



## LENGTH-WEIGHT RELATIONSHIP AND CONDITION INDEX OF THE RED BELLY TILAPIA (*Coptodon zillii*) IN THE GREAT KWA RIVER

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### ABSTRACT

The Red Belly Tilapia (*Coptodon zillii*) is a widely distributed fish species in freshwater ecosystems, including the Great Kwa River in Nigeria. This study aimed to investigate the length-weight relationship and condition index of *C. zillii* in the Great Kwa River. The research involved data collection over a three-month period, from January to March 2023. Descriptive statistics were used to analyze the length and weight measurements of *C. zillii*. The total length of the fish ranged from 2.4 cm to 20.5 cm, with mean values ranging from 8.77 cm to 9.51 cm. Similarly, the weight of the fish varied from 0.2 g to 67.0 g, with mean values ranging from 8.91 to 11.88 g. Regression analysis indicated a significant relationship between length and weight, with R values ranging from 0.9875 to 0.9921, suggesting a strong correlation. Furthermore, the length and weight regression parameters indicated isometric growth for *C. zillii* in all the months and pooled data. The values of the regression slope (b) did not deviate significantly from the standard value of 3 for isometric growth. Additionally, the t-test for isometry confirmed the results, as the calculated t-values were less than the critical t-values, indicating isometric growth of *C. zillii* in the Great Kwa River. The study also examined the condition factor of *C. zillii*. The condition factor ranged from 0.7 to 1.3, with no significant difference observed between the sampling months. This suggests that the fish maintained a relatively stable condition throughout the study period. Overall, this research provides valuable insights into the length-weight relationship, isometric growth, and condition factor of *C. zillii* in the Great Kwa River. The findings contribute to the understanding of the fish population dynamics and can serve as a basis for further studies on the species' ecology and conservation in Nigerian freshwater ecosystems.

**KEYWORDS:** Red belly tilapia, condition factor, length-weight, Great-Kwa River.

### INTRODUCTION

Fish and fisheries play a significant role in the global economy. They contribute to food security, livelihoods, employment, trade, and economic development in numerous countries around the world. Fish is a vital source of animal protein, essential nutrients, and fatty acids, especially for populations in coastal communities and developing countries (Eteng and Inyang-Etoh, 2024).

According to the Food and Agriculture Organization (FAO), fish provide around 17% of the global population's intake of animal protein and 7% of all protein consumed worldwide (FAO, 2020). The fishing industry, including capture fisheries and aquaculture, supports millions of people's livelihood. It provides employment opportunities for fishermen, fish farmers, processors, traders, and associated industries.

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The FAO estimates that around 60 million people are directly employed in the fisheries and aquaculture sector (FAO, 2020).

Fish and seafood products have substantial economic value. In 2019, global fish exports reached a record high of \$169 billion, making fish and seafood among the most traded food commodities worldwide (FAO, 2021; Asuquo & Ifon, 2019). These exports contribute significantly to the economies of several nations, including China, Norway, Vietnam, Thailand, and the United States. The international fish trade plays a crucial role in economic development and generates substantial foreign exchange earnings, particularly for developing and coastal countries that rely heavily on fisheries. Moreover, the economic significance of fish exports is closely linked to the availability and distribution of fish populations, which are influenced by environmental conditions and fishing practices (Petrakis, Stergiou, & Koutsikopoulos, 2019; Asuquo & Ifon, 2021). The relationship also serves as an indicator of fish condition, reflecting changes in body condition due to environmental factors, feeding patterns, or other ecological processes (Ortega-Salas, Dumas, & Girardin, 2020). Accurate length- weight relationships are essential for estimating the biomass and productivity of fish populations, which are vital for sustainable management and conservation efforts (Freire, Araújo, Nóbrega, & Barletta, 2020). These relationships provide valuable insights into the health and status of fish populations and contribute to informed decision-making in fisheries management.

The condition factor in fish is an important parameter used in fisheries biology and ecology to assess the overall health, well-being, and physiological condition of individual fish and fish populations. It provides valuable insights into factors such as growth, reproduction, feeding, habitat quality, and environmental stress. The condition factor serves as an indicator of the general health and physiological status of fish. It reflects the energy reserves and allocation to growth and reproduction. Fish with higher condition factors are typically healthier, have better growth rates, and are more likely to reproduce successfully (Silva *et al.*, 2021; Jobling, 2013). The condition factor can indicate the quality of the habitat and the availability of food resources. Fish in good condition generally inhabit environments with abundant food sources and suitable living conditions (Pauly, 1993). Changes in the condition factor can provide insights into variations in resource availability and environmental conditions (Inyang-Etoh *et al.*, 2024).

