DIVERSITY INDICES OF ZOOPLANKTON IN LAKE ALAU, NORTH-EAST ARID ZONE OF NIGERIA

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ABSTRACT
Zooplankton species of Lake Alau were investigated in five stations, designated as station A, B, C, D and E ($S_{A,}$ $S_{B,}$ S_C $S_{D,}$ S_E). The sampling was done in the morning before 8:00 am, on monthly basis for a period of ten months (July 2012 to April 2013) covering both wet and dry seasons and analysed. Pour-through method was used to collect the samples. The results show that the monthly trend of Shannon-Weiner index for the Lake decreased as follows: January > November > December > February > October > March > April > July > August > September. The maximum (2.119) values of zooplankton species diversity was recorded in January whereas the minimum (1.911) was observed in September. The concentration of dominance was in the order September > August > July > April > October > March > February > December > November > January. The species richness index ranged from 1.564 (April) to 1.414 (July). The equitability or evenness index was highest in January (0.920) and least (0.830) in September. Species heterogeneity was in the order January > November > December > February > March > October > July=April > August > September. The trend of Shannon-Weiner index for stations in Lake Alau was depicted as $S_A>S_B>S_D>S_C>S_E$. The minimum value (2.021) of zooplankton species diversity was recorded in S_A where as the minimum (1.875) was observed for $S_{E.}$ In conclusion, Lake Alau is fairly rich in terms of zooplankton abundance and diversity. More intensive study of the zooplankton species in Nigerian lakes will lead to the documentation of other species and wider distribution of many others than those that were recorded in the current study. This will lead to greater understanding of the factor that controls the distribution of these species.
Keywords: Zooplanktons Species, Diversity index, Lake Alau, Arid zone, Season.

INTRODUCTION

Lake Alau is the second largest lake in the arid region of Borno State after Lake Chad. Its importance is not only for fish production, but also because of its domestic use by the people of Maiduguri. In addition, it has the potentials to serve industrial establishments and irrigation (Nwoko, 1991). Successful management of aquatic ecosystems such as the Lake Alau requires fundamental knowledge of dynamic interactions among its various components. Thus, monitoring the biological and physio-chemical characteristics of the lake in time and space is vital for both short and long term sustainable exploitation of the aquatic resources. It will provide an early warning signal for decisions to be made and action taken to minimize impending deleterious effects on the water quality, and any other purpose the water might be intended to serve. In the long-term, it can provide greater insight into why problems occur, help to discern trends and assess potential remedies (Nwankwo, 1990).

Zooplankton species inhabit all freshwater habitats of the world, including industrial and municipal waste water (Mukhopadhyay *et al.,* 2007), and they play an important part in the food chain as primary consumers and also serve as food for the higher tropic levels (Qasim, 1997). However, because zooplankton are closely linked to the environment and they tend to respond to changes more rapidly than do larger aquatic animal such as fish, they have proved valuable indicators of apparent and subtle alterations in the quality of aquatic environment (Marine Biology Organization (MBO), 2007). Zooplankton may show the effect of low level of chemical pollution in a water body and are good indicators of pollution in biological monitoring (Rutherford *et al.,* 1999; Soberon *et al.,* 2000; MBO 2007).

Freshwater zooplankton comprises three major groups of invertebrate animals; the rotifers, copepods, and cladocerans (Wallace and Snell, 1991). The rotifers constitute a phylum found almost exclusively in freshwater. The copepods and cladocerans are both groups of the large subphylum Crustacea. Copepods constitute a class that is widespread in both freshwater and marine environment. Cladocerans constitute a group of four orders living primarily in freshwater environments. All three of these major groups have species adapted to Pelagic (open water), or littoral (vegetated), and benthic (bottom) environment. However, Soil Water Conservation Society of Metro Halifax (SWCSMH, 2007) pointed out that freshwater zooplankton are dominated by four major groups of animals; protozoa, rotifers, and two sub-classes of the crustacean, the cladocerans and copepods. The planktonic protozoa have limited locomotion, but the rotifers, cladoceran and copepod micro crustaceans, and certain immature insects larvae often move extensively in quiescent water.

Zooplankton play an important role in energy transfer from primary producers to secondary consumers higher in the food web, therefore its productivity is generally tightly coupled with phytoplankton productivity (Mallin & Pearl, 1994), in that phytoplankton serve as food for zooplankton which in turn serves as food for fish. According to Suantama (2004), an advantage of zooplankton as fish food is that they contain lower amount of environmental toxin than organisms higher up the food chain. This is because environmental toxins accumulate as they move up the food chain. With the exception of Fasesan (2000), there has not been any study of zooplankton populations in Lake Alau. Furthermore, the relative importance of individual phylum has not been fully evaluated in any lake in Borno State. Therefore, this study is necessary to update information on the species diversity index in Lake Alau, North East Arid Zone of Nigeria. In view of this, the objective of this study is to assess and to compare the zooplankton diversity indices in Lake Alau in relation to its richness and evenness index.

