ASSESSMENT OF LENGTH-WEIGHT RELATIONSHIP OF NILE TILAPIA *Oreochromis niloticus* (LINNAEUS 1758) FROM QUA IBOE RIVER ESTUARY, SOUTHEASTERN, NIGERIA

Abstract

The Length-Weight Relationship (LWR) of *Oreochromis niloticus* from the Qua Iboe River Estuary was studied for 12 months; from April 2021-March 2022. Fish samples were collected from the catches of artisanal fisheries using various mesh sizes of gill and cast nets. The b values in males ranged from 2.25-3.08 with a mean of 2.7333± 0.2743 while that of the females varied between 2.41 and 2.930 with a mean value of 2.7075 ± 0.1804). The overall growth coefficient in the LWR ($W=aL^b$) ranged from 2.25-3.08 with a mean value of 2.72±0.04. Both males and females recorded negative allometric growth, and the exponents were significantly less than isometric ($p<0.05$). Higher b values were recorded in males. There was no significant difference between the b-values of males and females ($p> 0.05$) during this study with the respective exponential relationships. These data indicated that the length-weight relationships were similar in both sexes during the study period. A higher b-value was recorded in the wet season but there was no significant difference ($p> 0.05$) between the dry (November-March) and wet season (April-October).This study provides the basic information which could enhance production potential of *O. niloticus* and its sustainable development, culture and management in Qua Iboe River Estuary, Nigeria.

Keywords: *Oreochromis niloticus* (Nile tilapia) Length-weight relationship Qua Iboe River Estuary.

1. INTRODUCTION

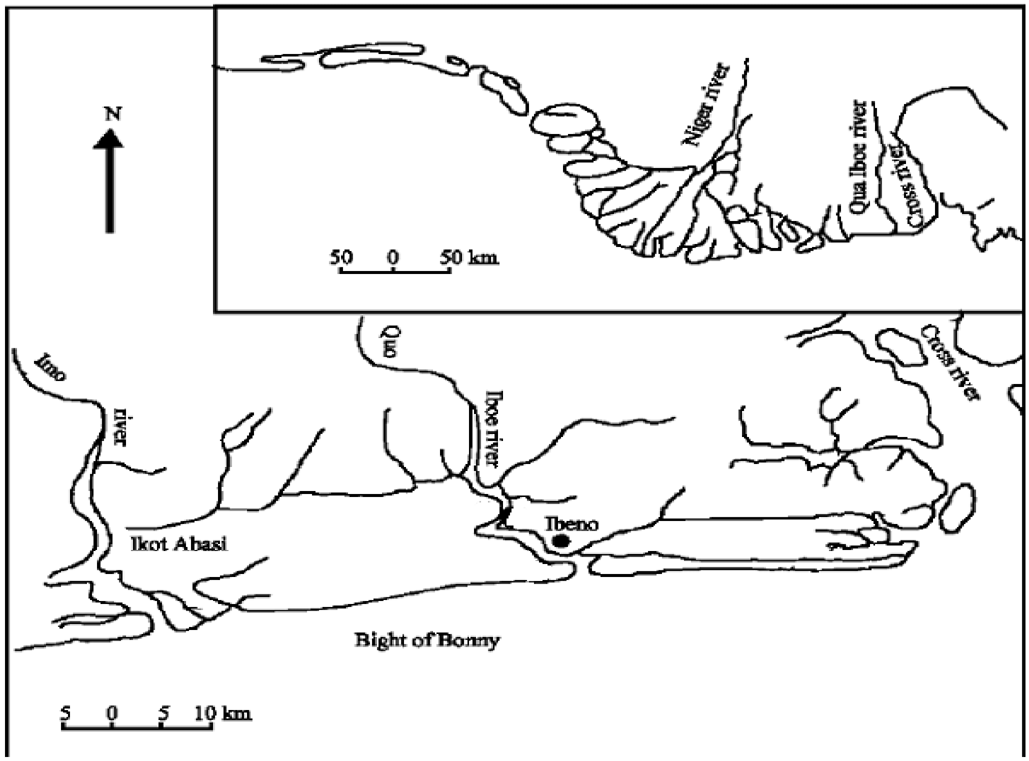
"An aspect of fish biology such as the length-weight relationship is important in studying fish biology. The Length-weight relationship can be used to predict weight from length measurements made in their yield assessment" (Pauly 1993, Nehemia 2012). The relationship between the length and weight may part from cube law value three depending on the ecological and physiological condition, which may affect their niche.

“Fish can attain either isometric growth, negative or positive allometric growth. Isometric growth is when b =3 meaning that the fish is in a stable condition and associated with no change in body shape as the fish grows. Negative allometric growth indicates that the fish becomes more slender as its increases in weight. Finally, the positive allometric growth implies that the fish become relatively deeper-bodied as it increases in length” (Riedel *et al* 2007).

