Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.14, 2014

The Role of Abiotic Factors in Diurnal Vertical Distribution of Zooplankton in Awba Dam, Ibadan, Nigeria

Olagbemide Peter Taiwo
Biological Sciences Department, Afe Babbalola University, Ado-Ekiti, Nigeria.
Email: Petseko2004@Yahoo.Co.Uk

Abstract
Zooplankton density at the different depths was determined. Physico-chemical parameters were related to the vertical distribution of zooplankton in the dam. Temperature, pH, dissolved Oxygen decrease with depth while alkalinity, dissolved Carbon dioxide, Nitrate contents and conductivity increase with depth. Zooplankton density decreases with increase in the sampling depths. Two genera of Cladocera, four genera of Protozoa, four genera of Copepoda and five genera of Rotifera were identified. The highest number of zooplankton was recorded in the month of May. The study demonstrates that the differences in the vertical distribution and species diversity are directly related to the influence of lake stratification. A connection was detected between the depth and number of individuals. In this study, the average vertical position of the zooplankton ranged from less than one metre to more than 3 metres, and relationships to environmental factors were quite variable, depending on zooplankton group and sampling date. However, for individual zooplankton groups and sampling dates, temperature and oxygen profiles also significantly influenced zooplankton vertical position.

Keywords: Zooplankton, Awba dam, physico-chemical parameters, distribution, sampling depths.

1.0 Introduction

Awba dam, in the University of Ibadan campus was constructed as a fish pond in 1962 from a freshwater stream, Awba stream. It is located in the south-western part of the university. It is between latitudes 7^0 26^I N and longitude 3^0 53^I – 3^0 54^I E. It is bounded on the North by Ijoma and Ekwumo roads, on the East by the Department of Zoology and on the West and South by Staff Quarters and Faculty of Technology respectively. A lot of anthropogenic activities go on around the dam throughout the year, hence, there is need to constantly re-assess the limnological features of the dam.

The name plankton is derived from the Greek word *planktos* meaning to wander, and refers to the weak swimming movements of organisms in this category. Zooplankton are small floating or weakly swimming organisms that drift with water currents and with phytoplankton, make up the planktonic food supply upon which almost all aquatic organisms are ultimately dependent. Zooplankton can be further subdivided into holoplankton, i.e. permanent members of the plankton, and meroplankton, i.e. temporary members of this category. Meroplanktons consist of larval and young stages of animals that will adopt a different lifestyle once they mature. For example bottom-living animals such as crabs and lobsters enter the plankton as larvae for the purpose of dispersion. Also many fish are planktonic in the early stages of their development.

Although zooplanktons are defined as "floating" in the water column, their populations show distinct horizontal and vertical distribution patterns (Lampert & Sommer, 1997) and they are normally found in different types of aquatic environments and their occurrence and distribution are influenced by ambient physical factors such as wind, temperature, salinity, dissolved oxygen etc (Pilkaityte and Razinkivas, 2006). Zooplankton*s* are heterotrophic and derive members mainly from Protozoa, Rotifera, Cladocera and Copepoda (Rocha *et al*., 1999). The community structure of zooplanktons depends on the trophic status of the lake and individual species may reflect the level of eutrophication (Rogozin, 2000). In freshwater system, total zooplankton abundance may increase with increasing eutrophication (Pace, 1986), and the abundance and diversity of zooplanktons vary according to limnological features and trophic state (Tallberg *et al*., 1999; Jeppensen *et al*., 2002). Environmental fluctuation which corresponds to the diel light variation influences vertical migration of zooplankton (Ana *et al*., 2009) and thus their vertical distribution is the result of active habitat choice (Lampert, 2005) determined by temperature, food condition and predation (Leibold, 1990; Dini & Carpenter, 1992). Consequently, zooplankton community may respond to this variation and optimize the use of food resources during a favourable period and at a particular depth, resulting in a synchronized vertical migration behavior (Haney *et al.,* 1990). Several factors are said to be responsible for the vertical migration of zooplankton by a numbers of investigators (Dodson, 1990; Haney *et al.,* 1990; Dawidomicz *et al.,* 1990). Zooplanktons respond quickly to environmental changes, and hence the species composition indicates the quality of the water mass in which they are found (Boucherie & Zulling, 1983). Also because of their small sizes and often great numbers, they not only strongly influence certain non-biological aspects of water quality such as pH, colour, taste and odour but in a very practical sense, they are a part of water quality (APHA, 1995). Furthermore, the distribution of zooplankton can be used to indicate the areas where the organisms that feed on them can be found.

Zooplanktons are important as both prey and consumers in the aquatic food web. Zooplankton also acts as bio-monitors because they are also highly sensitive to environmental change or disturbance in lakes. Zooplanktons are sampled to provide quantitative estimates of community composition, densities and/or biomass within lakes (CCME, 2011). Zooplankton mean length is also an indicator of overall fishing quality (Mills et al. 1987). Zooplanktons are an essential part of aquatic ecosystems; they have numerous roles, the two most prominent of which are serving as a food resource for higher trophic levels and providing grazing pressure on the algal community (Whitmore & Webster, 2008). Zooplankton plays an essential role in the transformation of substances and energy in bodies of water. Zooplankton is a very convenient object for the assessment of biocenosis diversity, because it is represented not only with different taxonomic groups, but it is also represented at different trophic levels (Brakovska and Skute, 2009).
The aim of this study was to determine the diurnal vertical distribution pattern of zooplankton in relation to the environmental variables in Awba Dam, University of Ibadan.

