Community Structure of Mochokidae (Jordan,1923) Species from the Lower Benue River, Makurdi, Benue State, Nigeria

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Abstract

The community stucture of mochokidae (Jordan,1923) species from the Lower Benue River,Makurdi, Nigeria was studied between January to December 2023. Fish samples (Mochokidae) were sampled monthly from four sampling locations with the help of fishers following the standard method. The obtained data were subjected to the software, Statistical Package for Social Sciences (SPSS) for the descriptive statistics such as percentage, mean, standard deviation and the inferential statistics for the determination of significant difference at probability level of 5%. A total of 1,103 individual from the three species (Synodontis membranaceus, S. courteti, S. batensoda) were encountered. S. membranaceus dominated the species while fishes were most abundant in station 2 (394) but least in station 4(232). Diversity indices varied across the stations with Simpson Dominance index highest in stations 4 and 2 respectively for all the species studied. Shannon Wienner values showed that the area is moderately polluted. A systematic management approach like comprehensive rational planning, precautionary and adaptive approaches toward management and development of Riverine areas is hereby recommended. Furthermore, government should take immediate action through public awareness and education to regulate fishing activities.

Keywords: *Community structure, Mochokid species, Lower Benue River, Makurdi, Nigeria*

Introduction

Riverine ecosystems are highly exposed to different forms of human activities and fish distribution and abundance in such habitats can be affected by different features of water. Fisheries of these habitats are also the mainstay of livelihoods. However, brutal human activities are affecting these ecosystems and the fish therein. It has been observed that over the past few decades, fish resources decreased dramatically, and endemic species have faced continuous threats globally (Guo *et al.,* 2018). Several researchers (Arthington *et al*., 2016; Fu *et al*., 2003) opined that overfishing, water diversion, pollution, global climate change, land erosion and other anthropogenic activities are considered as the main threats to fish biodiversity. Therefore, the

conservation of fish biodiversity has become more imperative and of utmost importance.

According to Dudgeon *et al*., (2006) fish diversity and associated habitats management is a great challenge and the ability to evaluate the effects of habitat change and other impacts on the fish population required extensive surveying of the fish population before and after the change occur. Fish diversity, community structure and species assemblages in the streams and rivers are symbiotic on many abiotic and biotic factors. These factors are therefore known to determine the success or failure of fish species assemblages in the rivers or streams within the range of spatial distribution limits (Minns, 1989). Hewitt *et al*., (2008) opined those parameters such as species composition, species richness, abundance have been used in many studies to describe and assess fish community and diversity.

Despite the high fisheries and commercial importance of the Mochokidae in the Lower Benue River, the diversity and community structure are unknown and not investigated. Meanwhile, the river is under severe degradation pressures that could jeopardize the quality and the fish biodiversity of this running water. According to Hamidou *et al* (2020) major degradation factors included proliferations of invasive floating vegetations, dumping of domestic wastes, overfishing, introduction of invasive exotic fishes, uses of chemical fertilizers and pesticides for agriculture etc. Consequently, knowledge on the fish community structure is important to assess the status of the fish biodiversity in order to contribute to document an ecosystem restoration scheme targeted to habitat protection, species conservation and valorization.

Odiko *et.al (*2009) identified the existence of 81 species of fish belonging to 42 genera and 27 families in Ovie River, Edo State. The most abundant in terms of frequency of occurrence were themormyrids, mochokids and the cichlids. In terms of number, the clariids (especially *Clarias agboviensis)* and mochokids(especially *Synodontis nigrita*) were predominant. Odiko (2012) reported fish species diversity indices to be relatively high (1.46) in River Ovie in comparison with that of other Nigerian freshwater bodies. Degree of similarity between stations assessed using the Sorenson's Index of Similarity (S) revealed a marked ichthyofauna similarity in all the sampling stations along River Ovie in Edo State of Nigeria (Idodo-Umeh, 2003). Wet season catches were significantly higher than that of the dry season.

This research in the lower Benue River is aimed to assess the Mochokidae fishes and its structure in order to better manage the species. Specific objectives of this study were 1) to investigate the dwelling Mochokidae species and evaluate the community structure, 2) to assess the relationships between physicochemical factors and the Mochokidae community indices and 3) to recommend actions for ecosystem restoration in order to assure the sustainable exploitation of the fishes.

