



Research Article

Composition, Abundance and Diversity Indices of Zooplankton  
in Lake Alau, Borno State Nigeria

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ABSTRACT

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The occurrence and abundance of zooplankton in lake Alau were documented during the rainy and dry seasons (July, 2012 to April, 2013) in station A, B, C, D and E respectively. The sampling was done in the morning before 8:00am on monthly basis. Pour-through method was used to collect the samples and analysed. A total of ten species belonging to four families were identified. The research reveals that seasonal population abundance and species composition of zooplankton envisaged *Brachionidae* (59.52%) as the dominant specie, followed by *Asplanthidae* (22.22%) *Cladocera* (10.76%) and *Copepoda* (7.50%). Throughout the study period, five species of rotifers, three species of *Cladocera* and two species of *Copepoda* were identified. Not all of the identified species were found in all the five stations, thus indicating that depth play a vital role in their vertical migration. Shannon-Weiner index showed that station A (2.021) and B (2.016) have high species diversity index compared to station C, D, and E (1.888, 1.894 and 1.875) respectively. Equitability index revealed that all the stations were within 0.908 to 0.963 ranged. Simpson's index shows that station C (0.170) has the highest diversity index while station A and B had the same value of 0.151 as the least. Lake Alau is fairly rich in terms of zooplankton population and abundance. The presence of typical zooplankton species, notwithstanding other limnological features strongly suggests that the water body is maintaining an Oligo-mesotrophic status. More intensive study of the zooplankton species in West African arid region 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.

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## INTRODUCTION

Zooplankton species inhabit all freshwater habitats of the world, including industrial and municipal waste water (Mukhopadhyay *et al.*, 2007; Gutzeit and Ludwig-Muller 2014), and they play a very important role in the food chain as primary consumers and also serving as food for the higher trophic levels (Qasim, 1997; Usman *et al.*, 2014). However, because the 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). They indicate 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; Zhu *et al.*, 2014).

According to Wallace and Snell (1991), the freshwater zooplankton comprises three major groups of invertebrate animals; the rotifers, copepods and cladocerans. The rotifers constitute a phylum found almost exclusively in freshwater. The copepods and cladocerans are both groups of the large subphylum crustaceans. 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 (Juhua *et al.*, 2016). 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 productivity is generally tightly coupled with phytoplankton productivity (Mallin and Pearl 1994; Mustapha 2010; Gutzeit and Ludwig-Muller 2014) 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.

Lake Alau is the second largest lake in the arid region of Nigeria after Lake Chad. Its importance is not only for fish production but also because of its other uses to the people of Borno state, Nigeria for domestic purposes (Usman *et al.*, 2014). As a tributary to Lake Chad, successful management of aquatic ecosystem such as the Lake Alau requires basic knowledge of dynamic interactions among its various components. Thus, monitoring the biological and physico-chemical characteristics of the lake in time and space is vital for both short term and long term sustainable exploitation of the aquatic resource (Stephen *et al.*, 2008; Shamir *et al.*, 2015). 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. However, it can provide greater insight into why problems occur; help to discern trends and assess potential remedies (Abubakar *et al.*, 2011; Martin and Madelene 2016; Shamir 2017). With the exception of Fasesan (2000), there has not been any study of specific zooplankton populations. Therefore, this study is necessary to update information on the species composition and abundance in lake Alau, arid zone of West Africa. The objective of this study is to assess and compare the zooplankton composition and distribution of lake Alau in relation to its diversity and abundance.

## MATERIALS AND METHODS

### Study area

The choice of lake Alau in Borno state of Nigeria stems not only for its importance as a source of fish production but also because of its other uses to the people of the entire catchment. Lake Alau is located between latitude  $13^{\circ} 24'N$  and  $13^{\circ} 29'N$  and longitude  $11^{\circ} 68'E$  and  $11^{\circ} 71'E$  with the total surface area of  $56\text{km}^2$  of the dam site. The climate is sahelian with two distinct seasons. A rainy season start from June to

September, with a means annual rainfall of about 600mm, the dry harmattan season precedes rainy season and starts from October to February. In a period of very low temperature between 16-19<sup>0</sup>C and cold dry harmattan wind with temperature value of between 26 and 29<sup>0</sup>C. The dry hot season start from

March to May, marking the driest period with intense heat. During this period temperature value of 46-48<sup>0</sup>C has been recorded (Chad Basin Development Authority [CBDA], 1986; Bankole *et al.*, 1994; Fasesan 2000; Idowu 2004; Abubakar *et al.*, 2011; Usman *et al.*, 2014).