2.0 Materials and Methods

2.1 Samples collection and analysis:
Water and zooplankton samples for the analysis of vertical distribution of Zooplankton were collected fortnightly from the middle of the dam at different depths (0.05metres; 0.75metres; 1.50metres; 2.25metres; 3.00metres; 3.75metres), from March to May between 8:30 and 9:30 a.m. Zooplankton samples were also collected at the depths in the afternoon between 2:00 and 3:00 p.m.
Water samples with Zooplankton were collected from the different depths with a calibrated rope attached to an insulated vertical column water sampler with closing mechanism. Zooplankton samples were obtained by filtering 5 litres of water sample from each of the depths through plankton net of 60 µm mesh size. The zooplankton concentrates were immediately preserved in 5% formalin and stored in clean labeled bottles. The volume of sample was standardized to 50 mL using distilled water. Samples were sub-sampled using a Hanson Stemple pipette to measure 3 separate, 1mL aliquots from the total sample. It is assumed that because the solution was mixed prior to counting, samples were random and representative of the size structure within the mixed solution. Standard identification guides (Jeje and Fernando, 1986; Koste, 1978; Braioni & Gelmini, 1983; Nogrady & Segers, 2002; Margaritora, 1983; Einsle, 1996; Fernando, 2002) were used in identifying the observed zooplankton. Counting and identification were done with Olympus Vanox Research Microscope, Model 230485. The abundance of zooplankton was determined according to Brakovska & Skute (2009); Akindele (2013).
Water temperature at the different depths was measured to the nearest 0.1^{o}C using mercury in glass thermometer of range 10 – 110^{o}C immediately the water samples were brought to the surface in the insulated water sampler. The transparency of the dam was taken by Seechi disc. The pH and conductivity of the samples were determined in the laboratory using Beckman electronic pH meter (Model E 512) and an electronic C M 25 conductivity meter Model W.P.A. respectively. The dissolved oxygen concentration (DO_2), dissolved carbon dioxide concentration (DCO_2) and alkalinity were determined by titrimetric methods described by Mackereth (1963). The determination of the nitrate and phosphate content was according to Boyd (1979).

2.2 Data Analysis:

All the Statistical analyses were carried out using SPSS for windows and Microsoft office Excel. Analysis of variance (ANOVA) was done for all the physico-chemical parameters.

3.0 Results:

The relative humidity (%) at University of Ibadan during the sampling period varied between 70- 83. The temperature decreased with depth from the surface to the bottom layer. The difference between the mean temperature of surface water (28.8^{0}C) and the water at the bottom layer (26.8^{0}C) is 2.0^{0}C (Table 1). ANOVA test on the temperature data showed that there was significant difference at the 5% level in the temperature of the water at different depths. The lowest mean monthly temperature for the surface water was recorded in March and the highest was recorded in May. The transparency of the water during the period of this investigation varied from 38cm to 55cm. The highest mean monthly transparency (50cm) was recorded in March and the lowest in May when the rain was higher.

Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.14, 2014

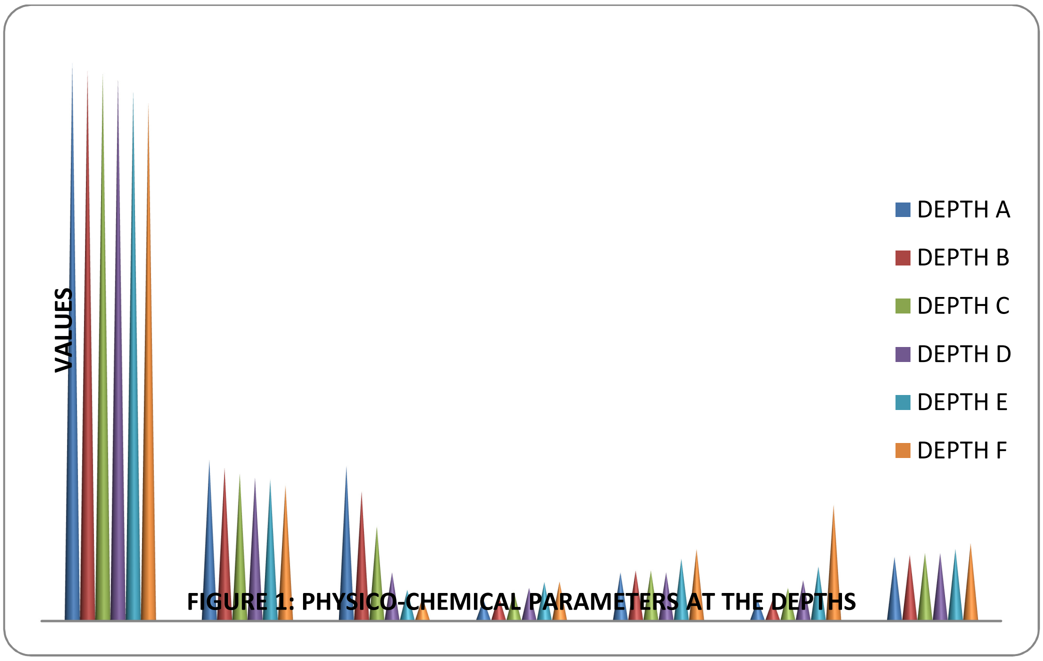
Table 1: Physico-chemical parameters at the different depths of Awba Dam

