International Journal of Innovative Scientific & Engineering Technologies Research 3(1):66-74, Jan-Mar 2015

© SEAHI PUBLICATIONS, 2015 **www.seahipaj.org** **ISSN: 2360-896X**

EVALUATION OF ZOOPLANKTON ABUNDANCE, COMPOSITION AND DISTRIBUTION AT THE UPPER COURSE OF KANO RIVER

Adamu MUSTAPHA

Department of Geography, Faculty of Earth and Environmental Sciences,
Kano University of Science and Technology Wudil, P.M.B. 3244, Kano State, Nigeria
Phone Number: +234-8033550765
E-mail of corresponding author: amustapha@kustwudil.edu.ng

ABSTRACT
This study investigates the abundance and distribution of zooplankton taxonomic composition and species diversity with the aim of determining the quality of water at the upper course of Kano River. Surface water was collected at 10 sampling sites (LK1 to LK10) vertically near the bottom surface with plank net. Samples were identified and counted under an inverted microscope and zooplankton densities were calculated in terms of number per individual/m^3. Results revealed that sample site L2 showed the highest species diversity and cladeceron was the dominant group in terms of density contributing 51.77% of the total zooplankton population. Further, two-way analysis of variance (2-way ANOVA) was applied on the spatial data to reveal the statistically significant differences between the zooplankton density and sampling sites. The result shows that there was a strong statistically significant main effect for zooplankton groups [(F 2, 10.237, p 0.0001)] and statistically significant main effect for zooplankton density in relation to sampling sites [(F 9, 3.107, p 0.001)]. Moreover, there was no significant interaction effect [(F 12, 1.176, p 0.276)]. Post hoc comparison test using Bonferroni correction on the zooplankton groups indicated that the mean of rotifers and copepods, cladeceron and copepods were significantly different (MD -.1730* p 0.035) and (MD -.3153* p 0.0001) respectively. Hierarchical agglomerated cluster analysis (HACA) was applied to identify the spatial variation between the sampling sites based on the density of zooplanktons population using Ward's method and Euclidean distance of similarity measures. HACA grouped 10 sampling sites into 3 statistical significant clusters with cluster 1 includes LK3, cluster 2 comprises LK2, LK7, LK1, LK9, LK10 and cluster 3 includes LK4, LK5, LK6 and LK8.
Keywords: Cladeceron, copepods, rotifers, distribution, Kano River

INTRODUCTION
Zooplanktons are sensitive to various substances that enrich or pollute water, and have often been used as indicators to monitor and assess the condition and change of the freshwater environment (Suthers and Rissik, 2009). Freshwater zooplankton such as rotifers, cladeceron and copepods can be used as bio-indicators to monitor water quality and the integrity of an ecosystem. Zooplankton biomass is the basis for estimating biological production and carrying capacity of the water body (Forsyth and McCallum, 2010). The understanding of zooplankton population in rivers can be useful in evaluating the pollution status and limnological condition in relatively short period (Nougueira, 2001). The zooplankton communities in lakes and rivers consist of a variety of organisms with different feeding modes, which exploit a wide diversity of food available in the environment. Studies have showed that grazing rates measured in different communities vary with zooplankton biomass, food concentration and zooplankton taxonomic composition (El-shabrawy and Dumont, 2003) as well as with their body size (Doulka and Kehayias, 2008). Large-bodied zooplankton such as Daphnia can graze more intensively on phytoplankton than communities of smaller bodies such as *Bosmina*.
Moore and Cotner (2011) revealed that, seasonal variation of cladeceron and the rotifer grazing rates followed the changes in the density of the main consumers. On the other hand, many studies suggest that the taxonomic composition of a zooplankton community is also important to determine its grazing rate

and selectivity for different types of particles (Doulka and Kehayias, 2008). It is generally believed that copepod-dominated communities should have lower grazing rates and consume larger particles than communities dominated by large cladocerans. Study done by Cyr (1999) investigated the relationship between the size structure and taxonomic composition of zooplankton communities with their *in situ* grazing rates and the range of algal sizes consumed. Researchers reported that small algae were usually grazed most intensively, but grazing rates were poorly related to algal size alone. The range in size of grazed algae increased with increasing zooplankton body size, but differed systematically with their taxonomic composition. In general, the zooplankton community structure is highly related to the phytoplankton species and their sizes. Other environmental factors such as physical, chemical and biological interactions also affect the zooplankton community structure directly or indirectly. Zooplankton can therefore be used as bio indicators of the environmental conditions of aquatic systems (Ferdous and Muktadir, 2009). The present study aims at evaluating the spatial patterns, distribution and abundance of zooplankton population in a dry land tropical river.

MATERIALS AND METHODS

Sampling Methods

Surface water samples were collected at the harbor of the upper course of Kano River (Fig. 1) approximately every 24 hours at 10 sampling sites (LK1 to LK10). The samples were collected vertically near the bottom surface (0-5 m) with plankton net (25 cm mouth diameter) and for each station, a small quantity of water (minimum of 30L) was collected at various points using water sampler. The water was then mixed and filtered through a 60-µm plankton net and preserved with formalin (final concentration of 5%). The volume of the samples was calculated based on the depth of each station. The samples were preserved in 5% formalin.

