Temporal and Spatial Variations in Abundance and Diversity of Zooplankton Fauna of Opa Reservoir, Obafemi Awolowo University, Ile-Ife, Southwest Nigeria

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Abstract

The present study investigated the ecological status of Opa reservoir, Obafemi Awolowo University, Ile Ife, Nigeria, based on the spatial and temporal variations in abundance and distribution of zooplankton. 72 samples were collected monthly with a quantitative net zooplankton from both the surface and bottom levels in three stations established at the dam site (Lacustrine), mid-lake (Transition) and inflow (Riverine) over a period of an annual cycle. A total of fifty-four (54) species were recorded from the reservoir comprising Rotifera (57.41%) > Arthropoda (33.33%) > Protozoa (5.56%) > Ciliophora (1.85%) = Cnidaria (1.85%), in the order of abundance. The least number of species (47) was recorded at the Transition station, while the highest number of species (49) occurred at the Lacustrine zone. Of all the zooplankton recorded, four species had significant spatial variation, while nine display seasonal variations during the study period (p ≤ 0.05). The highest species richness was observed in Transition surface station (4.18), followed by Lacustrine surface station (3.80) and Riverine surface station (3.23). Shannon’s index showed that zooplankton species were more diverse during the rainy season than dry season. The highest Trophic State Index (TSI_{CR}) with respect to Rotifer abundance occurred in Transition surface, followed by Riverine surface and the least occurred in Transition bottom portion. The mean TSI_{CR} value obtained was 65.20, indicative of hyper-eutrophic, while the mean TSI_{CL} value with respect to cyclopoid-calanoida obtained was 58.07 also revealing eutrophic status of the study area. Opa reservoir comprises mainly Rotifers and its TSI_{CR} showed the lake as eutrophic, tending towards becoming hyper-eutrophic, which could speed up the aging of the lake.

Keywords: Opa reservoir occurrence; spatial variation; species richness; temporal variation zones; trophic state index

Introduction

Zooplankton are passive drifters, moving with water currents, yet well adapted for their mode of life, hence can withstand diverse levels of environmental changes in physicochemical water quality, thereby useful for measuring the status of their environment (Paterson, 2001; Imoobe, 2011; Akindele and Adeniyi, 2013). Zooplankton also serve to link up the lower trophic level comprising of phytoplankton which are primary producers to the macroinvertebrates and fishes, which occupy a higher trophic level of the ecosystem (Akindele and Adeniyi, 2013). The zooplankton assemblage often influences energy flow through classical food chain, nutrient cycling and community population dynamics within a reservoir ecosystem. This ecological niche has made them key actors in top down grazing effect (trophic cascade) on the bottom up forces which play pivotal roles in bio-manipulation for lake restoration purposes as reported by Carpenter and Kitchell (1993). Despite this enormous role played by zooplankton in waterbodies, their distribution has been reported to be affected by factors such as the hydrologic regime of the waterbody (Casanova and Henry, 2004), physical and chemical variables (Sarkar and Chaudhary, 1999; Arimoro and Oganah, 2010), drainage density, sinuosity ratio and stream frequency (Akindele and Adeniyi, 2013), hydrological characteristics (Mitsch and Gosselink, 2000), according to Adedeji et al. (2011), their occurrence was found to be directly related to the concentration of the nutrient in the waterbody. Plankton is equally susceptible to a wide range of environmental factors such as water physicochemical properties comprising of temperature, light, pH range, oxygen, salinity and toxic contaminants (Paterson, 2001).
Adesakin et al. (2017) reported direct discharge of untreated municipal/industrial waste, as well as run off from agricultural areas into Opa reservoir, whose effect on the reservoir’s physicochemical parameters was significant both temporally and spatially; this could pose a level of risk to the inhabiting aquatic ecosystem. The last record of plankton research carried out on the reservoir, about eighteen years ago (Akinbua and Adeniyi, 1991), noted Rotifers only. The present study, therefore, attempts to evaluate the distribution of zooplankton fauna in Opa reservoir through an annual cycle with a view to determine the effects of the recent dredging of the inflowing River Opa and other smaller streams within the catchment basin. The study would also reveal the present ecological and trophic status of the reservoir.

