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Length-Weight Relationship and Condition Factor of *Oreochromis niloticus* (Linnaeus, 1758) in Selected Tropical Reservoirs of Ekiti State, Southwest Nigeria

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KEYWORDS

Length-weight relationship

Oreochromis niloticus

Condition factor

Growth pattern

ABSTRACT

In Ekiti State, southwest Nigeria, *Oreochromis niloticus* is significant to live. This investigation was conducted to improve its sustainable management and access the length-weight relationship and condition factor of *O. niloticus* across important reservoirs in Ekiti State from November 2017 to October 2019. Collected specimens were weighed to the nearest gram, while the entire lengths were measured to the closest centimetre. Log-transformed regression was used to determine the fish's growth pattern in the reservoirs. The gradient comparison was done using the T-test. The length and weight of the species in the reservoirs showed a significant association. All length-weight relationships had r^2 values greater than 0.8150 and were significant at $P < 0.05$. In the length-weight relationship of *O. niloticus*, the values of the exponent b in Egbe, Ero, and Ureje reservoirs varied from 2.45 to 2.87, 3.02 to 3.20, and 2.45 to 2.82, respectively. The results of regression coefficient b obtained showed that in the combined season, male, female and combined sexes from the Ero reservoir had isometric growth patterns with growth exponent b values of 3.18, 3.20 and 3.19 respectively that were not statistically different from 3. These results contradicted the negative allometric growth pattern in the Egbe and Ureje reservoirs. The condition factor during the dry season ranged from 1.93-2.05, 2.05-2.11, and 1.93-2.03 for fish in Egbe, Ero, and Ureje reservoirs, respectively while in the rainy season, it ranged from 2.00-2.02; 2.08-2.09 and 1.96-2.01 respectively. The fish species studied in the reservoirs lived above-average life and thus indicate that the prevailing ecological conditions in the reservoirs were not beyond the forbearance range for the fish species since their condition factors were within the range considered adequate for freshwater fishes in tropical waters.

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1 Introduction

Fish production plays a vital role in providing livelihoods, employment, and income, and it is also a very cheap source of proteinous foods to the riparian communities and over two million people who live in Ekiti state, Nigeria. It is significant to the Nigerian economy and contributes over US$ 1 billion to its gross domestic product (Fasae and Isinkaye 2018). Fishing and marketing of fish are very lucrative ventures contributing to Nigeria's food security, poverty alleviation, and economic growth. 3–4% of Nigeria's annual GDP comprises the fishing and aquaculture industries (Subansighe et al. 2021). The fish industry also plays a significant role in meeting the nation's nutritional needs by providing around 50% of the food derived from animals and as an indispensable part of the nation's economy (Subansighe et al. 2021). *O. niloticus* is one of significant global economic importance fish species and is raised in at least 85 nations worldwide, making it the second most significant category of farmed fish after carp (Burden 2014). It is considered to be one of the most important fish species in tropical and subtropical aquaculture (FAO 2012). It is the most prevalent species of fish in the waterways of the Ekiti State, and consumers choose it as their top protein source, especially in low-income households due to its undeniable market demand (Olagbemide and Owolabi 2023).

Nigerians' reservoirs contribute significantly to the nation's total indigenous fish production (Komolafe et al. 2014). Although its annual domestic harvest is projected to be 450,000 metric tons, Nigeria is one of the developing world's top fish importers, bringing in nearly 900,000 metric tons of fish (George 2020). Human activities, including industrial, urban, farming, and residential pollution, negatively affect the quality of the environment with its accompanying biological, ecological, and sociological consequences have put Nigerians' water bodies under increasing threat (Ouma 2015). Reservoirs in Ekiti State are sources of potable water, fish, and recreation centres but also receive inputs from domestic and agricultural activities. These various anthropogenic activities are likely to adversely affect the biology of the fish in the reservoirs. Thus, effective management of aquatic resources must be fully adopted to close the gap between fish demand and availability in the State. Biometric relationships are frequently used in fisheries management to convert field data into the proper indices (RobiulHasan et al. 2021). The length-weight relationship (LWR) is a crucial tool for managing and assessing fisheries (Tran et al. 2021), conducting growth studies and providing valuable data related to the habitat and aquatic ecosystem simulations (Moutopoulos and Stergiou 2002). Physiologically, fish size is more important than age because various environmental and physiological aspects depend more on size than age. As a result, size variation significantly affects fisheries knowledge and population trends (Alonso-Fernández et al. 2021) and is among the most basic fisheries data metrics (Mehmood et al. 2021). Hence, LWR offers helpful information about fish species in a specific geographic area (Olopade et al. 2018). Although LWRs are similar among fish species, they may differ due to hereditary body form and physiological parameters and fluctuate seasonally (De Giosa et al. 2014). Even in the same species living in different areas, the growth process that determines the length and mass of fish might differ due to various biotic and abiotic factors (Nazek et al. 2018).