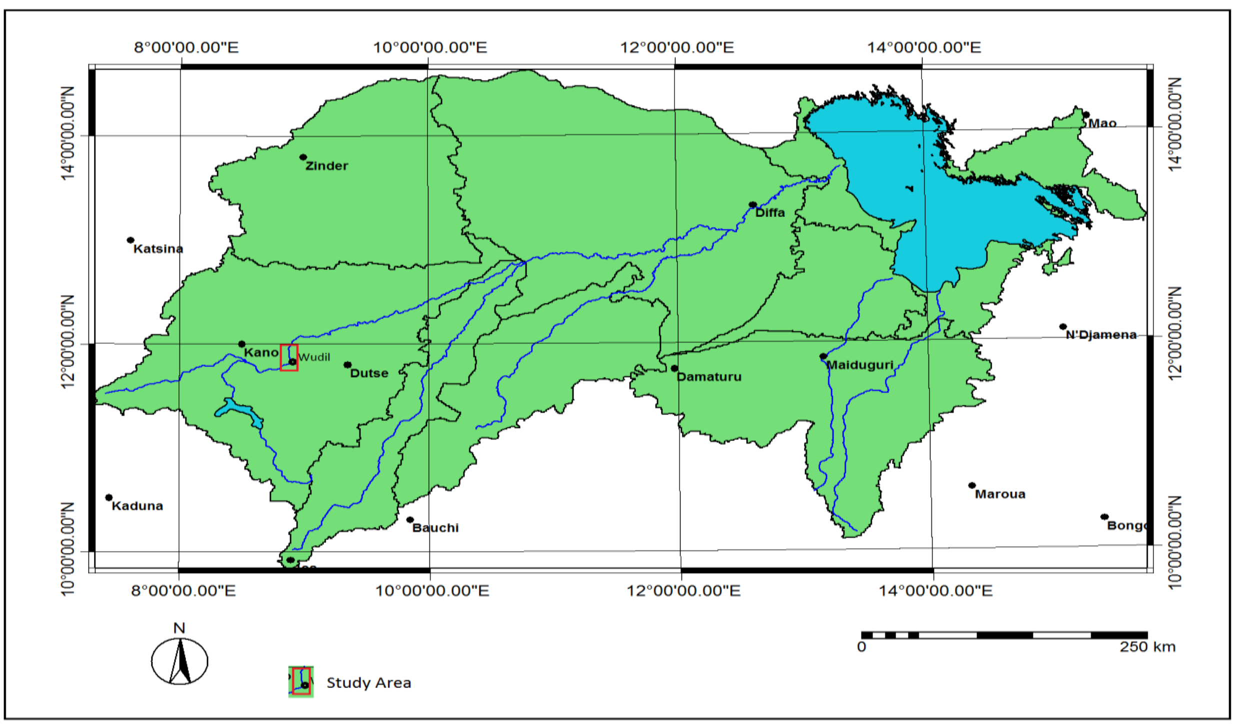

Fig. 1 Map of Hadejia-Komaduga watershed showing upper course of KanoRiver

Sample Processing, Identifications and Enumeration

Zooplankton samples collected were sedimented to working volumes ranging from 30-70 ml depending on the zooplankton densities. A known volume of the sample was placed in a counting chamber and was allowed to settle. The samples were identified to the highest taxonomic level possible and counted under an inverted microscope. Confirmation of the species was accomplished using a compound microscope. Densities were calculated in terms of the number of zooplankton individuals/m^3 of river water. Species diversity index and other related indices (H' max and equitability index) were determined using Shannon-Weiner diversity index. The different diversity indices were calculated using PRIMER (Plymouth Routines in Multivariate Ecological Research).

Statistical Analysis

To identify spatial variation of zooplankton density from the upper course of River Kano ecosystem, Two-way between subject's factorial analysis of variance (2-way ANOVA) or factorial design ANOVA was chosen. The advantage of factorial design is that it allows a set of hypotheses to be tested at a comparable level of power by using a fraction in the subject or factor. The experimental design allows the evaluation of the interaction effects between two or more independent variables. The design in 2-way ANOVA is a full factorial if all the levels of one independent variable occur in combination with all the level of the other independent variable(s) as in equation below:

$$Y = \mu + \alpha + \beta + \alpha\beta + e$$

Where Y is the deviation of score from the grand mean, μ is the main effect of the first independent variable, β is the deviation of a score due to the main effect of the second independent variable, and $\alpha\beta$ are the deviation of a score due to interaction or effect between the independent variables above and beyond their individual main effect on Y. Prior to the statistical analysis, exploratory data analysis was used on the data sets to detect outliers and extreme cases and further to test the assumptions of normality, linearity and equality of variance.

