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Assessment of Fish Species Composition and Abundance at Selected Landing Sites Along the Upper Benue River Basin in Taraba State, Nigeria

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Abstract

This study assesses fish species composition and abundance at selected landing sites along the Upper Benue River Basin in Taraba State, Nigeria. Fish sampling was conducted monthly over six months (February to August 2022) at Mayo-Renewo and Lau landing sites using various fishing methods, including traps, gillnets, and hook and line. A total of 6,519 fish specimens from 26 species and 22 families were recorded. The dominant species were *Tilapia galilaeus*, *Distichodus rostratus*, and *Alestes macroplepidotus* in Mayo-Renewo, while *Clarias gariepinus*, *Heterotis niloticus*, and *Alestes macroplepidotus* were most abundant in Lau. The Shannon-Weiner Diversity Index indicated moderate species diversity, with values of -3.20703 at Mayo-Renewo and -3.28523 at Lau. Length-weight relationships showed positive allometric growth in most species, with a mean condition factor (K) above 1, indicating a favorable aquatic environment. Physicochemical analyses revealed variations in temperature (21.46–24.58°C), dissolved oxygen (6.1–8.4 mg/L), pH (8.22–8.62), electrical conductivity (340–840 µS/cm), total dissolved solids (170–556 mg/L), and turbidity (192–320 NTU). Statistical analysis (ANOVA) confirmed significant seasonal differences in these parameters ($p < 0.05$). The findings

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highlight the ecological health of the river and the importance of continuous monitoring to sustain fish biodiversity and productivity.

Keywords: Fish Composition, Abundance, Species Diversity, Benue River, Condition Factor

INTRODUCTION

Water is the most vital resource and universal solvent that all living organisms rely on for survival, growth, and reproduction (Abbati *et al.*, 2019). Without it, the existence, development, and reproduction of life forms would be impossible, as water is the essence of life (Abbati *et al.*, 2020). Maintaining good water quality is essential for sustaining the composition of aquatic organisms, including fish; a decline in water quality can lead to reduced productivity. Fish, a cold-blooded vertebrate, is adapted to various aquatic environments and serves as a significant protein source. The fishing industry is garnering increased attention due to its critical role in meeting global protein demands (Nazeef and Abubakar, 2013). According to the Food and Agriculture Organization (FAO) (2018), fish contribute up to 17% of the global supply of animal protein.

as well as lakes such as Kainji and Chad, along with various ponds, reservoirs, and dams. These tropical freshwater ecosystems, supporting small-scale artisanal fisheries, provide both cash income and animal proteins to people in rural and urban areas of developing nations (Amos and Linus, 2017). Beyond their role as a major protein source, fish resources offer significant social and economic benefits, such as job creation, raw materials for industries, and recreational activities (Yakub, 2012).

Studies on fish population structures in West Africa indicate that over 200 species inhabit various freshwater environments. Fishing in Nigeria is widespread, encompassing major rivers like the Niger, Benue, Hadeja, Kaduna, Cross, Imo, Sokoto, Gongola, and the Lake Chad basin, along with coastal creeks and lagoons (Willoughby, 2006). Nigeria is rich in natural aquatic ecosystems, boasting some of the most fish-abundant inland waters in West Africa (Nazeef and Abubakar, 2013). The Federal Department of Fisheries (FDF) estimates that Nigeria has over 14 million hectares of reservoirs, lakes, ponds, and major rivers, capable of producing over 980,000 metric tonnes of fish annually. A report by the ECOWAS Commission in 2021 projected Nigeria's fish production at over 1,264.39 metric tonnes (ECOWAS, 2020). However, domestic fish production falls short of demand, with

surveys showing that the country's fish supply is insufficient to meet the needs of its growing population. Global fisheries data also indicate a decline in both the average size of fish species and the value of catches (FAO, 2014). The fishing sector is gradually adopting more efficient and environmentally sustainable fishing practices, and the abundance of fish species serves as a useful indicator of environmental health and pollution levels.

In 2009, Rondon and Nzeka (2010) reported that Nigeria's fish demand reached nearly 2.0 million metric tonnes, valued at over $1.8 billion, leaving a gap of about 600,000 metric tonnes in untapped market potential. Additionally, approximately 800,000 metric tonnes of fresh and frozen fish (mainly frozen mackerel, herring, and croaker), valued at around $900 million, were imported. Bridging this demand-supply gap through domestic production presents a significant investment opportunity for Nigerians, while also attracting foreign direct investment into the country.

Taraba State is richly endowed with abundant surface water resources, including ponds and rivers such as the Benue, Taraba, and Donga Rivers, along with their tributaries. The state boasts approximately 500,000 hectares of water bodies and 142 natural ponds. River Taraba flows through the Gashaka, Bali, and Gassol Local Government Areas (LGAs) before merging with the Benue River system. The state's annual fish production averages around 1,987 metric tonnes (Oruonye, 2014), with daily catches in areas like Ibi, Lau, and Donga reaching approximately 3,000 kg. More than 30,000 fishing families in the state are actively involved in daily fishing (Oruonye, 2014).

Fish stock assessment is critical in providing insights into the optimal exploitation, utilization, and conservation of fish as aquatic resources. This process involves researching the biological characteristics of fish species, including length, weight, reproductive biology, food habits, age, and growth parameters, as well as their relationship with the aquatic environment. The evaluation of fish species composition and abundance in an aquatic ecosystem is essential for understanding the ecosystem's potential and effectively exploiting its fishery resources. Consequently, this research focuses on identifying the fish species composition and abundance at selected landing sites along the Upper Benue River Basin in Taraba State, Nigeria.

The goal of this study is to assess fish species composition and abundance at selected landing sites along the upper Benue River basin in Taraba State, Nigeria.

METHODS

Study Area

The River Benue is a significant tributary of the Niger River, stretching approximately 1,400 kilometers. It originates from the Adamawa Plateau in Cameroon and flows westward through Garoua and Lagdo Reservoir before entering Nigeria. Its course takes it past Jimeta, Numan, Lau, Mayo Ranewo, Ibi, and Makurdi, ultimately merging with the Niger River at Lokoja in Kogi State. This river provides vast opportunities for agriculture, fishing, and various domestic activities (see Figure 1). Communities situated along the banks of the River Benue, as well as the Taraba, Donga, Ibi, Lau, and Mayo-Renewo rivers in the Ardo-Kola Local Government Area, engage in fishing year-round (Orounye and Bashir, 2014).

The primary fishing landing sites are located in the Ardo-Kola and Lau Local Government Areas. Mayo-Renewo, the largest district within Ardo-Kola LGA of Taraba State, is situated in the southwestern part of the confluence of the Fan Mangel River with the Benue River, positioned between latitudes 8° 47' to 8° 53'N and longitudes 10° 50' to 10° 55'E (Orounye, 2014). This district has a population of approximately 11,000 residents, predominantly comprising the Fulani, Hausa, Tiv, and Kona ethnic groups, who are involved in fishing and farming essential crops such as rice, maize, yams, cassava, tomatoes, and beans (see Figure 1). The area's soil is primarily sandy loam and clay loam, while the vegetation features wooded savanna with sparse trees and riparian zones along the riverbanks (Onemolease and Oriakhi, 2011).

