# ZOOPLANKTON COMMUNITY STRUCTURE AND SEASONAL VARIATION IN A TROPICAL LAKE IN NIGERIA

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**Abstract**

Bosso lake was constructed primarily for the Niger River basin municipal supply of drinking water and for other domestic use. Zooplankton of Bosso lake , Bosso, Nigeria were investigated monthly between September, 2015 and February, 2016 to determine zooplankton abundance and distribution, seasonal variation, as well as providing a baseline data for monitoring water quality changes prompted by human induced factors. Water samples were collected from three accessible stations of the dam for analyses of Zooplanton. Canonical Correspondence Analysis (CCA) were used to evaluate relationships between Zooplankton community and environmental variables with PAST. Findings on the Zooplankton of Bosso lake revealed that, Zooplanton was dominated by Rotifer species. The Rotifer families, Lecanidae and Brachionidae recorded highest number (3 each) followed by Filinidae and Notommetinae (2 each). *Brachionus falcatus* was the dominant Rotifer during the study period. In general, the Zooplankton was higher during the rainy season (September to November 2015) and lower during the dry season (December, 2015 to February, 2016). The physico-chemical parameters Phosphate, Nitrate, DO, BOD and Chlorophyll-*a* accounted for 31.27% of variation in the Zooplankton community assemblage using the Canonical Correspondence Analysis (CCA).

**Keywords**: Zooplankton, Seasonal variation, community, Multivariate and Bosso lake.

## Introduction

Lake and reservoirs are valuable natural resources that also possess tremendous economic value. They provide enjoyment as well as many beneficial uses such as flood control, recreation, aquatic life support, domestic water supply, irrigation and industrial water sources (Kansas Department of Health and Environment, 2011). Monitoring of a freshwater water bodies (i.e. sampling and analyzing water, sediments and biota) help to generate information on species richness in the ecosystem, as well as information on the health of the water body being studied (Ajuzie,2012). Healthy aquatic ecosystems are dependent on the abiotic properties of water and the biological diversity of the ecosystem (Mohammed *et al*, 2016).

Zooplankton are minute aquatic organisms that are non-motile or are very weak swimmers and they drift in water columns of ocean, sea or freshwater bodies and move great distance. They are heterotrophic in nature and play important role in food web by linking the primary producers and higher trophic levels. The freshwater Zooplankton comprise of Protozoa, Rotifers, Cladocerans, Copepods and Ostracodes (Sharma and Singh, 2012).

Most reservoir and dam ecosystems in Nigeria are threatened by anthropogenic activities (Ibrahim, *et al*, 2009). Zooplankton are very sensitive to the environment they live and any alteration in the environment leads to the change in the zooplankton communities in terms of tolerance, abundance, diversity and dominance in the habitat (Ahmed, 2007).

The anthropogenic inputs from neighbouring communities such as run-offs from agricultural farms containing manures and fertilizers are the major problem that the Bosso lake is experiencing. These inputs cause serious effect to the productivity, water quality and subsequently affect the biodiversity of the dam. Evaluation of Zooplankton community structure is essential and useful as an indicator of water quality. The use of diverse methods for water quality monitoring is of importance to management of fisheries, pollution, water supply, sewage treatment reservoirs and freshwater impoundments. This is usually reflected in biotic community structure. Bosso lake was constructed primarily for domestic consumption within Bosso town and its environment. There is dearth of information on zooplankton diversity, distribution and abundance. This present investigation will be aimed at filling the information gap and contribute to the knowledge of zooplankton diversity of the lake. The need of this study is necessary and timely especially as it will provide opportunity for monitoring changes in the zooplankton composition of the lake, which will help to initiate policy for the overall management of the ecosystem health and its productivity. The aim of this study is to evaluate the seasonal variation with respect to the zooplankton community structure of Bosso lake.

