PRELIMINARY STUDY ON ZOOPLANKTON COMPOSITION OF A CONCRETE STRUCTURED RAINFOREST LOTIC FRESHWATER ECOSYSTEM, NIGERIA

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ABSTRACT

This study investigated the zooplankton composition of Ogbei Stream. Fortnightly samples of zooplankton were sampled for twelve months (May 2018 – April 2019). A total of 1457 specimens belonging to 3 phyla, 5 classes and 7 orders were caught using plankton net with 80µm mesh size. Rotifera (706, 48.46 %) was the dominant phylum and Monogononta was the most abundant class. Ploima (590, 40.49 %) was the most abundant rotiferan order while Bdelloidea (47, 3.23 %) was the least abundant order. Monthly abundance of zooplankton was highest in September (465, 31.91 %) during the wet season and lowest in March (56, 3.84 %). Seasonally, zooplankton occurred most in the wet season and least in the dry season.

Keywords: Zooplankton, Concrete structure, Rainforest freshwater, Ecosystem, Ogbei Stream

INTRODUCTION

Aquatic ecosystem varies greatly in composition. The first life originated in the water and first organisms were aquatic where water was the principal external and internal medium for organisms (Omowaye *et al*., 2011). Thus life is aquatic. Different areas and habitats within the aquatic ecosystem allow for complex communities and patches to exist. Different biota including zooplankton composes lotic water communities. Zooplanktons are minute invertebrates which constitute the productive base of freshwater ecosystem. Zooplanktons are diverse and are affected by several factors. Ogbei Stream is a natural perennial lotic freshwater that has been the main surface water that supplies water to Nkpologwu community and her neighbouring towns particularly Ekwulobia, Uga, Amesi and Akpo. A concrete structure was erected in the stream in 2005. Thus the stream became a concrete structured stream. The concrete structure has dimensions of height 22.44 m, length 5.55 m and width 3.60 m. The concrete structure was erected in the stream to harness water for domestic, industrial and agricultural purposes. A pioneering study conducted by Ibemenuga (2005) indicated that the stream has a very rich macroinvertebrates fauna. Several studies have also been conducted on zooplanktons in southeastern Nigeria streams and rivers. Such studies include zooplanktons of Orogodo River (Arimoro and Oganah, 2010), total hydrobiological study of Okhuaihe River, Benin City, with emphasis on zooplankton population (Omoigberale and Oronsaye, 2011), Okamini Stream Port-Harcourt (Otene *et al*., 2019) and zooplankton species diversity and physico-chemical parameters in the lower Taylor Creek, Bayelsa (Kwen *et al*., 2019). No study on zooplankton of this important stream has been conducted. Concrete structure changes the physico-chemical conditions of water and affects stability and composition of aquatic fauna. There is therefore a dire need to have a comprehensive baseline documentation of the zooplankton assemblage of this stream. The present paper investigates the zooplankton diversity of Ogbei Stream.

MATERIALS AND METHODS

Study Area: The Ogbei Stream rises from Umuezeagwu highlands (Lat. 6° 01' N, 6° 58' N; Long. 7° 06' E, 7° 08' E) (Figure 1).

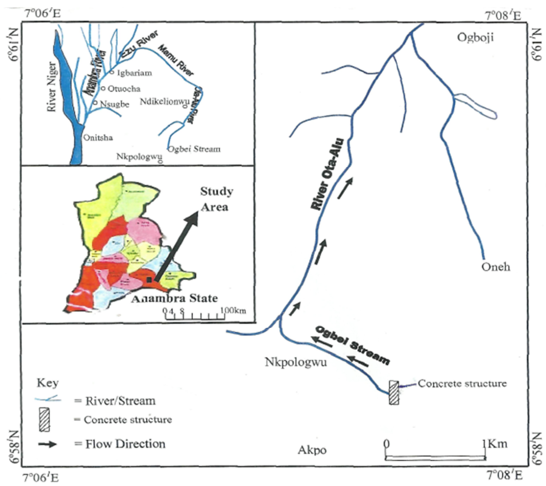

Figure 1: Map of the study area. (Source: Federal Survey Nigeria, 1967)

The stream flows through Akpo before joining Ota-Alu River. The climate of the study area shows two distinct seasons' namely wet season (April – September) and dry season (October – March). Water temperature ranged from 26.8 – 32.2°C (Ibemenuga, 2005). The stream which lies within the tropical rainforest region has riparian vegetation of macrophytes, sedges, grasses, shrubs and trees dominated by *Elaeis guineensis, Oxytenanthera abysinica, Raphia hookeri* and *Maranthochola leucantha.* A concrete structure was constructed at the source of the stream (Ibemenuga, 2005).