Lau town serves as the headquarters for Lau LGA in Taraba State. Located along the western banks of the Benue River at latitude 9° 12'N and longitude 11° 16'E, it covers an area of 1,660 square kilometers (see Figure 1) and has a population of 96,590 people. The town is predominantly inhabited by the Mumuye, Hausa, Fulani, and Yangdang ethnic groups, who primarily engage in farming and fishing. Lau is bordered to the northeast by Demsa LGA in Adamawa State, to the north and west by Karim Lamido LGA, and to the south by Ardo Kola, Jalingo, and Yorro LGAs. This lowland area lies on the floodplains of the Benue River, drained by the Mayo Donga and several other tributaries that flow into the river. Many of these tributaries are silted, and sand deposits have leveled the river valleys in numerous locations. Lau LGA experiences a tropical continental climate and features Sudan savanna vegetation, which consists of grasses and scattered tall trees. Acacia

plants and a type of palm known as giginya in Hausa are the dominant vegetation, with these palms dotting the landscape along the floodplain of the River Benue. The soil in the area is primarily alluvial, rich in deposits, with clay loamy soil prevalent in some places and sandy loamy soil in others (Oruonye, 2015).

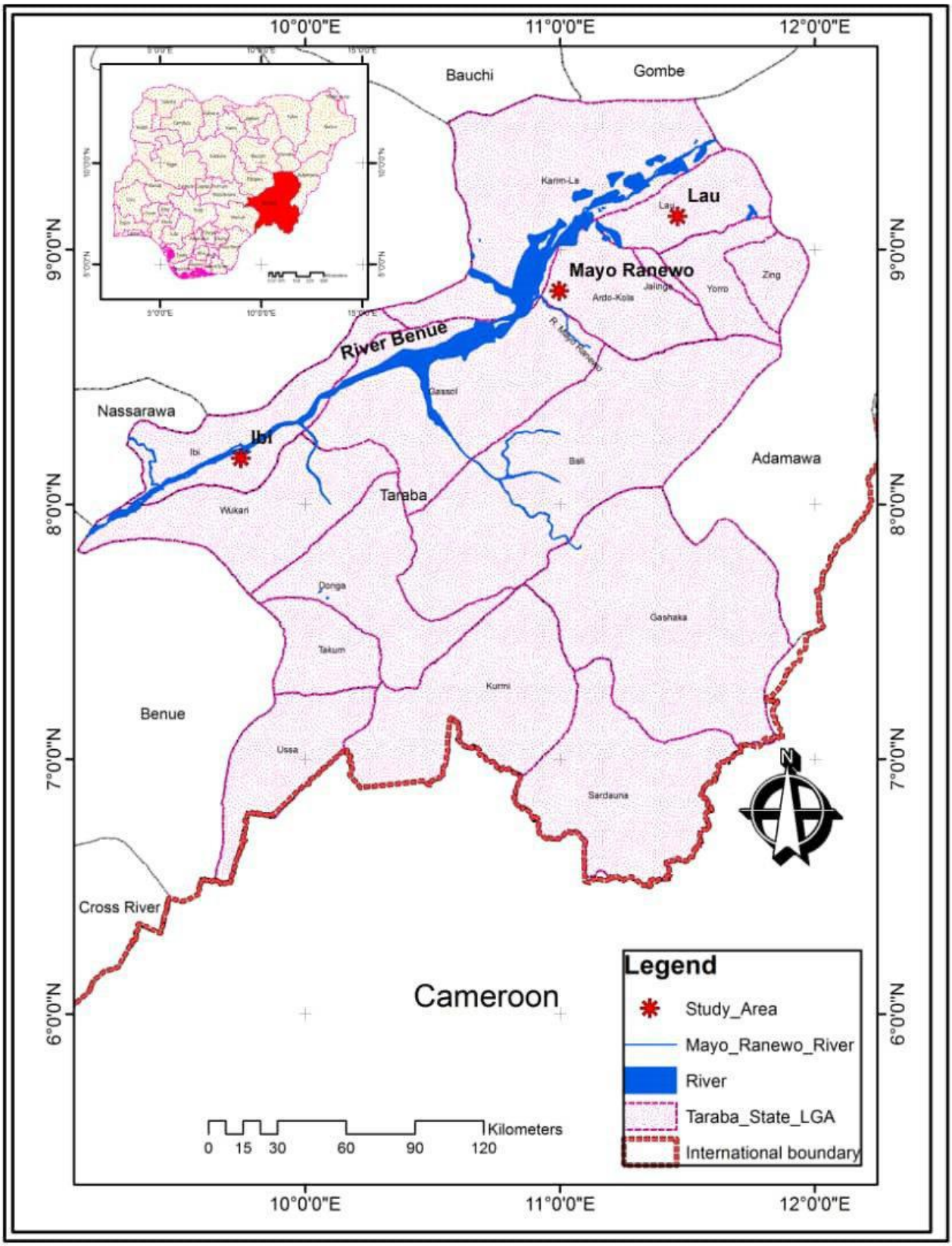


Figure 1: Map of Nigeria showing Taraba State and the landing Sites of River Benue

Fish Sampling Procedure

Two landing sites, Mayo-Renewo and Lau, were chosen along the river's length due to their accessibility, high fish populations, and low water current. The distance between these two sites is 40 meters. Data for this study was gathered monthly over six months, from February to August 2022, at the selected landing sites. This involved a thorough examination, counting, and recording of all fish caught by artisanal fishers. The fishing methods employed included traps (Gura), gillnets (Kelle-kelle), and hook and line (Kugiya). Other gear utilized in the study area consisted of dragnet (Taro), cast net (Birgi), long line (Mari-mari), and clap net (Homa), as referenced by Danba *et al.* (2020). Fishermen used plank canoes in the study area. All landed fish were sorted by species and counted. Additionally, water samples were collected monthly to assess physicochemical parameters and water quality. Fish caught during each sampling were separated by mesh size, and their lengths and weights were measured at the landing sites, following the methods outlined by Ahmed *et al.* (2011).

Collection and Identification of Fish

Fish caught in each net were carefully removed and placed into large, labelled plastic bowls, organized by species and mesh size. The following morphometric measurements were taken for each fish: total weight was recorded to the nearest 0.1 grams using a Hanna mechanical spring scale with a 20 kg capacity, standard length (SL) was measured from the snout to where the caudal rays attach, and total length (TL) was measured from the tip of the snout to the longest lobe of the caudal fin using a measuring board. Fish were collected monthly from February to August 2022, with the total number of individual species recorded, allowing for the assessment of the relative abundance of various species in the water body. Fish identification was conducted using the field guide by Froese and Pauly (2015).

