River

A summary of the diversity indices calculated for the four stations is shown in Table 2. Taxa richness calculated as Margalef index (R) was least in Slaughter station (6.377) while Narrow creek dredge area station accounted for the highest diversity (7.256). In Shannon diversity index (H), sand mining station accounted for highest diversity (1.383) and least in Obong palace station (1.241). Equitability was least in Obong palace station (0.376) and highest in Sand mining station (0.420). The four stations had more or less equal diversity indices values. The spatial distribution of zooplankton groups in the intertidal regions of Calabar River in Adiabo River System are shown in figure 3. *Calanoida, Cladocera, Chaetognaths, Decapoda, Lamellibranch, Mysidae, Rotifera and Salps* appear in all the stations except for *Echinodermata* which appear only in Narrow creek dredge station during the study period.

Table 1: Species composition of zooplankton encountered in the intertidal regions of Calabar River (September-November, 2012)

Species composition		S1		S2		S3		S4		Total	
Taxonomic Group	**Species**	**No**	**%Ra**	**No**	**% Ra**	**No**	**% Ra**	**No**	**% Ra**	**No**	**%**
Calanoida	*Eurytemora hirundoides*	1	2.50	1	2.77	3	5.08	1	1.85	6	2.03
	Calanoides carinatus	1	2.50	3	8.33	5	8.47	3	5.55	12	6.24
	Calanus finimarchicus	3	7.50	1	2.77	4	6.77	4	7.40	12	6.24
	Eucalanus elongatus	0	0	1	2.77	1	1.69	1	1.85	3	1.47
	Euchaete marina	1	2.50	1	2.77	1	1.69	1	1.85	4	2.10
	Paracalanus parvus	9	22.50	2	5.55	14	23.72	15	27.77	40	19.78
	Temora longicornis	1	2.50	1	2.77	1	1.69	1	1.85	4	2.10
	Pseudocalanus elongatus	2	5.00	1	2.77	1	1.69	2	3.70	6	3.19
	Oithona halgolanidica	1	2.50	1	2.77	1	1.69	1	1.85	4	2.20
	Metridia lucens	1	2.50	1	2.77	1	1.69	1	1.85	4	2.10
Cladocera	*Evadne spinifera*	1	2.50	2	5.55	3	5.08	1	1.85	7	3.51
	Podon polyphemides	1	2.50	1	2.77	1	1.69	1	1.85	4	2.30
	Evadne nordmanni	1	2.50	1	2.77	1	1.69	1	1.85	4	2.30
	Conchoecia elegans	1	2.50	1	2.77	1	1.69	2	3.70	5	2.40
	Philomedes globosa	1	2.50	1	2.77	1	1.69	1	1.85	4	2.30
	Evadne tergestina	1	2.50	1	2.77	1	1.69	1	1.85	4	3.30
Chaetognaths	*Sagitta elegans*	1	2.50	1	2.77	2	3.38	1	1.85	5	2.87
	Sagitta serratodentata	1	2.50	1	2.77	1	1.69	1	1.85	4	2.79
	Sagitta decipiens	1	2.50	2	5.55	2	3.38	2	3.70	7	3.87
	Sagitta friderica	1	2.50	1	2.77	1	1.69	1	1.85	4	2.69
Decapoda	*Pasiphaea tarda*	2	5.00	2	5.55	1	1.69	1	1.85	6	3.54
	Caridion gordoni	1	2.50	1	2.77	1	1.69	1	1.85	4	2.07
	Nauplius larva	2	5.00	4	11.11	5	8.47	2	3.70	13	4.17
Echinodermata	*Echinopluteus larva*	1	2.50	0	0	0	0	0	0	1	1.02
Lamellibranch	*Tellina fibula*	1	2.50	1	2.77	1	1.69	2	3.70	5	2.68
Mysidae	*Hyperia galba*	2	5.00	1	2.77	2	3.38	3	5.55	8	4.37
Rotifera	*Keratella quadrata*	1	2.50	1	2.77	1	1.69	2	3.70	5	3.07
Salps	*Salpa democratic*	0	0	1	2.77	2	3.38	1	1.85	4	3.07
Total number of Taxa		**26**		**27**		**27**		**27**		**189**	
Total number of individuals		**40**	**100**	**36**	**100**	**59**	**100**	**54**	**100**		

%Ra=Percentage Relative Abundance, S1=Station 1, S2=Station 2, S3=Station 3, S4=Station 4