The fish condition factor (K) acts as a physiological indicator of the well-being of the fish (Ajibare and Loto 2022). According to Olopade et al. (2018), it assesses various biological and environmental parameters, including extent of fitness, gonad maturation, and appropriateness of environment concerning nutritional condition. It refers to the relative fatness of the individual fish, which represents stored energy. When comparing the two populations subjected to particular feeding densities, climatic circumstances and other influences, condition factors are valuable (Fafioye and Ayodele 2018). It helps assess fish's feeding frequency, age, and growth pace (Ndimele et al. 2010). The condition factors of fish species are used to understand their life cycles, manage fish populations appropriately and preserve environmental equilibrium (Imam et al. 2010). Biotic and abiotic environmental conditions strongly influence condition factors and can be used as a metric to evaluate the state of the fish-supporting aquatic ecosystem (Famoofo and Abdul 2020).

Despite numerous studies on the length-weight association and condition factor for fish in Nigerian water bodies (Imam et al. 2010; Ndimele et al. 2010; Ayoade 2011; Ikongbeh et al. 2012; Dan-Kishiya 2013; Fagbuaro 2015; Kareem et al. 2015; Fagbuaro et al. 2016; Kareem et al. 2016; Moslen and Miebaka 2017; Omotayo et al. 2018; Laurat et al. 2019; Oladimeji et al. 2020; Olatunde 2020; Mohammud et al. 2020), but the reports on length-weight relationship and condition factor of *O. niloticus* from Ekiti State reservoirs are scarce. This study compares the length-weight relationship and differences in the condition factor of *O. niloticus* from Egbe, Ero and Ureje reservoirs in Ekiti State, southwest Nigeria, to improve sustainable fishing management.

2 Materials and Methods

2.1 Area of Study

Ekiti State is situated between latitudes 7° 15 and 8° 5' North of the equator and between longitudes 4° 45' to 5° 45' East of the International Meridian, and Kwara, Kogi, and Osun States are its neighbours to the North, east, and south, respectively. Three largest reservoirs of the State included in this study are Egbe reservoir, located between latitudes 7^{o} 36$^{'}$N North and longitude 5^{o} 35$^{'}$ East of the equator; Ero reservoir at Ikun-Ekiti, Moba Local, located between latitudes 7^{o} 15$^{'}$ N and longitude 5^{o} 31$^{'}$ E; and Ureje

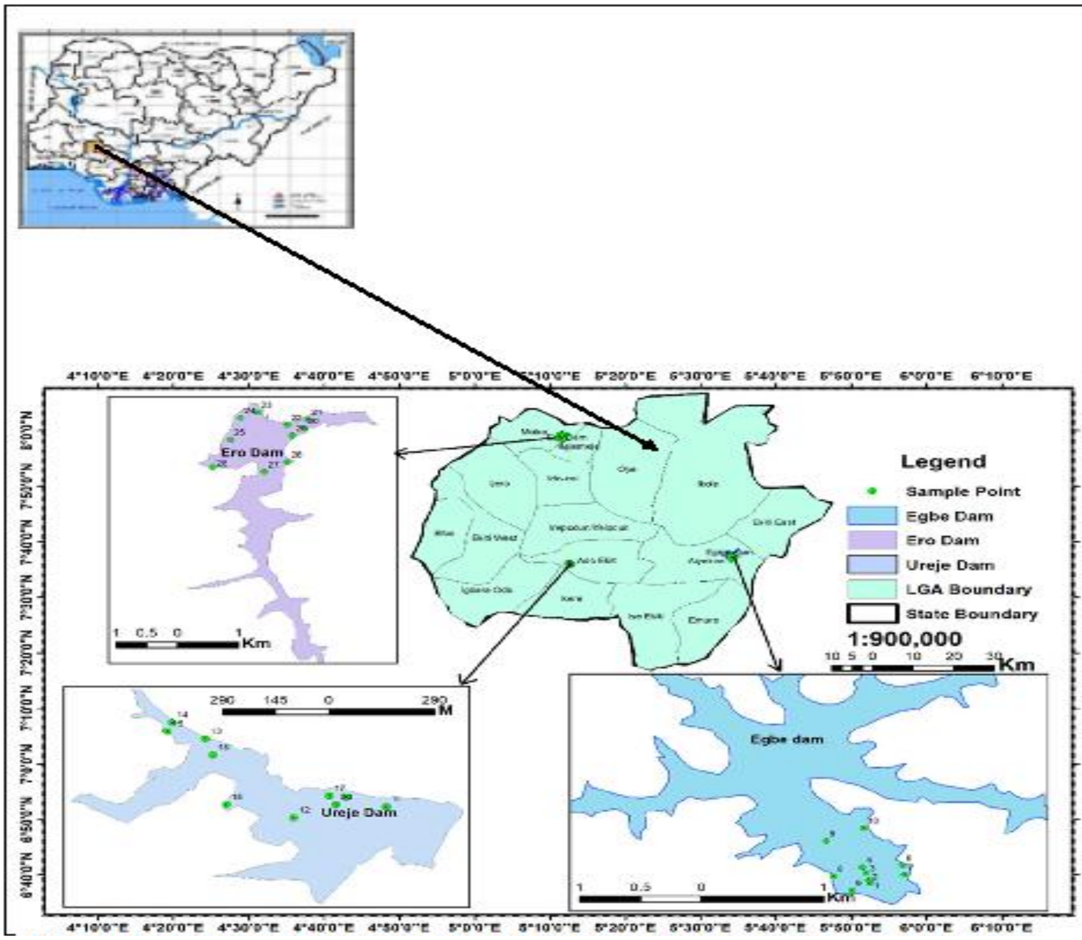

Figure 1 Map of Ekiti State showing the locations of the Reservoirs (Egbe, Ero, and Ureje), southwest Nigeria

reservoir, located between latitude 7° 35' N and longitude 5° 13' E. (Figure 1). Ekiti State reservoirs are very significant and central to the economy of the State's people as they are water sources for domestic and agricultural purposes. Further, these reservoirs are sources of livelihood for the rural fishermen and market women and also a major source of animal protein for the populace, especially the rural dwellers who feed on fish from the reservoirs.