Fish Composition Determination

Fish composition was determined by estimating the total count of all landed fish. Subsequently, the specimens were identified and categorized into their respective families and species, with counts taken using identification keys such as "Nigeria Freshwater Fish" by Olasebikan and Raji (2013), "Taxonomy, Ecological Notes, Diet, and Utilization" by Idodo-umeh (2003), and Fish Base by Froese and Pauly (2011).

Length-Weight Relationship

The analysis of length-weight data aimed to mathematically describe the relationship between fish length and weight, allowing for conversion from one to the other. This analysis also assesses the deviation from the expected weight for each length of individual fish, following the equation W = aLb (Pauly, 2019).

Condition Factor (K)

The condition factor is an indicator of a species' fatness or overall health. It is evaluated through the condition factor (KF).

4o mini

$K(f) = \frac{100\,W}{L^3}$

Where

W = weight in grammes (g)

L = standard length (Cm)

The condition factor („K") which shows the degree of well-being of the fish in their habitat will be determined using the equation:

where

K = condition factor

W = the weight of the fish in gram (g)

L = the total length of the fish in centimetres (cm)

Physico-Chemical Parameters

Temperature

Temperature was recorded in the morning and evening at various landing sites using a Hanna measuring instrument. The meter was calibrated with buffer solutions at pH levels of 4.0, 7.0, and 9.0. It was then submerged in the water, and readings were taken as soon as the timer stabilized.

Dissolved Oxygen (DO)

Dissolved oxygen levels were assessed using the modified Winkler test. Water samples were collected in 25ml stoppered bottles. To each sample, 0.1ml of manganese (II) sulfate

solution was added, ensuring no air entered the bottle during mixing. Next, 0.2ml of alkaline potassium iodide was added without exposing the sample to air, resulting in a pinkish-brown precipitate. These samples were set aside for laboratory analysis. In the lab, 0.3ml of sulfuric acid was added to each sample, which was then mixed and allowed to sit for 2 minutes. If the precipitate did not dissolve in the iodine solution, an additional 0.1ml of acid was added. A burette was filled with 0.0125N sodium thiosulfate solution and set to zero. Ten milliliters of the sample were transferred to a conical flask, and a few drops of starch solution were included, causing the sample to turn blue. The titration with thiosulfate continued until the solution turned clear, which was more visible when the flask was placed on a sheet of filter paper. The final reading was recorded in mg/L.

Hydrogen Ion Concentration (pH)

pH levels were measured in the morning (between 7 a.m. and 9 a.m.) and in the evening (between 4 p.m. and 6 p.m.) at landing sites during sampling, using the Hanna measuring instrument (combo pH/EC/TDS/T°C model HI98129). The meter was calibrated with buffer solutions at pH levels of 4.0, 7.0, and 9.0 before being submerged in the water, and readings were taken immediately after the timer stabilized.

Electrical Conductivity (EC)

Electrical conductivity was assessed using the same Hanna measuring device (combo pH/EC/TDS/T°C model HI98129). The instrument was calibrated with buffer solutions at pH values of 4.0, 7.0, and 9.0. It was then immersed in the water body, and readings were taken as soon as the timer stabilized. This measurement was conducted concurrently with the previously mentioned parameters.

Total Dissolved Solids (TDS)

Total dissolved solids were measured during two-time frames: in the morning (between 7 a.m. and 9 a.m.) and in the evening (between 4 p.m. and 6 p.m.) at the landing sites while sampling. The same Hanna measuring instrument (combo pH/EC/TDS/T°C model HI98129) was utilized, which was calibrated with buffer solutions at pH 4.0, 7.0, and 9.0. The meter was lowered into the water body, and readings were taken immediately after the timer stabilized.

Relative Abundance of Fish

Fish collected from the two landing sites were combined, sorted, counted, and documented. The species abundance was determined as the percentage representation of each species within the total catch for each location. Catch data were averaged over monthly intervals and presented as average monthly catches for the water body, as described by Alphonse and Rudi (1995). The relative abundance was calculated using the following formula:

$$Relative\ Abundace = \frac{Frequency\ of\ Species\ x\ 100}{Frequency\ of\ all\ Species}$$

Data Analysis

Morphometric data were analyzed using descriptive statistics to calculate means and standard deviations. Fish abundance data were examined using a one-way analysis of variance (ANOVA) to identify seasonal differences. When significant differences were found, Duncan's multiple range test (DMRT) was applied at a 0.05 significance level. The Shannon-Wiener index (H'), calculated using the formula below, was employed to assess fish species diversity and similarity between Lau and Mayo-Renewo landing sites and across different seasons:

$$H = -\sum Pi(InPi),$$

Where.

H' represents the diversity indices, and pi is calculated as the number of individuals of a species divided by the total number of samples, which reflects the number of species or species richness. Relative abundance is determined by taking the number of individuals of a specific species and dividing it by the total number of individuals across all species.

RESULTS

Shannon-Weiner Diversity Index

Table 1 shows that a total of 3,421 species were documented at the Mayo-Renewa landing site, with a Shannon-Weiner Diversity Index of -3.20703. In terms of abundance, Tilapia galilaeus was the most prevalent species, with 329 individuals, followed by *Distichodus*

rostratus with 231 and *Alestes macroplepidotus* with 226. The least abundant species recorded were *Hemichromis fasciatus* with 27 individuals and *Citharinus citharus*.

Table 1: Composition and the Relative Abundance of fish species in Mayo-Renewo landing sites along upper Benue River basin in Taraba State.

S/N	Species	Abundance	P_i	$\ln(P_i)$	$P_i \times \ln(P_i)$
1	*Clarias gariepinus*	103	0.030108	-3.50296	-0.10547
2	*Clarias anguillaris*	124	0.036247	-3.31741	-0.12025
3	*Marcusenius abadii*	121	0.03537	-3.3419	-0.1182
4	*Mormyrops anguilloides*	117	0.034201	-3.37551	-0.11544
5	*Hydrocynus vitfatus*	123	0.035954	-3.3255	-0.11957
6	*Auchenoglanis biscutatus*	125	0.036539	-3.30937	-0.12092
7	*Synodontis guttatus*	105	0.030693	-3.48373	-0.10693
8	*Bagrus docmak*	115	0.033616	-3.39276	-0.11405
9	*Schilbe mystus*	97	0.028354	-3.56298	-0.10103
10	*Procatapus similis*	123	0.035954	-3.3255	-0.11957
11	*Alestes baremose*	98	0.028647	-3.55272	-0.10177
12	*Brycinus macrolepidotus*	133	0.038878	-3.24734	-0.12625
13	*Oreochromis aureus*	140	0.040924	-3.19605	-0.13079
14	*Oreochromis niloticus*	131	0.038293	-3.26249	-0.12493
15	*Heterotis niloticus*	117	0.034201	-3.37551	-0.11544
15	*Bagrus bajad*	140	0.040924	-3.19605	-0.13079
16	*Synodontis batensoda*	121	0.03537	-3.3419	-0.1182
17	*Protopterus annectens*	122	0.035662	-3.33367	-0.11889
18	*Decapoda*	109	0.031862	-3.44634	-0.10981
19	*Marcusenius mento*	94	0.027477	-3.59439	-0.09876
20	*Malapterurus electricus*	97	0.028354	-3.56298	-0.10103
21	*Lates niloticus*	115	0.033616	-3.39276	-0.11405
22	*Tilapia galilaeus*	329	0.096171	-2.34163	-0.2252
23	*Citharinus citharus*	38	0.011108	-4.5001	-0.04999
24	*Distichodus rostratus*	231	0.067524	-2.69527	-0.182
25	*Alestes macroplepidotus*	226	0.066063	-2.71715	-0.1795
26	*Hemichromis fasciatus*	27	0.007892	-4.84185	-0.03821
		Total=3,421			**-3.20703**

