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Abundance and ecological classification of fish Species: A case study of Owalla Reservoir, Osun State, Nigeria

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Abstract Globally, we are experiencing higher species extinction rates than ever before which can critically affect food and nutrition security. The ecological classification of fish species was assessed in Owalla reservoir, Okinni, Osun State, Nigeria. Fish landings of fishermen were sampled for 12 months from September 2019 to August 2020). The species were identified and grouped into herbivores, carnivores, and omnivores, and the fish abundance was recorded. The Forage-Carnivore ratio (F/C ratio) was calculated to express the ecological structure of the reservoir. A total of 15 fish species (n=1035 fish) were identified. In the dry and wet seasons, 15 species (692 fish) and 11 species (343 fish) were recorded, respectively, and herbivores were more abundant than carnivores. *Chrysichthys nigrodigitatus* (25.9%) was the most abundant species and Cichlidae (55.5%) was the most abundant family. The overall F/C ratio during the combined, dry and wet seasons were 1.35, 1.01 and 2.57, respectively. The ecological structure as indicated by the F/C ratio was unbalanced, but in the wet season, it was close to being balanced. We proposed management measures such as fishing across the trophic levels, efficient monitoring and surveillance, regulation of mesh sizes, and registration of fishermen in addition to routine data collection.

Keywords: Feeding classification, fish abundance, fish composition, Owalla Reservoir, sustainability.

1 Introduction

Fish abundance and growth in tropical waters can be influenced by food availability, changes in environmental factors, fishing pressure, pollution, water depth (Soyinka *et al*. 2010) and climate change. Exploitation is a major tool that alters the fish species

diversity, food webs, and species interaction in an ecosystem. Fishing can cause changes in the food web interactions because it can reduce the components in the food web thereby altering the interactions and duration of interaction between fish species (NRC 2012). From an ecological view, all fish species have a particular function which is important in regulating various functions in an ecosystem. Therefore, fishing may either reduce the lower trophic level from predation or reduce the availability of prey for higher trophic level predators. When this occurs, the fish species in an ecosystem may tend to have an unbalanced assemblage. Over the years, fluctuations in fish abundance have been reported in Owalla reservoir, Nigeria (Taiwo 2010) and it was attributed to human activities and exploitation.

Despite the small catchment area, Owalla reservoir in Osun State, Nigeria has been reported to be rich in fish species. As a result, there have been intense fishing activities that might have caused the trophic balance of fish species in the reservoir. Taiwo (2010) reported an unbalanced fish population with an abundance of piscivorous fish species. Thus, there is a need to constantly monitor the fish resources in this water body. Abban *et al.* (2001) reported that studies on fish abundance in African waters are inadequate, and information is scarce for decision-making. Of all ecosystems, freshwaters are among the most threatened in the world (Dudgeon *et al.*, 2006). Over the past two decades, research efforts have been tailored toward the enhancement of inland fisheries in Nigeria (Neiland and Ladu 1998). Due to the lack of documented information on the ecological structure of fish species in the Owalla reservoir, the present study aims to investigate the current status of fish species, feeding categories and their ecological relationship in the reservoir. This will enable the development of appropriate management measures by the relevant agencies and stakeholders for the sustainability of the reservoir fisheries as well as the acceleration of Nigeria's effort towards achieving the 2030 Agenda of the Sustainable Development Goals (Goal 6 “Clean water and sanitation; Goal 14: Life below water).

2 Material and Methods

2.1 Study Area

Owalla reservoir is located between Latitudes 7°44′30.44″ and 7°57′00.79″ N, and Longitudes 4°26′21.71″and 4°41′23.48″ East of the Greenwich Meridian in Okinni town, Osun State, Nigeria (Figure 1). The reservoir is situated in the Erinle River basin, which is part of the Osun River basin (Ita 1993). It supplies water to Osogbo and the environs. Its elevation is between 250 and 400 meters above sea level with a maximum width of 3.5m. Diverse human activities such as farming, laundry activities and dredging were observed around the reservoir. Some parts of the reservoir were shaded by dense vegetation. Three sampling sites were selected in the reservoir based on fishing activities.

