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Length-weight Relationship and Condition Factor of Cichlids in Eniong and Lower Cross Rivers, Niger Delta, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author UAP designed the study, wrote the protocol and wrote the final draft of the manuscript. Authors EVJ and AGC managed the analyses of the study an performed the statistical analysis, Authors EVJ and ULI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Length-weight relationship and condition factor are essential parameters used in determination of growth and well-being of fish. The length-weight relationship and condition factor of eight species of cichlids were examined from a total of 358 cichlids belonging to fourteen species and seven genera. Sampling was between January and June, 2020 in Eniong River and lower Cross River in the Niger Delta from three stations: station one in Eniong river, station two at the confluence of Eniong and lower Cross River, and station three at the lower Cross River. The length and weight of each fish was measured to the nearest millimeter and gram, respectively. The length-weight relationship (LWR) and condition factor (K) of the species *Coptodon dageti, Coptodon guineensis, Coptodon zilli, Chromidotilapia guntheri, Hemichromis elongatus, Oreochromis niloticus, Pelmatolapia mariae and Sarotherodon melanotheron* were determined using standard methods. Total length of fish ranged from 12.9 ± 5.01 in *H. elongatus* to 20.7 ± 3.37cm in *C. zilli*. Total weight

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ranged from 24.8 ± 13.80 in *H. elongatus* to 146.4 ± 68.0 g in *C. zilli*. The exponent *b* ranged from 1.54 for *H. elongatus* to 3.34 in *Pelmatolapia mariae.* The coefficients of determination (r^2) varied between *H. elongatus* (0.74) and *O. niloticus* (0.96). Fulton's condition factor (K) ranged from 1.2 6 ± 0.50 (*H. elongatus*) to 1.89 ± 0.43 (*O. niloticus*). Length-weight relationship revealed negative allometry for six species and positive allometry for two species (*O. niloticus and P. mariae)*. Cichlids in this study were observed to be in good condition, as the K values were greater than one.

Keywords: Cichlids; length-weight relationship; Niger Delta; growth determination; allometry; condition factor.

1. INTRODUCTION

Fish body length and body weight are two useful empirical measures in stock assessment, in population ecology, community and ecosystem ecology studies [1,2]. Fish growth is generally measured by the increase of length and weight, which are used to determine population development. The length-weight relationship (LWR) is a mathematic model that allows for the conversion of length into weight, and weight into length in stock assessment models, as well as the estimation of biomass from the length frequency distribution. LWR can be used to determine possible differences between separate stock units of a species, provided all units are studied with the same fully standardized sampling methodology [2-4]. LWR is also used for estimating the condition factor of fish, which is used to compare the health of fish populations. A high condition factor indicates that a fish is heavier than a fish of the same length with a lower condition factor, and thus always refers to a deviation from the average LWR for a population [4-6]. The analysis of LWR and condition factor of fish populations are important tools to support the rational management of fishing resources, and may help in the implementation of public policies [7].

In fisheries science, the condition factor is used to compare the "condition", "fatness" or wellbeing of fish, and it is based on the hypothesis that heavier fish of a particular length are in a better physiological condition [8]. Condition factor is also a useful index for the monitoring of feeding intensity, age, and growth rates in fish [9]. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live. Furthermore, the Fulton's condition factor (K) provides some information regarding physiological state of the fishes, based on the assumption that individuals of a given body length are in better condition when their biomass is greater.

LWR may give an idea about the variations from the expected weight for a particular length of fish or fish populations based on fatness, general wellbeing or gonad development [10]. It also helps to evaluate the condition, reproduction history, life cycle and general health of fish besides being useful in local and inter-regional morphological and life history comparisons among fish populations. However, the LWR plays a vital role in fisheries biology, population dynamics and comparative growth studies in fish population [10]. It helps to estimate the standing stock or biomass thereby establishing the yield by converting one variable into another and it is often done during field studies from different regions of trophic places. LWRs in fish population were originally used to provide information on the condition of fish and to determine whether somatic growth was isometric or allometric [5]. Herein, fish are said to exhibit isometric growth when length increases in equal proportions with body weight for constant specific gravity. The seasonal variations of growth in fishes in relation to size attained by the individual fish may vary because of variations in food supply, availability of food which may reflect variations in climatic parameters and supply of nutrients or degree of competition of the food. Thus, a change in fish size through a certain period of time may indicate a change in average age resulting from those factors [11]. The isometric and allometric relationships based on regression analysis are still useful for estimation of the body composition in fish and other animals in the production sector [12].

