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Zooplanktonic Community Assessment over Space and Time: A biomonitoring Tool in an Artificial Lake

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Authors' contributions

This work was carried out in collaboration among all authors. Author HYO designed the study, performed the statistical analysis and wrote the manuscript. Author AAA and Author IFA supervised the research. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The prime objective of this study is to determine the taxonomic composition of the zooplankton fauna of Esa-Odo Reservoir in Osun State and determine the spatial (horizontal and vertical) and seasonal variations in the composition, distribution abundance, and community structure of the zooplankton community in the reservoir.
Study design: sampling stations were selected horizontally and vertically to cover the entire zones of the reservoir. Planktonic samples were collected at two months intervals for two years.
Methodology: Samples were collected from the depth using an improvised Meyer's water sampler. Net and Total plankton were sampled by filtration and sedimentation methods. Planktonic samples were preserved as 5% formalin and 1% Lugol's solution. Measurement, enumeration, and scaled pictures of the recorded zooplankton were taken using a photomicrograph. The taxonomic composition of zooplankton biota was determined using identification keys. Data analysis was done using PAST Statistical Package. ANOVA was used to determine the spatio-temporal variations.
Results: Fiftyty-three (53) pecies of total zooplankton recorded in this study belong to 4 groups: Rotifera, Cladocera, Copepoda, and Insecta. Rotifera was the most represented group (61.21%). Horizontally, 24 species with the highest mean abundance characterized the lacustrine; while 12 species and 10 species were unique to the transition and riverine zones, respectively. Vertically, most species had their mean abundance decreased from the surface to the bottom of the reservoir.

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A total of nine (9), two (2) and one (1) species were peculiar to the surface, bottom and mid-depth, respectively. Zooplankton organisms were most abundant during the dry season.
Conclusion: Esa-Odo Reservoir comprised highly diversified zooplankton fauna with great potential to support rich aquatic community and fishery production. The reservoir can be classified as fairly clean based on the abundance of the rotifer group. However, the lake should be subjected to regular proper monitoring because of the presence of some pollution tolerant copepod species identified among the zooplankton fauna.

Keywords: Zooplankton; spatial; temporal; abundance; biodiversity; reservoir.

1. INTRODUCTION

This study of the biodiversity, community structure, and production capacity of the zooplankton community for assessment of waterbodies status is an aspect of bio-monitoring of the aquatic ecosystem. Bio-monitoring is a process of using resident biota (biological indicators) in terms of diversity and abundance to provide information on the state of the ecosystem [1]. Biological indicators are selected according to various criteria which include sedentary life, abundance and, wide distribution, the simple procedure of identification and sampling, high tolerance for pollutants, population stability, and high accumulating capacity [2]. Based on these categories, planktonic organisms (Phyto and Zooplankton) are very suitable for the biological assessment of water bodies. Of these two groups, zooplankton are the most valuable indicator for they are larger and easier to identify than phytoplankton [3]. Moreover, the zooplankton community is composed of highly sensitive organisms that respond to a large number of environmental changes in relatively short periods of time [4]. Consequently, studies of the structure and population dynamics of this community in lentic aquatic systems could be very useful tools in the analysis of the environmental disturbances to which such water bodies are subjected [5].

In addition, zooplankton are microscopic aquatic animal life forms having little or no resistance to currents and therefore free-floating or suspended in open or pelagic waters [6]. While some forms of zooplankton move by vertical migration, their horizontal position is mostly determined by the current movements of the body of water they inhabit [7]. Furthermore, because of their short life cycles, plankton responds quickly to environmental changes and species composition is more likely to indicate the quality of water in which they are found. Based on these important roles zooplankton play in aquatic ecosystems as well as open water fisheries production, it is very necessary to find out their community structure and distribution.

Only a very few studies have been conducted on the zooplankton diversity and abundance in Nigeria. Unfortunately, such types of studies along Esa-Odo Reservoir are poorly known. The prime objective of this study is to determine the taxonomic composition of the zooplankton fauna of Esa-Odo Reservoir in Osun State and the spatial (horizontal and vertical) and seasonal variations in the composition, distribution abundance, and community structure of the zooplankton community in the reservoir. It is hoped that the research will contribute to information for the maintenance of a sound and healthy ecosystem in Esa-Odo Reservoir thus enhancing fisheries production in the reservoir.

2. MATERIALS AND METHODS

2.1 Area of Study

Esa Odo Reservoir, one of the major impoundments on Osun River (Fig. 1) was impounded in 1973 [8]. The reservoir is located approximately on the geographical coordinates of longitudes 07° 35' to 07° 55' North of the Equator, and latitudes 004° 30' to 004° 55'East of Greenwich Meridian on an altitude of about 350 (meters) above mean sea level in Obokun Local Government Area of Osun State, Nigeria. The reservoir's dam axis is approximately 30km East of Osogbo (Osun State capital), about 20km North-East of Ilesa, about 210 km Southwest of Lagos (the major commercial city in Nigeria), and about 330 km Northeast of Abuja (the Federal capital territory of Nigeria) [9]. The reservoir was created primarily to supply potable water to communities in the Obokun Local Government Area of Osun State. The reservoir also supplies raw water for industrial use to the International Breweries, Ilesa, Nigeria. The reservoir also generates a regular supply of water for industries sited around Esa-Odo and also provides the potential for fishery enterprise as well as tourism. The reservoir site is linked with motorable roads with the state capital, Osogbo.

2.1.1 Sampling Programme and Field Determinations

Sampling Stations were selected horizontally (Lacustrine, Transition, and Riverine) and vertically (surface, mid-depth, and close to the bottom) to cover the entire zones of the reservoir (Fig. 2). At shallow Stations, an only surface water sample was collected for zooplankton while water samples were collected from three levels through the water column (surface, mid-depth and close to the bottom) of the reservoir at other stations (1S 1B, 2S, 2M, 2B, 3S, 3M, 3B) using an improvised Meyer's water sampler (2.5 L capacity). Riverine station (station 1) was established at the point of inflow of River Osun into the reservoir at 200 meters away from the inflow while Transition station (station 2) was established at the open water area of the reservoir. Lacustrine station (station 3) was established close to the dam area. In addition, stations 2L1, 2L2, 3L1, and 3L2 were established at the littoral zones of the transition and lacustrine stations of the reservoir.