MATERIALS AND METHODS

Study Area

The research was carried out in the Lower Benue River at Makurdi, Nigeria. The specimens were collected in the lower Benue River as defined by Reid and Sydenham

(1979) to be the Benue River Basin downstream of the Benue confluence, an area, which is contained within the Federal Republic of Nigeria and lies on the coordinates; 8º 31'N and 7º 35'E (Figures 3.1). The Benue River strongly flows through an extensive alluvial plain which stretch for approximately 1,160 kilometres along the river route. River is the portion of the Benue River that is contained within the Benue and Kogi States of Nigeria (Reid and Sydenhan, (1979). River Benue originates from the Adamawa Mountains of Cameroun and flows west across East-Central Nigeria (Nedeco, 1959. It is the largest tributary of the Niger which it joins at Lokoja in Kogi State, Nigeria.

Sampling Method

Four sample stations were established along the River Benue between Makurdi and Katsina ala which were far apart (500m apart) intending to capture a good representation of the lower Benue River. Mochokidae family (*Synodontis batensoda, Synodontis courteti and Synodontis membranaceus)* were sampled from the four stations, Wiiyaakara, Luubara, Duburo and Bane- stations respectively for a year by assessing the artisanal fisher men catches directly from normal operations. The fish samples were collected once every month, preserved and transported to the Fisheries Departmental laboratory. The fish assemblages were preserved in 10% formalin and shipped to the Laboratory of the Faculty of Agriculture, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt where they were identified to species level from monographic description, checklist and keys from authors (Idodo-Umeh, 2003; Olopade, 2017; Nkuene, 2020; Ekpo *et al*., 2023; Dodeye *et al*., 2023).

Data Analysis

The morphometric (total length, standard length, weight) data of Mochokid fishes were recorded in Excell spreadsheet 2017 and SPSS (Morgan *et al.,* 2001) spreadsheets.

The fish diversity was estimated for each sampling point and it included: Simpson's dominance index (D), Simpson index of diversity (1-D), Simpson's reciprocal index (1/D), Shannon diversity index (H'), evenness index (E1), Brillouin (HB), Menhinick's Index of Species Abundance, Margalef's index of species richness (S), equitability (J), fisher alpha and Berger-parker (d).

