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# EFFECTS OF TIDES ON THE ZOOPLANKTON OF THE GREAT KWA RIVER, CALABAR, NIGERIA

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**ABSTRACT:** *This study investigated the tidal effects on the composition, diversity, abundance and distribution of zooplankton species in the Great Kwa river, Nigeria. Zooplankton samples were collected fortnightly between July 2019 and September 2019 at low, mid and high tidal regimes. A total of 59 zooplankton species belonging to 41 taxa (genera) and 16 classes groups were identified and recorded during the study. Zooplankton comprised of 199 individuals of which 49 were recorded in low tide, 95 (mid tide) and 55 (high tide). Generally, Rhizopoda (37.19%) were dominant, followed by Copepods (25.13%) while invertebrate, Lepidoptera and Malacostracan were less than 1% each. Copepods were dominant at low tide, while Rhizopoda were dominant at mid-tide and high-tide. Weiner Index (H) showed that zooplankton species was high at low tide (3.95), followed by high tide (2.95) and least in mid tide (2.22). The absence of some zooplankton species at Mid tide and High tide suggests that zooplankton species had vertically migrated downward the river before high tide and mid tide. Despite the highest number of individuals recorded at mid-tide, an evenness value of 0.49 compared to 0.74 (high-tide) and 0.85 (low-tide), suggests that the numerical abundance was less evenly distributed among species.*

**KEYWORDS**: Tides, Zooplankton, Species, Great Kwa River, Sampling Station

## INTRODUCTION

Plankton constitutes the most important component of the food chain in every water body. They do not only provide food for higher trophic levels, but produce oxygen, cycle nutrients and process pollutants (Suthers et al., 2019). Plankton may also serve as bioindicators to monitor the water environment for pollution and monitoring fish population dynamics. (Nwankwo, 2004). Zooplankton are animal-like. They include many kinds of protozoa, micro-crustaceans and other microinvertebrates that are planktonic in water bodies (Omudu and Odeh, 2006). Some eggs and larval stages of some animals also constitute the zooplankton. Zooplankton play important roles in the transfer of energy from producers to carnivores. They serve as food for carnivorous and omnivorous fish (Thurman, 1997; Adeyemi et al., 2009). Natural factors such as current variations, tides and man-made factors such as river dams strongly affect zooplankton abundance, which can



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in turn strongly affect fish larval survival (Abo-Taleb, 2019). Tides are changes in sea levels caused by gravitational interactions between the sun, moon, and earth (Hicks, 2006). They are responsible for obvious mid-term (spring-neap cycles) and short-term (low-high water cycles) variations in the abiotic and biotic characteristics of these systems (Villate, 1997). Tidal activity influences the nutrient concentration, salinity, and suspended particulate matter of an estuary or water body (Montani *et al*. 1998; Davies and Ugwumba 2013). Several studies have been documented on the zooplankton diversity and ecology in the Great Kwa River and other similar water bodies in Nigeria (Ajah, 2002; Ekwu and Sikoki, 2005; Offem et al., 2009; Ikomi and Anyanwu, 2010; Eyo et al., 2013). However, there is no report on the tidal influence of zooplankton diversity in the Great Kwa River. Therefore, this study is aimed at investigating the tidal effects on the composition, diversity, abundance and distribution of zooplankton species in the Great Kwa River, Nigeria.

## MATERIALS AND METHODS

### Study Area

The Great Kwa River is one of the major tributaries of the Cross River Estuary. It is located around latitudes 4°45'N and longitudes 8°20'E (Akpan, 2000). The river takes its raise from the Oban Hills of South-Eastern Nigeria and meanders Southwards through an estimated 30km of thick forest before discharging into the Cross River estuary near Calabar, South-South Nigeria. The lower Great Kwa River is characterized by semi-diurnal tides and extensive mud flats. (Moses, 1979).