“The study of the weight relationship of the Nile tilapia (*Oreochromis niloticus)* family (Cichlidae, Linnaeus 1758) is of crucial importance to fisheries biologists as it serves many purposes”. “It establishes the mathematics relationship between two variables; length and weight so that the unknown variable can be calculated from the known to solve practical fisheries problems. The relative condition can be estimated to assess the general wellbeing of the fish. Finally, it is used in the estimation of potential yield per recruit in the study of population dynamics” (Karal Marx et al., 2013).

Tilapias are plastic animals because their growth and maximum obtainable size can be seriously influenced by their physical and biological composition of their environment. Olurin and Aderibigbe (2006) stated that “the length and weight of the fish is important yardstick used for the purpose of fish stock assessment in fishery management”. Thus, the aims of this study are to determine monthly and seasonal variations in the growth pattern of male and female *Oreochromis niloticus* obtained from Qua Iboe River Estuary in Ibeno Local Government Area, Akwa Ibom State ,Nigeria using length weight relationship.

2. MATERIALS AND METHODS



Map 1. Map showing study location

Study Area: This study was carried out at Qua Iboe River Estuary Ibeno Local Government Area, Akwa Ibom State, Nigeria. Ibeno is located in the Southeastern part of Nigeria (4^0.49 02.88N;$7^0 56^1$ 61.09"E). It is one of the three major hydrographic features in Akwa Ibom State. It is located in the tropical belt with an equatorial climate characterized by dry season (November-March) and wet season (April – October) (Map 1).

The vegetation of the mangrove swamp comprises red mangroves (Rhizophora harrisonii, R. mangle and R. racemosa), white mangroves (Avicennia africana) sand black mangroves (Laguncularia racemosa) and Nypa fruticans (Ekpo, *et al.*,2014)

Fish sampling collection, preservation and measurement

Fish sampling and collection: Specimen collection was done with the help of local fishermen using traditional fishing gears such as hook and line, traps, baskets and gillnets from April 2021 to March 2022 and was preserved in a container containing 10% formation solution. Using a measuring board, each specimen was measured to the nearest 0.1cm total length (TL). The total weight (TW) was taken to the nearest 0.1g using a top loading mettle PR-series model 2202/E electronic balance PR-series model PR-2202/E OHAUS.

Determination of Length-Weight Relationship

The length-weight (L-W) relationships were computed using empirical allometric equation of the form (Lagler, Bardach, Miller and Passion, 1977; Tyler and Gallucci, 1980; Dulcic, and Kraijevic, 1996; Ecoutin and Albaret, 2003).

$$Wt = a(TL)^b \quad \ldots\ldots\ldots \quad 1$$

Where Wt = Total weight of fish (g)

TL = Total length of fish (cm)

a = proportionality constant, and

b = Regression exponent

The values of a and b were estimated by least square linear regression using double log transformed weight and length data according to the formula (Khaironizam and Norma-Rashidi, 2002) below

$$\text{Log } WT = \text{Log } a \pm b \log TL \quad \ldots\ldots\ldots 2$$

Where: WT is total weight of fish (g), TL is the total length (cm), a is the intercept on the Y-axis and b is the exponent or slope indicating isometric growth when b= 3 (Pauly, 1984). Values other than 3 indicate allometric growth. If b > 3, its positive allometric and the fish becomes heavier for its length as it grows larger. If b < 3, it is negative allometric and the fish becomes lighter, and thin for its length as it grows larger. The length-weight relationship was tested using a linear regression model significant level $p < 0.05$and the confidence limit for the regression coefficient interval.

The exponent (b) of the length-weight relationship was tested for departure from Isometry (b = 3) i.e. whether b values differ from 3 significantly, using a t-statistic function given in Pauly (1984). The degree of association between the length and weight was expressed by a correlation coefficient "r". The correlation coefficient could take values ranging between -1 and $\pm$1.

When "r" is negative, one variable tends to decrease as the other increases. A negative correlation corresponds to a negative value of "b" in regression analysis. On the other hand, when "r" is positive, it means that one variable increases as the other, which corresponds to a positive value of b in regression analysis (Pauly, 1983). The parameters of this relationship were computed for each sex, month, and season.

Statistical Analysis

Student's t-test (Snedecor and Cochran, 1980) was used to test the means of biological data between dry and wet seasons, male and female. The length-weight data pairs, correlation coefficient (r) were used to examine the strength of the association in length-weight data pairs (Beyer, 1978; Pauly, 1987; Haruna, 2006; Udo, 2002). To meet the requirement for normality in parametric statistics, logarithmic transformation was performed on the length-weight data pairs following the methods of Gregory (1974); Ukpong (1995); Nyaku, Okayi, Yem, and Abdulrahman (2008) and Udofia (2011). Microsoft Excel was employed for the graphical presentation of data. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS, version 19.0) for Windows, Paleontological Statistical Software, PAST, version 20.0. Data analyzed were presented in summary format in tables, graphs and histograms for easy interpretation of data analyzed.