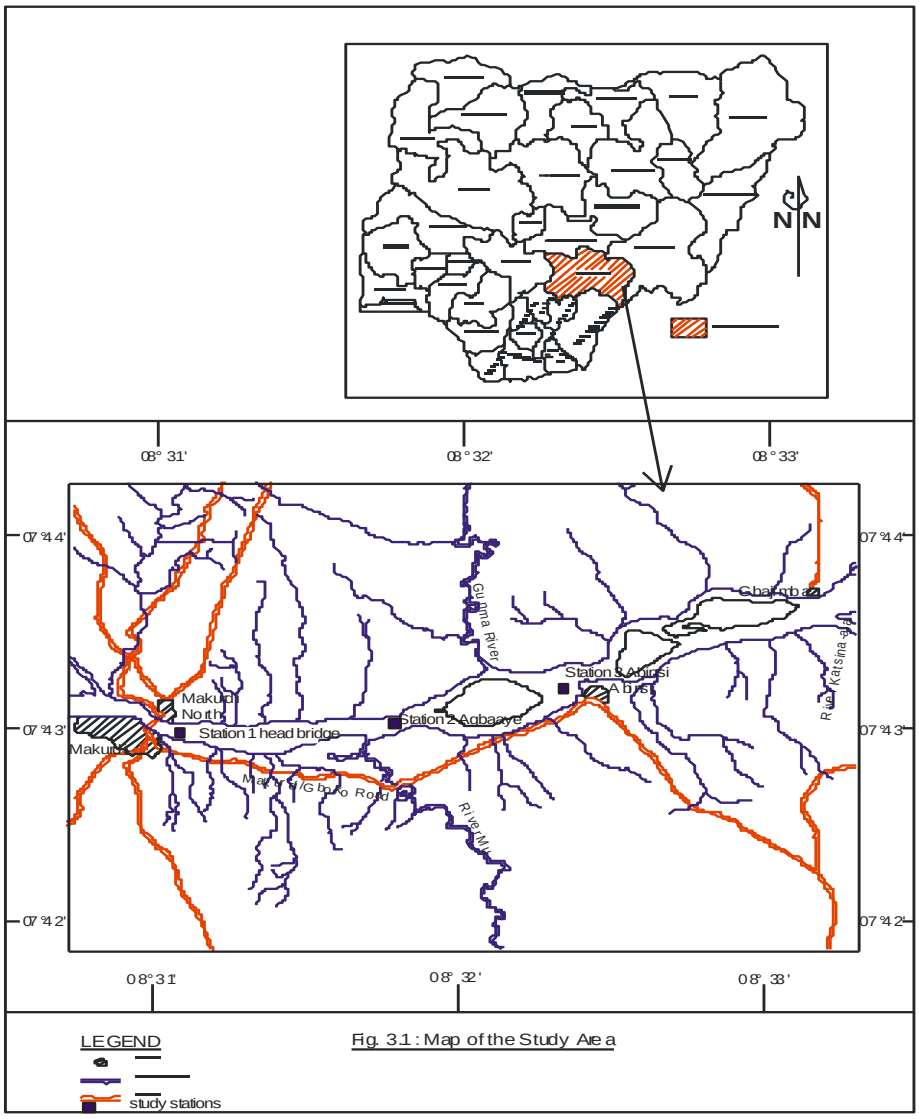

Fig. 3.1 : Map of the Study Area

Fish species richness in the sites was evaluated using two indices; menhinick's and margalef's indices.
These indices were used to obtain estimation of species diversity, species richness and species evenness.
1. Species richness (R1 and R2) obtained using the equations

R1 = (Margalef, 1958) $\frac{S-1}{N} = S - 1/\ LogeN$

R2 = (Menhinick, 1964) $\frac{S}{\sqrt{\Sigma ini}}$

Where,
R = Index of species richness
S = Total number of species

N = Total number of individuals
Ln= Natural logarithm

3. Shannon and Wiener (1949) and Simpson (1949) as in Otene, et al.,(2021 diversity index values were obtained by using the following equation:
(Shannon's index)

(Shannon's index) $-\sum_{n}^{\square}\left(\square\frac{ni}{N}-log2\,(\frac{ni}{N})\right)$

Simpson's Diversity Index (D)
This is a measure of diversity used to quantify the biodiversity of a habitat. It takes into account the number of species present as well as abundance of each species. It measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

(Simpson index) $\frac{\Sigma ini(ni-1)}{N(N-1)}$

Where ni = the number of individuals in the ith species
N = the total number of individuals
S = the total number of species
The value of D ranges between 0 and 1.

Simpson's indices of diversity (1-D) and reciprocal (1/D) are obtained from Simpson's dominance index by subtracting dominance index from 1 and dividing 1 by dominance index respectively.

Dominance index = $1-(\frac{\Sigma ini(ni-1)}{N(N-1)})$

4. Species evenness index (E) was determined using the following expression:

H^{I}/ LogeS

(Pielou, 1966)

Shannon's equitability (EH) was calculated with the equation:

$\frac{\Sigma i(\frac{ni}{N}-\ln(\frac{ni}{N})}{\ln N}$

Species Equitability or Evenness (J) Jaccard
This is a measure of how evenly the individuals are distributed among the species present in a sample. It ranges between 0 and 1,the maximum value. One represents a situation where individuals are spread evenly among the species present Jaccard (1912). It was calculated as follows:

5. Dominance index is used to characterize most conspicuous and abundant species with its relative importance related to degree of influence it has on ecosystem components.

RESULTS

Species Composition and Abundance

The annual *Synodontis species* sampled to ascertain its species composition and abundance was carried out between January and December, 2023. In all, a total of one thousand one hundred and three (1103) individual *Synodontis* specimen consisting of three species were identified during the period of study (Table 1). The *Synodontis* species were of fresh water origin dominated by *Synodontis membranceus* followed by the other two species, *S. Courti* (354) and *S. batensoda* (157). The species *S. membranaceus* dominated the sample with a total of five hundred and sixty-two (562) (58.952%) followed by *S. courteti* with a total of three hundred and fifty four (354) (32.094%).