MATERIALS AND METHODS

Study Area

Lake Alau is located between latitude 12 °N and 13 °N and longitude 11 °E and 13 °E with the total surface area of 56 km^2. The climate is Sahelian with two distinct seasons. The rainy season starts from June and end in September, with a mean annual rainfall of about 600mm, the dry harmattan season precedes rainy season and starts from October to February. During the dry harmattan very low temperatures between 16-19 °C occur and the cold dry harmattan wind with temperature values of between 26 and 29 °C. The dry hot season is from March to May, marking the driest period with intense heat. During these period temperature values of 46 to 48 °C have been recorded (Chad Basin Development Authority [CBDA], 1986; Bankole *et al.,* 1994; Fasesan, 2000; Idowu, 2004).

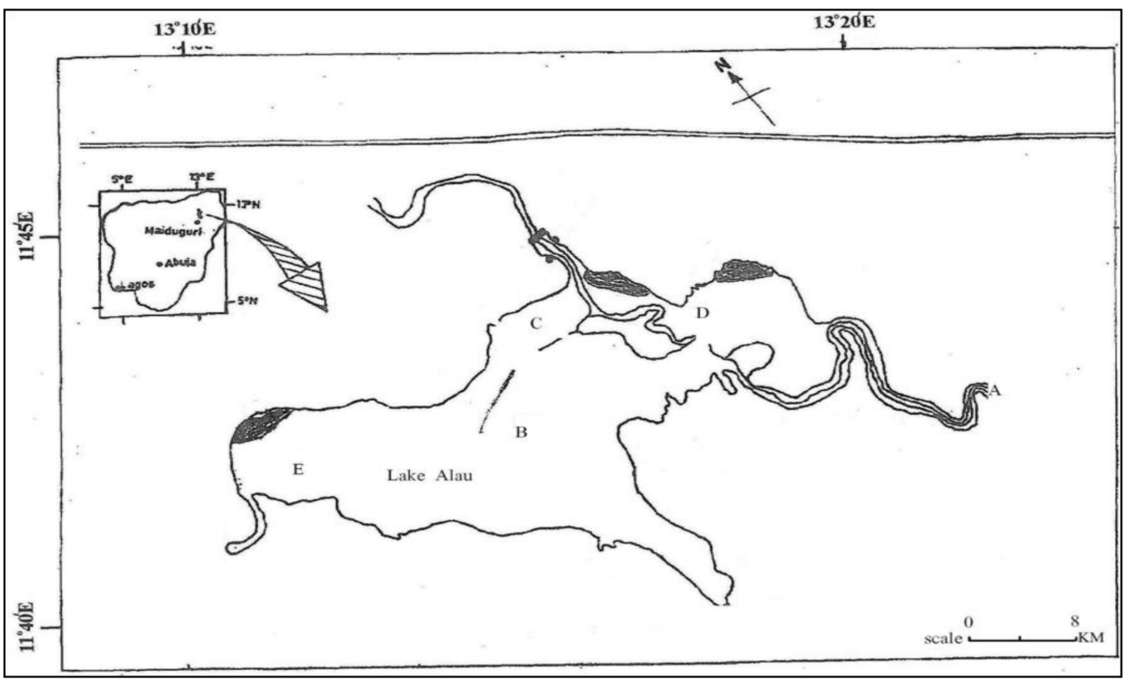

Fig. 1: Map of Lake Alau showing sampling stations (inset: Map of Nigeria showing location of Lake Alau)
Source: Abubakar *et al.* (2011)
Key: A= Ngawofete B= Usmanti C= Spillway D= Abbari E= Dam site

Sampling Stations

Sampling station was chosen based on preliminary surveys of the lake and factors such as average depth, volume of water, accessibility, security and various activities taken place in and around the lake was given high consideration (Figure 1).

Sampling Frequency and Duration of Study

The sampling was done in the morning before 8:00 am on monthly basis from July 2012 to April 2013. Pour- through method was used to collect the samples. A 10-liter graduated bucked was used to collect water at a depth of about 30cm below the water surface, and pour into a plankton net of mesh size 80 µm, this was done 10 times to make a total of 100 litres of filtered water. This was then transferred into labeled collecting bottles and preserve in 5% formalin. The samples were taken to the laboratory for further analysis.