As shown in Table 2, the Lau landing site documented a total of 3,098 species, with a Shannon-Weiner Diversity Index of -3.28523. In terms of abundance, Clarias gariepinus led

with 146 individuals, followed closely by Heterotis niloticus with 140, and Alestes macroplepidotus with 136. The species with the lowest numbers was Lates niloticus, recorded at 75, followed by Mormyrops anguilloides and Procatapus similis, both at 93.

Table 2: Composition and the Relative Abundance of fish species in Lau landing sites along upper Benue River basin in Taraba State.

S/N	Species	Abundance	P_i	$\ln(P_i)$	$P_i \times \ln(P_i)$
1	*Clarias gariepinus*	146	0.0479	-3.03863	-0.14555
2	*Clarias anguillaris*	118	0.038714	-3.25156	-0.12588
3	*Marcusenius abadii*	102	0.033465	-3.39727	-0.11369
4	*Mormyrops anguilloides*	93	0.030512	-3.48964	-0.10648
5	*Hydrocynus vitfatus*	119	0.039042	-3.24312	-0.12662
6	*Auchenoglanis biscutatus*	126	0.041339	-3.18596	-0.1317
7	*Synodontis guttatus*	118	0.038714	-3.25156	-0.12588
8	*Bagrus docmak*	128	0.041995	-3.17021	-0.13313
9	*Schilbe mystus*	95	0.031168	-3.46836	-0.1081
10	*Procatapus similis*	93	0.030512	-3.48964	-0.10648
11	*Alestes baremose*	111	0.036417	-3.31271	-0.12064
12	*Brycinus macrolepidotus*	115	0.03773	-3.27731	-0.12365
13	*Oreochromis aureus*	122	0.040026	-3.21822	-0.12881
14	*Oreochromis niloticus*	128	0.041995	-3.17021	-0.13313
15	*Heterotis niloticus*	140	0.045932	-3.0806	-0.1415
15	*Bagrus bajad*	134	0.043963	-3.1244	-0.13736
16	*Synodontis batensoda*	106	0.034777	-3.3588	-0.11681
17	*Protopterus annectens*	108	0.035433	-3.34011	-0.11835
18	*Decapoda*	106	0.034777	-3.3588	-0.11681
19	*marcusenius mento*	116	0.038058	-3.26865	-0.1244
20	*Malapterurus electricus*	98	0.032152	-3.43727	-0.11052
21	*Lates niloticus*	75	0.024606	-3.70475	-0.09116
22	*Tilapia galilaeus*	114	0.037402	-3.28604	-0.1229
23	*Citharinus citharus*	96	0.031496	-3.45789	-0.10891
24	*Distichodus rostratus*	96	0.031496	-3.45789	-0.10891
25	*Alestes macroplepidotus*	136	0.044619	-3.10959	-0.13875
26	*Hemichromis fasciatus*	109	0.035761	-3.33089	-0.11912
		Total=3,098			**-3.28523**

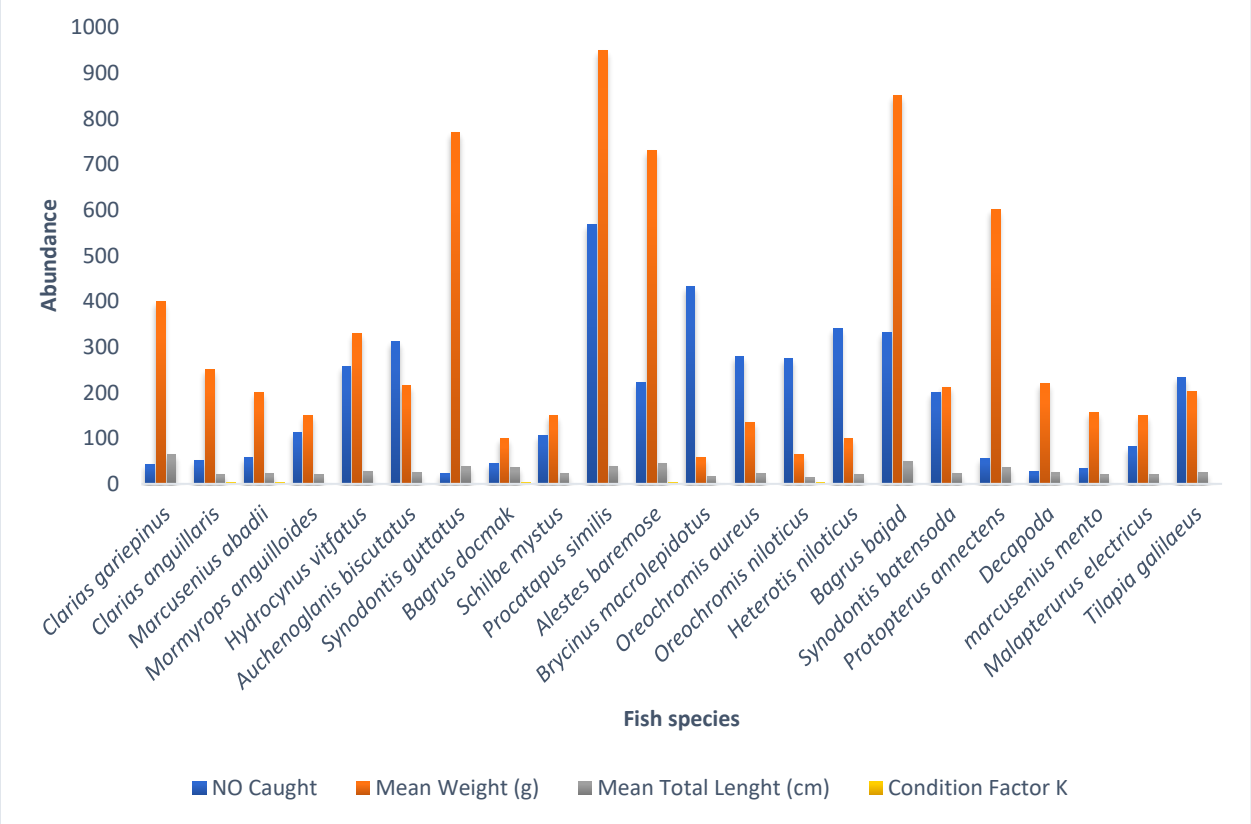


Fig.2: Condition Factor and sizes of the Fish Species in Lau water body

Figure 2 illustrates that the species with the highest number of fish caught was Procatapus similis, totaling 568, followed by Brycinus macrolepidotus with 432, and Hetetotis niloticus with 341. The species with the fewest catches was Synodontis guttatus, with only 23 individuals. In terms of mean weight, Procatapus similis had the highest average at 950 grams, followed by Bagrus bajad at 850 grams, and Synodontis guttatus at 770 grams. The lowest mean weights were recorded for Brycinus macrolepidotus at 58 grams and Oreochromis aureus at 64 grams. For mean total length, Clarias gariepinus had the highest value at 65 cm, followed by Bagrus bajad at 48 cm and Alestes baremose at 45 cm. The species with the smallest lengths were Oreochromis niloticus at 15 cm and Brycinus macrolepidotus at 17 cm. Regarding the condition factor, Clarias anguillaris recorded the highest value at 2.58, followed by Bagrus docmak and Alestes baremose, both at 2.24. The lowest condition factors were observed in Oreochromis aureus at 1.11 and Brycinus macrolepidotus at 1.18.