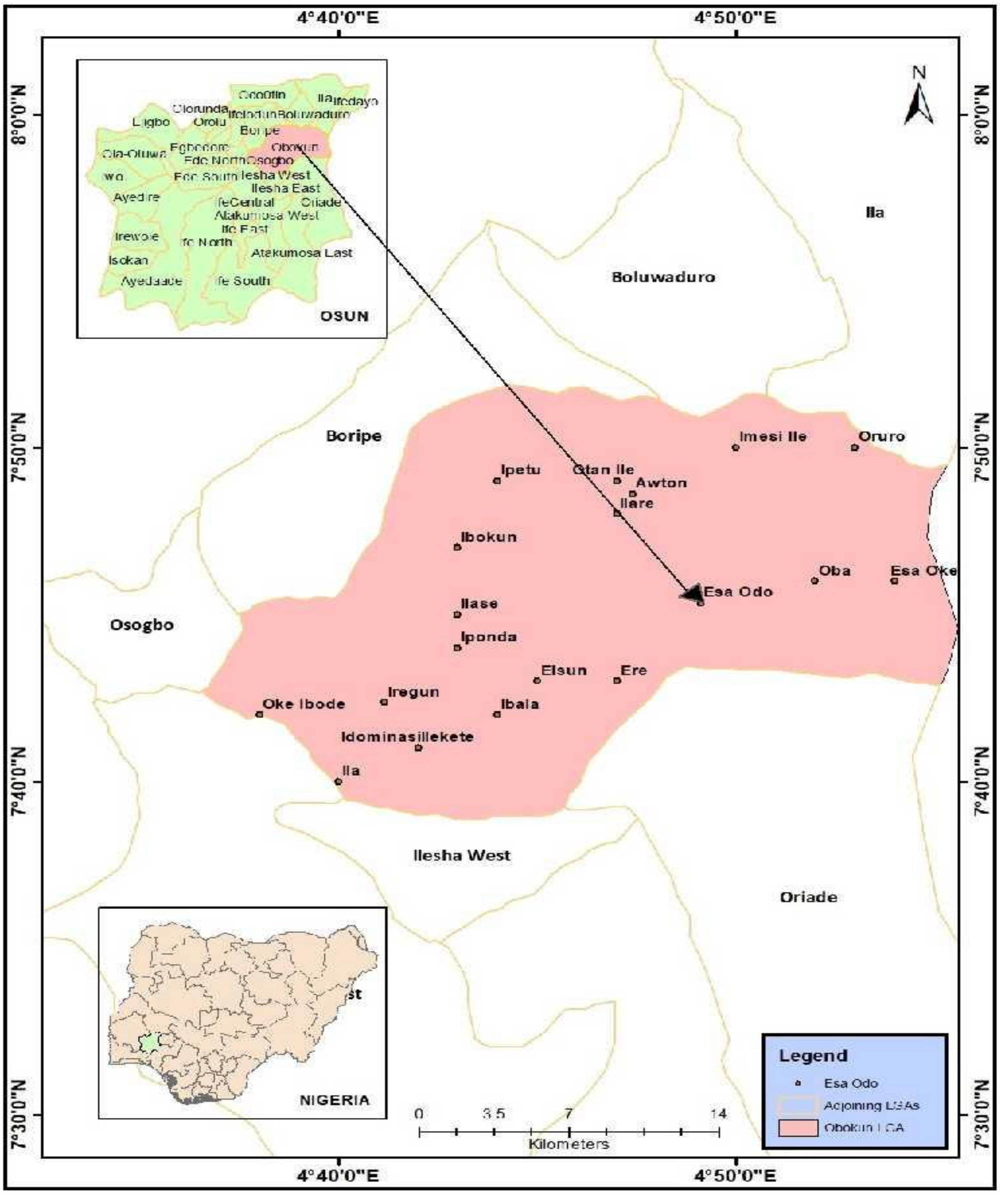

Fig. 1. Map of Obokun Local Government Area showing Esa-Odo

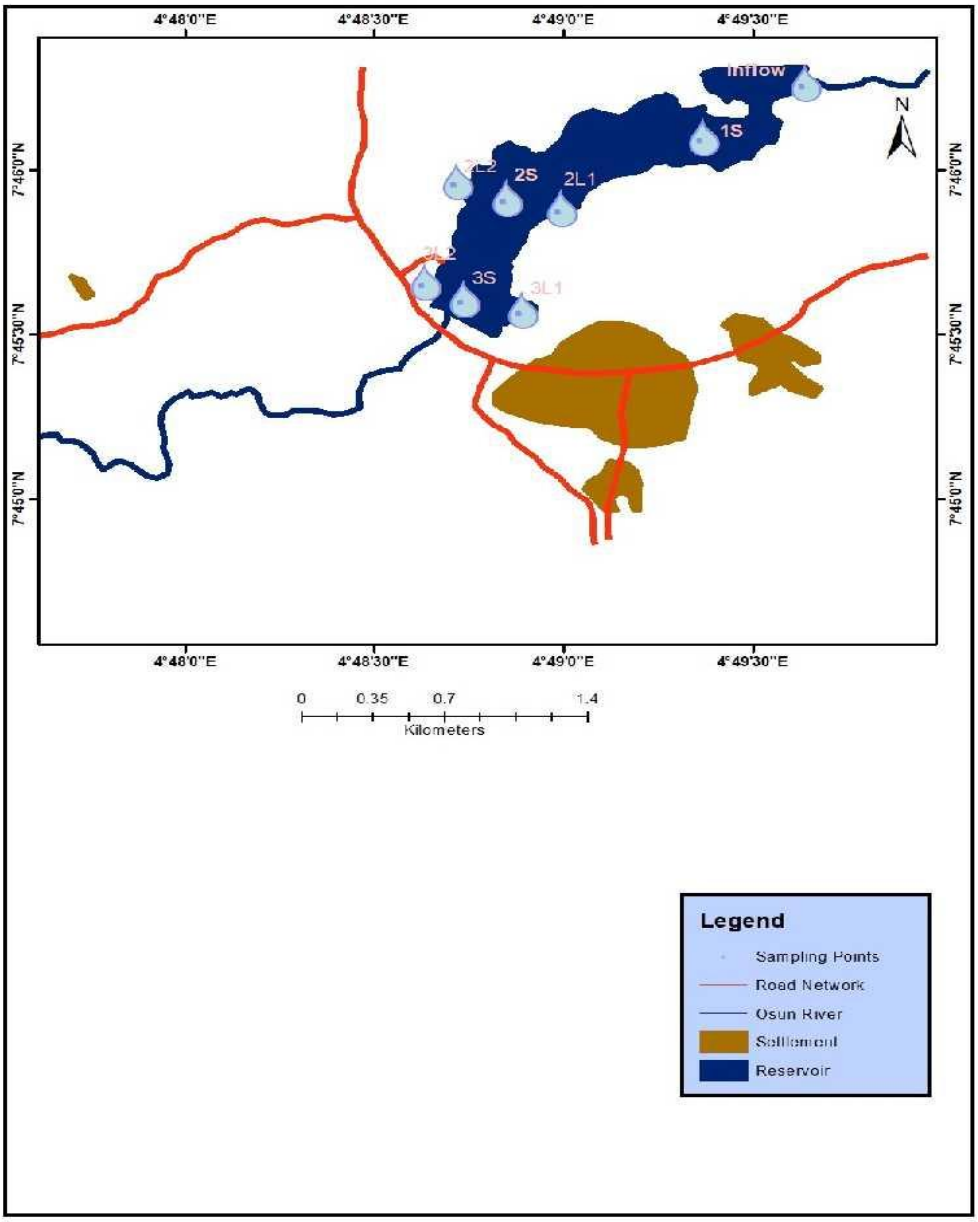

Fig. 2. Map of Esa-Odo Reservoir showing the selected sampling stations

2.1.2 Zooplankton Collection and Analysis

Net plankton was sampled by filtering 50 litres of water through a plankton net of 50 µm mesh size and the plankton contained strained into a 30 ml universal bottles and preserved as 5% formalin solution and Lugol's solution for examination and identification.

Total Zooplankton was determined in the laboratory by taking 500 ml of water samples into total plankton flask and Lugol's solution was added (1:100) after which the water was reduced to 30 ml, poured into a universal bottle, and preserved as 5% formalin solution. The preserved zooplankton samples were examined in the laboratory using a photomicrograph (AC 100-240V, 0.2/0.1A 50/60Hz). Scaled pictures of the specimen were taken and the specimen was also enumerated for abundance determination.

2.1.3 Taxa Identification

The taxonomic composition of zooplankton biota was determined using identification keys by [10,11,12].

2.1.4 Estimation of Plankton Standing Crop / Biomass

The different species of the zooplankton observed in each plankton chamber were counted and recorded. Abundance was calculated and expressed in the number of organisms per meter cube.
(Org/m^3) of original water sample using the formula:

$$A = \frac{ab}{c} X 1000 \ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

Where,

A = Abundance of specie per litre of original water sample
a = Abundance of specie in the counting chamber
b = Total concentrated volume of water in counting chamber
c = Original volume of water used

3. RESULTS

3.1 Total Zooplankton Composition, Classification, Distribution, and Occurrence

From the Esa-Odo Reservoir, 53 species of total zooplankton were recorded. Most of them (37) were identified to species level, while the remaining 16 were identified only to the generic level. The fauna comprised mostly rotifers and arthropods. There were about 40 species of rotifers belonging to 9 families and one order. The Arthropods comprised 8 Cladocerans, 3 Copepods, 2 Insecta species.

