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ABUNDANCE AND DIVERSITY OF ZOOPLANKTON IN THE LOWER REACH OF THE OPOBO RIVER, RIVERS STATE NIGERIA

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ABSTRACT: *Zooplankton are diverse group of organisms with little or no swimming ability. They are the animal component of plankton, have short life cycle and quickly respond to changes in their environment; hence, their abundance and community structure serve as an essential tool in providing information on the water quality of a given aquatic environment which may serve as an indicator of the ecological status of the water body. The aim of this study is to determine the abundance and diversity of zooplankton in the lower reach of the Opobo river. In this study, 6 stations namely Opu-Kala-Ama (ST 1), Uta-Ewa (ST 2), Ascon Jetty (ST 3), Opobo Town (ST 4), Queens Town (ST 5) and Down-Below (ST 6) were chosen along the river. Zooplankton samples were collected monthly by towing a plankton net of 35 µm mesh size and 0.196m^2 mouth surface area from a motorized boat and preserved in 4% formalin. Sampling was for a period of 6 month (March- August 2008). Identification and counting of zooplankton were done with a compound microscope of 10x10 magnifications. Data was analysed using XLSTAT and JMP statistic package. Comparing of means and multivariate analysis was done using ANOVA and PCA (Principle Component Analysis) respectively. A total abundance of 30,368 zooplankton measured in cell/ml was recorded. The diversity structure comprised of 12 Zooplankton species belonging to 9 families (Copepoda 82%, Decapoda 3%, Gastropoda 4%, Bivalve 3%, Echinodermata 2%, Spirotricha 2% Polychaete 1%, Rotifera 3% and Cladocera 0.1%). Acartia longiremis showed high dominance in nearly all the stations exception of Opu Kala-Ama which was dominated by Calamus finmarchicus. Zooplankton diversity indices showed a fairly high Shanon diversity index only in ST4 (2.05) and low Margalef diversity index in all the stations. The findings of this work revealed that the Opobo river has high zooplankton abundance with low diversity.*

KEYWORDS: Abundance, Diversity, Zooplankton, Opobo River, Microscopic Animal

INTRODUCTION

Zooplanktons are the microscopic animal components of the aquatic system which move at the mercy of the water current. They are heterotrophic in nature. They comprise different size of organisms ranging from micrometer to as large as 2 meters. Zooplankton are mainly classified based on their size and by the length of time they are planktonic. Based on size, zooplankton are classified as microplankton (2-20µm), mesoplankton (200µm-2mm), macroplankton (2-20mm), micronekton (20-200mm), and megaloplankton (200mm- above) (Lagus, 2009). Based on the length of time they are plankton, zooplankton is composed of two major types of organisms: firstly, those permanent members with their whole life-cycle spent in the plankton (holoplankton), and secondly; those egg and larval stages of organisms whose adults are benthic or pelagic nekton (meroplankton). Protozoans, rotifers, cladocerans,

isopod and copepods constitute the major groups of zooplankton. Zooplankton are one of the most vital biotic components that influence all functional aspects of the marine ecosystem including trophic network and the marine food chains (Keller *et al.,* 2008). They feed on phytoplankton (Dejen *et al.,* 2004) and so they are primarily found in surface waters where food (phytoplankton) are mostly abundant. Just as any other organism, zooplankton are not uniformly dispersed within a region of the ocean, although they exist throughout the ocean. Specific species of zooplankton are strictly restricted by salinity and temperature gradients, while other species can withstand wide temperature and salinity gradients. Zooplankton distribution in the environment can also be influence by biological factors and other physical factors (Vilela *et al.,* 2003, Imoobe and Adeyinka, 2010). Biological factors include breeding, predation, phytoplankton concentration and vertical migration. The physical factors include mixing of the oceanic water (upwelling and down welling) that affect nutrients availability which in turn affect phytoplankton production and in the long run, affect the zooplankton. Zooplankton play a major role in the marine food web (Kennie *et al.,* 2017), they constitute an important link between primary producers (mostly phytoplankton) and higher consumers (mostly fishes). They serve as a link in the food web and mediate the transfer of energy from lower to higher trophic level (Lagus, 2009).

