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Effects of Nutrient Dynamics on the Abundance of Some Zooplanktons in Wasai Reservoir in Kano, Northern-Nigeria

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Abstract
The distribution, relative abundance and species diversity of some zooplanktons and the changes in nutrients composition and concentrations was studied for the period of three months in Wasai reservoir Kano, Nigeria. *Protozoa, Rotifera, Cladocera* and *Copepoda* were identified. Protozoan number was dominant over the other zooplankton group throughout the period of sampling and in all the sampling points; then followed by *Rotifera, Cladocera* and *Copepoda* was represented by few species. Total individuals of *Rotifera* and *Cladocera* observed were 236 and one hundred and thirty six respectively. Highest and least occurred *Rotifera Cladocera* and *Rotifera* were observed have 79 species and twenty-nine, while *Cladocera* has fifty and twenty species respectively. The reservoir was within small range of pH 7.8 to 8.5 of mild alkaline condition, PH values decrease from the sampling point I down the sampling point V. Surface water temperature variations recorded was minimal. Maximum temperature observed was 23℃, and the least was 16℃. These slight variations resulted in a weak relationship (r =0.398) with zooplankton Physical parameters (e.g. transparency) in this research work was fairly uniform, ranges from 0.30m to 0.35m at all the sampling points, and throughout the period of this research there was no rainfall which might increase the level of reservoir water and its transparency. This slight variation in the water transparency among the sampling points when correlated with zooplankton counts were found to have a weak relationship (r=0.382). It has no influence on the distribution and abundance of zooplankton. The value of dissolved oxygen (DO) was observed to be increasing gently from sampling point I to V (3.7 mg/l to 4.4 mg/L), although there was sharp rise in sampling point III (4.6 mg/L). While Biochemical Oxygen Demand (BOD) decreases from sampling point I to V (2.7 to 2.4 mg/L), unlike DO, there was sharp decline in sampling point III (2.1 mg/L). The increase in dissolved oxygen and decreased in biochemical oxygen demand along the sampling point II, III, IV, V), and (I was due to nutrient enrichment from the continuous influx of sewage from the Jakara River. It revealed that highest phosphate ion concentration recorded was in sampling point I. This might be because of incoming domestic wastewater from Jakara River
Keywords: Jankara, Rotifera, Cladocera, Copepoda, , Wasai

1.Introduction

Distribution and abundance of zooplankton communities may be a reflection of three major environmental pressures, physical or chemical, food resources, and vertebrate predation (Brooks & Dodson, 1965 and Post, 2002). On the other hand, it is evident that individual size, aggregation in clusters, deil vertical migration, filtration rate, birth rate of the zooplanktons, size and density of the algae, predation and distribution pattern of the temperature and oxygen concentration with depth are among the most important factor influencing the structure of the zooplankton association. Decrease of the diversity of zooplankton is commonly attributed to decrease in pH value resulting from increase in chemical pollutants or extreme environmental condition. Chemical pollutants significantly influence aquatic community structure and functions. For example Odum (1985), Marmorek and Korman, (1991) predicted the following trends in chemically stress communities; decreased efficiency of resource use, a decline in average body size and a decrease in the length of food chain. Chemicals acidification and pesticides contamination affects structure of fresh water zooplankton (Havens and Hanazato, 1993). Pollutants from insecticides stress decreases the average size of the organism, reduces energy flow, transfer efficiency and reduces food web complexity shortening the length of the food chain, and sometimes decreases species richness (Hanazato, 1998)

It has been recognized (Matsumura-Tundisi, 1991) that the composition, abundance, and diversity of zooplankton can be modified slowly over time by continuous or increased artificial Eutrophication of aquatic ecosystem. Consequently, many of these organisms have been found useful and reliable as biological indicators of the quality of the water and its sediments (Marmorek and Korman, 1991). Accordingly, zooplankton revealed early warning indicators that give a number of advantages over benthos organisms and fish. First, they are easy to collect, relatively homogeneously distributed in lakes, live in the water column where they are exposed to changing water chemistry, and have a generation time that would allow changes in recruitment success to rapidly be manifested as changes in population size and community structure. Second, they are easy to culture; hence, toxicity data are not too difficult to assemble. Third, sample processing for bio-monitoring studies is relatively inexpensive.