The condition factor is sensitive to environmental stressors and pollution. Fish exposed to adverse conditions, such as poor water quality, contaminants, or habitat degradation, often exhibit reduced condition factors (Sloman *et al.*, 2013). Monitoring the condition factor can help identify areas impacted by pollution and assess the health of fish populations in these environments. The condition factor of fish serves as a

bioindicator of ecosystem health. Changes in the condition factor can reflect alterations in the availability and quality of food resources, ecological interactions, and ecosystem productivity (Brijs *et al.*, 2020). Monitoring the condition factor helps evaluate the overall status and functioning of aquatic ecosystems. The condition factor is useful in fisheries management and stock assessment. It provides information on the well-being of fish populations and can assist in determining sustainable harvest levels and fishing regulations (Sparrevik *et al.*, 2018). Changes in the condition factor can indicate overfishing, habitat degradation, or changes in prey availability, prompting adaptive management strategies.

*Coptodon zillii*, commonly known as the Zilli's tilapia or the redbelly Tilapia, is a species of fish belonging to the family Cichlidae. It is native to various regions in Africa, including the Nile River basin, Lake Chad, and other freshwater habitats in West and Central Africa. The species is a relatively small fish with an average length ranging from 15 to 20 centimeters, although larger individuals have been reported. It has an elongated and laterally compressed body shape with a slightly arched dorsal profile. The coloration of this species is variable, but it generally has a silver to yellowish body with distinct reddish to orange coloration on the belly and lower parts of the head. They are commonly found in freshwater habitats such as rivers, lakes, swamps, and reservoirs. It exhibits a wide distribution throughout Africa, including countries like Egypt, Sudan, Nigeria, Chad, Cameroon, and Congo. It can tolerate a range of environmental conditions and is often found in both stagnant and flowing waters. *Zilli* tilapia is a social and territorial species. It typically forms small groups or pairs and defends its territory from intruders. The male fish are known to exhibit more intense territorial behavior, especially during the breeding season. They construct nests and guard the eggs and fry. It is primarily herbivorous, feeding on algae, aquatic plants, and detritus. However, they can also consume small invertebrates and insect larvae when available. Like other cichlids, *C. zilli* is a mouthbrooder, meaning the female carries the fertilized eggs and later the hatched fry in her mouth for protection. The male establishes and defends a nesting territory, where the female deposits the eggs. After spawning, the female takes the eggs into her mouth until the fry hatch. The species has gained economic importance in aquaculture and has been introduced to various regions outside its native range.

## **MATERIALS AND METHODS**

### **Description of study area**

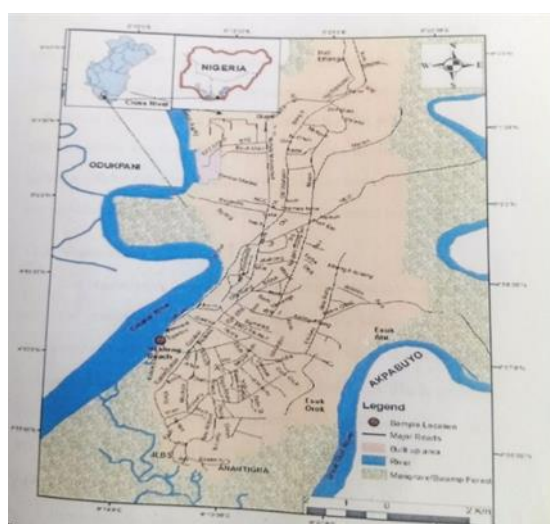
The study area is located in the Great Kwa River which is one of the major tributaries of the Cross River estuary. The Great Kwa River flows through Cross River State, Nigeria, draining into the eastern side of the city of Calabar.

The river originates from the urban hills in the Cross River National Park and flows southward towards the estuary. Its lower reaches are tidal with broad mudflats consisting of mangrove plant species such as *Rhizophora*. It drains the eastern coast of the city of Calabar (Antai and Joseph, 2015). It is located between latitudes 4°45' and 5°15'N and longitude 8°15'E and 8°30'E (Fig 1). The river is 56 km long and 28 km wide at the mouth where it empties into the Cross River estuary. The river exists within a meso-tidal setting and is characterized by semi-diurnal tide. It has for a long time been covered by tropical rain forest

and in recent times become a beehive of agricultural, road construction and forestry (Eteng, & Ifon, 2019).

### **Climate**

The region has a raining season from April to October during which 80% of the annual rain falls, with peaks in June and September annual rain fall average 1830 millimeters. Average temperature ranges from 24 °C (75°F) in August to 30 °C (86 °F) in February. Relative humidity is high, between 70% and 90%. The Great Kwa River is known for its rich biodiversity, including various fish species, and it is of ecological importance. The river also provides water resources for agriculture, and recreation in the region.



