ICHTHYOFAUNA COMPOSITION AND DIVERSITY OF A TROPICAL WATER SUPPLY RESERVOIR: A CASE STUDY OF LOWER USUMA RESERVOIR IN BWARI, ABUJA, NIGERIA

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ABSTRACT

Studies on Ichthyofauna composition and diversity of Lower Usuma Reservoir was conducted from July 2009 to April 2011 using static fleets of graded gillnets consisting of nine multifilament nets of 25.4, 38.1, 50.8, 63.5, 76.2, 88.9, 101.6, 127.0 and 177.8mm stretched meshes. Each net measured 30m long and 3m deep, with 210/3 twine used for the first eight meshes and 210/6 for the 177.8mm mesh. The nets were set simultaneously at the shore, surface and bottom of each sampling station of the Reservoir. A total of 2698 fishes belonging to 11 species and 5 families were encountered. The fish families Cichlidae (78.84%), Cyprinidae (16.31%), Clariidae (3.93%), Bagridae (0.78%) and Mormyridae (0.15%) constituted the fishery resources then *Tilapia zilli* (45.44%), *Oreochromis niloticus* (19.94%), *Tilapia mariae* (13.27%) and *Barbus occidentalis* (11.71%) were the major species while *Barilius loati* (2.63%) and Barilius *niloticus* (1.96%) were few other remaining species were very rare in the Reservoir. The estimated diversity indexes from the five stations were H'= 1.476, 1.555, 1.638, 1.470 and 1.482 respectively for Shannon while for Simpson's index the values were 0.711, 0.670, 0.729, 0.681 and 0.706, respectively for each station. Fishes of forage feeding habits were the major feeding group in the Reservoir. The forage-carnivore ratios of 24.45 and 18.78 obtained for both number and weight respectively was an indication that the fish population was not maintaining a desirable prey- carnivore relationship or a balanced ecological community.

Key words: Ichthyofauna, composition, diversity, Reservoir, tropic.

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INTRODUCTION

Reservoirs are created usually for a particular purpose either to generate electricity, irrigation or domestic usage. Irrespective of the main objective, the Fish yield from such Reservoirs may constitute a substantial contribution to a country's total domestic Fish production (Dan-kishiya *et al*., 2012) but, the effectiveness of their contributions depends largely on adequate fish assemblages and proper management of the Reservoir fisheries (Mustapha, 2008). Organisms that occur in a particular place may be classified as an assemblage or composition. Ichthyofaunal composition is the total number of individual's fish species that can be collected at a particular sampling location using single or combination of techniques. Individual fish species vary widely in their morphology, physiology, tolerance and response to their surroundings. A number of physical factors can limit the ecological success of fish populations, including water quantity, water quality, and physical habitat structure, which in turn set the framework in which biotic interactions occur, such as growth, reproduction, trophic dynamics, and competition (Karr *et al*., 1986). A Reservoir with water quality problems could be remedied through biomanipulation by structuring the fish community (Mustapha, 2008), which could be achieved by knowing the fish composition and other fish ecology studies. Most studies on fish population dynamics in Nigeria has been documented (Balogun, 2005; Fapohunda and Godstates, 2007; Komolafe and Arawomo, 2008; Ibrahim *et al*., 2009; Mustapha, 2009; Lawson and Olusanya, 2010; Avoaja, 2011). However, little similar work has been carried out in Lower Usuma Reservoir notable among them are the works of Dan-kishiya (2012) and Dan-kishiya *et al*. (2012). The present study was aimed at assessing the ichthyofauna composition and diversity in Lower Usuma Reservoir using experimental gillnetting method.

MATERIALS AND METHODS

Study area

Lower Usuma Reservoir was constructed across River Usuma at Bwari Area council. The area council has the highest elevation than any of the settlement areas in Abuja the federal capital territory (FCT) of Nigeria. The Reservoir lies between the latitude of $9^o10''$ and $9^o14''$N and longitude $7^o24''$ and 7^o 28''E with a surface area of $8km^2$, crest length of 1300metres, crest width of 10metres, maximum depth of 45metres and a maximum storage capacity of 100million cubic meters of raw water (Fig.1).

