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Correlation between seasonal physicochemical parameters and zooplankton diversity in Asejire reservoir, Southwest Nigeria

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Abstract
Occurrence and distribution of zooplankton community in Asejire reservoir was carried out between April 2017 and March 2018 to ascertain the critical association between zooplankton and physicochemical parameters of the water. A total of 130 taxa were recorded comprising of six taxonomic groups (Rotifera, Copepoda, Cladocera, Protozoa, Ostracoda and Insecta). The zooplankton in the reservoir follows a sequence as Rotifera > Copepoda > Cladocera > Protozoa > Ostracoda > Insecta. Zooplankton abundance was higher in the rainy season compared to the dry season. Correlation was drawn between the different physicochemical parameters and zooplankton occurrence. Zooplankton population showed a positive correlation with conductivity, transparency, total dissolved solids, dissolved oxygen and sulphate, whereas negative correlation with pH, temperature, turbidity, biological oxygen demand, phosphate, nitrate and chloride. Observed changes in the zooplankton community structure were related to seasonal fluctuations in water conductivity, pH, transparency, total dissolved solids and turbidity of the water. Elevated levels in water transparency, dissolved oxygen and nutrients such as phosphate indicate favorable conditions for the growth of zooplankton. Turbidity, biological oxygen demand and increased pH has a negative effect on the zooplankton abundance.

Keywords: Zooplankton, physicochemical, taxa, abundance, parameters, correlation

1. Introduction

Zooplankton organisms play a major role in the food webs of aquatic environment. They are a vital part of both the lentic and lotic community contributing greatly to the freshwater ecosystem's biological production [1]. Several studies have been conducted on the ecological status of freshwater bodies in Nigeria [2]. Pollution due to industrialization and other anthropogenic activities have greatly affected the water needs of zooplankton and other aquatic species. Aquatic ecosystems are influenced by the physical and chemical parameters in the water [3]. Zooplankton is an essential part of the food chain and plays a crucial role in the organic matter cycling in an aquatic ecosystem [4, 5, 6]. The diversity of zooplankton indicates a chronic water pollution problem [7, 8, 9]. Zooplankton organisms like *Asplanchna brightwelli, Brachionus angularis, B. falcatus, Filinia terminalis and Polyarthra remata* have been associated with rich aquatic environment [10].

The survival of commercially significant fish populations is anchored on zooplankton presence in waterbodies. Their seasonal occurrence, diversity, abundance and impact are significant in fisheries planning and management. The most significant parameters influencing planktonic biomass production are the physicochemical conditions and the nutrition statuses of water [11]. They are the connecting links between phytoplanktons (producers) and fish (secondary consumers) in any aquatic ecosystem. The toxicity of different contaminants to freshwater organisms and the vulnerability of these organisms to pollutants are affected by changes in environmental and climatic conditions. During fish culture, the presence of zooplankton is critical to ensuring high fish output [12]. The current study evaluate the different zooplankton species in Asejire reservoir in relation to the physicochemical condition of the water quality and the seasonal fluctuations.

Materials and Methods

Study area

Asejire Reservoir is located in the southwest region of Nigeria. It has an equatorial tropical climate [13], characterized by a relative humidity ranging from 58% (dry season) to 95% (rainy season) according to [14]. It has an average temperature of 28±1.04 ^{o}C and an annual regime of rainfall with two peaks (July and September) [15]. The vegetation is lowland tropical rainforest, with dense savannah woodland. The Reservoir extend from longitudes 004^{0} 07’017”E - 004^{0} 08’925”E and from latitudes 07^{0} 21’48”N and 07^{0} 26’84”N (Figure 1). The lake was created to provide potable water for the city Ibadan and environs [16]. The bulk of the water to the reservoir comes from River Osun and its main tributary River Oba.

