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Influence of physico-chemical conditions on abundance of fish species in Tagwai Lake, Minna, Nigeria

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Abstract

The need for a better understanding of the influence of physico-chemical parameters on the distribution of fish species in fresh-water habitats, a pre-requisite for improved fishery productivity, was the driving force behind this study. Standard procedures were followed in evaluating ambient physico-chemical conditions in relation to fish species caught in Tagwai Lake from January to June, 2013. The results indicated the following prevailing physico-chemical conditions: dissolved oxygen (DO) 7.61±1.42 mg/l, biochemical oxygen demand (BOD) 2.90±0.33 mg/l, alkalinity 25.09±4.95, hardness 57.32±6.66 mg/l, chloride 11.56±1.02 mg/l, conductivity 148.07±13.30 µΩ/cm, pH 6.55±0.72 and water temperature 27.53±0.86 °C. Eight fish species were encountered in the lake during the study period, in order of decreasing abundance: *Tilapia galilaea* > *Alestes dentex* > *Chrysichthys auratus* > *Tilapia zilli* > *Auchenoglanis occidentalis* > *Clarias gariepinus* > *Mormyrus hasselquistii* > *Hemichromis fasciatus*.

Fish-species abundance varied significantly (P<0.05), ranging from 290.00±135.18 specimens per sample for *Tilapia galilaea*, to 0.17±0.37 specimens per sample for *Hemichromis fasciatus*. Correlational analysis between physico-chemical parameters and fish abundance revealed no significant (P>0.05) relationship between water hardness and fish abundance (r=<0.04). The pH correlated significantly with abundance of fish species (r=>0.05), except those of *Tilapia zilli* and *Mormyrus hasselquistii* (r=<2.00). On the other hand, BOD correlated significantly with abundance of four species, namely: *Auchenoglanis occidentalis, Tilapia zilli, Alestes dentex and Hemichromis fasciatus*. Alkalinity correlated strongly with the abundance of three species (*Auchenoglanis occidentalis, Tilapia galilaea and Alestes dentex*). DO and chloride correlated strongly with abundance of only two species each, namely *Tilapia galilaea* and *Alestes dentex* for DO and *Auchenoglanis occidentalis* and *Mormyrus hasselquistii* for chloride. Significant correlation between conductivity and fish abundance was limited to *Hemichromis fasciatus*. The findings of this study will promote the development of an optimum water-quality management protocol, for increased productivity of fish species in the lake.

Key words

Physico-chemical parameters, abundance, Tagwai Lake.

1. Introduction

Fish is known to be one of the cheapest sources of protein and other essential nutrients required in the human diet. On a global scale, fishery products are the most important source of protein and are known to have relatively high digestibility when compared to other sources of animal protein like egg, milk and beef (Balfour and Yoel, 1981).

Nigeria has about 268 species of freshwater food fishes, distributed across 34 well known freshwater bodies (rivers, lakes and reservoirs) that constitute about 12% of Nigeria's total surface area (94 185 000 ha). The importance of fish in developing countries increased greatly after the Sahalian drought of 1971–1974, which greatly decimated the cattle population and made the price of livestock so high for the majority of Nigerians. This development expectedly triggered a corresponding increase in the demand for fish, which became the main alternative animal protein (Abowei, 2009). Due to the large consumption of fish by a large percentage of the Nigerian populace, some communities in both coastal and inland regions engage in culture-fishery or wild-fishery activities for their income and/or as a source of animal protein (Ekelemu

and Ogba, 2005). In consequence, there was a decline in fish yield from most Nigerian inland waters. This decline has been attributed to a wide range of causes, ranging from inadequate management of fisheries to environmental degradation of the water bodies.

In the case of Tagwai Lake, a crucial management tool for the sustainable exploitation of fisheries resources is to initiate studies that promote the development of optimum water-quality-management protocols leading to increased productivity of the fish species. Amongst other factors, the fishes' environment ranks foremost in determining the abundance and diversity of fish species.

Surprisingly, this aspect of a wild fishery is often neglected and therefore can be poorly understood. This study investigates the relationship between physico-chemical parameters and fish species in Tagwai Lake, Nigeria.

