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Length-Weight Relationship and Condition Factors of the African Silver Catfish *(Chrysichthys nigrodigitatus)* from Freshwater and Brackish Water in Nigeria

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Abstract
Length-Weight Relationships (LWR) and condition factors K have been used as management tools to determine fish stock and its wellbeing for sustainability measures. This study was aimed at evaluating the LWR and K of the African Silver Catfish, *Chrysichthys nigrodigitatus* from Yola, Upper River Benue and Epe Lagoon, Lagos. A total of one hundred and twenty fish sample were randomly selected from artisanal fishers at the landing sites. The lengths were measured using a measuring board while the weights were taken using an electronic weighing balance (ATOM-120). The LWR gave a high correlation coefficient “r” to be 0.8949 and 0.9918 while the coefficient of determination “r^2” were 0.8008 and 0.9837 for Lagos and Yola respectively. The two populations had negative allometric growth but good condition factors (>1). Lagos population recorded a lower weight at unit length (2.0989) and had a negative allometric growth pattern. So also, Yola population which had lower condition factor (1.010) but higher “b” value of 2.9225. It was concluded that both populations gave good conditions for the fish but Yola population was stouter compared to Lagos population. It is therefore recommended that fisheries managers should setup management measures to control overexploitation for sustainable fish production.

Keywords: Length-Weight Relationship, Condition factor, Freshwater, Estuarine, *Chrysichthys nigrodigitatus*, Wellbeing.

Introduction

The African Silver Catfish, *Chrysichthys nigrodigitatus* (Order: Siluriformes, Family: Claroteidae) occurs in most of the major rivers in Africa including Nigeria, Senegal, Gambia, Ivory Coast, Liberia, Zaire, and Gabon (Ezenwa 1981) and constitutes one of the most dominant fish species in Nigerian inland (Kareem *et al*., 2015) and estuarine waters. They are highly valued food-fish in these native African waters and are among the dominant fishes of commercial catches (Offem *et al*., 2008). These carnivorous species are good quality food fish of white and very tasty flesh serving as delicacy for many low-income earners, especially in riverine communities thereby providing food security. In addition, they are important both in ecological and economical terms, playing salient role in determining the dynamics and structure of aquatic ecosystem. The rapid urbanization and land use over the past decade have influenced the sustenance of fish species because of various waste discharges from human and industries within the river catchments (Iyiola *et al*., 2024). The major environmental stress affecting Nigeria’s freshwater resources as reported by Ogwu *et al*. (2022) are human population growth, industrialization, and urbanization; not withstanding improper waste disposal systems and indiscriminate agricultural practices (Ipinmoroti, 2013). All these have caused an acute reduction in population of this species in Nigeria. Effort has been geared towards the conservation of these species through fisheries regulation.

The Length-Weight Relationships (LWR) and condition factors have been used as management tools to determine fish stock and its wellbeing for sustainability measures (Akin-Oriola, 2005; Oboh and Olowo, 2016; Ragheb, 2023;). It is also used to determine the growth and reproduction of fish species, to assess the fish population dynamics and stock assessment (Abowei, 2010 and Barua *et al*., 2023) and used in estimation of average weight of fish at a given length (Pauly, 1993; Oboh and Olowo, 2016; Mehanna and Farouk 2021). They are all geared towards determining the welfare and growth of the fish which can either be isometric in which there is no change in the shape of the fish as the fish grows, or negative allometric which means the fish becomes slender as it increases in weight or positive allometry which implies that the fish becomes very stout as the length increases (Fafioye and Ayodele, 2018; Iyiola *et al*., 2024). The condition factor gives information about the well-being of fish species, information about food supply and the timing and duration of breeding (Ighwela *et al*., 2011). It also gives information when comparing two populations which differ in different density, climatic and other environmental conditions (Abowei, 2010; Barua *et al*., 2023; Ragheb, 2023) such as freshwaters and brackish waters. Various research on the LWR and condition variables of fish have been conducted in Nigeria. Bolarinwa and Popoola (2013) studied the LWRs of various economically important fish in Ibeshe Waterside in the Lagos Lagoon, Nigeria. Obasohan *et al*., (2012) investigated the LWRs and condition factor of five fish species from the Ibiekuma stream in Edo State, Nigeria.

Upper River Benue and Epe Lagoon contributes significantly to fish production in Nigeria and their catchment areas are heavily affected by anthropogenic activities which can have impact on fisheries resources of the water bodies. It is therefore imperative to investigate the wellbeing of *C. nigrodigitatus* in the two water bodies in order to recommend conservation and management plans for sustainable fish production.