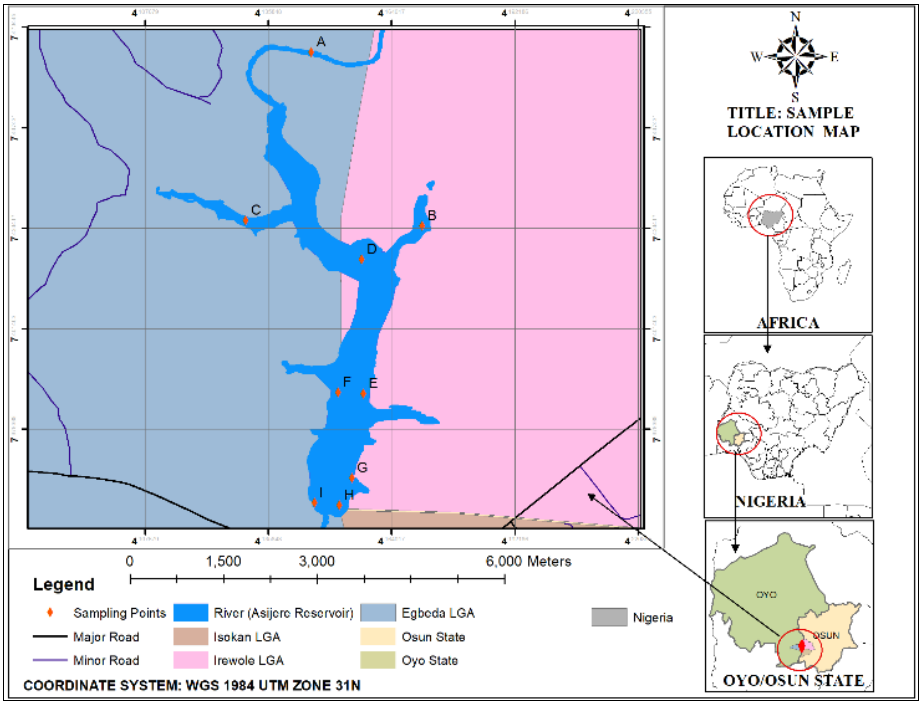

Fig 1: Asejire Reservoir showing the different sampling stations

Sampling Collection

The samples were collected monthly (April 2017 to March 2018) for twelve months from ten sampling sites of the reservoir based on some ecological landmarks. Temperature, water depth and transparency were determined *in -situ*) using thermometer and Secchi disc. Other parameters determined *in-situ* were pH and electrical conductivity using a calibrated meter. Dissolved oxygen samples were fixed *in-situ* using Winkler's reagents. For other physicochemical analyses, samples were collected in clean 2L plastic containers, transported to the laboratory and stored in refrigerators pending. Samples for zooplankton were collected at each station by filtering 100 litres of water through a 60 µm mesh size plankton net. The filtrate was further reduced to 30 ml and preserved in 5% formalin solution.

Laboratory Analyses

All the physicochemical methods were based on manuals provided by [17, 18].

Zooplankton Analysis

The 30 ml sample was reduced to 5 ml and observed under a compound microscope. Zooplankton organisms were identified using guides provided by [19, 20, 21, 22, 23, 24, 25, 26]. Zooplankton abundance were computed from the final concentrated volume. Species community structure and diversity indices was calculated using Simpson's dominance index (S). Abundance of each species was estimated based by multiplying the number in the final concentrate volume by 1000 and expressed as Organism/L (Org/L).

Statistical Analysis

The data were subjected to various statistical analyses (e.g., descriptive analysis and correlation analysis) and diversity analyses using the Paleontological Statistics (PAST) software [27], Statistical Ecology [28] and Statistical Package for Social Sciences Software package.

Results and Discussion

Species diversity and seasonal fluctuation of zooplankton

A total of one hundred and thirty (130) zooplankton species were recorded in the reservoir during the period of this study (Table 1). The annual periodicity shows that Rotifera dominancy constitutes 56.9%, Copepoda 15.4%, Cladocera 14.6%, Insecta and Protozoa 4.6% each and Ostracoda 3.9% (Figure 2). Rotifera was the dominant among zooplankton groups throughout the study period, followed by Copepoda and Cladocera. The least number and abundance were recorded for Ostracoda. The zooplankton population density was higher in the rainy season (35200 individuals) than in the dry season (32275 individuals). The percentage of seasonal variation of the zooplankton recorded from reservoir are shown in Figures 2 to 4 and Table 1.

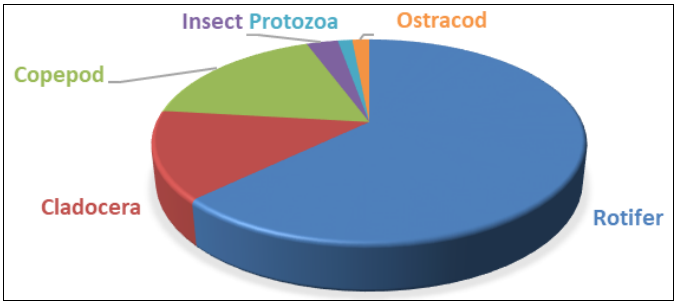

Fig 2: Percent abundance of zooplankton group in Asejire Reservoir

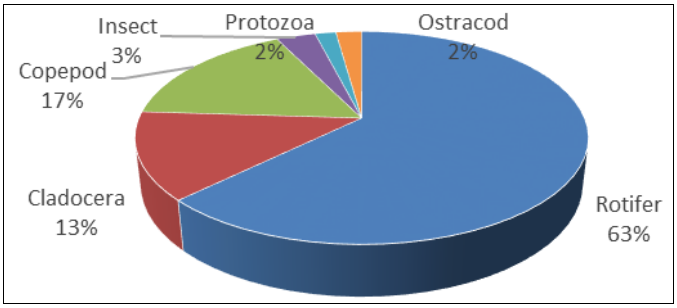

Fig 3: Percent of seasonal abundance of zooplankton groups at Asejire Reservoir (Rainy Season)