In several years, the study of zooplankton abundance and diversity have been done in many aquatic ecosystems including rivers, lake, estuaries, seas and ocean (Savin *et al*., 2004). Many studies carried out on zooplankton abundance and diversity have shown that zooplankton populations usually change with spatial-temporal variation of the physico-chemical parameters (Talling, 2002), changes in salinity and depth (Francoise *et al*., 1997), and also, as a result of predators (Purvaja and Rasmesh, 2000). Zooplankton which is an animal component of plankton, form a major link in the transfer of energy in the aquatic environment and their ecology is of important interest in assessing the production potential of any water body (Jeyaraj *et al.,* 2014). They form the largest group of organisms in the aquatic environment and play a vital part in the aquatic food chain (Vilela *et al.,* 2003). They are the link through which energy is transferred from the lower trophic level to the higher trophic level in the aquatic environment (Agnieszka *et al.,* 2015). Zooplankton which is an important plankton component regulates phytoplankton and microbial productivity by grazing on them. They feed on bacteria and phytoplankton, and serve as primary food for larval and juvenile fishes and other carnivorous aquatic animals (Fielding *et al*., 2007). By grazing, they also help in transfer of energy from the primary producers to fishes and other consumers (Dejen *et al.* 2004). They serve as a bridge in the trophic link connecting the primary producers and the higher trophic level (Iloba, 2002). Their community and biomass determine the amount of energy that is transferred (Tadesse, 2011). Zooplankton community which is a component of the marine ecosystem is highly sensitive to slight environmental changes (Gooday, 2003). They are important indicator of environmental change as they are very sensitive to changes in their environment. A slight change in their environment will cause change in their abundance and species diversity (Emmanuel *et al*., 2013). They respond quickly to change in their environment due to their short life cycle. Zooplankton species diversity and abundance in the aquatic environment has a vital influence on the healthiness of the aquatic environment and fisheries (Jafari *et al.,* 2011) and differs temporally and spatially from river to river, and may be influence by competition, predation, physical, biological and chemical parameters (Emmanuel *et al*., 2013). Also, the distribution of zooplankton in terms of biomass and diversity is affected by the environmental condition of the water body, as well as

competition and predation (Berasategul *et al.,* 2005; Agnieszka *et al.,* 2015). Knowledge of the spatial distribution of zooplankton is necessary for understanding plankton ecology and fishery management (Hitchcock *et al*., 2002), making plankton to be considered a very useful bio-indicator of water quality in different aquatic environments (Minutoli *et al.,* 2007). The study of zooplankton is very vital in fisheries and aquaculture (Aoyagul *et al*., 2004). Zooplankton are recognized as indicators of pollution in the aquatic habitat (Yakubu *et al*., 2000) due to the fact that their seasonal dynamics and the mechanisms controlling their variability are highly vulnerable to changes in their environmental variables (Marcus, 2004). Zooplankton diversity in rivers has been reported by different researchers (Robert *et al*., 2010; Ikhuoriah *et al*., (2015); Arazu *et al*., 2017; Kennie *et al*., 2017). Ikhuoriah *et al*., (2015) recorded zooplankton species diversity of twenty-two crustaceans, eleven species of cladocera, six species of copepods and five species of rotifers; with *Lepadella ovalis* as the dominant rotifer in River Ossiomo. The Zooplankton organisms are richly and evenly distributed in the water body and varied seasonally.