The climate of the study area is defined by fairly distinct wet and dry seasons. The dry season spans November to March, or sometimes April and the wet season between June and October. A short dry period known as August break occurs in August. There is usually a cold dry and dusty period between December and January, referred to as harmattan season. According to Ama-Abasi *et al*., (2004) and Akpan and Ofem (1993), temperatures generally range from 22°C in wet seasons to 35°C in the dry seasons. Relative humidity is generally above 60% at all seasons, with close to 90% during wet season (Ama-Abasi *et al*., 2004).

### Sampling Station

The study was conducted at Obufa Esuk (Fig. 1) along the Great Kwa River.



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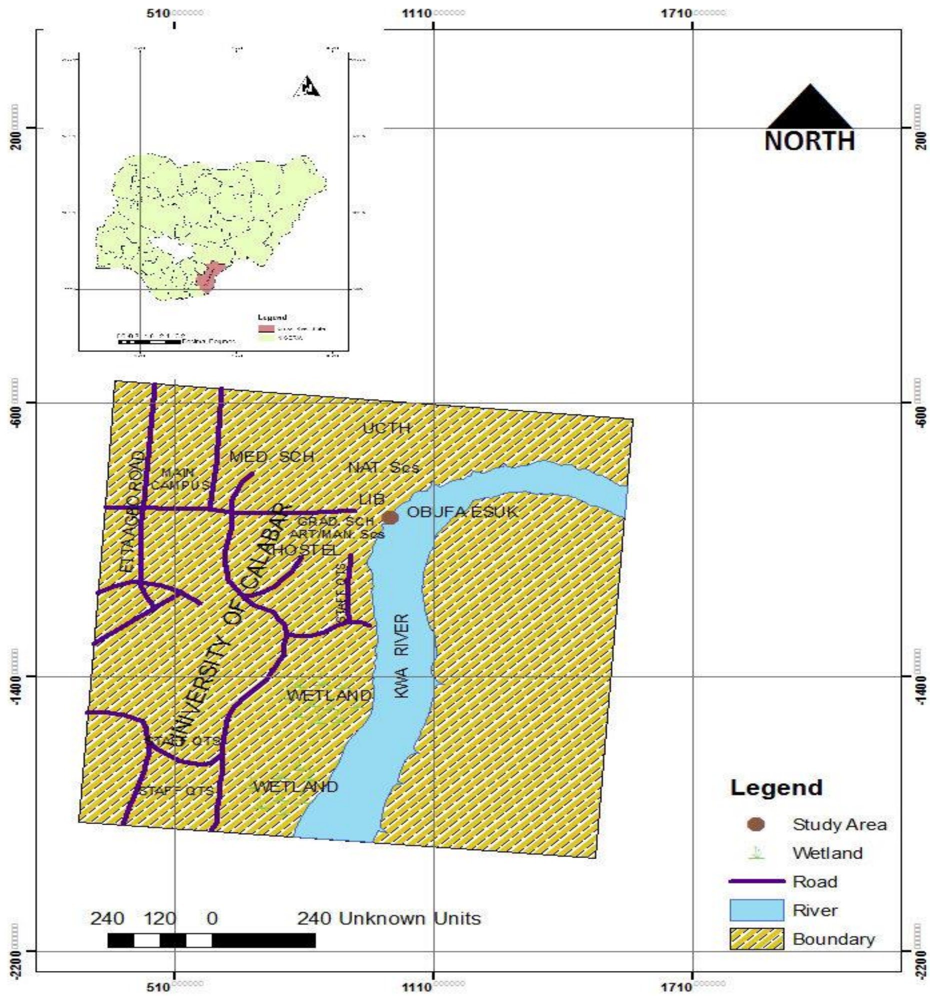


**Fig. 1 Map showing the study area**

## Samples Collection and Analyses

Water samples were collected between July and September 2019 at different tidal regimes (low, mid and high tides) using 10 litres plastic container. The water was filtered through a plankton net of 55µm pore size or mesh size according to the methods of Boyd (1981). The filtrate was transferred into a 20ml properly labelled sterile plastic container with a screw cap and fixed in 4% formalin and transported to the laboratory for analysis. The filtered plankton was taken to the laboratory for plankton count using Sedge-wick Rafter (Model: Ajah 001). The analysed



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zooplankton was thereafter, classified taxonomically using standard schemes and guides of Newell and Newell (1977) and Waife and Frid (2001). Identification was done to the nearest taxon possible.

