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Research article

Evaluation of Physico-Chemical Water Quality, Length-Weight Relationship and Condition Factor of Fish Species Inhabiting Thomas Reservoir, Kano, Nigeria

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Abstract

Evaluation of quality of aquatic medium and the growth of fish stock unveil the level of well-being of any fisheries. This study investigated the current physico-chemical water parameters, length-weight relationship and condition factor of fish species inhabiting Thomas reservoir. Five physico-chemical parameters namely; Temperature, Dissolved oxygen (DO), pH, Electrical conductivity (EC) and Total Dissolved solids (TDS) of the reservoir's surface water were tested *in situ* on monthly basis for 12-months at three stations using digital meters. Fish samples were also collected on monthly basis from catches of the local fishermen at two landing sites of the water body. Body weight of each sampled fish was measured *in situ* in grams and also total length in centimeter. Length-weight relationships (LWRs) analysis was conducted using the least square regression equation and the condition factor (K) was calculated. Analysis of the water parameters' data indicated significant differences ($p \leq 0.05$) among monthly water parameters with clear indication of influence of changes in seasons. Nevertheless the result indicated the parameters falls within tolerable range fit for the well-being of freshwater fish. Ten fish species were identified from the Reservoir. All the species exhibited negative allometric growth pattern except *Sarotherodon galillaus* with positive allometry (b=5.6) in the wet season. All the species during dry and wet seasons exhibited K values above '1' except for *Lates niloticus* and *Protopterus annectens*. It is recommended that more ecological and biodiversity studies be conducted for detail information needed for efficient fisheries management of the reservoir.

Keywords: Allometric, Biodiversity, Ecological, Growth, Isometric and Season

Introduction

Water quality is a crucial element in any aquatic ecosystem, playing a vital role in the health and sustainability of fish populations (Tiwari, 2015). Deterioration in water quality can cause significant stress to fish, leading to diseases and adversely affecting their overall well-being (Anusuya *et al*., 2017). Therefore, maintaining optimal water conditions is needed for the survival and growth of fish, as the entirety of their life processes is dependent on the quality of their environment.

Physico-chemical water parameters provide critical information about the available resources in an aquatic environment for supporting life (Bolorunduro and Abdullah, 1996). Good quality water is essential for sustaining fish populations and maintaining the ecological balance within aquatic communities. Monitoring these parameters aid in identifying the sources and magnitude of pollution loads, which can have detrimental effects on fish health (Anusuya *et al*., 2017).

Understanding the length-weight relationship and condition factor of fish species within freshwater ecosystems has immense importance for several compelling reasons. Firstly, the length-weight relationship gives critical insights into the growth patterns and overall health of fish populations, supplying researchers with valuable data on size-specific variations in body mass (Abdul *et al*., 2016). This relationship helps in estimating biomass, understanding reproductive potential, and evaluating the ecological dynamics within aquatic communities (Nasri *et al.*, 2021). Additionally, by analyzing this relationship, researchers can derive essential parameters such as Fulton's condition factor, which serves as an indicator of fish health and well-being. A change from the expected condition factor may signify environmental stressors, such as poor water quality, habitat deterioration, or food availability issues (Stavrescu-Bedivan *et al.*, 2018).

Monitoring the length-weight relationship and condition factor facilitates the evaluation of fisheries sustainability, informing management practices and regulatory frameworks targeted at maintaining balanced and resilient aquatic ecosystems (Hazoume *et al.*, 2017). By delving into these metrics, researchers would have profound insights into the physiological, ecological, and anthropogenic factors shaping fish populations, ultimately guiding conservation measures, fostering biodiversity conservation, and ensuring the sustainable utilization of freshwater resources for both ecological and socio-economic benefits (Stavrescu-Bedivan *et al.*, 2018).

Despite the abundance of reservoirs across Nigeria, their contribution to fish production remains disproportionately minimal (Ahmad *et al.*, 2015). This deficiency in fish production can be attributed to a myriad of interconnected factors such as fish habitat degradation and the broader environment, inadequate fish assemblages and inappropriate harvesting techniques. Ahmad *et al.* (2015) illustrated the imperativeness of acquiring a comprehensive understanding of species composition, diversity, and relative abundance within water bodies to facilitate the sustainability of aquatic resources. In relation to this sentiment, Singh and Serajuddin (2017) emphasized the pivotal role of length-weight relationship in evaluating crucial aspects of a fish's habitat, particularly in explaining patterns associated with climate change and environmental alterations. Moreover, the condition factor serves as an invaluable metric for gauging fish feeding frequencies, age structures, and developmental rates, thereby providing indispensable insights into the health and vitality of fish populations (Abdul *et al*., 2016). Consequently, the exploration of these parameters becomes necessary as fisheries managers would require it for the formulation of informed management strategies aimed at enhancing the resilience and productivity of freshwater ecosystems (Zargar *et al.*, 2012).

