

## MORPHOLOGICAL CHARACTERISTICS AND STATE OF WELL BEING OF THREE CICHLID SPECIES (CICHLIFORMES, CICHLIDAE) IN LAKE ALAU, SEMI-ARID ZONE, NIGERIA

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### ABSTRACT

Fish food supply from inland waters are plummeting due to the global environmental changes. Information on growth dynamics of fish populations is key to understanding the status of stock for effective planning and management decision. This study investigated the growth patterns and state of well-being of three cichlid species in Lake Alau, Nigeria. A total of 50 specimens each of *Coptodon zillii*, *Oreochromis aureus* and *Sarotherodon melanotheron* were examined using 9 morphometric parameters. The 'b' value for *C. zillii*, *O. aureus* and *S. melanotheron* were 2.069, 1.518 and 1.914, respectively while the regression equation for *C. zillii* was  $\text{Log } W = 2.069 - 0.291 \text{ Log } L$ ,  $\text{Log } W = 1.518 + 0.093 \text{ Log } L$  for *O. aureus* and  $\text{Log } W = 1.914 - 0.320 \text{ Log } L$  for *S. melanotheron*. The condition factor was  $2.32 \pm 0.63$ ,  $1.87 \pm 0.50$  and  $1.71 \pm 0.20$  for *C. zillii*, *O. aureus* and *S. melanotheron*, respectively. The three cichlid species exhibited negative allometric growth pattern, and were all in good physiological condition in Lake Alau. Mean size of all the morphometric parameters show significant higher values in *O. aureus* compared to *C. zillii* and *S. melanotheron*. This study will assist in conservation and sustainable management of these stock in Lake Alau.

**Keywords:** Cichlid fishes, morphometric analysis, artisanal fisheries, Lake Alau, Sustainability

### INTRODUCTION

Tropical freshwater commercial and artisanal fisheries are key components of food security in Africa. It provides cheapest and healthy source of animal protein for hundreds of thousands of people and many more in Africa depend on capture fisheries for their livelihood (Obiero *et al.*, 2018). In Nigeria, inland waters (e.g., rivers, lakes and reservoir) are surrounded by artisanal fishermen who engage in fishing operation on daily basis for sustenance. These waters are very rich in resources with over 300 fish species inventoried (Olaosebikan and Raji, 2013). However, the face of artisanal fisheries in Nigeria is changing due to incessant weather changes, pollution and overexploitation of fisheries resources (Aphunu and Nwabeze, 2013). These problems have caused many inland waters to recede, and declined resources. Therefore, knowledge of growth dynamics and condition factor of fish populations are required to enhance effective stock management and conservation.

The Cichlid species of the family Cichlidae (order Perciformes) often referred to as Tilapias are abundant in Nigeria inland waters including Lake Alau, where they are exploited for food and ornamental purpose. They are highly valued food fishes and most aquaculturally important resources after Clariid species in Nigeria. The fish has a

delightful taste, tender texture, with good source of vitamins, minerals, and Omega-3 fatty acids that make it a healthy food (Karapanagiotidis, 2016). The preponderance of cichlid fishes in Lake Alau support the demand for fish protein, and contribute vastly in solving the problem of food security, malnutrition and micronutrient deficiencies among the riparian communities and metropolis. In any case, the potential of these species is becoming compromised lately due to changes in riparian structure and function, chemical and organic pollution, overfishing and destructive fishing practices, alterations in hydrological regimes and global climatic changes.

Length and weight are basic parameters for estimation of standing stock biomass and to compare the ontogeny of fish population from different water bodies for sustainable fish production (Olanrewaju *et al.*, 2016). The relationships between length and weight provide information on species status in an environment and characterize patterns of growth (Froese, 2006). Fisheries scientist have commonly been analyzed data on the length and weight to yield biological information. Meanwhile, the knowledge of morphometric parameters offers valuable data for the differentiation of taxonomic units and identifying differences between fish population. Also, the interplay between environmental factors

and fish morphology in freshwater systems is vital for predicting how these species will adapt to changing conditions. Moreover, without a comprehensive understanding of these relationships, it becomes challenging to assess the impacts of environmental changes and human activities on fish health and population viability.