Synodontis membranaceus had the highest length and weight of 65.4cm and 1500g respectively with the range of 10-65.4cm and 150-1500g followed by *S. courteti* with the length and weight of 47.5cm and 776g respectively with the range of 5.0-47.5cm and 98-776g (Table 2). The least length range (5.0-42.5cm) and weight range (70-487g) was observed in *S. batensoda.*

The highest catch (132) was observed in the month of May with *Synodotis membranaceus* having 66 individual followed by July (12) while the least catch (56) was observed in June in the wet season. Table 3 showed the monthly mean values of the three species of Mochokidae with little variations between the months. Table 4 showed that the highest mochokid abundance (395) was observed in station 2 while the least ((232) was observed in Station 4.

Table 1 Mochokid Abundance and Length-Weight Range in the Lower Benue River

S/N	Mochokid Species	Abundance	Percentage	Length Range(cm)	Weight Range (g)
1	*S. membranaceous*	562	50.952	10-65.4	150-1500
2	*S. courteti*	352	32.094	5-47.5	98-776
3	*S. batensoda*	187	16.954	5-42.5	70-487
	Total	**1103**	**100.00**		

Table 2: Monthly Values of Synodontis Species Caught from the Lower Benue River

Month	*S. Courteti*	*S. membranacius*	*S. batensoda*	Total	Percentage
January	40	30	6	76	6.890
February	24	60	6	90	8.160
March	24	48	20	92	8.341
April	30	40	6	76	6.890
May	36	66	30	132	11.967
June	20	30	6	56	5.077
July	32	60	30	122	11.061
August	24	30	10	64	5.802

September	48	44	12	104	9.429
October	40	55	21	119	10.789
November	28	56	20	104	9.429
December	8	40	20	68	6.165
Total	354	562	187	1103	100.00
Percentage	32.094	50.952	16.954	100.00	

Table 3: Spatial Abundance of Mochokids Species from the Lower Benue River

S/N	Mochokid Species	ST 1	ST 2	ST 3	ST4	Total
1	*S. membraneceus*	99	204	134	122	562
2	*S. courteti*	76	117	86	73	352
3	*S. batensoda*	61	74	18	37	187
	Total	**236**	**394**	**238**	**232**	**1103**
	Percentage	21.396	35.721	21.578	21.0335	100.00

Key:ST=Station, 1,2,3,4= Stations 1-4 respectively

Diversity Indices

Tables 4-6 showed the diversity indices of the mochokid species in the study area across the stations. Dominance index for *S. membranaceus* ranged between 0.08869(station 4) and 0.1109 (station 1), while the value for the *S. batensoda* ranged from 0.0905 (Station 2) and 0.1316(Station 1) while that of *S. batensoad* ranged from 0.1234(Station 4) to 0.1443 (Station 1) respectively with the Station 1 being the highest n all (Table 4-7). Simpson index for *S. membranaceus* ranged between 0.8891(Station 1) and 0.9113(Station4), *S.courteti* ranged between 0.8684(Station 1) and 0.9035(Station 2) while that of *S. batensoda* ranged from 0.8557 (Station 1) to 0.8766 (Station 4) (Table 4-6). Shannon Weinner index (H) for *S.membranaceus* ranged between 2.2480(Station 3) and 2.449 (Station 4), followed by *S. courteti* which ranged from 2.0530 (Station 1) to 2.3630 (Station 2) while that of *S batensoda* ranged from 2.026 (Station 3) to 2.236 (Station 4) (Table 4-6). Evenness index for *S. membranaceus* ranged between 0.9468 (Station 1) and 0.9646(Station 4) S. courteti ranged from 0.9129 (Station 4) to 0.9735 (Station 1) while the value for the *S. batensoda* ranged from 0.8009 (Station 1) to 0.9482(Station 3) (Tables 4-6).

Menhinick index for *S. membranaceus* ranged between 0.8402(Station 2) and 1.0860 (Station 4), followed by *S. courteti* which ranged between 0.9177 (Station 1) and 1.1700 (Station 4) while that of *S. batensoda* ranged from to 1.155 (Station 2) to 2.066 (Station 3).

Margalef index for *S. membranaceus* ranged between 1.959 (Station 1) and 2.2900 (Station 4), *S. courteti* ranged between 1.616 (Station 1) and 2.100 (Station 2) while *S. batensoda* ranged from 2.085(Station 2) to 2.769 (Station 4).