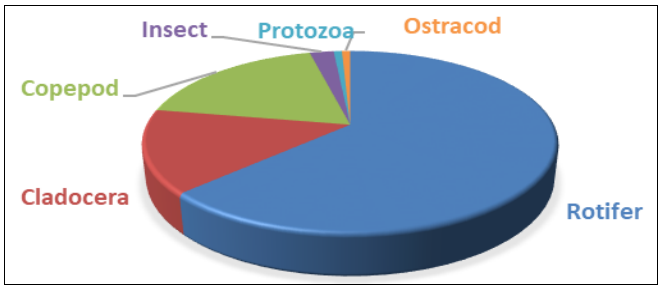

Fig 4: Percent of seasonal abundance of zooplankton at Asejire Reservoir (Dry Season)

Table 1: Seasonal zooplankton diversity and abundance in Asejire Reservoir

Taxa	Total		Rainy Season		Dry Season		Total Abundance
	Occurrence	%	Abundance	%	Abundance	%	
Rotifer	74	56.92	22075	52.06	20325	47.94	42400
Cladocera	19	14.62	4675	49.47	4775	50.53	9450
Copepod	20	15.38	5875	49.68	5950	50.32	11825
Insect	6	4.62	1175	61.84	725	38.16	1900
Protozoa	6	4.62	625	71.43	250	28.57	875
Ostracod	5	3.85	775	75.61	250	24.39	1025

Physicochemical Water Parameters

Table 2 shows a summary of the physicochemical parameters of the reservoir. The Table shows the minimum, maximum, mean, and standard deviations of the monthly variation of the measured physicochemical parameters of Asejire Reservoir measured during the study period. The lowest mean of water temperatures was recorded in January while the highest mean temperature was in August. Lowest Secchi disc transparency was recorded in August while the highest water transparency was recorded in February during the sampling period. DO and BOD had the lowest value in in June and April, while highest values were recorded in December for both parameters. Highest value for TDS in Station 2 in the month of April while the lowest value was obtained in Station 3 in the month of February. In general, the following parameters were higher in the dry season compared to the rainy season: conductivity, transparency, total dissolved solids, dissolved oxygen, sulphate, and chloride.

Table 2: Summary of the physicochemical parameters of Asejire Reservoir.

Month	Cond	pH	Temp	Transp.	TDS	Turb	DO	BOD	PO_4^{2-}	NO_{3-}	SO_4^{2-}	Cl^-
	(µS/cm)		^{0}C	m	mg/L							
Jan	118.56	7.49	24.67	2.06	86.17	10.20	5.23	0.54	0.33	0.20	4.40	8.04
Feb	119.60	7.46	24.66	2.17	90.39	8.94	4.85	0.55	0.41	0.29	4.84	8.26
Mar	120.60	7.46	24.61	2.21	93.46	7.47	5.21	0.55	0.50	0.28	4.75	8.03
Apr	117.60	7.53	25.39	2.13	90.97	8.88	5.34	0.68	0.53	0.36	4.94	8.46
May	110.80	7.57	25.73	1.49	88.68	9.60	4.04	0.56	0.56	0.40	4.72	8.06
Jun	103.10	7.94	25.98	1.38	83.49	11.41	3.32	0.70	0.54	0.39	4.44	8.08
Jul	99.60	8.07	26.22	1.13	81.42	11.49	3.46	0.68	0.53	0.38	4.36	8.30
Aug	103.40	8.02	28.74	0.73	80.92	12.71	3.46	0.75	0.57	0.37	4.28	8.23
Sep	98.20	8.01	29.20	0.74	76.76	14.55	3.84	0.99	0.54	0.35	4.22	8.30
Oct	100.40	8.02	26.93	0.91	75.81	13.55	5.07	1.08	0.58	0.40	4.37	9.52
Nov	104.20	7.92	26.56	1.25	84.65	12.81	5.34	1.05	0.60	0.51	4.84	11.00
Dec	106.30	7.91	25.61	1.38	87.25	12.36	5.64	1.10	0.77	0.68	5.99	12.11
min	98.20	7.46	24.61	0.73	75.81	7.47	3.32	0.55	0.50	0.28	4.22	8.03
max	120.60	8.07	29.20	2.21	93.46	14.55	5.64	1.10	0.77	0.68	5.99	12.11
mean	106.42	7.84	26.50	1.33	84.34	11.48	4.47	0.81	0.57	0.41	4.69	9.01
s.d.	7.61	0.23	1.45	0.51	5.83	2.21	0.93	0.22	0.07	0.11	0.52	1.43