From earlier studies, Eniong River is a humid fresh water while the lower Cross River from Ayadeghe down to its mouth at the coast is brackish [13]. The Cross River estuary has been described as one of the richest inland fisheries resources in Nigeria, contributing one of the highest quotas of fish production [14] and 90% of Nigeria's total marine/brackish water output comes from this estuary. However, overfishing in inland waters is a major problem to fisheries in the Niger delta, as the catch from the inland water bodies steadily increases with the many fish stocks now classified as overfished due to continuous overfishing, use of small mesh, unselective fishing gear, fish poisons and explosives. The overexploitation of the finite resources has led to a reduction in fish production from inland rivers and lakes from 213,996 metric tonnes in 1998 to 181,268 and 194,226 metric tonnes in 2000 and 2001, respectively [15].

This study on the length-weight relationship and condition factor of cichlids in Eniong and lower Cross River was carried out to ascertain the condition and growth type in the species found in the area.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was carried out in Eniong River and lower Cross River. Three sampling stations where selected: one at Eniong River (Station 1), another at the meeting point of Eniong River and the Cross River estuary (station 2) and One in the lower Cross River (Station 3). Sampling sites were selected according to the accessibility to the sampling locations. Station one was at Ntan Mbat, station two was at Itu and station three was at Ayadeghe (Fig 1). The climate within the three stations is tropical with average annual rainfall above 2700 mm with seasonal flooding during the wet seasons. Wet season begins from April to September/October and dry season from October/ November to March. The average annual mean relative humidity is 86% (66 – 96%) with mean annual temperature of 25°C ranging from 22 to 32°C. In addition, the freshwater ecosystem of Eniong river is unique because the river is characterized by intense brown coloration due to the presence of humid substances and possibly soluble iron [16]. The Cross River is white water (clay coloured) during the rainy season and dark brown during the dry season. The ethnic groups living in the area are mainly Ibibios and Efiks. The occupation of the people includes farming, fishing and timber logging. The vegetation is mainly dense tropical rainforest with mixed mangrove swamp forest at the lower Cross River.