Materials and Methods

Study area

Opa reservoir is sited between latitude 07030’N to 07031’N and longitude 004031’40”E to 004 032’45”E, within the Obafemi Awolowo University community, Ile-Ife, Southwestern Nigeria (Fawole and Arawomo, 2000). The artificial lake was built on the Opa River within the University community in 1978 (Fig. 1) and the project was eventually completed and commissioned in 1979 (Akinbua and Adeniyi, 1991). Opa reservoir has a catchment area covering parts of Ile central, Ile East and Atakumosa West Local Government Areas of Osun state, Nigeria. Opa reservoir is one of the African tropical reservoirs, small and shallow, a knowledge of which can be of benefit to the management of the reservoir in meeting its primary need of water supply and secondarily, as a source of fisheries.

Water sampling

Three sampling stations were established as follows: location A for Lacustrine portion, close to the dam wall; location B at the midlake (Transition) and location C for the Riverine portion, towards the inflow of the lake. The coordinates and depths of the three sampling stations as well as their respective depths can be found in Table 1.

Water sampling was done between November 2012 and October 2013 covering a period of one year for the zooplankton analysis. Water was collected with an improvised water sampler of 2.5 L capacity used to take bottom water samples and then 20 L of water were sieved through a plankton net of 50 μm mesh size and then strained into a universal bottle of about 30 ml and preserved with both Lugol solution and few drops of 5% formalin before being taken to the laboratory for analysis. In the laboratory, a plankton chamber of about 1.5 ml capacity was filled with the preserved water sample to be viewed under the microscope using an Omax binocular light compound photo-microscope (Model Number: G013050830). Scaled pictures were taken and measurements of identified plankton were also recorded.

Identification of planktonic species was later done based on standard identification guides and keys prepared by Jeje and Fernando (1986), Fernando (2002).

Estimation of plankton abundance and trophic status

On each of the concentrate taken on the plankton chamber, a count was made so as to estimate the planktonic population abundance with respect to the volume of the subsample and to the original volume of water filtered with plankton net. The results were then expressed in organisms per cubic metre of the original water sample (Goswami, 2004):

\[ A = \frac{a}{b} \times 1000 \]

where:

- A – Abundance of species per litre of original water source;
- a – Abundance of species in the subsample;
- b – Total concentrate volume of water used (1.5 ml);
- c – Original volume of water (20 L).

The above equation was used to estimate the abundance of zooplankton species.
In determining trophic status of a water body, few quantitative models have been developed. Duggan et al. (2001) developed a potential Rotifer bio-indicator schemes for lake trophic state using TLI (Burns and Rutherford, 1998) and traditional OECD, taken into consideration the following:

i. Indicative species of eutrophic waters

ii. Indicative species of Mesotrophic and Oligotrophic waters

iii. Number and diversity of species

iv. Mean zooplankter weight, mean Cladoceran weight, mean Rotifer weight and mean copepod weight

v. Rotifer abundance

vi. Percentage of Rotifer in total plankton abundance

vii. Ratio of abundance of large Cladocerans to abundance of all Cladocerans

viii. The ratio of Calanoids to Cyclopoids abundance

ix. Ratio of Crustacean abundance to Rotifer abundance (Haberman and Haldna, 2014).

The model proposed by Ejsmont-Karabin (2012) was used to estimate the trophic status of the reservoir:

\[ TSI_{Kr} = 5.38 \ln(N) + 19.28 \]

where N is the abundance of Rotifers in Ind/L and

\[ TSI_{Ca} = 5.08 \ln(CY/CA) + 46.6 \]

where CY is the abundance of Cyclopoida; CA is the abundance of Calanoida in Org/L, according to Ejsmont-Karabin and Karabin (2013).

For the interpretation of the results the following were considered: TSI < 45 = Mesotrophic; TSI (45 – 55) = Meso-eutrophic; TSI (55 – 65) = Eutrophic; TSI > 65 = Hypertrophic lake.

**Qualitative analyses and statistical procedures**

The reagent bottles and other sampling bottles were washed with detergent and subsequently rinsed several times and thoroughly with tap water and distilled water before use. Other procedures were followed duly. In order to ensure good results were obtained during the course of the sampling, certain necessary precautions were taken into consideration.