**Fig. 1: Map of Great Kwa River showing the sampling station (Obufo Esuk Orok)**

### **Vegetation**

The vegetation of the study area is a rainforest close to the mangrove belts. The mangroves species that are found in the study area include *Rhizophora racemosa* (red). *Avecinia africana* (blue) which also constitutes the vegetation in the area especially in the river flood plains. The nypa palm (*Nypa fruticans*) and *Pandanus* sp. constitutes the other trees, shrubs and mix vegetation are characteristics of the area (Job & Udo, 2002).

### **Human activity**

Human activities in the Great Kwa River are limited to small scale farming, aquaculture and artisanal fisheries.

### **Reconnaissance survey**

Reconnaissance survey was carried out in the Great Kwa River of Cross River State where samples were collected to determine the feasibility of working on the fish samples found in the sampling stations.

Arrangements were made with local fishermen in the area to make purchases of fish samples

### **Sampling regime (work plan)**

Sampling duration for the study was three months. Sampling in the study area was undertaken monthly for three months (January 2023 to March 2023). Time frame of sampling was in the morning (7am - 9am).

### **Collection of samples**

In this study, samples of *Coptodon zillii* were purchased from landings of the artisanal fishers at Obufo Esuk Orok of the Great Kwa River. The fishermen use various fishing gears like hand net, cast net and gills net of various mesh sizes (20.2, 25.4 & 39.5mm).

A total of ninety (90) samples of the fish species which comprised of all the size groups were randomly selected and used for this study. All fish specimens were obtained in their fresh state immediately after landing at the beach. Samples were transported on ice to the laboratory for further studies.

# Laboratory study

## Identification of samples

Fish samples (Plate 1) were identified using taxonomical key (Fischer et al., 1989).



Plate 1: Picture of *Coptodon zillii*

## Counting and measurement of specimens

In the laboratory, specimens were counted to ascertain the number of species collected in Nsidung beach of the Calabar River. Length (cm) and weight (g) parameters of the fish were measured using a measuring board calibrated in centimeters (cm). Total length was measured from the tip of the mouth (snout) to the end of the caudal fin (Enin & Enidiok, 2002; Ekpo *et al.*, 2021) with a Meter Rule to 0.1cm below. For weight, fishes were weighed with the help of electronic weighing balance and recorded.

The length-weight relationship was estimated using the function in equation 1 below (Enin & Enidiok, 2002):

$$\text{Equation 1: } W = aL^b$$

Where:

$$\tilde{t} = \frac{|b-3|}{\sqrt{\frac{(1-r^2)}{(n-2)} \cdot \text{s.d.}(x)}}$$

Where:

- s.d.(x) = standard deviation of the log-transformed length values (Log L)
- s.d.(y) = standard deviation of the log-transformed weight values (Log W)
- n = number of specimens used in the analysis
- b = estimated exponent from the LWR

$r^2$  = coefficient of determination of the regression

The value of b is considered significantly different from 3 (i.e., indicating allometric rather than isometric growth) if the calculated  $\tilde{t}$  exceeds the tabulated critical value of t for n – 2 degrees of freedom (Pauly, 1984).

W = weight of the fish (g)

L = total length of the fish (cm)

a = intercept (a constant)

b = slope (growth exponent)

## Statistical Analysis

Regression and correlation analyses were used to test the relationship between the length and weight (LWR) of the fish species. A test was considered statistically significant at  $P < 0.05$ . All the correlation coefficients (r) obtained from the various linear regression analyses were tested for significance using the Student's t-test.

To determine whether the exponent (b) of the length-weight relationship deviated from isometry (i.e.,  $b=3$ ), a t-statistic function described by Enin (1994) was applied. The formula is given as:

## RESULTS

Descriptive statistics on length and weight of *Coptodon zillii* results of the total length measurement of the red belly tilapia (*C. zillii*) revealed a range between 2.4 and 17.0 cm with a mean of  $8.77 \pm 0.61$  cm in January 2023, 4.3 and 19.8 cm ( $10.4 \pm 0.80$  cm) in February 2023, 3.1 and 20.5 cm ( $9.35 \pm 0.75$  cm) in March 2023, 2.4 and 20.5 cm ( $9.51 \pm 0.42$  cm) for pool data. Weight ranged between 0.2 and 40.1 g ( $8.91 \pm 1.57$  g) in January 2023, 0.8 and 59.4 ( $14.95 \pm 3.11$  g) in February 2023, 0.4 and 67.0 g ( $11.77 \pm 2.84$  g) in March 2023, 0.2 and 67.0 g ( $11.88 \pm 1.5$  g) for pooled data (Table 1).

### Length and weight regression parameters of *Coptodon zillii*

Results of the length and weight regression of *C. zillii* landing in Great Kwa River, Calabar are depicted in Figures 2 to 5. Results showed that the intercept of the regression line "a" ranged from -1.84 in March 2023 to -1.94 in January 2023. However, the slope of the regression line "b" ranged from 2.81 in March 2023 to 2.92 in January 2023. There was significant relationship between length and weight of *C. zillii* landing in the Great Kwa River, Calabar with  $r^2$  values that ranged from 0.9875 in February 2023 to 0.9921 in January 2023.