Although, previous studies on Lake Alau have explored the growth patterns and ecology of various fish species (Olanrewaju *et al.*, 2021; Olanrewaju and Agbelege, 2019a; Olanrewaju and Agbelege, 2019b; Olanrewaju *et al.*, 2017), there is a notable lack of specific data on the allometry, condition, and morphometric characteristics of cichlid species. Addressing this knowledge gap is critical for informing sustainable management practices for these commercially and nutritionally important fish. This research is thus, undertaken to determine the allometry, condition and morphometry of *Sarotherodon melanotheron*, *Oreochromis aureus* and *Coptodon zillii* in Lake Alau,

## MATERIALS AND METHODS

### Study area

The study was carried out in Alau Lake, which is located about 22 km from Maiduguri, along Bama road in Borno State (Fig. 1). The Lake is the second largest in Borno State, Nigeria and lies within the geographical coordinates of 11°39'84"-11°40'02"N Latitude and 13°39'92"-13°40'12"E Longitude at the highest altitude of about 354m above sea level (Olanrewaju *et al.*, 2017). It has been noted to serve dual functions of potable water source and artisanal fisheries domain in Borno State.

### Statistical analysis of data

The relationship between the length (L) and weight (W) of the fish samples was expressed by the equation (Le Cren, 1951):

$$W = a L^b \quad \dots\dots\dots \text{Equation 1}$$

Where; W = Weight of fish in gram (g);

L = Total Length (TL) of fish in centimeter (cm);

a = Constant (intercept);

b = Slope (i.e., change in weight per unit change in Length)

The parameters 'a' and 'b' that was obtained from a least square linear regression (Zar, 2010) of the length and weight of Eq. (1), to derive:

$$\text{Log}_{10} W = \text{Log}_{10} a + b \text{Log}_{10} L$$

The Fulton's condition factors (K) of fish as expressed by Bagenal and Tesch, (1978) was used to estimate the well-being of the fishes, that is, compare the health or fattening of the fishes. This was estimated using the relationship:

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

Where;

K = condition factor;

W = weight of fish (g);

L = length of fish (cm).

### Collection of fish specimens

A total of 50 samples each of Black chin tilapia (*Sarotherodon melanotheron*), Mango tilapia (*Oreochromis aureus*), and Redbelly tilapia (*Coptodon zillii*) were collected from various landing sites at Lake Alau and used for the study. The collected specimens were mainly juveniles, which constitute the bulk of fish harvest of the artisanal fishermen in Lake Alau during the period of study. The significant of this study lies in these predominant sizes in artisanal fisher's catch. Fish samples were collected weekly for two months (September and November, 2024). These specimens were identified by the use of field guides of Idodo-Umeh (2003) and Olaosebikan and Raji (2013). The specimens of each species were measured and weighed in-situ, while their biometrics was recorded separately on different record sheets.

### Sample identification and morphometric measures

Nine morphometric characters were measured with respect to each individual and species. Morphometric measurements consisted of total body length (TL), standard length (SL), eye diameter (ED), head length (HL), dorsal fin length (DL), pectoral fin length (PL), pelvic fin length (PvL), anal fin length (AL), and caudal fin length (CL) were considered. The measurements taken was defined in Table 1. The individual body weight (BW) was measured to the nearest 0.1 g by the use of a digital analytical balance (Camry model EK5350), while linear measurements were made to the nearest 0.1 cm using 30 cm wooden board. Repeated measures of all individuals are taken by multiple observers to avoid measurement error.