Data collected were subjected to various descriptive and inferential analyses such as the means and standard deviations which revealed planktonic species abundance with respect to season and location. Analysis of Variance (ANOVA) was used to compare mean abundance of identified planktonic species while correlation was used to estimate the strength of relationship between various planktonic groups. Moreover, Principal Component Analysis (PCA) was used to reduce all interactions into components that also showed the relationship among recorded planktonic species as applicable using SPSS Version 21 software (SPSS, 2012).

### Results

A total of fifty-four (54) species of zooplankton were recorded belonging to thirty-five (35) genera, twenty-four (24) families, thirteen (13) orders, ten (10) classes and five (5) phyla of zooplankton, as summarized in Table 2 and Fig. 2. Temporally, nineteen zooplankton (19) species occurred in either of the two seasons, while thirty-nine (39) species were found in both seasons. A total of fifty-one (51) species occurred in the rainy season and forty-four (44) in the dry. Of the species recorded, the season had effect on nineteen species (19), which were recorded either during dry or rainy season only; these include a Protozoan (*Vermamoeba vermiformis*), a Ciliophora (*Favella attingata*), thirteen members of phylum Rotifer (*Asplanchna* sp. 1, *Asplanchna* sp. 2, *Argonotholca* sp. 2, *Anuraeopsis* *fissa*, *Brachionus urceus*, *Ascomorpha* sp., *Ascomorpha ecaudata*, *A. ecaudis*, *Filinia opoliensis*, *Polyarthra dolichoptera*, *Polyarthra remata*, *Trichocerca cylindrica*, *Horaella brehmi*) and four species of Arthropoda phylum (*Mesocylops* sp., *Calanus* sp., *Hesperocorixia obliqua*, *Hydrozoan actinula*) (Table 3).

Spatially, a total of 37 species were found in the three sampled stations both at the surface and bottom water (Table 3). Species that occurred specific to a station were *Vermamoeba vermiformis* and *Hydrozoan actinula* as recorded from bottom portion of Lacustrine and Riverine stations respectively. Some members of the phylum Rotifer namely *Argonotholca* sp. 2 and *Ascomorpha ecaudata* were also recorded at the bottom portion of the Riverine station only, while *Asplanchna* sp. 1, *Asplanchna* sp. 2, *Anuraeopsis fissa*, *Brachionus urceus*, *Ascomorpha* sp. were also recorded specific to Riverine, but at the surface water (Table 3). The least number of species (47) was recorded from Lacustrine zone of the reservoir (Table 3).

The highly abundant species include *Asplanchna herrickii*, *A. priodonta*, *Keratella crassa*, *Brachionus falcatus*, *Ascomorpha ovalis*, *Trichocerca flagellata*, *Discorbis* sp., *Copepod nauplii*, *Copepod larva*, *Cyclops vicinus*, *Macrocylops albidus*, *Diaphanosoma brachirum*, *Acanthocyclops* sp. and *Seneccia calanoides*.

Statistically significant seasonal difference were shown by *Trinema* sp., *Hesperocorixia obliqua* and *Favella attingata* (*p* ≤ 0.05), while *Asplanchna herrickii*, *A. priodonta*, *Brachionus falcatus*, *Trichocerca flagellata*, *T. bicristata* and *Chironomid* larvae showed highly significant differences between the two seasons (*p* ≤ 0.01) (Table 4). Recorded species that showed statistically significant difference spatially included *Trinema* sp., *Macrocylops albidus* and *Favella attingata* (*p* ≤ 0.05), while *Trichocerca flagellata* had a highly significant difference (*p* ≤ 0.01) (Table 5).