The Nigerian marine environment is richly dominated with zooplankton species of cladocera, copepoda and rotifera, with *Lepadela ovilis* being one of the dominant rotifers in many of the water bodies (Arazu *et al*., 2017). Robert *et al*. (2010) reported a high dominance of copepods, which is followed by cladocera and a single species of rotifer (*Lepadela ovilis*) at the Ogba River in Benin City. Kennie *et al*., (2017) reported high abundance of copepods in terms of species abundance, followed by cladocera, with rotifers as the most diverse species in the Jebba Upper Basin. Emmanuel *et al.,* (2013) recorded a high zooplankton diversity consisting of Calanoid copepods (55.3%), Cyclopoida (10.2%), Harpacticoida (5.8%), Copepod larvae (17.0%); Annelida/Polychaeta larvae (1.9%); Chaetognatha (2.3%); Appendicularia (2.2%); Pisces larvae (2.6%); Tunicate larvae (0.6%); Cnidaria (0.1%); Ctenophora (0.1%); Echinodermata larvae (0.9%); Mollusca larvae (1.2%); Copepoda /Cladocera (0.03%); and Malacostraca (0.1%)**.** Eyo *et al*., (2013) recorded a zooplankton diversity of forty (44) species belonging to seven (7) taxonomic groups in the Great Kwa River, Cross River State, Nigeria. The groups Heterodonta and Salpida were represented by one species consisting of 2.27% composition by species, which was followed by two species of Chaetognatha and Decapoda consisting of 4.55% species by composition. Rotifera was represented by seven species making up 15.91%, while Cladocera consist of eleven (11) species making 25.0% and twenty (20) species of Copepode making up 45.45% of the total zooplankton. The order of dominance of the zooplankton groups is Copepods > Cladocerans > Rotifers > Decapods > Chagtognathans > Salpidans > Heterodontans**.** Abdul *et al*., (2016) recorded a relative zooplankton abundance and diversity of 28 species belonging to four (4) classes in a tropical Coastal Estuary, South-West, Nigeria. The zooplankton diversity consists of twelve (12) species of Rotifera, seven (7) species of Copepode, eight (8) species of Cladocera and a single species of Ostracoda.

The Opobo River is the tidal segment of the Imo River which flows from the south Eastern Nigeria into the Atlantic Ocean. The river which is estuarine serves as a tributary through which the Imo River flows into the Atlantic Ocean. The river plays a very vital role in the economy and aquatic food supply of the Opobo kingdom and its neighbouring communities, serving as their major source of fish and employment to the people. In spite of these vital roles played by the Opobo River to the Kingdom and River State at large, little or no published information exist on the plankton community of the River. A good information on the abundance, diversity and physic-chemical parameter of the river will not only help in

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understanding the dynamics of its numerous fishery resources, but will also serve as a tool for foretelling the impact of human activities in the river.

The aim of this study is to provide information on the zooplankton abundance and diversity in the lower reach of the Opobo River, Nigeria

MATERIALS AND METHODS

Study Area

The Opobo river is located between latitude 04^0 29' 44.10"N and longitude 07^0 34' 09.0"E (Fig. 1). It is tidal in nature and a segment of the Imo River which flows from the south Eastern Nigeria into the Atlantic Ocean. The river which is an estuary serves as a tributary through which the Imo River flows into the Atlantic Ocean. The River is located in between Rivers State and Akwa-Ibom State of the Niger Delta area of Nigeria. The dominant vegetation of the area is Nypa palm (*Nypa fructicana*) and mangroves - red mangrove (*Rhizophora racemosa*) and white mangrove (*Avicennia nitida*). Numerous human activities within the river include boating, navigation, washing, disposal of refuge and sewage, bathing, swimming and fishing (which is the major occupation of the people). This research study was conducted in six months from March to August 2018. Six stations were selected along the river, at least one km apart (Fig.1). The stations were: station 1 (Opu-Kala Ama), station 2 (Uta-Ewa Jetty/Beach), station 3 (Alscon Jetty), station 4 (Opobo town) station 5 (Queens Town) and station 6 (Downbelow). Station 1 (Opu-Kala Ama) and station 2 (Uta-Ewa Jetty/Beach) are offshoot of the main river, while station 3 (Alscon Jetty), station 4 (Opobo town) station 5 (Queens Town) and station 6 (Downbelow) are on the main river.