Zooplankton Collection: Fortnightly samples of zooplankton were collected for a period of 12 months (May 2018 – April 2019). Zooplankton samples were collected using plankton net with mesh size 80 μm. A 10litre bucket was filled with water collected diagonally from different points of the stream. The water was filtered through the plankton net. This was repeated 10 times making 100 litres volume. The filtrate was preserved in 4 % formalin. The preserved samples were transported to the laboratory for observation and identification.

Zooplankton Observation and Identification: Zooplankton was observed using a compound microscope. Identification of zooplankton was done using the keys of Pennak (1978) and Jeje and Fernando (1986). Prior to observation and identification, samples were concentrated to 10 ml by centrifugation at 1000 rpm for 5 minutes. The concentrated samples were thoroughly mixed before 0.1 ml sample was pipetted carefully into the haematocytometer of the Fuchus Rosenthal type (Ibemenuga *et al.*, 2013). The chamber was carefully covered with cover slip. The counting chamber was placed underneath the microscope and a random field selected. The zooplankton seen within the ocular microscope field were identified and counted (Rao, 2009). The monthly percentage occurrence of each zooplankton was calculated using the formula: Percentage occurrence = m/n x 100/1, where m = number of individuals, n = total number of all the zooplankton species.

Diversity Indices: Faunal diversity indices were analyzed using Margalef's species richness index (d), Shannon-Wiener diversity index (H), evenness (equitability) and dominance index (C) according to Ogbeibu (2005) as follows:

$$d = \frac{S-1}{log_e N} (1) \quad H = \sum_{i=1}^{S} Pi\, log_e Pi \ (2)$$

$$E = \frac{H}{Hmax} = \frac{H}{logS} (3) \quad C = \Sigma \left(\frac{ni}{N}\right)^2 (4)$$

Where S = number of species, Pi = proportional abundance of the i^{th} species, ni = number of individuals in the i^{th} species and N = total number of individuals

Seasonality: Surveys undertaken covered wet and dry seasons. The wet season samples were collected twice monthly from May 2018 – April

2019 while dry season samples were collected twice monthly from October 2018 – March 2019.

Data Analysis: Zooplankton diversity was calculated using diversity indices (Margalef's richness, Shannon-Wiener index, evenness and dominance) to determine zooplankton diversity in the stream. Paired t-test was used to compare zooplankton abundance in the wet and dry seasons.

RESULTS

Zooplankton Composition: The study revealed that 3 phyla, 5 classes, 7 orders and 1457 individuals' zooplanktons were sampled from Ogbei Stream (Table 1).

Table 1: Summary of phyla, classes and orders of zooplankton and indices of zooplankton diversity in Ogbei Stream, Nigeria (May 2018 – April 2019)

Parameters	Total Zooplankton Sampled
Number of phylum	3
Number of class	5
Number of order	7
Margalef's richness	3.709
Shannon-Wiener Index (H)	1.347
Evenness (E)	0.931
Dominance Index (C)	0.049
Simpson's Index (D)	0.053

In the ascending order, the percentage contribution of the different orders encountered in the study are Ploima (590, 40.49 %), Cyclopoida (257, 17.64 %), Cladocera (247, 16.95 %), Amoebina (144, 9.88 %), Peritrichida (103, 7.7 %), Monimotrocha (69, 4.74 %), and Bdelloidea (47, 3.23 %). In terms of zooplankton biodiversity, Ogbei Stream is polydiversed with many orders and individuals belonging to a taxon (Table 1). The 1457 individuals sampled reveal approximately 208 individuals implying a polydiversed condition. The dominant phylum was Rotifera which accounted for 48.46 % of all the individuals recorded in this study (Figure 2).