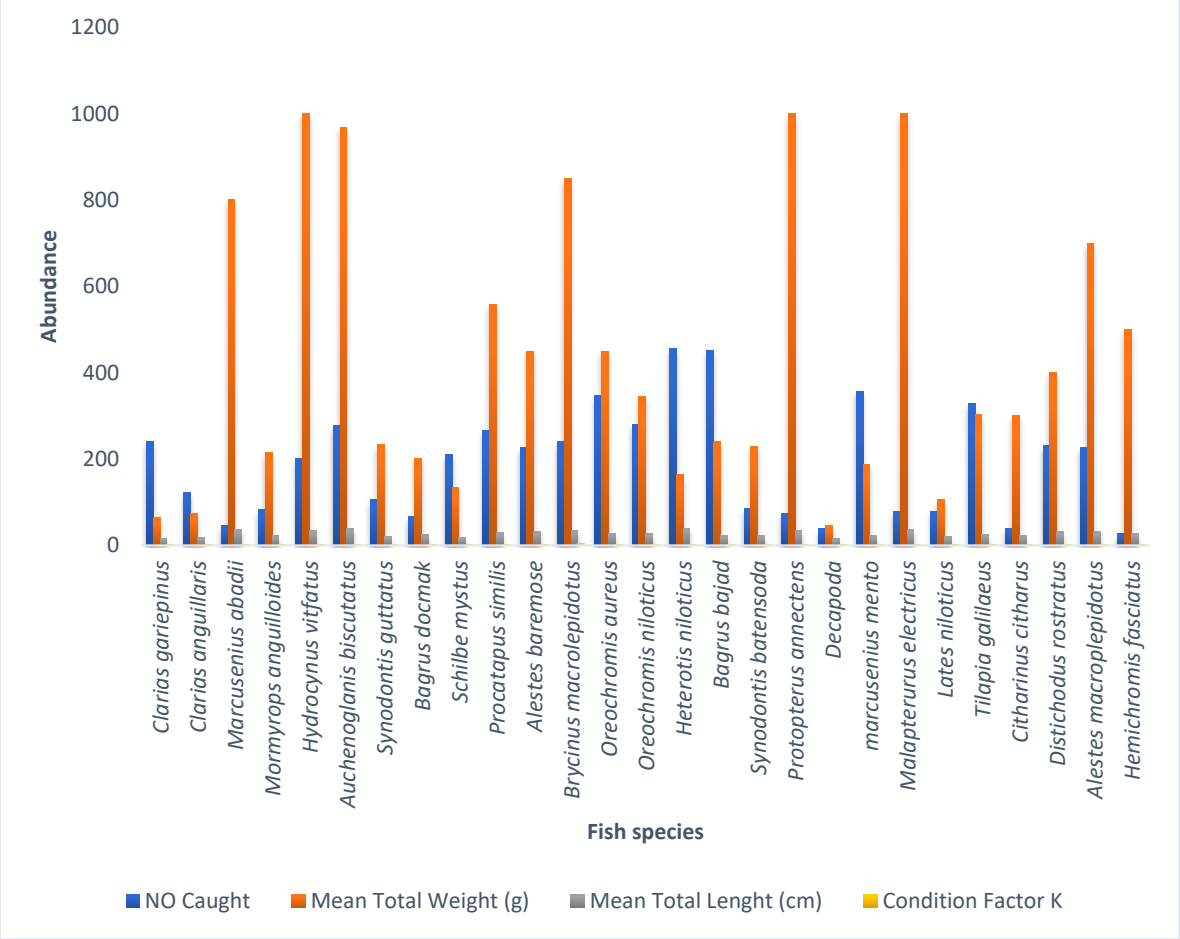


Fig. 3: Condition Factor and sizes of the Fish Species in Mayo-Renowo water body

At the Mayo-Renowo landing site, the most abundant fish species captured during the study period was Heterotis niloticus, with a catch of 457 individuals, followed closely by Bagrus bajad at 452 and Marcusenius mento at 356. The species with the lowest catches were Hemichromis fasciatus (27) and Citharinus citharus (38). In terms of mean total weight, Hydrocynus vittatus, Protopterus annectens, and Malapterurus electricus each recorded the highest weight at 1000 grams, followed by Auchenoglanis biscutatus at 987 grams. The species with the lowest mean total weight was Decapoda, at 45 grams. For mean total length, Heterotis niloticus had the highest measurement at 40 cm, followed by Auchenoglanis biscutatus at 38 cm and Marcusenius abadii at 37 cm. The species with the shortest length was Clarias gariepinus, measuring 16 cm. The highest condition factor was observed in Brycinus macrolepidotus at 3.15, followed by Heterotis niloticus at 2.55. Hydrocynus vittatus and Protopterus annectens both recorded a condition factor of 2.54. The lowest condition factors were noted in Distichodus rostratus (1.22) and Lates niloticus (1.31).