### Table 1. Grid location of selected sampling stations

| Stations     | Longitude     | Latitude     | Elevation (m) | Depth (m)  |
|--------------|---------------|--------------|---------------|------------|
| Lacustrine (A) | 07° 03.45’ E | 00° 03.45’ N | 240 ± 10      | 6.01       |
| Transition (B) | 07° 03.28’ E | 00° 03.80’ N | 245 ± 07      | 4.99       |
| Riverine (C)  | 07° 03.45’ E | 00° 03.10’ N | 252 ± 08      | 1.22       |

*Note:*, *a* highly significant difference (*p* ≤ 0.01) (Table 5).
Fig. 2. Taxonomic composition of recorded species of zooplankton taxa

Table 2. Outline classification and taxa composition of the zooplankton fauna

| Phylum      | Class | Order | Family | Genus | Species | Percentage occurrence (%) |
|-------------|-------|-------|--------|-------|---------|---------------------------|
| Protozoa    | 3     | 3     | 3      | 3     | 3       | 5.56                      |
| Cnidaria    | 1     | 1     | 1      | 1     | 1       | 1.85                      |
| Ciliophora  | 1     | 1     | 1      | 1     | 1       | 1.85                      |
| Rotifera    | 1     | 2     | 8      | 12    | 39      | 57.41                     |
| Arthropoda  | 4     | 6     | 11     | 18    | 39      | 33.33                     |
| TOTAL       | 10    | 13    | 24     | 35    | 54      | 100.00                    |

Table 3. Spatial and temporal occurrence of zooplankton and related species

| Temporal          | Lacustrine | Transition | Riverine |
|-------------------|------------|------------|----------|
|                    | Dry season | Wet season | surface  | bottom | surface  | bottom | surface  | bottom |
| Vermamoeba vermiformis |           |            |          |        |          |        |          |        |
| Trinema sp.        |           |            |          |        |          |        |          |        |
| Discorbis sp.      |           |            |          |        |          |        |          |        |
| Hydra vulgaris     |           |            |          |        |          |        |          |        |
| Favella attingata  |           |            |          |        |          |        |          |        |
| Aplanchna sp. 1    |           |            |          |        |          |        |          |        |
| Aplanchna sp. 2    |           |            |          |        |          |        |          |        |
| A. borsbicki       |           |            |          |        |          |        |          |        |
| A. praedonita      |           |            |          |        |          |        |          |        |
| Keratella crassa   |           |            |          |        |          |        |          |        |
| Keratella tropica  |           |            |          |        |          |        |          |        |
| Keratella brezi    |           |            |          |        |          |        |          |        |
| Argounotholca foliacea |         |            |          |        |          |        |          |        |
| Argeunotholca sp. 1 |          |            |          |        |          |        |          |        |
| Argeunotholca sp. 2 |          |            |          |        |          |        |          |        |
| Anuraoepis fissa   |           |            |          |        |          |        |          |        |
| Anuraoepis sp.     |           |            |          |        |          |        |          |        |
| B. falcatus        |           |            |          |        |          |        |          |        |
| B. angulatus       |           |            |          |        |          |        |          |        |
| B. calyciflorus    |           |            |          |        |          |        |          |        |
| B. quadridenticatus |           |            |          |        |          |        |          |        |
| Brachionus urceus   |           |            |          |        |          |        |          |        |
The highest species richness was observed in Transition surface station (4.18) followed by Lacustrine surface station (3.80) and Riverine surface station (3.23) (Table 6). These values were higher than the recorded species richness of their corresponding bottom stations. Such a result implies that more species were recorded in the surface portion than the bottom. Shannon index also showed a similar pattern spatially, with the highest value at Transition surface station, thus corroborating the highest number of species and abundance recorded at the Transition station of the reservoir.

Seasonally, Shannon’s index showed that the recorded zooplankton species were more diverse during the rainy season than in the dry season. The result was further confirmed by Hill’s first diversity index (N1), which revealed that 26 species were abundant in the wet season compared with 14 species in the dry season. Spatially, Hill’s diversity indices showed that 26 species (highest value) were abundant at the Transition surface portion, while 13 species (the least value) at the Lacustrine surface (Table 6).