3. RESULTS

GROWTH OF *O. NILOTICUS* FROM QUA IBOE RIVER

Length-Weight Relationship (LWR)

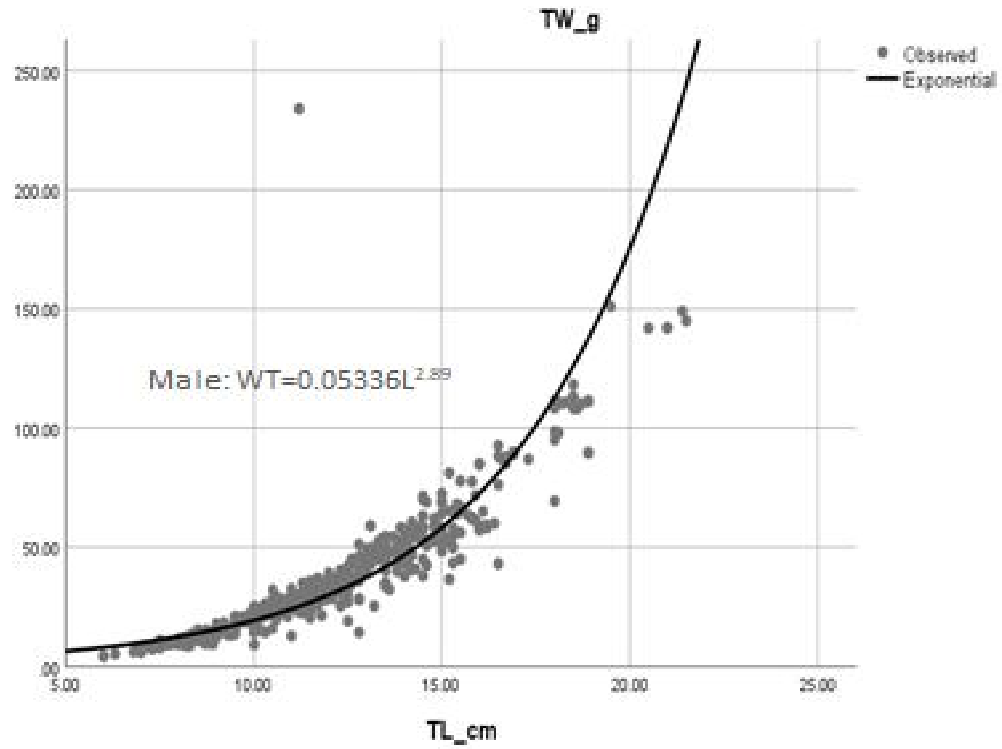
Table 1. Variation in LW Parameters of *O. niloticus* from Qua Iboe River Estuary, Southeastern, **Nigeria**

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
N	Male	12	57.41667	9.317221	2.689650	47.000	76.000
	Female	`12	48.16667	7.383438	2.131415	33.000	61.000
	Total	24	52.79167	9.482153	1.935536	33.000	76.000
a	Male	12	.06283167	.042047834	.012138164	.015590	.140860
	Female	`12	.05519250	.043635942	.012596612	.013080	.151380
	Total	24	.05901208	.042088630	.008591306	.013080	.151380
b	Male	12	2.73333	.274270	.079175	2.250	3.080
	Female	`12	2.70750	.180359	.052065	2.410	2.930
	Total	24	2.72042	.227395	.046417	2.250	3.080
R	Male	12	.87491750	.093997784	.027134823	.669910	.977510
	Female	`12	.90523917	.061986518	.017893966	.804230	.988610
	Total	24	.89007833	.079392654	.016205958	.669910	.988610

The intersexual variation in Length-weight parameters of *O. niloticus* is presented in Table 1. The b-values in males ranged from 2.25-3.08 with a mean of 2.7333$\pm$ 0.2743 while that of the females varied between 2.410 and 2.930 (mean = 2.7075$\pm$0.1804). Both males and females recorded negative allometric values and the exponents were significantly less than isometric ($P<0.05$). A higher mean b-value was recorded in males, however, there was no significant difference (p>0.05) between the b-values of males and female during the study with the respective exponential relationships.

Male: $TW=0.06283TL^{2.7333}$

Female: $TW=0.05519TL^{2.7075}$



These indicated that the LWRs were similar in both sexes during the period of study.

Fig. 1: Length-Weight Relationship of Male *O. niloticus* from Qua Iboe River Estuary