After they were taken to the laboratory, each preserved plankton sample was poured into a graduated centrifuge tube and centrifuged using a 'Gallen Kamp- Medico' model (90) centrifuge. This was allowed to settle and the supernatant decanted. After decanting the concentrated plankton was analyzed. A pipette was used to place the concentrated plankton on a glass slide with a cover slip and then viewed under a binocular microscope model BH2 and an Olympus microscope model AH2 Vanox 7. The plankton were then identified (qualitative analysis) and counted (quantitative analysis) using standard identification keys and taxonomic guide (Pennak, 1979; Jeje and Fernando, 1986). The above processes were repeated four times, in order to determine the abundance and diversity of zooplankton at the five stations.

Statistical Analysis

The estimation of species abundance and diversity of zooplankton was done using Margalef's Diversity Index (D), Shannon-Wiener Diversity Index (H^I) and Simpson's Index (D) methods (Simpson, 1949). The fauna similarities at different sites based on nominal data, were analyzed using indices of Jackson (1989). The relative abundance of taxa that were common among the tributaries was calculated using Renkonen similarity (1975). Simpson index (d) and Jackknife Estimator (S) were employed to evaluate species richness. The Shannon-Weiner index (H) and evenness index (E) of Shannon and Wiener(1963) were used to evaluate species diversity. Jackknife index (S) estimate was employed to account for the probability of missing some of the actual total number of species present in any count based on a sample population.

RESULTS

Table 1 shows the monthly zooplankton diversity index of Lake Alau for the months studied. The monthly trend of Shannon-Wiener index for the lake can be depicted as January is higher than November is higher than December is higher than February is higher than October is higher than March is higher than April is higher than July is higher than August is higher than September. The maximum (2.119) values of zooplankton species diversity was recorded in January whereas the minimum (1.911) was observed for September. The concentration of dominance was in the order September is higher than August is higher than July is higher than April is higher than October is higher than March is higher than February is higher than December is higher than November is higher than January. The species richness index ranged from 1.414 (July) to 1.564 (April). The equitability or evenness index was highest in January (0.920) and lowest (0.830) in September. Species heterogeneity was in the order January is higher than November is higher than December is higher than February is higher than March is higher than October is higher than July have the same value with April, and April is higher than August is higher than September.

TABLE 1: MONTHLY DIVERSITY INDICES OF ZOOPLANKTON SPECIES OF LAKE ALAU NIGERIA (JULY, 2012 TO APRIL, 2013)

Months	Number of species	Number of individuals per litre	Diversity Indices				
			Species richness index (*d*)	Shannon-Weiner index (H')	Equitability index (*J*)	Simpson's index (*D*)	Species heterogeneity (1 – *D*)
July	10	581	1.414	1.964	0.853	0.168	0.832
August	10	546	1.428	1.935	0.840	0.175	0.825
September	10	567	1.419	1.911	0.830	0.185	0.815
October	10	385	1.512	2.007	0.872	0.162	0.838
November	10	404	1.500	2.066	0.897	0.147	0.853
December	10	372	1.521	2.043	0.887	0.153	0.847
January	10	349	1.537	2.119	0.920	0.135	0.865
February	10	355	1.533	2.036	0.884	0.156	0.844
March	10	391	1.508	2.005	0.871	0.158	0.842
April	10	316	1.564	1.982	0.861	0.168	0.832

The trend of Shannon-Wiener index for stations on Lake Alau (Table 2) depicted as S_A is higher than S_B is higher than S_D is higher than S_C is higher than S_E. The minimum value (2.021) of zooplankton species diversity was recorded in S_A whereas the minimum (1.875) was observed for $S_{E.}$ The concentration of dominance was in the other S_C is higher than S_D is higher than S_E is higher than S_A is the same as that of $S_{B.}$ The species richness index ranged from 0.926 (S_E) to 1.194 (S_A). The Equitability or evenness index was highest in S_E (0.963) and least (0.908) in $S_{C.}$ Species heterogeneity was in the order S_A is the same as that of S_B is higher than S_E is higher than S_D is higher than $S_{C.}$

TABLE 2: DIVERSITY INDICES OF ZOOPLANKTON SPECIES AT VARIOUS STATIONS IN LAKE ALAU NIGERIA (JULY, 2012 TO APRIL, 2013)