## Materials and Methods

### Study Area

The study was conducted in Bosso lake, Bosso Local Government Area, Minna. The climate in Minna is tropical with annual temperature, relative humidity and rainfall of 30.2°C, 61% and 1334mm, respectively. The climate represents two distinct seasons, a rainy season (April and October) with the highest mean monthly rainfall in September and a dry season (November-March) completely devoid of rain. Bosso lake was constructed in 1945 for the Niger River basin municipal supply of drinking water and for other domestic use and is located between latitude 9°39′ 56.45″N to 9°40′ 56.67″ N and longitude 6°30′54.10″E to 6°32′21.45″E. It is surrounded by trees and shrubs; the littoral zone is open void of any hydrophytes. It is underlain by granite (Amadi and Olasehinde, 2010). The lake plays host to crocodiles and is always serene void of any human activities. There are farm lands down the slope on a level ground around the lake. Crops cultivated are *Zea mays* and *Sorgum*sp. Inorganic fertilizer such as Nitrogen, Phosphorous and Potassium popularly refered to as N.P.K are used in the farms.

### Sampling Stations

For the purpose of this study, the lake was divided into three accessible stations (Station A, B & C) surrounded with shrubs and the bank of each station had igneous rocks and a little further were silt, clay and sand. No human activity goes on there. Figure1 shows the sampling.