The fifty-three (53) species identified from the investigated sampling stations through total zooplankton analysis belonged to 4 groups namely: Rotifera, Cladocera, Copepoda, and Insecta. Rotifera was the most represented group (Fig. 3) with 61.21% of the species and was followed by Cladocera with 19.83% of the total composition. Protozoa and Insecta had the least percentage representation of 15.08% and 3.80% each (Fig. 3). *Argonotholca foliacea, Argonotholca* sp*. Anuraeopsis fissa, Anuraeopsis navicula, Asplanchna* sp*. Brachionus falcatus, Filinia pejleri, Lepadella ovalis, Polyarthra vulgaris, Polyarthra* sp*, Trichocerca tropis* were the dominant species of Rotifera while the Cladocerans comprised mostly of *Simocephalus* sp*, Alonella dentifera, Daphnia* sp*.* during the period of study. Copepod and Insect with the least percentage composition had Nauplius larva, *Eubranchipus* sp., and *Chironomus* sp. Larvae, and *Coenoagron* respectively as their most dominant species. Most of the recorded total zooplankton species especially rotifers were found to be abundant at the surface water, littoral, and riverine zone of the reservoir; among these were *Asplanchna* sp*, Brachionus* spp*, Argonotholca* spp*, Cephadella gibba, Euchlanis dilatata.* Also, copepods were richly represented at this part of the reservoir (Table 1). Seasonally, more zooplankton species were recorded during the dry season through total than net zooplankton analysis.

3.2 Spatio-temporal Variation in the Total Zooplankton Species Abundance

The pattern of horizontal variation revealed that 24 species recorded their highest mean abundance at the lacustrine of the reservoir while only 12 species and 10 species had their maximum mean abundance at the transition and riverine zone of the reservoir respectively (Table 1). Only *Trichocerca tropis* and *Filinia teminalis* showed highly significant horizontal variation in abundance (P = .01) as their mean abundance decreased towards the riverine zone while *Brachionus havanaensis* increased towards the riverine zone with very highly significant horizontal variation (Table 1). Moreover, nine (9) of the recorded species had no horizontal variation spatially (Table 1).

Vertically, 13 species exhibited a similar pattern of vertical variation with their mean abundance decreasing insignificantly from surface water to the bottom of the reservoir while 7 species had a non-significant increase from the surface water to the bottom of the reservoir (Table 1). *Filinia terminalis* and *Lecane monostyla bulla* revealed very highly significant vertical variation (P < .001) in mean abundance with maximum abundance at the bottom and mid-depth respectively. Moreover, the variation in vertical abundance of *Cephalodella gibba*, *Euchlanis dilatata,* and *Trichotria tetractis* was also significant (P =.05) as these were absent at the bottom, mid-depth, and surface water respectively. A total of nine (9) species, two (2) species and one (1) species were peculiar to the surface, bottom, and mid-depth respectively though these did not show any significant vertical variance in abundance (Table 1). Of the recorded species, (14 species were absent from the mid-depth but occurred abundantly at the surface water and bottom of the reservoir (Table 1). The highest mean abundance at the mid-depth of the reservoir was observed for eight (8) species while five (5) species had their lowest mean abundance also at the mid-depth of the reservoir (Table 1).

Seasonally, 25 species out of the recorded total zooplanktonic species had higher mean abundance during the dry season while only 19 species were higher in mean abundance during the rainy season. Some of these species showed significant to very highly significant seasonal variation ($0.05 \geq p \leq 0.01$) in the mean abundance (Table 1). These include *Lepadella ovalis and Filinia pejleri* that had higher mean abundance in rainy and dry seasons respectively. *Brachionus angularis* also had its maximum abundance in the dry season with highly significant variation. Very highly significant variations were observed for the abundance of *Polyarthra* sp. and *Argonotholca foliacea* with higher mean abundance in dry and rainy seasons respectively (Table 1). Of the encountered total zooplankton species, 5 species and 4 species were recorded only in dry and rainy seasons respectively hence showing no variances in abundance.

3.3 Time-depth Abundance of Zooplankton Groups

Figs. 4 to 7 show the vertical distribution diagram pattern of major zooplankton groups of Esa-Odo Reservoir. The vertical distribution diagram revealed the monthly variation in abundance, rotifer was most abundant in surface to 1 m depth with a gradual decrease in density at the lower depths (Fig. 4). Thus, the rotifers were very scanty at the bottom level (5m). Likewise, the bulk of the copepod group population (Fig. 5) were found within the 2.5 m depth with a sparse population below 4m. The cladoceran population was also found to be concentrated in the surface to 2 m levels and these gradually decrease with depths. More also, the bulk of the insect group generally congregated in the uppermost 2 m levels and was relatively scanty in density at a lower depth. While the lower depths were completely avoided by the Insecta group in February, June, and October months (Fig. 6). The bottom depths were also avoided by cladocerans in August 2017 as well as February and December 2018 (Fig. 7).

3.4 Diversity, Evenness, and Richness of Zooplankton Species

Simpson and Shannon's indices showed that Riverine surface water was the most diverse station in species while the transition littoral zone was the least diverse. Also, Evenness was above 0.40 in most stations of the reservoir except riverine bottom water, transition littoral and lacustrine mid-depth showing that the relative abundance of species in the area did not totally diverge from evenness and also that suggested the dominance of few abundant species in the riverine bottom water, transition littoral and lacustrine mid-depth (Table 1).

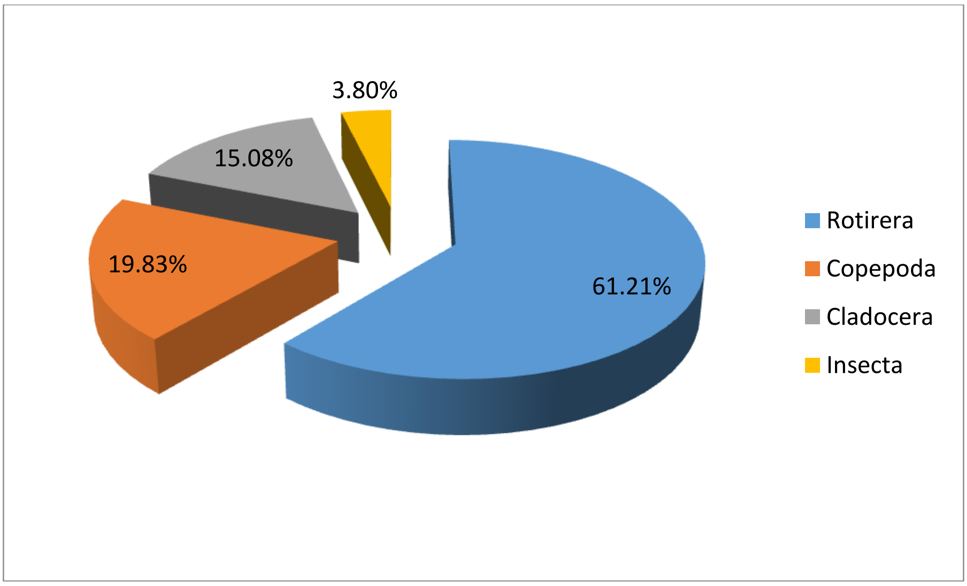

Fig. 3. Percentage abundance of zooplankton species

Table 1. ANOVA statistics of the horizontal, vertical and seasonal variation in the mean abundance (Org/m^3) of total zooplankton species