Materials and Methods

Fish samples were purchased from artisanal fishers from Epe Lagoon (06° 35' 02.83" N, 03° 59' 00.10" E), Lagos (Brackish Water) (Figure 1). Epe is a town and a Local Government Area (LGA) in Lagos State, Nigeria, located on the north side of the Lekki Lagoon. It is a Yoruba town located next to the Lagos lagoon with 294 rural and 24 semi-urban communities. Epe is known for its fish market which feeds off the hard work of those men and women whose lives depend on the lagoon – and the fish inside it; and Upper River Benue, Yola (09° 17' 14.07"N, 12° 27' 51.90" E) Adamawa State. (Freshwater) (Figure 2). It is the capital of Adamawa State and also the seat of Lamido Fombina. It experiences migratory fishers from all over the nation especially the Northern Nigeria. The different locations have variations in ecological conditions such as rainfall, temperature, vegetation, etc.

Fish Identification and Sampling

Experimental sampling was done monthly and fishes purchased from artisanal fishers over a period of nine months from November 2023 to July, 2024. The fish species were identified according to Olaosebikan and Raji (2013), Duwal *et al*. (2016) and Froese and Pauly (2019). A total of one hundred and twenty samples were randomly collected over the period. The standard and total lengths were measured using a metre rule on a measuring board and recorded to the nearest centimetre (cm). The total length (TL) was determined by measuring from the tip of the mouth when closed to the tip of the caudal fin. Standard length (SL) was from the tip of the mouth to the caudal peduncle. Their body weights were taken using an Electronic Weighing Balance (ATOM A-120) and recorded in grams (g)

Length-Weight Relationship and Condition Factor

The Length Weight Relationship (LWR) was determined using the equation $W = aL^b$ (Le Cren, 1951; Froese, 2006). Where: W = Weight of fish in grammes, L = Total length in cm, a = constant (intercept) and b = length exponent (slope of the log - transformed relationship), referred to as the growth constant. The logarithm -transformed data gives the linear regression equation, Log W = Log a + b Log L (Le Cren, 1951), used to estimate regression parameters 'a' and 'b' of the length - weight relationships. The growth pattern of the fish population, whether Isometric (b = 3), negative allometric (b < 3) or positive allometric (b > 3), was determined as previously described by Quarcoopome (2017) and Froese *et al*. (2011). The degree of association between length and weight was expressed by a correlation coefficient "r" and coefficient of determination "r^2" (ranging between -1 and +1) with a negative correlation corresponding to a negative value of 'b' and positive correlation corresponding to a positive value of b in regression analysis (Pauly, 1983).

Fulton's condition factor (K) was estimated using the formula: $K = (100*W)/L^b$, Where W = weight of fish (g), L = Total length of the fish (cm), b =

coefficient of allometry and considered equal to 3 (Akmobo *et al*., 2015; Nguyen *et al*., 2024). Fulton's K Factor assumes that weight of fish is proportional to the cube of the length and is used to assess the general wellbeing of fishes, on individual and population level (Achu *et al*., 2023). The Fulton's K factor was multiplied by 100 to get it close to 1 indicating a normal condition of the fish, and a value greater than 1 indicated fat fish and less than 1 indicated skinny fish. This morphometric index assumes that the heavier a fish for a given length the better its condition (Omitoyin *et al*., 2013).