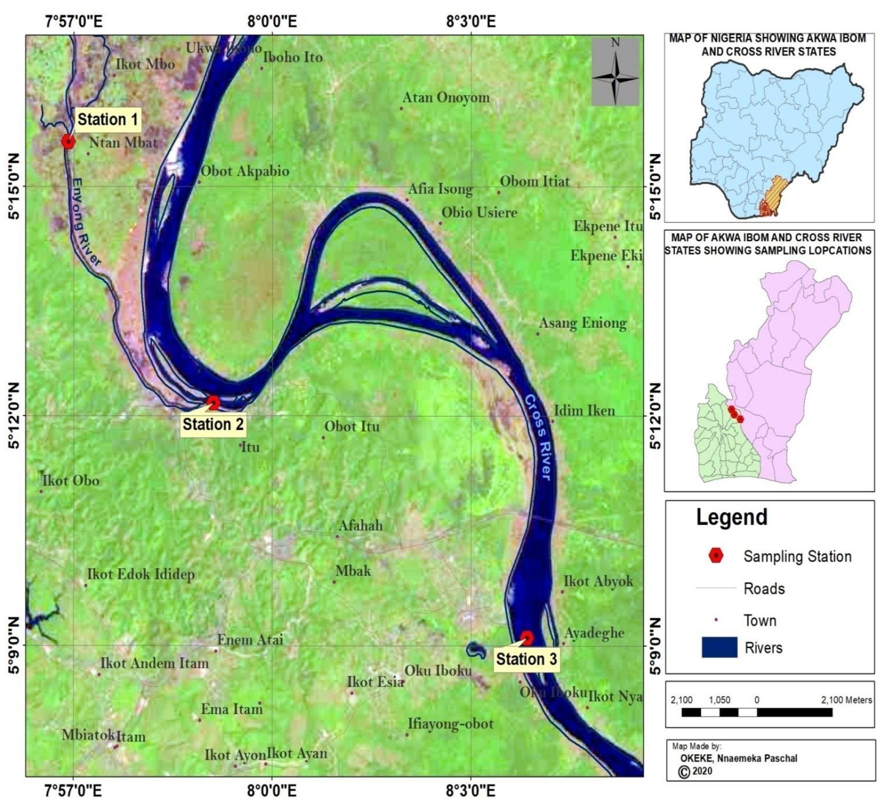

Fig. 1. Map of study area showing the sampling stations in the study areas

2.2 Sampling

Sampling period was from January to June, 2020, conducted with active and passive sampling techniques with the help of local fishermen using various fishing gears including beach net (10 – 15 m length, 2 –3.5 m height, mesh size of 0.5 – 5cm), fixed gill net (40 – 60 m long, mesh size 15 – 57 mm), cast net (2 – 5 m diameter, mesh size 15 – 20 mm) and local traps (made from raffia palm). The sampling duration with the fishing gear and methods were approximately the same: gillnets and traps were set between 1600 h and 1800 h and fishes caught were removed from the gear between 0600 h and 0900 h the following day. Specimens collected were preserved in an ice cooler in the field before being taken to the laboratory for sorting and identification.

2.3 Sorting and Identification of Samples

At the laboratory, cichlids were sorted from the total catch. Samples of cichlids were identified using guidelines for fish identification by [17,18]. The taxonomy and nomenclature was done in accordance with FishBase [19]. Among 14 cichlid species from 7 genera caught during the study, 8 species were selected for analysis of length-weight relationships because of their abundance.

2.4 Measurement and Calculation of Length-Weight Relationship/ Condition Factor

Fish samples were weighed to the nearest 0.1g using a digital platform scale of model 1-2000 G/OZ/OZT/DWT/CT/GN. Standard and total lengths of fish samples were taken using a meter rule and a tape with accuracy to the nearest 0.1mm.

Condition factor of the fish was calculated using the formula:

$$K = W \times 100/L^3$$

Where K= condition factor, W= fish wet weight in grams, L= total length of fish in cm.
The log transformation formula of Le Cren was used to establish the length-weight relationships [5] expressed as:

$$W = aL^b$$

where W represents weight and L the length of fish. This formula was used to estimate the relationship between the weight (g) of the fish and its total length (cm). Using the linear regression of the log-transformation;

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

Parameters a and b were calculated with "a" representing the intercept and "b" the slope of the relationship. The correlation (r^2) that is the degree of association between the length and weight was computed from the linear regression analysis.

2.5 Statistical Analysis

All data were analyzed using Microsoft excel and SPSS 21.

3. RESULTS

3.1 Size and Weight Structure

A total of 358 cichlid fishes belonging to 14 species and 7 genera were caught and examined, but only 8 species (*Coptodon dageti, Coptodon guineensis, Coptodon zilli, Chromidotilapia guntheri, Hemichromis elongatus, Oreochromis niloticus, Pelmatolapia mariae and Sarotherodon melanotheron*) were used for length-weight relationship. The total length of fish ranged from 12.9 ± 5.01 in *H. elongatus* to 20.7 ± 3.37cm in *C. zilli*. Total weight ranged from 24.8 ± 13.80 in *H. elongatus* to 146.4 ± 68.0g in *C. zilli*.(Table 1).

3.2 Length weight Relationship and Condition Factor of Cichlids Across the Three Stations

The matrix of slopes, intercepts and correlation coefficients obtained from cichlid length-weight regression equations are shown in Table 2. The linear regression equation (Log SL – Log W) calculated to show length–weight relationship of eight cichlids shows the exponent b ranging from 1.54 recorded for *Hemichromis elongatus* to 3.34 in *Pelmatolapia mariae*. The coefficients of determination (r^2) of the length-weight relationship regressions varied between *H. elongatus* (0.74) and *O. niloticus* (0.96). The intercepts (a) were all negative ranging from -1.862 for *O. niloticus* to - 0.224 for *H. elongatus*. The condition factor of fish species ranged from 1.26 ± 0.50 (*H. elongatus*) to 1.89 ± 0.43 (*O. niloticus*). The matrix of slopes, intercepts and correlation coefficients obtained from cichlid length-weight regression equations are shown in (Fig.2).