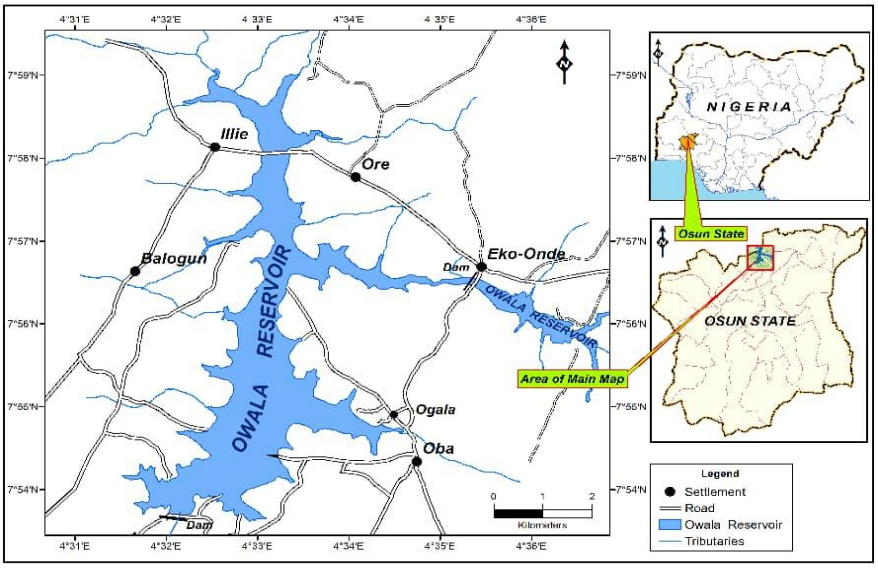

Fig 1. Map of Owalla reservoir, Osun State, Nigeria

2.2 Fish sampling and identification

Fishermen's landings were collected fortnightly from purposively identified points on the reservoir from September 2019 to August 2020. The gears used for fishing were monofilament gill nets of 25mm, 40mm, 45mm and 60mm mesh sizes. The fishing nets were set by the fishermen at 2000GMT and retrieved at 0700GMT. The fish species were sorted and identified with combination of guides by Holden and Reeds (1978) and Olaosebikan and Raji (2013). The relative abundance of fish species and families was recorded by months and seasons (dry and wet seasons).

2.3 Feeding categories and ecological structure of sampled fish species

The sampled fish species were grouped based on feeding habits as described by Holden and Reeds (1978) into three, namely;

i. Herbivores which are the primary consumers and are plant eaters
ii. Carnivores which are the secondary consumers and are flesh eaters and highly predatory
iii. Omnivores which fed on both plants and animals, although omnivory is defined as feeding at more than one trophic level (Pimm and Lawton 1974; Williams and Martinez 2004)

The abundance of fish species was computed based on their feeding habits and seasons. The Forage/Carnivore ratio (F/C) as stated by Ipinmoroti (2013) was based on fish abundance and used to determine the ecological structure of the fish species. It was calculated as follows:

$$\frac{F}{C} = \frac{Herbivores}{Carnivores+Omnivores}$$

2.4 Statistical Analysis

The data collected on fish abundance were analyzed using descriptive statistics involving percentages. The comparison between mean fish abundance per feeding habits in the wet and dry seasons was done using Student's t-test to determine their level of significance ($P<0.05$). Minitab 17.0 statistical software was used for statistical analyses.

3 Results

3.1 Sampling and Identification of fish

Table 1: Relative abundance of fish species identified during the study.