Principal component analysis was used to check the correlation of the planktonic organisms recorded. The result of the analysis revealed twenty-one significant ($p < 0.05$) components with a cumulative variance of 84.92%. Component 1 showed a strong positive correlation for nine (9) species with variance of 10.95%. The strongest loading of 0.929 revealed positive correlation between Asplanchna sp. 2 (Sp 2) and Acanthocyclops vernalis (Sp 40), while Keratella lenzi (SP 7), Brachionus falcatus (Sp 13),Horaella brebmi (Sp 31), Trinema sp. (Sp 33), Mesocyclops sp. (Sp 38), and Scapholebris spinifera also showed strong positive correlation within Component 1. Component 2 revealed correlation between highest number of species with strong positive loading 14 different zooplankton species contributing 7.76% of the total variance.

Brachionus urceus (Sp 17) and Platyiias quadricornis (Sp 18) with strong loadings, and moderate loadings for Keratella tropica (Sp 6), Discorbis sp. (Sp 34), Copepod nauplii (Sp 35), Limnocalanus macrurus (Sp 52) and Chaoborus sp. (Sp 59) (Table 7). The highest Trophic State Index (TSI) with respect to Rotifer abundance was recorded for Transition surface station, followed by Riverine surface and the least occurred in Transition bottom portion. The mean value obtained was 65.20, which
is an indication of hyper-eutrophication process. While comparing the seasons, TSI<sub>CR</sub> value for rainy season was higher than that of the dry season (Table 8). Moreover, the mean TSI<sub>CR</sub> value of 58.07 obtained from the ratio of the abundances of Cyclopoida and Calanoida also confirmed the eutrophic status of the reservoir. When comparing the TSI<sub>CR</sub> values from the Cyclopoida-Calanoida abundance ratio in the different sampling stations, Transition bottom had the highest TSI<sub>CR</sub>, followed by the Lacustrine surface, while Lacustrine bottom has the lowest TSI<sub>CR</sub> value (Table 9).

**Discussion**

Rotifera species were the most abundant zooplankton recorded within the study, which is in agreement with various studies previously carried out on Opa reservoir (Akinbuwa and Adeniyi, 1991, 1996; Ayodele and Adeniyi, 2006; Akindele and Adeniyi, 2013), as well as data on waterbodies in other parts of Nigeria (Ibrahim, 2009; Arimoro and Oganah, 2010; Okogwu, 2010; Imoobe, 2011 and Ekpo, 2013). However, thirty-one (31) species of Rotifera recorded in the present study connote a reduction in the Rotifer composition of the reservoir as compared to sixty-one (61) species reported by Akinbuwa and Adeniyi in 1991. This is an indication of ecological changes that must have affected the reservoir’s zooplankton diversity. Akinbuwa and Adeniyi (1991) also reported that the recorded dominance and abundance of Rotifer species in Opa reservoir, during

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**Table 4. Seasonal variation of aquatic microfauna between dry and wet seasons under study**

| Organisms             | Dry season | Wet season | ANOVA |
|-----------------------|------------|------------|-------|
|                       | Min-Max (Ind/L) | Mean ± SD | Min-Max (Ind/L) | Mean ± SD | F Ratio | p    |
| *Trinema* sp.         | 150-1,500 | 707.14±451.53 | 150-450 | 321.43±124.95 | 6.035* | 0.017 |
| *Hepetocora obliqua*  | 300-2,100 | 1.087±506.98 55 | 0 | 0 | 5.839* | 0.019 |
| *Farella atingata*    | 150-750 | 450.00±24±4.95 | 0 | 0 | 4.772* | 0.033 |
| *Aplanchna herrickii* | 600-27,500 | 7.366±78.293.20 | 150-14,700 | 2.034±3.207.36 | 11.380*** | 0.001 |
| *A. priondon*         | 150-14,250 | 4.625±3.961.45 | 150-7,650 | 1.676±1.796.45 | 17.287*** | 0.000 |
| *Brachionus falcatu*  | 150-19,500 | 4.510±5.297.68 | 150-21,150 | 2.520±4.618.64 | 10.247** | 0.002 |
| *Trichocerca flagellata* | 300-4,700 | 7.565±12,934.07 | 0 | 0 | 9.058** | 0.004 |
| *Trichocerca bicristata* | 1,800-8,850 | 4.600±2.326.48 | 150-750 | 325.00±219.37 | 9.058** | 0.004 |
| *Chironomus* sp.      | 150-1,050 | 570.00±3.472.28 | 0 | 0 | 8.758** | 0.004 |