Table 4: Diversity indices of *S. membranaceus* from the Lower Benue River

Indices/Station	1	2	3	4
Taxa_S	10	12	11	12
Individuals	99	204	134	122
Dominance_D	0.1109	0.08939	0.09757	0.08869
Simpson_1-D	0.8891	0.9106	0.9024	0.9113
Shannon_H	2.2480	2.4480	2.3600	2.4490
Evenness_e^H/S	0.9468	0.9633	0.9623	0.9646
Brillouin	2.074	2.329	2.2080	2.2730
Menhinick	1.005	0.8402	0.9503	1.0860
Margalef	1.959	2.0680	2.0420	2.2900
Equitability_J	0.9762	0.985	0.984	0.9855
Fisher_alpha	2.7770	2.7860	2.8380	3.2990
Berger-Parker	0.1515	0.1275	0.1269	0.1148
Chao-1	10	12	11	12

Key: 1,2,3,4= Statios 1-4 respectively

Table 5: Diversity Indices of S. courteti from the Lower Benue River

Indices/Station	1	2	3	4
Taxa_S	8	11	10	10
Individuals	76	117	86	73
Dominance_D	0.1316	0.0965	0.1098	0.1173
Simpson_1-D	0.8684	0.9035	0.8902	0.8827
Shannon_H	2.0530	2.3630	2.2470	2.2110
Evenness_e^H/S	0.9735	0.9653	0.946	0.9129
Brillouin	1.878	2.194	2.054	1.9960
Menhinick	0.9177	1.017	1.078	1.1700
Margalef	1.616	2.100	2.020	2.0980
Equitability_J	0.9871	0.9853	0.9759	0.9604
Fisher_alpha	2.2560	2.9750	2.9300	3.1350

Berger-Parker	0.1579	0.1282	0.1512	0.1507
Chao-1	8	11	10	10

Key: 1,2,3,4= Statios 1-4 respectively

Table 6: Diversity Indices of S. batensoda from the Lower Benue River

Indices/Station	**1**	**2**	**3**	**4**
Taxa_S	10	10	8	11
Individuals	72	75	15	37
Dominance_D	0.1443	0.136	0.1378	0.1234
Simpson_1-D	0.8557	0.864	0.8622	0.8766
Shannon_H	2.081	2.106	2.026	2.236
Evenness_e^H/S	0.8009	0.8219	0.9482	0.8507
Brillouin	1.874	1.904	1.509	1.871
Menhinick	1.179	1.155	2.066	1.808
Margalef	2.104	2.085	2.585	2.769
Equitability_J	0.9036	0.9148	0.9744	0.9326
Fisher_alpha	3.154	3.0990	6.9660	5.2930
Berger-Parker	0.2361	0.200	0.200	0.2162
Chao-1	10	10	8.167	11

Key: 1,2,3,4= Statios 1-4 respectively

DISCUSSION

The distribution and composition of species in each habitat is closely related to various factors such as food availability, breeding sites, depth, topography and water chemistry (Ali *et al*., 1988). The type of ecosystem, mean depth, water level fluctuations, morphometric features and bottom of the river may also have great implications ((Adaka *et al*.,2016). The total number of individual species (3) caught from the study area in this study is completely in disagreement with the fourteen (14) species and three (3) genera reported by Essien – Ibok *et al* (2015) from the lower Cross River, Akwa-Ibom. The result of this study is also contray to the fourteen (14) species dominated by *Synodontis membranceus* reported by Hamidou et al (2020) form Niger River at Northern Benin. Paugy and Levque (2004) reported thirty three (33) species if mochokidae belonging to the three (3) genera (nochokus, chiloglomis and synodontis from the same river (Niger), Koba (2005) reported eight (8) species if mochokidae dominated by *Synodontis Schall*. This study is inline with the two (2) species of

mochokidae (*Synodontis schall* and *Synodontis nigrita*) reported by Hazoume *et al* (2018) from a Sourthern Benin stream. In a similar vaine, Djidohokpin *et al* (2017) encountered only one (1) species (Synodontis Shall) from Tove River in Sourth Benin.