The observed fluctuations in the Reservoir may be linked with water use and rainfall [29]. Temperatures were lower in January - March than in August - November. Water temperature values followed similar pattern with air temperature. This may be ascribed to the sampling programme, which was usually early in the morning, when the water is warmer than air. Primary production in reservoir is usually influenced by temperature [30]. The dissolved oxygen value ranges from 3.32 – 3.64 mg/L for the reservoir with a mean value of 4.47±0.93 mg/L. The low DO level could be related to the upwelling as well as the chemical and biological oxidation process. Atmospheric oxygen and photosynthesis are the major sources of dissolved oxygen in the aquatic environment, while loss is usually associated with. on respiration, decay by aerobic bacteria and decomposition of dead decaying sediments (Gupta and Gupta, 2006). The mean pH value of the reservoir was 7.84±0.23, this indicates that the reservoir is tending towards alkaline medium. A similar value was reported in Awba Reservoir by [31] and some other southern fishponds in southern Nigeria [29]. An indication that the reservoir water is good for fish cultivation and production. According to [32, 33], the buildup of free carbon dioxide due to little photosynthetic action of phytoplankton will decrease the pH concentration of the water while increase photosynthetic action of the phytoplankton will reduce the free carbon dioxide content result to elevated pH values. The mean value of conductivity (106.62±7.61 µS/cm) indicates that the conductivity level is intermediate. Generally, conductivity levels <50 µS/cm are regarded as low, while 50-600 µSs/cm

and above 600 µS/cm are regarded as medium and high. Obtained TDS values followed similar pattern displayed by conductivity in the reservoir. This may be due to organic and inorganic substances dissolved and washed into the reservoir due to runoffs from the catchment basins. The low transparency from August to October may be due to the increase in water turbidity due to run-off deposits carried into the reservoir from heavy rainfall during this period of the year. This agrees with [32] who reported that the pattern of change of transparency varies inversely with that of turbidity and rainfall. Increased water transparency usually leads to deeper light penetration and consequently a wider depth of photosynthetic activity of phytoplankton.

Relationship between physicochemical parameters and zooplankton

A significant relation was shown between physicochemical parameters and zooplankton density (Table 3). Zooplankton population showed a positive correlation with conductivity, transparency, total dissolved solids, dissolved oxygen and sulphate, whereas negative correlation with pH, temperature, turbidity, biological oxygen demand, phosphate, nitrate and chloride. The similar observations were made by [34, 35, 36, 37]. This indicate that it is possible to infer that the density of zooplankton is directly or indirectly affected by several abiotic factors as shown in the significant changes in temperature fluctuations.

Table 3: Correlation of physicochemical parameters with zooplankton

S/N	Parameter	Correlation coefficient ('r' Value)
1	Conductivity	0.74381
2	pH	-0.763589
3	Temperature (^{0}C)	-0.542884
4	Transparency (m)	0.7135
5	Total Dissolved Solids (mg/L)	0.84495
6	Turbidity (mg/L)	-0.800618
7	Dissolved Oxygen (mg/L)	0.340957
8	Biological Oxygen Demand (mg/L)	-0.509259
9	Phosphate (mg/L)	-0.115138
10	Nitrate (mg/L)	-0.179608
11	Sulphate (mg/L)	0.30367
12	Chloride (mg/L)	-0.213948

Zooplankton abundance were higher in dry season compared to the rainy season. Environmental conditions clearly impact on zooplankton abundance in freshwater and physicochemical variables influence population dynamics in this habitat [37]. Food availability and predation pressure are other factors that impact greatly on the zooplankton occurrence, development and abundance.

Zooplankton population increases significantly during the early rainy season because of favorable climatic conditions and a large supply of food in the form of microorganisms and suspended debris, washed down by upsurge of inflow of food from the catchment basins.

Conclusion and Future Scope

Zooplanktons are an important assemblage of organisms in the aquatic food chain. Their occurrence and abundance are regulated by the different water physicochemical parameters, as well as the interactions of biological factors. Throughout the study period, the physicochemical parameters of the water and the population of the zooplankton's species were found to vary with the different seasons indicating that the physicochemical parameters have an impact on zooplankton diversity.

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