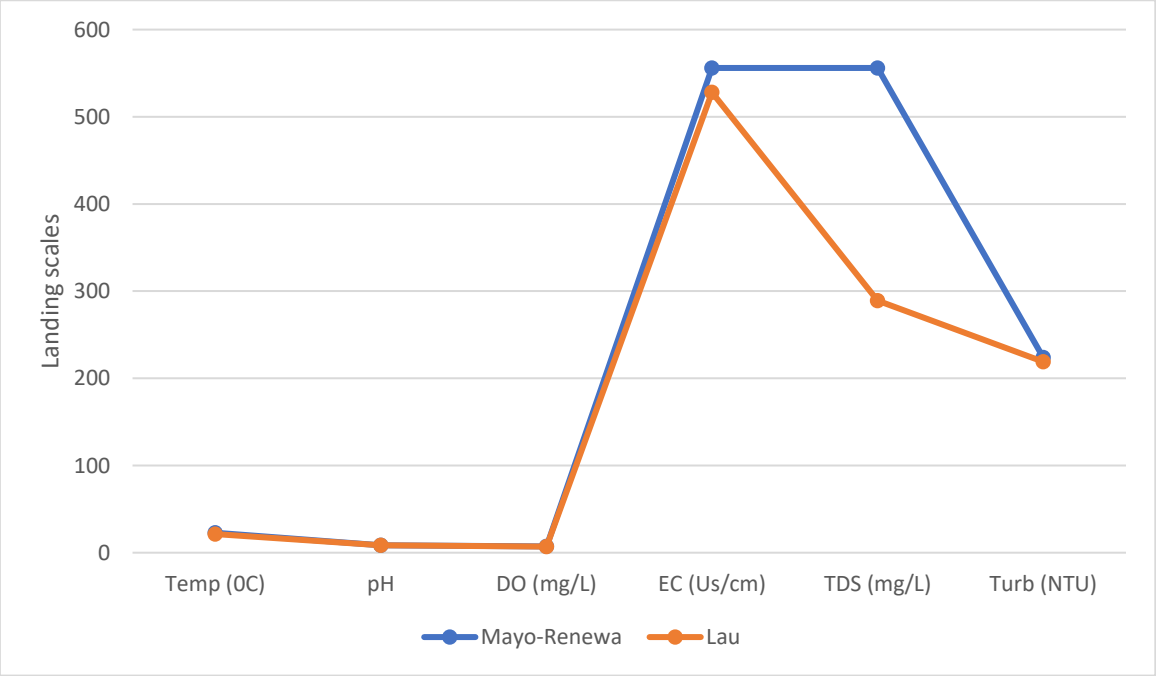


Fig. 3: Physico-chemical Parameters of Mayo-Renewo and Lau Landing Sites of River Benue

Seasonal Physico-chemical Parameters of Mayo-Renowo and Lau Landing Sites of River Benue

At the Lau landing site, the highest seasonal physico-chemical parameters measured were: EC (528 µS/cm), TDS (289 mg/L), DO (7.09 mg/L), pH (8.62), turbidity (219 NTU), and temperature (21.46°C). In comparison, the Mayo-Renowo landing site recorded EC at (556 µS/cm), TDS at (556 mg/L), turbidity at (224 NTU), DO at (7.17 mg/L), pH at (8.48), and temperature at (21.46°C) (Fig. 3).

Table 3: One-way ANOVA for Mayo-Renowo and Lau Landing Sites of River Benue

		Sum of Squares	Df	Mean Square	F	Sig.
Temp (0C)	Between Groups	42.750	11	3.886	12.436	.000
	Within Groups	7.500	24	.313		
	Total	50.250	35			
PH	Between Groups	5.810	11	.528	13.205	.000
	Within Groups	.960	24	.040		
	Total	6.770	35			

DO (mg/L)	Between Groups	21.500	11	1.955	21.717	.000
	Within Groups	2.160	24	.090		
	Total	23.660	35			
EC (us/cm)	Between Groups	705546.000	11	64140.545	64140.545	.000
	Within Groups	24.000	24	1.000		
	Total	705570.000	35			
TDS (mg/L)	Between Groups	183215.000	11	16655.909	16655.909	.000
	Within Groups	24.000	24	1.000		
	Total	183239.000	35			
Turb (NTU)	Between Groups	44396.000	11	4036.000	4036.000	.000
	Within Groups	24.000	24	1.000		
	Total	44420.000	35			

The one-way ANOVA conducted for the Mayo-Renowo and Lau Landing Sites along the River Benue revealed significant differences in several parameters: temperature (°C) with F(12.436), pH with F(13.205), dissolved oxygen (DO) in mg/L with F(21.717), electrical conductivity (EC) in µS/cm with F(64140.545), total dissolved solids (TDS) in mg/L with F(16655.909), and turbidity in NTU with F(4036.000). All these parameters had p-values less than 0.05 ($P<0.05$) (see Table 2).

Table 4: Duncan Multiple Range Test for Mayo-Renowo Landing Sites of River Benue

Season	**Month**	**Temp (0C)**	**pH**	**DO (mg/L)**	**EC (µS/cm)**	**TDS (Mg/L)**	**Turb (NTU)**
Dry season	November	21±0.28	8.8±0.12[a]	7.2±0.17	840±0.58[a]	421±0.58[b]	198±0.58[b]
	December	22±0.58	7.6±0.12[a]	6.8±0.17	620±0.58	320±0.58[a]	224±0.58
	January	24±0.28	8.1±0.12	6.4±0.17	810±0.58	170±0.58	190±0.58
	February	22±0.28	8.6±0.12[a]	7.1±0.17[b]	510±0.58	315±0.58[a]	320±0.58
	March	23±0.28	8.4±0.12	8.4±0.17	630±0.58	332±0.58	192±0.58
	April	21±0.28	8.6±0.12	8.3±0.17	520±0.58	318±0.58	201±0.58
Rainy season	May	24±0.28[a]	9.1±0.12[b]	8.3±0.17	467±0.58	225±0.58[a]	223±0.58
	June	22±0.28	8.9±0.12	6.7±0.17	515±0.58	404±0.58	220±0.58
	July	24±0.28	8.2±0.12	7.1±0.17	460±0.58	255±0.58[b]	248±0.58
	August	24±0.28	8.7±0.12[b]	7.4±0.17	480±0.58	230±0.58[b]	230±0.58
	September	23±0.28	8.1±0.12	6.1±0.17	340±0.58	240±0.58	195±0.58
	October	23±0.28	8.7±0.12	6.2±0.17[a]	480±0.58	260±0.58[b]	251±0.58

As shown in Table 3, the highest mean value of electrical conductivity (EC) during the dry season was 840±0.58 µS/cm in November, followed by 810±0.58 µS/cm in January. In contrast, dissolved oxygen (DO) had the lowest value of 6.4±0.17 mg/L in January. During the rainy season, the highest EC value recorded was 515±0.58 µS/cm in June, while DO reached its lowest value of 6.7±0.17 mg/L, also in June.

Table 5: Duncan Multiple Range Test for Lau Landing Sites of River Benue

Season	Month	Temp (^{0}C)	pH	DO (mg/L)	EC(µS/cm)	TDS (Mg/L)	Turb (NTU)
Dry season	November	28±0.58	8.1±0.29 [a]	8.3±0.23	760±0.58	380±0.58	248±0.57
	December	13±0.58	8.6±0.29[b]	8.3±0.23[a]	840±0.58[a]	421±0.58[b]	201±0.57
	January	10±0.28	8.4±0.29	7.4±0.23	626±0.58	256±0.58	193±0.57
	February	21±0.58	8.7±0.29[a]	7.4±0.23[b]	340±0.58	318±0.58	243±0.57
	March	24±0.58	8.4±0.29	7.2±0.23	510±0.58	225±0.58	181±0.57
	April	24±0.58	8.8±0.29[a]	6.8±0.23	30±0.58[a]	431±0.58	198±0.57
Rainy season	May	24±0.58	36.4±27.30	7.4±0.23[a]	810±0.58[a]	320±0.58	224±0.57
	June	22±0.58	8.4±0.29	7.1±0.23	613±132.8[a]	170±0.58	320±0.57
	July	23±0.58	8.2±0.29	6.8±0.23	510±0.58	255±0.58	190±0.57
	August	21±0.58	9.9±0.29	6.2±0.23	520±0.58	240±0.58	192±0.57
	September	23±0.58	8.4±0.29	6.1±0.23	460±0.58	230±0.58	223±0.57
	October	21±0.58	8.4±0.29	6.1±0.23	460±0.58	230±0.58	223±0.57

At the Lau landing site during the dry season, electrical conductivity (EC) peaked at a mean value of 810±0.58 µS/cm in December, while dissolved oxygen (DO) showed its lowest level of 7.2±0.23 mg/L in March, both of which were statistically significant. In the rainy season, EC again reached its highest value of 810±0.58 µS/cm in May, whereas DO recorded its minimum at 6.1±0.23 mg/L in both September and October, with all values being statistically significant at $P<0.05$ (Table 4).