Considering habitat, past and current Ichtyological studies showed that mokidae fishes usually prefer to colonize running waters (stream, rivers) and were considered to be of trivial importance in most lakes as opined by Adite *et al* (2013). In Benin coasted legion for instance, Adite *et al* (2013) reported one (1) individual of *Synodontis schall*, in Lake Hilan, a food plain of the Oueme River-Hlan River system, no mochokidae was found while in the river floodplain, Montchowili *et al* (2007) reported one(1) mochokidae species (*Synodontis nigrita*). Araoyo (1999) reported Synodontis to be one of the largest genius of the mochokidae of the orders sillrru-formes and most widely distributed. The species of this germ (Synodontis) occur throughout most of the freshwater of sub-Sahara, Africa and the Nile river system but are mostly restricted to water systems within the tropics. They were considered be found in large rivers, smaller fast flowing streams and massive African riff lakes. Considering the abundance of mochokidae in this study, it is higher than the 1,300 individual fish reported by Samuel and Balogun (2015) from the Zaria, Kaduna State, but in agreement with the 1,104 individual specimens collected from the lower Benue river reported by Akombo *et al* (2016) dominated by *Synodontis membranaceus.*

The higher abundance of mochokid species in station 2 could be attributed to favorable physiochemical condition, presence of food and high level of spawning in the area. The higher abundance of mochokids. In the dry season than the wet season could be attributed to the fact that fish spawning occurred in the wet season and resulting offspring and juveniles were concentrated and recruited in the dry season during which the water volume was reduced. Additionally, water evaporation during the dry season, water withdrawal for activities such as rice farming lower down the water level and concentrated the fished (Ajibade *et al*, 2019)

Diversity index is considered to be a qualitative measure reflecting how many different species in a data set are simultaneously taken into account and how evenly the basic entities (such as individual are distributed among these types (De-Hoog *et al.,*2000 and Otene *et al.,*2020). According to Chiu *et al*.,(2011) biological diversity, abundance, tolerance and composition are community metrics frequently used in an environment to assess an ecosystem health.
The observed diversity indices varying slightly across stations in this study could be attributed to similarity in anthropogenic activities in the respective stations. The observed higher values of Simpson dominance index in stations 4 and 2 for *Synodontis membranaceus* and *S. courteti* respectively could be attributed to the assertion by Otene *et al*.,(2020) in Whittaka (1969) that Simpson diversity index is usually higher where community is dominated by less number of species and when the dominance is shared by large number of species.
Considering the range of value of Shannon Weinner index for the respective species, the water is therefore considered to be moderately polluted. This is in line with the assertion by William and Doris (1969) in classification as contained in Otene *et al*.,2020) that values of the index greater than 3 indicates clean water, range between 1

to 3 is moderately polluted than 1(<1) is heavily polluted. The range of Shannon Weinner index observed for the mochokid species in this study is higher than that (1.0-1.42) reported by Hamidou *et al*.,(2020) from the Niger River at Northern Benin. This variation could be attributed to difference in environmental factors caused by anthropogenic activities in the area. The consistent higher values of Shannon Weinner index across the Stations 1-4 in this study confirmed the assertion by Davies and Otene (2009) that they are indicators of environmental pollution. Shannon Weinner value less than 4.17- 4.30 reported by Bonjour *et al*.,(2019) in the Upper Benue River. The observed high level of evenness in this distribution among the three (3) species of mochokid in these various stations in this study could be attributed to uniformity in environmental factors due to uniform anthropogenic activities in the areas.

The consistent fluctuation in Margalef and Menhinick indices in this study across the stations could be attributed to fluctuation in mochokid speces across the stations which could also be attributed to difference in environmental factors. The Margalef and Menhinick indices obtained here is similar to the ranges (3.19-3.25) and 0.51-0.56) reported by Bonjoru *et al.*,(2019) from the upper Benue river Basin, Nigeria which was attributed to increased living space leading to increased number of microhabitats. According to Udoidiong and King (2010), diversity is higher in od communities than newly established ones. According to Kocatas (1992), Margalef index measures the richness of species in an ecosystem which has no value but shows a variation depending upon the number of species hence used for comparism of sites.

Conclusion and Recommendation

This study revealed that the three (3) species of Synodontis (*S.menbranaceus, S. courteti and S. batensoda*) observed in this study is dominated by *S. membranceus*. The major threats recorded during this survey require an implementation of a community-based approach of ecosystem management that should include habitat protection, species conservation and valorization in order to guaranty a sustainable exploitation of the Mochokid fishes in the lower Benue River.

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