2.2 Sample Collections, Identification and Laboratory Procedures

Permission was obtained from the Ekiti State Water Corporation, and ethical clearance was acquired from the University of Ilorin ethical committee. Samples of *O. niloticus* were collected monthly from the landing sites of Egbe, Ero, and Ureje reservoirs with the help of fishermen working on these reservoirs during both dry (November-March) and rainy season (April-October) of 2017 to 2019 to explore the effect of season on the fish growth pattern. The rainy season is characterized by rainfalls, high relative humidity, lower temperature and reduced photoperiod, while during the dry season, there is no rainfall, relative humidity is low, and temperature and photoperiod are higher. The fishermen used gill nets left overnight with surface marker buoys for easy relocation. Fish were given labels and identification numbers before being transported to the laboratory in ice-packed containers for further analysis. Fish experts at the Zoology Department, Ekiti State University, Ado-Ekiti, Nigeria, validated the fish samples' identity in the laboratory using the standard identification key developed by FAO (2009) and Olaosebikan and Raji (2013).

Blotting paper was used to remove water from the fish body, and with the aid of a measuring board, the total length (TL), the tip of the head (mouth closed) to the expanded tail fins of each fish, was determined to the nearest 0.1 centimetres (cm). Using an Ohaus CS 5000 model digital top-loading balance, the fish body weight was taken to the nearest g. The genital papillae were visually inspected to determine the fish's sexes, which was later confirmed by dissecting the fish's belly to view the gonads. The male fish has only one opening (a urine pore) in the genital papilla, located directly behind the anus, while the female possesses two (oviduct and urinary pore). Additionally, the transverse slit of the genital papilla was used to distinguish males from females, whereas the longitudinal slit was used to identify females (Wangatia 2012). The equation below was used to represent the relationship between fish length (L) and weight (W):

$W = aL^b$ …………………………….... (1) (Kahraman et al. 2014).

Before the calculations, the equation mentioned above (1) and data were turned into logarithms. As a result, equation 1 becomes:

Log W = log a + b log L.. (2) (Zar 1984).

W = fish's weight in grams (g)

L is the fish's total length in centimetres (cm)

a = is the intercept of the regression.

b = Regression slope coefficient (Pauly 1983).

The parameter, a, is a scaling factor for the fish species' weight at length. The shape parameter b refers to the fish species' particular body type. The exponent's value, b, provides biological information on the pattern of fish growth (Abobi 2015). A linear regression of the logarithms of fish length and weight generated the "a" and "b" values. According to Yilmaz et al. (2012), an isometric growth is ascribed when b is not significantly different from 3 and an allometric change is implied when the difference between b and 3 is statistically significant at P <0.05 (Morey et al. 2003).

$ts = (b-3)/s_b$ ……………………….……………………………. (3)

where ts = Student's t-test, b = slope, and s_b = standard error of the slope. Because the fish grows isometrically, the b value of 3 was chosen for comparison and as a reference.

The 95 percent confidence interval (CI) of 'b' was obtained using the equation (Egbal et al. 2011).

$CI = b \pm (1.96 \times SE)$……………………………………………. (4)

where SE stands for "b's standard error."

Using the method published by Pauly (1983), the condition factor, which indicates the level of fish welfare in the Egbe, Ero, and Ureje reservoirs for each month, was calculated for each fish species:

$100W/L^b$ is the condition factor (K). …………...……………. (5)

Where W is the weight in grams (g), L is the total length of the fish (cm), and b is the calculated LWR growth coefficient.

The condition factor of fish is related to both male and female body types. The calculation was done separately for male and female fish to obtain their statistical differences. According to Bolognini et al. (2013), the data reported were the mean values of the samples collected over two years.

2.3 Statistical Analysis

All statistical analyses were deemed significant at P < 0.05. One-way analysis of variances (ANOVA) was performed to compare the means of K of *O. niloticus* among the examined reservoirs. A t-test was used at a predetermined significant level (P < 0.05) to determine whether the b-values from the linear regression analysis varied significantly from the optimal value (b=3). This study used Microsoft Office Excel and the Statistical Package for Social Sciences, version 23.