Physico-chemical parameters	Depth A (0.05M)	Depth B (0.75M)	Depth C (1.50M)	Depth D (2.25M)	Depth E (3.00M)	Depth F (3.75M)
Temperature (^{0}C)	28.8±0.48 (28.2-29.5)	28.4±0.56 (27.5-29.0)	28.3±0.75 (27.0-29.0)	28.0±0.89 (26.5-28.8)	27.4±1.64 (24.2-28.5)	26.8±1.89 (23.0-28.0)
Ph	8.3±1.01 (6.5-9.6)	7.9±0.96 (6.1-8.9)	7.6±0.77 (6.1-8.3)	7.4±0.85 (5.8-8.2)	7.3±0.82 (5.7-7.9)	7.0±0.92 (5.4-7.8)
Dissolved oxygen (mg/l)	8.0±1.4 (6.0-10.1)	6.7±0.93 (5.5-8.0)	4.9±0.68 (4.0-5.5)	2.5±0.87 (1.4-3.8)	1.6±0.53 (1.2-2.5)	1.2±0.54 (1.1-2.3)
Dissolved CO_2 (mg/l)	1.1±0.09 (0.9-1.1)	1.30±0.22 (1.1-1.5)	1.50±0.09 (1.3-1.6)	1.7±0.25 (1.5-2.2)	2.0±0.34 (1.5-2.4)	2.03±0.31 (1.8-2.4)
Alkalinity ($mgCaCO_3^{-1}$)	2.5±0.45 (1.5-3.0)	2.6±0.38) (2.0-3.0)	2.6±0.49 (2.0-3.0)	2.5±0.43 (2.0-3.0)	3.2±0.75 (2.0-4.0)	3.7±0.76 (2.5-4.8)
Nitrates (mg/l)	1.1±2.64 (0-2.5)	1.1±0.83 (0-1.8)	1.7±0.17 (1.4-2.0)	2.1±0.28 (1.8-2.5)	2.8±0.59 (2.3-3.6)	6.0±1.43 (3.7-8.0)
Conductivity (x 10^{-4} mho)	3.3±0.27 (3.0-3.7)	3.7±0.12 (3.2-3.6)	3.5±0.14 (3.3-3.7)	3.5±0.09 (3.4-3.6)	3.7±0.12 (3.5-3.8)	4±0.35 (3.7-4.6)

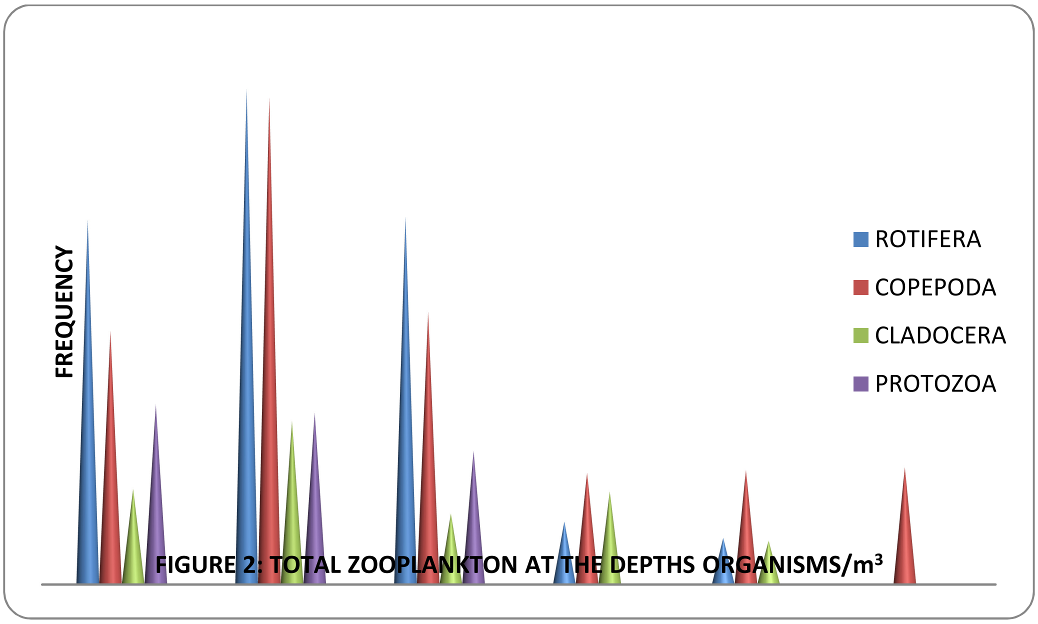
Conductivity value increased from surface to bottom. The highest mean monthly conductivity for surface water (340umhos) was recorded in May and the lowest value (320umhos) was recorded in March. The highest mean monthly conductivity for the bottom layer (415umhos) was recorded in March and the lowest value (382.5umhos) was recorded in April. ANOVA test on the conductivity values at the depths showed that there was a significant difference at 5% level at the depths. The dissolved carbon dioxide increased with depth. The highest mean monthly value of dissolved carbon dioxide for surface water (1.10$mgCO_2L^{-1}$) was recorded in March and May and the lowest value (0.99$mgCO_2L^{-1}$) was recorded in April. The lowest mean monthly value of carbon dioxide for bottom layer (1.76$mgC0_2L^{-1}$) was recorded in March and the highest value (2.42$mgCO_2L^{-1}$) was recorded in May. ANOVA test on the values showed that there was significant difference at 5% level at the depths.

Dissolved oxygen decreased with increase in sampling depth. The highest mean monthly value of dissolved oxygen for surface water (9.35mgO_2L^{-1}) was recorded in April and the lowest for surface water in March. The highest mean monthly value (1.7mgO_2L^{-1}) was recorded in March and the lowest value (0.85mgO_2L^{-1}) was recorded in April for bottom water. ANOVA test on the values showed that there was significant difference at 5% at the sampling depth. The pH value decreased with depth. The highest mean monthly pH value for surface water (9.0) was recorded in April and the lowest value (7.6) was recorded in May. The highest mean monthly pH value (7.6) was recorded in April for bottom water and the lowest value in May. ANOVA test showed that there was no significant difference at 5% level in the values at the depths.

Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.14, 2014



The value of alkalinity increased with depth except at 2.25m. The highest mean monthly value of alkalinity for surface water (2.5mgCaCO$_3$L^{-1}) was recorded in March and the lowest value (2.25mgCaCO$_3$L^{-1}) was recorded in April and May. The highest mean monthly value for bottom water (4.0mgCaCO$_3$L^{-1}) was recorded in May and the lowest value (3.25mgCaCO$_3$L^{-1}) was recorded in March. ANOVA test on the values showed that there was a significant difference at 5% level in values at the depths.



Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.14, 2014

Table 2: total zooplankton (per litre) at the sampling depths

CLASS	GENUS	ORGANISMS/m³	GENUS % IN CLASS	GENUS % IN TOTAL ZOOPLANKTON	CLASS % IN TOTAL ZOOPLANKTON
DEPTH A					
CLASS	GENUS	ORGANISN/m³	GENUS % IN CLASS	GENUS % IN TOTAL ZOOPLANKTON	CLASS % IN TOTAL ZOOPLANKTON
ROTIFERA	*Keratella* *Trichocerca*	101 33	75% 25%	31% 10%	41%
PROTOZOA	*Volvox*	66	100%	20%	20%
COPEPODA	*Latanopsis* *Cyclops* *Nauplius larva*	9 35 49	10% 38% 53%	3% 11% 15%	28%
CLADOCERA	*Daphnia*	35	100%	11%	11%
DEPTH B					
ROTIFERA	*Keratella* *Testudinella* *Trichocerca* *Lecane*	91 8 74 9	50% 4% 41% 5%	19% 2% 15% 2%	38%
PROTOZOA	*Euglena* *Volvox*	21 42	33% 67%	4% 9%	13%
COPEPODA	*Cyclops* *Nauplius larva*	81 98	45% 55%	17% 35%	37%
CLADOCERA	*Daphnia*	60	100%	12%	12%
DEPTH C					
ROTIFERA	*Keratella* *Testudinella* *Trichocerca* *Lecane* *Filinia*	45 20 34 24 12	33% 15% 25% 18% 9%	15% 6% 11% 8% 4%	44%
PROTOZOA	*Euglena* *Volvox* *Chilomonas* *Paramecium*	8 17 16 8	16% 35% 33% 16%	3% 5% 5% 3%	16%
COPEPODA	*Cyclops* *Nauplius larva* *Limnocalanus* *Laptodora*	48 34 9 9	48% 34% 9% 9%	15% 11% 3% 3%	32%
CLADOCERA	*Daphnia*	26	100%	8%	8%
DEPTH D					
ROTIFERA	*Keratella* *Trichocerca*	15 8	65% 35%	15% 8%	23%
PROTOZOA	-	-	-	-	-

COPEPODA	*Cyclops* *Nauplius larva*	31 10	65% 24%	32% 10%	42%
CLADOCERA	*Daphnia*	34	100%	35%	35%
DEPTH E					
PORIFERA	*Keratella* *Trichocerca*	8 9	47% 53%	11% 12%	23%
PROTOZOA	-	-	-	-	-
COPEPODA	*Cyclops* *Nauplius larva*	18 24	43% 57%	24% 32%	56%
CLADOCERA	*Ceriodaphnia* *Daphnia*	7 9	44% 56%	9% 12%	21%
DEPTH F					
ROTIFERA	-	-	-	-	-
PROTOZOA	-	-	-	-	-
COPEPODA	*Cyclops* *Nauplius larva*	17 26	40% 60%		100%
CLADOCERA	-	-	-	-	-

The value of nitrate increased with increase in the sampling depth. The highest mean monthly nitrate value ($1.24mgNO_3L^{-1}$) was recorded for surface water in May and the lowest value (nil) was recorded in March and April. The highest mean monthly nitrate value for bottom water ($7.3mgNO_3L^{-1}$) was recorded in March and the lowest value ($5.8mgNO_3L^{-1}$) was recorded in May. ANOVA test on the nitrate values showed that there is a significant difference at 5% level at the sampling depths.

The total zooplankton per litre decreased with increase in depth as from depth B. Table 2 shows the total zooplankton collected at the sampling depths. Among the zooplankton, there was preponderance of Rotifera in depth A to depth C and a preponderance of Copepoda from depth D to depth F. Cladocera showed irregular distribution while Protozoa were completely absent from depth D to depth F (Figure 2).

Two genera of Cladocera were identified. Four genera of Protozoa were also identified. The highest density of Protozoa was recorded at depth 0.75 metre. Rotifera ranked first of the zooplankton collected. Five genera of rotifers were identified. Copepod was represented by four genera. The highest density of zooplankton was recorded in the month of May (Figure 3). Table 3 shows the correlations of the zooplankton with the physico-chemical parameters. Rotifera and Protozoa showed significant correlations to temperature, pH, dissolved oxygen and dissolved Carbon dioxide; Cladocera showed significant correlations to nitrates content and Conductivity while Copepoda showed no significant correlations to any of the parameters.

Table 3. Correlation between zooplanton and physico-chemical parameters

S/N	VARIABLES	R	P. VALUES
1.	Rotifera/Temperature	0.830*	0.041
2.	Rotifera/pH	0.821*	0.045
3.	Rotifera/DO_2	0.916*	0.010
4.	Rotifera/DCO_2	-0.884*	0.019
5.	Rotifera/Alkalinity	-0.672	0.143
6.	Rotifera/Nitrates	-0.753	0.084
7.	Rotifera/Conductivity	-0.767	0.075
8.	Copepoda/Temperature	0.627	0.183
9.	Copepoda/pH	0.643	0.168
10.	Copepoda/DO_2	0.770	0.073
11.	Copepoda/DCO_2	-0.721	0.106
12.	Copepoda/Alkalinity	-0.490	0.324
13.	Copepoda/Nitrates	-0.595	0.213
14.	Copepoda/Conductivity	-0.587	0.220
15.	Protozoa/Temperature	0.842*	0.036
16.	Protozoa/pH	0.892*	0.017
17.	Protozoa/DO_2	0.970**	0.01
18.	Protozoa/DCO_2	-0.931**	0.07
19.	Protozoa/Alkalinity	-0.628	0.182
20.	Protozoa/Nitrates	-0.702	0.120
21.	Protozoa/Conductivity	-0.759	0.080
22.	Cladocera/Temperature	0.795	0.059
23.	Cladocera/pH	0.723	0.104
24.	Cladocera/DO_2	0.738	0.094
25.	Cladocera/DCO_2	-0.769	0.074
26.	Cladocera/Alkalinity	-0.805	0.054
27.	Cladocera/Nitrates	-0.841*	0.036
28.	Cladocera/Conductivity	-0.839*	0.037