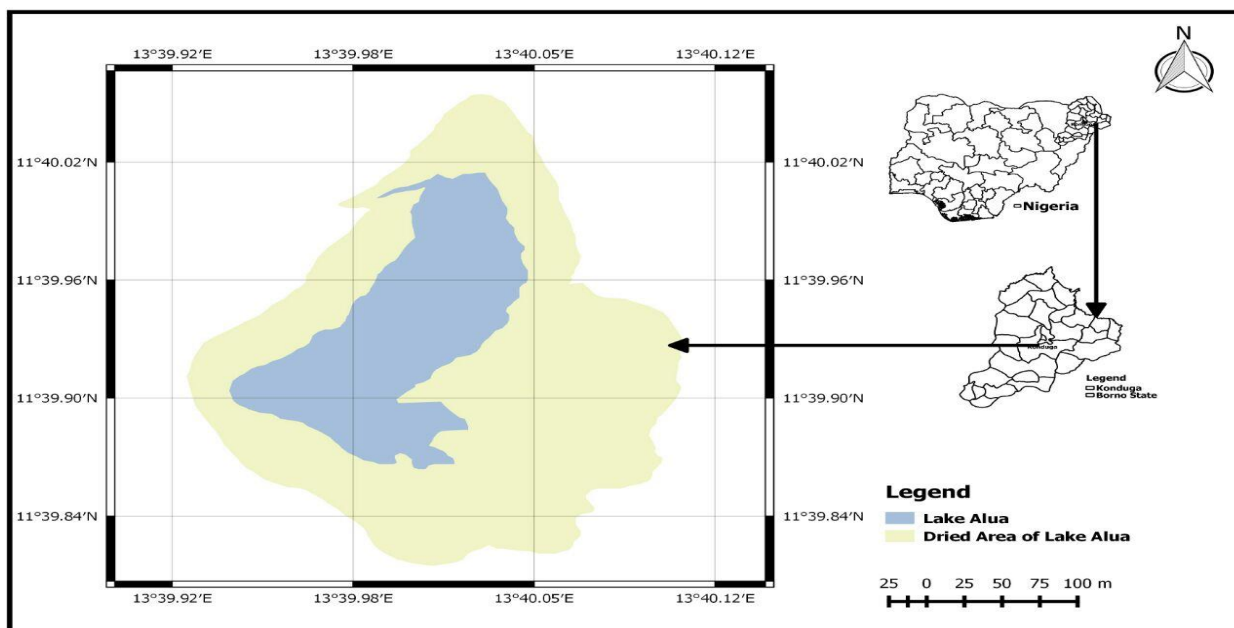


Figure 1. Map of Lake Alau

**Table 1: Details of morphometric parameters of the three Cichlid species in the study**

Parameters	Measurements
Total length	Length from tip of the snout (mouth closed) to the extended dorsal tip of the caudal fin
Standard length	Length from the tip of the snout to the mid-lateral tip of the caudal peduncle
Eye diameter	Length from the horizontal distance between both lateral eye margins
Head length	Length from the front of the snout to the back of the operculum
Dorsal fin length	Length from the start of the fin to the end by the dorsal side
Pectoral fin length	Distance between the origin and place of insertion into the body to the extreme tip
Pelvic fin length	Distance between the origin and place of insertion into the body to the extreme tip
Anal fin length	Length from the start of the fin to the end by the anal side
Caudal fin length	Length from the caudal region to the end of the fin
Body weight	Weight of the body

The linear measurements data collected were analysed using mean, standard error, standard deviation, maximum and minimum and recorded for each species separately. The coefficient of variation (CV%) was computed as:

$$CV\% = \frac{100 \times SD}{x}$$

Where;

SD = standard deviation;

X = mean of the measurements of morphometric characters in each species.

The Statistical Programming for Social Science (SPSS, version 20.0) software was used to analyze the data from condition factors and morphometry. One-way Analysis of Variance (ANOVA) followed

by Fisher’s LSD post-hoc test was used to test the significance of differences in the condition factor and morphometric traits between species ( $p < 0.05$ ). The data generated from the condition factor,

morphometric characters and weights were subjected to descriptive statistics (mean and standard deviation). The relationships between morphometric characters were performed by correlation and regression analyses using SPSS. The Length-weight relationships (LWRs) was calculated from linear regression analysis using FISAT II software. Student t-test comparison was performed to determine whether each species is statistically significantly different from the predictions assigned for isometric growth ( $b = 3$ ).