3 Results and Discussion

3.1 Length-weight relationships (Combined seasons)

Fish length-weight relationship studies are a useful resource for characterizing the biological characteristics of the fish species. *Oreochromis niloticus* in the Egbe, Ero, and Ureje reservoirs had mean total lengths of 18.66 ± 0.21, 20.11 ± 0.09, and 18.14 ± 0.13 cm and mean weights of 139.17 ± 4.73, 173.35± 2.14, and 117.73± 4.76 grams, respectively. Results presented in Table 1 revealed the sample size and the length-weight features, and Figure 2 displays scatter plots or regression graphs of the total length and weight relationships of the species in the reservoirs. Since the body weight of fish species increases as total length increases (Tah et al. 2012; Ezekiel and Abowei 2014), the high coefficient of determination value calculated in the evaluation of LWRs over the mean year in the reservoirs validates or explains the quality and reliability of the LWR model or linear regression for the fish species, thus, according to Nazek et al. (2018), the extrapolation of body weight in future catches can be done in Egbe, Ero, and Ureje for the observed size range in the reservoirs. All the reservoirs had a significant relationship at P < 0.05 for *O. niloticus*. Negative allometric growth was reported for *O. niloticus* in all reservoirs except Ero, indicating that *O. niloticus* in Egbe and Ureje reservoirs has a slimmer growth rate. Positive allometric growth indicates the fish gets robust, weightier, and deeper-bodied as its length increases as opposed to isometric growth, which means the fish's length and weight increase at the same rate. *O. niloticus* showed isometric growth (b = 3) in the Ero reservoir. This shows that b-values could vary amongst the different populations of similar species. Bernard et al. (2010) found a similar isometric growth pattern (b = 3.04) for *O. niloticus* in the Egah River, Kogi State, Nigeria. In contrast, Getso et al. (2017) discovered a negative allometric coefficient (b) ranging from 0.1441 to 0.8058 for the same species in Nigeria's Wudil River of Kano State. Similarly, Lauret et al. (2019) found a negative allometric coefficient (0.332 female, 0.365 male) for *O. niloticus* in the lower river Benue, Nigeria. However, most fishes

Table 1 The regression assessment of the correlation between *O. niloticus* body weight and total length from studied reservoirs in Ekiti State, Nigeria

	N	Mean TL	Mean BW	a	B	SE (b)	Cl (b)	Growth Type	R^2	P value of r	t value	K
Egbe (CS)	634	18.66	139.17	0.249	2.75	0.056	2.64-2.86	- Allometric	0.93	5.6×10^{-47}	-4.46	2.01
Egbe (CSM)	409	18.02	126.92	0.241	2.78	0.074	2.63-2.93	- Allometric	0.93	1.64×10^{-29}	-2.97	1.99
Egbe (CSF)	225	19.29	151.43	0.261	2.71	0.088	2.54-2.88	- Allometric	0.94	2.8×10^{-18}	-3.30	2.03
Egbe (CR)	368	18.39	134.47	0.263	2.71	0.059	2.59-2.83	- Allometric	0.93	2.34×10^{-40}	-4.92	2.01
Egbe(MR)	252	17.89	130.52	0.284	2.65	0.066	2.52-2.78	- Allometric	0.94	1.82×10^{-28}	-5.30	2.00
Egbe (FR)	116	18.90	138.41	0.217	2.87	0.130	2.62-3.12	- Allometric	0.90	4.8×10^{-13}	-1.00	2.02
Ero (CS)	610	20.11	173.35	0.143	3.19	0.037	3.12-3.26	Isometric	0.98	6.9×10^{-97}	5.14	2.09
Ero (CSM)	406	20.11	172.57	0.144	3.18	0.049	3.08-3.28	Isometric	0.97	2.42×10^{-56}	3.67	2.07
Ero (CSF)	204	20.11	174.13	0.141	3.20	0.057	3.09-3.31	Isometric	0.97	4.30×10^{-40}	3.51	2.10
Ero (CR)	354	19.80	164.97	0.174	3.05	0.064	2.92-3.18	Isometric	0.94	2.57×10^{-45}	0.78	2.09
Ero (MR)	245	19.78	163.85	0.169	3.07	0.085	2.90-3.24	Isometric	0.93	1.04×10^{-29}	0.82	2.08
Ero (FR)	109	19.81	166.10	0.177	3.02	0.100	2.82-3.22	Isometric	0.95	1.55×10^{-17}	0.20	2.09
Ureje (CS)	640	18.14	117.73	0.321	2.58	0.067	2.45-2.71	- Allometric	0.88	1.07×10^{-28}	-6.27	2.09
Ureje (CSM)	358	18.07	115.67	0.317	2.60	0.085	2.43-2.77	- Allometric	0.87	8.62×10^{-19}	-4.71	2.07
Ureje (CSF)	282	18.21	119.80	0.329	2.57	0.109	2.36-2.78	- Allometric	0.89	4.93×10^{-11}	-3.94	2.10
Ureje (CR)	374	17.36	106.35	0.379	2.46	0.086	2.29-2.63	- Allometric	0.83	1.23×10^{-13}	-6.28	2.09
Ureje (MR)	208	17.08	102.40	0.383	2.45	0.117	2.22-2.68	- Allometric	0.85	1.45×10^{-8}	-4.70	2.08
Ureje (FR)	166	17.64	110.29	0.366	2.49	0.146	2.20-2.78	- Allometric	0.82	1.24×10^{-6}	-3.49	2.09
Egbe (CD)	266	18.92	143.88	0.330	2.52	0.081	2.36-2.68	- Allometric	0.92	6.63×10^{-18}	-5.92	1.98
Egbe(MD)	157	18.15	123.31	0.361	2.45	0.094	2.27-2.63	- Allometric	0.94	6.68×10^{-11}	-5.85	1.93
Egbe (FD)	109	19.69	164.45	0.246	2.77	0.133	2.51-3.03	- Allometric	0.91	2.05×10^{-10}	-1.73	2.05
Ero (CD)	256	20.43	181.73	0.158	3.11	0.066	2.98-3.24	Isometric	0.96	1.42×10^{-42}	1.67	2.08
Ero (MD)	161	20.44	181.30	0.174	3.02	0.089	2.85-3.19	Isometric	0.95	1.98×10^{-23}	0.22	2.05
Ero (FD)	95	20.42	182.16	0.148	3.17	0.088	3.00-3.34	Isometric	0.97	2.62×10^{-19}	1.93	2.11
Ureje (CD)	266	18.92	129.12	0.309	2.63	0.092	2.45-2.81	- Allometric	0.89	1.31×10^{-18}	-4.02	1.98
Ureje (MD)	150	19.06	128.94	0.347	2.53	0.113	2.31-2.75	- Allometric	0.89	9.73×10^{-10}	-4.16	1.93
Ureje (FD)	116	18.78	129.30	0.240	2.82	0.135	2.56-3.04	- Allometric	0.89	6.52×10^{-11}	-1.33	2.03