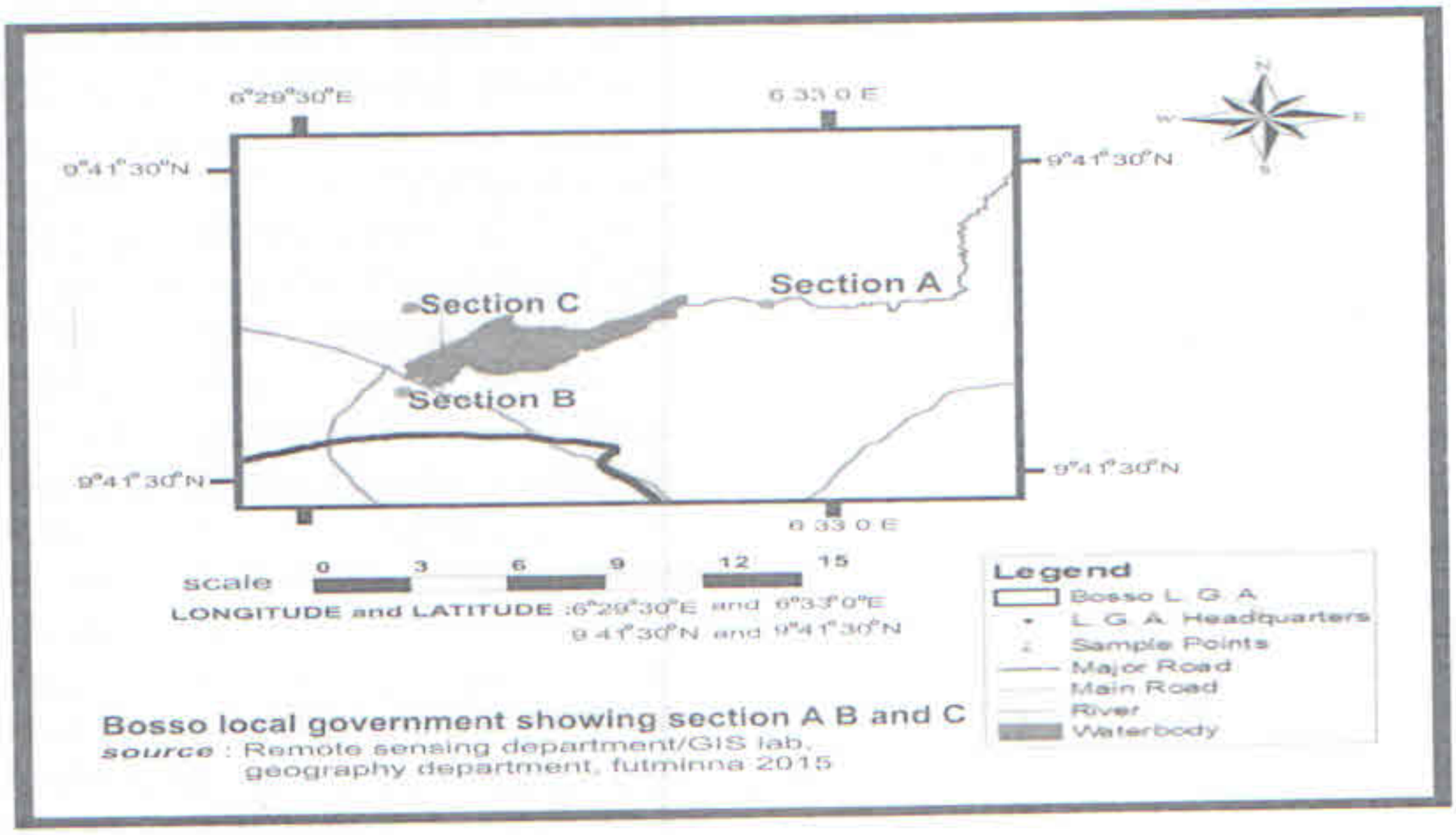


**Figure 1: Showing the Sampling Stations of Bosso Lake**

### Sampling Techniques

Monthly sampling of the three study stations was carried out from September to November 2015 for the wet season and December 2015 to February 2016 for the dry season towards the end of every month, between 9am and 11.30am every sampling day.

### Collection and Analysis of Zooplankton

Water sample of 100 litres was passed through a 30µm mesh size plankton net with a small bottle container of 30ml capacity attached to its narrow end. The sample was transferred to a 30 ml well labeled sample bottle with a cork and was preserved in 10% formalin. Five (5) ml of the samples was investigated for zooplankton. The samples were homogenized by inverting the container few times. With a dropper pipette, zooplankton subsample was withdrawn from the field samples and placed on a slide and observed by direct microscope at different magnification (×40, ×100) using a wild II Binocular Microscope, since each sample drop from the dropper accounts to 0.5ml, the results on abundance and occurrence were multiplied accordingly to give the values as number of organisms per ml. Organism per litre was calculated from the following relationship as described by Ovie (1993).

$$\text{Organism per litre} = \frac{\text{organism per ml of concentration} \times 1000}{\text{Litres of filtered concentration}}$$

Keys provided by Needhem & Needhem (1975); Shiel (1995) and Witty, (2004) were used for species identification.

### Data Analysis

Canonical correspondence analysis (CCA) was used to evaluate relationships between Zooplankton communities and environmental variables with PAST. Taxa richness (Margalef and Menhinick indices), diversity

(Shannon, and Simpson dominance indices), evenness indices and Hutcheson T-test for inter-site comparison were calculated using the computer BASIC programme SP DIVERS (Ludwig and Reynolds, 1988).

## Result

### Composition, Distribution and Abundance of zooplankton in Bosso dam

The composition and seasonal occurrence of Zooplankton recorded in the various stations during the period of the study is shown in Table 1. Quantitatively, the fauna of each station was dominated by Rotifers followed by Cladocerans and Copepods in that order (Rotifers>Cladocerans>Copepods>Calanoid) . A combined total of 10 families were encountered. The Rotifer fauna consisted of 12 species belonging to the family Trochosphaeridae, Filiniidae, Brachionidae, Lecanidae, Notommatinae and Synchaetidae. Station B had more representative taxa (9) in terms of diversity and abundance than Station A and Station C. The Zooplankton community was restricted to the Plioma rotifers consisting of the following families, Filiniidae, Brachionidae, Lacanidae, Notommatinae and Synchaetidae, the Cladoceran, *Moina micrura*, the Cyclopeds, Cyclopoid nauplis and the Calanoid, Nauplis calanoid. Generally, the Plioma rotifers dominated the entire Zooplankton abundance. Quantitatively, the Rotifer, *Brachionus falcatus* was the most abundant and preponderant species present in appreciable number in all the stations sampled in the study. While *Lecane* sp was another dominant rotifer encountered. The minimum values were recorded during the dry season month of December 2015, January and February 2016. While the maximum values were recorded during the months of September, October and November 2015 in the rainy season.