A 2 x 10 x 3 two-way analysis of variance (2-way ANOVA) between subjects effect (completely randomized) factor design was performed on the logtransformed dataset to explore the significant mean differences spatially between zooplankton populations, sampling site and group of zooplanktons. For zooplankton, three different communities were studied (rotifers, cladocerans and copepods). For the sampling sites, ten sampling sites were selected (LK1, LK2, LK3, LK4, LK5, LK6, LK7, LK8, LK9 and LK10).

Hierarchical Agglomerated Cluster Analysis (HACA) is a multivariate statistical technique whose primary purpose is to assemble objects based on characteristic they possesses (Shrestha and Kazama, 2007). The resultant clusters exhibit high internal (within clusters) homogeneity and high external (between groups) heterogeneity and the level of similarities at which observations are merged are used to construct a dendrogram (Singh *et al.*, 2004; Chen *et al.*, 2007). The distance between each cluster is determined by Euclidean, Manhattan, Mahalanobis and Minkowski distances. HACA (agglomerative bottom-up approach) was used to identify the spatial variation between the sampling sites based on the density of zooplanktons population. Cluster analysis was performed by Ward's method using Euclidean distance as similarity measure.

RESULT AND DISCUSSIONS

Mean differences of Zooplankton density in the sampling sites

The number of species at each station ranged from 100 individual/M^3 at station LK1 LK3 to over 1200 individual/M^3 at station LK2 (Fig. 2). LK2 showed the highest density of zooplankton species while LK10, LK9 and LK8 had a slight decrease in the number of species as compared to LK2.

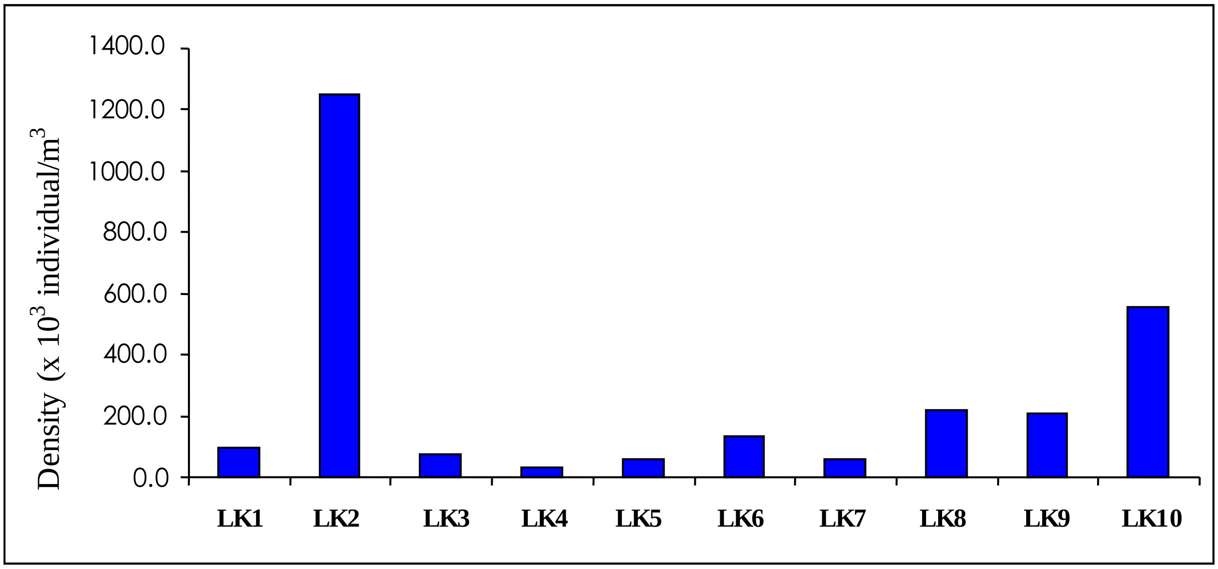

Fig. 2 Population of Zooplankton density in sampling sites

The increase in zooplankton density in LK2, LK8, LK9 and LK10 as shown by the radar diagram in Figure 3was probably related to the shift of cyanobacterial to green algal and diatoms dominance in this sampling. Diatoms and green algae form better and more nutritious foods for the zooplankton. During this sampling period, the highest zooplankton density was recorded at station LK2 with 1, 249,380 individuals/m^3. The lowest zooplankton density was recorded at LK4 station with 32,839 individuals/m^3.

