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Plankton diversity in the upper Benue river of Taraba state, Nigeria

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Abstract
A study to determine the plankton abundance and diversity of the Benue River in Taraba State was conducted between the months of July, 2017 – February, 2018. Water samples were collected along the River in Lau and Mayo-Ranewo towns and was analyzed for both phytoplanktons and zooplanktons. The results showed that 5,321 individual plankton were collected out of which, phytoplankton recorded 3,551 individuals (66.74%) and zooplankton recorded 1,770 individuals (33.26%). A total of twenty four (24) plankton genera belonging to nine (9) taxa was observed, out of which Phytoplankton's recorded fourteen (14) genera equivalent to 58.33% while Zooplankton's recorded only ten (10) genera representing 41.67%. In the phytoplankton category, the Chlorophyceae taxon had the highest species representative of seven (7) and the least Viridiplantae taxon with only one (1) species. In the zooplankton category, the taxon Arthropoda had more representative species of eight (8) and the least was the Rotifera taxa with one (1) species. The Shannon-Weiner Diversity Index (H′) showed that Lau is more diverse in terms of phytoplanktons 2.223 with an Equitability Index (H′E) of 0.31 as compared to the 1.049 and 0.14 respectively obtained for Mayo-Ranewo. While interms of zooplankton, Mayo-Ranewo is more diverse 1.76 as compared to the 1.43 obtained in Lau. However, Lau showed more species Evenness (H′E) of 0.65 compared to only 0.25 obtained in Mayo-Ranewo. Hence, it was concluded that the Benue River at both location is productive and continuous monitoring is required for conservation practices.

Keywords: Plankton diversity Benue river of Taraba state, Nigeria

1. Introduction
Rivers have over the years constitute very important water systems because they provide life-saving services with their abundant and diverse categories of flora and fauna [1], and the enormous biotic community of any water system is a direct reflection of the inter-play of abiotic conditions existing in such environments [2].
Rivers and other surface water reservoirs have provided most of the planet's freshwater resources and have also constitute ecological systems for aquatic life creating a reservoir for biological diversity and recreational activities that include tourism [3,4].
The sustainable utilization of any water system would hence, lie in maintaining their natural states in relation to both abiotic and biotic communities and their ecological importance [5]. To further comprehend this complex system, scientists have suggested the regular monitoring of water quality by the use of both biotic and abiotic parameters.
Biological monitoring of water quality is an important tool that involves the use of plankton abundance and diversity as indices of water quality in relation to many forms of pollution affecting the aquatic system [6]. Plankton is a large and diverse group of simple organisms that could be unicellular or multicellular, which are widely distributed in moist terrestrial environments as well as all forms of aquatic systems, where they occur as microscopic organisms [7]. Almost all aquatic systems are dominated by these species, either as free-floating or benthic organisms where they constitute food resources to the many organisms in the water, thereby enriching the food chain. Hence, their density and diversity in such waters is highly influenced by the quality of such waters [8], and hence, signifies the extent of the water body's productivity. Due to insufficient literature in this regards on the study area, this study was designed with the aim of investigating the composition and diversity of plankton in the Upper Benue River at Lau and Mayo Ranewo.

2. Study areas

2.1 Benue river

The Benue River, previously known as the Chadda River is a major tributary of the Niger River. It is approximately 1,400km (870 mi) long and is almost entirely navigational during the summer (dry) months. As a result, it provides an important transportation route in the regions through which it flows. The River rises from the Adamawa Plateau of Northern Cameroun, flowing West through the town of Garoua and Lagdo Reservoir into Nigeria South of the Mandara Mountains, and through Jimeta to Numan, Lau, Mayo-Ranewo, Ibi and Makurdi before meeting at the confluence town, Lokoja-Kogi State, Nigeria. Large tributaries of the Benue are the Gongola River and the Mayo Kebbi which connects it with the Logone River (Part of the Lake Chad system) during floods. Other tributaries are the Rivers Taraba and Katsina-Ala. At the point of confluence, the Benue exceeds the Niger by volume. As at 1960 the Benue had a discharge rate of 3,400 cubic meters per second compared to the 2,500 cubic meters per second of the Niger [9]. A greater part of the Benue traverse through Taraba State providing enormous opportunity for farming and fishing activities [10].

