ZOOPLANKTON COMMUNITIES OF THE RIVER OSSIOMO, OLOGBO, NIGER DELTA, NIGERIA

IKHUORIAH, **Suleman Ovuehor, ORONSAYE**, **Charity G. and ADEBANJO, Isaac Adeniyi**
Department of Animal and Environmental Biology, University of Benin, Benin City, Edo State, Nigeria.

Corresponding Author: Ikhuoriah, S. O. Department of Animal and Environmental Biology, University of Benin, Benin City, Edo State, Nigeria. **Email:** Suleman.ikhuoriah@uniben.edu **Phone:** +234 8037368623

ABSTRACT

Zooplankton communities of the River Ossiomo at Ologbo, Niger Delta, Nigeria were investigated from April 2012 to December 2012. Three stations were studied from upstream to downstream with a distance of about 2 kilometres between each station. A total of 42 taxa were identified; 11 species of cladocerans, 6 copepods and 5 rotifers in the following order of dominance: copepoda > cladocera > rotifera. A total zooplankton population of 1330 individuals was recorded during the study period. Copepods and cladocera represented the predominant species (51.1% and 43.6% of the total zooplankton community respectively) followed by rofiters (5.3%). Copepods and cladocerans were dominated by both cyclopoid (51.1%) and chydorids (27.8%), respectively. The dominant copepod and cladocera species were Thermocyclops neglectus and Alona eximia representing 33.1% and 15.8% of the total zooplankton, respectively. The calculated diversity indices indicated that station 1 was more diverse followed by station 3, while zooplankton species in station 2 were least diverse. Community composition was similar at both stations 2 and 3, but varies seasonally across the three stations. Higher species number and density was found during the wet season with a trend of declining proportion towards the dry months.

Keywords: Zooplankton, Species, Population, Diversity, Abundance, River Ossiomo

INTRODUCTION

Zooplanktons are heterotrophic planktonic animals floating in water which constitute an important food source for many species of aquatic organisms (Guy, 1992). Cyclopoida, Ostracoda, and Cladocera are very important in the food chain of freshwater fish (Egborge, 1981). Their characteristics, coupled with high sensitivity to changes in environmental factors have drawn the attention of several hydrobiologists worldwide, who had investigated their occurrence composition, distribution and their significant roles in the study of aquatic pollution. Zooplankton studies are of necessity in fisheries, aquaculture and paleolimnological research as they have been known to leave an impression record of geological past (Stout, 1974; Aoyagui and Bonecker, 2004). They are globally recognized as pollution indicator organisms in the aquatic environment (Rutherford *et al.,* 1999; Yakubu *et al.,* 2000; Abowei and Sikoki, 2005). Zooplankton plays an important role in the biological cycling of carbon and other elements in the ocean. Seasonal zooplankton dynamics and the mechanisms driving their variability are highly susceptible to changes in environmental variables, especially in shallow, semi-enclosed bays with heavily populated shores where increased anthropogenic nutrient input severely affects marine communizes (Marcus, 2004). An increase in nutrient loading can cause an increase in phytoplankton productivity and standing stocks, especially in large-sized phytoplankton (Breitburg *et al.*, 1999).

Less attention has been given to the study of zooplankton community of smaller rivers such as Ossiomo River, which are all over the country and contain significant proportion of nation's aquatic biodiversity. This study reports a survey of zooplankton communities of the River Ossiomo in Ologbo, Edo State, Niger Delta, Nigeria.

MATERIALS AND METHODS

Study Area: The study was carried out on a stretch of River Ossiomo (Latitudes $6^0$30' – $6^0$32'0''N; Longitude $5^0$39'- $5^0$40'30''E) (Figure 1), which is a tributary of Benin River, South-South, Nigeria.

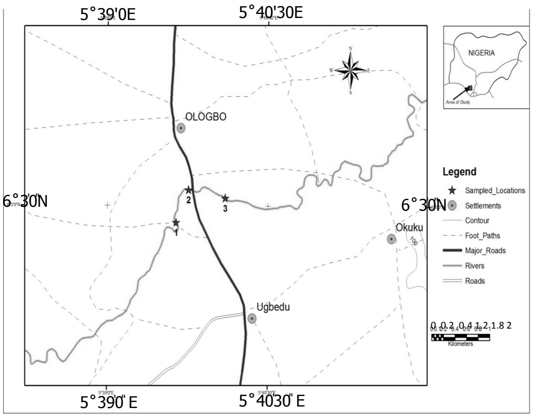

Figure 1: Map of Ologbo showing sampling locations along River Ossiomo

River Ossiomo stretches over a 250 km distance within Edo State and Delta State, South-South, Nigeria. It is supplied by rivers Ikpoba, Okhuaihe and Akhaianwan. Ossiomo River drains into the Benin River at Koko, a coastal community in Delta State, Nigeria and where Benin River empties into the Atlantic Ocean (Tawari-Fufeyin *et al.*, 2008).