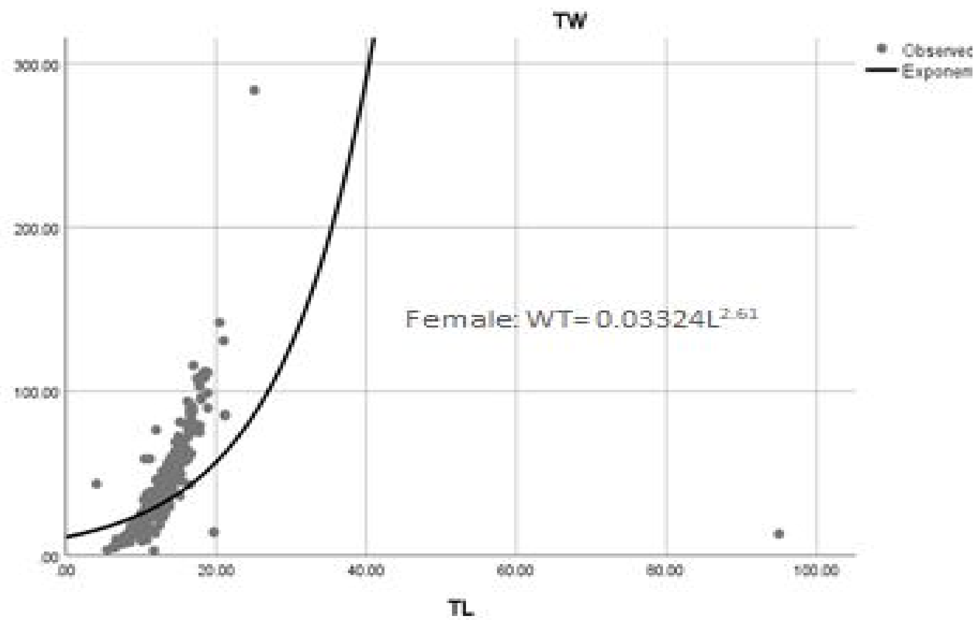


Fig. 2: Intersexual Variation in Length-Weight Relationship of Female O. niloticus from Qua Iboe River Estuary

Table 2: **Overall Mean Growth Value ± Standard Deviation, minimum and maximum values of (a intercept, b exponent and Regression coefficient variables of *O. niloticus*) from Qua Iboe River estuary** Southeastern, **Nigeria**

	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
N	33.000	76.000	1267.000	52.79167	1.935536	9.482153
a	.013080	.151380	1.416290	.05901208	.008591306	.042088630
b	2.250	3.080	65.290	2.72042	.046417	.227395
R	.669910	.988610	21.361880	.89007833	.016205958	.079392654

The b values ranged from 2.25-3.08. The mean value of 2.72±0.04 indicates negative allometric growth. The frequency distribution showed dominance of b-values between 2.80 to 3.00 (Fig 3). There was significant difference ($p > 0.05$) between the b-value obtained here and isometric. This implies that the fish increase in length was not accomplished with increase in body weight resulting in a slim fish.

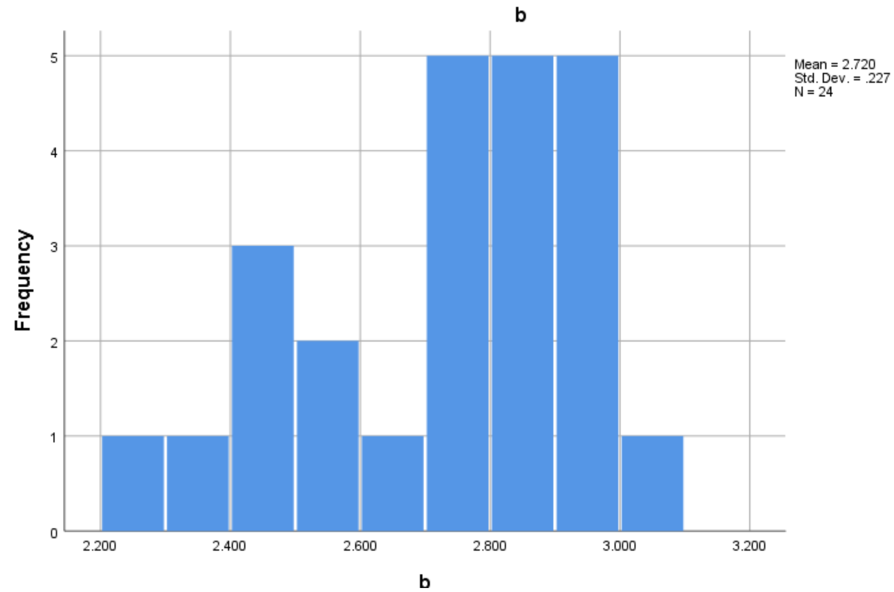


Fig. 3: Length and Weight Frequency Distributions

A plot of total weight (TWg) against total length (TLcm) of pooled specimens of *O. niloticus* during the period of study is shown in Fig. 4.There was a positive correlation between total length and weight with an exponential relationship of the form:$TW = 0.059012TL^{2.7204}$