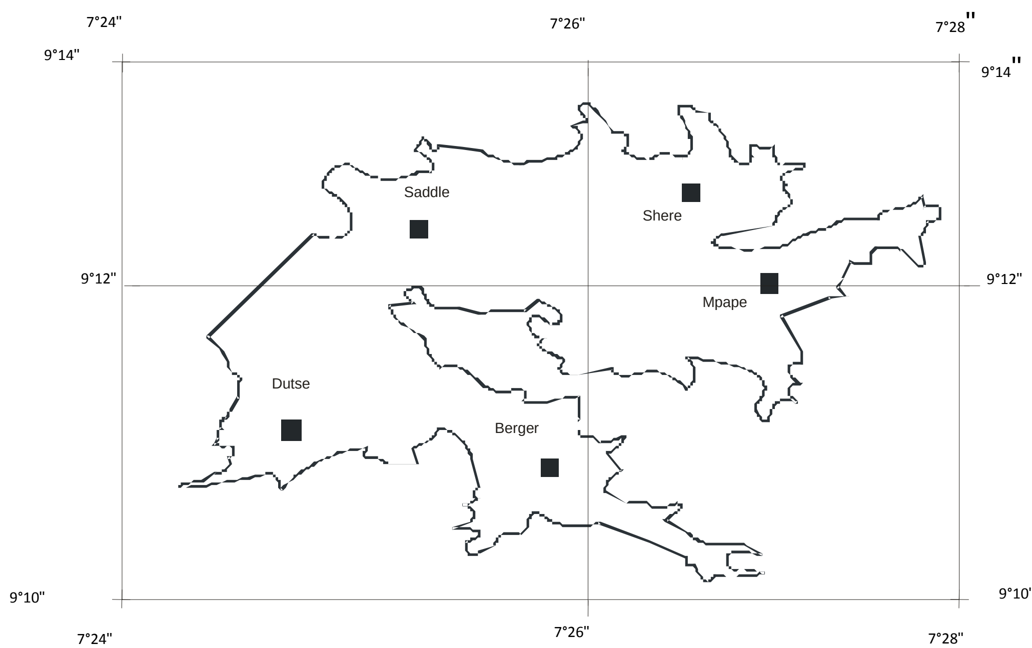

Fig. 1: Map of Lower Usuma Reservoir showing sampling stations.

Sampling Stations

Five sampling stations (Duste, Berger, Mpape, Shere and Saddle) were established around the central basin to be representative of various habitats existing within the Reservoir. The name of each station represents the entry points of Major River and streams in to the main

Reservoir besides numerous tributaries as well as the exit point. The Usuma river which is the major river enters the reservoir through Shere axis at Ushafa town and the major streams enters the reservoir through Dutse, Berger and Mpape axis while the only exit of the reservoir is trough saddle dam station.

Fish Sampling and Sampling Gears

Fish were sampled once in every month for each station throughout the sampling periods using static fleets of graded gillnets consisting of nine multifilament nets of 25.4, 38.1, 50.8, 63.5, 76.2, 88.9, 101.6, 127.0 and 177.8mm stretched meshes. Each net measured 30m long and 3m deep, with 210/3 twine used for the first eight meshes and 210/6 for the 177.8mm mesh (Olatunde, 1977; Balogun, 1986; 2005). The nets were set simultaneously at the shore, surface and bottom of each sampling station of the Reservoir. The gill nets were usually set in the evening between 5.00pm and 6.00pm and lifted the following morning between 7.00am and 9.00am. Previous experience (Ajayi, 1972) had shown that setting the nets in the mornings and lifting them in the afternoons or evening had always yielded very poor catches. All the fishes caught during the night by the gill nets were removed from the nets the following morning and kept in polythene bags which had been labeled.

Laboratory Analysis

In the laboratory, the fishes were brought out of the bags and sorted according to species and mesh sizes of the nets. The number of each species caught was recorded. Each fish specimen was measured for total length and standard length (Olatunde, 1977), weight and the sex were determined. The sex was determined by visual examination of the reproductive structures where visual determination proved difficult to determine, the specimen were dissected for visual inspection of the gonads. The fishes obtained were identified individually using the keys by Reed *et al., (*1967), Holden and Reed (1972) and Olaosebikan and Raji (2004).

Ichthyofauna composition and diversity

The ichthyofaunal composition of the Reservoir was estimated from the checklist of fishes obtained from identification of monthly samples. Some indices of diversity were used to describe the diversity of the fish communities in the Reservoir as follows:

The Shannon's Index (H') of species diversity (Shannon & Weaver, 1949) was calculated as;

$$H' = -\sum_{i=1}^{s} (P_i)(\log_e P_i) \quad \text{------------------------------------} \mathbf{1}$$

Where,

s = number of species, and p_i = proportion of the total sample represented by the ith species.