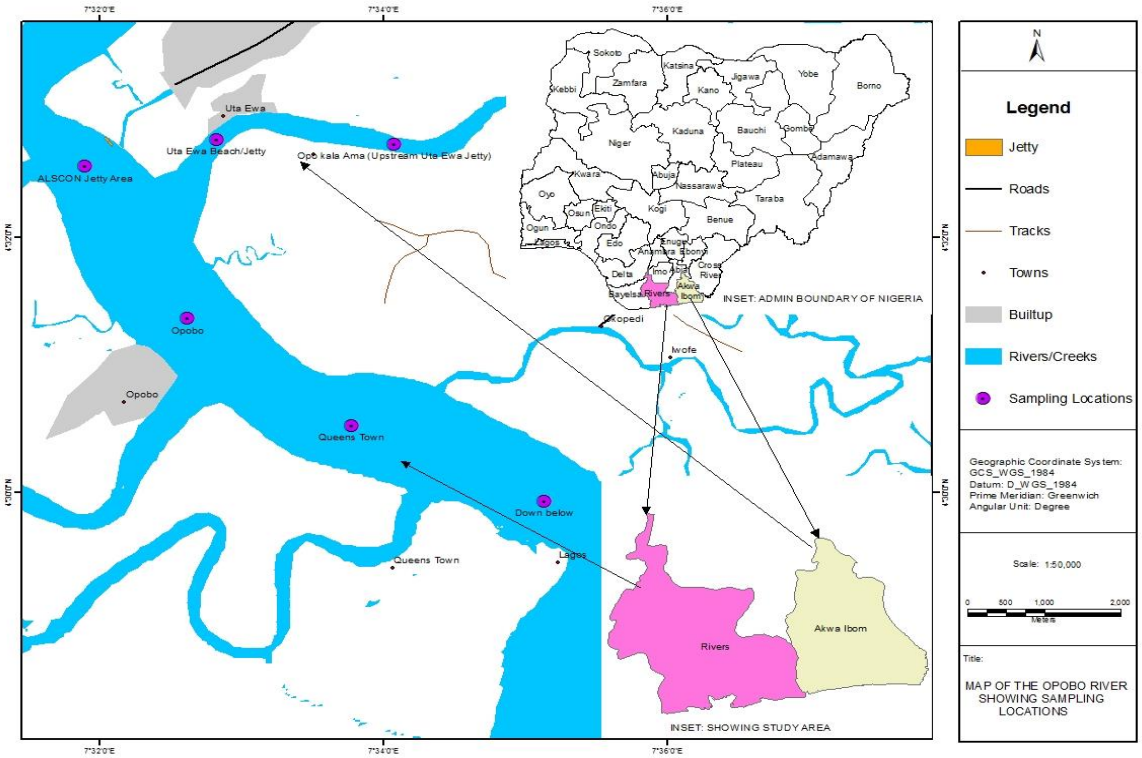

Fig. 1 Map of Opobo River and the Six Stations

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Sample Collection

Zooplankton samples were collected monthly between the hours of 12noon and 2pm at the various stations. Zooplankton samples were obtained by towing a plankton net of 35 µm mesh size and 0.196m^2 mouth surface area from a motorized boat through a distance of 100m against the current at a mild speed. The net was hauled and the zooplankton sample was transferred into a 100ml plastic bottle with a screw cap and preserved using 4% formaldehyde solution. Three replicates were collected at each station.

Sample Analysis

In the laboratory, zooplankton samples were allowed to settle for two days, thereafter some liquid were decanted to get concentrated samples which were stored in 50ml bottle. During analysis, plankton samples were gently shaken for proper mixing, after which one ml of the sample was transferred onto a microscope glass slide using a Pasteur pipette for identification. After identification, enumerations (standing crop estimation) of the plankton was carried out under a binocular compound microscope with 10 x 10 magnifications using the Lackey Drop Micro-transect counting method (APHA, 1998). Subsamples of the three replicates were counted and the results expressed as the number of organisms per ml of sample. In the Lackey Drop Micro-transect counting method, the sub-sample was well mixed, after which a drop of 0.05ml was taken with a Pasteur pipette onto the microscope glass slide and covered with a cover slip. Identification of plankton species was done using Newwell and Newwell (1977) and Phytoplankton Manual by Sournia, 1987. The number of individual organism (density) per ml of sample was calculated as follows:

$$\text{Number of Individual Organism/ml} = \frac{C \times TA}{A \times S \times V}.$$

Where,

C = number of organisms counted,

TA = area of the cover slip (mm^2),

A = area of one strip (mm^2),

S = number of strips counted; and

V = volume of sample under the cover slip (ml) (APHA, 1998)

Statistic Analysis

The statistic software package XLSTAT and JMP were used to analysed biological parameters to determine the zooplankton abundance and diversity of the Opobo river. Three indices were used to determine the zooplankton diversity: species diversity, species evenness and species richness. Proximity matrix of zooplankton was done using Bray and Curtis. The turkey HSD was used in separation of mean.