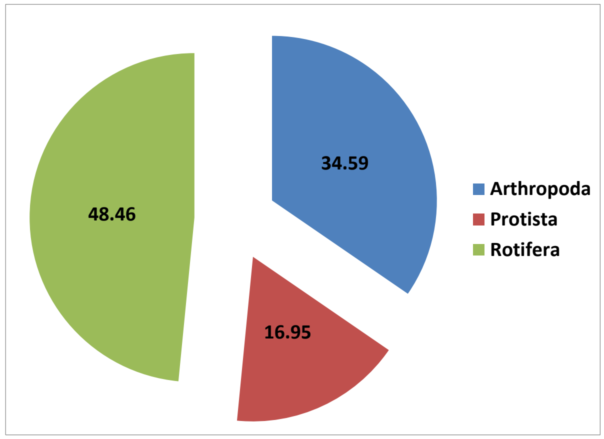

Figure 2: Percentage abundance of zooplankton phyla in Ogbei Stream, Nigeria

This was followed by the phylum Arthropoda (34.59 %), and Protista (16.95 %) was the least phylum. The zooplankton classes encountered during the study indicated that the class with highest abundance was Monogononta, while the least abundant class was Digononta (Figure 3).

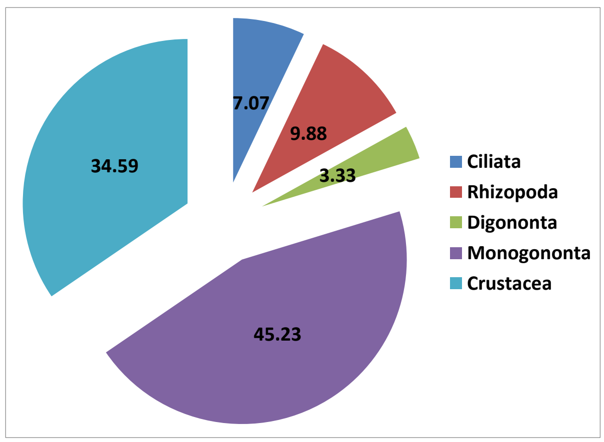

Figure 3: Class abundance (%) of zooplankton in Ogbei Stream, Nigeria

The two classes respectively formed 45.23 and 3.23 % of the total zooplankton population collected in the study (Table 2). The various taxa and their percentage contributions are shown in Figure 4.

Zooplankton Variations in Relation to Months: Zooplankton varied in relation to the months (Table 2).

Table 2: Monthly variations of zooplankton of Ogbei Stream, Nigeria (May 2018 – April 2019)

Taxa (spp./litre)	Months												N	% N
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.		
Protista	8	36	18	23	63	24	8	20	17	25	2	3	247	16.95
Ciliata	-	19	7	8	27	19	5	10	5	-	-	-	103	7.07
Peritrichida	-	19	7	8	27	19	5	10	5	-	-	-	103	7.07
Rhizopoda	8	17	11	15	36	5	3	10	12	25	2	-	144	9.88
Amoebina	8	17	11	15	36	5	3	10	12	25	2	-	144	9.88
Rotifera	39	46	86	68	227	31	36	39	33	27	22	52	706	48.46
Digononta	2	2	6	3	8	1	5	-	5	2	5	8	47	3.23
Bdelloidea	2	2	6	3	8	1	5	-	5	2	5	8	47	3.23
Monogononta	37	44	80	65	219	30	31	39	28	25	17	44	659	45.23
Monimotrocha	-	2	12	9	26	-	-	-	5	-	-	15	69	4.74
Ploima	37	42	68	56	193	30	31	39	23	25	17	29	590	40.49
Arthropoda	36	24	70	59	175	22	20	5	29	12	32	20	504	34.59
Crustacea	36	24	70	59	175	22	20	5	29	12	32	20	504	34.59
Cladocera	14	7	38	16	87	4	4	5	23	9	22	18	247	16.95
Cyclopoida	22	17	32	43	88	18	16	-	6	3	10	2	257	17.64
Grand total	83	106	174	150	465	77	64	64	79	64	56	75	1457	
Monthly % N	6.70	7.28	11.94	10.30	31.91	5.28	4.39	4.39	5.42	4.39	3.84	5.15		