CS= combined seasons both sexes, CSM = combined seasons male, CSF= combined seasons Female, CR = Combined sexes rainy season, MR = Rainy season male, FR = Rainy season female, CD = combined sexes dry season, MD = Dry season male, FD = Dry season female, TL = overall length (cm), BW = Body mass (g), SE = Standard error; Cl = confidence intervals of b; K = Condition factor, N = number of samples.

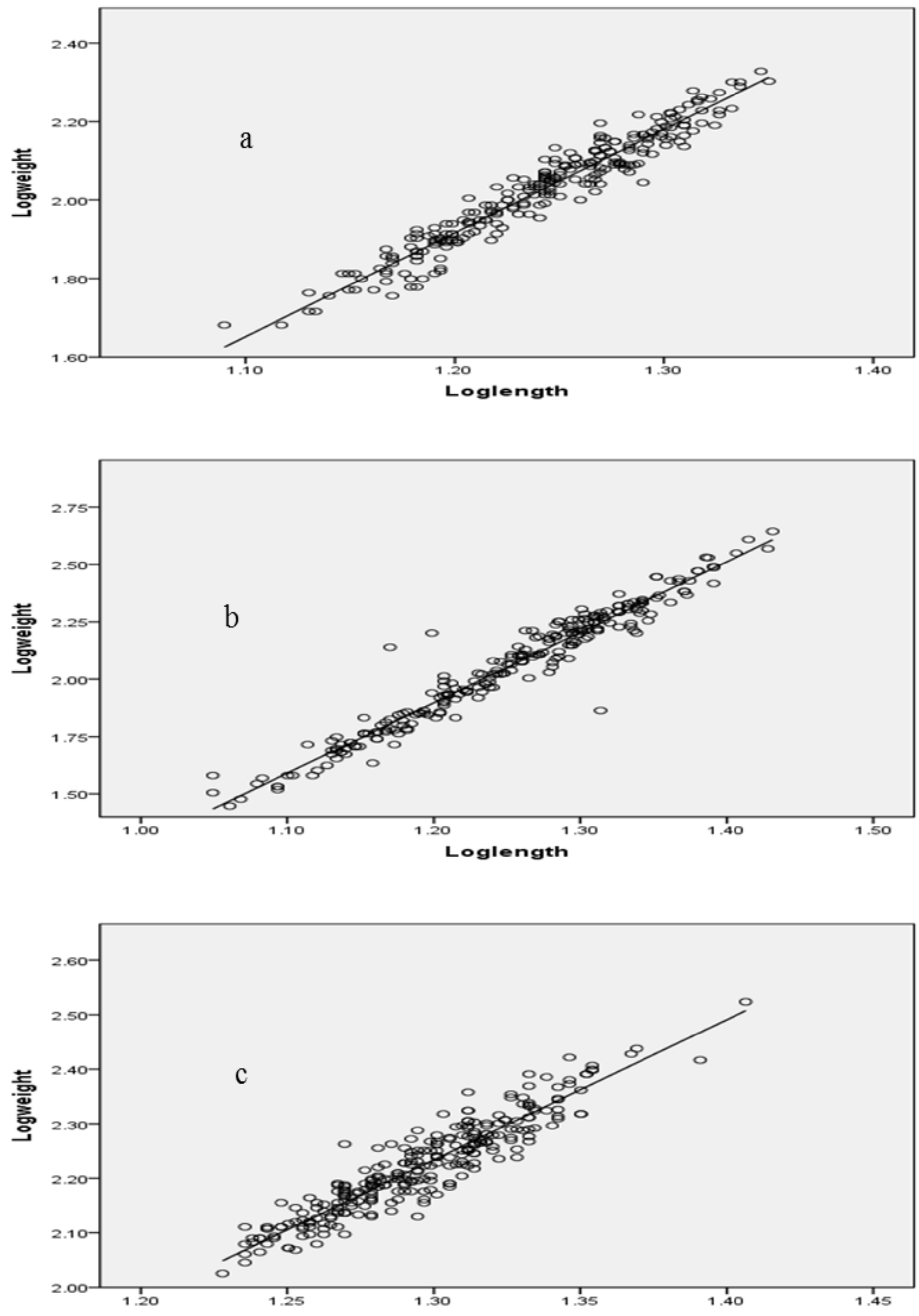

Figure 2 Length and weight relationships of *O. niloticus* in (a) Egbe, (b) Ero and (c) Ureje reservoirs