**Figure 1:** Google map of Lake Alau showing sampling stations

### Sampling stations

Five sampling stations 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 8:00am 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 150-300  $\mu$ m, this was done 10 times to make a total of 100 litres of filtered water. This was then transferred into labelled collecting bottles and preserve in 5% formalin. The samples were taken to the laboratory for further analysis.

Having taken to 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 Supe-natant decanted. After decanting the concentrated plankton was analyzed. A dropping pipette was used to place the concentrated plankton on a glass slide with a cover slip and then viewed under a wild binocular microscope model BH2 and wild Olympus universal microscope model AH2 Vanox 7. The plankton was therefore identified (qualitative analysis) using standard identification keys and Chart to identify them to species level in addition the taxonomic guide according to Pennak, (1979); Jeje and Fernando (1986) and then counted (quantitative analysis). The above processes were repeated four times, in order to determine the abundance and diversity of zooplankton at the five stations.

### Statistical analysis

The evaluation of species abundance and diversity of zooplankton was done using Margalef's Diversity Index(D), Shannon-Weiner Diversity Index( $H^1$ ) and Simpson's Index(D) methods (1949). The faunal similitude 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 ( $H^1$ ) and evenness index (E) of Shannon-Weiner (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 zooplankton species recorded during the study in relation to numbers per litre, and percentage as summarized. In total, ten (10) species

belonging to four (4) families were identified. The result dominated by family *Brachionidae* comprising a significant fraction 59.52% include *Branchionus bidentata*, *B.caudatus*, *B.calyciflorus* and *B.falcatus* with 19.10%, 19.90%, 12.05% and 8.46% respectively. This is followed by *Asplanchna sieboldi* (22.22%) which is the only specie from the family *Asplanchnidae*. Other less prominent species arranged in the descending order of percentage were *Chydorus spp.* (4.95%), *Daphnia spp.* (3.12) and *Camtocercus spp.* (2.70%) in family *Cladocera* (10.76%). The least percentage are 5.41% (*Diaptomus spp.*) and 2.09% (*Metacyclops spp.*) found in *Copepoda* family (7.50%).

**Table 1:** Monthly Composition of Zooplankton in Lake Alau (No./litre) and percentage

Family	Species	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total	%	%
<i>Asplanchnidae</i>	<i>A. sieboldi</i>	160	92	97	111	57	94	74	81	97	85	948	22.22	22.22
<i>Brachionidae</i>	<i>B. bidentata</i>	104	80	140	59	65	64	64	89	80	70	815	19.10	
	<i>B. caudatus</i>	106	166	161	62	101	70	35	31	61	56	849	19.90	
	<i>B. calyciflorus</i>	73	70	45	50	61	33	56	48	56	22	514	12.05	59.52
	<i>B. falcatus</i>	48	65	38	30	35	35	31	32	27	20	361	8.46	
<i>Cladocera</i>	<i>Daphnia spp</i>	14	14	21	12	14	11	13	11	10	13	133	3.12	
	<i>Camtocercus spp</i>	12	11	12	9	12	13	16	12	9	9	115	2.70	10.76
	<i>Chydorus spp</i>	23	21	19	23	22	22	23	21	21	16	211	4.95	
<i>Copepoda</i>	<i>Diaptomus spp</i>	31	20	23	21	27	21	28	20	21	19	231	5.41	
	<i>Metacyclops spp</i>	10	7	11	8	10	9	9	10	9	6	89	2.09	7.50