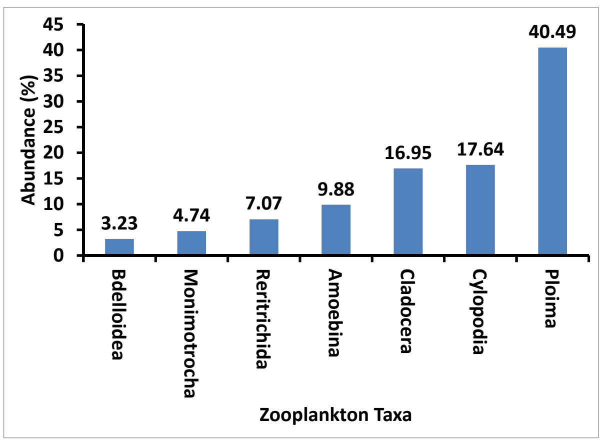

Figure 4: Relative abundance of zooplankton orders in Ogbei Stream, Nigeria

Zooplankton occurrence which peaked in September 465(31.91 %), followed by July 174(11.94 %) and August 150(10.30 %), crashed in March 56(3.84 %) (Table 2). Similar abundance (4.39 %) of zooplankton was recorded in November, December and February. All the phyla recorded in the study were widely distributed in the various months. Among the classes of zooplankton recorded in the study, Monimotrocha was mostly restricted in distribution. Out of the 7 orders recorded in the study, Ploima and Cladocera were widespread occurring in all the months.

Ploima was very prominent in September where it contributed 13.25 % of the total density. Bdelloidea the least abundant taxon, was restricted in distribution having equal and highest abundance in September and April with respective percentage contribution of 1.72 and 10.67 to the total density. It formed the 3.23 % of the total zooplankton caught in the study. The variation in the abundance of total zooplankton groups in relation to months revealed that zooplankton occurred more from April to September and decreased from October to March. Peritrichida, Amoebina, Monimotrocha, Ploima, Cladocera and Cyclopoida peaked in September (Figure 5).

Seasonality: Table 3 indicated that the zooplankton varied in relation to seasons. There was higher total abundance (1053 L^{-1}, mean 4.10 ± 22.41 L^{-1}) of zooplankton in the wet season and lower abundance (404 L^{-1}, mean 9.62 ± 10.29 L^{-1}) in the dry season. Zooplankton abundance varied significantly between seasons ($p<0.05$). All the zooplankton groups occurred in both seasons. Rotifera was the dominant phylum in both seasons being higher in the wet season (86.33 ± 70.95 L^{-1}) than in the dry season (31.33 ± 6.15 L^{-1}). The class Monogononta and the order Ploima followed the same trend.

