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Length-weight relationship and condition factor of West African Lungfish (*Protopterus annectens*) in Kware Lake, Sokoto State, Nigeria

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Abstract

This study examined the length–weight relationship (LWR) and condition factor (K) of West African lungfish, *Protopterus annectens* from Kware Lake, Sokoto State, Nigeria, to assess its growth pattern, health status, and environmental adaptation. A total of 77 specimens were collected and analysed using standard morphometric methods. The relationship between length and weight was expressed by the equation $W = aL^b$, with the logarithmic transformation used to determine regression parameters. Results showed that *Protopterus annectens* exhibited a negative allometric growth pattern across sexes, with regression coefficients (b) of 0.41 for males, 0.56 for females, and 0.39 for combined sexes all less than 3, indicating that the fish grows faster in length than in weight. The coefficient of determination (R^2) ranged from 0.69 to 0.76, revealing a strong positive correlation between length and weight. The mean total length and body weight were 32.70 ± 1.42 cm and 100.90 ± 6.99 g, respectively. The mean condition factor values were 0.41 (male), 0.34 (female), and 0.37 (combined sex), suggesting that *Protopterus annectens* populations in Kware Lake are in moderate physiological condition. The observed growth pattern and condition factors may be attributed to environmental factors, food availability, and anthropogenic influences within Kware Lake. The study concludes that *Protopterus annectens* in Kware Lake maintains a relatively stable population structure and ecological balance despite exhibiting negative allometric growth. It recommends the implementation of sustainable fisheries management practices, regular monitoring of water quality, and control of anthropogenic activities to maintain ecosystem integrity and ensure long-term fish productivity.

Key word: Length-Weight relationship, condition factor, *Protopterus annectens*, Kware Lake

Introduction

Fish are among the most important aquatic organisms that contribute significantly to human nutrition, ecology, and the economy (Helfman *et al.*, 2009). They provide a major source of animal protein, essential fatty acids, and micronutrients for millions of people worldwide. Understanding fish biology and ecology is therefore essential for effective fisheries management and conservation. One

of the most fundamental aspects of fish biology is the study of length–weight relationship and condition factor, which are critical tools for assessing growth patterns, population structure, and general well-being of fish species within aquatic ecosystems (Froese, 2006). *Protopterus annectens*, commonly known as the West African lungfish, is a freshwater species belonging to the family Protopteridae. It is widely distributed across

West and Central Africa, inhabiting rivers, lakes, and swamps (Olaosebikan & Raji, 2013). The species is noted for its ability to survive periods of drought through aestivation a physiological adaptation that allows it to burrow into the mud and breathe atmospheric oxygen. This unique adaptation enables it to thrive in seasonal or temporary water bodies where other fish species may not survive (Thompson, 2018). The West African lungfish (*Protopterus annectens*) is an ecologically important species in freshwater systems across sub-Saharan Africa. Despite its adaptive capabilities and economic relevance, there is limited information on its growth dynamics and physiological condition within Kware Lake. The length–weight relationship and condition factor are fundamental parameters in fisheries biology, providing insight into growth patterns, environmental influences, and fish well-being (Bolger & Connolly, 1989).

The study of the length weight relationship (LWR) provides insight into the relative growth rate of a fish species, describing how weight increases in relation to length (Bagenal and Tesch, 1978). It helps determine whether growth is isometric (when body proportions remain constant as size increases) or allometric (when body proportions change with growth). The relationship is often expressed as $(W = aL^b)$, where (W) is the weight, (L) is the length, (a) is a constant, and (b) is the exponent indicating growth type (Froese, 2006).

Condition factor (K) serves as an index of the general health and well-being of fish. It reflects the degree of plumpness or robustness of an individual fish and provides information on environmental conditions, feeding adequacy, and reproductive status (Le Cren, 1951). A high condition factor usually indicates that a fish is in good health, while a low condition factor may suggest stress, poor feeding conditions, or environmental challenges (Imam *et al.*, 2010).

In Kware Lake, Sokoto State, *Protopterus annectens* plays an important ecological and economic role. It contributes to the biodiversity of the lake and serves as a protein source for

local communities. However, changes in environmental quality, pollution, and unregulated fishing activities may affect the growth and condition of fish populations. Therefore, evaluating the length–weight relationship and condition factor of *P. annectens* in Kware Lake provides valuable baseline information on its growth pattern, health status, and suitability of the lake for sustaining viable fish populations. The main objective of this study is to determine the length–weight relationship and condition factor of *Protopterus annectens* in Kware Lake, Sokoto State, Nigeria.