## ECOLOGICAL DIVERSITY INDICES

Ecological diversity indices evaluated in this study include Shannon weiner index, Simpson's index of diversity, Margalef's index and Eveness. They were analysed using PAST (version 3) and also calculated according to formulas given by Ogbeigbu (2005) as follows:

### Margalef's index (d)

This index is dependent on sample size (Margalef, 1965; Ogbeigbu, 2005). It is based on the relationship "S" and the total number of individuals observed (N) (Job et al., 2017), and is generally known to increase with increase in sample size (Ogbeigbu, 2005). The index is given by the formula:

$$d = \frac{s-1}{\ln N}$$

(Ogbeigbu, 2005; Eyo, *et al*., 2013 and Job, *et al.*, 2017).

Where: S= total number of species

N = total number of individual samples and

ln = the natural logarithm ($Log_e$).

### Shannon-Wiener index (H)

This is sensitive to the number of species present and how evenly the individuals are distributed in the sample (Ogbeigbu, 2005 and Shannon-Wiener, 1949), and is given by the formula:

$$H = \frac{N \log N - f \log fi}{N}$$

Where N = total number of all individuals in the sample

fi = total number of individual species or group of species.



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**Evenness index (E)**

Evenness of the zooplankton was determined by dividing the number obtained from Shannon-Weiner index (H), by the maximum possible value of H (i.e $H_{max}$) (if every species was equal) using the formula:

$$E = \frac{H}{H_{max}}$$ (Pielou, 1966, 1984 and Ogbeigbu, 2005).

**Simpson's Dominance index (D)**

Simpson's dominance index was determined using the formula:

$$D = \frac{ni(ni-1)}{Ni\ (Ni-1)}$$ (Ogbeibgu, 2005)

Where ni = the number of individual species

Ni = the total number of all species from each group or family.

## RESULT AND DISCUSSION

The overall zooplankton composition, distribution, abundance and frequency of occurrence in the different tidal intervals are shown in Table 1. A total of fifty-nine (59) species and forty-one (41) taxa (genera) of zooplankton belonging to sixteen classes groups were recorded during the study. They included Copepoda (11 species, 9 taxa), Rhizopoda (8 species, 5 taxa), (Rotifera (7 species, 6 taxa), Cladoceran (6 species, 5 taxa etc), Protozoa (5 species), Actinopoda, Nemata and Ostracoda (4 species), Coleoptera, Echinodermata, Ephemeroptera, Invertebrata, Lepidoptera and Malacostraca (1 species) and 2 unidentified species. The total of 59 species of Zooplankton is higher than the 44 species recorded by Eyo *et al*., (2013) and 23 species of zooplankton recorded by Antai and Joseph, (2015).

A summary of the relative percentage composition of the major taxonomic groups to the overall zooplankton population at the different tidal intervals (Fig. 2) revealed that the study area was dominated Rhizopoda (37.19%) and Copepods (25.13%). This is contrary to Ajah (2002), who found Ciliata as the dominant group of zooplankton in the Great Kwa River.

Number of species was highest at low tide with 33 species, followed by high tide, 26 species. The least was recorded at Mid-tide with a total number of 22 species. Density of zooplankton species, however, is highest at Mid-Tide with 95 ind/ml, followed by High-Tide with 55 individuals/ml and 49 ind/ml at Low-Tide. Compared to other waters in the South-South geopolitical area, the zooplankton density observed in this study was relatively low (Akpan and Ofem, 1993; Ekwu and Sikoki, 2006). This is probably due to the general perturbation of the area which prevents build-


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up of zooplankton biomass and anthropogenic activities such as fishing, swimming and Sand mining carried out in the area of study.