Simpson's Index of species Diversity (D) was calculated according to Simpson (1949) as;

$$D = \sum_{i=1}^{s} (P_i^2) \quad \text{--} \mathbf{2}$$

Where,

D = Simpson's measure of concentration,

$1 - D$ = Simpson's diversity index,

s = number of species, and

p_i = proportion of the total sample represented by the ith species.

Species evenness (E) was calculated based on Shannon's Index (J') according to Pielou (1969) as

$$J' = \frac{H'}{H'_{max}} = \frac{H'}{\log_e S} \quad \text{--} \mathbf{3}$$

Where

H' is the species diversity index

$H'_{max} = \log_e S$ = maximum possible value of Shannon's index

S = number of species.

Analogous equation was used to calculate evenness (V') for Simpson's diversity index ($1 - D$) as follows

$$V' = \frac{1 - D}{(1 - D)_{max}} = \frac{1 - D}{1 - \frac{1}{s}} \quad \text{--------------------------------------} \mathbf{4}$$

Where

$(1 - D)_{max} = 1 - 1/s$ = maximum possible value of Simpson's index

s = number of species.

Species dominance was expressed as the relative abundance of a subset of the most numerous species with the assumption that the proportion of the assemblage composed of the three most abundant species would be inversely related to evenness. The dominance for the three most abundant species (D_3) was calculated as follows;

$$D_3 = \sum_{i=1}^{3} (P)_i \quad \text{--}\mathbf{5}$$

Where

p_i = proportion of the total sample represented by the *i*th species.

The ecological balance of the community was estimated by the ratio of forage to carnivores fishes (F/C) ratio both in terms of number and weight as follows:

$$F/C = \frac{\text{Total foragers (Herbivores + Omnivores)}}{\text{Carnivores}} \quad \text{----------------}\mathbf{6}$$

RESULTS

Fish Species composition

Species composition showed the presence of fishes of freshwater origin. A total of 2,698 individuals belonging to 5 families and 11 species were identified from the Reservoir (Table 1). The fish family cichlidae topped the list (78.84%) and was represented by *Tillapia zilli, Oreochromis niloticus, Tillapia mariae,* and *Tillapia guineensis*. This was followed by the fish family Cyprinidae (16.31%) represented by *Barbus occidentalis*, *Barilius niloticus* and *Barillus loati*. Family Clariidae was represented by *Clarias gariepinus* and *Heterobranchus bidorsalis* all representing 3.93% of all the catches. While the fish families Bagridae and Mormyridae constituted 0.78% and 0.15% of all the catches and were represented by *Auchenoglanis occidentalis* and *Mormyrus macropthalamus,* respectively. The Cichlids were the most abundant Species comprising of *Tillapia zilli* (45.44%), *Oreochromis niloticus* (19.94%) and *Tillapia mariae* (13.27%). This was followed by the Cyprinids which comprised 16.31% of the entire population. While others like the Bagrids, Clariids and Mormyrids were very rare in the Reservoir.

The diversity indexes of fish species from the five stations in the Reservoir indicated low fish species diversity (Table 2). The estimated diversity indexes from Duste, Berger, Mpape, Shere and Saddle stations were H'= 1.476, 1.555, 1.638, 1.470 and 1.482, respectively for Shannon while for Simpson's index the values were 0.710, 0.669, 0.728, 0.680 and 0.706 respectively for each of the station.

Species evenness or the distributions of individuals among the five stations based on H' and 1-D were even. Based on H' the values were 0.758, 0.748, 0.683, 0.755 and 0.713 for Dutse, Berger, Mpape, Shere and Saddle stations, respectively. While evenness based on 1-D values were 0.829, 0.765, 0.801, 0.794 and 0.807 for each of the station accordingly.

The dominance of the three most abundant species (*Tilapia zilli*, *Oreochromis niloticus* and *Tilapia mariae*) among the five stations was estimated between the range of 76 and 82%.