This study area falls within the well-known rainforest belt of Nigeria, with a wet season ranging from March to October and a dry season from November to March. The Ologbo community, an adjacent settlement to River Ossiomo is essentially rural and it is situated in Ethiope West, Delta State, Nigeria, its geographical coordinate are 6°3'0" North and 5°40'0" East (Tawari-Fufeyin *et al.*, 2008). The River Ossiomo thus provides a source of water for domestic use especially for many rural settlers and communities. The river is fairly wide and flanked by secondary vegetation of rubber trees *Hevea brasilensis*, palm trees *Elaeis guinensis*, Bamboo trees *Bambusa* sp. and shrubs. On the river are floating vegetation such as *Salvinia* sp., *Lemna* sp. and *Eichorrnia crassipes* (Tawari-Fufeyin *et al.*, 2008). No major industry, except few logging merchants and few extractive industries is sited in this area. Farming is the major occupation of the inhabitants, while fishing is secondary (Tawari-Fufeyin *et al.*, 2008).

Three sampling stations were chosen: Station 1 (Upstream), Station 2 (Midstream) and Station 3 (Downstream). The upstream station (Station 1) is about 2 km away from station 2 at Ologbo community. Apart from boating and fishing activities, the marginal vegetation here is mainly grasses and macrophytes like water hyacinth (*E. crassipes*). Station 2 is the wharf side at Ologbo community; the river has marginal vegetation encroaching into the river waterways consisting of shrubs and grasses. This station has highest level of human activities/disturbance, these include; bathing, swimming, and washing of clothes and household utensils. Station 3 (downstream) is also about 2 km downstream from station 2. The human activities here include fishing, dredging, occasional oil spillage and lumbering.

Sampling: Samples were collected at monthly interval for 9 months from April, 2012 to December, 2012. Samplings were done between 10.00 hours and 14.00 hours local time (GMT +01) on each sampling day in three sampling stations. Zooplankton samples meant for identification was collected at each station. Composite zooplankton samples were collected in each sampling location, using both qualitative and quantitative methods of sampling. Qualitative plankton samples were collected by towing 55µm mesh students plankton net just below the water surface for 5 minutes at each sampling station. In quantitative sampling, 100 liters of water was filtered through 55µm students' plankton net with the aid of a 10 liters bucket sampled randomly 10 times at each station.

The sampled zooplanktons were preserved in 4% formalin solution in a 250 ml plankton bottles (UNESCO, 1974).

In the laboratory, zooplanktons were sorted into their various taxa under a binocular dissecting microscope (American Optical Corporation, Model 570), and slides were prepared using polyvinyl lactophenol as mountant, while drawing, counting and identifications were done with an Olympus Vanox Research Microscope (Model 230485) at x60 magnifications with an attached drawing tube (Model MKH 240-790). Identification of specimens was carried out at the University of Benin, Animal and Environmental Biology Laboratory using the relevant taxonomic keys (Onabamiro, 1952; Green, 1962; Smirnov, 1974; Dumont, 1981; Van de Velde, 1984; Jeje and Fernando, 1986; Gabriel *et al.*, 1987; Jeje, 1988; Boxshall and Braide, 1991).

Data Analysis: The percentage relative abundance of the specimens was estimated by direct count. Each quantitative sample was concentrated to 10 ml and from this 1 ml of sample was taken and all individual taxa present were counted. Relative abundance was calculated as the number of individuals per litre of water filtered through the net. Species diversity indices (Margalef's index, Evenness index and Shannon-Wiener index) were used in analysing the zooplankton community structure. The BASIC programme SPDIVERS.BAS for diversity index was used for diversity, while Kruskal-Wallis non-parametric test was used to test for significant differences between stations. All statistical methods used to analyze the zooplankton community structure including inter station comparisons carried out to test for significance differences in the abundance of zooplankton using one-way ANOVA. The Pearson correlation coefficient at a confidence limit of 95% was applied using SPSS 16.0 to study the relation between zooplankton distribution and the environmental variables (Zar, 1984; Ogbeibu, 2005). The Bray-Curtis similarity index was computed using the software packages PRIMIER program V 5.1.

RESULTS

Environmental Parameters: Most of the physico-chemical conditions of the water investigated namely pH, depth, transparency, turbidity, suspended solids, conductivity, hydrogen carbonate, sodium, potassium, calcium, magnesium, chloride, sulphate, nitrate, phosphate, dissolved oxygen and BOD all showed no significant variations ($p>0.05$) among the three sampled stations (Table 1). However, the flow rate, air temperature, water temperature, differed significantly ($p<0.05$) among the stations. The flow rate at station 3 was significantly faster than those of the other two stations which were not significantly different ($p>0.05$) from each other, while temperature (air and water) at station 1 were significantly higher ($p<0.05$) than the other two stations which were also not significantly different ($p>0.05$) from each other (Table 1). The water was generally fresh with conductivity values ranging from 70.11µScm – 62.03µScm.