Family	Species	Abundance	Relative Abundance	Abundance (family)	Relative Abundance (family)
Cichlidae	*Oreochromis niloticus*	214	20.7		
	Coptodon marie	205	19.8		
	Sarotherondon galileaus	44	4.3		
	Coptodon zilli	54	5.2		
	Coptodon aurea	5	0.5		
	Hemichromis fasciatus	52	5.0	574	55.5
Gymnarchidae	*Gymnarchus niloticus*	1	0.1	1	0.1
Hepsetidae	*Hepsetus akawo*	9	0.9	9	0.9
Mormyridae	*Mormyrus rume rume*	79	7.6		
	Mormyrops anguilloides	40	3.9	119	11.5
Schilbeidae	*Schilbe mystus*	13	1.3	13	1.3
Clariidae	*Clarias gariepinus*	3	0.3	3	0.3
Bagridae	*Chrysichthys nigrodigitatus*	268	25.9	268	25.9
Mochokidae	*Synodontis budgetti*	27	2.6	27	2.6
Clupeidae	*Sardina pilchardus*	21	2.0	21	2.0

The relative abundance of fish species and grouping by family is presented in Table 1. A total of 1035 individuals comprising of 15 species belonging to 9 families were identified. Cichlids were the most abundant family (55.5%) and comprised of 6 species with *Oreochromis niloticus* being the most abundant species (20.7%). Gymnarchidae

was the least abundant family (0.1%) which comprised of only 1 species. *Chrysichthys nigrodigitatus* was the most abundant (25.9%) and *Gymnarchus niloticus* was the least abundant (0.1%) fish species identified during the entire study.

3.2 Ecological structure of fish species

The sampled fish species during the study period were grouped based on their feeding habits into herbivores, carnivores and omnivores (Table 2).

Table 2. Trophic classifications of fish species encountered during the study period (abundance values are given for wet and dry seasons separately and combined).

Trophic group/ species	Wet season	Dry season	Wet + dry seasons	CRA
Herbivores				
O. niloticus	91	123	214	36.0
C. marie	52	153	205	34.5
S. galileaus galileaus	36	8	44	7.4
C. zilli	48	6	54	9.1
H. fasciatus	NE	52	52	8.7
C. aurea	NE	5	5	0.8
S. pilchardus	20	1	21	3.5
Total (herbivores)	247	348	595	100
Carnivores				
G. niloticus	NE	1	1	4.3
H. akawo	8	1	9	39.1
S. mystus	10	3	13	56.5
Total (carnivores)	18	5	23	100
Omnivores				
C. gariepinus	2	1	3	0.7
C. nigrodigitatus	65	203	268	64.3
S. budgetti	2	25	27	6.5
M. rume rume	NE	79	79	18.9
M. anguilloides	9	31	40	9.6
Total (omnivores)	78	339	417	100
Total fish species	343	692	1035	

CRA= combined relative abundance; NE = Not Encountered

Herbivores were the most abundant in the combined season with an average of 57.5%, and in the wet (72.0%) and dry (50.3%) seasons with 7 fish species, respectively. *O. niloticus* was the most abundant in the combined with an average of 36.0% and in the wet season (36.8%) while *C. marie* (44.0%) was the most abundant in the dry season. Omnivores had a relative abundance of 40.3% (5 species), 22.7% (4 species) and 40.9% (5 species) for the combined, wet and dry seasons, respectively. *C. nigrodigitatus* was the most abundant omnivore with 64.3%, 59.9% and 83.3% in the

combined, wet and dry seasons, respectively. Carnivores were the least abundant family with 2.2% (comprising of 3 species), 0.7% (comprising of 5 species) and 5.2% (comprising of 2 species) in the combined, wet and dry seasons, respectively. *Schilbe mystus* (56.5%), *Hepsetus akawo* (60.0%) and *Schilbe mystus* (55.6%) were the most abundant carnivores in the combined, dry and wet seasons, respectively. The F/C ratio was calculated as 1.35, 1.01 and 2.57 for the combined, dry and wet seasons, respectively. The illustration on the trophic classification of sampled fish species is presented in Fig 2.