Degradation rate of organic sewage in water may bring about pH and temperature a change, which may affect zooplankton sensitive life stages and processes, hence decreases their abundance. Lai and Lam, (1995) reported that carbon dioxide supplied by organic degradation in water is less than those produced by photosynthesizing algae, and these resulted in pH depression inside the egg, leading to either prolongation of the hatching or to a reduced hatching success. Predation by planktivorous fish has a major impact on zooplankton species composition, abundance; age and size structure (Bendorf *et al.,* 2000). Intra and inter specific zooplankton competition can alter the population abundance by reducing species fecundity or raising the mortality of juveniles (Mutsumura – Tundisi, 1991). Predation by invertebrate usually has greater impact upon micro-zooplankton than on macro-zooplankton, frequently reducing the abundance of the former (Zaret, 1980). However, body shape and size of zooplankton prey has been shown to be an important criterion in food selection of visually feeding fish (Twombly and Tisch, 1999). Body colouration and transparency also influence the vulnerability of prey (Kerfoot *et al.* and Zaret, 1980). For example, *Daphnia magna* is large and relatively strongly coloured, as a result is unable to survive fish predation.

2. Materials and Methods

2.1 The Study Area

The Wasai – reservoir is sited on the Jakara River at a point about two kilometres southeast of Wasai village in Minjibir Local Government Area of Kano State (Amin, 1992). It is located within the latitude 12^{o}N, 13ºN, longitude 8ºE, and 9^{o}E. The reservoir was constructed in 1976 for recycling purposes. It has a maximum height of 9. 33m, surface area of 1,250 hectares and a total storage capacity of 65. 38m^3, this places the reservoir among the medium size man-made lakes in Kano State.

The Jakara River is the highest order stream channel in the reservoir catchments area The Jakara River originates from Jakara Quarters at an altitude of 487. 68m above sea level, in the traditional city of Kano (Nichol, 1987) and flows from there in a sinuous pattern draining most part of the Kano metropolis as it meanders down slope in a northeast direction. The Jakara River was known to be a perennial stream that flows throughout the year. Never the less, the present contributions by the Jakara River and consequently the yields at the reservoir are far from natural. The entire urban Kano discharge domestic effluents into the Jakara River directly or through tributaries to it. One important tributary to the Jakara River is the Getsi River, which is known to drain the entire Bompai industrial area. Additionally, the effluents of Kano abattoir are discharged directly into the Jakara River on a continuing basis.

2.2 Sampling of Zooplanktons

Zooplankton was collected three times per week from five sampling points using 20µm mesh size plankton net, the net was held firmly by hand and lowered down onto the surface water level from a canoe, and drag slowly to a distance of 5-10m. The water that flowed through the net aperture filtered the zooplankton and collected in a small bottle attached at the end of the net. The net and bottle content was emptied first in to a tray and then in to a sampling bottle.

2.3 Preservation of Zooplankton

Zooplankton samples were preserved in 70% formalin as adopted by Harris *et al.* (2000).

Identification of zooplankton

A binocular microscope was used for identification of zooplankton with the help of illustrations and charts as described by Fischer and Frost, (1997).

2.4 Counting of Zooplankton

The procedure of Gannon, (1971) was adopted where the zooplankton was placed in graduated trays and enumeration was carried out to prevented duplication of count.

2.5 Collection of Water Samples

Water samples was collected in acid rinsed plastic bottles monthly for the period of 3 months for the determination of Phosphate, Nitrite, Nitrate ,and Dissolved Oxygen (DO). Water for the determination of Biochemical Oxygen Demand (BOD) was collected in BOD bottles.

