E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(2): 89-93

www.fisheriesjournal.com
Received: 03-01-2018
Accepted: 04-02-2018

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Fish composition and diversity assessment of Apodu reservoir, Malete, Nigeria

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Abstract
The pilot study on fish composition and diversity of Apodu reservoir, Malete, Nigeria was carried out between January to May 2017 using cast and gill net. A total number of 3333 fish, comprising 8 families and 17 species were recorded. *Brycinus nurse* were most dominant for the period of study contributing 29.31% and *Auchenoglanis occidentalis*, least abundant made up of 0.03% of total catch. Other families and there percentage contribution in the total catch were Mormyridae (34.14%); Cichlidae (15.24%); Mochokidae (14.01%); Clariidae (6.84%); Protopteridae (0.21%) and Clupeidae (0.21%). The range of physico-chemical parameters of the water body were: temperature (24.1ºC-29.8ºC); dissolved oxygen (4.4mg/l-6.00mg/l); conductivity (84.7µs/cm-105µs/cm); pH (6.63-7.97); transparency (125.7cm-191.3cm) and total dissolved solids (42ppm - 69.7ppm). All values were within the limits for fish tolerance, survival and production. This establishes the species composition of the reservoir and management strategy for sustainability and conservation were suggested.

Keywords: fish composition, physico-chemical, management, conservation

1. Introduction
Reservoirs are invaluable ecological resources that serve many human needs and therefore enhance our lives by providing a lot of opportunities. This explains why a large proportion of population lives near water bodies such as reservoirs, lakes, rivers, and swamps. Many depend heavily on the resources of such water bodies as their main source of animal protein and family income [1]. The Apodu reservoir serves these purposes after construction in a way of improving water availability to the villages around it and Malete town due to water scarcity in the area. Fish are important in that they contribute as much as 17% of the world's animal protein [2]. Inland fisheries play an important role in the provision of protein to Nigerians with high population of about 178.5 million people [3], especially when imported fish is becoming too expensive for low income earners [2]. Nigeria studies of fish biodiversity, abundance, distribution and yield of most of the inland lacustrine water bodies have been limited to large sized water bodies (greater than 1,000 ha) such as Kainji, Jebba, Shiroro, Tiga, Bakolore and Gorongo among others and some small/medium sized reservoirs [4]. One of the means of studying reservoir is to determine the fauna component especially the fish composition, distribution and diversity in respect to the abiotic component of such ecosystem [5].
A comprehensive understanding of the dynamics of a fish population is an important management tool for the sustainable exploitation of any fisheries resource. Thus, biological surveys of fish species composition and abundance are regular features in the management of fisheries [6]. The fish assemblage and the abiotic study can give an indication of the quality of water in the reservoir and helps to improve how reservoirs are essential for adequate protein intake in Nigerian diets. This study set out to determine the baseline abundance assessment and diversity of fish species in Apodu reservoir, Malete, Nigeria for the first time and their interaction with some abiotic factors of the water body. This will create baseline information on the present species for better management of the reservoir.

2. Materials and Methods
The study was carried out in Apodu reservoir of about 7 Km away from Malete town in Moro Local Government Area of Kwara State, Nigeria. The dam was constructed in the year 1980

and the re-impoundment of the dam was carried out in 2016, lies between the longitude 8º45"25.9"N, 8º, 45'27.7"N and latitude 4º 27'41.4"E, 4º27'35.5"E. The main purpose of the reservoir is to provide water for drinking and irrigation for Apodu village, Malete town and other nearby communities in Moro Local Government of Kwara State. Subsistence farming and commercial fishing activities were seen been carried out around the reservoir. It has a maximum length of 560m, maximum width of 400m and maximum depth of 8.2m. The storage capacity is about 0.75MCM with the surface area of about 15 hectares.