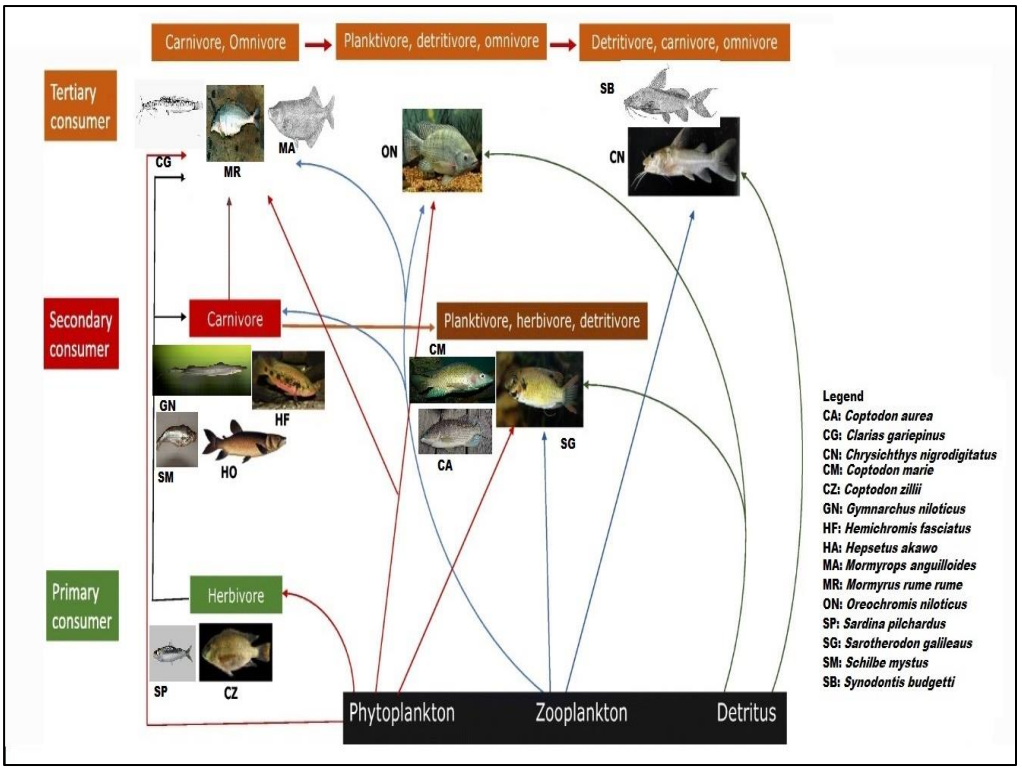

Fig 2. Trophic web locations of identified fish species in the reservoir (Adopted from Adeogun *et al.* 2020)

3.3 Forage-Carnivore ratio

The F/C ratio calculated for the entire study (combined), dry season and wet seasons were 1.35, 1.01 and 2.57, respectively. The fish species richness identified in each feeding habit was high for herbivores, carnivores and omnivores in the dry season with 7, 3 and 5, respectively (Table 3) whereas a significant value ($P<0.05$) was observed for the herbivore species between the wet and dry seasons.

Table 3: Summary of fish species richness in each feeding habit.

Feeding Habit	Dry season	Wet season	Dry + Wet (combined)	[a] T-value	[a] Significance
Herbivores	7	5	7	-0.81	0.049*
Carnivores	3	2	3	2.51	0.087
Omnivores	5	4	5	-2.15	0.098
Total species	15	11	15		
F/C ratio	1.01	1.35	1.35		

[a] T-test comparison between dry season and wet season (*significance at $p<0.05$);
F/C = Forage (Herbivores)/ Carnivore + Omnivores