The water was slightly acidic in nature with the mean hydrogen ion concentration ranged from 6.01, 5.86 to 5.76, respectively in stations 1, 2 and 3 (Table 1). The concentration of calcium and magnesium salts with carbonates constitutes the total hardness of water; this was also generally low indicating that the river was soft water. The range in dissolved oxygen concentration (7.54 – 7.12 mgl^{-1}) was high. The range values for the essential primary productivity nutrients; nitrate (0.20 – 0.16 mgl^{-1}), sulphate (0.94 – 0.88 mgl^{-1}) and phosphate (0.33 – 0.25 mgl^{-1}) were low.

Species Composition and Population Density: A total of 22 species of zooplankton were identified from River Ossiomo during the period of study. Most of them were cladocerans (11 species), copepods (6 species) and rotifers (5 species) (Table 2). The lowest number of species was recorded in station 2 during all seasons. On the other hand, the upstream sustained the highest number of species (21 taxa) at station 1 (Figure 2).

Zooplankton was represented by holoplanktonic groups with a total of 1330 individuals.

Table 1: Physical and chemical conditions of the studied stations in River Ossiomo, April 2012 – Dec. 2012

Parameters	Station 1			Station 2			Station 3			P-Value	FMEnv. Permissible Limits	WHO Standard/ Guideline Value
	Mean ±SD	Min	Max	Mean ±SD	Min	Max	Mean ±SD	Min	Max			
Ambient Temperature	29.57[a]±1.63	26.60	32.30	27.01[b]±1.48	25.0	29.50	28.32[b]±1.44	26.50	30.40	**P<0.05	N/A	-
Water Temperature	27.56[a] ±1.48	25.30	29.50	25.87[b]±0.85	24.8	27.40	26.46[b]±0.84	25.0	27.80	**P<0.05	35^0C	-
Depth(m)	1.75±0.85	0.63	2.70	1.47±0.19	1.10	1.70	1.32±0.25	1	1.75	P>0.05	-	-
Flow Rate(m/s)	0.09 [b]±0.05	0.04	0.18	0.08 [b]±0.04	0.01	0.15	0.13[a]±0.30	0.1	0.19	*P<0.05	-	-
Transparency (m)	1.26±0.60	0.50	2.30	1.30±0.22	1.00	1.70	1.01±0.14	0.70	1.20	P>0.05	-	-
pH	6.01±0.43	5.42	6.8	5.76±0.29	5.40	6.13	5.86±0.39	5.19	6.38	P>0.05	6.5-8.5	6.5-8.5
EC(uS/cm)	70.11±22.85	40	99	62.03±21.64	28	90	64.1±24.15	30	94	P>0.05	N/A	1000
Turbidity (NTU)	4.37±0.82	3.5	5.7	3.97±0.74	3.1	5.2	4.19±0.82	3.3	5.4	P>0.05	5.0NTU	-
TSS (mg/l)	5.8±1.14	4.5	7.5	5.52±0.91	4.1	7	5.01±1.62	2.3	7	P>0.05	<10	-
TS (mg/l)	42.11±10.00	24.1	56.6	38.82±15.30	22.7	76.3	40.73±19.39	22.5	87.3	P>0.05	-	-
TDS (mg/l)	33.84±11.39	17.6	49.1	29.6±9.07	18.6	45.7	30.57±9.75	18.1	47.2	P>0.05	500	1000
DO(mg/l)	7.48±2.06	5.6	12.1	7.12±1.20	5.8	8.9	7.54±1.66	5.4	10	P>0.05	5.0	-
HCO_3^- (mg/l)	53.28±11.66	30.5	62	48.63±19.54	24.4	91.5	50.53±21.64	24.4	91.5	P>0.05	-	-
Na(mg/l)	1.37±1.67	0.33	4.99	1.35±1.87	0.32	5.75	1.43±1.87	0.32	4.89	P>0.05	200.00	200
K(mg/l)	0.26±0.37	0.03	1.23	0.25±0.36	0.05	1.2	0.25±0.35	0.03	1.17	P>0.05	-	-
Ca(mg/l)	1.00±0.50	0.01	1.55	0.92±0.46	0.04	1.43	0.97±0.51	0.06	1.89	P>0.05	-	200
Mg (mg/l)	0.52±0.32	0.05	0.94	0.44±0.27	0.05	0.8	0.48±0.28	0.06	0.85	P>0.05	-	200
Cl (mg/l)	36.39±24.55	9.3	88.8	31.12±20.78	7.75	74.4	26.44±24.46	5.2	88.8	P>0.05	200	250
P (mg/l)	0.33±0.21	0.1	0.76	0.25±0.11	0.12	0.39	0.31±0.28	0.07	0.94	P>0.05	-	-
NO_3^- (mg/l)	0.19±0.22	0.04	0.69	0.16±0.23	0.02	0.71	0.20±0.22	0.02	0.63	P>0.05	10.0	10
SO_4^- (mg/l)	0.94±0.77	0.12	2.56	0.88±0.66	0.2	2.48	0.91±0.85	0.22	2.97	P>0.05	500.0	250