	Horizontal variation					Vertical variation					Seasonal variation			
Taxa	**Lacustrine Mean**	**Transition Mean**	**Riverine Mean**	**F**	**P**	**Surface Mean±SE**	**Mid-Depth Mean±SE**	**Bottom Mean±SE**	**F**	**P**	**Dry Mean±SE**	**Rain Mean±SE**	**F**	**P**
Anuraeopsis fissa	0.56±0.39	1.33±0.65	0.33±0.23	1.31	0.27	0.93±0.38	0.42±0.42	0.42±0.42	0.35	0.71	1.15±0.52	0.38±0.22	1.89	0.17
Anuraeopsis navicula	5.83±3.50	4.00±1.45	2.67±0.98	0.66	0.52	3.98±1.34	5.00±2.69	2.50±1.73	0.22	0.80	2.31±1.29	5.51±1.64	2.36	0.13
Asplanchna sp.	2.78±1.17	0.67±0.67	2.67±1.09	1.58	0.21	2.04±0.67	1.67±1.30	1.67±1.67	0.35	0.71	22.95±11.07	2.51	0.12	0.12
Argonotholca sp.	49.72±28.56	25.67±10.02	43.33±15.11	0.55	0.58	26.02±6.92	38.75±28.02	91.25±45.39	0.35	0.71	49.72±28.56	25.67±10.02	43.33±15.11	0.55
Argonotholca foliaceae	7.22±2.13	6.67±1.82	6.00±1.73	0.10	0.91	8.15±1.37	5.00±3.01	0.83±0.83	0.35	0.71	2.05±0.86	11.03±1.85	19.36	0.0001***
Beauchampiella eudactylota	0.00±0.00	0.00±0.00	0.00±0.00	NV	NV	1.39±0.69	0.00±0.00	0.00±0.00	NV	NV	1.92±0.95	0.00±0.00	NV	NV
Brachionus angularis	2.78±1.57	0.17±0.17	1.50±0.75	2.33	0.10	0.00±0.00	0.00±0.00	0.00±0.00	NV	NV	2.44±0.92	0.13±0.13	6.23	0.01**
Brachionus falcatus	22.50±11.40	8.50±2.42	14.50±7.17	0.92	0.40	12.31±4.18	2.50±1.73	33.33±16.78	0.05	0.96	14.62±4.69	13.46±6.31	0.02	0.88
Brachionus havanaensis	0.00±0.00	0.33±0.33	3.00±0.93	6.43	0.00***	0.93±0.41	4.17±1.69	0.00±0.00	0.22	0.80	1.54±0.61	1.03±0.50	0.42	0.52
Brachionus quadridentatus	0.00±0.00	3.17±1.69	2.00±1.06	1.23	0.30	1.85±0.79	1.25±1.25	3.33±3.33	0.56	0.57	3.97±1.51	0.00±0.00	NV	NV
Cephalodella gibba	0.00±0.00	0.33±0.33	1.50±1.34	0.73	0.49	0.83±0.75	0.83±0.83	0.00±0.00	3.01	0.05*	0.00±0.00	1.41±1.06	NV	NV
Euchlanis dilatata	1.11±0.66	2.67±1.06	1.67±0.68	0.76	0.47	2.50±0.70	0.00±0.00	1.25±0.92	3.17	0.04*	2.82±0.89	1.03±0.47	3.17	0.08
Euchlanis lucksiana	0.00±0.00	0.00±0.00	0.33±0.23	NV	NV	0.19±0.13	0.00±0.00	0.00±0.00	NV	NV	0.00±0.00	0.26±0.18	NV	NV
Filinia longiseta	0.00±0.00	0.00±0.00	0.17±0.17	NV	NV	0.09±0.09	0.00±0.00	0.0±0.00	NV	NV	0.13±0.13	0.00±0.00	NV	NV
Filinia pejleri	0.28±0.28	21.00±8.30	24.50±7.59	2.45	0.09	17.22±4.91	36.25±17.43	0.42±0.42	2.66	0.07	27.18±6.85	7.95±5.26	4.96	0.03*
Filinia terminalis	4.72±1.80	2.17±1.04	0.00±0.00	4.90	0.01***	0.74±0.45	1.67±1.15	7.50±2.84	5.54	0.001***	1.79±0.75	2.05±0.92	0.05	0.83
Elosa woralli	0.28±0.28	0.67±0.40	1.00±0.39	0.75	0.47	1.02±0.32	0.00±0.00	0.00±0.00	0.31	0.73	0.64±0.33	0.77±0.30	0.08	0.78
Keratella. tropica	1.39±0.71	3.67±1.99	0.67±0.32	1.46	0.23	2.41±1.12	0.00±0.00	2.08±1.04	0.16	0.85	2.18±0.91	1.79±1.31	0.06	0.81
Lecane bulla	7.78±3.17	3.00±0.93	5.33±1.75	1.51	0.22	6.39±1.46	2.50±1.73	1.25±0.69	1.70	0.19	3.72±1.08	6.28±1.82	1.47	0.23
Lecane	2.78±2.78	1.50±0.75	0.67±0.40	0.63	0.54	2.04±1.03	0.42±0.42	0.00±0.00	0.58	0.56	2.82±1.41	0.13±0.13	3.60	0.06