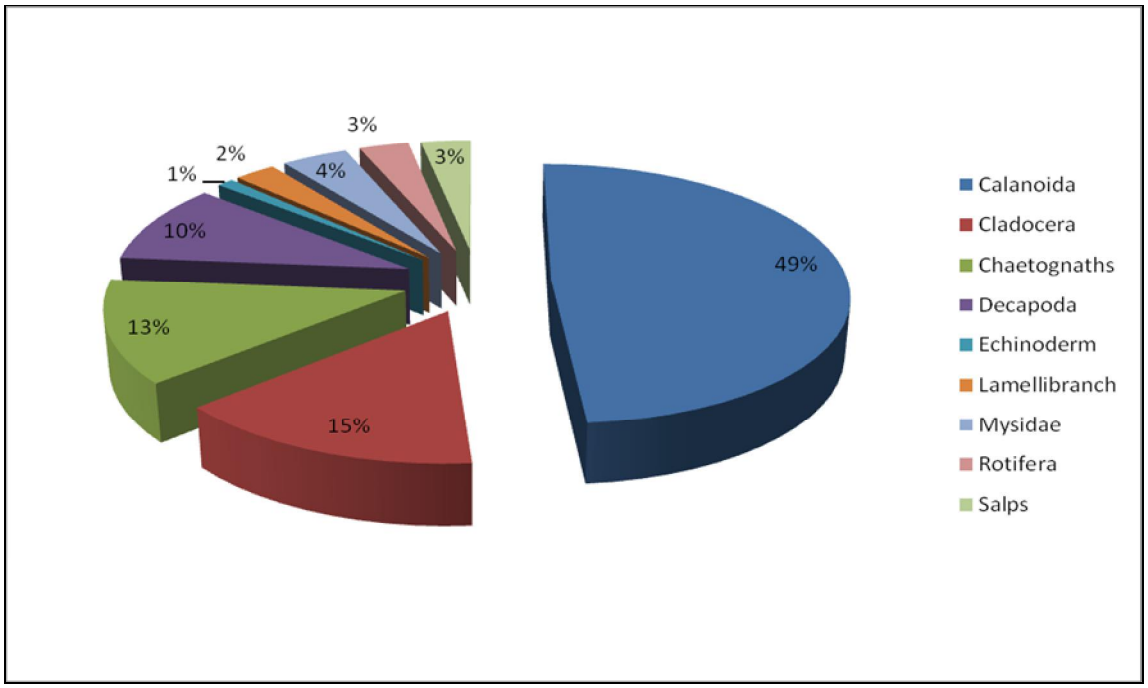

Figure 2: Percentage Composition and Abundance of Zooplankton Groups in the Intertidal Regions of Calabar River (September to November, 2012)

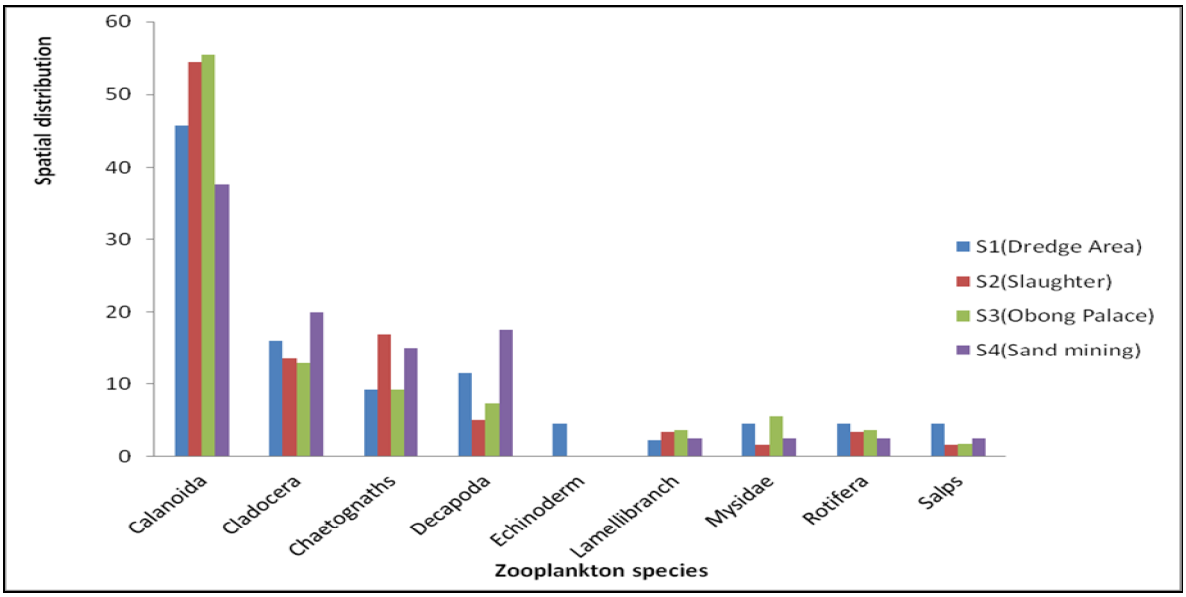

Figure 3: Spatial Distribution of Zooplankton Groups in the Intertidal Regions of Calabar River (September to November, 2012)