***Note**: P>0.05 - Not Significant,*P<0.05 – Significant, **P<0.05- Highly Significant; Similar superscript across the row shows that there is no significant difference between the mean of the stations*

Table 2: Species composition and population density in River Ossiomo, April 2012 – Dec. 2012

Species Composition (taxonomy)	Station 1	Station 2	Station 3	% Relative Abundance	Total
Phylum Arthropoda	-	-	-	-	-
Class Crustacea	-	-	-	-	-
Sub Class Branchiopoda					
Order Cladocera	-	-	-	**43.61**	-
Bosminidae	-	-	-	-	-
Bosmina longirostris	60	-	-	-	**60**
Cercopagididae				-	-
Bythosrephes longimanus	10	-	-	-	**10**
Chydoridae	-	-	-	-	-
Dadaya macrops	50	20	30	-	**100**
Alona eximia	70	50	90	-	**210**
Euryalona orientalis	10	-	-	-	**10**
Pseudochydorus globosus	20	10	20	-	**50**
Daphnidae	-	-	-	-	-
Daphina hyaline	20	-	10	-	**30**
Simocephalus expinous	10	-	-	-	**10**
Macrothricidae				-	-
Grimaldima brazzai	20	10	20	-	**50**
Moinidae		-	-	-	-
Moina reticulata	10	-	-	-	**10**
Sididae	-	-	-	-	-
Diaphanosoma excisum	20	10	10	-	**40**
Sub Class Copepoda	-	-	-	**51.13**	-
Order Cyclopoida	-	-	-	-	-
Cyclopidae	-	-	-	-	-
Cryptocyclops bicolor	80	-	10	-	**90**
Eucyclops macruroides denticulatus (Lilljeborg, 1901)	10	-	-	-	**10**
Metacyclops minutes	10	30	10	-	**50**
Mesocyclops bodanicola	30	10	20	-	**60**
Microcyclops varicans	20	-	10	-	**30**
Thermocyclops neglectus	210	160	70	-	**440**
Superclass Rotifera	-	-	-	**5.26**	-
Class Monogononta	-	-	-	-	-
Order Ploima	-	-	-	-	-
Lecanidae	-	-	-	-	-
Monostyla hamata	10	-	-	-	**10**
Monostyla cornuta	10	-	-	-	**10**
Lepadellidae	-	-	-	-	-
Lepadella ovalis	10	-	-	-	**10**
Proalidae				-	-
Proales decipiens	20	-	10	-	**30**
Proales simplex	-	10	-	-	**10**
(Total)No of Individuals	**710**	**310**	**310**	-	**1330**

Copepods were the predominant component of the holoplankton in River Ossiomo during both seasons in terms numerical abundance, while cladocerans were the predominant component in terms of species diversity. Numerically copepods made up 51.1% of the total zooplankton population with 680 individuals m^{-3} (Figure 3). Among the most dominant copepods species were *Thermocyclops neglectus* and *Cryptocyclops bicolor* (64.7%, 33.1% and 13.2%, 6.8% of the total copepods and total zooplankton, respectively).

Cladocerans form the second most important group in terms of numerical abundance, comprising about 43.6% of the total zooplankton count representing 580 individuals (Figure 3). Cladocerans were mostly represented by *Alona eximia* and *Dadaya macrops* (forming 36.2%, 15.8% and 17.2%, 7.5% of total cladocerans and total zooplankton respectively). Although rotifers were represented by 5 species, collectively they formed only 5.3% of the total zooplankton density in the river, with relatively higher densities at the upstream of the river (station 1).

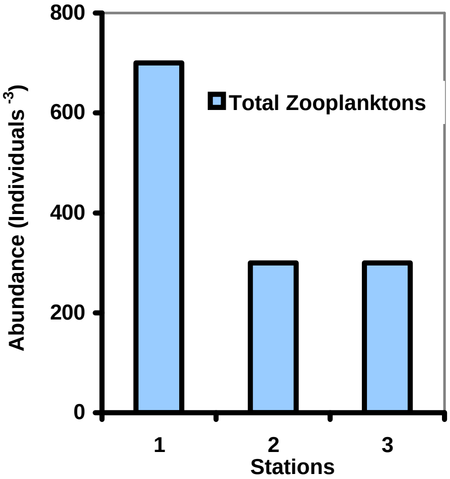

Figure 2: Spatial distribution of the total zooplankton recorded across study stations in River Ossiomo during the period of study

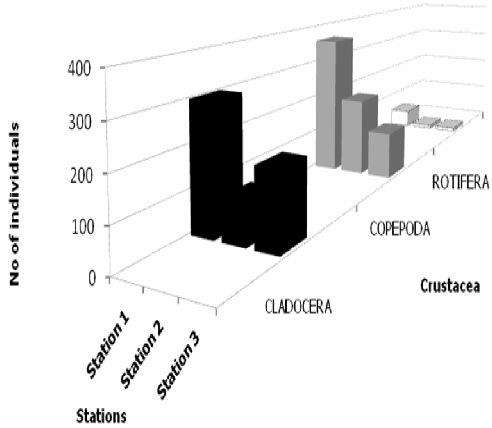

Figure 4: Spatial distribution of zooplankton groups in River Ossiomo during the period study

Spatial and Seasonal Distribution of Zooplankton: The zooplankton standing crop throughout the study area was 1330 individuals. As illustrated in Figure 2, the highest density (710) was recorded at station 1. Station 2 and 3 haboured a lower standing crop with a density of 310 at both stations. Based on numerical abundance copepods were the most dominant zooplankton group, making up half of the zooplankton population in most of the studied stations (Figure 3).