2.1.1 Mayo ranewo town

Mayo Ranewo is one of the largest districts and political wards of Ardo-kola LGA of Taraba State. It is located in the South Western part of the confluence of River Fan Mangel with the Benue River. It roughly lies between Latitude 8˚ 47′ to 8˚ 53′N and Longitude 10˚ 50′ to 10˚ 55′E and was an important station for the French and British Colonists [11]. It has a population of about 11,000 people [12] with predominantly Fulani, Hausa and Kona tribes that engage in fishing and farming important crops such as rice, maize, yams, cassava, tomatoes and beans etc.

2.1.2 Lau town

Lau town is the administrative center of Lau Local Government Area in Taraba State; it is located some 47km away from Jalingo, the State capital. It is mostly dominated by the Mumuye and Hausa-Fulani people and has an area of 1,660km^2 and a population of 96, 590 individuals [12]. Lau town is located along the Western River banks of the Benue River at Latitude 9˚ 12′N and Longitude 11˚ 16′E. The people are predominantly farmers and fishermen [10].

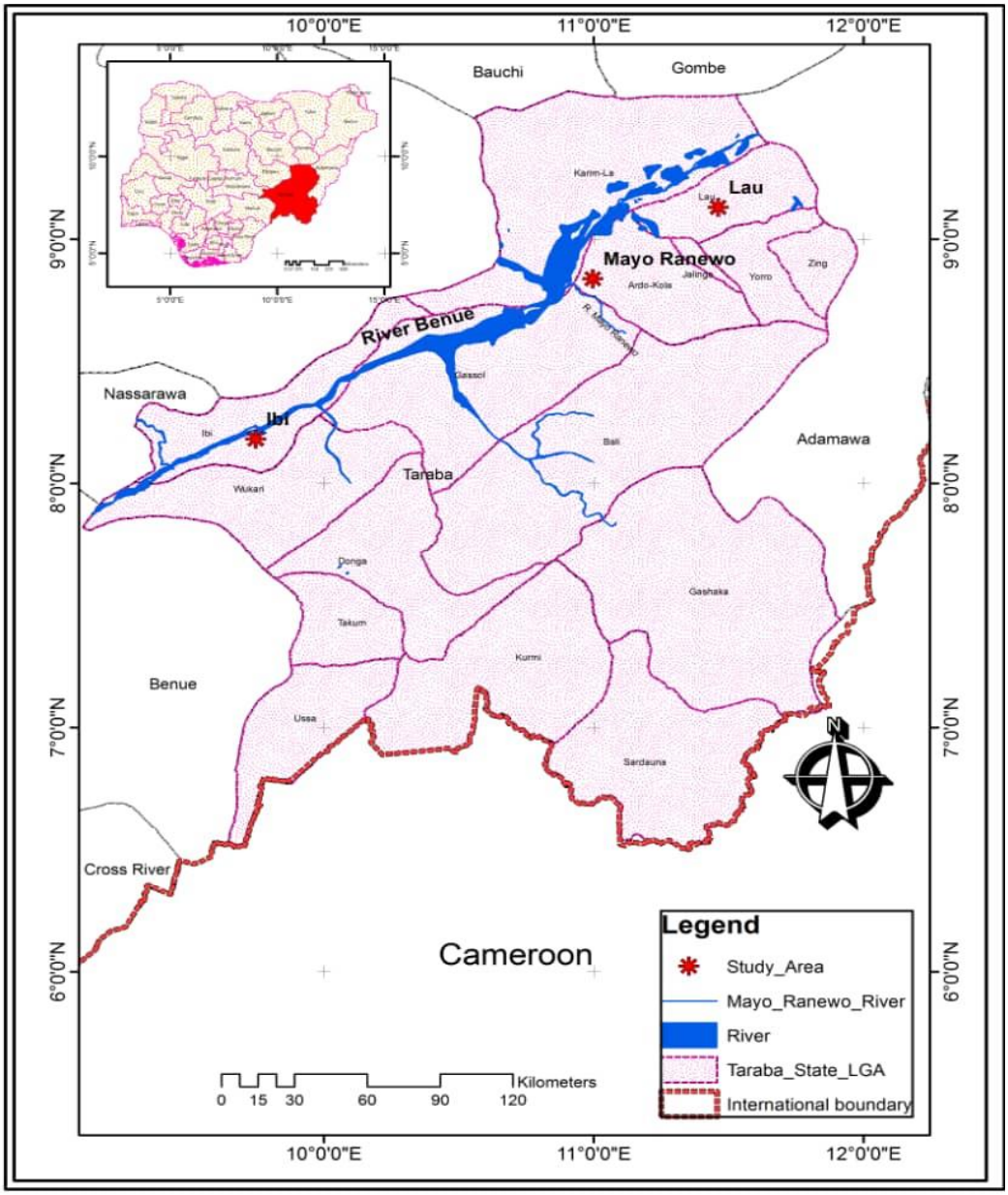

Fig 1: Map of Taraba State Showing River Benue and the Sampling Sites

2.2 Sample collection and analysis