2. Materials and methods

The study was carried out in Minna, the Capital of Niger State, North Central, Nigeria. The area is located at longitude 6˚ 33' East and latitude 9° 37' North; it is surrounded by sedimentary rock, characterized by sandstones and alluvial deposits and granites.

Niger State experiences two seasons—the dry season (between November and March) and the rainy season (between April and October). The area has a tropical climate with mean annual temperature of 30 °C, relative humidity of 61.00% and mean annual rainfall of 1334 mm. The vegetation of the area is typically Guinea Savannah (grassland with scattered trees).

Tagwai Lake is about 10 km from the heart of the City. The reservoir has a capacity of holding 28.3 million cubic metres of water, thus increasing the flow of the nearby river and supply to the existing water-treatment plant of the Niger State water board. The secondary benefits from the dam include fisheries, recreation and wild-life conservation. The major occupation of the Nupe and Gwari people who dominate the Tagwai settlement is fishing.

3. Collection and analysis of water samples for physico-chemical properties

Water samples for all physico-chemical parameters were collected bi-weekly from five different stations on the lake, based on entries of the major tributaries into the lake. The physico-chemical parameters sampled were: pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), conductivity, transparency, chloride, nitrite and phosphorus, using the standard method of American Public Health Association (APHA) (1992). The water samples were collected using DO bottles and plastic containers. Water for DO was fixed in the field. The water samples were taken to the Water Resources Aquaculture and Fisheries Technology (WAFT) laboratory of the Federal University of Technology, Minna, to test for physico-chemical parameters.

4. Collection, processing and identification of fish species

Routine sampling of fish species from Tagwai Lake was conducted bi-weekly for six months (January to June, 2013). Standard fishing techniques were engaged by fishermen who deployed cast net, gill net, and hook and line.Fishes caught were identified to species level using standard taxonomic keys (Olaosebikan, 2004). All fish species collected were counted to determine species abundance. The relative abundance of the species was estimated using:

$$R.A = NS/NA \times 100\ \%$$

where R.A = relative abundance, N.S = numbers of particular species of fish collected and N.A = numbers of all fish species collected.

5. Statistical analysis

All fish species collected were counted to determine species abundance. The abundance score of the species was estimated by calculating the relative abundance (%) of each species as given above as adopted from Benech *et al.* (1983).

6. Data analysis

Data collected on physico-chemical parameters and fish species were processed into mean ± standard deviation, using the SPSS statistical package (version 16.0). Relationship between physico-chemical

properties and fish-species abundance were determined using linear-coefficient correlation.

7. Results

Table 1, shows the monthly physico-chemical properties in Tagwai Lake, Minna, Nigeria, from January to June, 2013. The physical properties in the lake during the study period included: pH—5.76 (June) to 7.47 (January); temperature—25.02 °C (January) to 30.30 °C (March); conductivity, 120.80 (January) to 160.69 (March); and hardness 44.54 (March) to 63.60 (January). The chemical properties included: alkalinity—19.00 (April) to 32.65 (February); DO—6.70 (April) to 10.60 (February); BOD—2.26 (April) to 3.60 (January); and chloride—9.61 to 12.80.

Table 1. Monthly physico-chemical parameters of Tagwai Lake, Minna, Nigeria, from January to June, 2013.

SAMPLES	DO mg/l	BO D mg/l	ALKALINITY mg/l	HARDNESS mg/l
JAN	7.10±0.53	3.60±0.56	28.50±2.58	63.60±1.86
FEB	10.60±1.03	2.90±0.67	32.60±1.03	65.20±2.60
MAR	8.00±0.52	2.80±0.43	27.20±2.22	44.54±3.34
APR	6.70±0.60	2.60±0.22	19.00±0.87	56.20±2.59
MAY	6.80±0.49	2.70±0.26	24.20±6.43	57.40±1.52
JUN	6.48±0.34	2.82±0.24	19.04±0.67	57.00±1.24
TOTAL	7.61±0.31	2.90±0.17	25.09±1.35	57.32±1.25