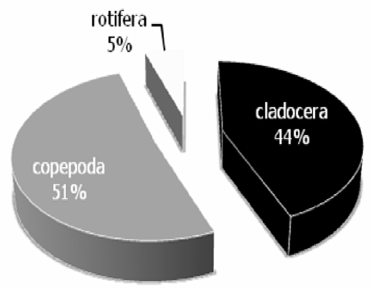

Figure 3: Percentage of occurrence of the recorded zooplankton groups in River Ossiomo during the period of study

The highest copepod densities were observed in the upstream and midstream (stations 1 and 2) decreasing gradually towards the downstream (station 3). The abundance was lowest at station at station 3. The freshwater copepod *Eucyclops macruroides* was recorded only at station 1 with 10 individuals (Figure 4).

Cladocerans were the most dominant group in the downstream (station 3) making up 58.1% of the total zooplankton population at this station. Their abundance decreased gradually: densities were minimal in the midstream (station 2). Rotifers showed nearly the same distributional pattern as copepods. Their densities were highest at in the upstream (station 1) and decreased gradually towards the downstream (station 3). Freshwater rotifers *Proales decipiens* and *Proales simplex* were only recorded at station 3 and 2 respectively (Figure 4).

The seasonal total zooplankton standing stock throughout the study showed that the river was productive through the period of study. Abundance was lower during dry season. The zooplankton population was higher in the wet season, showing a distinct peak in the month of June and July for nearly all stations.

In wet season, the zooplankton standing crop was larger than in dry season. Copepods represented 53.6% (590 individuals) of the total zooplankton. They were represented by 6 species with the dominance of *Thermocyclop neglectus* (420 individuals, 38.2%). *Cryptocyclops bicolor* and *Mesocyclops bodanicola* were fairly frequent species. Cladocerans were the second dominant group with a density of 460 individuals, accounting for 41.8% of the total count. Regarding species composition, cladocerans were more diversified (13 species).

Rotifers contributed about 4.6% to the total community. They were represented by 5 species

During dry season, cladocerans dominated the zooplankton community (110 individuals) consisting 47.8% of the total population. Cladocerans were represented by *Bosmina longirostris, Dadaya macrops* and *Alona eximia.* Of these *Dadaya macrops* was the dominant at stations 1and 3 for the month of December. Copepods were the second dominant group with a density of 100 individuals, representing 43.5% of the total zooplankton count. Copepods were represented by *Cryptocyclops bicolor, Thermocyclop neglectus, Microcyclops varican* and *Mesocyclops bodanicola.* The leading species was *Thermocyclop neglectus* in station 1 for the month of October and November. Rotifers constituted 8.7% of the total zooplankton represented only by *Proales decipiens.* It was present in stations 1 and 3 in the month of December only (Figure 5).

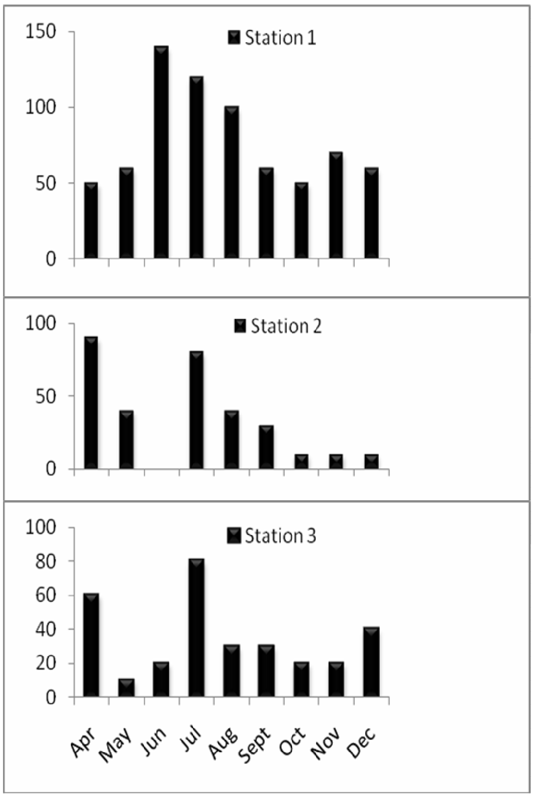

Figure 5: Spatial and seasonal distribution of the total zooplankton across study stations in River Ossiomo during the period of study

Species Diversity: The diversity indices were designed to measure species richness, the number of species in a community and the degree of evenness of the species' relative abundance. However, spatial variations in the number of species and individuals were reflected by the species diversity (Shannon-Weiner index). River Ossiomo showed the lowest average species richness (1.592) recorded at station 2, while the highest average of 2.508 was recorded at station 1 (Figure 6). The zooplankton in station 3 recorded d the highest Evenness index (0.6916); this was followed by station 1(0.5846) then station 2 (0.5461), in their order of decreasing values (Table 2).