Water sample for plankton analysis was also collected for eight (8) months (July, 2017 – February, 2018) using a conical net of bolting nylon of 0.069mm mesh width with a ring diameter of about 35cm tied to a canoe and dragged through the water for about 15 minutes. The filtrate was collected in a sample bottle and fixed with 4% formalin; a few drops of Lugol's iodine solution were added as described by [5]. This was transported to the Laboratory of Biological Sciences, Taraba State University for plankton analysis using binocular microscopes for identification and reference was made to the guides [13, 14, 15].

2.3 Data analysis
The Shannon-Wiener Diversity Index was used to determine the Species Abundance, Diversity and Evenness as described by [16]. Where;

Abundance (S) = Σn - - - - - - - - - Eq. 1
Diversity (H′) = $-\Sigma pi\ ln\ pi$ - - - - - - - - Eq. 2
Evenness (H′E) = H'/H_{max} *or* lnS - - - - - - - Eq. 3

3. Results and discussion
3.4 Plankton
3.4.1 Composition and checklist
As revealed in Figure 2 below, it can be deduced that during the period of study, a total number of twenty four (24) plankton genera belonging to nine (9) taxa was observed and recorded, out of which the Phytoplankton's group recorded fourteen (14) genera equivalent to about 58.33% while the Zooplankton's group recorded only ten (10) genera representing 41.67%.

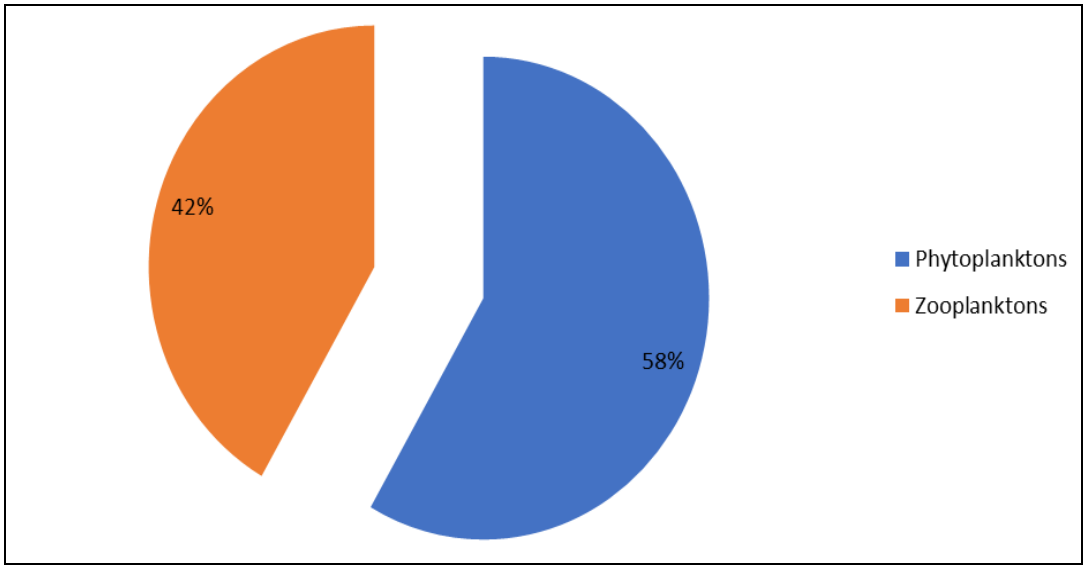

Fig 2: Composition of Plankton Community in the Benue River at Lau and Mayo-Ranewo (July, 2017 – February, 2018)