Table 1: The sum of number of individuals from twenty two samples from each of five stations according to family, species and station in Lower Usuma Reservoir gill nets catches

S/N	Family/species	Station					Total	%
		Dutse	Berger	Mpape	Shere	Saddle		
	Cichlidae							
1	*Tilapia zilli*	260	233	228	263	242	1226	45.44
2	*Oreochromis niloticus*	127	109	120	72	110	538	19.94
3	*Tilapia mariae*	78	93	48	61	78	358	13.27
4	*Tilapia guineensis*	0	1	4	0	0	5	0.19
	Subtotal						2127	78.84
	Cyprinidae							
5	*Barbus occidentalis*	96	62	46	61	51	316	11.71
6	*Barilius loati*	13	8	14	14	22	71	2.63
7	*Barilius niloticus*	0	0	25	21	7	53	1.96
	Subtotal						440	16.31
	Claridae							
8	*Clarias gariepinus*	11	42	24	17	10	104	3.85
9	*Heterobranchus bidorsalis*	0	0	2	0	0	2	0.07
	Subtotal						106	3.93
	Bagridae							
10	*Auchenoglanis occidentalis*	10	8	3	0	0	21	0.78
	Mormyridae							
11	*Mormyrus macropthalamus*	0	0	2	0	2	4	0.15
	Grand total	595	556	516	509	522	2,698	100

Table 2: Indices of fish assemblage structure for five stations in Lower Usuma Reservoir gill nets catches from July 2009 - April 2011

Assemblage structure index	Station				
	Dutse	Berger	Mpape	Shere	Saddle
Richness					
Species	7	8	11	7	8
Family	4	4	5	3	4
Diversity					
Shannon's H'	1.476	1.555	1.638	1.470	1.482
Simpson's (1-D)	0.71073	0.66959	0.7287	0.6808	0.70644
Evenness					
Based on H'	0.758	0.748	0.683	0.755	0.713
Based on (1-D)	0.82919	0.76525	0.80157	0.79426	0.80736
Species dominance (3 Species)	78.15%	78.24%	76.74%	77.80%	82.38%

Based on the feeding habits of the species in the Reservoir, an estimated F/C ratio of 24.45 and 18.78 were obtained in the Reservoir for both number and weight, respectively (Table 3). The aufwuchs-detritus and Herbivores were the most dominant in terms of number (65.38%) and in Weight (77.45%). This was followed by the semi pelagic omnivores representing 29.76% (number) and 15.64% (weight). The carnivores represented 3.93% in number and 5.07% by weight. While the least were the benthic omnivores 0.93% and 1.85% for both number and weight, respectively.

Table 3: Forage - Carnivores ratio in terms of number and weight in Lower Usuma Reservoir, Bwari from July 2009 - April 2011

Feeding type	Number	%	Weight(kg)	%
Aufwuchs- detritus and Herbivores				
1. *Tilapia zilli*	1226	45.44	31.66	52.84
2. *Oreochromis niloticus*	538	19.94	14.75	24.62
Sub total	**1,764**	**65.38**	**46.41**	**77.45**
Semi Pelagic Omnivores				
3.Barbus occidentalis	316	11.71	4.13	6.89
4.Barilius loati	71	2.63	1.19	1.99
5. *Barilius niloticus*	53	1.96	1.03	1.72
6. *Tilapia mariae*	358	13.27	2.79	4.66
7. *Tilapia guineensis*	5	0.19	0.23	0.38
Sub total	**803**	**29.76**	**9.37**	**15.64**
Benthic Omnivores				
8.*Auchenoglanis occidentalis*	21	0.78	0.91	1.52
9. *Mormyrus macropthalamus*	4	0.15	0.20	0.33
Sub total	**25**	**0.93**	**1.11**	**1.85**
Carnivores				
10. *Clarias gariepinus*	104	3.85	2.94	4.91
11. *Heterobranchus bidorsalis*	2	0.07	0.09	0.15
Sub total	**106**	**3.93**	**3.03**	**5.07**
Grand total	2,698	100	59.92	100
F/C	24.45		18.78	

DISCUSSION

Studies on an existing ichthyofauna composition, diversity and state of balance between fish populations in a water body are crucial tools for an effective fisheries management and also very essential in predicting the possibility or otherwise of the populations yielding annual harvestable crops (Swingle, 1950). A total of 11 fish species belonging to 5 families were identified from the experimental gill net in the present study and this was an indication that the Reservoir in the present study was not rich in species when compared with other findings in different water bodies all over the world. For example, Boulenger (1916) published a list of African fresh water fishes to include 976 species, referable to 185 genera and 43 families. NARESCON (1992) showed that the fresh water fishery resources in Nigeria comprised of over 200 species from the inland waters, with Kainji having about 100 species while Lake Chad has 87 species. However, there are documented work on species diversity of Nigerian Reservoirs (Balogun and Auta, 2001; Komolafe and Arawomo, 2008; Mustapha, 2009; Offem *et al*., 2011).