**RESULTS**

**Length and Body Weight Attributes of Fish Samples**

The length and weight attributes of examined three species of Cichlidae fish in the study are presented in Table 2. The body weight presented the following mean values: 18.16±9.92 g for *Coptodon zillii*, 23.40±5.99 g for *Oreochromis aureus*, and 13.64±6.23 for *Sarotherodon melanotheron*. There was significant difference ( $p < 0.05$ ) in the mean weight values obtained between the fish samples. *Sarotherodon melanotheron* had significant lower standard length (5.47±1.11 cm) compared to *O. aureus* (6.67±0.96 cm) and *C. zillii* (6.03±3.97 cm). *Oreochromis aureus* had significant highest mean total length (10.72±1.33 cm) followed by *Sarotherodon melanotheron* (9.04±1.25 cm), while

*Coptodon zillii* had the least (8.92±2.42 cm). However, there was no significant difference in total length between *Sarotherodon melanotheron* and *Coptodon zillii*.

**Length-Weight Relationships and Condition Factor**

Table 3 showed the condition factor and regression coefficient for length-weight relationships of the fish samples. The correlation coefficient for *C. zillii* (0.95) and *S. melanotheron* (0.81) is highly significant ( $p < 0.05$ ), but *O. aureus* show the least correlation coefficient of 0.68. The growth exponent ‘b’ ranged from a minimum of 1.52 for *O. aureus* to a maximum of 2.07 for *C. zillii*. The estimated relationships showed negative allometry in all the three fish species. This indicates that the body changes form is not proportionate to the body weight (following cube law; volume =  $L^3$ ). Significant differences were observed between standard length and body weight in all the three sampled species ( $P < 0.05$ ). The condition factor varies between 1.55 and 3.70 in *Coptodon zillii*, between 0.91 and 3.71 in *Oreochromis aureus* and between 1.37 and 2.10 in *Sarotherodon melanotheron*. Significantly mean higher ( $p < 0.05$ ) condition factor (2.32±0.63) was found in *C. zillii*. However, there was no significant difference in condition factor between *O. aureus* (1.87±0.50) and *S. melanotheron* (1.71±0.20).

**Table 2:** Lengths and body weight attributes of the three Cichlid species in the study

Parameters	Fish species		
	<i>Coptodon zillii</i>	<i>Oreochromis aureus</i>	<i>Sarotherodon melanotheron</i>
SL Range (cm)	3.00 – 8.50	4.50 – 8.00	3.50 – 7.00
Mean SL (cm)	6.03±3.97 <sup>ab</sup>	6.67±0.96 <sup>a</sup>	5.47±1.11 <sup>b</sup>
TL Range (cm)	5.50 – 13.00	8.00 – 13.00	6.50 – 11.00
Mean TL (cm)	8.92±2.42 <sup>b</sup>	10.72±1.33 <sup>a</sup>	9.04±1.25 <sup>b</sup>
BW Range (g)	5.00 – 42.00	9.00 – 37.00	4.00 – 28.00
Mean BW (g)	18.16±9.92 <sup>b</sup>	23.40±5.99 <sup>a</sup>	13.64±6.23 <sup>c</sup>

SL Standard length, TL Total length, BW Body weight, cm centimeter, g gramme. Means across the same row differently superscripted differ significantly ( $P < 0.05$ ).

**Table 3.** Condition factor and regression coefficient for Length-weight relationships of the three Cichlid species in the study

Parameters	Fish species		
	<i>Coptodon zillii</i>	<i>Oreochromis aureus</i>	<i>Sarotherodon melanotheron</i>
a	-0.29	0.09	-0.32
b	2.07	1.52	1.91
MSE (b)	0.09	0.18	0.16
r <sup>2</sup>	0.95	0.68	0.81
P-value	<0.05	<0.05	<0.05
Allometry	Negative (-)	Negative (-)	Negative (-)
K range	1.55 – 3.70	0.91 – 3.71	1.37 – 2.10
Mean K	2.32±0.63 <sup>a</sup>	1.87±0.50 <sup>b</sup>	1.71±0.20 <sup>b</sup>

a intercept, b growth exponent, MSE (b) mean standard error of growth exponent, r regression coefficient, r<sup>2</sup> coefficient of determination, K condition factor. Means across the same row differently superscripted differ significantly (P<0.05).