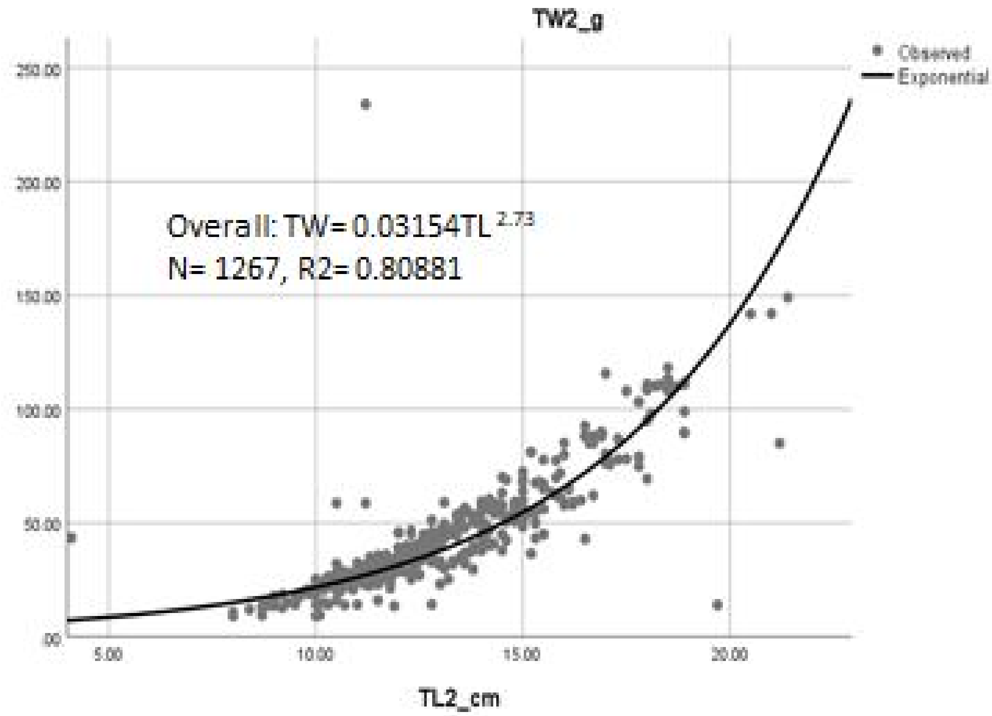


*Fig. 4: Length and Weight Frequency Distributions (*TW = $0.059012TL^{2.7204}$

Seasonal Variation in Length-Weight Parameters of *O. niloticus*

Table 3: **Seasonal Variation in Length-Weight Parameters of *O. niloticus* from Qua Iboe River estuary** Southeastern, **Nigeria**

		Mean	Std. Deviation	Std. Error	Minimum	Maximum
N	wet season	54.21429	12.223424	3.266847	33.000	76.000
	dry season	50.80000	2.529822	.800000	47.000	56.000
	Total	52.79167	9.482153	1.935536	33.000	76.000
a	wet season	.08713643	.032645876	.008724977	.026170	.151380
	dry season	.01963800	.005885341	.001861108	.013080	.028150
	Total	.05901208	.042088630	.008591306	.013080	.151380
b	wet season	2.79286	.188901	.050486	2.410	3.080
	dry season	2.61900	.247002	.078109	2.250	2.950
	Total	2.72042	.227395	.046417	2.250	3.080
R	wet season	.93327071	.049043776	.013107500	.834650	.988610
	dry season	.82960900	.075292841	.023809687	.669910	.918510
	Total	.89007833	.079392654	.016205958	.669910	.988610

During the study, the dry season b values ranged between 2.25 and 2.95 (mean = 2.62$\pm$0.24) while the wet season exponents ranged from 2.410-3.080 with a mean value of 2.793$\pm$0.18891. Both seasons recorded negative allometric values as there was a significant departure from isometric. However, a higher b-value was recorded in the wet season, but no significant difference existed ($p > 0.05$) between the dry and wet seasons. The correlation coefficient showed a positive relationship between the total weight and total length as shown by the correlation coefficient.

The seasonal exponential relationships can be presented as:

Dry season: $TW=0.01964TL^{2.61900}$

Wet season: $TW=0.08714TL^{2.7929}$

The results indicated that the length-weight data pairs were similar in both season. Plots of total weight (TWg) against total length (TLcm) of pooled specimens of *O. niloticus* in respect to season are shown in Fig. 5a ad b.