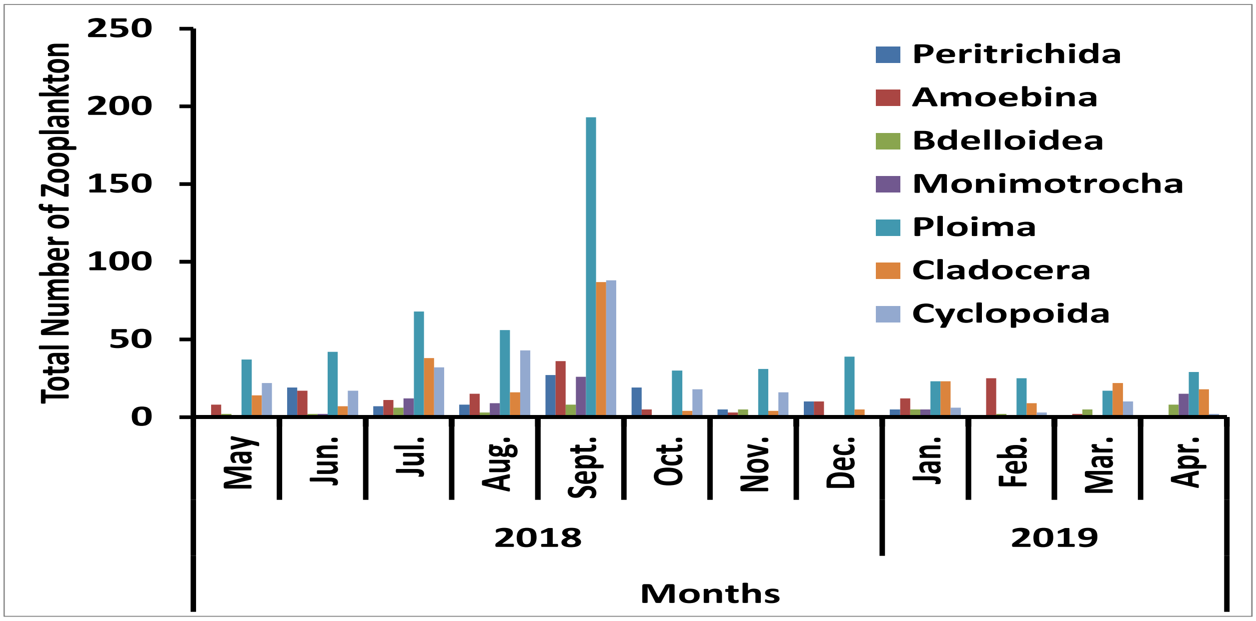

Figure 5: Monthly variations in total number of different groups of zooplankton in relation to months in Ogbei Stream

Table 3: Seasonal Variations of zooplankton major groups in Ogbei Stream, Nigeria (May 2018 – April 2019)

Taxa (spp./litre)	Seasons	
	Wet	Dry
Protista	25.17±21.87[a]	16.00±9.19[b]
Ciliata	10.17±10.80[a]	6.50±7.18[b]
Peritrichida	10.17±10.80[a]	6.50±7.18[b]
Rhizopoda	14.50±12.11[a]	9.50±8.55[b]
Amoebina	14.150±12.11[a]	9.50±8.55[b]
Rotifera	86.33±70.95[a]	31.33±6.15[b]
Digononta	4.83±2.86[a]	3.00±2.28[a]
Bdelloidea	4.83±2.86[a]	3.00±2.28[b]
Monogononta	81.50±69.24[a]	28.33±7.26[b]
Monimotrocha	10.67±9.46[a]	0.83±2.04[b]
Ploima	70.83±61.45[a]	27.50±7.58[b]
Arthropoda	64.00±57.80[a]	20.00±10.18[b]
Crustacea	64.00±57.80[a]	20.00±10.18[b]
Cladocera	30.00±29.80[a]	10.50±8.98[b]
Cyclopoida	29.50±30.55[a]	10.50±7.53[b]
Total mean composition	24.10±34.41	9.62±10.29

Mean values with the same superscript on the same row are not significantly different from each other (p<0.05)

All the zooplankton groups recorded in the study were non-seasonal in distribution. With the exception of Digononta, all other groups occurred significantly ($p<0.05$) higher in the wet season than in the dry season.

Zooplankton Diversity: Ecological indices calculated indicated that Margalef's richness was high (3.709). The Shannon-Wiener index was 1.347. Evenness was 0.931 while dominance was 0.049.

DISCUSSION

Rotifera was the most abundant phylum, while Monogononta was the dominant class. Similar high dominance of rotifers was reported by Imoobe (2011) in Okhuo River, Omowaye *et al.* (2011) in Ojofu Lake, Adeyemi (2012) in Ajelo Stream and Waidi and Akinpelu (2016) in tropical estuarine ecosystem, South-West, Nigeria. The seven orders of zooplankton obtained in this study are greater than five orders Agouru and Audu (2012) obtained in River Benue. The Ploima which include most of the free swimming limnetic plankton and littoral species (Pennak, 1978) was the most dominant order. The dominance of rotifers in Nigeria aquatic ecosystems has been documented (Aneni and Hassan, 2003; Ogbeibu and Osokpor, 2004). The dominance of rotifers may be attributed to reduced predation pressure from planktivorous fishes that selectively prey on larger sized zooplankton and their reproductive success and short developmental rates under favourable conditions in most freshwater systems (Akin-Oriola, 2003; Imoobe and Adeyinka, 2009; Waidi and Akinpelu, 2016).

