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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2024 21(3): 544-552. **OPEN ACCESS**

Zooplankton assemblages of Oguta lake

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The abundance and composition of zooplankton in Oguta lake were studied. Oguta lake is strategic as the largest natural lake in the Imo River Basin of South Eastern Nigeria. A plankton net of 2µm mesh size and 30cm diameter was used to obtain the zooplankton and samplings carried out according to stations for a period of one year. Zooplankton samples collected were preserved in 4% formalin before laboratory analysis. With the aid of a compound microscope the zooplankton were identified to species level using relevant taxonomic keys. 38 species of zooplankton belonging to four taxonomic groups; Protozoa, Copepoda, Cladocera and Rotifera were recorded, and in this order: Rotifera > Cladocera > Copepoda >Protozoa. The four sampling stations of Osemoto, Utu, Njaba and Orashi had different relative abundance of 24.3%, 23.79%, 21.66% and 30.17% respectively. Margalef's index of species richness, Simpson's index of species dominance and Jaccard's index of similarity showed less variations among the study stations. The status of Oguta lake could be said to be moderately eutrophic as evidenced by the diversity of zooplankton.

Keywords: Zooplankton, Diversity, Abundance, Oguta Lake

INTRODUCTION

The animal members of the plankton community collectively known as zooplankton (Mukhopadhyay et al. 2007) are an important component of freshwater food especially for the fishes. Zooplankton communities of fresh water bodies constitute an extremely diverse assemblage of organisms represented by most of the invertebrate phyla, however, the dominant zooplankton includes rotifers, cladocerans, copepods and ostracods (Usman et al. 2014) and their distribution and diversity are influenced by seasonal variations of physicochemical properties, biotic factors including feeding ecology and predation pressure (Imoobe and Adeyinka, 2010). The rotifers constitute a phylum found almost exclusively in fresh water, it also shows its presence in marine environment. The copepods and cladocerans are both groups of the large subphylum crustacea. Copepods constitute a class that is widespread in both freshwater and marine environments. 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 zooplanktons 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 often move extensively in quiescent water.

Ojituku et al. (2017) reported that zooplankton constitutes very important natural fish food and their abundance is important for growth and fish production. Kitto and Bechara (2004) and Fafioye and Omoyinmi (2006) equally indicated that rotifers are highly nutritive to planktivorous fish, its protein supports fast growth of fish larvae and juveniles and as such a booster to fish farmers. Amali and Solomon (2001) demonstrated the successful use of zooplankton in place of Artemia nauplii for fish larval rearing. Zooplanktons are useful indicator of future fisheries health because they are of great importance in bio-monitoring of pollution (Davies et al. 2009). The biomass, abundance and species diversity of zooplankton are used to determine the conditions of aquatic environment (MBO, 2007) while the nature of species occurring, diversity, biomass and season of maximum abundance of zooplanktonic organisms differ in water bodies (FAO, 2006). The ecological health of Oguta lake is important given its strategic position in oil

exploration (Isinkaye and Emelue, 2015) and sewage disposal (Nfor and Akaegbobi, 2012). The lake also serves as a source of fishing and sand mining (Nfor and Akaegbobi, 2012). This study attempts to shed light on the current state of the zooplankton community of Oguta lake which could serve as a biomonitoring tool.

MATERIALS AND METHODS

Study area:

Geographically, Oguta Lake is located between latitude $5^{o}41^{1}$ - $5^{o}44^{1}$ north of Equator and longitude $6^{0}56^{1}$ - $6^{0}45^{1}$ east of Greenwich with an average annual rainfall of 3100mm. (Ahiarakwem *et al,* 2012). Its surface area is 1.80km^2 at peak flood with maximum depth of 7.00m and mean depth of 5.50m during the dry season. The lake is fed mainly by the Njaba and Awbana River and empties itself into the River Niger drainage system through River Orashi (Figure 1).

Sampling locations:

Four sampling locations were designated within the lake. An area where the water is shallower with reduced water current was considered as suitable sample location.