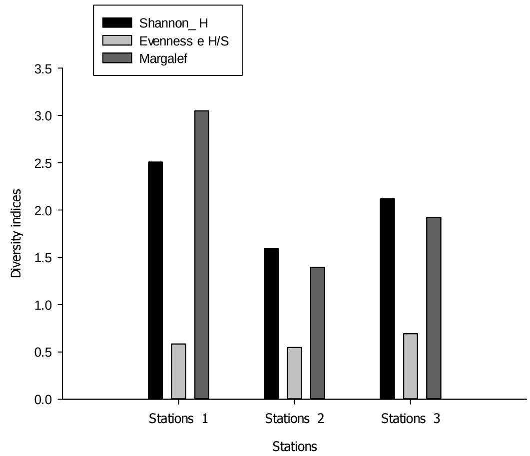

Figure 6: Diversity indices of total zooplankton recorded at different stations in River Ossiomo during the period of study

Cluster Analysis: In order to reveal the similarities and differences among the investigated stations, cluster analysis was performed based on the total abundance of the zooplankton community (Figure 7).

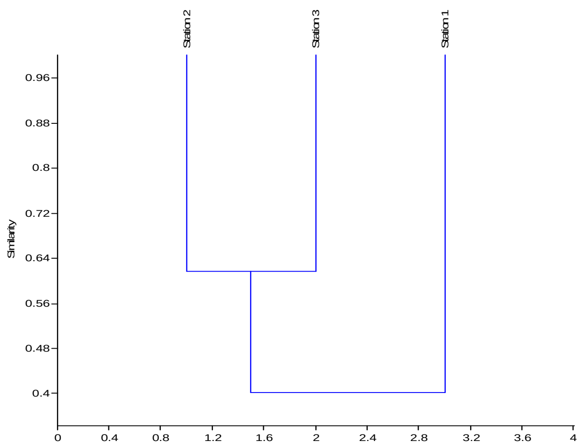

Figure 7: Dendogram showing similarity of sampling stations on the basis of their zooplankton composition in River Ossiomo during the period of study

The results showed the presence of two main clusters with a high similarity. The first cluster contains only station 1, which is located in the upstream, where copepods are dominant. The second cluster consists of the other stations (2 and 3) located in the midstream (wharf side) and downstream of the river, were characterized by relatively low abundance.

DISCUSSION

Twenty two (22) species of crustacean zooplankton made up of 11 species of Cladocera, 6 species of Copepoda and 5 species of Rotifera were recorded in River Ossiomo during the study. The numbers of zooplankton species recorded from this study were common in several other rivers in Nigeria and elsewhere (Bidwell and Clarke, 1977; Jeje and Fernando, 1986; Egborge, 1994; Imoobe and Egborge, 1997; Tawari-Fufeyin *et al.,* 2008; Imoobe *et al.*, 2008; Imoobe and Akoma, 2009; Imoobe, 2011). The values of Margalef's index, Evenness index and Shannon-Wiener index indicated a fairly rich diversity of zooplanktons supported by the nutrient status of the water body. This suggested that the river was not under serious pollution threat at the time of the study. This was in agreement with the earlier studies by Imoobe (1997) who reported fifty-one species of crustacean zooplankton from Jamieson River located within the same locality.

The calculated diversity indices using Shannon-Wiener index revealed that station 1(2.508) was more diverse, followed by station 3(2.116), while station 2(1.592) was the least diverse. This pattern was expected because station 2 had more disturbances especially from human activities and the rate of flow of water was high at this station. Also the distribution pattern of the individuals found in this station was few, low and least even.

Zooplankton abundance and species number in Ossiomo River varied monthly. The high abundance of zooplankton recorded during the wet season (June – July) was similar to reports in previous studies elsewhere (Saint-Jean, 1983; Okogwu, 2010; Imoobe, 2011). Seasonal alteration of zooplankton abundance observed in this study may be due to physico-chemical condition of the water. Flooding during the wet season may have contributed positively to zooplankton population growth as a result of species recruitment from other flooded water bodies and inflow of nutrients from the drainage basin that will trigger off increase in phytoplankton production and consequently zooplankton productivity. However, seasonal dynamics of zooplankton communities in the tropics has been attributed to a number of other factors such as the environmental characteristics of the water, predation, quality of edible algae and competition (Hellawell, 1986; Ovie and Adeniji, 1994).