The abundance of zooplankton in September may be due to abundance of food during the period (Udo, 2012). More so, allochthonous food materials and nutrients are brought into the Ogbei Stream during this period due to inundation. Cyclops were the next in abundance. The long antennae or calanoid copepods and especially the middle length antennae forms (Cyclops) were more abundant in smaller bodies of water (Odum, 1959). Cyclops has been collected from the surface of bottom muds in stratified lakes during summer and winter periods of stagnation and oxygen depletion (Pennak, 1978).

Cladocera was the next abundant and diversified order. Cladocera is of great importance in the aquatic food chain as food for both young and adult fish (Pennak, 1978). Thus Egborge (1993) listed Cladocera among choice food items important in the energy cycles of fish conservation through induced population increases and aquatic pollution control is advocated. The very low abundance of Bdelloids may be attributed to environmental changes associated with concrete structures in aquatic environments. Concrete structures affect flow regimes, habitat conditions as well as alter faunal communities up and down barriers.

On the monthly variations of zooplanktons observed in this study, Badsi *et al*. (2010) attributed the variations to interactions of biotic and abiotic factors on the composition, abundance and dominance of zooplankton. The density of zooplankton observed from April to September coincides with the period of rainfall. This was in agreement with the observation of Kitheka *et al*. (1996). Nutrients become significantly higher during the wet season due to surface runoff and increased groundwater flow (Kitheka *et al*., 1999). This explained the peaks of zooplankton in the wet months of September and August. The low zooplankton abundance observed in March is in line with the low zooplankton abundance recorded by Mwaluma *et al*. (2003) in their study on the composition, abundance and seasonality of zooplankton in Mida Creek, Kenya.

Zooplankton density, composition, distribution and abundance were principally influenced by season. Thus zooplankton abundance and distribution were widely associated with environmental conditions (Hassan *et al*., 2019). The peak of zooplankton abundance recorded in the wet season was in agreement with the reports of Saint-Jean (1983), Masundaire (1994) and Okogwu and Ugwumba (2006). Rainfall and flooding are among the features of wet season. Flooding washes down nutrients from watershed and farmlands into water bodies. The nutrients trigger off food production (phytoplankton). Also rich nutrient loading may support the high zooplankton abundance population (Manickam *et al*., 2017; 2018). Zooplankton abundance recorded in the wet and dry seasons were significantly different ($p<0.05$). The dominance of the phylum Rotifera and the order Ploima may be attributed to their ability to undergo vertical migration which minimizes competition through niche exploitation and food utilization (Ekpo *et al*., 2015). The lower abundance of zooplankton recorded in the dry season could be due to predation by fish. The juveniles of *Oreochromis* spp. and *Clarias* spp. are obligate planktivores (Mwebaza-Ndawula, 1994; Ovie and Ovie, 2002; Okogwu, 2010). Seasonal succession of zooplankton communities in the tropics has been attributed to a number of factors such as the environmental characteristics of the water, predation, quality and quantity of edible algae and competition (Onwudinjo and Egborge, 1994; Ovie and Adeniji, 1994).

The general diversity indices (Margalef's richness, Shannon-Wiener index, diversity evenness and dominance index) values obtained in this study depicts high diversity. Thus the zooplankton community and the ecosystem assessed using diversity indices is highly diverse and stable. According to Ogbeibu and Oribhabor (2001) the overall diversity may be the product of all spatial and temporal changes affecting the community.

Conclusion: Ogbei Stream is rich in zooplankton taxa composition. Rotifera, Monogononta and Ploima were the dominant groups in the stream. Zooplankton occurred most in September (wet season) and least in March (dry season). Both species richness and diversity were high implying a polydiversed community. A two year in-depth study of zooplankton and physico-chemical conditions of Ogbei Stream is recommended.

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