Taxa	Horizontal variation					Vertical variation					Seasonal variation			
	Lacustrine	Transition	Riverine	F	P	Surface	Mid-Depth	Bottom	F	P	Dry	Rain	F	P
	Mean	Mean	Mean			Mean±SE	Mean±SE	Mean±SE			Mean±SE	Mean±SE		
closterocerca														
Lecane leontina	0.28±0.28	2.50±1.57	0.67±0.67	1.09	0.34	1.67±0.94	0.00±0.00	0.83±0.58	2.02	0.14	2.44±1.31	0.13±0.13	3.09	0.08
Lecane luna	2.78±2.78	0.33±0.23	1.50±0.85	0.84	0.43	0.09±0.09	3.75±2.07	4.58±4.17	0.71	0.49	2.44±1.43	0.26±0.18	2.29	0.13
Lecane sp	0.28±0.28	0.33±0.33	0.33±0.23	0.01	0.99	0.37±0.23	0.00±0.00	0.42±0.42	0.44	0.65	0.64±0.33	0.00±0.00	NV	NV
Lepadella ovallis	0.28±0.28	1.83±1.10	1.67±0.98	0.60	0.55	1.48±0.68	2.08±2.08	0.42±0.42	0.34	0.71	2.56±1.10	0.26±0.26	4.16	0.04*
Lepadella patella	2.22±1.06	1.17±0.48	1.17±0.59	0.68	0.51	1.76±0.51	0.00±0.00	1.25±0.92	1.37	0.26	1.54±0.52	1.28±0.56	0.11	0.74
Mytilinia mucronata	0. 00±0.00	2.00±0.78	1.00±0.52	2.28	0.11	1.11±0.42	2.50±1.38	0.00±0.00	1.86	0.16	0.77±0.44	1.54±0.58	1.12	0.29
Monostyla bulla	0. 00±0.00	0. 00±0.00	0.67±0.40	NV	NV	1.20±0.49	6.67±2.53	0.00±0.00	8.34	0.00***	0.90±0.55	2.82±0.91	3.26	0.07
Monostyla lunaris	0.00±0.00	0.67±0.40	0.00±0.00	NV	NV	0.37±0.23	0.00±0.00	0.00±0.00	NV	NV	0.64±0.33	0.77±0.30	0.08	0.65
Notholca sp	0.00±0.00	0.00±0.00	0.67±0.31	NV	NV	0.00±0.00	0.00±0.00	0.42±0.42	NV	NV	1.03±0.65	2.31±0.93	1.23	0.26
Platyias sp	0.83±0.61	0.50±0.50	0.00±0.00	0.95	0.39	0.46±0.33	0.00±0.00	0.42±0.42	0.24	0.79	0.13±0.13	0.64±0.46	1.16	0.28
Macrochaetus sp.	3.89±1.51	2.50±0.97	3.50±1.82	0.22	0.80	0.00±0.00	0.00±0.00	0.00±0.00	NV	NV	2.31±1.29	5.51±1.64	2.36	0.13
Polyarthra vulgaris	0.83±0.83	0.00±0.00	0.00±0.00	NV	NV	0.28±0.28	0.00±0.00	0.00±0.00	NV	NV	0.00±0.00	0.38±0.38	NV	NV
Polyarthra sp.	16.11±4.90	7.00±1.63	12.67±5.47	1.08	0.34	13.61±3.34	2.92±1.41	9.17±5.28	1.25	0.29	18.59±4.66	3.97±1.23	9.22	0.001***
Scaridium longicaudum	0.28±0.90	1.00±0.57	2.33±1.15	1.38	0.25	1.85±0.71	0.42±0.42	0.00±0.00	1.19	0.31	1.54±0.75	1.15±0.66	0.15	0.70
Trichocerca leontina	0.00±0.00	0.33±0.23	0. 17±0.17	0.67	0.51	0.28±0.16	0.00±0.00	0.00±0.00	NV	NV	0.13±0.13	0.26±0.18	0.34	0.56
Tricocerca multicrinis	0.00±0.00	0.00±0.00	0. 17±0.17	NV	NV	0.00±0.00	0.42±0.42	0.00±0.00	NV	NV	0.00±0.00	0.13±0.13	NV	NV
Trichocerca elongata	0.00±0.00	2.37±1.26	0. 33±0.23	2.33	0.10	1.12±0.67	0.00±0.00	1.67±1.15	0.47	0.62	1.03±0.70	1.04±0.71	0.00	0.99
Trichocerca weberi	0.00±0.00	0.17±0.17	0.50±0.28	1.28	0.28	0.37±0.18	0.00±0.00	0.00±0.00	NV	NV	2.05±0.67	2.28±1.16	1.75	0.23
Trichocerca tropis	6.11±2.33	2.67±0.85	1.33±0.60	3.72	0.03*	3.15±0.83	2.50±1.73	2.50±1.73	0.10	0.91	2.05±0.72	3.85±1.16	1.74	0.19
Trichotria sp	0.28±0.28	0.00±0.00	0.00±0.00	NV	NV	0.09±0.09	0.00±0.00	0.00±0.00	NV	NV	1.17±0.72	1.00±0.39	2.20	0.12
Copepod nauplius	8.61±2.56	12.83±6.57	7.83±1.72	0.37	0.69	0.00±0.00	0.00±0.00	0.00±0.00	NV	NV	0.42±0.42	0.50±12.50	1.97	0.14
Euclyclops agilis	0.83±0.83	1.67±0.96	2.17±1.01	0.40	0.67	1.85±0.72	0.00±0.00	2.50±1.73	0.87	0.42	1.03±0.65	2.31±0.93	1.28	0.26
Eudiaptomus gracilis	0.56±0.56	1.33±0.93	1.17±1.01	0.15	0.8	1.57±0.78	0.00±0.00	0.00±0.00	NV	NV	2.05±1.07	0.13±0.13	3.19	0.08
Eucyclops sp.	0.56±0.39	19.67±13.32	1.00±0.52	1.59	0.21	11.39±7.43	0.42±0.42	0.83±0.58	0.46	0.63	8.33±7.32	7.82±7.31	0.00	0.96
Diaptomus sp.	0.00±0.00	0.67±0.47	1.00±0.57	0.90	0.41	0.56±0.32	0.00±0.00	1.67±1.15	1.45	0.24	0.26±0.26	1.03±0.50	1.86	0.17

Taxa	Horizontal variation					Vertical variation					Seasonal variation			
	Lacustrine	Transition	Riverine	F	P	Surface	Mid-Depth	Bottom	F	P	Dry	Rain	F	P
	Mean	Mean	Mean			Mean±SE	Mean±SE	Mean±SE			Mean±SE	Mean±SE		
Alonella dentifera	0.83±0.47	1.33±0.84	0.00±0.00	1.50	0.23	0.74±0.41	1.25±1.25	0.00±0.00	0.52	0.59	0.77±0.54	0.64±0.42	0.03	0.85
Daphnia sp.	10.00±8.38	2.17±1.41	0.33±0.33	1.77	0.17	1.85±0.89	0.42±0.42	0.50±12.50	1.97	0.14	6.03±3.98	0.51±0.51	1.88	0.17
Diaphanosoma sp	1. 11±1.11	1.00±0.57	0.00±0.00	1.15	0.32	0.46±0.38	0.00±0.00	2.08±1.34	1.81	0.17	0.26±0.18	1.03±0.65	1.31	0.25
Eubranchipus sp	1. 67±0.85	0.17±0.17	1.00±0.62	1.75	0.18	0.93±0.41	0.83±0.83	0.42±0.42	0.16	0.85	1.67±0.62	0.00±0.00	NV	NV
Dunhevedia crassa	1. 11±0.87	0.00±0.00	0.00±0.00	NV	NV	0.00±0.00	0.00±0.00	1.67±1.30	NV	NV	0.38±0.38	0.13±0.13	0.40	0.53
Pleuroxus denticulatus	0. 56±0.56	0.50±0.28	0.00±0.00	1.15	0.32	0.28±0.16	0.00±0.00	0.83±0.83	1.02	0.36	0.38±0.29	0.26±0.18	0.14	0.70
Simocephalus sp	3.61±1.74	1.17±0.72	1.00±0.39	2.20	0.12	1.76±0.63	0.00±0.00	2.92±1.75	1.28	0.28	2.18±0.91	1.15±0.48	1.00	0.32
Chironomus sp larva	1.39±1.39	3.67±2.02	1.50±0.71	0.74	0.48	2.50±1.19	1.25±1.25	2.50±1.73	0.13	0.88	2.69±0.99	1.92±1.46	0.19	0.66
Coenagrion sp	0.56±0.39	1.33±0.73	1.50±1.06	0.27	0.76	1.57±0.71	0.00±0.00	0.83±0.58	0.67	0.51	1.28±0.76	1.15±0.66	0.02	0.90