N. B. * = Correlation is significant at the 0.05 level, ** = Correlation is highly significant at the 0.05 level

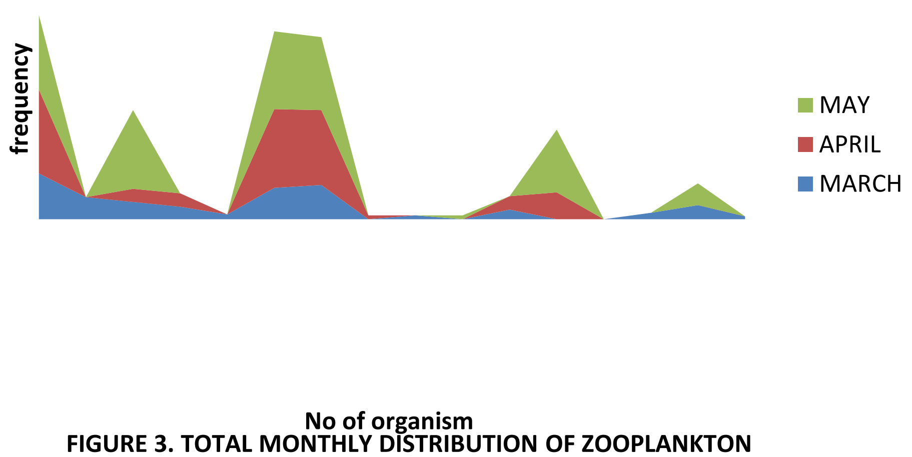


FIGURE 3. TOTAL MONTHLY DISTRIBUTION OF ZOOPLANKTON (organisms/m³)

4. Discussion

Temperature of water is basically important because it effects biochemical reactions in aquatic organisms. A rise in temperature of water leads to the speeding up of chemical reactions in water, reduces the solubility of gases and amplifies the tastes and odour (Ramesh and Krishnaiah, 2014). The changes observed in the surface temperature on the sampling days may be due to changes in relative humidity of the air at University of Ibadan during the sampling days. Egborge (1970) reported that surface water temperature is influenced by a combination of hours of sunshine and relative humidity. The temperature on each sampling day decreased with increase in the sampling depths irrespective of the surface water temperature. This may be due to adsorption of light energy by chlorophyll of plants which make lesser light intensity to be available to the next sampling depth. This could also be due to the interception of light rays by particles in the water which reduce the amount of light that penetrate the water body. The absorption of solar energy as light passes through water heats the water and light energy is absorbed exponentially with depth, so most heat is absorbed within the upper layer of water (Boyd, 1979). The temperatures recorded at the sampling depths during this study are within the range recommended for fish survival (Fryer and Iles, 1972). Hence, the dam supports fishing activities by local fishermen.

Transparency of the water was highest in March and lowest in May. This was opposed to what was obtained for temperature. This decrease in transparency from March to May is due to increase in turbidity of the water as a result of run-off carried into the dam as a result of rains which began in March. The transparency gives an idea about the degree of suspended particles in the water of lakes, which in turn affect light penetration (Verma, 2002). Conductivity values increased with depth. This means mineralization increased from surface to bottom and the highest value obtained in the bottom layer may be to due to the breaking down of organic matter to inorganic particles at the bottom of the pond. This explains the preponderance of Rotifers in the dam as high rotifer density has been reported to be a characteristic of eutrophic lakes (Sendazc, 1984). This eutrophication may be due to polluted state of the dam brought about by human activities in and around the dam (Olagbemide, 2011). Conductivity is a good criterion in the knowledge of the degree of mineralization (APHA, 1995) as indicated in this study. Rainfall seems not to influence the conductivity of the water in the dam. This observation contradicted the finding of Adebisi (1981) in Upper River Ogun but fall in line with the reports of Welcome (1976).

Values of dissolved CO_2 obtained throughout the sampling period were very low and increased from surface to the bottom as opposed to dissolved O_2 which decreased from surface to the bottom layer. The low values obtained for dissolved CO_2 and high values of dissolved O_2 recorded could be due to photosynthetic activity which utilized CO_2 but released O_2. The highest mean value of dissolved CO_2 obtained in the bottom layer could be due to CO_2 produced at this layer as a result of decomposition of organic matter. The solubility of O_2 in water decreases as temperature and salinity increase (Olaniyan, 1969; Boyd, 1979). In this study, the effect of temperature on the dissolved CO_2 and O_2 is minimal. The major factors controlling the gradients of the dissolved gases in Awba dam are photosynthesis and the decomposition of organic matter.

The pH values decreased from the surface to the bottom layer. Photosynthetic activity removed CO_2 from the water and since this activity decreased down the sampling depths, hence the pH also decreased down the sampling depths. It had been reported that pH decreased with rainfall (Holden & Green, 1960). This is not glaring in this study. This may be due to inconsistency in rainfall during the period of the study. The values of alkalinity obtained were very low and they increased from surface to the bottom. This is similar to the pattern of gradient of dissolved CO_2 in the dam and this observation combined with the low values of dissolved CO_2 in the dam explains the fact that dissolved CO_2 in water determines the value of alkalinity. This is similar to the report of Khan and Zutshi (1980) in Nilag Lake. The nitrate concentrations recorded throughout the period of this study could be due to the fact that the dam is well oxygenated as earlier discussed. In well oxygenated lake and river waters, most of the ammonium is usually rapidly oxidized to nitrate by nitrifying organisms (Visser, 1974). Carpenter (1928) reported that nitrate content curves of freshwater are pretty nearly the reverse of those of oxygen. Similar observation was made in this study.