Table 1. Size and weight ranges of cichlids

Species	n	Min (cm)	Max (cm)	Mean±SD (cm)	Min (g)	Max (g)	Mean±SD (g)
C.dageti Thys Van den Audenaerde, 1971)	112	10.5	27.0	19.8±3.56	16.4	290.8	133.10±70.9
C.guineensis (Gunther, 1862)	59	9.5	26.5	17.8±3.73	12.0	346.3	104.9±68.5
C. zilli (Gervais,184)	21	12.6	25.5	20.7±3.37	40.0	272.0	146.4±68.0
C.guntheri (Sauvage 1882)	37	7.5	18.9	15.7±2.48	7.2	75.0	56.8±14.14
H.elongatus (Brendel, 1890)	23	8.0	27.0	12.9±5.01	5.2	55.2	24.8±13.80
O.niloticus (Linnaeus, 1758)	19	10.2	30.0	20.6±5.46	16	500	198±138.0
P. mariae (Boulenger, 1899)	44	8.2	19.4	14.8±2.51	10	154.7	74.9±37.50
S.melanotheron (Ruppell,185)	13	12	18.8	14.9±2.45	33.3	120	64.2±29.60

Table 2. Length-weight relationship and condition factor of eight cichlids from Eniong and Lower Cross Rivers

Species	a	b	r^2	K	Growth Pattern
C. dageti	-0.692	2.35	0.94	1.58±0.03	Negative allometry
C. guineensis	-1.422	2.98	0.80	1.64±0.32	Negative allometry
C. guntheri	-1.120	2.61	0.88	1.51±0.33	Negative allometry
C. zilli	-0.742	2.39	0.82	1.55±0.28	Negative allometry
H. elongatus	-0.224	1.54	0.74	1.26±0.50	Negative allometry
O. niloticus	-1.862	3.10	0.96	1.89±0.43	Positive allometry
P. mariae	-1.720	3.34	0.91	2.14±0.69	Positive allometry
S. melanotheron	-1.008	2.64	0.94	1.85±0.19	Negative allometry