2.5.1 Physico-Chemical Analysis

2.5.1.2 Determination of Temperature

The surface water temperature was determined in situ using a mercury bulb thermometer.

2.5.1.3 Determination of Transparency

The transparency of water was determined using black and white painted Secchi disc. The disc was lowered in the water until it disappears and the depth was recorded. The disc was raised until it reappeared and the depth will be recorded in meters. Then average of the two readings was recorded to estimate the transparency.

2.5.1.4 Determination of pH

The pH of water was estimated *in situ* with a 620-pH electro meter as described by Deninger, (1980).

2.5.1.5 Determination of Dissolve Oxygen (DO)

Dissolved oxygen was determined by Winkler's method. The 200ml water sample was acidified using adding 2ml of concentrated sulfuric acid and then shaken. 100ml of the acidified sample was measured using a conical flask and titrated with 0.0125N Sodium thiosulphate solution until a faint yellow colour appeared. 2ml of starch solution was then added and titration continues until the blue colour disappeared. Each 1ml of the sodium thiosulphate solution used trimetrically equivalent to 1ml of oxygen using the formula.

Dissolved Oxygen (DO) (mg/L) =

v = volume of the sample titrated
V = volume of the thiosulphate used
N = normality of thiosulphate used

2.5.1.5 Determination of Biochemical Oxygen Demand (BOD_5)

The 250 ml water in BOD bottles was incubated at 20^0C for 5 days. Then the procedure used in determination of dissolved oxygen was carried out for BOD_5 determination as adopted by Best and Rosse, (1977).

BOD_5 (mg/L) = $DO_1 - DO_5$

D_1=Dissolve Oxygen before incubation
DO_5 = Dissolve Oxygen after 5 days incubation

2.5.1.6 Nitrite (NO_2) Measurement

About 5ml of 4-chloroaniline and 2ml of 2M-hydrochloric acid was transferred to 250ml volumetric flask. The flask was then put into an ice water for 10 min then 5ml of the water sample was added. The resulting solution was mixed thoroughly for 2 min, followed by addition of 1ml of 10% sulphuric acid. The solution was then allowed to stand for 15 min with frequent shaking. Then 1ml of 1-naphthel and 3ml of 3M sodium hydroxide solutions was be added to the solution. The resulting solution was diluted to the mark with water sample. The absorbance was read at 500nm. The experiment was repeated several times for each sample.

2.5.1.7 Determination of Nitrate (NO_3)

About 0.5ml of the sample was taken using a micropipette and added into a test-tube. 1ml of salicylic acid solution was added and mixed. The solution was allowed to stay for 30 min. 10ml of sodium hydroxide solution was added and then allowed to stay for 1 hour for colour to develop. The solution was analyzed using HACH digital spectrophotometer.

2.6 Statistical analysis

Data for the physical and chemical analysis and distribution and abundance of zooplankton recorded from this research work were analysed using regression, Null Hypothesis and F – tables for significance test as post – Experimental to compares and contrast analysis.

3. Results and Discussion

Results for physical, chemical, and biological analysis obtained from the field and laboratory analysis of water samples from sampling points of Wasai reservoir from December 2006 to March 2007 were presented in Figures: 2-11 showing monthly variations. The highest temperature recorded was 23^oC at all the sampling points in December 2006 and lowest temperature was recorded as 16^0C at all the samples in January 2007.

The transparency of the reservoir is shown in Figure: 3. the highest transparency was recorded as 0.35m in four sampling points (III, IV, and V) in December and sampling point II in January. The lowest transparency was recorded as 0.25m in sampling point I and II in February.

pH records from the sampling points were presented in Figure. 4. The highest pH values was recorded in sampling point I as 8.6 in February and the lowest pH (7.6) was observed in sampling point V in December. Dissolve oxygen (DO) is presented in Figure.5 while Biochemical Oxygen Demand (BOD) record was presented in Figure. 6. Highest DO and BOD were recorded as 4.7 mg/L and 2.8 mg/L in sampling point III in February and sampling point I and II both in December respectively. Lowest value for DO and BOD were recorded as 3.6 in sampling point II and 2.0 in sampling point I both in December respectively.