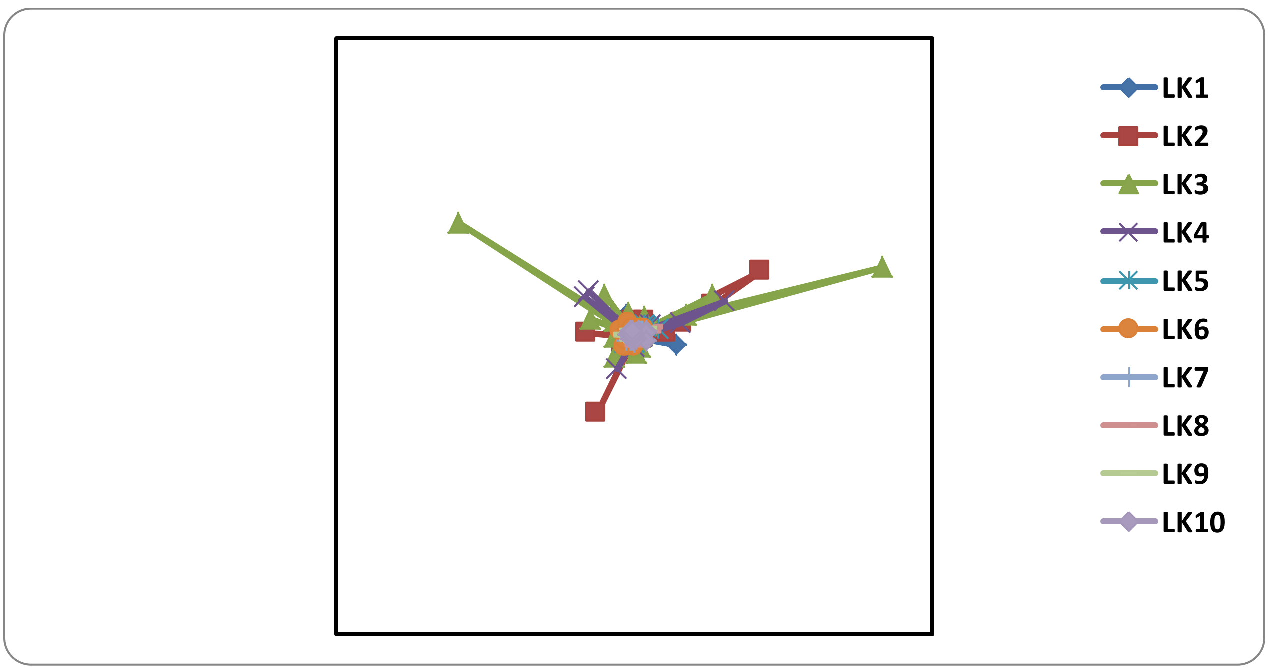

Fig 3 Radar diagram showing abundance of zooplankton in density (x10^3 individuals/m^3) at the study area

Cladeceron were the most dominant group in terms of density, contributing 51.77% of the total zooplankton populations, whilst rotifers, copepods and protozoan's formed 30.34%, 17.51% and 0.38% respectively (Figure 3). The increased in zooplankton abundance observed at station L2 may be attributed to the enrichment of the amount of nutrients and chlorophyll-a which provide food for many zooplankton (Rezai *et al.*, 2009). Zooplankton distribution is closely related to environmental factors such as light, temperature and abundance of food (Rezai *et al.* 2010).