do not display isometric growth in real life or under natural conditions since their size changes as they develop or grow, making them heavier in one season and lighter in the following. Le Cren (1951) concluded that the existing relationship between the length and weight of fish may deviate from the ideal value (3.0), which certain environmental parameters or fish-related factors may cause. The productivity of the immediate environment of fish species greatly determines the degree of deviation from b. Highly productive aquatic settings typically encourage positive allometric development, and low productivity conditions facilitate negative allometric growth (Thomas et al. 2003). The environmental conditions of the habitat may be responsible for the variations in fish species' growth. This observed variation in fish development is consistent with the findings of Adeyemi et al. (2009), who discovered that fish growth pattern fluctuation is a common occurrence in tropical and subtropical waters due to environmental variations, spawning, and nutrient composition variations. Therefore, there is a direct proportionality between the length and weight of fish species and their environmental conditions, and this relationship varies according to the species. Consequently, even while fish growth pattern varies depending on the species, as this study's observations show, it might fluctuate significantly among the same species living in different geographic regions. These results are confirmed by Armstrong et al. (2004) and Gerritsen et al's. (2006) findings and showed that some biological parameters vary over constrained geographic regions. In the Kashmir Himalayas, the Crucian carp (*Carassius carassius*) exhibited positive allometric growth in the Manasbal and Anchar lakes and isometric growth in the Dal Lake (Zargar et al. 2012). Ahmed (2016) also communicated both allometric and isometric growth in freshwater snow trout (*Schizothorax niger*) from Dal Lake. According to Moslen and Miebaka (2017), the variations in the b values for the same species may result from variations in fish conditions and habits, ages and development rates, maturation stages, availability of food, and biological factors. As a result, the differences in the values of b found among the three reservoirs within the same species (*Oreochromis niloticus*) could be due to the different environmental changes experienced in the reservoirs during sampling. However, the b values of *O. niloticus* in the three reservoirs were consistent with the range 2.5 and 3.5 published by Gayanilo and Pauly (1997) for the majority of tropical fish species, as well as the range 2-4 often recorded for tropical freshwater fish species (Thomas et al. 2003). The range of the 95 percent confidence interval for the exponent "b" in the length-weight relationships in the reservoirs under study was 2.2 to 2.3, which was similar to the range (2.1–2.3) discovered by Dan-Kishiya (2013) in *O. niloticus* in a tropical lake in Abuja, Nigeria. In this study, the effects of sex on the variation of b showed no significant difference ($P < 0.05$). However, the b values were higher in females than the male fish in the three studied reservoirs. Equations describing the length-weight association for both sexes in this study are (i) fish in Egbe reservoir ($n = 634$), $\log W = 0.25 + 2.75 \log L$ ($r = 0.93$), (ii) fish in Ero reservoir, ($n = 610$), $\text{Log } W = 0.14 + 3.19 \log L$ ($r = 0.97$) and fish in Ureje reservoir ($n = 640$), $\log W = 0.32 + 2.58 \log L$ ($r = 0.88$).

3.2 Length-weight associations by seasons

The b values of the fish in the reservoirs were higher during the rainy season than the dry season, which indicates that season may have an impact on the LWRs reported in this study, even if there was no statistically significant difference ($P > 0.05$) between the dry and rainy seasons.

3.3 Condition Factor

Figure 3 shows the monthly fluctuations in K of *O. niloticus* in the three reservoirs during the dry and rainy seasons. The lowest average K values for the Egbe reservoir in combined sexes during the dry season (1.79 ± 0.03) were witnessed in November 2018, and the highest mean K value was 2.12 ± 0.04 in March 2018. In