SAMPLES	CHLORIDE mg/l	CONDUCTIVITY µS/cm	pH	TEMPERATURE ℃
JAN	11.05±0.73	120.80±18.54	7.47±0.11	25.02±0.63
FEB	12.21±0.41	160.60±5.34	7.39±0.08	25.82±0.60
MAR	9.61±2.01	160.69±3.22	6.89±0.29	30.01±0.81
APR	12.08±1.73	149.00±1.32	5.96±0.08	29.10±0.69
MAY	11.62±1.82	148.30±1.14	5.82±0.14	28.90±0.70
JUN	12.80±1.16	149.00±1.32	5.76±0.16	30.30±0.50
TOTAL	11.56±0.59	148.07±3.58	6.55±0.11	27.53±0.86

Table 2, shows the monthly variation of fish species in the lake from January to June, 2013. A total of eight fish species were the major fishes encountered, namely *Auchenoglanis occidentalis, Tilapia zilli, Tilapia galilaea, Chrysichthys auratus, Clarias gariepinus, Alestes dentex, Mormyrus hasselquistii* and *Hemichromis fasciatus*. Dominant were *Tilapia galilaea, Alestes dentex, Chrysichthys auratus* and *Tilapia zilli*. Present, though very rare, was *Hemichromis fasciatus*. The degree of association between physico-chemical parameters and fish species abundance are highlighted in Table 3.

Table 2. Monthly variations of fish species in Tagwai Lake, Minna, Nigeria, from January to June, 2013.

SPECIES	Auchenoglanis occidentalis	Tilapia zilli	Tilapia galileae	Chrysicthys auratus
JAN	17.00±6.00^{c} -25.04%	3.50±2.50^{a} -0.89%	292.00±67.00^{c} -16.78%	5.00±2.00^{a} -1.23%
FEB	12.50±8.50^{c} -18.66%	95.50±7.50^{c} -24.42%	516.00±89.00^{c} -29.66%	16.00±3.00^{b} -3.94%
MAR	14.00±10.00^{d} -20.89%	45.50±32.50^{c} -11.64%	317.00±201.00^{d} -18.22%	89.00±69.00^{c} -21.92%
APR	4.00±3.00^{a} -5.97%	159.00±79.00^{d} -40.66%	360.00±151.00^{d} -20.69%	55.00±24.00^{d} -13.55%
MAY	12.50±10.50^{c} -18.66%	71.00±0.00^{d} -18.16%	120.00±5.00^{a} -6.89%	200.50±1.50^{f} -49.38%
JUN	7.00±4.00^{b} -10.45%	16.50±5.50^{b} -4.22%	135.00±64.00^{b} -7.76%	40.50±4.50^{c} -9.98%
TOTAL	67.00±42.00	391.00±127.00	1740.00±577.00	406.00±104.00

SPECIES	Clarias gariepinus	Alestes dentex	Mormyrus hasselquistii	Heamichromis fasciatus
JAN	2.00±1.00^{b} -6.45%	1.50±0.50^{a} -0.24%	2.50±1.50^{a} -9.80%	1.00±0.00
FEB	1.50±0.50^{a} -4.48%	3.50±0.50^{b} -0.55%	8.00±6.00^{b} -31.37%	-
MAR	3.502.50^{c} -11.29%	122.00±67.00^{c} -19.17%	1.50±0.50^{a} -5.88%	-
APR	2.50±0.50^{b} -8.06%	171.00±121.00^{d} -26.87%	1.50±0.50^{a} -5.88%	-
MAY	16.00±1.00^{c} -51.61	206.50±48.50^{c} -32.44%	1.50±0.50^{a} -5.88%	-
JUN	5.50±0.50^{d} -17.74%	132.00±17.00^{c} -20.74%	10.50±0.50^{c} -41.18%	-
TOTAL	31.00±6.00	636.50±254.50	25.50±9.50	1.00±0.00

Table 3. Correlation co-efficient for the relationship between physico-chemical parameters and fish-species abundance in Tagwai Lake, Minna, Nigeria; January to June, 2013.