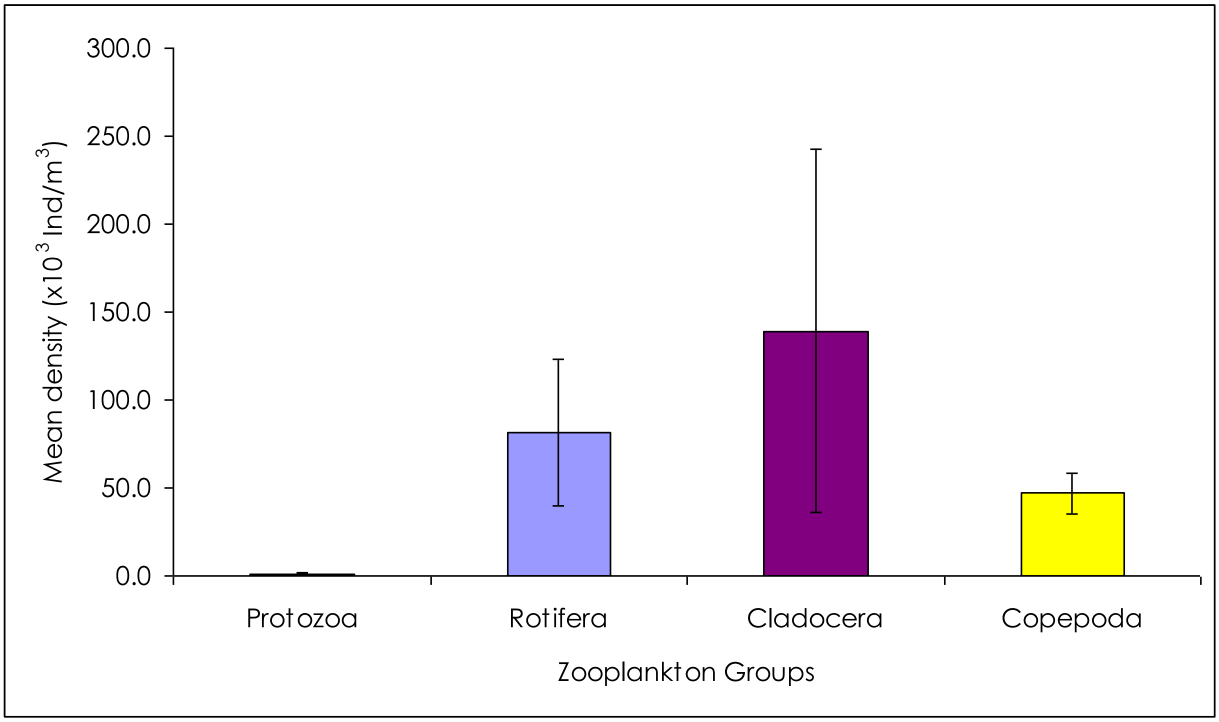

Fig. 3 Bar showing group of Zooplankton individuals /m^3 in the sampling sites

The order of abundance of cladeceron zooplankton group among the sampled stations were LK 2 > LK 3 > LK 6 > Lake 8 > LK 10 > LK 9 > LK 7> LK 5 > LK 1> LK 4 (Fig. 4 and 5). The highest mean cladeceron density of 100,195.8 individual's m^{-3} was found at LK 2, whilst the lowest occurrence was at LK 1 with a mean density of 30,614.9 individual's m^{-3}. Similar to the rotifers, the order are LK 10 > LK 9 > LK 8 > LK 2 > LK 5 > LK 7 > LK 1 > LK 3 > LK 4 > LK 6. Copepods were in abundance as follows; LK 2 > LK 10 > LK 8 > LK 6 > LK 1 > LK 7 > LK 5 > LK 3 > LK 9 > LK 4. Figure 4 shows bubble diagrams of zooplankton abundance and density at the upper course of Kano River.

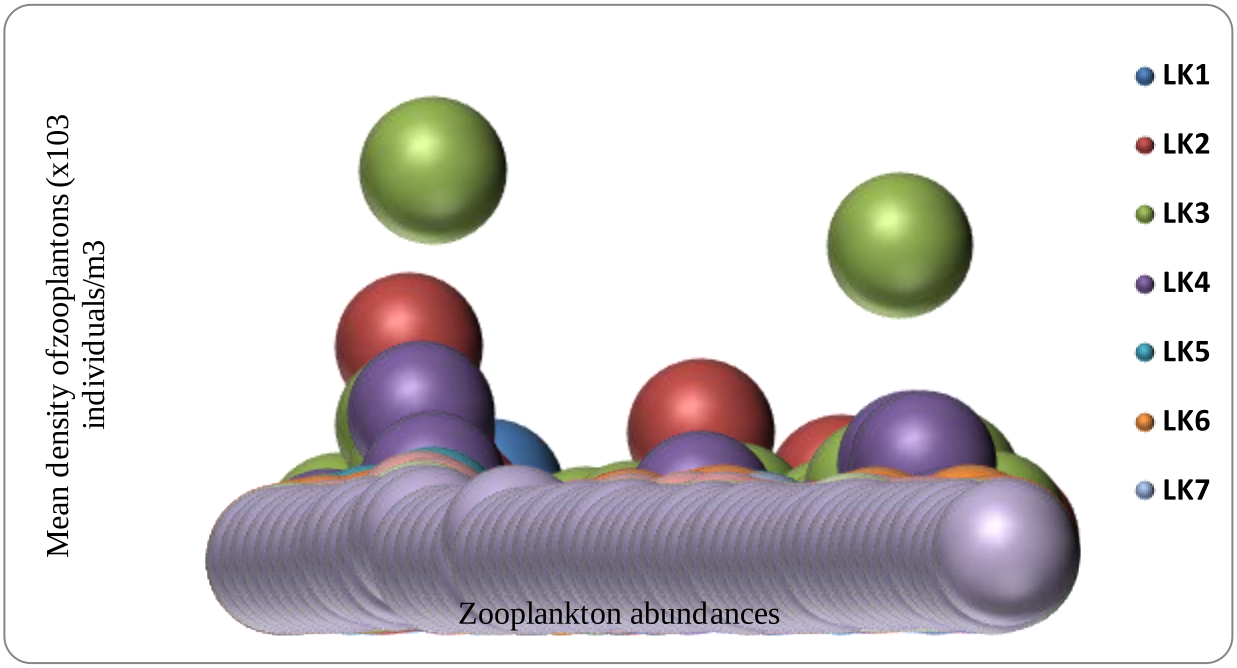

Fig. 4 Bubble diagram showing Zooplankton density(x10^3 individuals/m^3) and abundances at the study area