Fish samples were collected randomly from all parts of the reservoir between the month of January to May 2017, in the morning hours between 06.00 and 09.00 A.M. Fish samples were caught with cast and gill nets that were set at the surface and bottom habitats as described by Araoye (1999) [7]. The fishes were sorted, classify into different family and identified into species level as described by Babatunde and Raji (1998) and Idodo-Umeh (2003) [8, 9]. Water samples were taken randomly with three replicates in the sampling sites to determine various physicochemical parameters. Water temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in situ on the water surface using Hanna portable pH/ EC/ TDS/ Temperature combined waterproof tester model HI 98129. Electrical conductivity was measured in µS/cm, temperature in degree Celsius (^{0}C) while total dissolved solids values measured in mg/l. Transparency levels were also determined using secchi disc with a calibrated rope attached and surface water velocity was measured by floatation method (12). The dissolved oxygen (DO), nitrite (NO_3), phosphate (PO_4^-) iron (Fe), total chlorine (Cl) and Chromium (Cr) were determined using Hanna multi-parameter bench photometer for laboratories model HI 83200.

3. Results

3.1 Physicochemical Factors

The physicochemical factors that were recorded during the study period were shown in Table 1. The temperature of the reservoir during the period ranged between 24.1ºC to 29.8ºC with the highest value of 29.8ºC recorded in week 7 and the lowest value of 24.1ºC was recorded in week 1. The dissolved oxygen was relatively close except week six that it drops to 4.40mg/l. The highest dissolved oxygen was 6.00 mg/l in week four. The conductivity ranges between 84.7 µs/cm -105 µs/cm while TDS within 42 ppm - 69.7 ppm. The water current varies throughout the period of sampling. The highest and lowest water current observed was 36.96cm/s and 5.24 cm/s respectively. The transparency of the reservoir ranged between 125.7cm and 191.3cm with the highest value of 191.3 cm recorded in week 3. The pH value range of 6.63-7.97 was recorded during the study period. Nitrate and phosphate range between 0.00 - 30.0 mg/l and 0.00 - 5.5 mg/l respectively. The chlorine, iron and chromium also range between 0.00 mg/l - 0.15 mg/l; 0.07 mg/l - 0.23 mg/l and 0.00 - 0.17 mg/l respectively.

Table 1: Physico-chemical Parameters of Apodu Reservoir during Sampling Period

Parameters	N	Mean±SE	Range
Temperature (^{O}C)	12	28.41±0.48	24.10-29.80
pH	12	7.42 ± 0.11	6.63-7.95
Conductivity (µs)	12	90.14 ±1.68	84.70-105.00
TDS (ppm)	12	47.00±2.14	42.00-69.70
Current (m/s)	12	14.24±2.57	5.24-36.96
Transparency (cm)	12	147.14±5.92	125.70-191.30
DO (mg/l)	12	5.50±0.16	4.40-6.70
Nitrate (mg/l)	12	18.82±3.28	0.00-30.00
Phosphate (mg/l)	12	0.97±0.44	0.00-5.00
Total chlorine (mg/l)	12	0.88±0.02	0.00-0.15
Iron HR (mg/l)	12	0.16±0.02	0.07-0.37
Chromium VI LR (mg/l)	12	0.08±0.04	0.00-0.50

3.2 Fish community structure and composition in Apodu Reservoir, Kwara State.

A total number of 3333 fish species were caught during the 12 sampling periods. The samples were made up of 17 species, 11 orders and 8 families (Table 2). The family Mormyridae and Characidae were the most abundance making up of 34.14% and 29.31% respectively of the total abundance. The Mormyrids was represented by 3 species made up of 1,138 individuals and Characidae with only one species and it had the highest number of individual occurrence of 977 fishes. The family Cichlidae was represented by 4 species recorded during the sampling period with 508 fish species representing 15.24% of the total fish population (Table 2). The species in the genus Tillapia were well present why the genus *Sarotherodon* and *Oreochromis* were rarely encountered. The family Bagridae was the list abundant during the sampling period represented by only 1 species, having 0.03% of the total population. The number and percentage of the population of other fish families in the reservoir include Mochokidae having 467 individuals, Clariidae with 228 individual, Protopteridae and Clupeidae with 7 fish species each representing 14.01%; 6.84%; 0.21% and 0.21% of the total population respectively (Table 2).