The total zooplankton per litre decreased down the sampling depths from surface water to bottom water. This pattern corroborated the findings from reservoirs in Turkey and tropical lakes in South America (Bozkurt and Dural, 2005; López and Zoppi de Roa, 2005; Bozkurt and Sagat, 2008; Guevara et al., 2009). And this could be an indication that the physico-chemical parameters which change along the sampling depths are responsible for zooplankton distribution. This observation agrees with many reviews and investigations (Stich & Lampert, 1981; Primicerio & Klemetsen, 1999; Primicerio, 2000; Kehayias et al., 2004; Kessler & Lampert, 2004; Pinel Alloul et al., 2004; Trifonova & Makartseva, 2006; Adamczuk, 2009; Doulka & Kehayias, 2011). However, the lower total zooplankton recorded in the sampling depth A than sampling depth B (Tale 3) points out to the fact that temperature and light played an important role in zooplankton distribution in Awba dam. Huntley (1986) reported that factors involved in regulating habitat selection of zooplankton include light, temperature and food availability. And since many zooplankton species are phototaxic (Buchanan and Haney, 1980), light intensity and food availability appear to be primary factors in the migration. However, selective predation by visually orienting planktivorous fish, larger zooplankton, and invertebrates, as well as other abiotic factors, cannot be ruled out (Dorak *et al*., 2013). To avoid predation, zooplankton migrates downwards to a depth where low light intensity prevents detection by planktivorous fish. Increase in temperature has been associated with a higher abundance and species diversity of zooplankton in lakes (Castro et. al., 2005; Buyurgan et. al., 2010). The genera of Rotifera observed in this study indicated that dam is highly polluted (Saksena, 2006). The positive correlation between temperature and zooplankton can be attributed to the increase of phytoplankton and algae providing food resources for zooplankton (Matsubara, 1993; Ismael and Dorgham, 2003; Castro et. al., 2005). The vertical oxygen profile can limit the depth at which zooplankton species occur. For most zooplankton species 2.3 mg L^{-1} of oxygen is the limiting amount for survival (Dodson, 2005). This may explain why majority of zooplankton is found in depth A to depth C where the oxygen concentration is higher than that value. Indeed, in this study, there is a close relationship between the abundance of Rotifera and Protozoa and water temperature, pH, dissolved oxygen and carbon dioxide. Significant relationships of oxygen, Carbon dioxide, pH and temperature, especially with Rotifera and Protozoa, were evident in Awba dam and showed that the deeper water column had less Rotifera and Protozoa abundances because of lower temperatures and oxygen concentrations and higher acidic medium as a result of higher pH and carbon dioxide concentrations.

The correlations between Cladocera and the physico-chemical parameters except for nitrate concentration and conductivity are not significant. The correlation of Cladocera to nitrate concentration and conductivity is negative, which means that distribution of Cladocera in the dam is may be adversely influenced the conductivity and nitrate concentration. However, this needs further investigation.

The total zooplankton though showed a particular pattern of distribution, individual genus showed no particular pattern of distribution on the sampling days. This could be explained as either due to their abilities to move about as they were disturbed during the sampling days, resulting in different genera being collected on each sampling day at the sampling depths. The total zooplankton distribution shows monthly variation with lowest in March and the highest in May. This shows similar pattern with the increase in rainfall and this is an indication that the total zooplankton in a lake is influenced by the amount of rainfall.

5.0 Conclusion

The water column of the dam seemed to be stratified and thus provide vertical gradients of physico-chemical parameters to make conducive habitat qualities for zooplankton. The surface layer supported more zooplankton than the bottom layer. The vertical distribution of zooplankton along the depth of the dam may have to do with organisms being able to make their habitat choice which they found variable from surface layer to bottom layer. And since the surface water layer seemed to be more conducive, more zooplankton are found in this region; the zooplankton density decrease with depths. Thus physico-chemical parameters play a great role in the distribution of zooplankton in the dam.

6.0 Acknowledgements

I wish to thank Dr. T. I. Ojeizeh for his encouragement in writing this paper and Mr. M. I. Adarabioyo for helping with the statistical analyses.

References

Adamczuk, M. (2009). Predation follows competition in depth selection behaviour of Cladocera in a deep lake (E Poland). *Biol. Lett.*, 46(1), 29.36.

Adebisi, A. A. (1981). The physico-chemical hydrology of a tropical seasonal River –Upper Ogun River. *Hydrobiologia* 79, 157-165.

Akindele, E. O. (2013). Relationships between the physico-chemical water parameters and zooplankton fauna of Tiga Lake, Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences,* 6(1): 95 – 100.

Ana, M. A. S**.,** Paulo, R. M., Maria, C. B. C. S. and José, E. L. B. (2009). Diel vertical migration and distribution of zooplankton in a tropical Brazilian reservoir. *Biotemas*, 22 (1): 49-57.

APHA (1995). *Standard methods for the examination of water and waste water*. American Public Health Association, Washington, USA, 953pp.

Boucherie, M. M. and Zulling, H. (1983). Cladoceran remains as of change in trophic state in three Swiss lakes. *Hydrobiologia*, 103: 141-146.

Boyd, C.E. (1979). *Water quality in warm water fish ponds*. Craftsman printers Inc. Auburn, Alabama 353p.

Bozkurt, A. and Dural, M. (2005). Topboğazı Göleti (Hatay) zooplanktonunun vertikal göçü. *Türk Sucul Yaşam Dergisi* 4: 104–109 (in Turkish).

Bozkurt, A. and Sagat, Y. (2008). Birecik Baraj Gölü zooplanktonunun vertikal dağılımı. *J. Fish. Sci*. 2(3): 332–342 (in Turkish).