## Relative species in stations

The samples from the five stations showed relevant difference in number of taxa and relative abundance of zooplankton (Table 2). All the species occurred throughout the depth (30cm) except *B. falcatus* which was absent in station A. The most well represented species in all the stations were *A. sieboldi*, *B.bidentata*, *B. caudatus* and *B. calyciflorus*. The

highest values representing the peak were recorded between station D and B in all the stations which are varied between 214 -231 organism per litre. The least concentration was observed in station C (30 organisms per liter). *Daphnia spp.* was absent in station C and E, in the same vein *Camtocercus spp.* was also absent in station B and E throughout the study. However, *Chydorus spp.* was absent in station

D and *Metacyclopes spp.* was absent in station C, D and E.

**Table 2:** Composition of Zooplankton (No. /litre) of Lake Alau at the various stations

Family	Species	Stations					Total
		A	B	C	D	E	
Asplanchidae	<i>A. sieboldi</i>	197	231	204	185	131	948
Brachionidae	<i>B. bidentata</i>	147	157	180	214	117	815
	<i>B. caudatus</i>	145	179	207	202	116	849
	<i>B. calyciflorus</i>	85	107	111	101	110	514
	<i>B. falcatus</i>	0	88	79	106	88	361
Cladocera	<i>Daphnia spp</i>	50	49	0	34	0	133
	<i>Camtocercus spp</i>	32	0	36	47	0	115
	<i>Chydorus spp</i>	64	31	65	0	51	211
Copepoda	<i>Diaptomus spp</i>	48	70	30	45	38	231
	<i>Metacyclops spp</i>	44	45	0	0	0	89

Zooplankton species diversity indices of lake Alau studied is presented in table 3. The monthly trend of Shannon-Weiner index for the Lake can be depicted as 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 for September. The concentration of dominance was in

the order September > August > April=July > 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 > April=July > August > September.

**Table 3:** Monthly Diversity indices of zooplankton species of Lake Alau

Months	No. of Species	No. of Individuals per Litre	Diversity Indices				
			Species Richness Index ( <i>d</i> )	Shannon-Weiner Index ( $H^1$ )	Equitability Index ( <i>J</i> )	Simpson's Index ( <i>D</i> )	Species Heterogeneity ( $1 - D$ )
Jul	10	581	1.414	1.964	0.853	0.168	0.832
Aug	10	546	1.428	1.935	0.840	0.175	0.825
Sept	10	567	1.419	1.911	0.830	0.185	0.815
Oct	10	385	1.512	2.007	0.872	0.162	0.838
Nov	10	404	1.500	2.066	0.897	0.147	0.853
Dec	10	372	1.521	2.043	0.887	0.153	0.847
Jan	10	349	1.537	2.119	0.920	0.135	0.865
Feb	10	355	1.533	2.036	0.884	0.156	0.844
Mar	10	391	1.508	2.005	0.871	0.158	0.842
Apr	10	316	1.564	1.982	0.861	0.168	0.832

The trend of Shannon-Weiner index for stations of lake Alau (Table 4) can be depicted as  $S_A > S_B > S_D > S_C > S_E$ . The minimum value (2.021) of zooplankton species diversity was recorded in  $S_A$  whereas the minimum (1.875) was observed for  $S_E$ . The concentration of dominance was in the other  $S_C > S_D >$

$S_E > S_A = S_B$ . 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  $S_A = S_B > S_E > S_D > S_C$ .