3.3 Periodic abundance of fish species and family in Apodu Reservoir, Kwara State

The 17 species from 8 families observed during the study period were *Brycinus nurse* from family Characidae; *Hemichromis fasciantus, Tilapia guineensis, Sarotherodon macrocephala and Oreochromis niloticus* from family Cichlidae; *Synodontis gambiensis, Synodontis eupterus and Synodontis courtetti* from family Mochokidae; *Clarias gariepinus, Clarias angullaris and Clarias cameroonensis* from family Clariidae; *Mormyrus hasselquisti, Gnathonemus senegalensis and Gnathonemus cyprinoides* from family Mormyridae; *Auchenoglanis occidentalis* from family Bagridae*; Protopterus annectens* from family Protopteridae and *Sirrathrissa leonensis* from family Clupeidae (Table 3). The checklist and population index of the fish recorded in the reservoir during the study period were presented

Table 2: Composition and Relative Abundance of Fish Species and Families in Apodu Reservoir, Kwara State.

Family	Species	Total Number	Species % in family	Species % in population
Cichlidae	*Tillapia zilli*	283	55.7	8.49
	Tillapia guineensis	192	37.8	5.76
	Sarotherodon macrocephala	24	4.70	0.72
	Oreochromis niloticus	9	1.80	0.27
Total		508	100	15.24
Mormyridae	*Mormyrops hasselquisti*	5	0.44	0.15
	Gnathonemus cyprinoides	416	36.55	12.48
	Gnathonemus senegalensis	717	63.01	21.51
Total		1138	100	34.14
Characidae	*Brycinus nurse*	977	100.0	29.31
Total		977	100	29.31
Protopteridae	*Protopterus annectens*	7	100.0	0.21
Total		7	100	0.21
Mochokidae	*Synodontis gambiensis*	81	17.35	2.43
	Synodontis eupterus	292	62.52	8.76
	Synodontis courtetti	94	20.13	2.82
Total		467	100	14.01
Bagridae	*Achenoglanis occidentalis*	1	100.0	0.03
Total		1	100	0.03
Clariidae	*Clarias gariepinus*	124	54.39	3.72
	Clarias angullaris	99	43.42	2.97
	Clarias camerunensis	5	2.19	0.15
Total		228	100	6.84
Clupeidae	*Sirrathrissa leonensis*	7	100.0	0.21
Total		7	100	0.21
Grand total		3,333		100

Table 3: Fish Population Index

Family	Species	Population Index
Cichlidae	*T. zilli*(Gervals, 1948)	Abundant
	T. guineensis(Bleeker, 1862)	Abundant
	S. macrocephala(Boulenger, 1899)	Sparse
	O. niloticus (Linnaeus, 1758)	Rare
Mormyridae	*M. hasselquisti* (Valenciennes, 1846)	Rare
	G. cyprinoides (Linnaeus, 1764)	Highly abundant
	G. senegalensis (Steindachner)	Highly abundant
Characidae	*B. nurse* (Ruppel, 1832)	Highly abundant
Protopteridae	*P.annectens* (Owen, 1839)	Sparse
Mochokidae	*S. gambiensis* (Gunther, 1864)	Common
	S. eupterus (Boulenger, 1901)	Abundant
	S. courteti (Pellegrin, 1906)	Common
Bagridae	*A. occidentalis* (Valenciennes, 1840)	Rare
Clariidae	*C. gariepinus* (Burchell, 1822)	Abundant
	C.angullarisi (Linnaeus, 1758)	Common
	C. cameroonensis (Lonnberg, 1895)	Rare
Clupeidae	*S. leonensis* (Audenaerde, 1969)	Rare

in table 3. The species that are rarely caught were tagged rare while frequently caught species were tagged highly abundant. The *Gnathonemus cyprinoide, Gnathonemus senegalensis* and *Brycinus nurse* were the highly abundant species.