Table 2: Diversity indices of zooplankton in the intertidal regions of Calabar River (September to November, 2012)

STATIONS	S1	S2	S3	S4
Margalef Index (R)	6.778	7.256	6.377	6.520
Shannon-Weaver (H)	1.290	1.383	1.250	1.241
Equitability (E)	0.395	0.420	0.379	0.376

DISCUSSION

The zooplankton groups during the study period consisted *Calanoida*, *Cladocera*, *Chaetognaths*, *Decapoda*, *Lamellibranch*, *Mysidae*, *Rotifera* and *Salps*. Zooplankton species composition and diversity give an insight into the characteristics and quality of the water [Marson, 1983, Uka *et al* 2006]. Zooplankton contributes to the economy of the ecosystem [Odum, 1971, Umoren and Edokpayi, 2006]. Bearing in mind their small size, their gross contribution to energy production apart from being the primary consumers (as the feed or graze on the phytoplankton) is far greater than one might expect. Zooplankton grazes on phytoplankton [Castro and Huber, 2005]. It is also a well-established fact that phytoplankton respond to seasonal influences of way of rearranging themselves to the constant variation in the physical and chemical structure of the environment [Goldman and Horne, 1983, Prasad, 2000], coupled with the grazing stress exerted by the zooplankton [Prasad, 2000]. This fact observed from the above might result to one of the factor affecting zooplankton such as reduction of zooplankton population over one another [Castro and Huber, 2005].

However, zooplanktons have short life span than phytoplankton [Chen, 1982], there is usually a natural compensatory provision for the zooplankton to enhance reproduction capacity such that they always are present in large numbers [Goldman and Horne, 1983]. But the law of predator ï prey relationship should not be forgotten in such ecological interplay in which the ones preyed upon would always be in their large numbers against the predators [Kadiri and Oputa, 1989]. This is clearly shown in general abundance of the zooplankton during the period of study. However, higher vertebrate like the fishes strongly contributes to their low abundances because the zooplanktons veracious prey upon [Odum 1971, Man, 2000] which agrees with the previous reports of Umoren and Edokpayi [2006] and Job and Asuquo [2011].

The ecological parameters considered in this study included species diversity indices. There was no significant variation in these parameters of zooplankton community during the period of study. Zooplankton ranging between 6.377ï 7.135 with Margalef index (d), Shannon weaver index (H) ranging between 1.2413-1.388 and Equitability (E) ranging between 0.379-0.4211 across all stations. Tse *et al* [2007] ascribed spatial distribution in species diversity and of richness in the coastal waters of northern Hong Kong to the weak flushing capacity of water in the Hong Kong Bay. This was also attributed in addition to the long history of eutrophication of the Bay [Morton, 1989]. The impact of eutrophication on species diversity of meso-zooplankton such as Chaetognaths has also been reported [Morton, 1989, Tse *et al* 2007].

Calabar River is however, characterized by strong tidal currents and river discharge, so the system does not suffer from poor flushing. Also, Eutrophication does not occur in the river system (Akpan and Offem, 1993). Phytoplanktons are a rich source of food for the zooplankton [Tse *et al* 2007, Job and Asuquo, 2011]. So for the former to constantly be in a state of abundance, as most of species can survive anoxic conditions while others and capable of generating high cell densities up to between 10^9 or even 10^{10} cells per liter for any one species and 10^7 cells per litre as an upper limit for the total population [Castro and Huber, 2005]. Hence the usually occurring high abundance of zooplankton in aquatic systems as the results of the present study shows.

CONCLUSION

Studies were conducted on the diversity and spatial distribution of zooplankton along the intertidal region of Calabar River, Adiabo River System, Nigeria. Twenty eight (38) genera of zooplanktons were identified during the study period with varying numerical and relative abundance of *Calanoida* 95 (48.2%), *Cladocera* 29 (14.71%), *Chaetognaths* 25 (12.74%), *Decapoda* 19 (9.64), *Echinoderm* 2 (1.02%), *Lamellibranch* 5 (2.54%), *Mysidae* 8 (4.06%), *Rotifera* 6 (3.04%) and *Salps* 6 (3.04%). Species diversity indices of the Zooplankton groups were also observed, where Margalef index (d) ranged between 6.377 and 7.135, Shannon-weaver (H) ranged between 1.2413 and 1.388 and Equitability (E) ranged between 0.379 and 0.4211. The population of Zooplankton was generally high in the river system during the study period. Zooplankton contributed a total of 197 individuals to the plankton community. This leads to the conclusion that the Adiabo River System is highly rich in taxa, diversity, evenness and productivity of zooplankton. This study provides vital details on zooplankton distribution and abundance along the intertidal regions of Calabar River, Nigeria which may unravel the information on the energy turnover of the river ecosystem. It will also serve as useful tool for further ecological assessment and monitoring of the river ecosystem.

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