Materials and Methods

Study Area

The experiment was conducted at the Feed mill Laboratory of the Teaching and Research Fish Farms, Department of Fisheries and Aquaculture at the main campus of Usmanu Danfodiyo University, Sokoto. The study site is located on latitude 13° 07' 78" N and longitude of 05° 12' 25" E at 275m above sea level (Google, 2011). The study site is located within the Sudan Savanna vegetation zone of Nigeria. The climate in the area is characterized by a long dry season, cool dry season or harmattan from November to February and hot dry season from March to May. Annual rainfall in the area ranged from 500 to 724 mm which fall during May/June – September/October (Mamman, 2000). The mean relative humidity is 14.9% and 40% between March and June and 41°C maximum (Mamman, 2000).

Collection of Samples

Sampling was carried out using both active and passive methods. A variety of fishing gears such as gill nets, cast nets, and traps were deployed at different sampling stations around the lake to capture a representative number of *Protopterus annectens*. The samples were collected early in the morning and late in the evening, which are the periods of highest fish activity. Some additional specimens were obtained directly from local fishermen operating around

Kware Lake to supplement the field samples. The fish samples were measured and analysed immediately after collection to avoid post-capture deterioration.

Sex Identification

Sexes of the fish were identified after dissection by examining the gonads. The testes were identified as long, whitish, and ribbon-like structures, while the ovaries appeared yellowish or cream-colored, containing visible eggs in mature females. The identification of sex was used to separate males from females for independent analysis where necessary.

Data Collection

Length and Weight Measurement of the Fish

The total length of each fish (in centimetres) was measured using a fine measuring rope placed from the tip of the snout to the end of the caudal fin. A calibrated measuring board was used to ensure accuracy. The body weight of each fish (in grams) was measured using a digital weighing balance with an accuracy of 0.01g.

Each measurement was recorded immediately after capture to minimize weight loss due to dehydration. All measurements were taken following the standard procedure described by Le-Cren (1951).

Length–Weight Relationship

The length–weight relationship was determined to establish the relationship between the length and weight of *Protopterus annectens* specimens collected from Kware Lake. The calculation was performed separately for males and females, and also for combined samples, using the conventional formula described by Le-Cren (1951):

$$W = aL^b$$

Where:

W = Weight of fish (grams)

L = Total length of fish (centimetres)

a = Constant (intercept)

b = Exponent (slope of regression line)

This equation was used to ascertain the growth pattern of the fish. The logarithmic

transformation of the equation was used to obtain a linear relationship:

$$\log W = \log a + b \log L$$

The slope (b) and intercept (a) were determined through regression analysis, providing the basis for identifying the type of growth exhibited by *Protopterus annectens*.

Condition Factor

The condition factor (K) was calculated to evaluate the general well-being and relative robustness of *Protopterus annectens*. The formula used was:

$$K = 100 \times \frac{W}{L^3}$$

Where:

K = Condition factor of the fish

W = Weight of the fish (grams)

L = Total length of the fish (centimetres)

The value of K was determined for each specimen and later averaged to obtain the mean condition factor for the population. A higher K value indicates a healthier and better-conditioned fish, while a lower K value signifies poor health or environmental stress (Bagenal & Tesch, 1978).

Statistical Analysis

Data obtained from the field measurements were subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. These software tools were employed to compute the regression parameters for the length–weight relationship, including the correlation coefficient (r) and the coefficient of determination (R^2).

Results and Discussion

Length–Weight Relationship

From the results in Table 1, the value of “b” for males was 0.41, for females 0.56, and for the combined sexes 0.39, while the corresponding correlation coefficients (r^2) were 0.72, 0.69, and 0.76, respectively. The “a” values ranged between 0.61 and 0.74, and the standard errors were within acceptable limits,

indicating the reliability of the regression analysis.

The study of length–weight relationship is important in understanding fish growth and assessing the condition of aquatic ecosystems (Froese, 2006). In this study, *Protopterus annectens* from Kware Lake exhibited a negative allometric growth pattern, as the “b” values obtained for males (0.41), females (0.56), and combined sexes (0.39) were all less than 3. This indicates that the fish increases more in length than in weight as it grows. This growth trend agrees with the findings of Adeyemi *et al.* (2019) and Ayoade and Ikulala (2021), who reported similar results in other tropical freshwater fishes. The negative allometry may be due to environmental conditions, feeding behavior, and the elongated body structure of the species. Overall, the pattern shows that *Protopterus annectens* is healthy and well adapted to its habitat, although body weight gain is slower compared to length increase.

Descriptive Mean of Length and Weight Distribution

Table 2 presents the mean values of total length (TL) and total weight (TW) distribution of *Protopterus annectens* sampled from Kware Lake. The data include the number of samples (N), mean, minimum, and maximum lengths and weights for both sexes and combined sexes. The combined sex samples recorded an average total length of 32.70 ± 1.42 cm and mean body weight of 100.90 ± 6.99 g, with a length range of 12.00–60.00 cm and a weight range of 10.00–320.00 g. For male specimens, the mean total length and weight were 33.00 ± 1.98 cm and 92.00 ± 8.85 g, respectively, while the female specimens had an average total length and weight of 32.11 ± 1.80 cm and 117.40 ± 10.89 g, respectively.