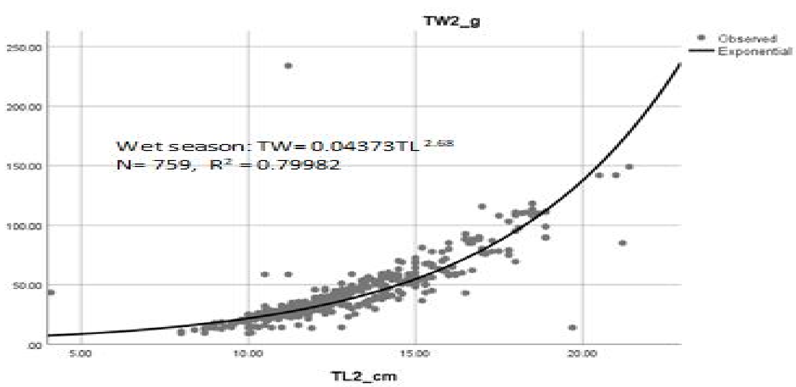


Fig 5a. Wet season graphs of LWR

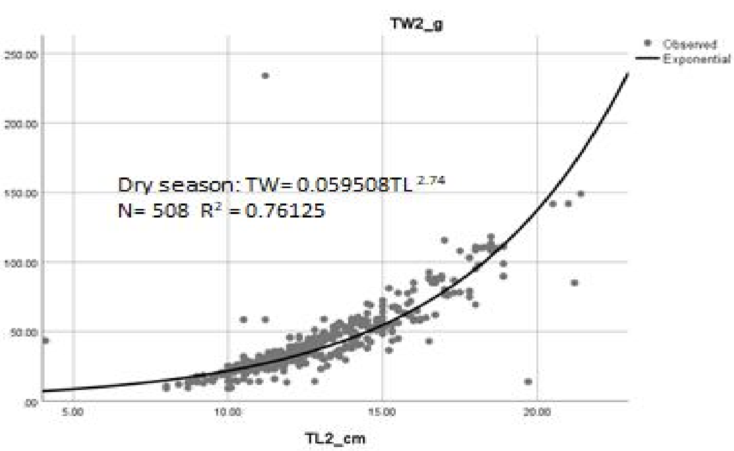


Figure 5b: Dry season graphs of LWR

The monthly variation in mean b-values + standard deviation and range of *O. niloticus* is depicted in Table 4.

Table 4: Monthly Variation in Mean b-values + Standard Deviation, Minimum and Maximum b Values of *O. niloticus* from Qua Iboe River estuary Southeastern, **Nigeria**

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
b	April	2	2.57000	.226274	.160000	2.410	2.730
	May	2	2.80000	.042426	.030000	2.770	2.830
	June	2	2.77500	.049497	.035000	2.740	2.810
	July	2	2.68500	.247487	.175000	2.510	2.860
	August	2	2.93000	.028284	.020000	2.910	2.950
	September	2	2.96000	.042426	.030000	2.930	2.990
	October	2	2.83000	.353553	.250000	2.580	3.080
	November	2	2.78500	.035355	.025000	2.760	2.810
	December	2	2.91000	.056569	.040000	2.870	2.950
	January	2	2.54000	.183848	.130000	2.410	2.670
	February	2	2.51500	.289914	.205000	2.310	2.720
	March	2	2.34500	.134350	.095000	2.250	2.440
	Total	24	2.72042	.227395	.046417	2.250	3.080

The results revealed variability in b-values with a peak in October and a trough in March (Fig. 6).

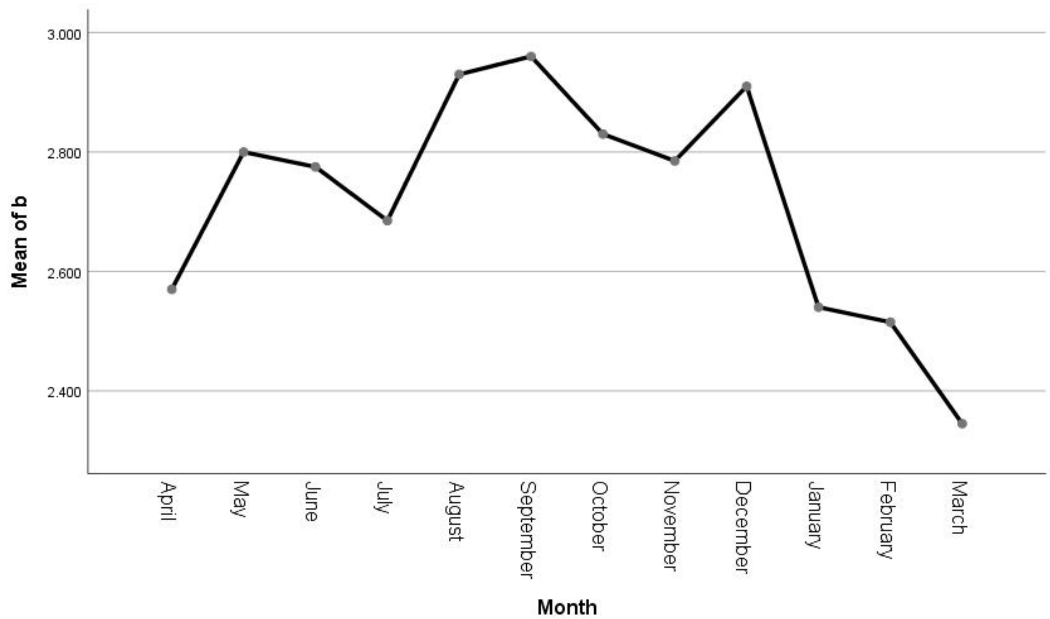


Fig.6: Monthly Variation in b Values in O. niloticus from Qua Iboe River Estuary

Monthly mean b-values ranged from 2.345-2.9600 with a mean of 2.7204±0.2274. All the months recorded mean b-values that were less than isometric, implying that they recorded negative allometric growth.