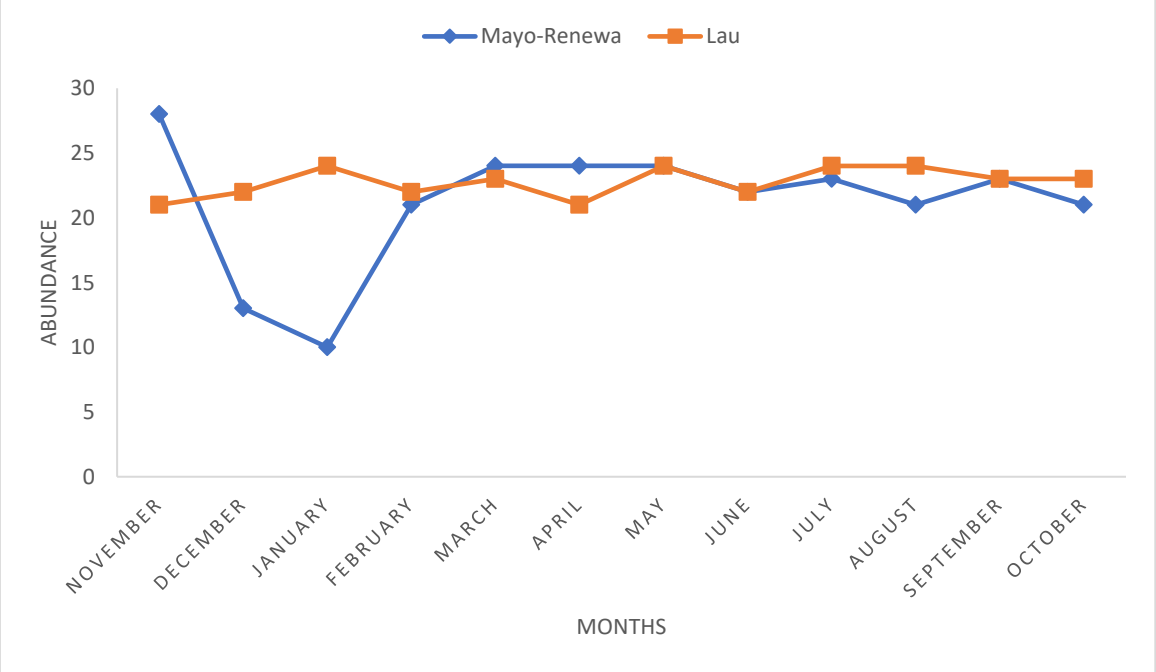


Fig.4: Monthly mean difference for Mayo-Renowo and Lau Landing Sites of River Benue

The Mayo-Renowo landing site showed the greatest mean difference in November (28), with March, April, and May each showing a mean difference of 24. The lowest mean difference was observed in January (10), followed by December (13). At the Lau landing site, the highest mean difference occurred in January, May, July, and August, each with a value of 24, while the lowest was noted in November and April, each with a mean difference of 21.

DISCUSSION

In this research, a total of twenty-six (26) fish species from twenty-two (22) families were identified at the two landing sites in the study area. The dominant fish groups were *Cichlids* and *Clarias*. The high number of species found in the River Benue can be attributed to the twelve (12) month study period, which allowed for a more thorough exploration of the available species compared to other studies, most of which were conducted over three (3) to six (6) months, with few extending to twelve (12) months in other rivers.

The prevalence of *cichlids* can be linked to several notable factors, including their high reproductive capacity and their status as the second most diverse family of freshwater fish globally. They exhibit good parental care, such as mouth brooding to protect fertilized eggs, as seen in species like *Tilapia galilaeus*. Other factors contributing to their dominance

include high juvenile and adult survival rates, strong competitive abilities, adaptability to various food sources, population resilience against predation and other population decline forces, as well as their ability to thrive in both lotic and lentic ecosystems, along with adaptations to changes in hydrological regimes.

The catfish species *Clarias gariepinus* was also prevalent, known for its tolerance to a wide range of environmental conditions. This is supported by Onemolease and Oriakhi (2011), who noted that cichlids represent the most diverse fish family in Africa. Similarly, Orounye and Abbas (2011) and Raji *et al.* (2015) observed that *C. gariepinus* can survive in polluted, stagnant waters due to its advanced accessory breathing organs, which allow it to utilize atmospheric oxygen. These organs are comprised of highly branched structures developed from two of the gill arches on each side. Additionally, their generalist feeding behavior means that food availability is not a limiting factor for their distribution.

The results from this study show higher values than those reported by Kwaji *et al.* (2015), who recorded 5,572 fish belonging to 15 families and 29 species caught from June to August 2015 at Lake Ribadu in Adamawa State, Northeast Nigeria. Similarly, Amos and Linus (2017) estimated seventeen (17) species from fifteen (15) families captured between June and August 2014 at Njoboliya Lake, Adamawa State, Nigeria. Yerima *et al.* (2017) reported forty-seven (47) species from fifteen (15) families captured from Kiri Reservoir between June 2016 and May 2017 in Shelleng, Adamawa State, Nigeria. Iber *et al.* (2018) documented twenty-eight (28) species from twenty-three (23) families caught from January to December 2016 in River Fete, Benue State, Nigeria. The dominance of cichlids in this study aligns with findings from various other studies across Nigeria, including those by Olaosebikan and Raji (2021), Mustapha (2008) from Omuechi stream, as well as Pius *et al.* (2020), Ahmed *et al.* (2011), Dienye *et al.* (2018), Olopade (2020), and Omoike (2021), all of which recorded similar dominance of cichlids.

The length-weight relationship of fish examined at both landing sites exhibited positive allometric growth in most species, indicated by a b value greater than 3. This suggests that the fish increase in weight at a faster rate than in length. Notably, species such as *Hydrocynus vittatus*, *Protopterus annectens*, and *Malapterurus electricus* showed an increase in weight, while *Heterotis niloticus* demonstrated length growth without a corresponding weight increase. This phenomenon can be linked to clean, well-oxygenated water, food availability, and favorable environmental conditions. The condition factor is also a valuable index for monitoring fish

feeding intensity, age, and growth rates, as noted by Anene (2005). It is significantly influenced by both biotic and abiotic factors and serves as an indicator of the aquatic ecosystem's status (Anene, 2005).