Plate I: ***Dorsal and Lateral Views of C. nigrodigitatus***

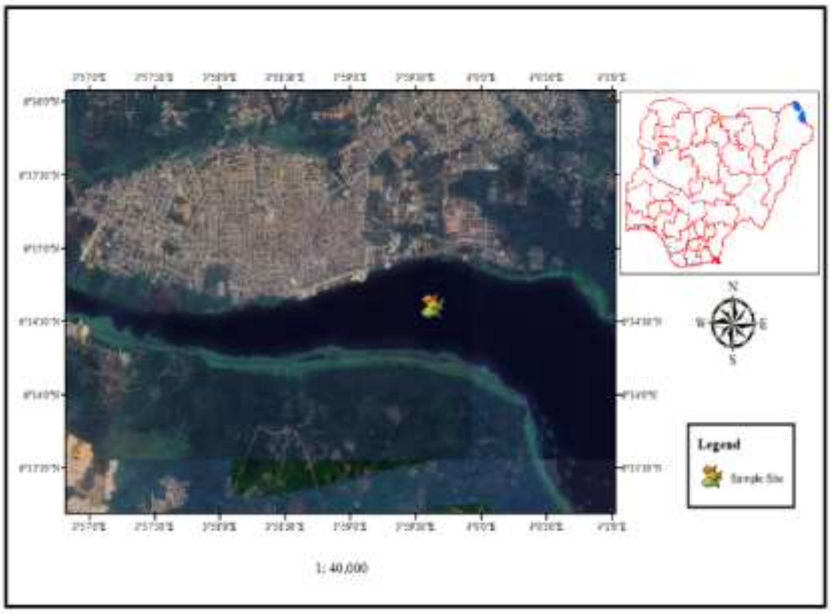

Figure 1: Google Map of Nigeria Showing Epe Lagoon Lagos Sample Station

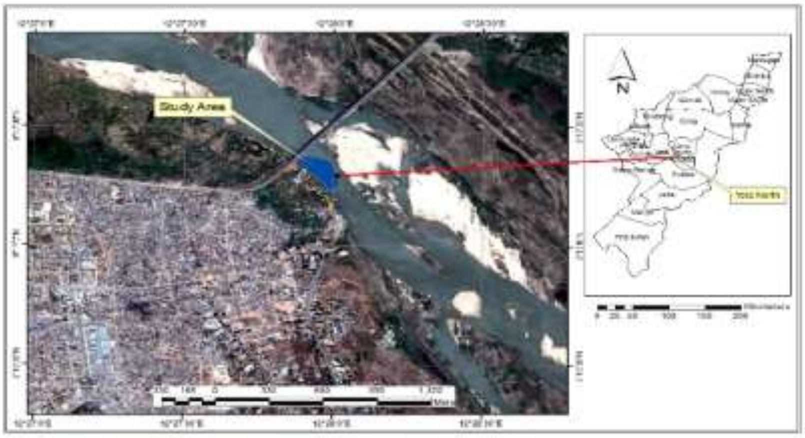

Figure 2: Google Map of Nigeria Showing Yola Sample Station
Source: Duwal *et al*., (2016)

Results

Length-Weight Relationships and Condition Factors

The length-weight relationships and condition factors of the two populations are presented in Table 1. Lagos gave a higher mean total length of 21.96±0.10 but lower mean weight and mean calculated weight of 74.38±0.95 and 74.55 respectively. Lagos population recorded a lower weight at unit length (2.0989) and had a negative allometric growth pattern. Yola population had lower condition factor (1.010). The regression graphs for the length-weight of each of the samples are presented as Figures 3 and 4. All the populations gave a positive coefficient of correlation (r). Lagos gave the least (0.8949) and Yola gave the highest (0.9918) correlation. The coefficient of determination (r^2) was best in Yola (0.9837) and least in Lagos (0.8008).

Table 1: Length-Weight Relationships and Condition Factors of the four Populations

Population	MTL(cm) ± SE	MW (g) ± SE	MCW	a	B	r	r^2	K	Growth type
Lagos	21.96±0.10	74.38±0.95	74.55	0.1046	2.0989	0.8949	0.8008	1.0124	N A
Yola	18.82±0.01	112.42±0.61	121.02	0.0108	2.9225	0.9918	0.9837	1.0100	N A

Key: MTL = Mean Total Length,; MW = Mean Weight; MCW= Mean Calculated Weight;
a = intercept (rate of change of weight with length); b = slope (weight at unit length); r = Correlation coefficient;
r^2 = Coefficient of determination; K = Condition factor,;P A= Positive Allometry; N A= Negative Allometry;
SE = Standard Error