NV = No Variance

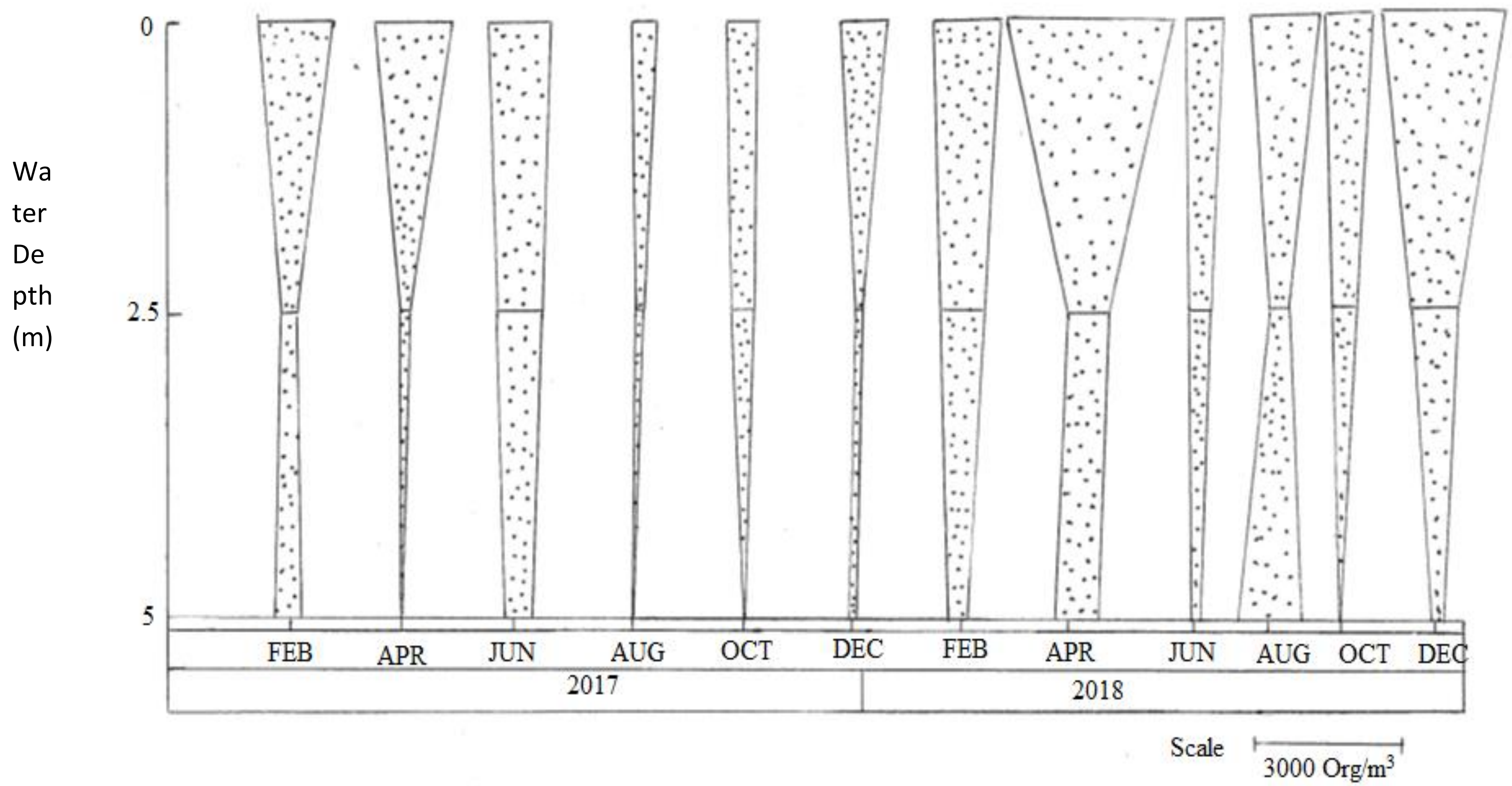

Fig. 4. Time-Depth abundance (Org/m^3) of Total Rotifera group at the lacustrine station