4 Discussion

The results recorded for fish abundance (1035 individuals; 9 families and 15 species) deviated from studies by Komolafe *et al.* (2014) and Badejo and Oriyomi (2015) who reported fish abundance of 547 individuals (8 species; 4 families) in Osinmo reservoir and 561 individuals (12 species; 7 families) in Erinle reservoir, respectively. Both studies reported a reduction in fish abundance and diversity while Taiwo *et al.* (2018) reported a higher abundance and diversity with 1915 individuals (17 species, 10 families) in Opa reservoir. *Chrysichthys nigrodigitatus* was observed to be the most abundant fish species with 25.9% while the least was *Gymnarchus niloticus* with 0.1%. Across the families, Cichlidae was the most abundant family (55.5%) comprising of 6 fish species namely *Coptodon marie, C. zilli, C. aurea, Hemichromis fasciatus, Oreochromis niloticus* and *Sarotherondon galileaus galileaus*. The abundance of the family Cichlidae has been reported from various reservoirs in Osun state; Ipinmoroti (2013) reported 61.1% abundance in Asejire reservoir, Komolafe *et al.*, (2014) reported 83% in Osinmo reservoir with 5 species while Taiwo *et al.* (2018) reported 89.8% in Opa reservoir with 7 species. This is due to the high prolific ability of cichlids (Negi and Mamgain, 2013).

Out of the total of 1035 fish samples identified during the study, herbivores were observed to be most abundant with 595 individuals (57.5%) from 7 fish species. *O. niloticus* was the most abundant species in the herbivores group (36.0%) whereas *C. aurea* was the least (0.8%). Herbivores which comprised mostly of Cichlids are at the base of the food chain and the most abundant in the ecosystem. These results corroborated the findings of Iyiola *et al.* (2020), Komolafe *et al.* (2016) and Taiwo *et al.* (2018) that reported an abundance of herbivores in Osun River as 34.14%, in abandoned goldmine reservoirs in Igun as 86.2% and in Opa river as 89.8%. The values reported by Iyiola *et al.* (2020) were however lower than the results from the present study. The omnivores were next abundant with 417 individuals (40.3%) from five (5) species with *C. nigrodigitatus* being the most abundant fish in the group (64.3%) and the least was *Clarias gariepinus* (0.7%). The least trophic group was the carnivores with 23 individuals (2.2%) comprising 3 fish species. When fishes with commercial value (in this case carnivores) are fished, there is more space for the herbivores.

Herbivores function in balancing the number of microalgae and sharpening the aquatic system. Based on this, their abundance in the reservoir indicates the availability of food for other trophic levels to attain ecological stability (ICRI 2021).

The combined Forage-Carnivore ratio (F/C) calculated indicates an unbalanced population of fish species because it was not within the range of 3–6 as stated by Swingle (1950). The F/C values from the current study were lower except for the wet season which was higher. The ratio value recorded during the wet season (2.57) close to 3 was expected because the carnivores and omnivores were a few when compared to herbivores which almost tripled the total abundance. For the dry season and the entire study period which had relatively low F/C values, the abundance of carnivores and omnivores almost equated to the herbivores. Balayut (1983) suggested management measures such as fishing across the trophic levels when an unbalanced fish population occurs as observed during this study. Based on this, fishing across the herbivores is suggested as a management measure for attaining a balanced population of fish species.

Similar results of F/C ratio indicating an unbalanced population were reported in Osun river by Iyiola *et al.* (2020) who stated a ratio of 0.64, 0.34 and 0.48 in the dry, wet and combined seasons, respectively. These ratios were lower when compared with the results of this study. The fish species richness identified in each feeding habit indicated that herbivores were abundant in the reservoir during the period of study. This is similar to the findings by Taiwo (2010) and Badejo and Oriyomi (2015) who reported a similar abundance of herbivores in Owalla and Erinle reservoirs, respectively. A significant difference ($p=0.049$) was observed between the herbivorous fish species identified in the dry and wet seasons. The possible reason for this is the breeding activities fish species undergo during the wet season which reduced their abundance when compared to the dry season.

5 Conclusions

It was observed that the reservoir is rich in fish abundance and diversity when compared with other reservoirs within South-Western Nigeria. *C. nigrodigitatus* was the most abundant, followed by two Cichlid species. The herbivores constituted the largest trophic group of fish species observed during the study. The F/C ratio observed during the entire study and dry season was not balanced while the ratio observed in the wet season was close to balanced. The unbalanced state of fish species is a result of the relative abundance of carnivores. Management measures such as fishing across the trophic levels for carnivores, monitoring, surveillance, regulation of mesh sizes and registration of fishermen are proposed for a balanced ecological structure.

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