The fish family Cichlidae in the present study was the most dominant. The dominancy of members of the family Cichlidae in the present study could be attributed to the high prolific breeding nature of members of the family Cichlidae and this compares favourably with that of Bakolori (Reynolds, 1973), Tiga (Ita *et al*., 1982), Geriyo (Dankishiya and Abdulrahman, 2007) and other African Reservoirs where cichlids are known to dominate (Balogun, 1986; 2005). Several research findings have also revealed the dominance of Cichlids in Nigerian Waters (Balogun, 1986; Akinyemi, 1987; Daddy *et al.*, 1991; Olaniran, 2000; Komolafe and Arawomo, 2003; Komolafe and Arawomo, 2008 and Mustapha, 2009).

In terms of diversity of species, the family Cichlidae *was* the most diversified in the present study with 4 species representations (*Tilapia zilli*, *Oreochromis niloticus*, *Tilapia mariae* and *Tilapia guineensis*) and dominated by *Tilapia zilli* and *Oreochromis niloticus*. This was attributed to good parental care of members of the family cichlidae which gives a considerable advantage in the colonization of their chosen habitat. The Cichlids were also the most diversified (4 species) and dominated by *Tilapia zilli* in Osinmo Reservoir in Osun State (Komolafe and Arawomo, 2008). The fish family Cichlidae was most diversified in Kangimi Lake with 5 species representation but dominated by *Hemichromis fasciatus* (Balogun, 2005).

All measures of community structure (species diversity, richness and evenness) were generally higher in the Reservoir. This was attributed to the morphology and hydrology of the Reservoir. The Reservoir is characterized by a rocky substratum interspaced by large boulders and shallow pools off stream, which increase its habitat heterogeneity resulting in greater habitat niches (Mwangi *et al*., 2012). According to Kadye and Marshal (2006), increased riverine habitat heterogeneity was associated with higher fish assemblages in African river basin. Also, Mpape station had the highest number of species (11 species) and families (5 families). The high species richness of Mpape station in the present study was attributed to the flow rate of Mpape which was much faster than the other stations and relatively shallow, resulting in higher disturbance effects on the communities. The higher disturbance may explain the increased diversity but low fish abundance. This observation is supported by the Intermediate Disturbance Hypothesis (IDH) of Connel (1978), which states that local species diversity is maximized when ecological disturbance is neither too rare nor too frequent. There are documented works on community structure of tropical water bodies. For example, Quarcoopome *et al.* (2008) showed that the values of all the diversity indices, namely species richness (D), species diversity (H') and species evenness (J), were lower in Bontanga Reservoir (1.11, 1.55 and 0.40) than Libga Reservoir (2.4, 2.36 and 0.52), respectively in Northern Ghana. Also, Mwangi *et al.* (2012) reported that community structure (species diversity, richness and evenness) were generally higher in the middle and lower reaches of River Kisian and Awach in Kenya which was attributed to their proximity to Lake Victoria.

The forage to carnivore's ratio of 24.45 and 18.78 obtained in the present study for both number and weight respectively was an indication that the fish population was not maintaining a desirable prey- carnivore relationship or a balanced ecological community. This is contrary to what was obtained in other African Reservoirs such as Kangimi (Balogun, 2005) with a recorded ratio of 1.17 and 2.28 for both number and weight respectively. Quarcoopome *et al.* (2008) recorded an estimated F/C ratio of 1.60 and 2.12 in Botanga and Libga reservoirs respectively in Northern Ghana. However, for a balance fish community and a suitable ecological balance between the foragers and their predators an acceptable range of 1.4 to 10.0 has been recommended (Blay Jr, 1985; Ofori-Danson *et al.*, 1993; Ofori-Danson & Antwi, 1994).

CONCLUSION

The Lower Usuma Reservoir has the potential of being rich in terms of icthyofauna if an appropriate strategy such as balancing the foraging (F) and carnivorous (C) population ratio is undertaken. The dominant fish family is the Cichlidae while, *Tilapia zilli* and *Oreochromis niloticus* were the dominant species. Although, *Tilapia zilli* has been documented as the dominant species in some African Reservoirs (Olaniran, 2003; Komolafe and Arawomo, 2008), the Reservoir in the present study has an unbalance population of foragers to carnivorous species. If the Reservoir can be stock with large numbers of effective predators (carnivorous species) to check the prolific breeding activity of members of the family Cichlidae as recommended by Swingle (1950), Blay Jr. (1985), Ofori-Danson *et al.* (1993) and Ofori-Danson & Antwi (1994), the Reservoir can be rich in ichthyofauna with high species diversity.

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