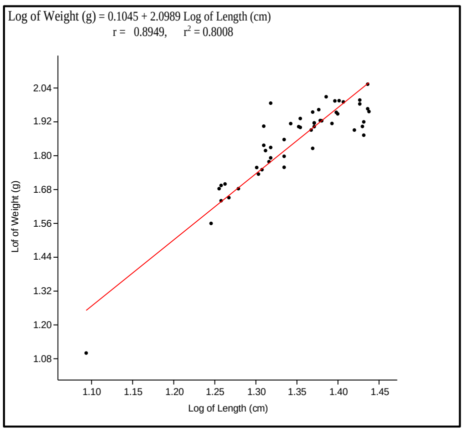

Figure 3: Length-Weight Relationship Graph of Lagos Population

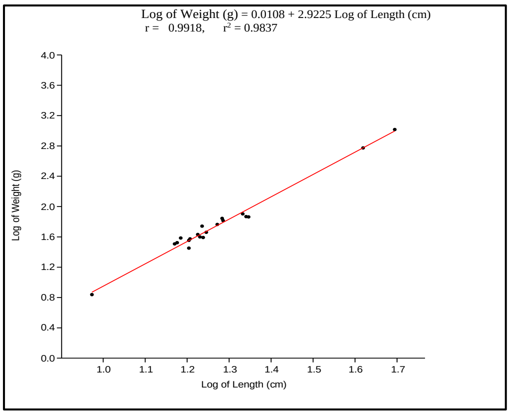

Figure 4: Length-Weight Relationship Graph of Yola Population

Discussion

This study attempted to present variations in the length-weight relationship LWR and condition factors (K) of *C. nigrodigitatus* in Lagos (esturine) and Yola (freshwater) populations. Length weight relationship and condition factors studies in fisheries management cannot be overemphasized as they are used to estimate an average weight of fish at a given length by establishing a mathematical relationship between them (King, 1996; Mir *et al*. 2012). The length-weight relationship is an important tool that provides information on growth patterns and growth of fish (Igwhela *et al*., 2011; Fafioye and Ayodele, 2018). The b value in the LWR have been used to determine the growth pattern of fish species. Alam *et al*. (2014) stated that the exponent b indicates the type of growth thus: b>3 means the fish growth has positive allometry, b=3 means isometry and b<3 is negative allometry. In this study, both populations gave negative allometric growth of 2.0989 and 2.9225 for Lagos and Yola respectively. This result did not agree with Fafioye and Oluajo (2005) who reported a positive allometric growth for *C. nigrodigitatus* in Epe Lagoon but did agree with Iyiola *et al*. (2024) who reported that the b values showed a negative allometric growth pattern for *C. nigrodigitatus* with b = 2.315 (b<3) and positive allometric growth for *O. niloticus* with b = 3.102 (b>3). Positive allometric growth pattern for *C. nigrodigitatus* was reported by Abowei and Hart, (2009) and Akmobo *et al*. (2015) in some water bodies within the region. The correlation coefficient ‘r’ for the populations were 0.8949 and 0.9837 for Lagos and Yola respectively and was an indication of a high correlation between the length and weight of *C. nigrodigitatus* in the two water bodies. In fisheries science, the condition factor is used in order to compare the condition, fatness or wellbeing of fish (Igwhela *et al*., 2011). Iyiola *et al*. (2024) defined condition factor as the state of wellbeing of the fish and reflects through variations, some information on the physiology of the fish, and it is assumed that the higher the value of condition factor, the better the state of wellbeing of the fish. Feeding intensity, age and growth rates in fish are determined using condition factor (Ndimele *et al*., 2010). It can therefore be suggested that the condition factor of the two populations is favourable since they are all greater than one. The K value of greater than one signifies that a fish is in good condition (Nehemiah *et al*., 2012). The K values are usually influenced by the prevailing environmental factors and can be used as a tool to assess an aquatic system (Iyiola *et al*., 2024). The condition factors of Lagos and Yola were 1.0124 and 1.01 respectively. This signified that they were in good condition at the time the samples were collected. Iyiola *et al*, (2024) reported that *O. niloticus* and *C. nigrodigitatus* had a mean K value of 2.8 and 1.9 respectively; both values were greater than one and were within the range recommended of 2-4 as stated by Bagenal and Tesch (1978). The results of K value of the two populations studied deviated from statements by Atobatele and Ugwumba, (2011) and Kareem *et al*. (2015) who reported mean K value of 2.37 and 2.05 respectively. This deviation in K values implied that the condition of the environment of the fish is affected negatively or positively which in turn affects the wellbeing of the fish species (Edah *et al*., 2010; Kumolu-Johnson and Ndimele, 2010;

Fricke *et al*., 2021). The K value of less than one translates that the fish is not in good condition and will appear to be starved and elongated but between 1 - 1.2 translates that the fish is doing well while an index of 1.4 means fish is near spawning (Abowei and Hart, 2009; Alhassan *et al*., 2014; Mehanna and Farouk, 2023) and mostly could be found in gravid females. The K value recorded for the four populations explained that the conditions of the fish are good indicating the presence of abundance of food and good quality of water that provided a habitable environment for the *C. nigrodigitatus* to thrive (Edah *et al*., 2010; Erguden and Ozdemir 2023).

Conclusion

It was concluded that the species of *C. nigrodigitatus* in Yola and Epe Lagoon are in good condition and have favourable environment for survival and growth. It is therefore recommended that the water bodies be maintained more so as to produce more fish for sustainable food security.

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