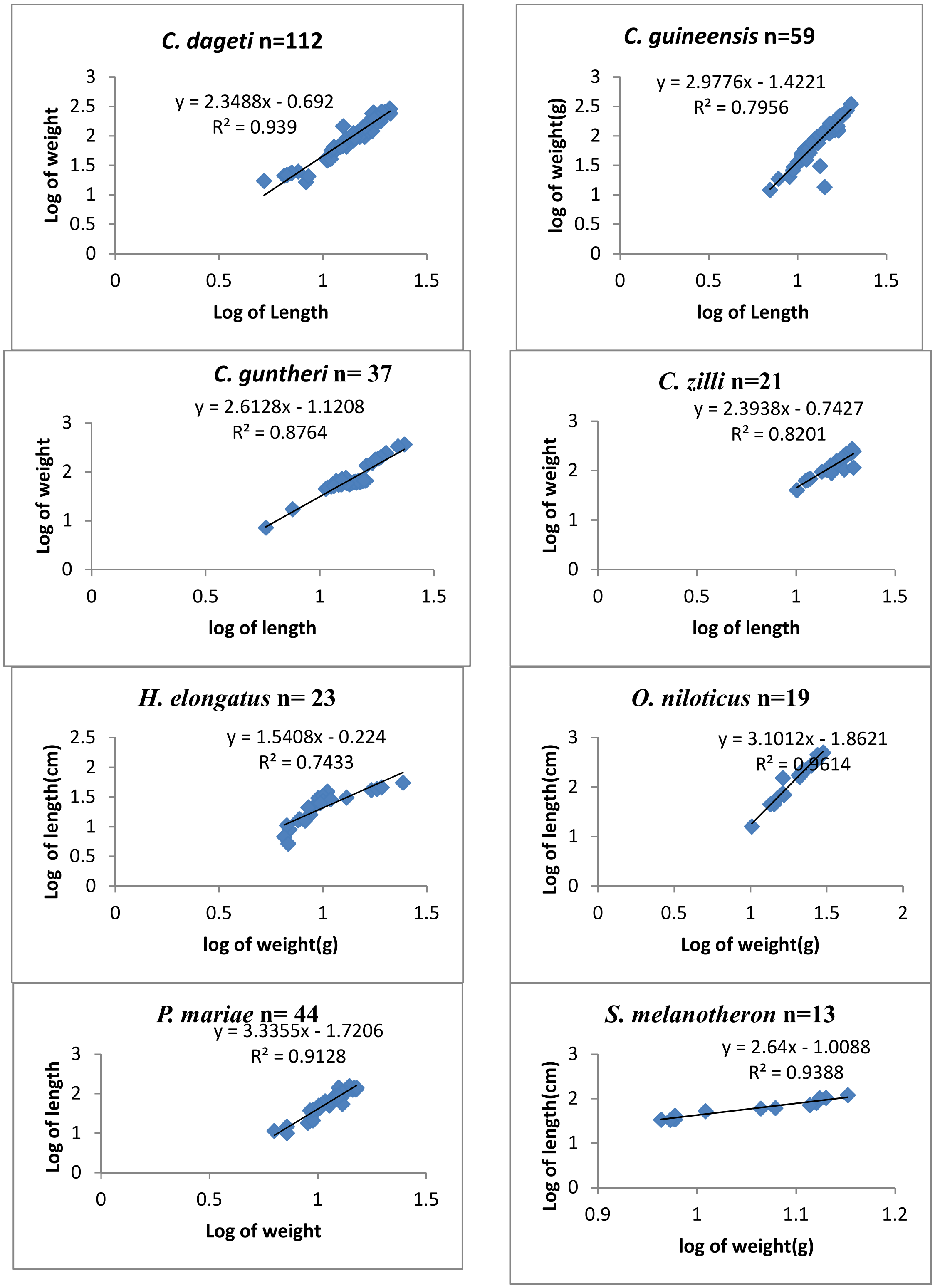

Fig. 2. Length-weight relationship of cichlids from the Eniong and Lower Cross river

4. DISCUSSION

4.1 Length-weight relationship

In the present study, the correlation coefficient r^2 between log length and log weight was found to be high in all the cichlids, indicating a close relationship between length and weight of the eight species of cichlids. Growth is considered isometric when b value is equal to 3 or allometric if less than or greater than 3 (positive allometry if b>3 and negative allometry if b<3). The values of b for the length-weight relationship were found to show negative allometry for six fish species out of eight cichlids selected for analysis of length-weight relationship in the study area. This indicates that these fish grew in such a way that fish becomes slimmer with increasing length. The allometric negative growth pattern has been observed in several freshwater fish species in Nigeria for example: *H. fasciatus* from Badagry Creek [20], *Tilapia zilli* from reservoir in Abuja [21] and *H. fasciatus* from Oyan Dam [22]. In this study the b values ranged from 1.54 (*H. elongatus*) to 3.34 (*P. mariae*). The values of b (growth exponent) for all species examined (exception of *H. fasciatus*) were within the limits two to four reported [23] for most fishes. However, *O. niloticus,* and *P. mariae* exhibited a positive allometric growth pattern; that is, the length and body of fish grows in such a way that the fish is fatter as the length increases. The findings are similar to the findings of other authors [24] on the length-weight relationship of four fish species cichlids from Magaga Lake, Kano, Nigeria.

Growth pattern and growth rates are highly species-specific and each species has growth characteristic of its own with respect to factors such as optimum temperature, adequate food and seasonal changes [25]. Several other factors could explain this variation in b values such as sexual maturity and dimorphism [26], and sampling procedure (sample size and length range) [27]. It is also inferred that higher b values imply relatively productive environmental conditions [28].

4.2 Condition Factor

Cichlids in this study were observed to be in good condition, as the K values were greater than 1. The K values ranged from 1.26 ± 0.50 (*H. elongatus*) to 2.14 ± 0.69 (*P. mariae*). The condition factor of the eight species in this study were within the range considered normal as recommended by [29] who stated that condition factor greater or equal to one was good, indicating a good level of feeding and proper environmental condition. However, a K value range of 2.9 - 4.8 as suitable for matured fresh water fish has been recommended [8]. The fishes used in this study (8 cm to 30 cm) were probably a mix of immature and maturing fish with a K of 1.26 – 2.14. It is possible that maturity with large gonads will influence the K values. The gender difference in condition factor was observed [30] in Lower Cross River where the condition factor of *Chrisycthyes nigrodigitatus* male was 1.93 ± 0.14 in August while in females it was 2.06 ±0.13 in May and 2.02 ± 0.89 in June. Gonadal development may have contributed to the higher K values observed in females. Some other studies reported [31] in Wasai Reservoir in Kano observed K values of 2.44, 3.4 and 2.73 in *O. niloticus, T. zilli* and *H. bimaculatus,* respectively. Also the condition factor of four cichlid species, *C. guntheri, T. cabrae, T. mariae and T. zilli* reported [32] in a man-made lake in Imo state Nigeria ranged from 4.3 ± 0.19 to 5.38 ± 0.56. These K values are higher than those observed in this study.

5. CONCLUSION

Six out of eight species of cichlids in Eniong and Lower Cross River showed negative allometry while two (*P. mariae* and *O. niloticus*) showed positive allometry. With K values higher than one, all cichlid species in the study area appeared to be in good condition.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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