**Morphometric Characteristics of Fish Samples**

Table 4 presents the summary of the nine morphometric characters assessed in the study. Descriptive analysis of morphometric variables reveals that mean sizes of all selected characters were found significantly higher in *O. aureus* compared to those of *C. zillii* and *S. melanotheron*. However, there was no significant difference in head length between *O. aureus* (1.88±0.24 cm) and *C. zillii* (2.01±0.51 cm). Also, slight difference was observed in standard length between *O. aureus* (6.67±0.96 cm) and *C. zillii* (6.03±3.97 cm). The coefficients of variation (CV) values of *C. zillii* population were relatively high (CV>25%) in total length (27.13%), standard length (65.84%), head length (25.37%), pectoral fin length (26.67%), pelvic fin length (30.44%), and caudal fin length (26.29%). The CV values of *O. aureus* population were relatively low (CV<25%) for all the measured variables (between 10.65 and 20.17%). The lowest value (10.65%) was recorded for caudal fin length while the highest (20.17%) was registered for pectoral fin length. The CV values of *S. melanotheron* were also found relatively low (CV<25%) for all standardised variables. The lowest value (8.98 %) was noted for head length while the highest (20.29%) was recorded for head length. The data presented in Tables 5, 6 and 7 show correlation

analysis of the morphometric parameters of the three Cichlid species in the study. Pearson’s correlation analysis shows that only total length and body weight were significantly positively correlated (r = 0.91, p<0.05) in *Coptodon zillii*, while the rest like in *Oreochromis aureus* and *Sarotherodon melanotheron* show no correlation at p<0.05.

**DISCUSSION**

This current study aimed at assessing the allometry, condition and morphometry of three cichlid species in the Lake Alau, Semi-arid Nigeria. The study findings revealed that the sizes (length and weight) of *O. aureus* is significantly bigger than those of *C. zillii* and *S. melanotheron*. Olanrewaju (2021) obtained similar result where *Oreochromis niloticus* had significant higher mean length (18.06±5.55 cm) and weight (257.96±263.72 g) than those of *Coptodon zillii* (15.57±4.51 cm, 168.83±170.88 g) and *Hemichromis fasciatus* (13.20±2.07, 87.12±35.31 g) in Eleyele Lake, Nigeria. However, the three species studied in the present study show low catch weight, which is an indication of overexploitation and degradation of ecological condition as advanced by Ecoutin and Albaret (2003). Sizes of *C. zillii*,

**Table 4.** Statistical results of the selected morphometric characters of three cichlid species in the study

Morphometric characters	<i>C. zillii</i>		<i>O. aureus</i>		<i>S. melanotheron</i>	
	Mean±SD	CV (%)	Mean±SD	CV (%)	Mean±SD	CV (%)
Total length	8.92±2.42 <sup>a</sup>	27.13	10.72±1.33 <sup>b</sup>	12.41	9.04±1.25 <sup>a</sup>	13.83
Standard length	6.03±3.97 <sup>ab</sup>	65.84	6.67±0.96 <sup>b</sup>	14.39	5.47±1.11 <sup>a</sup>	20.29
Eye diameter	0.63±0.12 <sup>a</sup>	19.05	0.71±0.08 <sup>b</sup>	11.26	0.62±0.07 <sup>a</sup>	11.29
Head length	2.01±0.51 <sup>b</sup>	25.37	1.88±0.24 <sup>b</sup>	12.77	1.67±0.15 <sup>a</sup>	8.98
Dorsal fin length	4.21±0.93 <sup>a</sup>	22.09	4.85±0.67 <sup>b</sup>	13.81	4.30±0.54 <sup>a</sup>	12.56
Pectoral fin length	1.65±0.44 <sup>a</sup>	26.67	2.43±0.49 <sup>b</sup>	20.17	1.57±0.20 <sup>a</sup>	12.74
Pelvic fin length	1.38±0.42 <sup>b</sup>	30.44	1.56±0.28 <sup>c</sup>	17.95	1.12±0.13 <sup>a</sup>	11.61
Anal fin length	1.31±0.30 <sup>a</sup>	22.90	1.68±0.23 <sup>b</sup>	13.69	1.25±0.15 <sup>a</sup>	12.00
Caudal fin length	1.75±0.46 <sup>a</sup>	26.29	2.16±0.23 <sup>b</sup>	10.65	1.88±0.20 <sup>a</sup>	10.64

CV coefficient of variation, SD standard deviation. Means across the same row differently superscripted differ significantly (P<0.05).