Utu Station: This is located at a point where Utu stream enters Oguta lake. From this station farm lands and human settlements could be observed. Utu station has a mean depth of 5.63±0.460 m

Osemoto Station: This is located where Awbana river joins Oguta lake. Anthropogenic activities like processing of cassava and breadfruit, refuse disposal and sewage disposal are predominant in this station. This station has a mean depth of 5.40±0.732 m

Njaba Station: This is where Njaba river joins Oguta lake. Sand mining is done close to this station. The mean depth of this station is 5.42±0.681m

Orashi Station: At this station, Oguta lake flows into Orashi river. A very serene environment and deeper than other stations with an average depth of 6.27±0.630 m

Zooplankton sampling:

A plankton net of 30cm diameter and mesh size of 2µm was used to obtain the zooplankton. Sampling was done once a month between April 2017 and March 2018 to cover periods of rainy season and dry season. Using a dug-out canoe, vertical haul and horizontal towing were made in each station. After sampling, the contents of the plankton net collecting bottle was transferred into a 250 ml bottle with the addition of 4% formalin for preservation. This was allowed to sediment for 48hours. Zooplankton observation was made using a binocular compound microscope (AXL LABO 1.3 mega pixel).

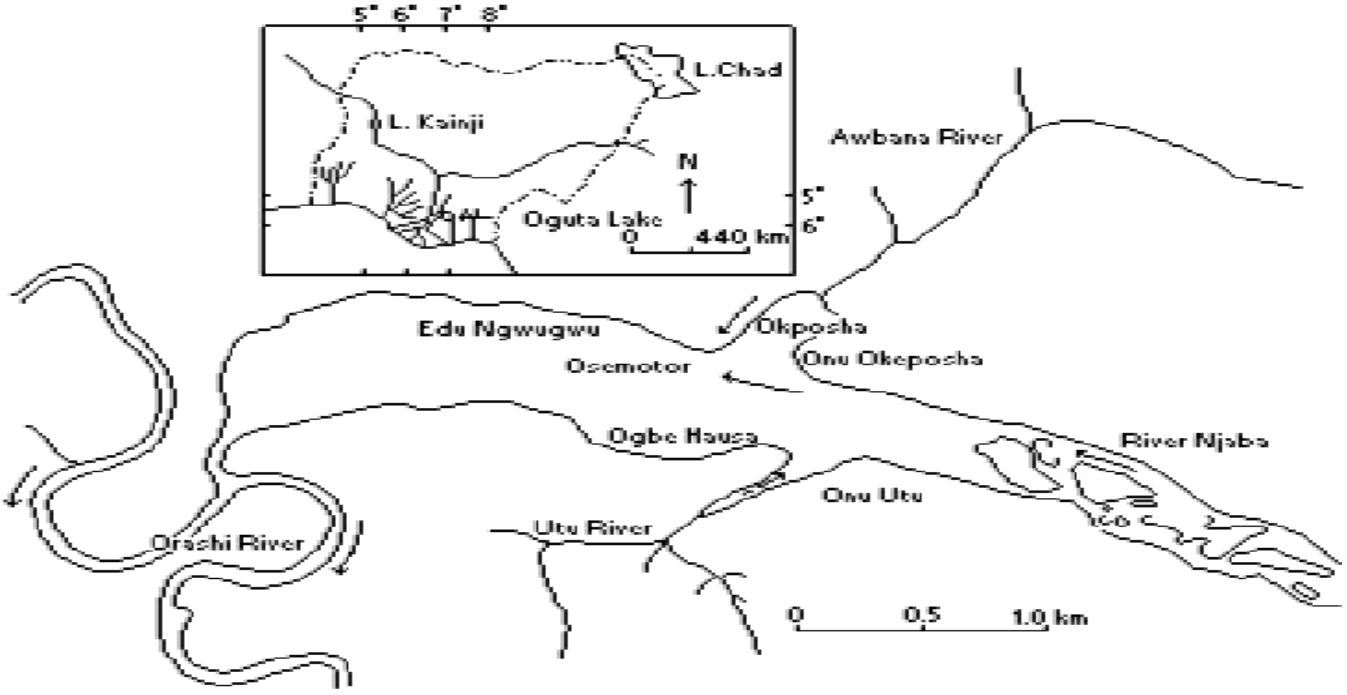

Figure 1: Map of Oguta Lake showing sampling locations.

Identification and enumeration of Zooplankton:

Before enumeration of the zooplankton, some liquid were decanted from the 250 ml zooplankton sample to get a concentrated sample which was later stored in a 50ml bottle. After shaking the bottle thoroughly, one ml of the sample was transferred onto a microscope glass slide using a standard dropper for identification and enumeration. Enumeration (standing crop estimation) of the zooplankton was carried out under a binocular

compound microscope with 10x, and 40x magnifications. Numerical estimates of the zooplankton were done by calculating organism concentration per ml of sample. This was done using the following relationship as described by Chandni (2018)

Total organism/ml = Total number of organism per drop × Number of drops per ml.