As mentioned in the above paragraph, b values did not deviate significantly from the standard value of 3 for isometric growth of fish. The results of the t-test for isometry showed that the t-calculated values were less than the t-critical values at the appropriate degree of freedom. The results therefore infer that the growth of *C. zillii* Obtained from Great Kwa River, Calabar was isometry in all the months and pooled data (Table 3).

### Descriptive statistics on condition factor of *Coptodon zillii*

Results of the analysis on condition factor of *C. zillii* obtained from the Great Kwa River from January to March 2023 are shown in Table 5 below. Condition factor ranged from 0.7 to 1.2 with a mean of  $0.97 \pm 0.02$  in January 2023, 0.8 to 1.2 ( $0.94 \pm 0.03$ ) in February 2023, 0.8 to 1.3 ( $0.99 \pm 0.03$ ) in March 2023, 0.7 to 1.3 ( $0.97 \pm 0.01$ ) for pooled data. Analysis of variance revealed no significant difference ( $P > 0.05$ ,  $F_{cal} 1.17$ ,  $F_{crit} 3.10$ ) in condition factor between the sampling months.

## DISCUSSION

In this study the size and number of *C. zillii* obtained from the Great Kwa River varied for each month. The variation in monthly fish samples observed in the present study could be due to fishing pressure exerted by the local artisanal fishermen target against adult population may lead to their few numbers in the river. The exponent ( $b=2.88$ ) in the length-weight equation of the Red belly tilapia (*C. zillii*) was not significantly different from 3, indicating that *C. zillii* of the Great Kwa River approximates an isometric weight growth.

This condition had already been assumed for the species with regards to growth analysis using von Bertalanffy growth function (VBGF) (Enin, 1994).

The implication of this finding is that the dynamics of the shad populations can be analyzed using the conventional fish population dynamics models, most of which assume isometry in fish and invertebrate growth (Pauly, 1984). A characteristic of the length-weight relationship in fishes and invertebrates is that the value of the exponent (b) is 3 when growth in weight is isometric (without changing shape). If b value is different, from 3, weight growth is said to be allometric (fish changes shape as it grows larger) Allometric growth may be negative ( $b < 3$ ) or positive ( $b > 3$ ) Decrying the general lack of adequate theory to guide research and to formulate testable hypothesis on the LWR of fish and aquatic invertebrates, Pauly (1993) stated that there is no theory that tells us in which case estimated b values can be expected to be below 3 (negative allometry) or above 3 (positive allometry) However, Pauly (1993) provides a rough idea on this situation, indicating that allometric growth is negative ( $b < 3$ ) if the fish gets relatively thinner as it grows larger, and positive ( $b > 3$ ) if it gets plumpy as it grows larger. Thus, some indication of the condition of fish in a population can be obtained from the length-weight equation. In the case of the present study, results indicate that both shad species change their shape as they grow larger.

Ama-Abasi (2004) reported that the length weight growth of bonga fish in Cross River estuary was isometric with  $b = 3$  and  $a = 0.00967$  and the author concluded that from all indications the growth of bonga fish was proportional in all directions. The difference between these findings and that of Ama-Abasi (2004) can be attributed to the species of fish measured. It is important to note that positive or negative allometry of any fish are not unconnected with the pattern of measurement adopted whether standard length or total (Asuquo & Ifon, 2022 a, b and c)

## SUMMARY AND CONCLUSION

This study aimed at establishing length weight relationship and condition factor of *Coptodon zillii* obtained from the Great Kwa River. It was observed in this work that the size of *C. zillii* varied between 12.2 and 30.3 cm ( $19.31 \pm 0.73$  cm) in length and weighed between 13.0-224g ( $53.7246 \pm 34$  g). In the Great Kwa River, the growth exponential value of "b" of cichlid species was 2.88. There was a strong relationship ( $r=0.92$ ) between total length and body weight measurements of the fish. Condition factor showed range from 0.7-1.3 ( $0.97 \pm 0.01$ ). This study concludes that *C. zillii* obtained from the Great Kwa River exhibited isometric growth. Also, *C. zillii* was in poor condition probably due to unfavourable ecological conditions or a period where the species might have undergone stress from low food availability, reproductive processes, and anthropogenic pressure.

## RECOMMENDATIONS

Based on the findings and limitations of this study, the following are recommended:

- i. Researchers should ensure that samples collected cover various size classes of fish for more comprehensive result.
- ii. Further studies should be carried out on how feeding and reproduction affect the condition of this species.
- iii. Fishing pressure and pollution should be reduced on *C. zillii* to improve their condition in the Great Kwa River.

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