*Significant  **Highly significant

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**Table 5. Spatial variation of aquatic microfauna between the three sampling stations**

| Organisms             | Lacustrine | Transition | Riverine | ANOVA |
|-----------------------|------------|------------|----------|-------|
|                       | Mean ± SD | Mean ± SD | Mean ± SD | F-ratio | p    |
| *Protozoa*            |           |           |          |       |
| *Trinema* sp.         | 495.00±373.80 | 350.00±187.08 | 1,200.00±0 | 4.069* | 0.022 |
| *Ciliophora*          |           |           |          |       |
| *Farella atingata*    | 700.00±308.22 | 600.00±150.00 | 0 | 3.539* | 0.035 |
| *Rotifera*            |           |           |          |       |
| *Trichocerca flagellata* | 5,589.47±12,330.27 | 1,488.46±2,269.88 | 1,360.71±1,110.21 | 6.506** | 0.003 |
| *Arthropoda*          |           |           |          |       |
| *Macrocylops albidus*  | 150.00±0 | 0 | 7,607.14±8,741.18 | 3.487* | 0.037 |

*Significant  **Highly significant

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**Table 6. Diversity indices for zooplankton at various sampling stations**

| Diversity Index | Temporal | Spatial |
|-----------------|----------|---------|
|                 | Lacustrine | Transition | Riverine |
|                 | N | 1,064,950 | 1,234,450 | 303,150 | 222,900 | 666,600 | 59,100 | 608,850 | 264,750 |
| Richness Index  | R1 | 2.88 | 51.56 | 3.80 | 3.49 | 4.18 | 2.46 | 3.23 | 3.20 |
| Simpson's Index | λ | 0.12 | 0.05 | 0.15 | 0.08 | 0.05 | 0.09 | 0.13 | 0.08 |
| Hill’s 2nd diversity | N2 | 7.99 | 20.19 | 6.87 | 12.92 | 18.27 | 10.80 | 7.72 | 11.97 |
| Shannon’s index  | H’ | 2.58 | 3.24 | 2.52 | 2.93 | 3.22 | 2.69 | 2.69 | 2.81 |
| Hill’s 1st diversity | N1 | 13.23 | 25.60 | 12.38 | 18.65 | 25.13 | 14.69 | 14.72 | 16.56 |
| Evenness Index   | E4 | 0.60 | 0.79 | 0.55 | 0.69 | 0.73 | 0.73 | 0.52 | 0.72 |
| Evenness Index   | E5 | 0.57 | 0.78 | 0.52 | 0.68 | 0.72 | 0.72 | 0.49 | 0.70 |

*Significant  **Highly significant
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Table 7. Principal component analysis for the zooplankton species based on their abundance