Relative abundance of the zooplankton species was calculated according to the following.

$$\% \text{ abundance} = \frac{X}{\text{Total no of species}} x \frac{100}{1}$$

Where x = number of species

For proper identification of the species, taxonomic keys of Han (1978), Jeje and Fernando (1986) and Egborge (1993) were employed.

Statistical analysis:

Descriptive statistics including means, percentages and graphical representations were determined using MS EXCEL 2016. Three ecological indices - Margalef Index(d), Simpson's index(1-D) and Jaccard's index(J)) used in the determination of the species diversity were analysed using PAST software.

RESULTS

Species composition and abundance:

The Zooplankton of Oguta Lake are presented in Table 1 and 2. Table 1 shows the composition and abundance of Zooplankton species recorded in Oguta lake. Table 2 shows the spatial distribution of Zooplankton species recorded in Oguta lake while Fig. 3 shows the temporal distribution of Zooplankton species.

A total of eight (8) orders and thirty eight (38) species were recorded during the study. The dominant phylum was Arthropoda, followed by Rotifera and Protozoa. The Arthropoda is composed of four orders, Harpacticoida, Calanoida, Cyclopoida (Copepoda), and Cladocera. The Rotifera is represented by two orders, Ploima and Collothecacea while the phylum Protozoa is represented by the order Ciliophora and Arcellinida. The order Ciliophora has a relative abundance of 8.51% from 44 individuals while the relative abundance of Arcellinida is 6.77% from 35 individuals. The highest relative abundance was recorded by *Difflugia sp*. (6.77%) from 35 individuals. Under the Arthropoda, Harpacticoida was 15.08% from 78 individuals, Calanoida, 6.19% from 32 individuals, Cyclopoida, 21.46% from 111 individuals, Cladocera, 19.91% from 103 individuals.

Among the Rotifera, the relative abundance of the order Ploima was 20.69% from 107 individuals while Colothecacea was 1.35% from 7 individuals.

The family Chydoridae (Cladocera) is the most abundant comprising of 9 species and 84 individuals with relative abundance of 16.23%.

Spatial Species variation and abundance:

The four sampling stations of Osemoto, Utu, Njaba and Orashi had different relative abundance of 24.3%, 23.79%, 21.66% and 30.17% respectively (Figure 2). Generally, Orashi study station recorded the highest number of species and individuals. The distribution and abundance of the taxonomic groups varied among the stations (Table 2). The Protozoa are represented by 4 species *Astylozoon faurei*, *Frontonia leucas*, *Paramecium* sp. and *Difflugia* sp. These species were ubiquitous in nature occurring in all the study stations though *Frontonia leucas* was not recorded in Osemoto. The Arthropoda was dominated by the class Crustacea and represented by 21 species from 4 orders (Table 1), Cladocera was the most dominant order represented by 11 species**.** The Rotifera dominated by the class Eurotatoria has 12 species. The dominant order in this group was the order Ploima with 11 species while the order Collothecacea was represented only by one species – *Colloteca sp*.