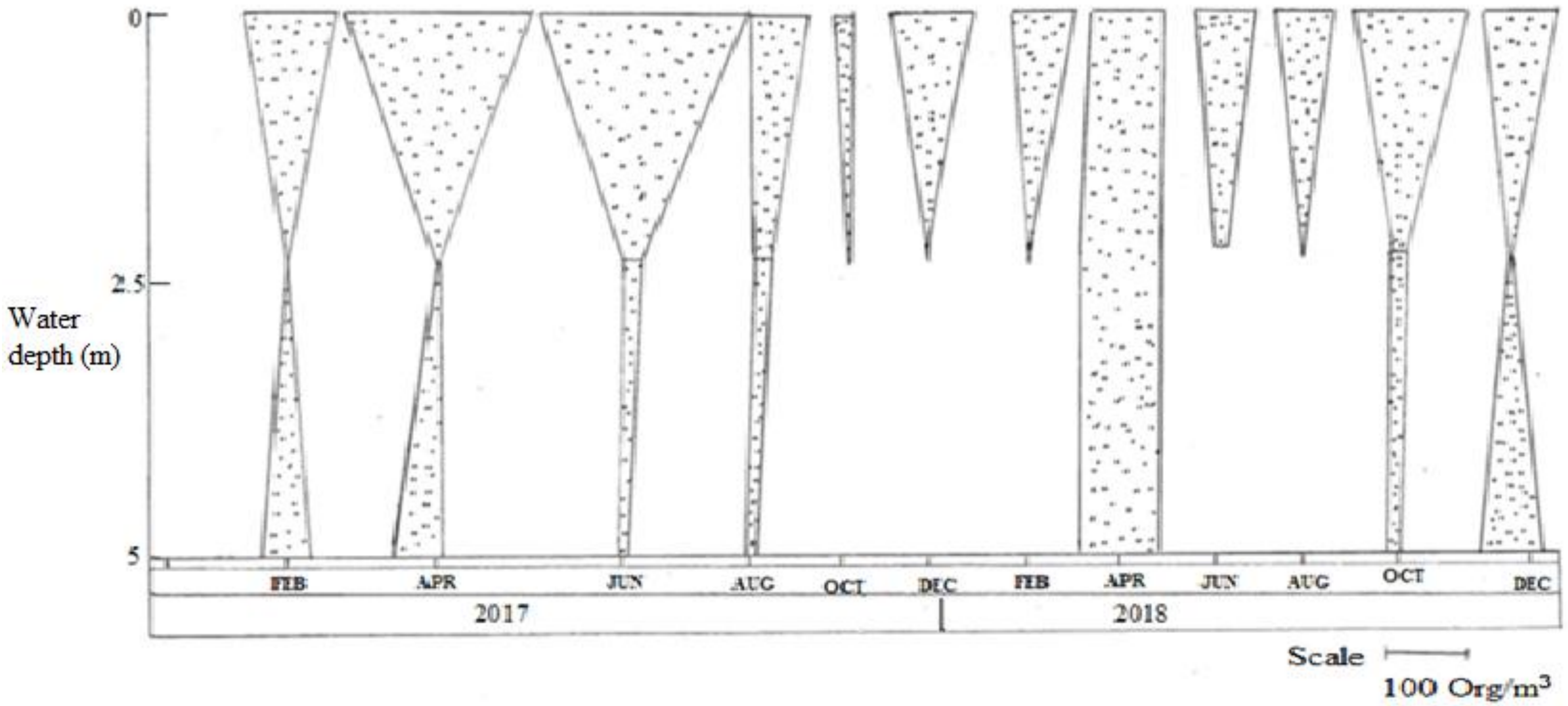

Fig. 5. Time-Depth abundance (Org/m^3) of Total Copepoda group at lacustrine

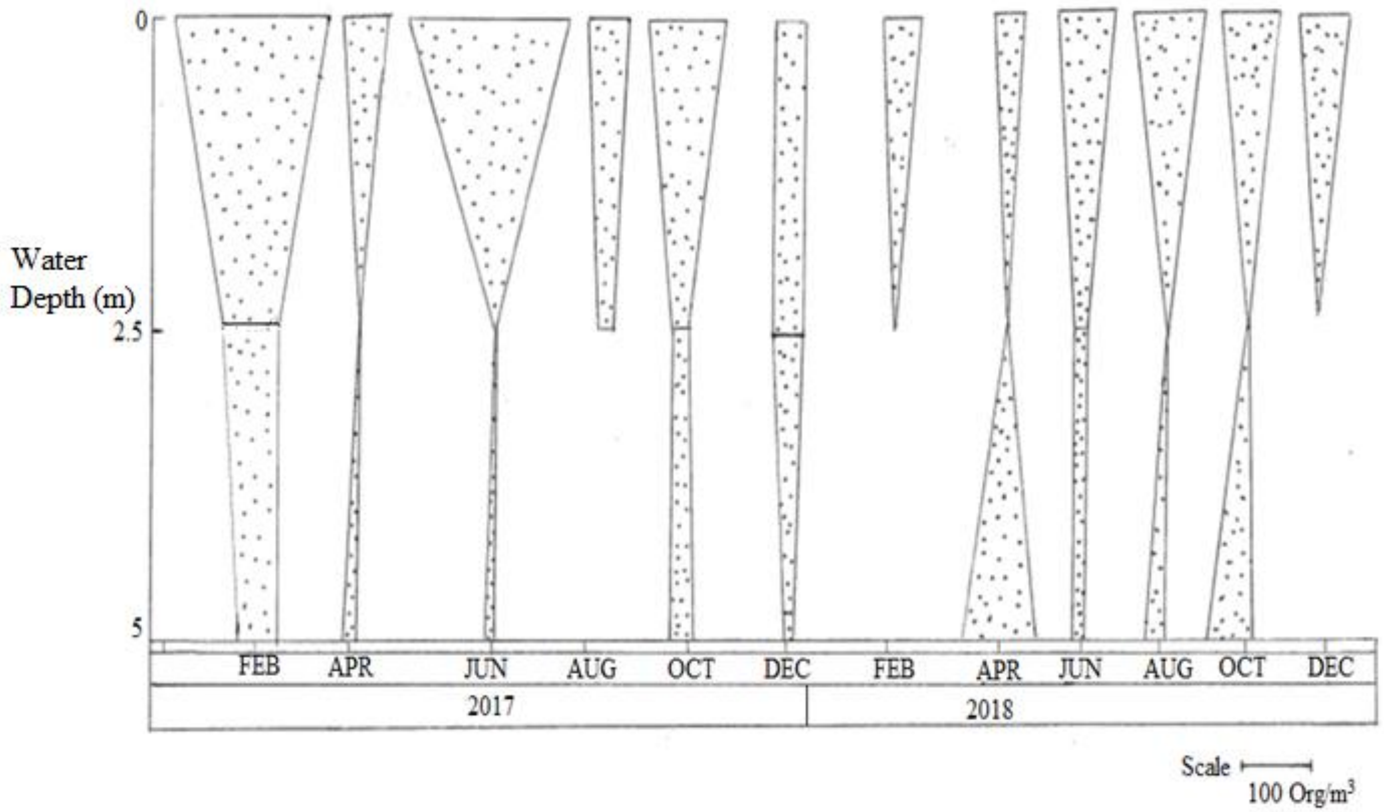

Fig. 6. Time-Depth abundance (Org/m^3) of Total Cladocera group at lacustrine

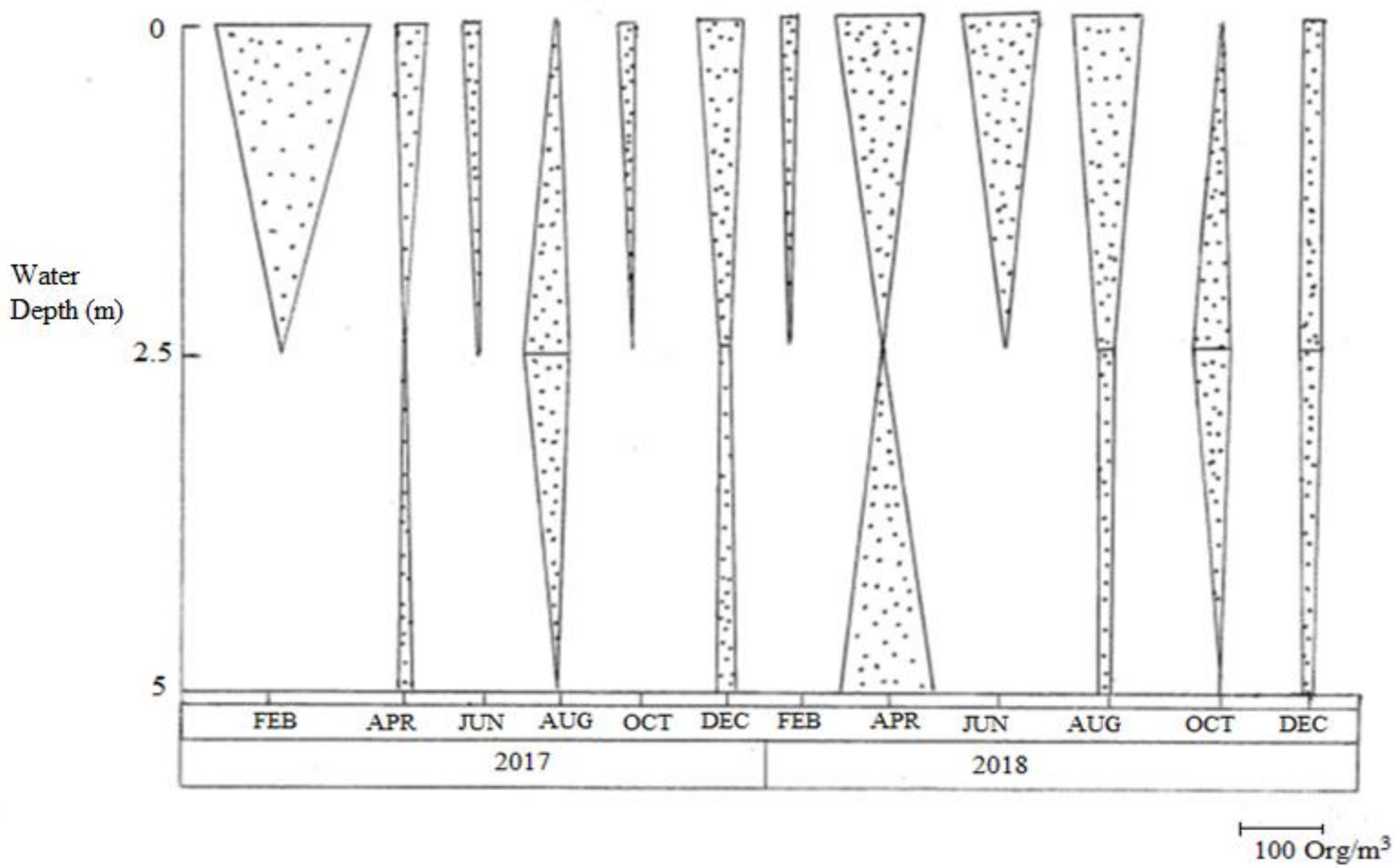

Fig. 7. Time-Depth abundance (Org/m^3) of Total Insecta group at lacustrine

Table 2. Diversity, Evenness, and Richness of zooplankton species

Indices	1S	1B	2S	2M	2B	2L1	2L2	3S	3M	3B	3L1	3L2	Inflow
Taxa_S	23	25	26	13	23	24	24	33	18	20	20	27	17
Individuals	1420	4840	2200	520	2130	5750	1990	4910	1440	1210	1060	2030	900
Dominance D	0.081	0.292	0.115	0.135	0.109	0.512	0.159	0.114	0.391	0.240	0.141	0.159	0.101
Simpson_1-D	0.920	0.708	0.885	0.865	0.891	0.488	0.841	0.886	0.609	0.760	0.859	0.841	0.900
Shannon H	2.781	1.851	2.634	2.240	2.649	1.372	2.364	2.709	1.636	2.120	2.386	2.497	2.503
Evenness e^H/S	0.702	0.255	0.536	0.722	0.615	0.164	0.443	0.455	0.285	0.417	0.543	0.450	0.719
Margalef	3.031	2.829	3.248	1.919	2.871	2.657	3.028	3.765	2.338	2.677	2.728	3.414	2.352
Equitability J	0.887	0.575	0.808	0.873	0.845	0.432	0.744	0.775	0.566	0.708	0.796	0.758	0.883
Fisher alpha	3.898	3.450	4.142	2.418	3.603	3.203	3.838	4.754	2.898	3.403	3.498	4.400	2.974
Berger-Parker	0.190	0.504	0.232	0.250	0.249	0.710	0.322	0.279	0.611	0.463	0.302	0.355	0.178

Margalef value revealed that the lacustrine littoral zone was richer in species than the lacustrine and transition mid-depth and inflow area. Fisher-alpha diversity index was highest at lacustrine surface water and lowest at transition mid-depth. Also, the Berger-Parker value was highest at the transition littoral zone and lowest at the inflow (Table 1).