The present study evaluates the length-weight relationship and condition factor of fish species inhabiting Thomas reservoir located in Kano, Nigeria. The study aspires to unravel the underlying dynamics underpinning fish ecology thereby providing useful information for the formulation of evidence-based conservation policies and sustainable management practices.

Materials and methods

Study Area

Thomas Dam is situated in Nigeria's Sudan Savannah Zone (12°16'44" N–21°18'35N and 8°30'5" E–8°31'34" E) with two distinct wet and dry seasons. June through September is the Wet season while October through May is the dry season (Tukur *et al.*, 2018). The Dam occupied 585 square meters and is located 30 kilometers from the historic Kano city, close to Danmarke, a town in Dambatta Local Government area of Kano State (Nafi'u & Ibrahim, 2017).

Water Sampling, Collection of Fish Sample and Identification.

Samples of surface water of the reservoir were collected on monthly basis into 1liter sampling bottles at three stations between 8:00am – 11:00am. The sampling was done for the period of 12-months (January, 2022 to December, 2022). Physico-chemical parameters such as Water temperature, pH, Electrical Conductivity (EC) and Total dissolved Solids (TDS) were measured using Extech Measuring meter (Exstik®11) while Dissolved Oxygen (DO) was measured using Hanna DO digital Meter. All the parameters were

measured *in situ* in triplicates and randomly at three stations.

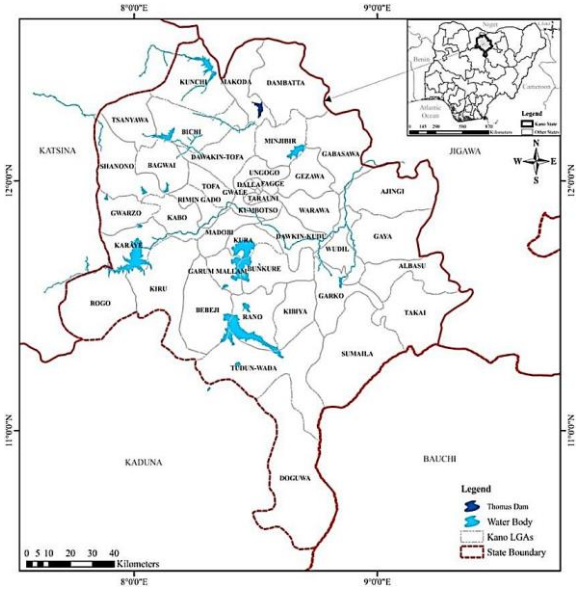

Figure 1: Map of Kano State Showing location of the Study Area.

Fish samples were collected monthly for a period of twelve months (January, 2022 to December, 2022) from two landing sites from catches of the local fishermen. Gill nets, cast nets, traps and hook were the common fishing gears used for fishing on the water body. Fish sample taxonomic identification were done with the aid of an identification (Olaosebikan and Raji, 1998). Representative samples of each species were imaged scanned for latter confirmation of the identification. Each sample was weighted using digital weighing balance (TF220 Model) while total length was measured using meter rule. The length-weight relationship was calculated using the least square regression equation on log transformed data. The length-weight relationship was expressed by the equation:

$W = aL^b$ which was transformed into a natural logarithmic as $\text{Log } W = \log a + b \log L$

Where:

W = Weight, a = exponent describing the rate of change of weight with length (intercept), b = weight at unit length.

Condition factor (K) was calculated as $K = 100W/ L^3$ (Ajibare *et al.*, 2020).

Where: K= condition factor, W = total weight (g), L =total length (cm) and the cubic relationship between length and weight.