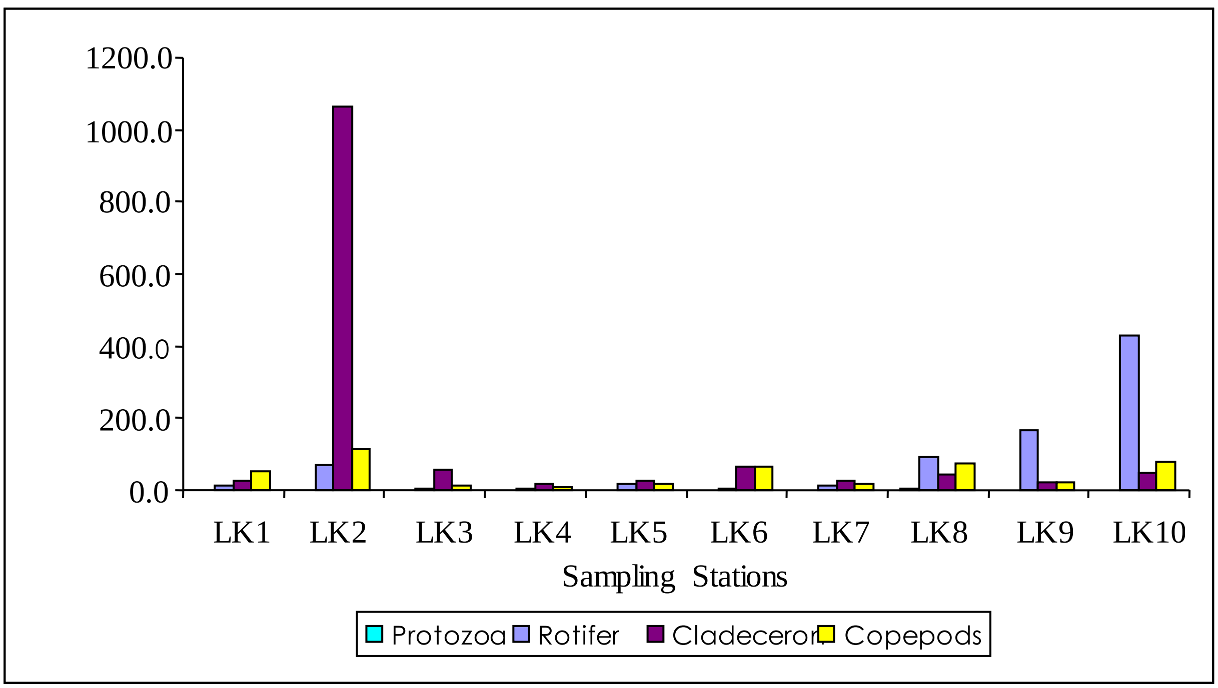

Fig. 5 Abundance of zooplankton population at the sampling sites

Mean differences of zooplankton populations using 2-way analysis of variance (2-way ANOVA)
A Two-way ANOVA between groups analysis was performed to investigate the mean differences between the dependent variable zooplankton density and the 2 factors sampling sites and group of zooplankton (Rotifers, cladeceron and copepods) obtained from the upper course of Kano River. The null hypotheses were states as follows:

$H0_1$: There is no significant difference in the mean of zooplankton density and sampling sites.

$H0_2$: There is no significant difference in the mean group of zooplankton (Rotifers, Cladeceron and copepods).
$H0_3$: There is no interaction between Sampling sites and group of zooplanktons.
The 2-way ANOVA on spatial differences in zooplankton populations and sampling sites showed that there was strong statistically significant main effect for zooplankton community in relation to the sampling site (F = 3.107, p = 0.001). There was a statistically significant main effect for zooplankton population and group of zooplankton (F =10, 237), p = 0.000). However there is no significant interaction between sampling sites and group of zooplankton, (F=1, 176, p = 0.276).

Table 1 Two-way analysis of variance results showing tests between subject effects

Source	Type III Sum of Squares	df	Mean Square	F statistics	*p* level
Corrected Model	37.389a	29	1.289	2.394	0.000
Intercept	13097.778	1	13097.778	24322.99	0.000
Sampling sites	15.056	9	1.673	3.107	0.001
Zooplankton groups	11.025	2	5.512	10.237	0.000
Sampling sites * group of Zooplankton	11.397	12	0.633	1.176	0.276
Error	330.635	614	0.538		
Total	13481.232	644			
Corrected Total	368.024	643			

Post hoc multiple comparison test on the groups of zooplankton using Bonferroni correction is presented in Table 2 and indicated that the mean differences between Rotifers and Copepods (MD = .1730*, p = 0.045) and Cladeceron and Copepods (MD = .3153*, p = 0.000) were statistically significantly different between the sampling sites. However, the mean differences between Rotifers and Cladeceron (MD = 0.1424, p = 0.137) did not differ significantly between the sampling sites.