4. DISCUSSION

Length-Weight Relationship (LWR) of *Oreochromis niloticus* from the Qua Iboe River Estuary was studied for 12 months, from April 2021-March 2022. The b-values in males and females recorded negative allometric growth, and the exponents were significantly less than isometric ($p<0.05$). The exponent values obtained in this study were higher than those of Steve and Okeyo (2019), who recorded b-value of less than 2 for *O. niloticus* in the wild and cage culture. "It was also higher than those recorded by Ojuok *et al* (2000); Njiru *et al* (2006) and Yongo *et al* (2018) in *O. niloticus* from Lake Victoria, Kenya, whose 'b' values were below 2". "The results here were also higher than those of a related species, *T. zilli",* as was reported by Ibrahim *et al* (2008) in Abu-zaba Lake, Cairo, Egypt.

Negative allometric growth shows that the fish becomes thinner as its body weight increases as opposed to positive allometric growth, which implies that the fish becomes relatively broader and fatter as its length increases. The value of the regression coefficient b in the length-weight relationship of fish is an important bio-indicator in revealing the amount of food intake and the pattern in which the fish is growing which varies depending on the ecological condition of the ecosystem. Negative allometric growth was recorded by other researchers; Bala *et al.* (2009) in the study of Ichtyopauna of Daberam reservoir in Katsina State, reported a negative allometric growth for *T. zilli* species recording a 'b' value of 2.19. Mossad (1990) in biological studies on five fish, species from Lake Qarun, Egypt, recorded a 'b' value of 2.9 for T. zilli in blackfish water. Ibrahim *et al* (2008) on the effect of environmental conditions of Abu-Zabai Lake on some biological, histological and quality aspects of fish in Cairo reported a negative allometric growth with a 'b' value of 2.92 for *T. zilli* in brackish water. Karal Marx *et al* (2013) on the length –weight relationship of Nile tilapia, *Oreochromis niloticus* from Barur Reservoir, recorded a slope value (b) estimated for both sexes to be 2.313. Waithaka *et al* (2017) reported a slope b of length-weight relationship of 2.86 for combined sexes of *O.nitoticus* from Lake Naivasha, Kenya. Asmamaw *et al*.(2019) on Length weight relationship and condition factor of Nile tilapia, *Oreochromis niloticus* in Kuka Reservoir, Ethiopia record 'b' values of 3.2095 (males), 2.868 (female) and 3.1703 for combined genes. Riedel *et al*., (2007) reported that during various stages in growth, the fish can record an isometric growth (b=3), negative allometric growth (b<3) or positive allometric growth (b>3). The actual relationship between length and weight may part from the cubic value 3 and this may be due to environmental condition in which the animal lives and also due to the animal's physiological condition. Ogunola *et al* (2017) reported that "negative allometric growth patterns could be attributed to low food items for fish species in the ecosystem or reduction of their body size to escape predation or high fishing mortality or intensity and adverse effects of oil pollution on their growth" (Law, 2000, Chilaka *et al*, 2014). It could also result from competition for food resources in the ecosystem, which could have affected their growth due to limited nourishment available to individuals. The negative allometric growth recorded in this study is different from the results of others: Bankole (1989) in biological study of selected fish species of Tiga Lake Kano State, reported a 'b' value of 3.10 for *O. niloticus*. Fafioye and Oluajo (2005) studied the length-weight relationship of the fish species in Epe Lagoon, Lagos, Nigeria and they reported that *O. niloticus* recorded a 'b' value of 3.04 for *O. niloticus*. Steve and Okeyo (2019) on the assessment of the length-weight relationship and condition factor of Nile Tilapia (*O. niloticus*) in cage and open waters in Winam Gulf of Lake Victoria, Kenya, reported that the slope "b" of the regression analysis in both habitats revealed a positive allometric growth; 3.16 and 3.09 for wild and Cage respectively. Boghoyinge (1984) on some observations on aspects of biology of the *tilapia marine* and the culture of tilapia in freshwater ponds in Port Harcourt recorded a 'b' value of 3.21 for Tilapia marine. Ojuok *et al*. (2000) reported a b value of 3.14 for *O.niloticus* from Lake Victoria, Kenya. Njiru *et al* (2006) recorded a b value of 3.07 – 3.32 for *O. nitoticus* harvested from Lake Victoria, Kenya. Yongo *et al* (2018) recorded a b value of 3.01 for *O.niloticus* from Lake Victoria Kenya. Yongo *et al* (2018) reported that the b value of the length –weight relationship was 2.98, 3.01 and 3.01 for males, females and combined sexes respectively. Steve and Okeyo (2019) investigated the difference between the length and weight of *O. niloticus* in cage and open waters. The slope 'b' of the regression analysis in both habitats revealed a positive allometric growth (3.16 and 3.09) for the wild and cage. However, the b-values recorded here, which were negative allometric but within the limit of 2 and 4 were in agreement with those recorded by Outa *et al* (2014) and Waithaka *et al* (2017) on *O. niloticus* from Lake Naivasha, they reported that the b-values recorded 2.30 and 2.86 respectively for combined sexes and Mossad (1990) on a related species *T. zilli* from Drackish water in Egypt. The feeding behavior of fish and morphological changes due to age may also cause the coefficient of regression on the logarithm of length to depart substantially from 3. Pauly and Gayannilo (1997) suggested that b-values may range from 2.5 to 3.5 while (Hile, 1936 and Martin, 1949) observed that the values of the regression coefficient 'b' usually lie between 2.5 and 4.0 and for an ideal fish to maintain its shape b=3 is required. The b values recorded in this study fall within the recommended range of 2.5 to 4.0. Higher mean b-value was recorded in males, however, there was no significant difference between the b-values of males and female ($p>0.05$) during the study with the respective exponential relationships. Intersexually, the b-values gotten for males and females in this research were higher than those gotten from the same species by Asmamaw *et al* (2019) in Kuka Reservoir, Ethiopia; Waithaka *et al* (2018) in Lake Naivasha, and Yongo *et al* (2018) in Lake Victoria Kenya who recorded b-values of less than 2 for males and females.