FISH SPECIES	DO mg/l	BOD mg/l	ALKALINITY mg/l	HARDNESS mg/l
Auchenoglanis occidentalis	0.3296	0.7054*	0.7988*	0.1169
Tilapia zilli	0.1785	-0.6538*	-0.1977	0.0067
Tilapia galileae	0.8108*	0.0912	0.6038*	0.2602
Chrysicthys auratus	-0.3225	-0.5218	-0.2235	-0.3983
Clarias gariepinus	-0.3912	-0.3515	-0.1184	-0.1184
Alestes dentex	-0.6254*	-0.7621*	-0.5573	-0.5573
Mormyrus hasselquistii	0.2815	-0.0106	0.3765	0.3765
Heamichromis fasciatus	-0.1616	0.9567*	0.4214	0.4214

FISH SPECIES	CHLORIDE mg/l	CONDUCTIVITY µS/cm	pH	TEMPERATURE °C
Auchenoglanis occidentalis	-0.6130*	-0.3354	0.7349*	0.5714
Tilapia zilli	0.2443	0.4461	-0.2598	0.7412
Tilapia galileae	-0.0876	0.2781	0.6886*	0.5182
Chrysicthys auratus	-0.1881	0.254	-0.5679	0.5044
Clarias gariepinus	-0.07	0.0492	-0.6015*	0.3609
Alestes dentex	0.0573	0.3005	-0.9059*	0.8386
Mormyrus hasselquistii	0.6662*	0.2164	-0.0444	0.0301
Heamichromis fasciatus	-0.2234	-0.9166*	0.5668*	0.7038*

8. Discussion

In 1983, Ita carried out a survey on Kainji Lake and reported that T*ilapia* species dominated the catch. In 1990, NIFFR (National Institute for Freshwater Fisheries Research) carried out a survey on the same Kainji Lake for two years. They reported a total of 19 species, amongst which *Tilapia* species also dominated the catch. Adekunle (2008) carried out a further survey on Kainji Lake, again reporting that *Tilapia* species dominated the catch.

In 2008, Ojutiku and Kolo conducted a survey on fish communities of Tagwai Lake, Minna. They reported a total number of 12 species within the period of study. They also reported that *Tilapia* species alongside *Auchenoglanis biscutatus* dominated the catch. Interestingly, Chukwuemeka *et al.* (2014) carried out a survey on the same Tagwai Lake. They reported a total number of eight fish species, when *Tilapia* also dominated the catch. It was observed that between 2008 and 2013 there was a decline in the fish species present in the Lake. It is possible that some of the original species, such as B*agrus bajad, Heterobranchus longifilis, Amphilius atesuensis* and *Labeo coubie,* have become extinct there*.*

The decline in fish species in Tagwai Lake, Minna, Nigeria over the years necessitated this study. Furthermore, *Tilapia* species, while dominant in most water bodies, does not have a high commercial value like *Clarias gariepinus* and so there might be an advantage in determining the features conducive to an increase in more valuable species.

Correlation analysis between fish species abundance and water hardness revealed no significant difference at P>0.05 (r=>0.40), implying that abundance of the different species does not depend on hardness. The pH correlated significantly with the abundance of most of the fish species, except for *Tilapia zilli* and *Mormyrus hasselquistii*. BOD correlated significantly with abundance of four species, namely; *Auchenoglanis occidentalis, Tilapia zilli, Alestes dentex* and *Hemichromis fasciatus.* Dissolved Oxygen and chloride correlated strongly with abundance of *Tilapia galilaea, Alestes dentex* and *Mormyrus hasselquistii*. Interestingly, temperature correlated with all fish except *Mormyrus* and *Clarias.* It is not surprising that calcium (hardness) and chloride were not significantly associated with fish abundance since in the aquatic environment calcium carbonate and calcium chloride may be derived from diet and therefore fishes may have little use for the compound in their free state in water. Fishes also survive with a narrow pH range (6.6–8.4), as explained by the strong correlation.

9. Conclusion

The findings of this study have revealed a paucity of fish species in Tagwai Lake, perhaps due to the impact of human or ecological factors. The species were dominated by *Tilapia, Chrysichthys* and *Alestes* species. Unfortunately these species are not ranked foremost in acceptability within the study area, where *Clarias* species are known to dominate the market. Distinctly, BOD, DO, alkalinity, pH and temperature were the major physico-chemical parameters that affect fish abundance in Tagwai Lake, Minna. There is therefore a need to manipulate these factors in the management protocols of the Lake to enhance fish species and abundance in productivity of the Lake.

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