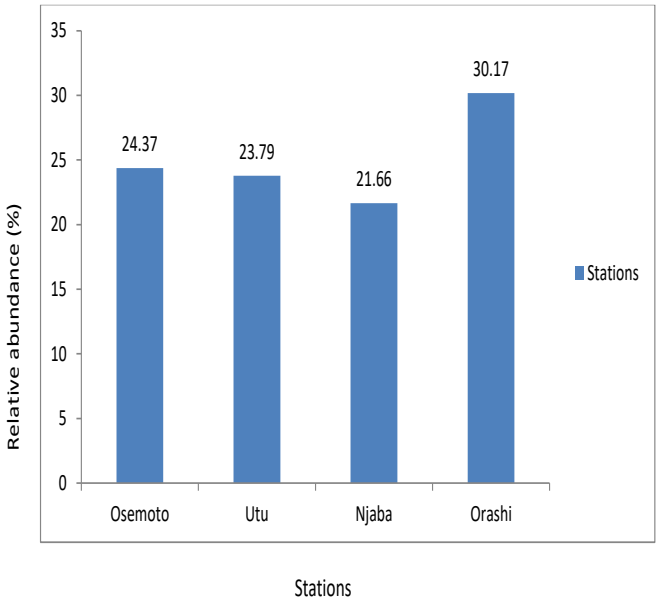

Figure 2: Relative abundance (%) of Zooplankton species in relation to stations

Table 1: Composition and abundance of Zooplankton in Oguta lake

Phylum	Class	Subclass	Order	Family	Species	Number Collected (Orgs/ml)	% Abundance
Protozoa	Oligohymenophorea		Ciliophora	Frontoniidae	*Astylozoon faurei*	14	2.71
					Frontonia leucas	17	3.29
				Paramelicidae	*Paramecium sp*	13	2.51
	Lobosa		Arcellinida	Difflugiidae	*Difflugia sp*	35	6.77
Arthropoda	Crustacea -	Copepoda	Harpacticoida	Canthocamptidae	*Canthocamptus staphylinus*	13	2.51
	-				*Mesochra suifunensis*	9	1.74
				Onchocamptidae	*Onchocamptus mohammed*	26	5.03
				Ameiridae	*Nitokra lacustric*	30	5.80
			Calanoida	Temoridae	*Eurytemora affinis*	19	3.68
				Aetideidae	*Senecella calanoids*	13	2.51
			Cyclopoida	Cyclopoidae	*Eucyclops macrurus*	30	5.80
					Thermocyclops neglectus	32	6.19
					Tropocyclops prasinus	13	2.51
					Cyclopoid copepodid	21	4.06
					Cyclopoid nauplius	15	2.90
		Cladocera	Cladocera	Chydoridae	*Chydorus sphaericus*	15	2.90
					Monospilus dispar	4	0.77
					Alonella exigua	13	2.51
					Alona rectangular	9	1.74
					Alona affinis	10	1.93
					Alonella excisa	10	1.93
					Dunhevedia crassa	9	1.74
					Alonella rostrata	8	1.55
				Monidae	*Moina macrocopa*	11	2.13
				Macrothricidae	*Macrothrix rosea*	8	1.55
				Chydoridae	*Leydigia acanthrocerocoides*	6	1.16
Rotifera	Eurotatoria		Ploima	Brachionidae	*Brachionus caudatus*	18	3.48
				Synchaetidae	*Ploesoma hudsoni*	6	1.16
					Ploesoma lenticular	6	1.16
					Synchaeta pectinata	7	1.35
				Lepadellidae	*Colurella uncinata*	13	2.51
				Lecanidae	*Monostyla hamata*	12	2.32
					Monostyla quadridentata	3	0.58
					Lecane luna	11	2.13
				Gastropodidae	*Ascomorpha saltans*	11	2.13
				Euchlanidae	*Euchlanis lyra*	14	2.71
				Trichocercidae	*Trichocerca lophoessa*	6	1.16
			Collothecacea	Collothecidae	*Collotheca sp*	7	1.35
					Total	517	100%