3.4 Limnological variables and fish family abundance relationship

The correlation of the physicochemical factors indicate a significant ($p \leq 0.05$) positive correlation of temperature with pH; electronic conductivity with total dissolve solids; Nitrite with chromium while a significant ($p \leq 0.05$) negative correlation of temperature with water current likewise pH with current (Table 5). The relationship between the physicochemical parameters and fish family abundance are shown in Table 6. A significant ($p \leq 0.05$) positive correlation of transparency with family bagridae; phosphate and chromium with family clariidae likewise iron with family mochokidae.

Table 4: Correlation of physicochemical factors in apodu reservoir during the sampling period

	Temp.	pH	EC.	TDS	Current	Trans.	DO	NO_3	PO_4^-	Cl	Fe	Cr
Temp.	1											
pH	0.803**	1										
EC	0.156	0.000	1									
TDS	0.130	-0.188	0.904**	1								
Current	-0.878**	-0.784**	-0.347	-0.272	1							
Trans.	-0.227	-0.300	-0.125	-0.210	0.307	1						

DO	-0.161	-0.298	-0.360	-0.134	0.312	-0.178	1					
NO_3	-0.143	-0.445	0.035	0.215	0.378	0.016	0.372	1				
PO_4^-	-0.056	-0.208	-0.160	-0.012	0.323	0.165	0.264	0.531	1			
Cl	-0.153	-0.299	0.405	0.424	0.016	0.111	-0.355	0.289	0.477	1		
Fe	0.112	0.311	0.117	0.061	-0.220	-0.167	0.103	0.114	-0.406	-0.426	1	
Cr	0.078	0.026	-0.196	-0.144	0.186	0.230	0.205	0.299	0.935**	0.355	-0.431	1

Table 5: Correlation of mean physicochemical factors and fish family abundance in Apodu Reservoir, Kwara State.

	Tem.	pH	Cond.	TDS	Curr.	Tran	DO	NO3	PO4	Cl	Fe	Cr
Characidae	-0.433	-0.190	-0.100	-0.185	0.330	0.240	-0.139	0.009	0.401	0.441	-0438	0.463
Cichlidae	-0.242	-0.333	-0.335	-0.151	0.216	0.359	-0.189	0.198	0.069	0.182	0.063	-0.121
Mormyridae	-0.354	-0.254	0.318	0.058	0.237	0.500	-0.182	0.001	0.135	0.394	-0.211	0.187
Mochokidae	0.410	0.515	-0.243	-0.284	-0.355	-0.148	0.169	0.193	-0.301	-0.562	0.698*	-0.246
Claridae	0.300	0.145	-0.527	-0.385	0.003	0.227	0.083	0.293	0.742**	0.239	-0.371	0.759**
Protopteridae	0.388	0.493	-0.158	-0.208	-0.302	0.080	-0.248	-0.339	0.278	0.094	-0.366	0.521
Bagridae	0.017	-0.02	-0.187	-0.158	-0.034	0.678*	-0.057	-0.242	-0.189	-0.238	0.282	-0.107
Clupidae	0.087	0.077	-0.323	-0.275	-0.205	0.462	0.073	-0.344	-0.296	-0.255	0.168	-0.178

4. Discussion

The study of the Apodu reservoir presents the checklist of the fish fauna diversity for the first time before and after channelization. Seventeen fish species were recorded despite the small size of the reservoir and the short time frame use in conducting the study. However, the fish composition of Apodu reservoir was closely in line with other reservoirs that have been estimated in Kwara state having moderate number of fish species diversity and structure with Asa, Oyun and Moro reservoir [5, 10].