**Table 1: The Overall Composition, Distribution and Abundance of Zooplankton in Bosso dam.**

| ZOOPLANKTOON | | Total Taxa | No. Of ind./L | | |
|---|---|---|---|---|---|
| Protozoa | Thecamoebidae | *Thecamoeba* sp Fromentel 1874 | 0 | 0 | 23 |
| Rotifer | | | | | |
| | Trochosphaeridea | *Horealla brehmi* Donner 1949 | 64 | 22 | 0 |
| | Filiniidae | *Filinia terminalis*Plate 1886 | 0 | 44 | 0 |
| | | *Filinia* sp Bory de Saint Vincent 1824 | 0 | 46 | 42 |
| | Brachionidae | *Brachionus falcatus* Zacharias 1898 | 22 | 42 | 21 |
| | | *Brachionus* sp Pallas 1766 | 24 | 0 | 22 |
| | | *Keratella* sp Bory de Saint Vincent 1822 | 0 | 0 | 24 |
| | Lecanidae | *Lecane crenata* Harring 1913 | 21 | 0 | 0 |
| | | *Lecane* sp Nitzsch 1827 | 23 | 62 | 0 |
| | | *Lecane monostyla* Daday 1897 | 0 | 0 | 22 |
| | Notommatinae | *Cephalodella exigua* Gosse 1886 | 22 | 24 | 0 |
| | | *Cephalodella* sp Bory de St.Vincent 1826 | 0 | 22 | 0 |
| | Synchaetidae | *Polyarthera* sp Ehrenbeg | 23 | 22 | 0 |
| Copepoda | | | | | |
| Calanoida | Immature calanoida | Nauplius calanoid | 0 | 22 | 0 |
| Cyclopoida | Immature cyclopoida | Cyclopoid nauplius | 24 | 0 | 22 |
| Cladocera | Moinidae | *Moina micrura* Kurz 1875 | 0 | 0 | 45 |

**Canonical Correspondance Analysis (CCA) ordination plot for stations and environmental variables in Bosso dam**

The CCA ordination showed a good relationship between Zooplankton species distributed and measured environmental variables as shown in Figure 2. The strong explanatory factors were the Phosphate and Nitrate. Phosphate and Nitrate were strongly negatively correlated with DO, Chlorophyll-*a* and BOD. There was a weak correlation between BOD and DO same also for Phosphate and DO. *Brachionus* sp, *Filinia* sp, *Filinia terminalis*, *Lecane crenata* were common with the station with low Phosphate and Nitrate value. 31.27% of the CCA was described by axis 1, 22.22% was described by axis 2 while 17.5% was described by axis 3 as showed in Table 2.

**Spatial and Temporal distribution and abundance of Zooplankton**

The spatial distribution of different species of zooplankton is shown in Figure 3. The study recorded 732 zooplankton made up of 3 taxa, 8 genera and 13 species. They include Rotifer (12 species), Copepod (1 each of Nauplius calanoid and Cyclopiod nauplius) and Cladocera (1 species) in the order of dominance: Rotifer> Copepod> Cladocera. Rotifer were the most abundant group consisting of a total number of 619 individuals while copepods were the second most abundant with a total of 68 individuals. Cladocera was the least abundant recording a total of 45 individuals.

Station A, had a total of 8 species of zooplankton with 223 individuals. The species *Horealla brehmi* was the highest occurring species recording 64 individuals while *Lecane crenata* was the least. Seven species *Filinia terminalis*, *Filinia* sp, *Keratella* sp, *Lecane monostyla*, *Cephalodella* sp, Nauplius calanoid and *Moina micrura*were absent.