Copepods and cladocerans were the most important groups of crustacean zooplankton in River Ossiomo, while the former was dominated by the cyclopoids, the later was dominated by the chydorids. A total of eleven species belonging to seven families and eleven genera were reported for cladocera, while a total of six species belonging to one family and six genera were recorded for copepods, the lowest zooplankton class recorded was rotifera which has total of five species belonging to three families and three genera.

Copepoda are known to occur in plankton of most water bodies and have been ranked as one of the most abundant. Raymont (1983) recorded that though ubiquitous; copepods are more in the marine environment than in the freshwater. The cyclopoids dominated in this study and this agreed with the findings of Egborge (1981) and Jeje and Fernando (1986), where the 11 cyclopoid copepods were the dominant group in Lakes Asejire and Kainji, respectively.

The five species of rotifers that were found belong to the families of Lecanidae (represented by *Monostyla hamata* and *M. cornuta*), Lepadellidae (*Lepadella ovalis*) and Proallidae (*Proales decipiens and P. simplex*). This result contrasted an earlier study of Tawari-Fufeyin *et al.* (2008) who recorded no representative of rotifer in the same river.

The spatial and seasonal distribution of crustacean zooplankton species (Figure 5) showed that while some species were restricted to certain stations for certain month, others were found in all the stations. Eight species of crustacean zooplankton, namely, *Dadaya macrops, Alona eximia, Pseudochydorus globosus, Grimaldima brazzai, Diaphanosoma excisum, Metacyclops minutes, Mesocyclops bodanicola* and *Thermocyclops neglectus* occurred in all the three stations. Out of the 22 species of the zooplankton, only 1 species was absent in station 1, 13 species were absent in station 2, while 10 species were absent in station 3. The predominant human activities in station 2 must have resulted in such high depletion in the population. The high density of zooplankton in station 1 was due to 6 species that were exclusively restricted to station 1 to include *Simocephalus expinous, Moina reticulate, Eucyclops macruroides, Monostyla hamata, Monostyla cornuta, Lepadella ovalis,* while only *Proales simplex* was restricted to station 3. No species was restricted to station 2, this might be because it is the downstream of the study area hence the water current drift many of the zooplankton in station 1 and 2 into station 3.

In conclusion, the study revealed there was no evidence of water pollution recorded in any of the stations. The contamination from occasional oil spillage was found to be below World Health Organization (WHO) and Federal Ministry Environment (FMEnv) acceptable limit for water pollution. The zooplankton showed a high significant positive correlation with air temperature. All parameters were found to influence the distribution and abundance of the fauna along the stretch of the river. Future work on this particular river is recommended to ascertain the extent of future composition, distribution, diversity and ecology of zooplankton and other higher taxa like the fishes in the river may be in a longer distance across the river to ascertain the trend of physico-chemical parameters and assemblage of the zooplankton and others invertebrates and vertebrates.

REFERENCES

ABOWEI, J. F. N. and SIKOKI, F. D. (2005) *Water Pollution Management and Control*. Double trust Publication Company, Calabar, Nigeria.

AOYAGUI, A. S. M. and BONECKER, C. C. (2004). Rotifers in different environments of the upper Parana River floodplain (Brazil): richness, abundance and relationship to connectivity. *Hydrobiologia,* 522: 281 – 290.

BIDWELL, A. and CLARKE, N. V. (1977). The invertebrate fauna of Lake Kainji. *Nigeria Field,* 42: 104 – 110.

BOXSHALL, G. A. and BRAIDE, E. I. (1991). The freshwater cyclopoid of Nigeria with an illustrated key to all species. *Bulletin of British Museum of Natural History (Zoology),* 57(2): 185 – 212.

BREITBURG, D. L, SANDERS, J. G., GILMOUR, C. C., HATFIELD, C. A., OSMAN, R. W., RIEDEL, G. F., SEITZINGER, S. P. and SELLNER K. G. (1999). Variability in responses to nutrient and trace elements, and transmission of stressor effects through an estuarine food web. *Limnology and Oceanography,* 44(3): 837 – 863.

DUMONT, H. (1981). Cladocera and free living copepoda from the Fouta Djalon and adjacent mountains areas in West Africa. *Hydrobiologia,* 85: 97 – 116.

EGBORGE, A. B. M. (1994). Salinity and the distribution of rotifers in the Lagos Harbour Badagry creek system, Nigeria. *Hydrobiologia,* 272: 95 – 104.

EGBORGE, A. B. M. (1981). The composition, seasonal variation and distribution of zooplankton in Lake Asejire, Nigeria. *Revue Zoologique Africaine,* 95(1): 136 – 180.

GABRIEL, C., MAAS, S., DUMONT, J. and EGBORGE, A. B. M. (1987). *Halicyclops korodiensis* Onabamiro (Crustacean, Copepoda) in the Estuary of the Warri River, Nigeria, West Africa. *Hydrobiologia,* 144: 155 – 161.