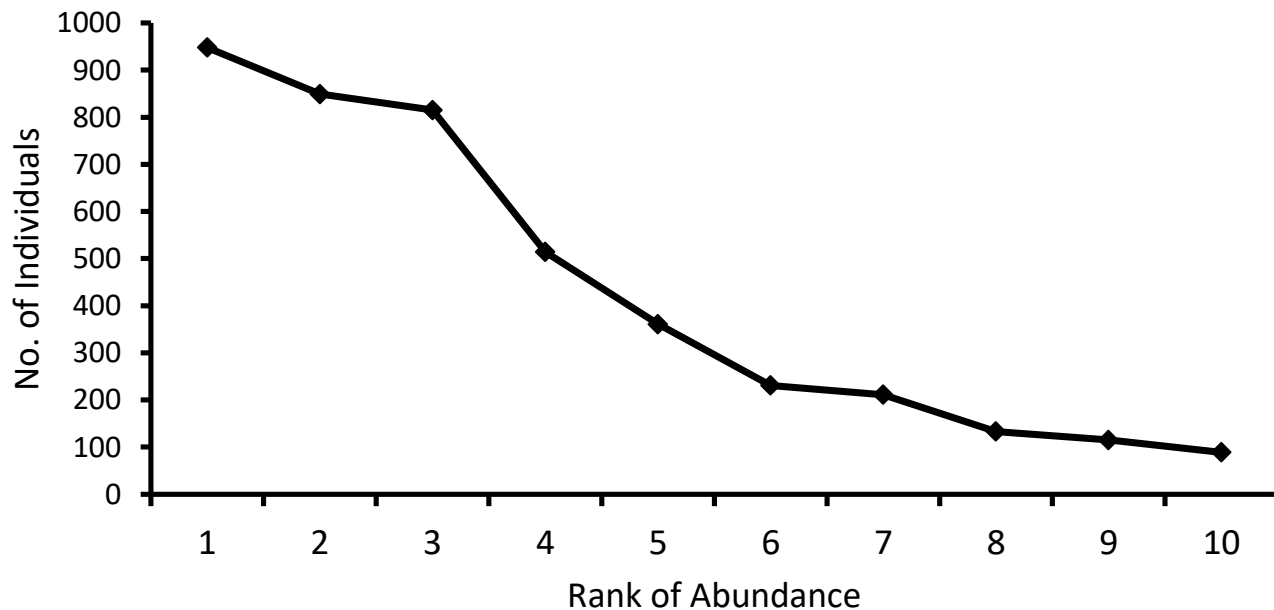
**Table 4:** Diversity indices of zooplankton species at various stations of Lake Alau

Stations	No. of Species	No. Of Individuals per Litre	Diversity Indices				
			Species Richness Index ( $d$ )	Shannon-Weiner Index ( $H^1$ )	Equitability Index ( $J$ )	Simpson's Index ( $D$ )	Species Heterogeneity ( $1 - D$ )
A	9	812	1.194	2.021	0.920	0.151	0.849
B	9	957	1.166	2.016	0.917	0.151	0.849
C	8	912	1.027	1.888	0.908	0.170	0.830
D	8	934	1.024	1.894	0.911	0.168	0.832
E	7	651	0.926	1.875	0.963	0.160	0.840

**Relative abundance**

The species abundance data was plotted as a rank abundance curve following Whittaker (1965). Each species is represented by a point on the line graph

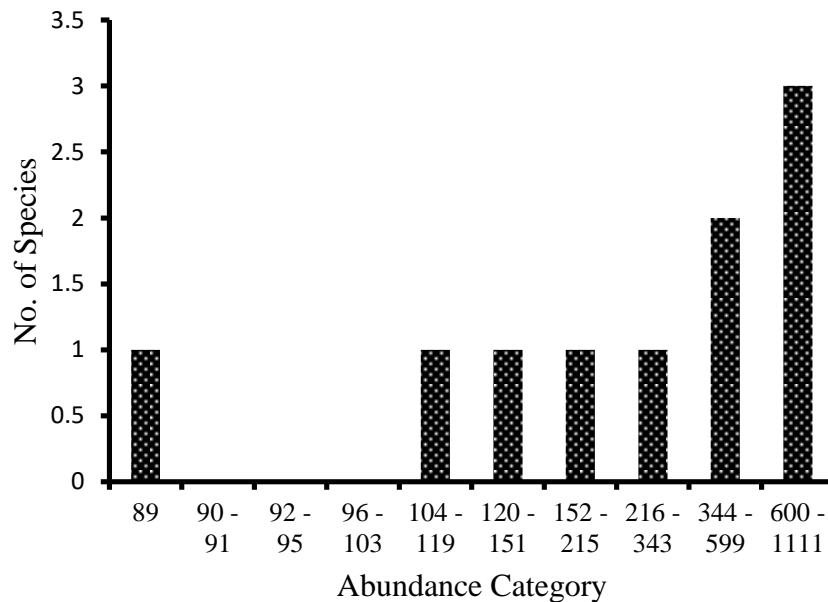
proportional to its abundance. Figure 2 shows the rank abundance plot, the long tail depicts rarer species hence the zooplankton community of lake Alau can be said to have high to moderate evenness.