Table 2 Bonferroni multiple comparison test between groups of zooplanktons

(I) Zooplankton	(J) Zooplankton	MD (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Rotifers	Cladeceron	0.1424	0.07111	0.137	-0.0284	0.3131
	Copepods	-.1730*	0.07095	0.035	-0.3433	-0.0027
Cladeceron	Rotifers	-0.1424	0.07111	0.137	-0.3131	0.0284
	Copepods	-.3153*	0.07045	0.000	-0.4845	-0.1462
Copepods	Rotifers	.1730*	0.07095	0.045	0.0027	0.3433
	Cladeceron	.3153*	0.07045	0.000	0.1462	0.4845

The drastic fluctuations in densities were probably due to the instability of the environmental conditions as well as the population succession strategies in adaptation and colonization of the new niches, especially at the upper course of a river. In the beginning, either cladeceron or copepods were the most dominant form, but there was a shift of dominance from the large-sized micro crustaceans to rotifers as time goes on. The rotifer populations decreased drastically, shifting the dominance once again to micro crustaceans at similar densities prior to the zooplankton density peaks. Shifts in dominance between the large sized zooplankton (micro crustaceans) and the smaller ones (rotifers) could be due to various factors including changes in water quality, food availability and predation pressure. Decline in copepod densities could have allowed the proliferation of rotifers. Rejas *et al.,* (2005) suggested in a new system, `bottom-up control' dictated by nutrients, chlorophyll *a*, dissolved oxygen seemed to favors micro crustaceans. The favorable environmental conditions and abundant supply of nutritive food were the major drivers for the high proliferation of the micro crustaceans, even in the presence of planktivorous fishes (Rejas, 2005; Abrantes, 2006). In addition, upper course of a river with high densities of beneficial phytoplankton species would have higher zooplankton populations (Merrix-Jones *et al.,* 2013). Abrantes *et al.,* (2006) demonstrated that phytoplankton increase supported the growth of cladeceron herbivore populations.

Spatial similarities of sampling site in zooplankton density using Hierarchical Agglomerated Cluster Analysis (HACA)

HACA grouped all the 10 sampling sites into 3 statistically significant clusters as shown by the dendrogram in Figure 6. The 3 groups/clusters generated from 10 sampling points are as follows: cluster 1 includes LK 3 cluster 2 comprises LK 2, LK7, LK 1, LK 9, LK10 cluster 3 includes LK 4, LK 5, LK 6 and LK 8. The objective of cluster analysis is to identify relatively similar homogeneous groups of object/cases (Gupta *et al.*, 2009). The result of cluster analysis considers the sites, points or stations in one group with similar characteristic features and natural background source type (Wu *et al.*, 2009). The result of the cluster analysis could be employed to design a future spatial sampling strategy in an optimal manner by reducing the number of sampling station or sites without losing any significant information (Shrestha and Kazama, 2007; Juahir *et al.,* 2009; Mustapha *et al.,* 2012a, b; Mustapha *et al.,* 2014).

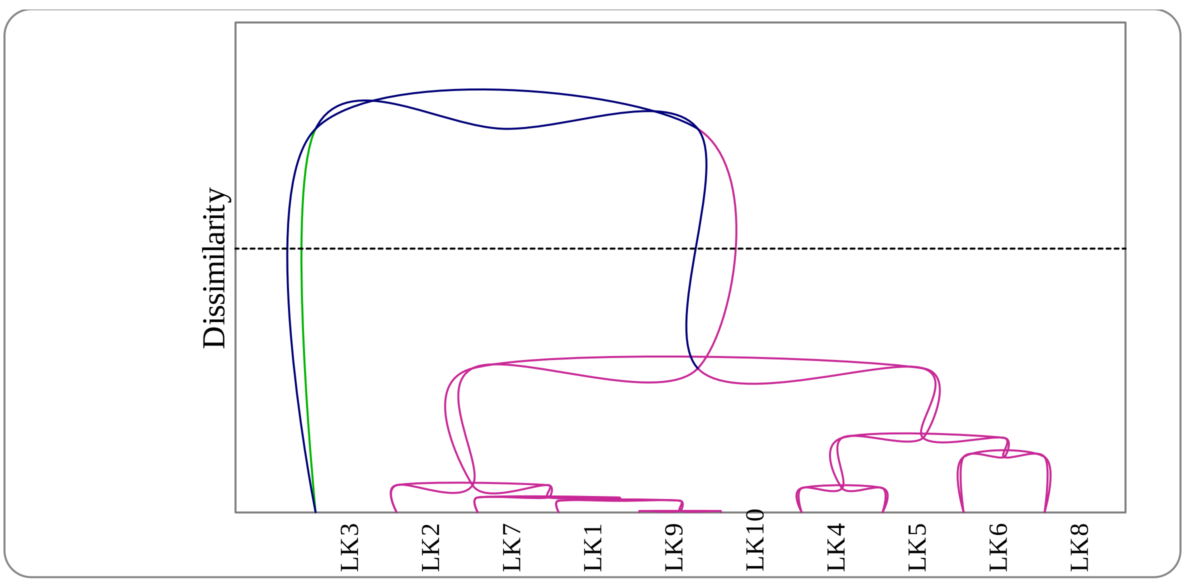

Fig. 6 Dendrogram showing 3 statistically group of clusters of sampling sites at the upper course of Kano River