Braioni, M. G. and Gelmini, D. (1983). Rotiferi Monogononti. *Guide per il riconoscimento delle specie animali delle acque interne italiane*, 23. Consiglio Nazionale delle Ricerche, Verona: 179 pp.

Brakovska, A. and Škute, R. (2009). Ecological evaluation of zooplankton groups in Lake Geranimovas-Ilzas and lake Garais. *Environment. Technology. Resources Proceedings of the 7th International Scientific and Practical Conference. Volume II © Rēzeknes Augstskola, Rēzekne, RA Izdevniecība.*

Buchanan, C. and Haney, J. F. (1980). Vertical migrations of zooplankton in the Arctic: a test of the environmental controls. In: *Evolution and Ecology of Zooplankton Communities* (Ed. W.C. Kerfoot). University Press of New England, Hanover, NH, USA, pp. 69–79.

Buyurgan, Ö., Altındağ, A. and Kaya, M. (2010). Zooplankton community structure of Asartepe Dam Lake (Ankara, Turkey). *Turk. J. Fish. Aquat. Sci*. 10: 135–138.
Carpenter, K. E. (1928). *Life in inland Waters with an introduction* by Julian S. Huxley. Sidgwick and Jackson, Ltd. 267p.

Castro, B. B., Antunes, S. C., Pereira, R., Soares, A. M. V. M. and Goncalves, F. (2005). Rotifer community structure in three shallow lakes: seasonal luctuations and explanatory factors. *Hydrobiologia* 543: 221–232.

CCME (2011). *Protocols Manual for Water Quality Sampling in Canada*. p3.

Dawidowicz, P., Pijanowska, J. and Ciechomshi, K. (1990). Vertical migration of *Chaoborus* larvae is induced by the presence of fish. *Limnology and Oceanography*, 35: 1631-1637.

Dini M. L. and Carpenter, S. R. (1992). Fish predators, food availability and diel vertical migration in *Daphnia*. *J. Plankton Res,* 14**:** 359-377.

Dodson, S. (1990). Predicting diel vertical migration of zooplankton. *Limnology and Oceanography,* 35: 1195-1200.

Dodson, S. (2005). *Introduction to Limnology*. McGraw-Hill, New York.

Dorak, Z., Gaygusuz, O., Tarkan, A. S. Aydin, H. (2013). Diurnal vertical distribution of zooplankton in a newly formed reservoir (Tahtalı Reservoir, Kocaeli): the role of abiotic factors and chlorophyll a. *Turkish Journal of Zoology*. http://journals.tubitak.gov.tr/zoology/ doi:10.3906/zoo-1206-21.

Doulka, E. and Kehayias, G. (2011). Seasonal vertical distribution and diel migration of zooplankton in a temperate stratified lake. *Biologia*, 66(2), 308.319.

Egborge, A. B. M. (1970). *The hydrology and plankton of the River Oshun*, Western State, Nigeria. M.Sc. Thesis. University of Ibadan. 126p.

Einsle, U. (1996). Copepoda: Cyclopoida. Genera Cyclops, Megacyclops, Acanthocyclops. In: Dumont H.J.F. (ed.), *Guides to the Identifi cation of the Microinvertebrates of the Continental Waters of the World*, 10. SPB Academis Publishing, Amsterdam: 82 pp.

Fernando, C. H. (2002): *A Guide to Tropical Freshwater Zooplankton*; Identification, Ecology and Impact on Fisheries. Backhuys Publishers, Leiden. 291 pp.

Fryer, G. and Iles, J. D. (1972). *The cichlid fishes of the Great lakes of Africa, their biology and evolution.* Oliver and Boyd. Oliver Edinburgh 641p.

Guevara, G., Lozano, P., Reinoso, G. and Villa, F. (2009). Horizontal and seasonal patterns of tropical zooplankton from the eutrophic Prado Reservoir (Colombia). *Limnologica* 39: 128–139.

Haney, J. F., Craggy, A., Kimball, K. and Weeks, F. (1990). Light Control of evening vertical migration by *Chaoborus punctipennis* larvae. *Limnology and Oceanography*, 35: 1068-1078.

Holden, J. N. and Green, J. (1960). The hydrology and plankton of River Sokoto. *Journal of Animal Ecology* 29: 65- 84

Huntley, M. (1986). Experimental approaches to the study of vertical migration of zooplankton. *Contrib. Mar. Sci. Suppl*. 27, p. 7 l-90

Ismael, A. A. and Dorgham, M. M. (2003) Ecological indices as a tool for assessing pollution in El- Dekhaila Harbor (Alexandria, Egypt). *Oceanologia*, 45 (1): 121- 131

Jeje, C. Y. and Fernando, C. H. (1986). *A practical guide to the identification of Nigerian zooplankton*. Nigeria. Kainji Lake Research Inst Publication. p.141

Jeppesen, E., Jensen, J. P. and Sondergaard, M. (2002). Response of phytoplankton, zooplankton and fish to re-oligotrophication: an11-year study of 23 Danish lakes. *Aquatic Ecosystems Health and Management*. 5: 31-43.

Kehayias, G., Michaloudi, E. and Bexi, A. (2004). Aspects on the seasonal dynamics and the vertical distribution of the crustacean zooplankton community and the *Dreissena polymorpha* larvae in Lake Trichonis. *Medit. Mar. Sci.*, 5(1), 19.27.

Kessler, K. and Lampert, W. (2004). Depth distribution of *Daphnia* in response to a deep-water algal maximum: the effect of body size and temperature gradient. *Freshwater Biol.*, 49, 392.401.

Khan, M. A. and Zutshi, D. P. (1980). Contribution to high altitude limnology of Himalayan System I: Limnology and productivity of the plankton community of Nilag Lake, Kashmir. *Hydrobiologia*, 75 No. 2: 103-112.

Koste, W. (1978). *Rotatoria. Die Rädertiere Mitteleuropas*. Koste W. (ed.) Gebrüder Borntraeger. Berlin, Stuttgart: 673 pp.