**Figure 2:** Rank-abundance curve for the zooplankton community of Lake Alau West Africa

In other to deal with the skewed nature of the rank abundance plot, the species abundance were transformed using Preston's (1948) method to give a

long-normal distribution of species abundance (Figure 3).



**Figure 3:** Log Abundance Plot of zooplankton species in Lake Alau West Africa

## DISCUSSION

The taxonomic dominance of Rotifera as reported in this study has been reported in several other water bodies. This pattern is common in tropical and subtropical freshwater, whether in lakes, ponds, reservoirs, rivers or streams (Green, 1960; Jeje and Fernando, 1986; Cavlli *et al.*, 2001; Nogueira, 2001; Sampaio *et al.*, 2002; Neves *et al.*, 2003; Kudari *et al.*, 2005; Imoobe and Akoma, 2008, 2009; Arimoro and Oganah, 2010; Usman *et al.*, 2014). The species composition of zooplankton with dominance of rotifers was also observed by Olaifa and Leilei (2007) in Ekole River. Mathivanan *et al.*, (2007) also notice dominance of rotifers in Cauvery river, with the predominance genus usually being *Brachionus*, *Keratella* or *Lecane*. In this study a total of 10 zooplankton species were identified belonging to 3

genera and 4 families. The rotifer fauna was dominated by the family *Brachionidae*, comprising a significant fraction 59.52% of the general species. An investigation of the family wise representation of recorded species depicted the relative quantitative sequence to be *Branchionidae* > *Asplanthidae* > *Cladocera* > *Copepoda*.

Rotifers in general, feed on detrital materials, bacteria and small algae and are capable of filtering one thousand time their own body volume in one hour (Bronmark and Hansson, 1998). In addition to the availability of food, the numerical abundance of rotifers in aquatic environments has been attributed to their parthenogenetic reproductive pattern and that they are S-strategist organism, with a short life cycle under favorable conditions, and a wide tolerance to fluctuation of environmental factors (Herzig, 1983;

Pourriot *et al.*, 1997; Wetzel, 2001; Neves *et al.*, 2003).

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, physico-chemical and biological components within each station may also be associated with tropic state as well as geographical factors observed by Arora and Narish (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 less compared with previous studies in northern Nigeria lakes. For example, Abdullahi (1989) observed 18 species from Tiga Lake in Kano, Ovie (1991), recorded 13 species in Kainji Lake. This is especially remarkable that the sampling assessed was from the arid lake with very low rain, as well as surface water sampled. 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 composition and abundance of zooplankton varies widely between stations. 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 factor to be considered.

However, this research revealed 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); Idowu and Gadzama (2011) that the major determinant of the 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 a 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 *et al.*, (2000) also suggest that flow velocity may be particularly important as a determining factor of composition and abundance of zooplankton assemblage. Vertical migration with respect 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.

## CONCLUSION

It can be concluded from this study that Lake Alau is fairly rich in terms of zooplankton composition and abundance and is maintaining an Oligo-mesotrophic status. However, settlement around the lake should be encouraged to adopt and monitor environmentally friendly initiated by embracing low and non-waste technologies (LNWT) at all stages of product life, so as to control the effluents that enters each station, through canals, that encourages eutrophication of lake which will adversely affect the zooplankton community as well as the whole ecosystem. In addition, the knowledge derived could be used as an index for further prolong research which would provide a broader understanding of this very economically and scientifically important water body and other lakes in West African arid zones. This will lead to greater understanding of the factor that controls the distribution of these species.



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