The mean total length and weight distribution of *Protopterus annectens* recorded from Kware Lake revealed an average total length of 32.70 ± 1.42 cm and mean weight of 100.90 ± 6.99 g for the combined sexes. Male fish recorded a mean length and weight of

33.00 ± 1.98 cm and 92.00 ± 8.85 g, respectively, while females had a mean length and weight of 32.11 ± 1.80 cm and 117.40 ± 10.89 g, respectively. The higher mean weight recorded in females suggests that they are generally heavier than males of similar length, which may be due to gonadal development during the breeding season. This observation agrees with the findings of (Ibrahim *et al.*, 2012), who reported that female fish often exhibit higher body weights due to the accumulation of egg mass and fat deposits. The wide variation in length and weight observed among the sampled individuals indicates a balanced population structure consisting of both juvenile and adult fish. Such variation may reflect successful recruitment, food availability, and suitable environmental conditions within Kware Lake.

Condition Factor (K)

Table 3 presents the mean condition factor (K) of *Protopterus annectens* from Kware Lake. The results showed that the mean condition factor (K) for males was 0.41, for females 0.34, and for the combined sexes 0.37, with all groups exhibiting a positive allometric growth pattern (+A). A higher K-value indicates that the fish are in better physical condition, which often correlates with adequate food availability, good environmental quality, and favourable physiological state. The observed slightly higher K-value in males compared to females could be due to differences in metabolic activity and reproductive status. Females may experience reduced condition during spawning periods as energy is redirected toward egg production.

The mean condition factor (K) of *Protopterus annectens* from Kware Lake was less than 1, suggesting that the fish were in moderate condition during the study period. Low K-values are often associated with seasonal food scarcity, reproductive stress, or environmental fluctuations (Ikomi & Sikoki, 2003). Despite this, the condition factor obtained falls within the acceptable range for tropical freshwater species (Ezenwaji *et al.*, 2018), indicating that Kware Lake provides a

suitable environment for the growth and survival of the species. Similar findings were reported by Bolarinwa (2019), who observed comparable K-values in elongated fish species.

Therefore, although *Protopterus annectens* shows negative allometric growth and moderate condition, the results suggest a stable and sustainable population within Kware Lake.

Table 1: Length-weight relationship of *Protopterus annectens* from Kware Lake

All samples sex	No	A	SE	B	SE	R ²
Male	50	0.73	0.07	0.41	0.04	0.72
Female	27	0.61	0.15	0.56	0.07	0.69
Combine sex	77	0.74	0.06	0.39	0.03	0.76

Table 2: Descriptive Mean of the Length–Weight Distribution of *P. annectens* from Kware Lake

All samples sex	NO	Total length (cm)			Weight (g)		
		Mean $\pm$ SD	Min.	Max.	Mean $\pm$ SD	Min.	Max.
Combine sex	77	32.701 $\pm$ 1.42	12.00	60	100.90 $\pm$ 6.99	10	320
Male	50	33.00 $\pm$ 1.98	12.00	55.30	92.00 $\pm$ 8.85	10.00	240
Female	27	32.11 $\pm$ 1.80	21.00	60	117.40 $\pm$ 10.89	50	320

Table 3: Condition Factor of *Protopterus annectens* from Kware Lake

All samples Sex	No	K	S.E	Growth pattern
Male	50	0.41	0.04	+A
Female	27	0.34	0.05	+A
Combine sex	77	0.37	0.04	+A

Conclusion

This study examined the length–weight relationship and condition factor of *Protopterus annectens* from Kware Lake, Sokoto State, to understand its growth pattern and ecological condition. The findings revealed that *P. annectens* exhibited a negative allometric growth pattern ($b < 3$), indicating that the fish grows more in length than in weight. The mean condition factor (K) was found to be less than 1, suggesting that the fish were in moderate physical condition throughout the study period. These results imply that while *Protopterus annectens* is well adapted to its environment, factors such as food availability, water quality, and seasonal changes may influence its growth and body composition. Overall, the study provides useful baseline information for understanding the population health and ecological status of this species in Kware Lake.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Further studies should be conducted on the feeding ecology, reproduction, and seasonal variation of *Protopterus annectens* to enhance knowledge of its biology and management.
2. Regular monitoring of water quality in Kware Lake is recommended to ensure a healthy aquatic environment suitable for fish survival and growth.
3. Fishing activities should be properly regulated to prevent overfishing and to allow natural population recovery and size variation.
4. The physico-chemical parameters of the lake should be examined periodically and corrective measures taken when necessary to maintain ecological balance.
5. Awareness programs should be organized for local fishermen on the importance of

sustainable fishing practices to ensure long-term conservation of *Protopterus annectens* and other aquatic resources.

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