Figure. 7, 8, and 9 showed the result analysis for Phosphate, Nitrite, and Nitrate. Highest and lowest value recorded for phosphate was 0.78 mg/L in sampling point III in February and 0.32mg/L in same sampling point III both in January respectively. Nitrite analysis presented 0.017 mg/L as the highest value recorded in sampling point III in January and lowest value as 0.000 mg/L in the sampling point V and II in December and January respectively. Nitrate results analysis was recorded as 0.400 mg/L as the highest value in sampling point I in both December and February. Lowest results value 0.000 mg/L for nitrate was recorded in sampling point III only in February.

Figure: 11 and 12 showed Zooplankton (Protozoa, Rotifera, Cladocera, and Copepoda) counts for each Station and Total Occurrence of Zooplanktons in each station. Total Zooplankton counts was recorded in sampling point V as 282 and least Zooplankton counts (37) was recorded in sampling point I. Rotifera was recorded as the second to highest counts (79) in sampling point V and Cladocera recorded as third to the highest counts (50) in the sampling point V. However, the record of identified Zooplankton genera showed that 1339 individual Zooplankton were identified. Nine hundred and forty eight were Protozoa, 236 were Rotifera, 136 were Cladocera, and 81 were Copepoda.

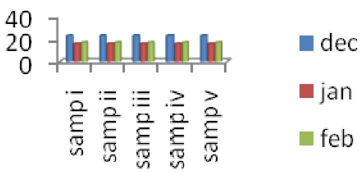

Figure: 2. Variation in temperature December 2005 – January 2006 Sampling Point I-V

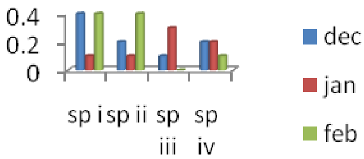

Figure: 3. Variation in transparency (m) December 2005 – January 2006 Sampling Point I-V

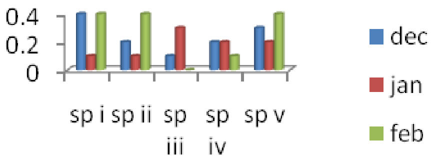

Figure :4. Variation in pH December 2005 – January 2006 Sampling Point I-V

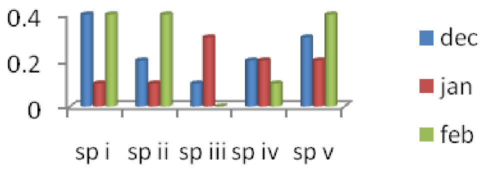

Figure: 5. Variation in Dissolved Oxygen (mg/L) December 2005 – January 2006 Sampling Point I-V

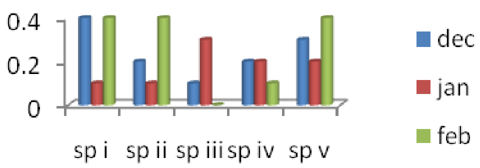

Figure 6.Variation in Biochemical Oxygen Demand (mg/L) December 2005 – January 2006 Sampling Point I-V

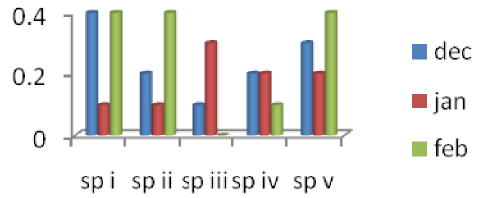

Figure 7. Variation in Phosphate (mg/L) December 2005 – January 2006 Sampling Point I-V

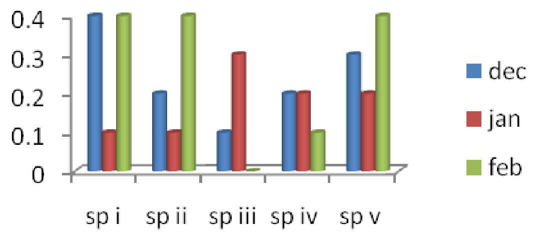

Figure 8. Variation in Nitrite (mg/L) December 2005 – January 2006 Sampling Point I-V