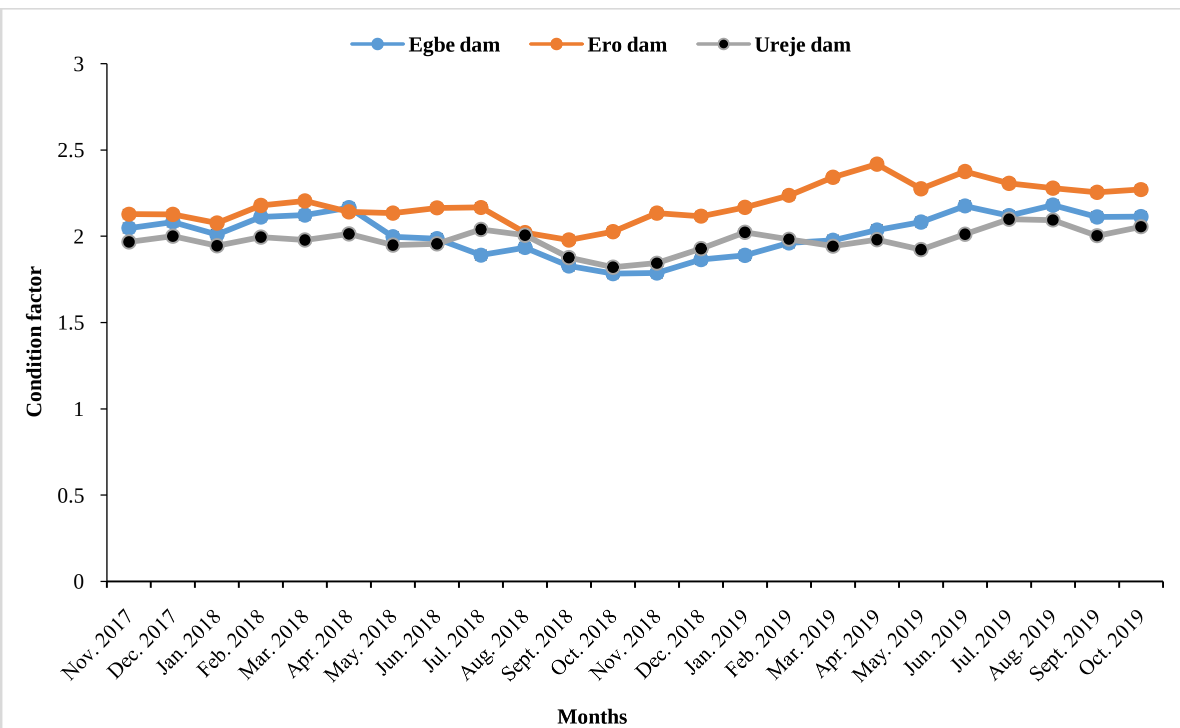

Figure 3 Monthly Changes in *O. niloticus* Condition Factors in Studied Water Reservoirs

the Ero reservoir, the lowest mean K values for combined sexes during the dry season (2.08 ± 0.04) were observed in January 2018, and the highest K values (2.34 ± 0.08) were reported in March 2019. In the case of the Ureje reservoir, the lowest mean K values for combined sexes during the dry season (1.84 ± 0.04) were witnessed in November 2018, and the highest K values (2.02 ± 0.03) were reported in January 2019. A significant difference at $P < 0.05$ existed in mean K values for combined sexes in all the months during the dry seasons between Ero and Ureje reservoirs. Between Egbe and Ero reservoirs, significant differences existed in mean K values at $P < 0.05$ in March, November-December, 2018 and January-March, 2019 while between Egbe and Ureje reservoirs, significant differences existed in mean K values at $P < 0.05$ in February-March, 2018 and January 2019.

The lowest mean K values in the Egbe reservoir for combined sexes during the rainy season (1.78 ± 0.03) were observed in October 2018, and the highest K value was 2.18 ± 0.02 in June and August 2019. In the Ero reservoir, the lowest mean K value for combined sexes during the rainy season (1.98 ± 0.02) was observed in September 2018 and the highest value of 2.42 ± 0.11 in April 2019. The lowest mean K values in the Ureje reservoir for combined sexes during the rainy season (1.82 ± 0.03) were observed in October 2018, and the highest (2.10 ± 0.04) was observed in July 2019. Significant difference at $P < 0.05$ existed in mean K values for combined sexes in May, June and July, September-October, 2018; April-July and September-October, 2019 between Egbe and Ero reservoirs. Between Ero and Ureje reservoirs, the significant difference at $P < 0.05$ existed in mean K values for combined sexes in April-June, September-October, 2018 and April-October, 2019. In April, July 2018 and May-June and September 2019, significant differences existed at $P < 0.05$ in mean K values between Egbe and Ureje reservoirs. The mean values of K in the three reservoirs during the dry and rainy seasons ranged from 1.85 ± 0.05 to 2.42 ± 0.12 and based on the health status and the fish condition factor measure of Barnham and Baxter (1998), who gave 1.6 K value as outstanding, 1.4 as good; 1.2 as fair; 1.0 as deprived and 0.8 as extremely poor. Furthermore, Ujjania et al. (2012) reported that fish condition factor equal or greater than 1 signifies adequate feeding and healthy surroundings. Hence, the mean value of condition factors of *O. niloticus* acquired in the reservoirs during this study suggests that the fish in the reservoirs were living above average life and thus indicates that the prevalent ecological conditions in the reservoirs were not beyond the forbearance range for the fish species. Ekpo et al. (2013) found a comparable high K value (1.24) for *Epinephelus aeneus* from the Qua Iboe River estuary, Akwa Ibom State, southern Nigeria, and *Hepsetus odoe* from the Ado Ekiti, Ogbomoso, and Eleiyele Reservoirs were reported to have K > 1 by Idowu (2013), Adedokun et al. (2013), and Kareem et al. (2016), respectively. However, the K value in this study is less than the 2.9 to 4.8 reported by Bagenal and Tesch (1978) for mature freshwater fish and within the range (1.97-2.63) documented by Outa et al. (2014) in the same fish species in Lake Naivasha. During the dry and rainy seasons, the monthly variations in K of *O. niloticus* from the reservoirs may be due to different environmental conditions that vary from month to month.

In the Egbe reservoir, there was a significant difference in the K values between the dry and rainy seasons at $P < 0.05$, while there was no difference at $P < 0.05$ in the K values between the dry and rainy seasons in the Ero or Ureje reservoirs.