| Components | 1    | 2    | 3    | 4    | 5    | 6    |
|------------|------|------|------|------|------|------|
| Eigen value| 6.35 | 4.5  | 4.334| 3.688| 2.997| 2.826|
| Total % variance | 10.948 | 7.758| 7.473| 6.359| 5.168| 4.872|
| Cumulative variance | 10.948 | 18.706| 26.179| 32.537| 37.705| 42.577|
| Asplanchna herrickii | 0.929*** |      |      |      |      |      |
| Asplanchna priodonta | 0.539** | 0.560* |      |      |      |      |
| Keratella tropica | 0.262* | 0.293* |      |      |      |      |
| Keratella levii | 0.918*** |      |      |      |      |      |
| Keratella sp. | 0.322* |      |      |      |      |      |
| Asplanchna folacza | 0.513** | 0.299* |      |      |      |      |
| Asplanchna sp. | 0.898*** |      |      |      |      |      |
| Brachionus falcatus | 0.273* | 0.661** | 0.301* |      |      |      |
| Brachionus angularis | 0.725*** |      |      |      |      |      |
| Brachionus ardens | 0.701*** |      |      |      |      |      |
| Platysus quadricornis | 0.635* |      |      |      |      |      |
| Ascomorpha saltans | 0.424* |      |      |      |      |      |
| Ascomorpha sp. | 0.787*** |      |      |      |      |      |
| Heterocorixa brehmi | 0.852*** |      |      |      |      |      |
| Trinema sp. | 0.663* |      |      |      |      |      |
| Polyarthra remata | 0.683** |      |      |      |      |      |
| Trichocerca flagellata | 0.787*** | 0.374* |      |      |      |      |
| Trichocerca cylindrica | 0.922*** |      |      |      |      |      |
| Mesocyclops sp. | 0.324* | 0.352* | 0.309* |      |      |      |
| Heterocorixa brehmi | 0.929*** |      |      |      |      |      |
| Acanthocyclops vernalis | 0.643** | 0.366* | 0.277* |      |      |      |
| Discorbis sp. | 0.443* | 0.448* |      |      |      |      |
| Copepod nauplii | 0.250* |      |      |      |      |      |
| Cyclodiopsis vicina | 0.284* |      |      |      |      |      |
| Mesocyclops sp. | 0.261* |      |      |      |      |      |
| Thermocyclus impusus | 0.351* | 0.768*** |      |      |      |      |
| Acanthocyclops vernalis | 0.272* |      |      |      |      |      |
| Macrocyclops albidi | 0.764*** |      |      |      |      |      |
| Lonnoosanum macrurus | 0.627** | 0.265* |      |      |      |      |
| Eukaptonus gracilis | 0.275* |      |      |      |      |      |
| Hesperocypris obscura | 0.373* | 0.318* | 0.344* |      |      |      |
| Chironomus luteus | 0.692** |      |      |      |      |      |
| Chaoborus sp. | 0.729** | 0.359* |      |      |      |      |
| Diaphanosoma brachyurum | 0.289* |      |      |      |      |      |
| Chaoborus sp. | 0.578** | 0.277* | 0.425* |      |      |      |
| Scapholeberis pinfera | 0.440* | 0.415* |      |      |      |      |
| Moina rotundata | 0.326* |      |      |      |      |      |
| Potamogeton illinoiensis | 0.669** | 0.337* |      |      |      |      |

Note: PC loadings < 0.25 are omitted
*Weak loading (0.25 – 0.50)
**Moderate loading (0.50 - 0.75)
***Strong loading (> 0.75) (Yao et al., 2014)

their study, was suggesting that the reservoir is unpolluted. However, results from the current study, especially the trophic status indices, showed the eutrophic feature of the reservoir, hence the reduction in the reservoir’s Rotifera species diversity.

The current dominance of Rotifers, as compared to other zooplankton species, could also be attributed to their tolerance to a wide range of impact that makes them adaptable to several environmental conditions such as high organic matter or nutrient loading (Arimoro and Oganah, 2010; Clark et al., 2013; Abioye, 2015). Seasonal and spatial variation in zooplankton abundance was also most
significant for phylum Rotifera, followed by Protozoa and Ciliophora which could be attributed to their ecological segregation related both to feeding behaviour and susceptibility to contaminants (Olaleye and Adeleji, 2005). Moreover, Rotifers had the highest and the lowest abundance in the Transition zone (the deeper part of the reservoir) at both the surface and bottom portion respectively. The higher abundance at the surface level might be suggestive of their feeding habit as most phytoplankton was found closer to the surface (Egborge, 1994; Burger et al., 2002; Moshood, 2002). Akinbua (1992) also linked this Rotifer’s abundance at the surface water to effect of light on their vertical distribution.

Arthropods, particularly Copepods and Cladocerans were the second most abundant zooplankton recorded in water to effect of light on their vertical distribution (1992) also linked this Rotifer’s abundance at the surface and bottom portions of the reservoir (at both the surface and bottom portion respectively). The higher abundance at the surface level might be suggestive of their feeding habit as most phytoplankton was found closer to the surface (Egborge, 1994; Burger et al., 2002; Moshood, 2002). Akinbua (1992) also linked this Rotifer’s abundance at the surface water to effect of light on their vertical distribution.