The most abundance families, the Characidae and Mormyridae were predominate by *Brycinus nurse and Gnathonemus senegalensis* species that prefer to live around fallen trees in water, where the current is less swift, worms and detritus were present which could explain the availability of food abundance [11]. The high occurrence of *Brycinus nurse* could be associated by their relatively small size and ability to feed on varieties of food items [12] *and Gnathonemus senegalensis* could be explain by their adaptation to the reservoir environment due to food abundance, good breeding ability, lack of predators and good water quality. This is in contract with many studies on Nigerian reservoir reporting Cichlids as the most abundant in terms of number and diversity in the studied reservoir [10, 13, 14] and may be as a result of the season this present study carried out, time of low vegetation that the cichlids inhabits and period of draw - down that makes them go deeper into water.

The moderate number of cichlids recorded throughout the study period indicate that the reservoir have enough plankton that form food chain base to support the ecosystem. Although the reservoir environment is characterise by presence of falling trees and detritus that support bottom feeders, but the presence of large amount of phytoplankton and zooplankton which serve as food for cichlids, their multiple habits, and their adaptation to lacustrine conditions of the reservoir could account for their presence [13, 14].

The occurrence and abundance of family Clariidae could be as a result of their tolerance ability to adverse water quality and difficulty in aquaculture. This agrees with the findings of Agali and Edema (2016) [15] in Eleiyele River, that the family Clariidae dominate the total catch in the study. The five families of fish species that were present throughout the study period in Apodu reservoir are likely due to the relative abundance of the species in northern Nigeria, as indicated by Ataguba (2014) and Adeosun *et al*. (2011) [16, 17] noted that the Mormyridae, Cichlidae, Characidae, Mochokidae, and Clariidae were more common in northern Nigeria and likewise, the type of harvesting method as indicated by Allison and Okadi (2013) [18].

The low abundance of *Protopterus annectens* and *Auchenoglanis occidentalis* may be attributed to occasional occurrence, low breeding rate and change in environmental condition of the reservoir. These species are therefore considered rare and call for conservation in these reservoir. These can be done by regulating the mesh size, capture-release method, having closed and protected areas in the reservoir, as well as education [14]. There is a good representative of fishes feeding at all ecological niches in the reservoir. For example, the *Tillapia* and *Gnathonemus* are primary herbivores, *Clarias* and *Protopterus* are omnivores and they are muddy bottom fishes while *Brycinus* are predatory fishes.

Analysis and studies of the physical constituent of water bodies have been known to be very important in limnology because the relationship of physical limnology to the distribution of chemical compounds within the inland water plays a major role and in-turn has a great influence on the aquatic life. The ranges of the physicochemical parameters of the reservoir are within the recommended level for fish production and good water quality for reservoir [19]. The low water temperature recorded in the reservoir could be as a result of seasonal changes in air temperatures associated with the cool dry North-East winds. Similar trend was also reported during dry season for the water temperature of Oyun reservoir [5]. In the case of water pH in the reservoir, it was circum-neutral during the study which makes it suitable for optimal biological activity and these concise with some reported that hydrogen ion concentration (pH) was nearly neutral throughout the study [20, 21, 22]. The negative correlation of temperature, pH, conductivity, TDS and DO with the family Characidae, Cichlidae and Mormyridae predict reduction in their production if those physicochemical factors were increased.

Moderate abundant of fishes caught during the study period was attributed to their high species density, low predation, availability of food and high reproductive rate. High abundance of primary consumers species shows sustainability of fish production with adequate management which could contribute to the success in the reservoir. Maintaining low water current, increase in fishing effort, high transparency and low water level may also contribute to the success.

5. Conclusion

In conclusion, based on this study result, improvement in the

water quality management, species harvest regulation and management sparse species in this reservoir is required. This can be achieved by the maintenance of the reservoir qualities, conservation of sparsely encountered species, fishing gear mesh-size regulation and education to the fishermen.

6. Acknowledgement
Mr. Quadri, the fisherman for the assistant during the sampling periods.

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