Station B, had a total number of 9 species with 306 individuals. *Lecane* sp was the highest occurring species recording 62 individuals while *Horealla brehmi*, *Cephalodella* sp, *Polyarthera* sp, Nauplius calanoid were the least recording 22 individual each. Six species *Brachionus* sp,*Keratella* sp, *Lecane crenata*, *Lecane monostyla*, Cyclopoid nauplius and *Moina micrura* were absent. Station C, had a total number of 7 species with 198 number of individuals.*Moina micruca* was the highest occurring species recording 45 individuals while *Brachionus falcatus* was the least recording 21 individuals. Eight species *Horealla brehmi*, *Filinia terminalis*, *Lecane crenata*, *Lecane* sp, *Cephalodella exigua*, *Cephalodella* sp, *Polyarthera* sp, Nauplius calanoid were absent.

Furthermore, the temporal variation of the temporal distribution and abundance of zooplankton is shown in Figure 4. The highest abundance of zooplankton was recorded in station B in the month of October 2015 and September 2015. Also, the least abundant (ind/L) was recorded in station A in October 2015. In January 2016, there was an absence of zooplankton.

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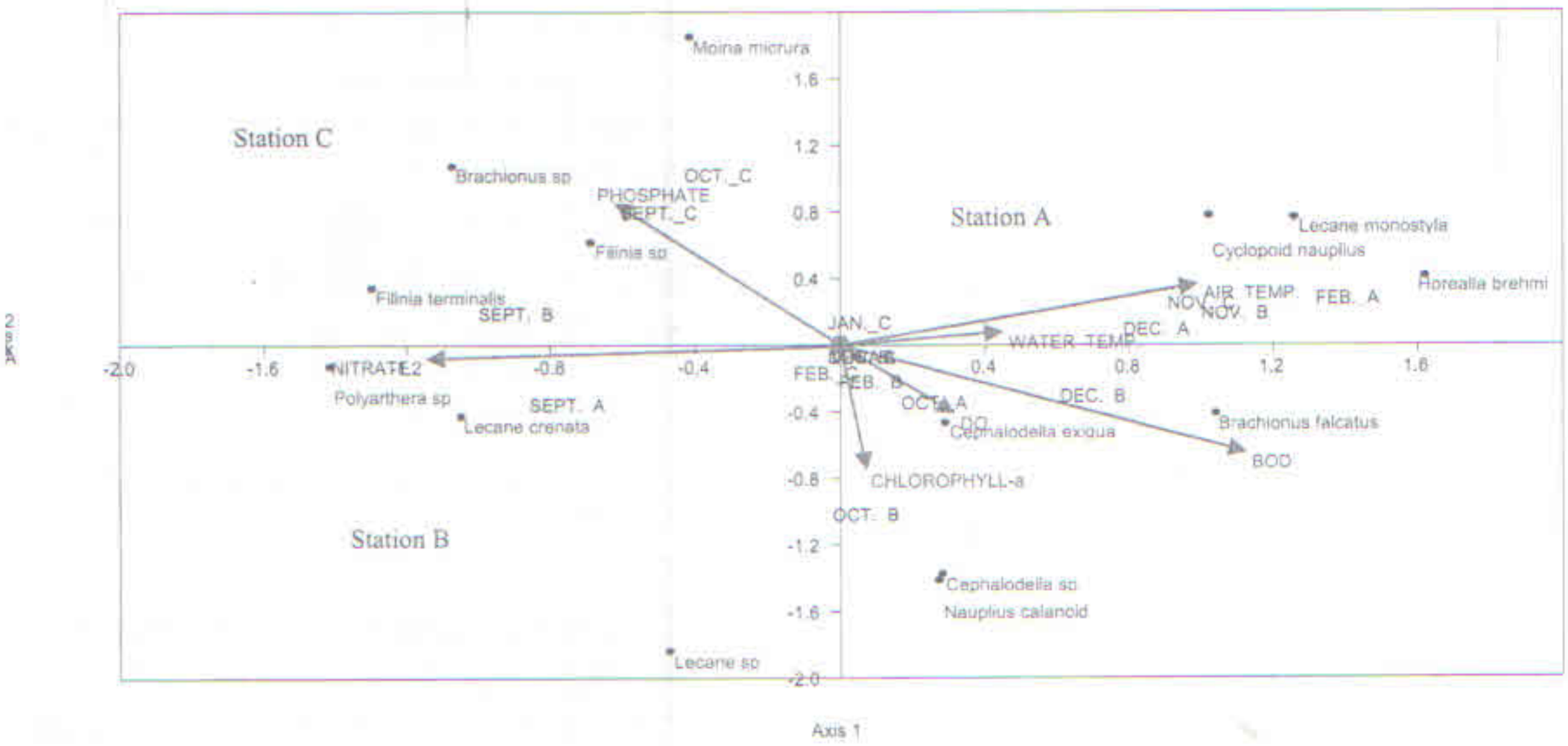