In the phytoplankton category, the Chlorophyceae taxon had the highest species representative of seven (7), followed by Bacillariophyceae and Xanthophyceae taxa each having three (3) species, then Cyanophyceae and Euglenophyceae taxa recording two (2) species each and the least Viridiplantae taxon with only one (1) specie. *Closterium gracile*, *Euglena gracilis*, *Gyrosigma attenuatum*, *Microcystis flos-aquae*, *Pediastrum duplex*, *Spirogyra* sp and *Volvox carterii* occurred in both locations (Lau and Mayo-Ranewo); *Anabaena circularis*, *Coleochaete scutata*, *Cosmarium* sp, *Oscillatoria princeps*, *Phacus longicauda*, *Scenedesmus* sp, *Staurastrum* sp, *Tribonema vulgare* and *Vaucheria dispermia* only occurred in Lau and not in Mayo-Ranewo, while only *Chlamydomonas reinhardtii* and *Navicula cuspidate* occurred in Mayo-Ranewo and not in Lau.

In the zooplanktonic category, the taxon Arthropoda had more representative species of eight (8), compared to Ciliophora and Rotifera taxa with two (2) and one (1) species respectively. *Bosmina longirostris*, *Brachionus calyciflorus*, *Copepod* sp, *Daphnia* sp, *Mayfly larva*, *Polypedilum vanderplanki* and *Vorticella convallaria* were all recorded in both locations; *Ostracod* sp and *Stonefly larva* only occurred in Lau and not in Mayo-Ranewo while *Damselfly larva* and *Paramecium caudatum* were only recorded in Mayo-Ranewo and not in Lau, as revealed in Table 1 below.

The availability of more phytoplankton than zooplankton could probably results from the fact that phytoplanktons are the primary producers in the water medium and so nature had designed their population and availability to be more than the zooplanktons which feeds on them to ensure a healthy and productive system. It could also be that since most of the zooplanktons are drifters, they can be easily carried along by the water current and dislodged at other location with lower water velocity.

The availability of some species in one location and not another could be purely by chance and it could also be that some of such species absent are naturally not available in such locations or it could be that during the sampling period the species had temporarily migrated or have been washed away or drifted with the water hence, could not be sampled and identified.

Table 1: Composition and Checklist of Plankton Community of the Benue River at Lau and Mayo-Ranewo (July, 2017 – February 2018)

S/No.	Taxa	Family	Species name	Site A (Lau)	Site B (M/Ranewo)
Phytoplankton's category					
1.	Bacillariophyceae	Microcystaceae	*Microcystis flos-aquae*	+	+
		Naviculaceae	*Gyrosigma attenuatum*	+	+
		Naviculaceae	*Navicula cuspidate*	-	+
2.	Chlorophyceae	Chlamydiaceae	*Chlamydomonas reinhardtii*	-	+
		Desmidiaceae	*Closterium gracile*	+	+
		Desmidiaceae	*Cosmarium* sp	+	-
		Desmidiaceae	*Staurastrum* sp	+	-
		Hydrodictyaceae	*Pediastrium duplex*	+	+
		Volvocaceae	*Volvox carteri*	+	+
		Zygnemataceae	*Spirogyra* sp	+	+
3.	Cyanophyceae	Nostocaceae	*Anabaena circularis*	+	+
		Oscillatoriaceae	*Oscillatoria princeps*	+	-
4.	Euglenophyceae	Euglenaceae	*Euglena gracilis*	+	+
		Euglenaceae	*Phacus longicauda*	+	-
5.	Viridiplantae	Coleochaetaceae	*Coleochaete scutata*	+	-
6.	Xanthophyceae	Scenedesmaceae	*Scenedesmus* sp	+	-
		Tribonemataceae	*Tribonema vulgare*	+	-
		Vaucheriaceae	*Vaucheria disperma*	+	-
Zooplankton's Category					
7.	Arthropoda	Bosminidae	*Bosmina longirostris*	+	+
		Chironomidae	*Polypedilum* sp	+	+
		Crustacea	*Copepod* sp	+	+
		Crustacea	*Ostracod* sp	-	+
		Daphniidae	*Daphnia pulex*	+	+
		Dystiscidae	*Water beetle*	-	+
		Ephemeropteroidea	*Mayfly larva*	+	+
		Placoptera	*Stonefly larva*	-	+
		Zygoptera	*Damselfly larva*	+	-
8.	Ciliophora	Parameciidae	*Paramecium caudatum*	+	-
		Vorticellidae	*Vorticella campanula*	+	+
9.	Rotifera	Brachionidae	*Brachionus calyciflorus*	+	+