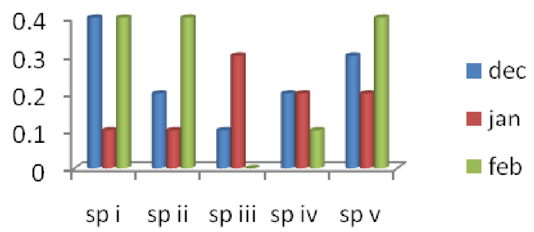

Figure 9. Variation in Nitrate (mg/L) December 2005 – January 2006 Sampling Point I-V

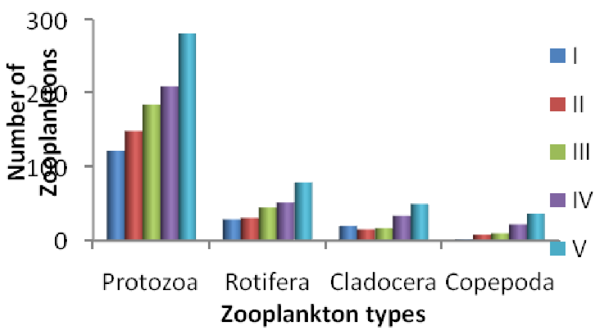

Figure.10: Total zooplankton counts in sampling points December 2005 – January 2006 Sampling Point I-V

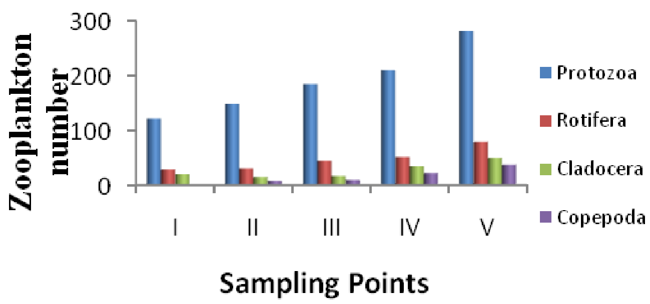

Figure.12: Total zooplankton counts in sampling points, December 2005 – January 2006

4. Conclusions

4.1 Physico - chemical Parameters

Aquatic ecosystems are known to vary in physical and chemical characteristics. The observed temperature of the water surface during the period of this study was low with slight variations in all the sampling points (16 to 23°C). These could be attributed to cold harmattan season. However, the depth of the reservoir was assumed shallow; estimated (14.33m). This could have contributed immensely to the low temperature variations. The temperature in water was comparatively more stable in larger and deeper water bodies and does not stratified in shallow natural bodies of water that is less than 120m deep.

Depth to which sunlight penetrates into water body depends mainly on it transparency of the water, which in turn is a function of turbidity and colour. It was observed that the transparency variation (0.30m to 0.35m) between the sampling points were uniform. Highest transparency was observed in sampling point III and IV in January. Throughout the period of study, there was no rainfall, therefore influx of Jakara River was very slow, hence the transparency of the reservoir assumed to be uniform.

In contrast to these finding Guntram *et al.,* (2000) reported that if the water is disturbed e.g. rainfall coming into river, pond or sea the transparency is reduced temporarily and the light cannot penetrate to any great depth, submerge plants are unable to received enough light for photosynthesis; and these may results in the reduction of food for animals.

For hydrogen ion concentration (pH), ranged between (7.8 to 8.9), pH values decrease from the sampling point I down the sampling point V. These decreases could be attributed to the influx of Jakara River which is the highest order stream channel of the reservoir entering into it. Sampling point I was located close to the mouth of Jakara River. Loads of domestic, organic and agricultural materials are carried by the river and were first deposited in sampling point I and subsequently to the other sampling points II, III, IV, and V. The pH values variation as shown above agreed with the research findings of Post, (2002) that fresh water environment is slightly neutral to alkaline.