The less negative allometric growth in females signifies that the rate of weight gain is less than the increase in length probably due to the timing of the batch where females empties their gonad losing energy for egg production hence less weight in relation to their length. The negative allometric growth observed here might be owing to various factors, including seasons, environmental parameters, and the presence of food, feeding ratio, habitat, sex and physiological conditions of the fish. Negative allometric growth patterns could be attributed to low food, items for fish species in the ecosystem or reduction of their body size to escape predator or higher fishing mortality or intensity and adverse effect of oil pollution on their growth. Chilaka *et al* (2014) also postulated that negative allometric growth might be as a result of competition for food resources in the ecosystem which could have affected their growth due to limited nourishment available to individuals. Steve and Okeyo (2019) reported that the variation in growth pattern could be due to different ecological parameters during the study periods which comprised of several biotic and abiotic interactions such as gear selectivity, sex and different season of the year can affect the length-weight relationship. Consequently, a higher b-value was recorded in the wet season but there was no significant difference between the dry and wet seasons (P>0.05). The seasonal b-values recorded here were also higher than those reported for a related species *T. zilli* whose b-values for dry and wet seasons were below than those observed by Mahomoud *et al* (2011) in Lake Timsha, Egypt. However, the b-values obtained here were lower than those obtained for the same species in Lake Victoria, Kenya by Ojuok *et al* (2000) and Njiru *et al* (2006) who recorded isometric growth. The b-values were also lower than those obtained for *O. niloticus* by Bankole (1989) and Fafioye and Oluajo (2005) who recorded isometric growth in Tiga Lake, Kano state, Nigeria and Epe Lagoon, Lagos State, Nigeria respectively. Imam *et al.* (2010) on length –weight relationship and condition factor of four fish species from Wasai Reservoir in Kano, Nigeria recorded a negative allometric growth reporting a ‘b’ value in *Tilapia zilli* of 1.53 and 2.5 for wet and dry seasons respectively. Haruna (2006) on the length-weight relationship of four fish species from Magaga Lake, Kano Nigeria recorded a ‘b’ value of 2.7 (wet season) and 3.2 (dry season) for *T. zilli*. In Qua Iboe River Estuary, the intersexual and seasonal pattern in length-weight relationship of *O. niloticus* revealed that the length-weight exponent for male, female and combined sexes were negatively allometric signifying that the b-values deviated significantly from isometric. The intersexual and seasonal negative allometric growth recorded in this study signifies that the fish did not grow symmetrically as they became thinner with increase in length (Abiaobo *et al.*, 2021).

The results revealed variability in b-values with a peak in October and a trough in March. All the months recorded mean b-values that were less than isometric implying that they recorded negative allometric growth. Positive correlation coefficients obtained here showed correlation between the total length and body weight measurements of the fish, meaning the fish increase in the body weight as it grows in total length. Similar trends were observed in *O. niloticus* by Fafioye and Oluayo (2005) in Epe Lagoon, Lagos; Waithaka *et al* (2017) in Lake Naivasha, Kenya; Ojuok *et al* (2000) Njiru *et al* (2006) and Yongo *et al* (2018) in Lake Victoria, Kenya.

5. Conclusion

The results of the length-weight relationship of *O. niloticus* from Qua Iboe River Estuary, Nigeria, exhibited negative allometric growth. The species become thinner as they grow older. The b value shows negative allometric growth, $b \geq = 3$. The females were sparingly found in the wet season, indicating that the wet season is the breeding period of the species while the dry season is fishing time. The species exhibited seasonal trends in sex differentiation, size structure, growth pattern and general well-being. These distinctions could serve as precursors for the species development, culture, management and sustainability of the species in Qua Iboe River Estuary Nigeria. The *Oreochromis niloticus* from Qua Iboe River Estuary, Nigeria is a commercial species of financial value and the species supplement the food and protein need of the surrounding communities. This study provides the basic information which could enhance the production potential of *O. niloticu s*and its sustainable development, culture and management in Qua Iboe River Estuary, Nigeria.

6. REFERENCES

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