3.4.2 Abundance and diversity

During the period of studies, a total of 5,321 individual plankton per ml were collected in the Benue River at Lau and Mayo-Ranewo; out of this, phytoplankton accounted for 3,551 individuals/ml which is equivalent to 66.74% while zooplankton recorded an abundance of 1,770 individuals/ml (33.26%).

In Lau, sixteen (16) phytoplankton species were recorded whereas only eleven (11) species were identified in Mayo-Ranewo. In Lau, *Volvox carterii* had the highest abundance of 293 (23.96%) while the least abundant species were *Oscillatoria princeps* and *Vaucharia disperma* with each recording a frequency of five (5) individuals which is equivalent to 0.41% of the phytoplankton biomass. In Mayo-Ranewo, *Volvox carterii* was again the most abundant species with a frequency of 1,724 individuals representing 74.05% while *Tribonema vulgare* showed the least abundance with only two (2) individuals representing only 0.09% of the phytoplankton biomass of Mayo-Ranewo. This result also showed that Lau town has more species diversity as revealed by the Shannon-Weiner Diversity Index (H′) of 2.223 with an Equitability Index (H′E) of 0.31 as compared to the 1.049 and 0.14 respectively obtained for Mayo-Ranewo. This could probably be that the less disturbances encountered in Lau as evident in the lack of engine boat activity during the course of this study had significantly help in creating an enabling environment for algae to thrive hence, boasting their diversity as opposed to the disturbed community encountered in Mayo-Ranewo with many motor boats that constantly disturbs the water medium and dislodges of destroys the algae present and hence, reduced their availability and subsequently their diversity (Table 2).

Table 2: Abundance and Diversity of Phytoplankton in the Benue River at Lau and Mayo-Ranewo (July, 2017 – February 2018)

S/No.	Taxa	Family	Species Name	Site A (Lau)	Site B (M/Ranewo)
1.	Bacillariophyceae	Naviculaceae	*Gyrosigma attenuatum*	105	69
		Naviculaceae	*Navicula cuspidate*	-	12
		Microcystaceae	*Microcystis flos-aquae*	152	36
2.	Chlorophyceae	Chlamydiaceae	*Chlamydomonas reinhardtii*	-	4
		Desmidiaceae	*Closterium gracile*	71	68
			Cosmarium sp	10	-
			Staurastrum sp	10	-
		Hydrodictyaceae	*Pediastrium duplex*	174	155
		Volvocaceae	*Volvox carteri*	293	1,724
		Zygnemataceae	*Spirogyra* sp	200	188

3.	Cyanophyceae	Nostocaceae	*Anabaena circularis*	67	29
		Oscillatoriaceae	*Oscillatoria princeps*	5	-
4.	Euglenophyceae	Euglenaceae	*Euglena gracilis*	59	41
			Phacus longicauda	10	-
5.	Viridiplantae	Coleochaetaceae	*Coleochaete scutata*	13	-
6.	Xanthophyceae	Scenedesmaceae	*Scenedesmus* sp	31	-
		Tribonemataceae	*Tribonemavulgare*	18	2
		Vaucheriaceae	*Vaucheriadisperma*	5	-
			N	1,223	2,328
			H'	2.223	1.049
			H'E	0.31	0.14