Table 2 shows seasonal fluctuations in the condition factor of the male, female, and mixed sexes during the dry and rainy seasons. For combined sexes, the highest mean seasonal K value during the dry season was obtained in Ero reservoir (2.08 ± 0.02), while the lowest mean seasonal K value was obtained in Egbe and Ureje reservoirs

Table 2 Mean Seasonal variations in the condition factor in male, female and combined sexes of *O. niloticus* from studied water reservoirs in Ekiti State, southwest Nigeria

Condition Factor												
	Combined sexes				Male				Female			
Reservoirs	N	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean
Dry season												
Egbe	266	1.54	2.45	1.98 ± 0.02^{a}	157	1.61	2.45	1.93 ± 0.03^{a}	109	1.5	2.29	2.03 ± 0.02^{a}
Ero	256	1.69	2.56	2.08 ± 0.02^{b}	161	1.69	2.56	2.05 ± 0.03^{b}	95	1.81	2.35	2.11 ± 0.02^{a}
Ureje	266	1.24	2.45	1.98 ± 0.02^{a}	150	1.24	2.35	1.93 ± 0.03^{a}	116	1.62	2.53	2.01 ± 0.03^{a}
Rainy season												
Egbe	368	1.65	2.58	2.01 ± 0.01^{a}	252	1.65	2.58	2.00 ± 0.02^{a}	116	1.70	2.42	2.02 ± 0.03^{a}
Ero	354	1.74	2.58	2.09 ± 0.01^{b}	245	1.74	2.58	2.08 ± 0.02^{b}	109	1.76	2.42	2.09 ± 0.02^{b}
Ureje	374	1.54	2.70	2.00 ± 0.02^{a}	208	1.24	2.70	1.96 ± 0.03^{a}	166	1.62	2.53	2.01 ± 0.03^{a}

Means with different superscripts along a row are significantly different at $P < 0.05$

(1.98 ± 0.02). Significant differences existed at P < 0.05 between the average seasonal values of K in Egbe and Ero reservoirs and between Ero and Ureje reservoirs during the dry season. In Egbe reservoir, the mean seasonal K values were 1.98 ± 0.02, 1.93 ± 0.03 and 2.03 ± 0.02 for combined sexes, males and females. The mean seasonal K values were 2.08 ± 0.02, 2.05 ± 0.03, and 2.11 ± 0.02 for combined sexes, males and females, respectively, in the Ero reservoir, while the mean seasonal K values in *O. niloticus* in the Ureje reservoir were 1.98 ± 0.02, 1.93 ± 0.03, and 2.05 ± 0.03 for combined sexes, males and females respectively. A significant difference at P < 0.05 existed in the mean seasonal K values between males of Egbe and Ero reservoirs and between the males of Ureje and Ero reservoirs, while the females showed no significant difference in mean K values among the reservoirs.

During the rainy season, the highest mean seasonal K value (2.09 ± 0.01) for combined sexes was obtained in the Ero reservoir, while the lowest mean seasonal K value (2.00 ± 0.02) was obtained in the Ureje reservoir. Significant differences existed at P < 0.05 between the mean seasonal values of K in Egbe and Ero reservoirs and between Ero and Ureje reservoirs. In the Egbe reservoir, the mean seasonal K values were 2.01 ± 0.01, 2.00 ± 0.02, and 2.02 ± 0.03 for combined sexes, males and females, respectively. The mean seasonal K values were 2.09 ± 0.01, 2.08 ± 0.02, and 2.09 ± 0.02 for combined sexes, males and females, respectively, in the Ero reservoir, while the mean seasonal K values in *O. niloticus* in the Ureje reservoir were 2.00 ± 0.02, 2.01 ± 0.03, and 1.96 ± 0.03 for combined sexes, males and females respectively. A significant difference existed in the mean seasonal K values at P < 0.05 between males and females of the Egbe and Ero reservoirs and between the males and females of the Ero and Ureje reservoirs.

The fish in the reservoirs were in a better physiological state during the rainy season than during the dry season, as indicated by the mean K values during the rainy season, which were typically higher than those during the dry season. This seasonal variation in K may be related to the availability of food and nutrients brought into the reservoirs by runoffs during the rains from residential houses around the reservoirs. Thus, increasing food availability in reservoirs and makes more food available to fish. The observed differences in the mean K values between the dry and the rainy seasons, the rainy period recorded a relatively higher K value than the dry season could also be explained in terms of the dissolved oxygen. Dissolved oxygen levels were higher during the rainy season (Olagbemide and Owolabi 2019), and thus, the water became well-saturated with oxygen, leading to the effective functioning of the fish's metabolic processes. Shinkafi and Ipimiolu (2010), Ibrahim et al. (2011), Keyombe et al. (2017), and Mohd and Khaironizam (2019) reported similar higher value of condition factors during the rainy season than the dry season. According to Gomiero and de Souza Braga (2005), the availability of food and enhancement throughout their gonad growth contributed to their superior condition during the rainy season, and Samat et al. (2008) revealed that specific external influences, such as variations in temperature and photoperiod, may have an impact on fish condition. This agrees with Alam et al. (2013) when they examined fish from freshwater in Bangladesh and recounted that fish exhibited extreme stoutness in the summer and rainy seasons owing to suitable environmental conditions. Therefore, the natural fluctuations or differences in K of fish must be considered when interpreting its values.

Conclusion

Although the condition factor varied between reservoirs, it was still within the productive and healthy range, and the b values of the fish in the three reservoirs were within the range frequently recorded for tropical freshwater fish species. Therefore, the information from this study will benefit future ecological research and fishery management in Ekiti State in line with the preservation, restoration, and management methods for fish species in the reservoirs.

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Conflict of interests

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