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RESULTS

A total of twelve (12) species of zooplankton belonging to nine taxonomic groups were recorded during the six months sampling period (Table 1). The order Copepoda was represented by four species (*Anomalocera patersoni, Calamus Finmarchicus, Nauplius larva, and Acartia loniremis)* consisting of 82% of the total abundance of species (Fig. 2), while the other taxonomic groups were represented by single species. The lowest number of species was recorded in Downbellow station during the six months study period. On the other hand, Opobo town station had the highest number of species with twelve (12) specie represented (Table 1). In all the Stations, *Acartia longiremis* showed high dominance with exception of Opu Kala-Ama station, which was dominated by *Calamus finmarchicus* (Table 1). The lowest number of species was recorded in the month of March (8 species recorded), while the highest number of species was recorded in the month of July (with 11species) as shown in Table 2

Tables 1: Relative Abundance (Percentage) of Zooplankton in the Stations

Family	Organisms	Opu Kala-Ama	Uta-Ewa	Alson Jetty	Opobo Town	Qweens Town	Down bellow	Total
Copepoda	*Anomalocera patersoni*	5	9	8	13	18	20	**13**
	Calamus finmarchicus	30	25	28	24	26	27	**27**
	Nauplius larvae	14	20	16	13	18	10	**15**
	Acartia longiremis	24	26	28	26	29	33	**28**
	Total	**73**	**80**	**80**	**75**	**92**	**90**	**82**
Rotifera	*Lepadella ovalis*	0	3	3	5	2	2	**2**
Decapoda	Crab larva	2	4	5	4	3	2	**3**
Bivalve	*Glycymeris glycymeris* (larva)	7	4	3	6	1	0	**3**
Gastropoda	*Janthina sp* (Snail larva)	6	7	5	3	1	3	**4**
Echinodermata	*Ophiura sp* (Brittle star)	7	2	1	2	1	0	**2**
Spirotrichea	*Favella ehrenbergii* (Tintinnid)	7	0	1	3	1	3	**2**
Polychaete	Polychaete larva	0	0	3	2	0	0	**1**
Cladocera	*Daphnia sp*	0	0	0	1	0	0	**0**
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