NB: N = Number of Species; H' = Diversity index; H'E = Evenness

For zooplankton, both Lau and Mayo-Ranewo recorded equal number of species, that is, nine (9) each, with Mayo-Ranewo recording 1,091 individuals/ml as compared to the 679 individuals per ml recorded in Lau. Out of the zooplankton collected, *Brachionus calyciflorus* recorded the highest species abundance of 274 (40.35%) in Lau while *Bosmina longirostris* and *Paramecium caudatum* showed least abundance recording four (4) individuals each which is equivalent to 0.59% of the total zooplankton biomass of Lau. In Mayo-Ranewo on the other hand, the most abundant species of zooplankton was the *copepods* with a frequency and relative frequency of 672 and 61.59% respectively while Stonefly larva with its frequency of three (3) and relative frequency of 0.27% was the least recorded. Shannon-Weiner Diversity Index (H′) showed that Mayo-Ranewo had a Diversity Index of 1.76 as compared to the 1.43 obtained in Lau. However, Lau showed more species Evenness (H′E) of 0.65 compared to only 0.25 obtained in Mayo-Ranewo. The higher diversity of zooplankton encountered in Mayo-Ranewo compared to Lau could be the presence of more macrophytes in the water body in Mayo-Ranewo than in Lau had created an anchoring place and served as a substratum for the zooplankyon to anchor and not be drifted away by the water current. Also because the river had wider banks in Mayo-Ranewo than in Lau, the water velocity had reduced and the speed at which the zooplankton drift is reduced making them become more available than in Lau.

Table 3: Abundance and Diversity of Zooplankton in the Benue River at Lau and Mayo-Ranewo (July, 2017 – February 2018)

S/No.	Taxa	Family	Species Name	Site A (Lau)	Site B (M/Ranewo)
1.	Arthropoda	Bosminidae	*Bosmina longirostris*	4	8
		Chironomidae	*Polypedilum* sp	11	22
		Crustacea	*Copepod* sp	262	672
		Crustacea	*Ostracod* sp	-	5
		Daphniidae	*Daphnia pulex*	63	70
		Dysticidae	*Water beetle*	-	10
		Ephemeropteroidea	*Mayfly larva*	10	8
		Placoptera	*Stonefly larva*	-	3
		Zygoptera	*Damselfly larva*	5	-
2.	Ciliophora	Parameciidae	*Paramecium caudatum*	4	-
		Vorticellidae	*Vorticella campanula*	46	67
3.	Rotifera	Brachionidae	*Brachionus calyciflorus*	274	236
			N	679	1,091
			H'	1.43	1.76
			H'E	0.65	0.25

N = Number of Species; H' = Diversity index; H'E = Evenness

The result of this study has shown that there are variations in the abundance and diversity of plankton species across the two locations, with phytoplankton having more abundance than zooplankton. The studies also showed that phytoplankton were more diverse in Lau than Mayo-Ranewo while zooplankton had more diversity and abundance in Mayo-Ranewo than in Lau. This study agrees with the work of many researchers among which are; Ogbuagu and Ayoade (2012) who reported more phytoplankton than zooplankton in a freshwater body in Etche, Nigeria. Ekweozor (2016) also reported that while studying plankton diversity in the Ekerekena and Okochiri creeks of the upper Bonny estuary, more phytoplankton were encountered than their zooplankton counterparts; he attributed the low abundance and diversity to deterioration in water quality of the aquatic system. Ashiru *et al*. (2017) who reported on the quality of aquatic life in Ugo-Aiyetoro water-ways, Nigeria reveals that there was more phytoplankton in relation the zooplankton. Onyebuchi *et al.* (2019) who studied the plankton abundance and diversity in Ivo river basin, Nigeria reported a similar trend of more abundant and diverse phytoplankton community than the zooplankton community.

Conclusion

The findings of this study reveal a plankton community that is more diverse and abundant in phytoplankton than zooplankton. It also recorded the presence of pollution tolerant genera such as *Euglena, Oscillatoria, Scenedesmus, Chlamydomonas* etc. signifying the water maybe heading towards becoming a polluted system.

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