As shown in Fig. 3, The most dominant groups at Low tide were Copepoda (21.21%) mostly represented by *Mircocyclops varicans* and Rhizopoda (18.18%) mostly represented by *Centropyxis sp*. Other sub-dominant groups were Actinopoda (9.09%), Ostracoda (9.09%), Rotifera (9.09%), Nemata (6.06%), and Protozoa (6.06%). Cladoceran, Coleoptera, Ephemeroptera, Invertebrata, Lepidoptera, Malacostracan and Polychaeta were the rare groups, each recording a relative percentage composition of 3.03%.

At mid tide, Rhizopoda (46.32%) and Copepoda (30.53%) were the most dominant groups of zooplankton. Other groups observed during this tidal interval include; Actinopoda, Cladoceran, Ephemeroptera, Nemata, Protozoa, and Rotifera.

Rhizopoda, mostly represented by *Paraquadrula irregularis*, was the most dominant zooplankton group at High tide with a relative percentage composition of 34.55%. Copepoda (16.36%), Cladoceran (10.91%), Protozoa (10.91%), Nemata (9.09%), an unidentified group (7.27%) and Rotifera (3.64%) were the sub-dominant groups of zooplankton observed at this tidal interval. Actinopoda, Echinodermata, Ostracoda, and Polychaeta were the rare groups, each recording a relative percentage composition of 1.82%.

The indices of diversity; Shannon Weiner (H), evenness (E) and dominance calculated for the three stations are presented in Table 2. Shannon Weiner index was observed to be higher at Low-tide and High-tide than Mid-tide, with values ranging between 2.22 and 3.95. Despite the highest number of individuals being recorded at Mid-Tide, an evenness value of 0.49 compared to 0.74 at High-Tide and 0.85 at Low-tide, suggested that the numerical abundance was less evenly distributed among species.

Tidal cycles were observed to affect zooplankton density, species diversity indices, composition (species richness) and distribution. Tides induce flow and transport of sediments, animals, plants, other organisms and suspended particles at high tides and leave the sediments and suspended particles behind but the biota go with the ebbing tide back to the sea (Blondeaux and Vittori, 2005; SlideShare Inc., 2009).

The tidal variations of the zooplankton abundance observed in this study may be indicative of varying nutrients concentrations. The low species diversity values might be associated with environmental stress. Dominance of copepods in terms of abundance and species composition indicates pollution (Krumme and Liang, 2004). This shows that copepods are resilent to the increased anthropogenic input and high turbidity.

High light intensity or transparency at low tide leads to high primary productivity and this might indicate that these zooplankters feed on microphytoplankton (Davies and Ugwumba 2013). The absence of some zooplankton species at Mid tide and High tide suggests that zooplankton species had vertically migrated downward the river before high tide and mid tide. This vertical migration of species is a behaviour common to all plankton. It can be influenced by a number of factors including food abundance and availability, predators and other environmental factors such as light, tide, salinity and temperature (Avent et al., 1998).

## CONCLUSION:

Tides affect the density, species diversity, composition (species richness) and distribution of zooplankton in the Great Kwa River. Rhizopoda and Copepoda were the most dominant groups of zooplankton observed in the study. Copepods were dominant at Low tide, while Rhizopods were most abundant at mid-tide and high-tide. This study provides useful information on the composition and ecology of species in relation to tides in the Great Kwa River, which could be used to monitor water quality and best periods for fishing.