Results and discussion

Physico-chemical Parameters of Thomas Reservoir Water

Table 1 shows the results of the different physico-chemical measurements in Thomas Reservoir water. In April, the water temperature was highest at 23.73℃, while lowest in January at 18.33℃, with significant difference between monthly water temperatures ($P \leq 0.05$). The water temperature generally increased in the dry season and decreased in the wet season. This result concur with other findings that established a direct influence of water temperature through the exchange of heat between the local atmospheric temperature and that of the water (Mariola and Wiejaczka, 2017). Thus, surface water of the reservoir experiences elevated temperature as ambient temperature rises during the hot period of dry season (i.e., March-May) (Abdullahi *et al*., 2023).

The pH of the water varied significantly ($P \leq 0.05$) across months and seasons, with the highest pH (10.80) in July during the wet season and the lowest (7.72) in April during the dry season. The DO, EC and TDS of the reservoir water also varied significantly ($P \leq 0.05$) across months. DO values range from 4.62 to 8.58mg/L. The EC ranges from 127.00 to 169.77 µS/cm while the TDS ranges between 59.37 and 78.48mg/L.

Despite these variations, all the recorded values for these parameters falls within normal range suitable for the growth and survival of freshwater fish species (Nielsen *et al.*, 2003; WHO., 2011; Ma *et al.*, 2020).

Table 1 Monthly physico-chemical parameters of Thomas reservoir water.

Months	Temp. (ºC)	DO (mg/L)	EC (µS/cm)	pH	TDS (ppm)
January	18.33 ± 0.16^{e}	8.57 ± 0.23^{a}	153.53 ± 0.39^{d}	9.37 ± 0.19^{c}	77.48 ± 0.33^{abc}
February	19.66 ± 0.28^{d}	4.67 ± 0.18^{ef}	129.77 ± 0.16^{g}	9.22 ± 0.21^{c}	68.92 ± 0.38^{de}
March	22.78 ± 0.25^{b}	5.50 ± 0.24^{d}	128.62 ± 0.29^{h}	9.70 ± 0.29^{b}	68.03 ± 0.35^{de}
April	23.73 ± 23^{a}	4.62 ± 0.16^{f}	142.62 ± 0.15^{f}	7.72 ± 0.24^{e}	69.78 ± 0.25^{cd}
May	22.65 ± 0.19^{b}	5.57 ± 0.21^{d}	145.63 ± 0.26^{e}	8.60 ± 0.26^{d}	59.37 ± 25.61^{f}
June	22.48 ± 21^{b}	5.55 ± 0.24^{d}	145.57 ± 0.23^{e}	8.55 ± 0.28^{d}	69.40 ± 0.37^{cde}
July	19.65 ± 0.24^{d}	7.80 ± 0.23^{b}	169.77 ± 0.26^{a}	10.80 ± 0.24^{a}	78.48 ± 0.38^{ab}
August	19.65 ± 0.35^{d}	8.58 ± 0.29^{a}	167.10 ± 0.43^{b}	10.70 ± 0.28^{a}	77.90 ± 0.63^{abc}
September	21.50 ± 0.40^{c}	7.42 ± 0.24^{c}	165.77 ± 0.36^{c}	10.55 ± 0.19^{a}	78.87 ± 0.23^{a}
October	18.50 ± 0.37^{e}	8.58 ± 0.63^{a}	127.00 ± 2.43^{i}	8.82 ± 0.34^{d}	61.02 ± 1.14^{ef}
November	18.47 ± 0.22^{e}	4.97 ± 0.24^{e}	129.15 ± 0.77^{gh}	8.58 ± 0.20^{d}	70.15 ± 0.58^{bcd}
December	18.57 ± 0.26^{e}	4.87 ± 0.19^{ef}	127.03 ± 0.41^{i}	7.87 ± 0.34^{e}	68.07 ± 0.50^{de}

Mean ± SD with the same superscripts alphabet in the same column are not statistically significant ($P > 0.05$).

Length Weight Relationships (LWRs) and Condition factor (K)

The results of the LWR indicated most of the species exhibited negative allometric growth pattern, an indication of their higher growth in length than in weight (Table 2). Thus, fish experiencing this type of growth tend to have slimmer body shape (Nasri *et al.*, 2021). However, *Sarotherodon galillaus* exhibited a positive allometric value (5.6) during the wet season, an indication of its fast growth in weight than in length thereby giving it a robust appearance. Some species, like *S. galillaus* and *Lates niloticus*, exhibited Isometric growth (b~3). This form of growth portrays the species as experiencing proportional growth in length and weight (Nasri *et al.*, 2021).