4. DISCUSSION

The fiftyty-three (53) pecies of total zooplankton recorded in this study are common to tropical freshwater bodies. The dominance of Rotifera in the zooplankton fauna of freshwater has been documented by many workers in Africa and Nigeria as reported by Green (1960) [13], Jeje and Fernando (1986) [14], Egborge and Tawari (1987) [15], Ayodele and Adeniyi (2006) [8]. The dominance of the families Brachionidae, Trichocercidae, and Lecanidae among the rotifer group has also been confirmed by many researchers in Africa and beyond [13,16,17,8]. The dominance of this group may be because most of the species are warm water adapted, occurring mostly in tropical water bodies, with high temperatures. Also, it may be attributed to their low environmental requirement hence their wide geographical distribution.

The vertical variation in the mean abundance of zooplankton revealed that the highest mean abundance of zooplankton species occurred at the surface. This has been explained to result from the fact that the surface provides adequate food sources (photosynthesis) to support the zooplankton community [18,19]. The increase The quantitative increase in species at some depths may be attributed to species vertical movement in the water column on daily basis. The diversity of species also followed the same pattern as Shannon and Margalef indices recorded the higher values at the surface [20]. This implies that the availability of food at the surface of the reservoir favors the diversity and richness of species of zooplankton at the surface. However, the evenness recorded was low in most of the stations of the reservoir, which implies that zooplankton species were not equally abundant across the reservoir.

Zooplankton groups had their highest mean abundance at the lacustrine. This was because the dam site provides a suitable environment for the species reproduction and development because of the abundance of phytoplankton, which serve as zooplankton's major source of food [19]. This may also be due to the stability of the reservoir's zone in terms of lower current, increased transparency, and also reduced suspended particles which normally clog their body forms. Yusoff *et al.* (2002) [21] also reported more abundant zooplankton species at the lacustrine area of Kenyir Reservoir in Malaysia, which was however attributed to higher oxygen concentration, higher total suspended solids, and lower transparency.

The seasonal variation of zooplankton recorded from the reservoir showed that zooplankton was most abundant during the dry season. This is in contrast to what was recorded by Aduwo, (2008) [22] on OAU. Teaching and Research Farm Lake, Yusoff *et al*. (2002) [21] for Kenyir Reservoir, Malaysia and Omoboye *et al*., (2015) [23] for Owalla Reservoir. They reported an increase in zooplankton abundance with rains. High abundance during the dry season followed an increase in phytoplankton abundance at this period since clearer water aids light penetration for photosynthesis. Moreover, increased temperature and solar radiation, which is associated with the dry season, also contribute to production in phytoplankton groups [24].

5. CONCLUSION

In conclusion, Esa-Odo Reservoir comprised highly diversified zooplankton fauna with great potential to support rich aquatic community and fishery production. Rotifer abundance plays a major role between phytoplankton and planktivorous fishes. Thus, the high abundance of the Rotifera group increased trophic status. Moreover, Esa-Odo Reservoir comprised highly diversified zooplankton fauna with great potential to support rich aquatic communities and fishery production. The reservoir can be classified as fairly clean based on the abundance of the rotifer group. However, the lake should be subjected to regular monitoring due to the presence of some pollution tolerant copepod (*Diaptomus sp* and *Eudiaptomus gracilis*) species.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. US. Environmental Protection Agency (EPA). International Decontamination Research and Development Conference. U.S. Environmental Protection Agency, Washington, DC. 2016
2. Gadzala-kopciuch R, Berecka B, Bartoszewwicz J, Buszewski B. Some considerations about bioindicators in environmental monitoring. Polish Journal of Environmental Studies. 2004:13(15): 453-460.
3. Kovalev VA. Grigoriev AY, Ahn HS. Robust Recognition of White Blood Cell Images, 13th Int. Conf. on Pattern Recognition (ICPR'96), Vienna, Austria. 25-1999:29(IV): 371-375.
4. Gazonato Neto AJ, Silva LC, Saggio AA, Rocha O. Zooplankton communities as eutrophication bioindicators in tropical reservoirs. Biota Neotropica 2004;14:1–12.
5. Esinazi-Santanna EM, Menezes R, Costa IS, Araújo M, Panosso R, Attayde JL. Zooplankton assemblages in eutrophic reservoirs of the Brazilian semi-arid. Braz. J. Biol. 2013;73(1): 37-52.
6. Thorpe JH, Covich, AP. Ecology and Classification of North Dakota Freshwater Invertebrates. Academic Press, New York, NY, USA. 1991:1021.
7. Abdulazeez MT, Bello AH, Alhassan N, Wada Y. Relationship between physicochemical parameters and zooplanktons in karidna reservoir, Kaduna state. Bayero Journal of Pure and Applied Sciences. 2017;10(1): 664 – 669.
8. Ayodele HA, Adeniyi IF. The zooplankton fauna of six impoundments on River Osun, Southwest, Nigeria. The Zoologist. 2006;1(4): 49-67.
9. True Knowledge. The Internet Answer Engine.
   Available: www.trueknowledge.com.
   Accessed on 18th May, 2018.
10. Witty LM. Practical guide to identifying freshwater crustacean zooplankton. 2nd edition, Sudbury, Ontario: Cooperative. Freshwater Zoology Unit. 2004:50.
11. Fernando CH. A Guide to Tropical Freshwater Zooplankton. Backhuys, Publishers, Leiden, Netherlands. 2002: 50-253.
12. Edmondson, WT. Freshwater Biology (Second Edition). John Wiley and Sons, Inc, London. 1959:421-450.
13. Green J. Zooplankton of the River Sokoto. The Rotifera. Proceedings of Zoological Society London. 1960;135: 491-523.
14. Jeje, CY, Fernado CH. A Practical Guide to the Identification of Nigerian. Zooplankton (Cladocera, Copepoda and Rotifera). The Kanji Lake Research Institute. 1986:142.
15. Egborge ABM, Tawari PL. The rotifer of Warri River, Nigeria. Journal of Plankton Research, 1987;9:1-13.
16. Egborge, ABM. The composition, seasonal variation, and distribution of zooplankton in Lake Asejire, Nigeria. La Revue de Zoologic Africaine. 1981;95: 137-165.
17. Akinbuwa O. Adeniyi IF. The Rotifers fauna of Opa Reservoir, Ile- Ife, Nigeria. J. Afr. Zool. 1991;105:383-391.
18. Benfield LA. The composition and distribution of zooplankton in the lower Waikato River, New Zealand. M. Sc. Thesis. The University of Waikato, Hamilton, New Zealand. 1990:120.
19. Burger, DF, Hogg, ID, Green, JD. Distribution and abundance of zooplankton in the Waikato River, New Zealand. Hydrobiologia. 2002;479: 31-38.
20. Dash, MC. Fundamentals of Ecology. Tata McGraw Hill Publishing company limited, New Delhi. 1996:525.
21. Yusoff, FM, Matias, HM, Khan, N. Changes of water quality, Chlorophyll a and zooplankton along the river-lacustrine continuum in a tropical reservoir. Verh. International Verein. Limnology, 2002;28: 295-298.
22. Aduwo, IA. The study of zooplankton fauna and physicochemical water properties of Obafemi Awolowo University Teaching and Research Farm Lake. M. Sc. Thesis, Obafemi Awolowo University, 2008:287.
23. Omoboye, HY, Adeniyi, IF. The Planktonic Community and Primary Productivity of Owalla Reservoir, Osun State, Southwest, Nigeria. M. Sc. Thesis, Obafemi Awolowo University. 2015: 263.

24. Mitrovic SM, Howden CG, Bowling LC, Buckney RT. Unusual allometry between in situ growth of freshwater phytoplankton under static and fluctuating light environments: possible implications for dominance. Journal of Plankton Research. 2003;25(5): 517-526.

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