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**Table 1: The Overall Composition, Distribution and Abundance of Zooplankton in the Great Kwa River**

| Species Composition | Low Tide | Mid Tide | High Tide |
|---|---|---|---|
| **ACTINOPODA** | | | |
| *Euglypha tuberculate* | 2 | 2 | - |
| *Heterophrys myriopoda* | 1 | - | - |
| *Phromis sp* | - | - | - |
| *Placosida spinose* | - | 2 | - |
| **CLADOCERAN** | - | - | - |
| *Alona intermedia* | - | - | - |
| *Alonella excigua* | - | - | - |
| *Chydorus ovalis* | - | - | 3 |
| *Chydorus sphaericus* | - | 2 | - |
| *Daphnia lacustris* | - | - | 1 |
| *Dunhevedia serata* | - | - | 1 |
| **COLEOPTERA** | | | |
| *Promoerescia sp* | 2 | - | - |
| **COPEPODA** | | | |
| *Bryocamptus besteinii* | 1 | 20 | 2 |
| *Calanoids sp* | 1 | - | - |
| *Copepod Nauplius* | - | - | - |
| *Diaptomus augustensis* | - | - | - |
| *Enhydrosoma uniaticulatus* | 1 | - | - |
| *Ergasilus centridadum* | | 1 | - |
| *Microcyclops varicans* | 6 | 7 | 5 |
| *Phalacrocera sp* | - | 1 | - |
| *Thermocyclops kamaruwai* | - | | 1 |
| *Thermocyclops sp* | 1 | - | - |
| *Tropocyclops longabdominal* | 1 | - | - |
| **ECHINODERMATA** | | | |
| *Echinodea sp* | - | 2 | 1 |
| **EPHEMEROPTERA** | | | |
| *Ephonon sp* | 1 | 2 | - |
| **INVERTEBRATA** | | | |
| *Hydrochnid sp* | 1 | - | - |

| | | | |
|---|---|---|---|
| **LEPIDOPTERA** | | | |
| Unidentified | 1 | - | - |
| **MALACOSTRACAN** | | | |
| *Gramarus sp* | 1 | - | - |
| **NEMATA** | | | |
| *Anaplectus granoluscus* | 1 | 1 | - |
| *Anonchlus monlystera* | 1 | - | 3 |
| *Prismatolaimus stenurus* | - | - | 1 |
| *Trilobus longus* | - | - | 1 |
| **OSTRACODA** | | | |
| *Candona sp* | - | 1 | - |
| *Candonocypris serata* | ***3*** | - | - |
| *Ostracod sp* | ***1*** | - | - |
| *Physiocypria inflate* | ***3*** | 4 | 1 |
| **POLYCHAETA** | | | |
| *Glycerid larva* | 1 | - | - |
| *Polychaeta sp* | - | | 1 |
| **PROTOZOA** | | | |
| *Arcella radiates* | - | - | 2 |
| *Paramecium caudatum* | 1 | - | - |
| *Stentor polymorphis* | - | - | 1 |
| *Strombidinopsis sp* | | - | 3 |
| *Tintinnopsis sinensis* | 1 | - | - |
| **RHIZOPODA** | | | |
| *Arcella vulgaris* | 1 | 5 | 2 |
| *Centropyxis aculleata* | 1 | - | 1 |
| *Centropyxis arcelloides* | 3 | 3 | 7 |
| *Centropyxis ecormis* | 3 | - | - |
| *Difflugia lebes* | - | 1 | - |
| *Paraquadrulla irregularis* | 2 | 35 | 8 |
| *Penarduchlamys arcelloides* | 1 | - | - |
| *Phrygenella sp* | | - | 1 |
| **ROTIFERA** | | | |
| *Asplanchna priodonta* | 1 | 1 | - |
| *Brachionus quadridentata* | - | - | 1 |
| *Lecane luna* | - | 1 | - |
| *Lecane ohiensis* | 1 | - | - |
| *Notholca sp* | 1 | - | - |
| *Platyias quadricormis* | | | 1 |
| *Scaridium longicaudum* | - | 1 | - |


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| | | | |
|---|---|---|---|
| **OTHER** | | | |
| *Heptagenia sp* | - | - | 4 |
| *Similium larva* | - | 1 | - |
| **Total No. of Organisms** | **49** | **95** | **55** |
| **Total No. of Species** | **33** | **22** | **26** |