**Table 5.** Pearson correlation table for morphometric parameters of *C. zillii* population from Lake Alau, Nigeria

	BW	TL	SL	ED	HL	DFL	PCFL	PVFL	AFL	CFL
BW	1									
TL	0.91 <sup>*</sup>	1								
SL	0.46 <sup>**</sup>	0.16	1							
ED	0.93 <sup>**</sup>	0.92 <sup>**</sup>	0.46 <sup>**</sup>	1						
HL	0.96 <sup>**</sup>	0.88 <sup>**</sup>	0.52 <sup>**</sup>	0.92 <sup>**</sup>	1					
DFL	0.94 <sup>**</sup>	0.92 <sup>**</sup>	0.47 <sup>**</sup>	0.97 <sup>**</sup>	0.93 <sup>**</sup>	1				
PCFL	0.93 <sup>**</sup>	0.87 <sup>**</sup>	0.48 <sup>**</sup>	0.91 <sup>**</sup>	0.96 <sup>**</sup>	0.88 <sup>**</sup>	1			
PVFL	0.91 <sup>**</sup>	0.80 <sup>**</sup>	0.60 <sup>**</sup>	0.88 <sup>**</sup>	0.91 <sup>**</sup>	0.88 <sup>**</sup>	0.93 <sup>**</sup>	1		
AFL	0.94 <sup>**</sup>	0.88 <sup>**</sup>	0.45 <sup>**</sup>	0.92 <sup>**</sup>	0.93 <sup>**</sup>	0.93 <sup>**</sup>	0.91 <sup>**</sup>	0.88 <sup>**</sup>	1	
CFL	0.93 <sup>**</sup>	0.92 <sup>**</sup>	0.45 <sup>**</sup>	0.95 <sup>**</sup>	0.94 <sup>**</sup>	0.97 <sup>**</sup>	0.91 <sup>**</sup>	0.90 <sup>**</sup>	0.95 <sup>**</sup>	1

\*\* Correlation is significant at the 0.01 level (2-tailed), \* Correlation is significant at the 0.05 level (2-tailed)

Table 4.6. Pearson correlation table for morphometric parameters of *O. aureus* population from Lake Alau, Nigeria

	BW	TL	SL	ED	HL	DFL	PCFL	PVFL	AFL	CFL
BW	1									
TL	0.88**	1								
SL	0.82**	0.99**	1							
ED	0.92**	0.94**	0.88**	1						
HL	0.80**	0.83**	0.76**	0.84**	1					
DFL	0.86**	0.98**	0.98**	0.90**	0.79**	1				
PCFL	0.85**	0.94**	0.91**	0.88**	0.77**	0.86**	1			
PVFL	0.88**	0.89**	0.82**	0.93**	0.81**	0.87**	0.91**	1		
AFL	0.78**	0.90**	0.90**	0.79**	0.69**	0.94**	0.89**	0.78**	1	
CFL	0.82**	0.78**	0.70**	0.86**	0.57**	0.76**	0.81**	0.86**	0.71**	1

\*\* Correlation is significant at the 0.01 level (2-tailed), \* Correlation is significant at the 0.05 level (2-tailed)

Table 7. Pearson correlation table for body weight and morphometric parameters of *S. melanotheron* population from Lake Alau, Nigeria

	BW	TL	SL	ED	HL	DFL	PCFL	PVFL	AFL	CFL
BW	1									
TL	0.95**	1								
SL	0.91**	0.97**	1							
ED	0.78**	0.89**	0.89**	1						
HL	0.51**	0.52**	0.33**	0.41**	1					
DFL	0.88**	0.97**	0.91**	0.91**	0.62**	1				
PCFL	0.92**	0.89**	0.87**	0.80**	0.48**	0.82**	1			
PVFL	0.89**	0.83**	0.75**	0.72**	0.64**	0.80**	0.87**	1		
AFL	0.88**	0.79**	0.71**	0.68**	0.67**	0.78**	0.89**	0.96**	1	
CFL	0.54**	0.57**	0.41**	0.50**	0.73**	0.65**	0.51**	0.52**	0.62**	1

\*\* Correlation is significant at the 0.01 level (2-tailed), \* Correlation is significant at the 0.05 level (2-tailed)

*S. melanotheron* and *O. niloticus* obtained from this study is similar to that recorded from works done by Silga *et al.*, (2024). El-Bokhty and Fetouh (2023) revealed the length range of 9.5 and 21.5cm in *O. niloticus* and *O. aureus* from El-Salam Canal, Egypt. According to Silga *et al.*, (2024) these low catch sizes suggests non-compliance with the regulations concerning the size of the mesh of the nets.