The value of Dissolved Oxygen was observed to be increasing gently from sampling point I to V (3.7 mg/L to 4.4 mg/L), although there was sharp rise in sampling point III (4.6 mg/L). While Biochemical Oxygen Demand decreases from sampling point I to V (2.7 mg/L to 2.4 mg/L), unlike dissolved oxygen there was sharp decline in sampling point III (2.1 mg/L). The increase in dissolved oxygen and decreased in biochemical oxygen demand along the sampling point (I, II, III, IV and V) could be due to nutrient enrichment from the continuous influx of sewage from the Jakara River. Moreover, sampling point I was located at the first receiving point of the reservoir. This concurs with the work of Guisande (2003) explained that as a result of components of sewage from domestic, industrial and agricultural sources large amount of oxygen for their decomposition is required. Accordingly decomposition of organic matter from domestic and industrial sources reduces oxygen availability, thus giving rise to biochemical oxygen demand.

Phosphorus in freshwater bodies and wastewater always exist solely as phosphate and when compared to the other major nutritional and structural components of the biota (carbon, hydrogen, nitrogen, oxygen and sulphur) it is the least abundant and yet most common compound limiting biological productivity (Boyle and Strand, 2001). Moreover, total phosphate ion concentration in fresh water bodies may range from 0.01mg/L to 200 mg/L. These supported the phosphate ion result findings of this research work that ranged from 0.32 mg/L to 0.78 mg/L. It was noted that highest phosphate ion concentration was recorded to sampling point I. This might be as a result of incoming domestic waste water from Jakara River, carrying used phosphate in detergents from washing and soaps from bathing.

Nitrites and nitrates are forms in which nitrogen occurred in water. Nitrogen along with phosphates constitutes cellular protoplasm of organisms. Nitrite and nitrates play a significant role in determining the productivity of a lake, because they are the key nutrients that contribute to chlorophyll production Jay *et al.,* (2000). The trend was high nitrite, nitrate values averaging 0.023 mg/L and 0.30 mg/L respectively were observed at the sampling point I, which was the first receiving point of organic loads into the reservoir and decreases at successful sampling points (II, III, IV and V). Throughout the sampling period, the least values of nitrite and nitrate averaging 0.006 mg/L and 0.03 mg/L respectively were recorded at sampling point V. These result agree with previous findings by Lai and Lam, (1995) that Eutrophication of receiving water bodies can caused nutrient enrichment from waste facilities and attention should be paid to the control of nitrogen in water bodies receiving point where is often limiting for algal growth.

4.2 Distribution and Abundance of Zooplankton

This research revealed the fact that the physico-chemical factors tend to control the distribution and abundance of Zooplankton as shown by other researchers such as Brett, (1989), Egborge, (1994), and Guisand *et al*., (2003). It was noted that water surface temperature variations recorded was very minimal. Maximum temperature observed was 23°C, and the least was 16°C. These slight variations resulted in a weak relationship ($r = 0.398$) with Zooplankton and was not likely to influence the distribution and abundance of Zooplankton. According to

Rusell *et al.,* (1998), seasonal temperature fluctuation in the tropics is an important factor controlling of Zooplankton life cycle. These act simultaneously to a different degrees (17°C to 32°C) modifying Zooplankton structure in different ways.

Physical parameters (e.g. transparency) in this research work was fairly uniform, ranges from 0.30m to 0.35m at all the sampling points, and throughout the period of this research there was no rainfall which might increase the level of reservoir water and its transparency. These slight differences in transparency between the sampling points were correlated with Zooplankton counts and found to have a weak relationship (r=0.382) and was not likely to influence distribution and abundance of Zooplankton. Gulati and Van Donk, (2002), reported that speedy influx of turbid flood from heavy rainfall especially coming after a long spell of draught greatly reduced transparency of water and results in reduction of food for Zooplankton particularly those obtained food by filtration.