Stations	Number of species	Number of individuals per litre	Diversity Indices				
			Species richness index (*d*)	Shannon-Wiener index (H')	Equitability index (*J*)	Simpson's index (*D*)	Species heterogeneity (1 – *D*)
Station A	9	812	1.194	2.021	0.920	0.151	0.849
Station B	9	957	1.166	2.016	0.917	0.151	0.849
Station C	8	912	1.027	1.888	0.908	0.170	0.830
Station D	8	934	1.024	1.894	0.911	0.168	0.832
Station E	7	651	0.926	1.875	0.963	0.160	0.840

DISCUSSION

The richness of the rotifers within Lake Alau is low compared with what was obtained in some southern Nigeria Lakes, and this may be attributed to influences such as climate change, aridity, and other environmental factors within each station. The differences may also be associated with trophic state as well as geographical factors (Arora and Naresh, 2003) in Yamuna River. Egborge (1981) recorded 78 species in Asejire Lake, Jeje and Fernando, (1986) recorded 65 species in Adada, Bonny and Oguta lakes. The average zooplankton species per station is higher in comparison with previous studies in northern Nigeria lakes. For example, Abdullahi (1989) observed 18 species from Tiga Lake in Kano, Ovie *et al.*, (2000) recorded 13 species in Kainji Lake. This is particularly remarkable knowing that the sampling assessed was done in an arid lake with very low rainfall and shallow water depth. A higher number would be expected if greater sampling frequency at a deeper depth was employed. Also low rain with reduced vegetation had a greater effect on the qualitative and quantitative level of zooplankton species.

The highest species recorded by Arora and Naresh (2003), and Egborge (1981) was associated with high vegetation which provides anchorage to the resting eggs and larva stage of zooplankton in those water bodies studied. Species abundance of zooplanktons varies widely between stations within study. It is difficult to make a definite conclusion on the causes of the species pattern but we can suggest that the depth significantly contribute, even though flow of water from the source through all other stations as well as homogeneity of the stations may be one of the factors to be considered.

Our result shows that the distribution of zooplankton varied among depths, some species recorded here are likely to be limited in their distributions by their tolerance to environmental conditions and their preferences for food quality and quantity. Not all the identified species were present in all the five stations. For instance, *B. falcatus* was totally absent in station A, *Daphnia spp* absent in station C and E, *Camtocercus* spp absent in station B and E, *Chydorus* spp absent only in station D, while *Metacyclops* spp was totally absent in station C, D and E, which agrees with the findings of Idowu *et al.*, (2008) that the determinant species (concentration) was depth played a vital role. Idowu, (2004) observed that majority of zooplankton were found to be sensitive to low, medium or high levels of illumination, and as transparency changes, their positions in the water column also changed. Zooplankton species diversity expressed as the number of species or combined abundance and number of species in Shannon-index was very low compared with what was obtained in Oguta Lake. But it was higher in Lake Alau compared with what was obtained in Tiga Lake (Abdullahi, 1989). Ovie (1993), also suggest that flow velocity may be particularly important as a determining factor of composition and diversity of zooplankton assemblage. Vertical migration with suspect to change in temperature can also be considered as limiting factor for zooplankton occurrence in Lake Alau for the variation in their distribution in relation to depth and stations. More intensive study of the pelagic rotifers in Nigerian Lakes will lead to the documentations of other species and wider distribution many others than those that were recorded in the current study. This will lead to greater understanding of the factors that controls the distribution of these species.

CONCLUSION

The presence of typical zooplankton species, notwithstanding other limnological features strongly suggests that the water body is maintaining an Oligo-mesotrophic status. Lake Alau is fairly rich in terms of zooplankton abundance and diversity. In order to uphold the United Nation Charter (1992) that all species and habitats should be safeguarded to the extent that is technically, economically and politically feasible, the following recommendation is hereby suggested. Settlement around Lake Alau should be encouraged to adopt environmentally friendly initiated by embracing low and non-waste technologies (LNWT) at all stages of product life. Monitoring of the Lake should be encouraged as part of environmental management policy, so as to control the effluents that enters each station, through canals, washing, etc. and hence maintains acceptable limits of metal concentration, such as phosphate-phosphorus that encourages eutrophication of Lake which will adversely affect the zooplankton community as well as the whole ecosystem. Substantial limnological research information has occurred from a relatively short period of research work, long period oriented study becomes increasingly vital and desirable. In doing so, further prolong research would provide a broader understanding of this very economically and scientifically important water body in the arid zone. In addition, the knowledge derived could be used as an index for other man-made lakes in arid zones. More intensive study of the zooplankton and fish species in Nigerian lakes will lead to the documentations of other species and wider distribution of many others than those that were recorded in the current study. This will lead to greater understanding of the factor that controls the distribution of these species.

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