**Figure 2: Canonical Correspondence Analyses for the Zooplankton species among the sampling stations of Bosso dam from Sep 2015-Feb 2016**

**Table 2 Weighted intraset correlations of eigenvalue parameters with the axes of CCA.**

| | Axis 1 | Axis 2 | Axis 3 |
|---|---|---|---|
| Eigenvalue | 0.40073 | 0.28473 | 0.22435 |
| % percentage explained | 31.27 | 22.22 | 17.5 |
| Eigenvalue | 0.4007 | 0.2847 | 0.2244 |
| P | 0.6634 | 0.7525 | 0.6535 |
| AIR_TEMP._ | **0.496412** | 0.182863 | -0.201203 |
| WATER_TEMP. | 0.22572 | 0.0390358 | 0.140888 |
| DO | 0.159297 | -0.206969 | -0.101297 |
| BOD | **0.564402** | -0.323832 | -0.267103 |
| NITRATE | **-0.710592** | -0.0351549 | -0.0868805 |
| PHOSPHATE | -0.339901 | **0.479475** | -0.138586 |
| CHLOROPHYLL-a | 0.0366741 | -0.378685 | **-0.497137** |

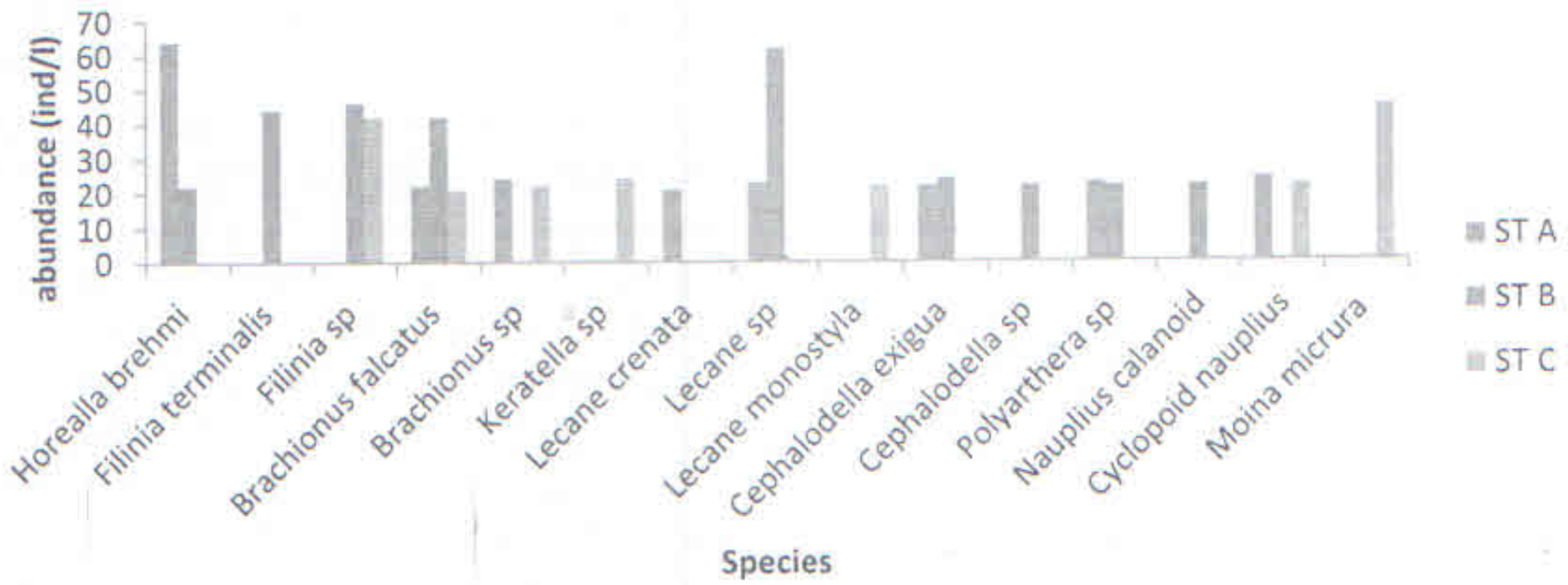


**Figure 3 Spatial variations of zooplankton species.**

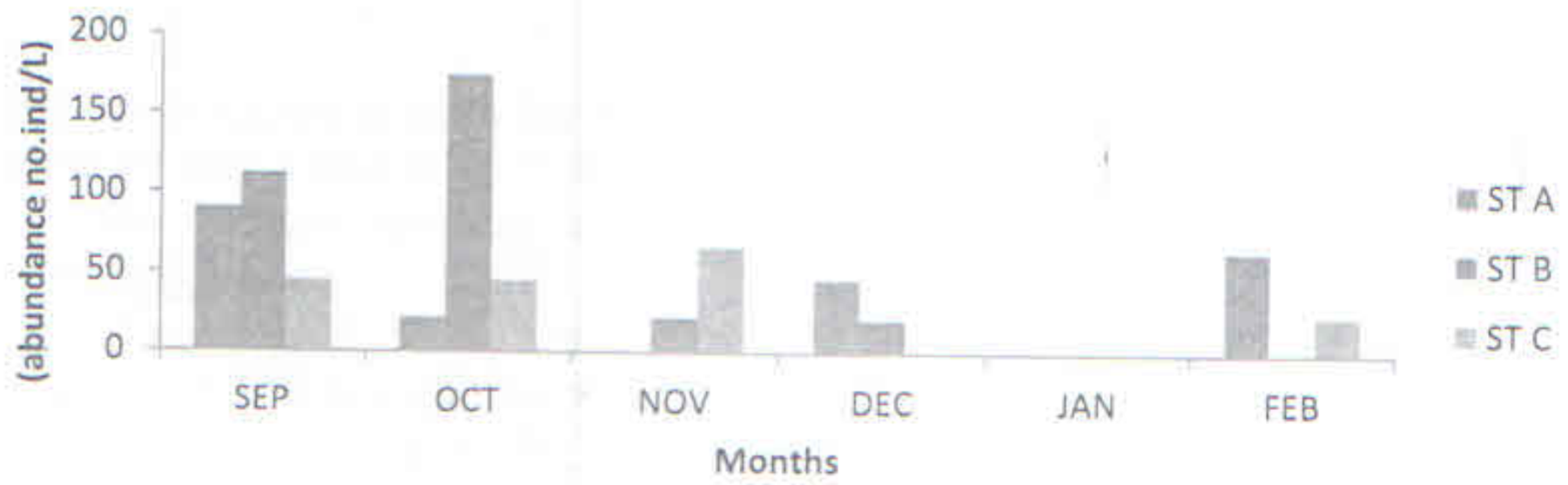


**Figure 4 Temporal variation in abundance (ind/L) of Zooplankton in the sampling stations of Bosso dam from September,2015 to February,2016.**

**Taxa Richness, Diversity, Evenness and Dominance indices.**

The summary of taxa richness, evenness and dominance indices for Zooplankton is shown in Table 3. The dominance indices was relatively high in Station C (0.1596) but low in Station A and B (0.1551 &0.13) respectively. Station B and Station A recorded high taxa richness (1.398 & 1.295) respectively. Margalef indices was low in Station C (1.135). Station B and C recorded high evenness values (0.9224 & 0.9473) respectively.