Lampert, W. (2005). Vertical distribution of zooplankton: density dependence and evidence for an ideal free distribution with costs. *BioMed Central Biology* 3:10. doi:10.1186/1741-7007-3-10. http://www.biomedcentral.com/1741-7007/3/10

Lampert, W. and U. Sommer (1997). *Limnoecology*. New York: Oxford University Press; 1997.

Leibold, M. A. (1990). Resources and predators can affect the vertical distributions of zooplankton. *Limnol Oceanogr*, 35**:** 938-944.

López, C. and Zoppi de Roa, E. (2005). Day-night vertical distribution and feeding patterns of fourth instar of Chaoborus larvae in a neotropical reservoir (Socuy Reservoir, Venezuela). *Int. Rev. Hydrobiol*. 90: 171–184.

Mackereth, F. J. H. (1963). *Some methods of water analysis for limnologists*. Freshwater biological Asso. Scientific publication No. 21, 69p.

Margaritora, F. (1983). Cladoceri. *Guida per il riconoscimento delle specie animali delle acque interne italiane*, 22. Consiglio Nazionale delle Ricerche, Verona: 169 pp.

Matsubara, T. (1993). Rotifer community structure in the south basin of Lake Biwa. Hydrobiologia 271: 1–10.

Mills, E. L., Green, D. M. and Schiavone, A. Jr. (1987). Use of zooplankton size to assess community structure of fish populations in freshwater lakes. *Journal of North American Fisheries Managemen*t 7(3):369-378.

Nogrady, T. & Segers, H. (2002). Rotifera. Volume 6: Asplanchnidae, Gastropodidae, Lindiidae, Microcodidae, Synchaetidae, Trochospaeridae and Filinia. In: Dumont H.J.F. (ed.), *Guides to the Identification of the Microinvertebrates of the Continental Waters of the World*, 18. Backhuys Publishers, Leiden: 265 pp.

Olagbemide, P. T. (2011). Phytoplankton density in Awba dam at different depths. *International Journal of Bioscience*, Volume 6, Number 1, 45-49.

Olaniyan, C. I. O. (1969). The seasonal variation in the hydrology and total plankton of the Lagoons of South West, Nigeria. *Nig. J. of Science*. Vol.3, No. 2, pp.101-119

Pace, M. L. (1986). An empirical analysis of zooplankton community size structure across lake trophic gradients. *Limnol. Oceanogr*. 31: 45-55.

Pilkaityte, R. and Razinkivas, A. (2006): Factors Controlling Phytoplankton Blooms in a Temperate Estuary: Nutrient Limitation and Physical Forcing. *Hydrobiologia*, 555: 41-48.

Pinel-Alloul, B., Methot, G. and Malinsky-Rushansky, N. Z. (2004). A short-term study of vertical and horizontal distribution of zooplankton during thermal stratification in Lake Kinneret, Israel. *Hydrobiologia*, 526, 85-98.

Primicerio, R. (2000). Seasonal changes in vertical distribution of zooplankton in an oligotrophic, subarctic lake (Lake Takvatn, Norway). *Limnologica*, 30, 301.310.

Primicerio, R. and Klemetsen, A. (1999). Zooplankton seasonal dynamics in the neighbouring lakes Takvatn and Lombola (northern Norway). *Hydrobiologia*, 411, 19-29.

Ramesh. N. and Krishnaiah, S. 2014). Assessment of physico-chemical parameters of Bellandur Lake, Bangalore, India. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 3, Issue 3, March 2014, ISSN: 2319- 8753, pp 10402-10407.

Rocha, O; Matsumura-Tundisi, T; Espindola, E. L. G; Roche, K. F. and Rietzler, A. C. (1999). Ecological theory applied to reservoir zooplankton, p. 29-51. *In* Tundisi, J.G & M. Straskraba (eds.). *Theoretical reservoir ecology and its applications*. International Institute of Ecology, Brazilian Academy of Sciences. Backhuys Publishers, Leiden, Holland.

Rogozin, A.G. 2000. Specific Structural Features of Zooplankton in Lakes Differing in Trophic Status: Species Populations. *Russ. J. Ecol.* 31: 405-410.

Saksena, D. N. (2006). *Rotifers as Indicators of Water Quality* (Published). School of Studies in Zoology, Jiwaji University, Gwalior. Retrieved from: http://www3.interscience.wiley.com/journal/

Sendacz, S. (1984). A study of the zooplankton community of Billing Reservoir-Sao Paulo. *Hydrobiologia*. 113: 121-127.

Stich, H. B. & Lampert, W. (1981). Predator evasion as an explanation of diurnal vertical migration by zooplankton. *Nature*, 293, 396.398.

Tallberg, P., Horppila, J., Vaisanen, A., Nurminen, L. (1999). Seasonal succession of phytoplankton and zooplankton along a trophic gradient in a eutrophic lake- implications for food web management. *Hydrobiologia*. 412: 81-94.

Trifonova, I. S. and Makartseva, E. S. (2006). Seasonal and longterm dynamics of phyto- and zooplankton and their relationships in a mesotrophic lake. *Biol. Vnutr. Vod*, 3, 18.25 (in Russian).

Verma, J. P. (2002). Ecological indicators of water quality. *Ecology of polluted water*, Vol. 1, pp 453-758.

Visser, S. A. (1974). Composition of waters of lakes and Rivers in East and W/Africa. *The African Journal of Tropical hydrobiology and fisheries* Vol. 3: No. 1.

Welcome, R. L. (1976). Some general and theoretical considerations on fish yield of African rivers. *J. Fish Biol*. 8: 351-364.

Whitmore, E. A. and Webster, K. E. (2008). *Zooplankton community structure and dynamics in lakes of contrasting water clarity in Acadia National Park.* School of Biology and Ecology, University of Maine, Orono. Pp47.