These findings align with previous research conducted in Nigeria's inland water bodies. For instance, Olatunde (1984) studied commercial fish landings in the Zaria central market, while Abida and Harikrishna (2008) investigated morphometric parameters of ten finfish species in the Lower Nun River of the Niger Delta. Similarly, Ibrahim *et al.* (2009) examined fish species in the Kontagora Reservoir, and Adetunji (2011) evaluated the length-weight relationship of fish in the Ebonyi River. The results indicated positive allometric growth for various species, with b values of 2.58 for *Clarias anguillaris*, 2.24 for *Bagrus docmak* and *Alestes baremose*, 3.15 for *Brycinus macrolepidotus*, and 2.55 for *Heterotis niloticus* and *Protopterus annectens*, suggesting that all studied species were in good condition. Variations in b values can be attributed to factors such as strain, species, stress, sex, food availability, and water quality. These findings differ from those of Fafioye and Oluajo (2005) and King (1996), who reported b values of 2.790 and 2.911 for *Clarias gariepinus*, respectively. Such differences may stem from variations in location, fish size, and collection season. Pauly (2019) reported that b values can range from 2.5 to 3.5, supporting the validity of this study's results.

The physical and chemical parameters analyzed in this research included temperature, hydrogen ion concentration (pH), electrical conductivity, dissolved oxygen (DO), and total dissolved solids (TDS). Among these, water temperature (T) is a crucial factor influencing fish survival, growth, and metabolic activities. The optimal water temperature range for fish growth is generally between 20 °C and 30 °C, which aligns with the findings of this study. The temperatures recorded in both rivers ranged from 23.28 °C during the rainy season to 24.58 °C in the dry season, likely due to low pollutant concentrations, promoting favorable conditions for fish growth and development (Apollos *et al.*, 2016)

Dissolved oxygen serves as an important water quality indicator, reflecting seasonal variations; oxygen is essential for all life forms in aquatic environments (Yerima et al., 2017). The observed DO levels were within standard ranges (in freshwater, DO reaches 14.6 mg/L at 0 °C and approximately 9.1, 8.3, and 7.0 mg/L at 20, 25, and 35 °C, respectively). These levels can be attributed to the cumulative effects of photosynthetic byproducts, wind-induced aeration, and temperature. The results were consistent with

reports from the tropical Niger Delta (Zabbey, 2013) and the Ogunpa River in Ibadan (Iyiola, 2015). Apollos *et al.* (2016) previously recorded DO values ranging from 6.10 mg/L to a maximum of 8 mg/L. The higher DO levels may be due to lower temperatures and increased water mixing, while elevated temperatures combined with a high decomposition rate could lead to reduced DO levels (Mustapha, 2008).

The pH range suitable for sustainable aquatic life is between 6 and 9 (EAF-FAO, 2012). The average pH during the study period ranged from 8.22 to 8.62, with significant variations observed between months ($p<0.05$). This indicates that water quality varies at different sites depending on the season. Fluctuations in pH levels may result from factors such as lake water infiltration, heavy metal contamination, and high biological activity. Additionally, human activities and atmospheric thermal conditions during the dry season likely impacted pH levels. Runoff from agricultural lands and flooding from nearby settlements can alter the hydrogen ion concentration, making the water more acidic or alkaline based on the types of waste and chemicals present (Abida and Harikrishna, 2008; EAF-FAO, 2012). These findings are consistent with observations made by Danba *et al.* (2018) and Yakubu *et al.* (2007) in Nun River, Nigeria. According to USEPA (1991), extreme pH levels can strain the natural structure of many aquatic organisms and reduce reproduction rates.

The monthly mean conductivity also exhibited fluctuations, aligning with WHO (2012) findings that electrical conductivity in freshwater varies. The observed variations in conductivity may correlate with the changing monthly pH levels in the river, groundwater, and surface runoff from surrounding agricultural areas, which likely contributed to increased ionic substances like nitrate, chloride, and phosphate from fertilizers. Acidic water ($pH < 4.5$) or highly alkaline water ($pH > 10$) tends to raise conductivity levels. Higher conductivity during warmer months is likely due to increased evaporation. Conductivity is generally more stable than temperature, dissolved oxygen, and pH, only experiencing significant changes with new inputs such as stormwater runoff or as the dry season progresses. These findings are lower than those reported by Raji *et al.* (2015) for the River Sokoto in Northwestern Nigeria. Carr and Neary (2006) noted that ion concentrations are typically lower in the rainy season compared to the dry season, as conductivity decreases in the rainy season due to greater dilution of salts. Consequently, seepages can impact water conductivity based on their composition, potentially increasing conductivity due to the presence of chloride, phosphorus, and nitrate (Apollos *et al.*, 2016).

The mean conductivity during the study period remained within the acceptable standards for aquatic life, supporting fish populations in the river.

Turbidity levels in the water body also showed slight monthly variations but remained within acceptable ranges. The highest turbidity levels may be associated with suspended particulate matter in the water. Increased turbidity can raise water temperatures, as suspended particles absorb more heat, which in turn reduces dissolved oxygen levels by limiting light penetration and thereby decreasing photosynthesis. The mean transparency throughout the study period met the World Health Organization (WHO, 2012) standards, indicating that there were no particles capable of suffocating fish eggs and other benthic microorganisms. These results are consistent with findings by Nafiu and Ibrahim (2017) and Sulaiman and Audu (2014).

Total Dissolved Solids (TDS) refer to the concentration of inorganic salts, organic matter, and other dissolved materials in water. TDS levels in natural waters often arise from sewage, waste, silt, pesticides, fertilizers, alterations to water balance (through reduced inflow, increased water usage, or heightened precipitation), or saltwater intrusion. High TDS concentrations can lead to toxicity through increased salinity, alterations in the ionic composition of the water, and the toxicity of individual ions. The samples used for TDS analysis remained within the maximum allowable concentration of 600 mg/l, as stipulated in relevant guidelines.

CONCLUSION

The river demonstrates a rich variety of fish species, likely due to ample food availability and suitable environmental conditions. Nonetheless, human-induced alterations to the river's physical and chemical properties could jeopardize the reproduction and survival of these fish species. Therefore, consistent monitoring of water quality is essential to preserve the river's fish species composition.

Recommendations

The following recommendations are suggested based on the findings:

1. Continuous monitoring of the river's physical, chemical, and biological status is necessary to identify and address any changes that may adversely affect fish production.

2. The unregulated activities at Lau and Mayo-Renowo landing sites should be managed through the enforcement of regulations by relevant agencies to prevent biodiversity loss.
3. Agricultural and other human activities near the river should be discouraged to mitigate further degradation of the aquatic environment.

Suggestions for Further Study

Future research should investigate fish species diversity and abundance over an extended period and on a larger scale to gain a comprehensive understanding of the water body and its fisheries potential.

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