GREEN, J. E. (1962). Zooplankton of the River Sokoto: The crustacean. *Proceeding of the Zoological Society of London,* 138: 415 – 453.

GUY, D. (1992). *The Ecology of the Fish Pond Ecosystem with Special Reference to Africa*. Pergamon Press, USA.

HELLAWELL, J. (1986). *Biological Indicators of Freshwater Pollution and Environmental Management*. Elsevier, London.

IMOOBE, T. O. T. (1997). *Crustaceans of Jamieson River Nigeria.* PhD Thesis, University of Benin, Benin City, Nigeria.

IMOOBE, T. O. T. (2011). Diversity and Seasonal Variation of Zooplankton in Okhuo River, a Tropical Forest River in Edo State, Nigeria.

IMOOBE, T. O. T. and AKOMA O. C. (2009). Spatial variations in the composition and abundance of zooplankton in the Bahir Dar Gulf of Lake Tana, Ethiopia. *African Journal of Ecology,* 48: 72 – 77.

IMOOBE, T. O. T. and EGBORGE, A. B. M. (1997). The composition, distribution and seasonal variation of crustaceans in Jamieson River, Southwestern Nigeria. *Tropical Freshwater Biology*, 6: 49 – 63.

IMOOBE, T. O. T., TAWARI-FUFEYIN, P. and EJOH, A. S. (2008). Community structure of crustacean zooplankton in Ekpan Creek, a perturbed tributary of Warri River, Niger Delta, Nigeria. *African Scientist*, 9(4): 123 – 134.

JEJE, C. Y. (1988). A revision of the Nigerian species of the genera *Mesocyclops* Sars, 1914 and *Thermocyclops* Kiefer, 1927 (Copepoda: Cyclopoida). *Hydrobiologia,* 164: 171 – 184.

JEJE, C. Y. and FERNANDO, C. H. (1986). *A Practical Guide to the Identification of Nigerian Zooplankton.* Kainji Lake Research Institute Nigeria.

MARCUS, N. (2004). An overview of the impacts of eutrophication and chemical pollutants on copepods of the coastal zone. *Zoological Studies,* 43(2): 211 – 217.

OGBEIBU, A. E. (2005). *Biostatistics: A Practical Approach to Research and Data Handling*. Mindex Publishing Company Limited, Benin City, Nigeria.

OKOGWU, O. I. (2010). Seasonal variations of species composition and abundance of zooplankton in Ehoma Lake, a floodplain lake in Nigeria. *Rev. Bio. Trop.* 58(1): 171 – 182.

ONABAMIRO, S. D. (1952). Four new species of *Cyclops* sensu Lat (Crustacean: Copepoda) from Nigeria. *Proceeding of the Zoological Society of London,* 122: 253 – 266.

OVIE, S. I. and ADENIJI. H. A. (1994). Zooplankton and environmental characteristics of Shiroro Lake at the extremes of its hydrological cycle. *Hydrobiologia,* 286: 175 – 182.

RAYMONT, J. E. G. (1983). *Plankton and Productivity in the Oceans: Zooplankton.* Pergamon Press, London.

RUTHERFORD, S. D. HONDT, S. and PRELL, W. (1999) Environmental controls on the geographic distribution of zooplankton diversity. *Nature,* 400(6746): 749 – 753.

SAINT-JEAN, L. (1983). The zooplankton. Pages 199 – 232. *In:* CARMOUZE, J. P., DURAND, J. R. and LEVEQUE, C. (Eds.). *Lake Chad: Ecology and Productivity of a Shallow Tropical Ecosystem, Nigeria.*

SMIRNOV, N. N. (1974). *Fauna of the USSR. Crustacea: Chydoridae. Volume 1 Number 2,* Academy of Sciences of the USSR English Translation, Israel Program Scientific Translation, Jerusalem.

STOUT, L. N. (1974). Polytypic species and hybridization in quaternary ostracods. *American Plaogeography, Paleoclimatology and Paleoecology,* 17: 257 – 266.

TAWARI-FUFEYIN, P., IMOOBE, T. O. T. and AWANA, B. B. (2008). The impact of bridge construction on the crustacean zooplankton of Ossiomo River, Niger Delta, Nigeria. *African Scientist,* 9: 117 – 122.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC and CULTURAL ORGANIZATION (1974). Review of methods used for quantitative zooplankton sampling. *UNESCO Technical Papers in Marine Science,* 18: 1 – 27.

VAN DE VELDE, I. (1984). Revision of the African species of the genus *Mesocyclops* Sars 1914 (Copepoda cyclopoidae). *Hydrobiologia,* 109: 3 – 66.

YAKUBU, A. F., SIKOKI, F. D., ABOWEI, J. F. N. and HART, S. A. (2000). A comparative study of phytoplankton communities of some creeks and borrow pits in the Niger Delta Area. *Journal of Applied Science, Environment and Management,* 4(2): 41 – 46.

ZAR, J. H. (1984). *Biostatistical Analysis*. 2nd Edition, Prentice Hall Incorporated, New Jersey, USA.