Table 2: Abundance of Zooplankton in relation to study stations

Phylum	Genus	Species	OSEMOTO	UTU	NJABA	ORASHI
Protozoa	*Astylozoon*	*Astylozoon faurei*	5 (3.97)	4 (3.25)	3 (2.68)	2 (1.28)
	Frontonia	*Frontonia leucas*	0 (0.00)	4 (3.25)	7 (6.25)	6 (3.85)
	Paramecium	*Paramecium sp*	3 (2.38)	1 (0.81)	4 (3.57)	5 (3.21)
	Difflugia	*Difflugia sp*	10 (7.94)	6 (4.88)	7 (6.25)	12 (7.69)
Arthropoda	*Canthocamptus*	*Canthocamptus staphylinus*	0 (0.00)	0 (0.00)	6 (5.36)	7 (4.49)
	Mesochra	*Mesochra suifunensis*	2 (1.59)	3 (2.44)	0 (0.00)	4 (2.56)
	Onchocamptus	*Onchocamptus mohammed*	6 (4.76)	5 (4.07)	7 (6.25)	8 (5.13)
	Nitokra	*Nitokra lacustric*	9 (7.14)	5 (4.07)	5 (4.46)	11 (7.05)
	Eurytemora	*Eurytemora affinis*	4 (3.17)	2 (1.63)	5 (4.46)	8 (5.13)
	Senecella	*Senecella calanoids*	3 (2.38)	5 (4.07)	0 (0.00)	5 (3.21)
	Eucyclops	*Eucyclops macrurus*	10 (7.94)	6 (4.88)	8 (7.14)	6 (3.85)
	Thermocyclops	*Thermocyclops neglectus*	7 (5.56)	10(8.13)	8 (7.14)	7 (4.49)
	Tropocyclops	*Tropocyclops prasinus*	3 (2.38)	5 (4.07)	0 (0.00)	5 (3.21)
	Cyclopoid	*Cyclopoid copepodid*	7 (5.56)	3 (2.44)	5 (4.46)	6 (3.85)
	Cyclopoid	*Cyclopoid nauplius*	4 (3.17)	4 (3.25)	3 (2.68)	4 (2.56)
	Chydorus	*Chydorus sphaericus*	2 (1.59)	3 (2.44)	3 (2.68)	7 (4.49)
	Monospilus	*Monospilus dispar*	2 (1.59)	0 (0.00)	0 (0.00)	2 (1.28)
	Alonella	*Alonella exigua*	2 (1.59)	4 (3.25)	4 (3.57)	3 (1.92)
	Alona	*Alona rectangular*	3 (2.38)	2 (1.63)	0 (0.00)	4 (2.56)
	Alona	*Alona affinis*	3 (2.38)	4 (3.25)	2 (1.79)	1 (0.64)
	Alonella	*Alonella excisa*	3 (2.38)	3 (2.44)	2 (1.79)	2 (1.28)
	Dunhevedia	*Dunhevedia crassa*	2 (1.59)	3 (2.44)	2 (1.79)	2 (1.28)
	Alonella	*Alonella rostrata*	4 (3.17)	0 (0.00)	2 (1.79)	2 (1.28)
	Moina	*Moina macrocopa*	3 (2.38)	4 (3.25)	0 (0.00)	4 (2.56)
	Macrothrix	*Macrothrix rosea*	0 (0.00)	1 (0.81)	5 (4.46)	2 (1.28)
	Leydigia	*Leydigia acanthocercoides*	0 (0.00)	3 (2.44)	0 (0.00)	3 (1.92)
Rotifera	*Brachionus*	*Brachionus caudatus*	6 (4.76)	4 (3.25)	5 (4.46)	3 (1.92)
	Ploesoma	*Ploesoma hudsoni*	2 (1.59)	2 (1.63)	2 (1.79)	0 (0.00)
	Ploesoma	*Ploesoma lenticular*	3 (2.38)	3 (2.44)	0 (0.00)	0 (0.00)
	Synchaeta	*Synchaeta pectinata*	2 (1.59)	2 (1.63)	3 (2.68)	0 (0.00)
	Colurella	*Colurella uncinata*	2 (1.59)	5 (4.07)	3 (2.68)	3 (1.92)
	Monostyla	*Monostyla hamata*	4 (3.17)	0 (0.00)	3 (2.68)	5 (3.21)
	Monostyla	*Monostyla quadridentata*	0 (0.00)	2 (1.63)	0 (0.00)	1 (0.64)
	Lecane	*Lecane luna*	3 (2.38)	3 (2.44)	0 (0.00)	5 (3.21)
	Ascomorpha	*Ascomorpha saltans*	0 (0.00)	3 (2.44)	4 (3.57)	4 (2.56)
	Euchlanis	*Euchlanis lyra*	5(3.97)	5 (4.07)	4 (3.57)	0 (0.00)
	Trichocerca	*Trichocerca lophoessa*	0 (0.00)	2 (1.63)	0 (0.00)	4 (2.56)
	Colloteca	*Colloteca sp*	2 (1.59)	2 (1.63)	0 (0.00)	3 (1.92)
Total			126(100%)	123(100%)	112(100%)	156(100%)

The figures in parenthesis shows relative abundance (%) of the species

Temporal Species variation:

The Zooplankton species varied in relation to the months. The highest relative abundance was recorded in July 2017 (23.40%) followed by August 2017 (14.51%) while the least was in February 2018 (1.93%) (Figure 3).