On the other hand chemical parameter variations observed in this research were generally higher, as a result strong relationships (r=0.785) with Zooplankton were existed. It appeared that sampling point I which is located in the upstrem of Jakarta River have higher pH level, less oxygen concentration and decreased number of Zooplankton. It is important to note according to Jeremy and Hans, (2004) that addition of organic material into water bodies is almost certain to increased the microbial population in the water and required oxygen for their activities, hence give rise to biochemical oxygen demand. As a result only very few number of Zooplankton was present. Furthermore, Zooplankton communities are highly sensitive to environmental changes, as such changes in their abundance, diversity and community composition can easily occurred. The Zooplankton communities are comprises of Protozoan, Rotifera, Cladocera and Copepoda, they all occurred in all sampling points at different composition. Total number of Zooplankton occurred in sampling point I, II, III, IV and V were found to be 173, 203, 257, 318 and 448 respectively. Protozoan number was dominant over the other Zooplankton group throughout the period of sampling and in all the sampling points; then followed by Rotifera, Cladocera and Copepoda. These high number of Protozoa was attributed to sewage inflow into the reservoir, hence more decomposition activities. Similar findings by Moss *et al.,* (2003) showed that Protozoa species are very numerous and that they therefore occurred abundantly in all types of fresh water and in damp soil. They further reported that their mode of reproduction made them multiply exceedingly; or reproduced either sexually or asexually or by both.

Similarly, Jeremy *et al.,* (2004) reported that Protozoan which live in the water where there is active decomposition of organic matter, do exist and multiply exceedingly even with or no oxygen present. They also showed that changing availability of food supply and oxygen association with decay typically results in distinct succession of population of Protozoa species.

As were noted in this research work that apart from the Protozoa group in the Zooplankton, the next dominant and abundant group was Rotifera and followed by Cladocera, and were represented by few species. Total individuals of Rotifera and Cladocera observed were 236 and 136 respectively. Highest and least occurred Rotifera and Cladocera were observed in sampling point V and I. Rotifera has 79 and 29, while Cladocera has 50 and 20 respectively. This was as a result of improvement of physico-chemical parameters noticed from sampling point I to V. The reservoir was within small range of pH 7.8 to 8.5 of mild alkaline condition. Individual Rotifera, as described by Hanazato, (1998) are more abundant than Cladocera in alkaline environment. Sampaio *et al.,* (2002) explained that, in non eutrophic reservoirs in temperate regions the Zooplankton are usually dominated by Cladocera species, but in tropical regions the Rotifera have been observed to be dominant irrespective of the level of eutrophication, thus suggestion that other factors particularly zooplankton interaction favour the Rotifera which have competitive advantage over the other main Zooplankton groups such as Cladocera and Copepoda.

Copepoda are the least occurred Zooplankton group in the studied reservoir. Sampling point V is the most abundant (37) of Copepods having being less polluted area of the reservoir. There are reasons to believe because several aquatic Ecologists considered Copepods communities to be highly responsive to a number of perturbations including eutrophication (Mamorek and Kormann, 2000). They further explained that good evidence has now accumulated that certain Zooplankton species (copepods) and community indices yield consistent responses to slight changes in water pH and other chemical parameters.

In all the sample collected from the five sampling points, a total of 1339 individual Zooplankton was identified. The largest fraction (948) of these number belong to fourteen genera of Protozoa 236 belong to six genera of Rotifera, 136 to four genera of Cladocera and 81 to two genera of Copepoda. The present finding provides evidence that there were more species of Protozoa, followed by Rotifera and Cladocera in Wasai reservoir. The least abundant group was observed to be the Copepoda. Besides the above-mentioned groups of Zooplankton, some invertebrates groups were also observed at low density and frequency, such as *Nematoda, Oligochaeta, Plecoptera*, *Trichoptera* and *Tubellaria*. However, they were not considered in the present study, due to taxonomical difficulties.

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