During the dry season, most species exhibited relatively lower allometric values, suggesting less favorable environmental conditions. The allometric values during the season ranged from 0.278 (*Oreochromis niloticus*) to 2.954 (*Clarias gariepinus*). *Polimyrus isidori* and *S. galillaus* had the lowest while highest 'b' values in the Wet season at 0.543 and 5.6, respectively.

Separation of the LWRs and condition factor estimates of the fish species on seasonal bases provided additional information when compared with similar study conducted without seasonal distinction (Nafiu *et al.*, 2017). The allometric coefficient (b) obtained by Nafiu *et al.* (2017) ranged from 0.9 to 2.7 while the condition factor ranged from 0.9 to 1.9. Comparison of their results with those obtained from the present study indicated higher values for most of the species with the lowest value of 'b' found to be 0.543 and highest as 5.618.

It should however be noted that differences in the observed LWRs growth coefficient (b) between the species depends a lot on the inherited body shape of each species. Other environmental factors that could contribute include physiological factors such as maturity and spawning (Jisr *et al.*, 2018). The observed higher allometric coefficient during wet season could be ascribed to increased weight of fish due to development of their gonads as spawning of most fish species is connected with period of high precipitation.

Condition factor (K) values indicate the well-being of fish populations. The K values were generally ≥1 for all the species in both dry and wet seasons, except for *Lates niloticus* (0.337 & 0.426) and *Protopterus annectens* (0.309 & 0.285) (Table 2). A condition factor of '1' or above is considered favorable for growth and development (Jisr *et al.*, 2018). This suggests that majority of the fish species studied are in good conditions and well-being.

Table 2: Summary of the fish species length-weight relationship and condition factor parameters

	Dry Season					Rainy Season				
Species	a	b	R^2	K	GT	a	b	R^2	K	GT
C.gariepinus	-3.825	2.954	0.760	1.987	A-	-1.812	2.217	0.582	1.475	A-
C.anguillaris	1.547	1.366	0.399	2.014	A-	-0.708	1.989	0.478	1.583	A-
O.niloticus	4.152	0.278	0.048	1.664	A-	-2.086	2.403	0.816	1.999	A-
O.aureus	2.101	1.000	0.336	2.239	A-	-2.108	2.282	0.622	1.744	A-
S.galillaeus	0.103	1.586	0.541	1.821	A-	11.112	5.618	0.232	2.527	A+
T.zilli	0.244	1.392	0.616	1.550	A-	-0.549	1.700	0.616	1.685	A-
L.niloticus	0.950	1.115	0.355	0.337	A-	-5.269	2.898	0.487	0.426	A-
B.nurse	1.856	0.806	0.348	1.367	A-	0.866	1.155	0.402	1.324	A-
P.annectens	-3.307	2.305	0.746	0.309	A-	-3.739	2.405	0.665	0.285	A-
P.isidori	3.125	0.441	0.537	5.274	A-	2.903	0.543	0.613	5.457	A-

a=Intercept, b=Slope, GT= Growth type, A-:=Negative Allometric growth, A+:= Positive Allometric growth, K=Condition factor

Conclusion

This study focused on two main aspects: the physico-chemical water parameters and the morphometric characteristics of fish in the Reservoir. Evaluation of the water parameters indicated monthly and seasonal variations of water temperature, pH, DO, EC, and TDS. Despite these fluctuations, the recorded values for these parameters fell within favourable ranges suitable for the growth and survival of freshwater fish species.

The length-weight relationship and condition factors revealed interesting patterns. Most fish species exhibited negative allometric growth, indicating a tendency to grow faster in length than in weight, resulting in a slimmer body shape. *Sarotherodon galillaus*, however, exhibited a positive allometric value during the wet season, suggesting it grows faster in weight than in length, giving it a more robust appearance. Condition factor values, that reflect the well-being of fish populations, were generally favorable for the majority of the species, indicating suitable conditions for growth and development.

Recommendation

Based on these findings in Thomas reservoir, it is suggested that wide range of environmental factors should be studied for adequate information on the environmental influence on fish yield. Studying more physico-chemical water parameters along with evaluation of heavy metals and essential nutrients will give clarity on the potentials of the reservoir in supporting fisheries productivity. Assessment of nutrient related water parameters, plankton biodiversity and abundance, and interlink between biota and the aquatic environment will provide adequate information needed for the effective management of the fisheries.

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