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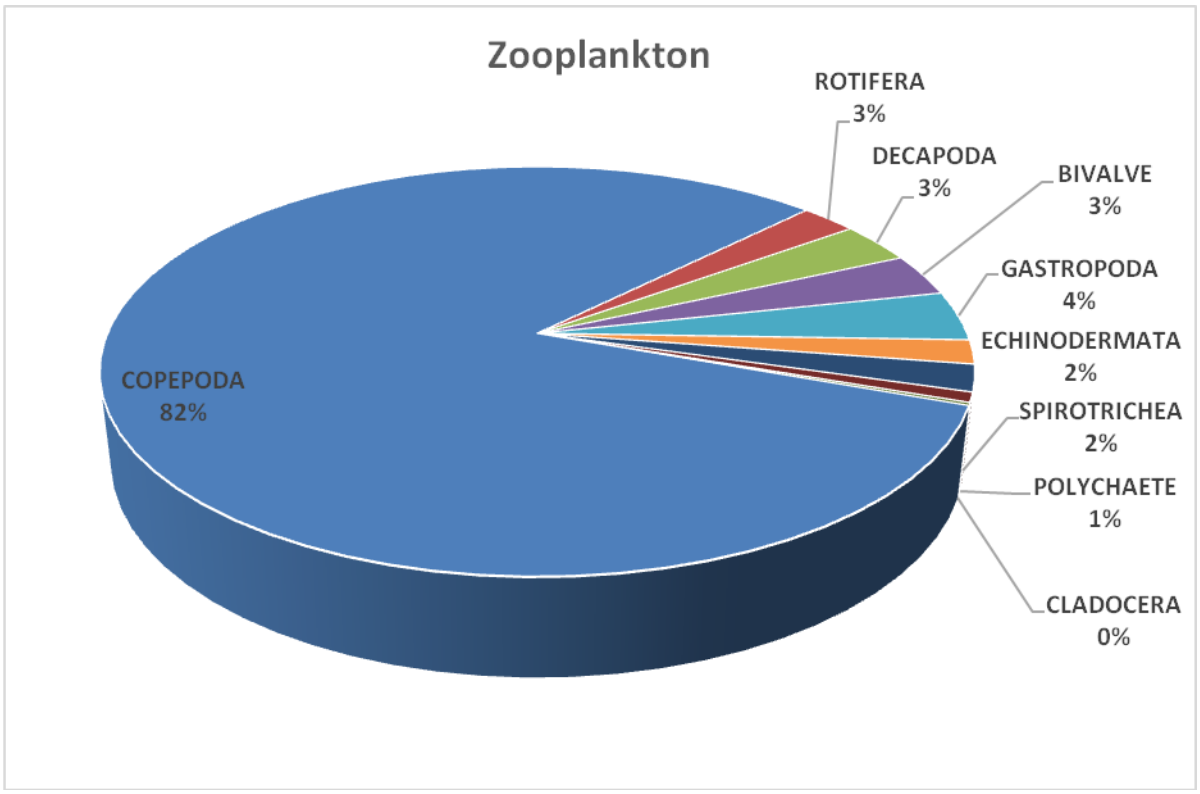

Fig. 2: A Pie Chart showing the relative Abundance of Zooplankton

Table 2: Relative Abundance (Percentage) of Zooplankton in the Months of Study

Family	Organisms	March	April	May	June	July	August	Total
Copepoda	*Anomalocera patersoni*	18%	15%	11%	6%	11%	14%	**13%**
	Calamus finmarchicus	28%	33%	29%	26%	18%	25%	**27%**
	Nauplius larvae	13%	14%	20%	7%	14%	20%	**15%**
	Acartia longiremis	30%	26%	28%	25%	29%	29%	**28%**
	Total	**89%**	**87%**	**88%**	**64%**	**72%**	**88%**	**82%**
Rotifera	*Lepadella ovalis*	0%	3%	2%	4%	4%	1%	**2%**
Decapoda	Crab larva	0%	0%	4%	10%	6%	3%	**3%**
Bivalve	*Glycymeris glycymeris* (larva)	4%	4%	2%	4%	4%	4%	**3%**
Gastropoda	*Janthina sp* (Snail larva)	0%	0%	0%	13%	9%	1%	**4%**
Echinodermata	*Ophiura sp* (Brittle star)	3%	2%	2%	3%	1%	1%	**2%**
Spirotrichea	*Favella ehrenbergii* (Tintinnid)	4%	3%	2%	0%	2%	0%	**2%**
Polychaete	Polychaete larva	0%	0%	1%	2%	1%	0%	**1%**
Cladocera	*Daphnia sp*	1%	1%	0%	0%	0%	0%	**0%**
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Zooplankton Diversity

The Zooplankton species diversity indices in the Opobo River were poor in nearly all the stations with exception of Opobo town which had a fairly high diversity index (Table 3). The Shannon index (H) ranged from 1.64 (Downbellow) to 2.05 (Opobo town), Margalef's index ranged from 0.950 (Uta-Ewa) to 1.283 (Alscon jetty), and Evenness (E) ranged from 0.730 (Queens town) to 0.860 (Opu Kala-Ama). Also, the proximity matrix (Bray and Curtis distance) showed that there were no similarities between the stations as all values were below 0.5 (Table 4).