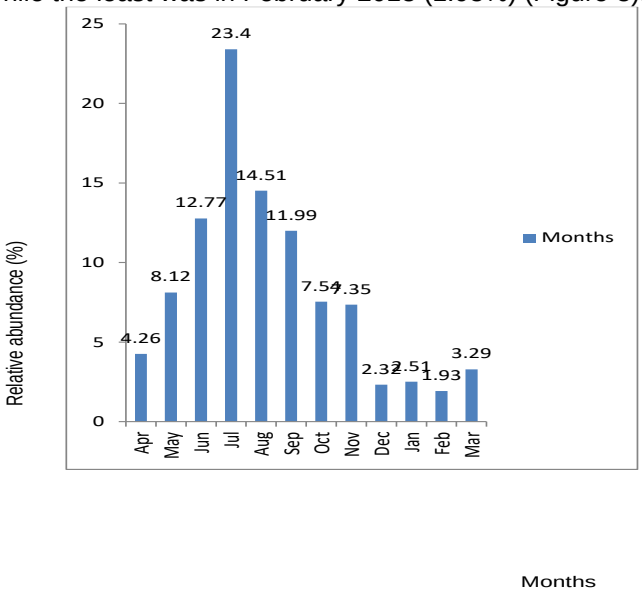

Figure 3: Relative abundance (%) of Zooplankton species in relation to months

Spatial Zooplankton diversity, dominance and similarity:

The spatial Zooplankton diversity and dominance indices are presented in Table 3. Utu station had the highest Margalef richness index of 15.7902, followed by Orashi (15.0470) while the least was in Njaba station (12.1998). The Simpson dominance index was highest in Utu station (0.9719) followed by Orashi station (0.9676), while the least was in Njaba station (0.9629). Jaccard similarity index showed high similarity exists between the study stations (Table 4). Utu and Osemoto had a similarity index of 75.68%, Njaba and Osemoto had 62.86% while Orashi and Osemoto had 71.05%. On the other hand, Njaba and Utu similarity index was 62.16%, Orashi and Utu was 78.95% while Orashi and Njaba was 85.19%.

Table 3: Zooplankton diversity and dominance at the study stations in Oguta Lake.

	STATIONS			
	OSEMOTO	UTU	NJABA	ORASHI
Number of Species	31	34	26	34
Number of individuals	126	123	112	156
Margalef's index (d)	14.2830	15.7902	12.1998	15.0470
Simpson's index (1-D)	0.9647	0.9719	0.9629	0.9676

Table 4: Zooplankton similarity coefficients of pairs of study stations in Oguta Lake.

STATIONS	JACCARD INDEX			
	OSEMOTO	UTU	NJABA	ORASHI
OSEMOTO	100%			
UTU	75.68%	100%		
NJABA	62.86%	62.16%	100%	
ORASHI	71.05%	78.95%	85.19%	100%

DISCUSSION

The zooplankton of Oguta lake are diversified in species composition. The 38 species reported in this study is low when compared to earlier studies by Imoobe and Adeyinka (2010) who reported 40 species in Ovia river and 67 species recorded in Eboma lake by Okogwu (2010) and 79 species reported by Arimoro and Oganah (2010) in Orogodo river. On the other hand, it is higher than 20 species recorded by Yakubu et al. (2000) in Orashi River, 24 species reported by Zabbey *et al*. (2008) in Imo River, 17 species encountered in Sombreiro River (Ezekiel et al. 2011) and 23 species reported by Ansa et al. (2015) in Forcados River.

The zooplankton was dominated by Rotifera, followed by Cladocera (Crustacea) and Cyclopoida (Crustacea), other groups recorded low number of species. This pattern is common in tropical freshwaters, whether in lakes, ponds, reservoirs, rivers, or streams (Neves et al. 2003). Cladocera and Cyclopoida were represented by 10 and 5 species each while Rotifera was represented by 12 species. The dominance of the Rotifera in Nigeria aquatic ecosystems has been documented (Ogbeibu and Edutie, 2002; Akin-Oriola, 2003; Aneni and Hassan, 2003; Ogbeibu and Osokpor, 2004, Imoobe and Adeyinka 2010; Okogwu 2010). Similar high dominance of rotifers was reported by Imoobe, (2011) in Okhuo River and Omowaye *et al.* (2011) in Ojofu Lake, Adeyemi, (2012) in Ajelo stream, Akindele and Olutona (2014) in Aiba Reservoir. Iloba and Ruejoma, (2014) observed this order of abundance (Rotifera > Protozoa > Cladocera > Copepoda) in Ekpan river while Rabiu et al. (2014) observed similar rotifera dominance in their study of the planktons of Kusalla reservoir. Overall, rotifers usually dominate zooplankton communities in terms of density. The dominance of rotifer may be due to predation pressure from planktivorous fishes that selectively prey on larger sized zooplankton and also on their reproductive success as well as short developmental rates under favourable conditions in most freshwater systems (Akin-Oriola, 2003; Imoobe and Adeyinka, 2010).