CONCLUSION

This study revealed that three groups of zooplanktons namely rotifers, cladeceron and copepods influence the total composition and distribution of zooplanktons at the upper course of Kano River. Zooplanktons are diverse and ubiquitous organisms at the upper course of the Kano River. Zooplankton occupy an intermediate trophic level and functioning as an important food source for a variety of animals, including juvenile and larger fish. In turn, they can be important in the control of bacterial and algal abundances and quickly increase in number following increased bacterial and algal numbers. Results revealed that sample site L2 showed the highest species diversity and cladeceron was the dominant group in terms of density contributing 51.77% of the total zooplankton population. Two way analysis of variance couple with Hierarchical Agglomerated Cluster Analysis (HACA) proved to be useful in spatial variation and distribution of zooplankton and reducing the number of monitoring stations into statistically significant clusters. Hence an integrated surface water management is essential especially at station L2 to ensure acceptable river water quality in the study area.

REFERENCES

Abrante N, Antune SC, Pereira MJ, Gonçalves F, (2006). Seasonal succession of cladocerans and phytoplankton and their interactions in a shallow eutrophic lake (LakeVela, Portugal), *Acta Oecologica* **29**:54-64.

Chen, K., Jiao, J. J., Huang, J. and Huang, R. (2007). Multivariate statistical evaluation of trace elements in groundwater in a coastal area in Shenzhen, China. *Environmental Pollution* **147**(3): 771–780.

Cyr, H. (1999). Zooplankton community size structure and taxonomic composition affects size-selective grazing in natural communities. *Canadian Journal of Fish and Ecologia*, 118: 306-316.

Doulka G, Kehayias G, (2008). Spatial and temporal distribution of zooplankton in Lake Trichonis (Greece). *Journal of Natural History* 42:575-595.

El-shabarawy GM, Dumont HJ, (2003). Spatial and seasonal variation of the zooplankton in the coastal zone and main khors of Lake Nasser (Egypt). *Hydrobiologia* 491: 119–132.

Ferdous, Z. And Muktadir, A.K.M. (2009). A review: Potentiality of zooplankton as bioindicator. *American Journal of Applied Sciences* **6** (10):1815-1819.

Forsyth DJ, McCallum ID, (2009). Zooplankton of Lake Taupo. New Zealand Journal of Marine and Fresh Water Research 14(1): 65-69.

Juahir H, Zain SM, Aris AZ, Yusoff MK, Mokhtar M (2009). Spatial assessment of Langat River water quality using chemometrics. *Journal of Environmental Monitoring* 12:287-297

Merrix-Jone FL, Thackeray SJ, Ormerod SJ, (2013). A global analysis of zooplankton in natural and artificial fresh waters. *Journal of Limnology* 72:140-153.

Moore CK, Cotner JB (2011). Zooplankton community structure of Lake Livingston, Texas as related to Paddlefish food resources. *Journal of freshwater Ecology* 13(1):115-128.

Mustapha A, Aris AZ (2012a). Multivariate statistical analysis and environmental modeling of heavy metals pollution by industries. *Polish Journal of Environmental Studies* 21: 1359-1367

Mustapha A, Aris AZ, Ramli MF, Juahir H (2012b). Spatial-temporal variation of surface water quality in the downstream region of the Jakara River, northwestern Nigeria: A statistical approach. *Journal of Environmental Science and Health Part A* 47:1551-1560

Mustapha A, Aris AZ, Ramli MF, Juahir H (2014). Statistical approach in determining the spatial changes of surface water quality at the upper course of Kano River, Nigeria. *Water Quality Exposure and Health* 6:127-142.

Nogueira MG, (2001). Zooplankton composition, dominance and abundance as indicators ofenvironmental compartmentalization in Jurumirin Reservoir (Paranapanema), Sao Paulo, Brazil. *Hydrobiologia* 455: 1-18.

Rejas D, Declerck S, Auwerkerken J, Tak P, Meester LD, 2005. Plankton dynamics in a tropical floodplain lake: fish, nutrients, and the relative importance of bottom-up and top-down control. *Freshwater Biology* 50: 52-69.

Rezai H, Yusoff FM, Arshad A, Othman BHR, (2009). Abundance and composition of zooplankton in the strait of Melacca. *Aquatic Ecosystem Health and Management* **12** (3): 264-270.

Rezai H, Yusoff FM, Othman BHR, (2010). Vertical distribution of zooplankton and copepods community structure in the strait of Melacca. *Journal of Persian Gulf* **2** (3): 17-23.

Shrestha S, Kazama F, (2007). Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. *Environmental Modeling and Software* 22: 464-475.

Singh KP, Malik A, Mohan D, Sinha S, (2004) .Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India) – a case study. *Water Resource* 38:3980-3992.

Suthers I.M., Rissik D, (2009). Plankton, A guide to to their ecology and monitoring for water quality, CSIRO Publishing, Collingwood, Australia.