| Organism       | Dry season | Wet season | Lacustrine | Transition | Riverine |
|----------------|------------|------------|------------|------------|----------|
| Asplanchna sp. |            |            |            |            |          |
| A. borriki     | 132,600    | 50,850     | 53,550     | 29,850     | 24,150   |
| A. pristonta   | 83,250     | 46,950     | 19,650     | 29,850     | 19,050   |
| Keratella crassa| 17,400    | 85,500     | 1,650      | 20,550     | 42,450   |
| Keratella t.   | 2,100      | 91,500     | 4,500      | 600        | 70,650   |
| Keratella l.   | 13,500     | 37,950     | 3,000      | 5,550      | 4,800    |
| Argonotholca f. | 2,700     | 3,750      | 1,350      | 1,050      | 1,200    |
| Anuraeopsis f. | 300        | 900        | 300        | 900        | 0        |
| B. angularis   | 8,100      | 43,050     | 3,450      | 4,050      | 18,750   |
| B. calyciflorus| 3,450      | 7,950      | 900        | 1,200      | 7,950    |
| B. quadridens  | 4,050      | 11,550     | 600        | 2,400      | 4,800    |
| Brachionus urceus | 0        | 150        | 0          | 0          | 150      |
| Platias quadr.  | 28,650     | 16,950     | 450        | 1,950      | 36,450   |
| A. ecaudatus   | 300        | 150        | 0          | 0          | 150      |
| A. ecaudatus   | 150        | 0          | 0          | 0          | 0        |
| A. ovatus      | 32,400     | 76,800     | 7,050      | 19,950     | 40,350   |
| Filinia sp.    | 0          | 11,700     | 6,450      | 2,700      | 2,100    |
| Lecane statyac | 150        | 3,550      | 0          | 0          | 1,050    |
| Polyarthra dol. | 0         | 12,600     | 1,200      | 1,200      | 5,850    |
| Polyarthra rem. | 0         | 4,500      | 0          | 300        | 3,150    |
| Trichocerca pl. | 121,950   | 23,550     | 85,950     | 20,250     | 18,000   |
| Trichocerca cy. | 0         | 7,800      | 450        | 150        | 4,050    |
| Trichocerca bi. | 27,600    | 1,950      | 3,900      | 2,100      | 6,600    |
| Horaella breb.  | 0          | 4,950      | 450        | 0          | 3,600    |

Mean abundance (N) = 17,869.35

TSM (50) = 71.96
Table 9. Estimation of Trophic State Index using Cyclopoda and Calanoida

| Copepodida | Lacustrine | Transition | Riverine |
|------------|------------|------------|----------|
|            | surface    | bottom     | surface  | bottom  | surface  | bottom  |
| Copepod nauplii | 37,950    | 8,400     | 78,300   | 15,900  | 21,150   | 19,950  |
| Copepod larva  | 9,150     | 12,000    | 19,650   | 150     | 60,600   | 14,850  |
| Cyclops vicinus | 7,650     | 1,950     | 39,000   | 1,350   | 14,100   | 43,800  |
| Mesoocylops sp. | 0         | 0         | 19,200   | 0       | 0        | 0       |
| Thermocylops spp. | 300      | 0         | 300      | 300     | 1,650    | 0       |
| Acartia tonsa | 150       | 0         | 0        | 0       | 43,050   | 10,200  |
| Macrocylops albicus | 12,450    | 7,500     | 19,350   | 0       | 33,900   | 22,800  |
| Total abundance | 67,650    | 29,850    | 175,800  | 17,700  | 174,450  | 110,700 |
| Calanoida |            |            |          |         |          |         |
| Limnocalanus macrurus | 150    | 2,700     | 600      | 0       | 7,650    | 4,950   |
| Senecella calanoides | 1,800    | 600       | 28,800   | 300     | 2,850    | 15,600  |
| Diaptomus sp. | 600       | 2,250     | 2,400    | 0       | 300      | 0       |
| Eudiaptomus gracilis | 300      | 1,950     | 750      | 450     | 0        | 150     |
| Calanus sp. | 300       | 0         | 2,100    | 0       | 1,350    | 600     |
| Total abundance (N) | 3,150    | 7,500     | 34,650   | 750     | 12,150   | 21,300  |
| TSI_R | 62.18      | 53.62     | 54.85    | 62.13   | 54.97    |         |

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