Among the Rotifera, Lecanidae, Brachionidae and Synchaetidae were represented by the highest number of species and the frequently encountered genera include *Brachionus, Lecane* and *Ploesoma.* Similar findings were reported by Aoyagui and Bonecker (2004)

in Parana River floodplain. Abundance of these species in Oguta lake may be due to high organic matter content. The distribution and abundance of zooplankton is determined by the amount of food (nutrients and phytoplankton) and predation by zooplankton and fish (Echeko et al. 2018). Matsumura-Tundisi, (1999) had also observed that reservoirs in which Branchionus and Asplanchna dominate have high amount of organic matter.

The Crustacean zooplankton community was composed mainly of Cladocera, Cyclopoida and Harpacticoida. Calanoida having only two species *Eurytemora affinis* and *Senecella calanoids*. Cladocera with 19.91% and 103 individuals constituted the second in total abundance. Eziekel et al. (2011) in Sombriero River, Okorafor et al. (2013) in Calabar River and Obot et al. (2020) in Stubbs Creek reported that Cladocerans and Copepods dominated the observed zooplankton taxa. The total number of Cladocera comprising of 11 species (*Chydorus sphaericus, Monospilus dispar, Alonella exigua, Alona rectangular, Alona affinis, Alonella excise, Dunhevedia crassa, Alonella rostrate, Moina macrocopa, Macrothrix rosea, Leydigia acanthocercoides*) were encountered in Oguta lake. These species are part of normal inhabitants of natural lakes, ponds, streams, and artificial impoundments in Nigeria (Mustapha, 2009; Arimoro and Oganah, 2010; Kolo et al. 2010). The relatively lower abundance of Cladocerans and Cyclopoids might be as a result of hydrodynamics of the lake, such as water volume, residence time and fish predation (Mustapha, 2009). The above assertion was also observed by Akin-Oriola (2003).

Nauplii and copepodids, the developmental stages of Cyclopoida, were quite common. Cyclopoid abundance was driven mostly by increases in *Cyclopoid nauplii* and *Cyclopoid copepodid*, although they were surpassed by Rotifers. The observed reproductive increment in Cyclopoida, represented by the high relative abundances of larval stages and the most frequent cyclopoids namely, *Eucyclops macrurus, Thermocyclops neglectus* and *Tropocyclops prasinus* indicates water of high quality. Cyclopod crustraceans are free-living filter feeder zooplankton and this account for their use in biomonitoring of water pollution (Ezekiel et al. 2011).

Zooplankton abundance increased with increase in the amount of rainfall. This may be due to the ability of rains to bring in allochthonous nutrients from the drainage basin as well as the mixing of autochthonous materials that accelerate primary production (Okogwu and Ugwumba 2006; Arimoro and Oganah, 2010). This is in contrast with lotic waters where Imoobe and Adeyinka (2010) reported a slight decrease in the total density and taxa richness during the wet season months of April to October. .

CONCLUSIONS

The Zooplankton structure of Oguta lake shows 4 major taxonomic groups, Protozoa, Copepoda, Cladocera and Rotifera. A total of 38 species were recorded. The dominant phylum is Arthropoda, followed by Rotifera and lastly by Protozoa. Oguta lake showed low density of zooplankton when compared to other lentic waters in Nigeria. This could be as a result of low nutrient inputs which hampers zooplankton species diversity.

Supplementary materials

Not applicable.

Author contributions

All authors contributed equally.

Funding statement

No specific funding was received for conducting this study.

Institutional Review Board Statement

Not applicable**.**

Informed Consent Statement

Not applicable.

Data Availability Statement

All of the data is included in the article/Supplementary Material.

Acknowledgement

We wish to acknowledge the contributions of Mr Johnson Clement of New Concepts Analytical Laboratory and Environmental Services LTD, Owerri, for field and laboratory analysis.

Conflict of Interest

All authors declare that they have no competing financial or personal interests.

Peer Review: ISISnet follows double blind peer review policy and thanks the anonymous reviewer(s) for their contribution to the peer review of this article.

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