Table 3: Zooplankton Diversity Indices

Stations	Shannon index (H)	Species Richness (Margalef Index)	Speices Eveness
Opu Kala-Ama	1.89	0.96	0.860
Uta-Ewa	1.86	0.95	0.847
Alscon Jetty	1.86	1.283	0.776
Opobo Town	2.05	1.279	0.825
Queens town	1.68	1.169	0.730
Downbellow	1.64	1.04	0.746

Table 4: Proximity matrix (Bray and Curtis Distance)

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Opu Kala-Ama	0					
Uta-Ewa	0.190	0				
Alson Jetty	0.236	0.111	0			
Opobo Town	0.213	0.159	0.118	0		
Queens Town	0.295	0.167	0.130	0.150	0	
Downbellow	0.304	0.274	0.200	0.189	0.134	0

DISCUSSION

Zooplankton Abundance and Diversity

The result obtained for the Zooplankton species abundance of the Opobo River showed that the Zooplankton species varied spatially and seasonally. The highest number of zooplankton species (11 species) was recorded during the wet season (July), while the lower zooplankton species (8 species) was recorded in the month of March. The finding of this study is similar to those of the findings of Ikhuoriah *et al.*, (2015), Okogwu (2010) and Imoebe (2011). The seasonal difference in Zooplankton species abundance as observed in this study maybe because of the chemical composition of the water. Flooding during the July period (wet season) as a result of high rainfall may also have contributed positively by recruiting zooplankton from other water bodies whereby causing an increase in the zooplankton community during the wet season.

Copepods were the most abundant group of Zooplankton in the Opobo River with a total number of four (4) species belonging to three different genera, making up 82% of the total abundance, the other taxonomic groups of zooplankton (Rotifera, Decapoda, Bivalve, Gastropoda, Echinodermata, Spirotrichea, Polychaete and Cladodocera) were represented by a single specie each. The high dominance of copepod in this study corresponds with the findings of Jeje and Fernando (1986), Ikhuoriah *et al., (*2015) and Robert *et al.,* (2010). These findings may be due to the fact that Copepoda is the most abundant zooplankton found in most water bodies (Ikhuoriah et al., 2015). The only species of Rotifera (*Lepadella ovilis*) that was found in this study belonged to the family Lepadellidea. This finding corresponds with the findings of Robert *et al.,* (2010) who recorded the same species (*Lepadella ovilis*) in the Ogba River Benin. However, it was not in agreement with the findings of Tawari-Fufeyin *et al.,* (2008) and Ikhuoriah *et al.,* (2015) who recorded no rotifer species and five different rotifers species including *L. ovilis* respectively in the River Ossiomo respectively. The difference in this finding and that of Tawari-Fufeyin *et al*., (2008) and Ikhuoriah *et al*., (2005) may be due to the sampling time or sampling method.

The diversity indices values: evenness index, Margalef's index and Shannon-Wiener showed a poorly/low diversified zooplankton. The low zooplankton species diversity maybe attributed to high abundance and dominance of Copepods (Kadiri, 2006). Although, the zooplankton community showed poor diversity, the different species of zooplankton that make up the community were evenly distributed. This finding corresponds with the finding of Ajuomu *et al.,* (2011) who reported a poor diversity of Zooplankton in the Bonny estuary. The values of the diversity indices using Shannon-Wiener index showed that zooplankton at station 4 (Opobo Town) were more diverse than other stations. The fairly high diversity shown by Opobo town may be due to the presence and high diversity of phytoplankton at the station (Station 4).

CONCLUSION

The Zooplankton structure of the river showed nine (9) major taxonomic groups: Copepoda, Gastropoda, Cladocera, Bivalve, Echinodermata, Polycheate, Spirotricheae and Rotifera; Copepoda having the highest abundance and diversity. The abundance of Zooplankton in the river varies spatially and seasonally, with more species recruited during the wet season. The river showed low zooplankton diversity. Also, the high dominance of Copepods indicates that the river is a natural breeding site for most aquatic fauna as Copepods constitute a major food source for fish.

RECOMMENDATION

1. More research on the zooplankton abundance and diversity of the Opobo river should be carried out.

2. The abundance and diversity of the Micro-benthic organisms of this estuary (Opobo river) should also be researched on

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