**Table 3: Taxa Richness, Diversity, Evenness, Dominance indices of Zooplankton in the sampling stations of Bosso Lake.**

| | STATION A | STATION B | STATION C |
|---|---|---|---|
| Tota number of Taxa | 8 | 9 | 7 |
| No. Of Individuals | 223 | 306 | 198 |
| Dominance_D | 0.1551 | 0.13 | 0.1596 |
| Evenness_e^H/S | 0.9109 | 0.9224 | 0.9473 |
| Margalef (Taxa richness) | 1.295 | 1.398 | 1.135 |

## DISCUSSION

**Composition, Distribution and Abundance of Zooplankton in Bosso Dam**

Most of the Zooplankton encountered in the study area appears to be normal inhabitants of natural lakes, ponds, streams and artificial impoundment in the tropics, subtropics, and Oriental regions (Ayodele and Adeniyi, 2005; Okogwu and Ugwumba, 2006; Mustapha, 2009; Arimoro and Oganah, 2010; Usman, 2015) in Mexico, Sarma *et al*., 2011 in India, Sharma and Singh, 2012; Thirupathaiah *et al*., 2012). Rotifers were the most abundant group of Zooplankton recorded in all the station. The ability of rotifers to undergo vertical migration, which minimizes competition through niche exploitation and food utilization, could probably be the reason for their dominance. The dominant status of rotifer species in the lake comparative to the cladocerans and copepods is characteristic of tropical lakes and rivers (Imoobe and Akoma, 2009; Majagi and Vijaykumar, 2009; Arimoro and Oganah, 2010; Imoobe, 2011;Sarma *et al*., 2011;Thirupathaiah *et al*., 2012; Sharma and Singh,2012; Usman, 2015).The high abundance of rotifers may be attributed to their parthenogenetic reproductive pattern and short development rates under favourable conditions in most fresh water systems (Akin-Oriola,2003), this also indicate that the dam is quite rich in nutrients. The number of Cladocera in Bosso Dam was relatively low; this may

be attributed to the absence of aquatic macrophytes, this may have accelerated the rate of predation by fish (Usman, 2015). This is however, in agreement with the findings of Arimoro and Oganah, (2010) in a perturbed tropical stream in the Niger Delta. The CCA indicated that Zooplankton organisms responded to a number of physico-chemical variables Arimoro and Oganah, (2010). The CCA also indicated that 31.27% of all the Zooplankton responded to the following physico-chemical parameters which are Water temperature, BOD, Dissolved Oxygen, Phosphate, Nitrate and Chlorophyll-*a*.

The dissolved oxygen, BOD, Nitrate and Phosphate has been found to be important in other tropical studies,(Imoobe and Akoma 2008; Ibrahim, 2009; Majagi and Vijaykumar, 2009; Arimoro and Oganah 2010; Joseph and Yamakanamardi, 2011; Sarma *et al*., 2011).

Zooplankton abundance and species number in Bosso Lake varied monthly. The high abundance of Zooplankton recorded during the rainy season (September-October 2015) was similar to previous studies reported elsewhere (Akinbuwa and Adeniyi, 2008; Arimoro and Oganah, 2010; Okogwu, 2010; Edward and Ugwumba, 2010; Imoobe, 2011; Olasehinde and Abeke, 2012; Ibrahim, 2014). This may be due to the ability of the rains to bring in nutrients from other water bodies, drainage basin and the environment that triggered off increase in primary production and consequently, Zooplankton productivity(Okogwu and Ugwumba, 2006; Edward and Ugwumba, 2010; Olasehinde and Abeke, 2012). This is however, in contrast with the findings of Ude *et al*., (2011) in Echara river Nigeria and Ogbuagu and Ayoade, (2012) in a fresh water body in Etche of Nigeria).They independently reported negative correlation between rainfall and Zooplankton abundance.

## Conclusion

Zooplankton was dominated by Rotifers indicating that the water in the dam is quite rich in nutrients and the least was Cladocera. There was also seasonal variation in the Zooplankton community structure in that the was more zooplankton present during the raining season than the dry season in Bosso lake.

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