The present work shows high degrees of the coefficient of determination ( $R^2$ ) of the length-weight relationships (LWRs) of the three Cichlidae (*O. niloticus*, *S. galilaeus* and *C. zillii*), which implied that the length increases with increase in weight of the fish (Olanrewaju *et al.*, 2017). Silga *et al.*, (2024) also noted that the high values of the  $R^2$  of the LWRs of these three species indicate good quality of the measurements and a strong relationship between the two parameters. Similar observations on cichlid species were reported by Olanrewaju *et al.*, (2016) in Asejire Lake, Olanrewaju *et al.*, (2017) in Eleyele Reservoir, and Kareem *et al.*, (2017) in Erelu Lake, all in Southwest Nigeria. Strong relationships in length and weight parameters have also been reported on cichlid fishes from Ghana (Alhassan *et al.*, 2015), Burkina Faso (Silga *et al.*, 2024), and Egypt (Shalloof *et al.*, 2024).

The estimated relationships result showed that the three cichlid species examined in this study exhibited allometric growth pattern where the length increased disproportionately to weight. Kareem *et al.*, (2023) advanced that growth is isometric when there is no change in body proportion and specific gravity, while allometric growth is characterized with dimensional change with growth. The b-values in the present study coincides with the study of Dankishiya (2013) and Imam *et al.*, (2010) on cichlid species from lower Usuma Reservoir, Abuja and Wasai Reservoir, Kano respectively. Silga *et al.*, (2024) also found similar growth exponent value (b) of 2.81 (negative allometric) for *Coptodon zilli* but 3.05 (isometric) for *Oreochromis niloticus* and *Sarotherodon galilaeus* from Volta basin, Burkina Faso. The findings also contradict that of Shalloof *et al.*, (2024) in *O. niloticus* (2.9615 – 3.0325), *O. aureus* (2.8178 – 3.0114), *C. zillii* (2.8503 – 2.951) and *S. galilaeus* (2.9238 – 3.2075) from Manzala Lagoon, Egypt. The b-values range (1.52 – 2.07) obtained in this study fell short from the recommended range values (2.5 – 3.5) by Froese (2006). The negative allometric growth established in the three cichlid species studied indicate hypoallometry where increase in length is not equal to the weight, thus, the fish becomes more-slender as they increase in weight. This growth pattern might be attributed to environmental conditions or linked to morphological characteristics specific to each species as identified by Jisr *et al.* (2018). This

can justify the fact that Lake Alau is prone to overfishing through obnoxious fishing means which violates the ethical standard that sustain productivity in Lake fisheries. Vega-Cendejas *et al.*, (2023) however suggested that the lower values ( $b < 3$ ) may have resulted from the fact that the majority of the specimens analyzed were juveniles due to their type of habitat.

The condition factor (K), which is a quantitative index that indicates the health of fish show values greater than 1 ( $1.71 \pm 0.20 - 2.32 \pm 0.63$ ), which indicate that the three cichlid species examined in this study enjoy good general environmental condition as predicated by Le Cren (1951). The range of K-value in present study is related to the values ( $1.75 \pm 0.58 - 1.89 \pm 0.68$ ) catalogued by Shalloof *et al.*, (2024), Silga *et al.*, (2024) and Dan-Kishiya (2013) for cichlid species from various freshwater bodies. However, the K-values in this study is greater than that recorded in the study of Olanrewaju (2021) in Eleyele Lake, Olufeagba *et al.* (2015) in Kainji Lake, and Alhassan *et al.* (2015) in Golinga Reservoir. By implication of the condition factor results in this study, it means these cichlid species are thriving in the Lake Alau. However, the species could be at the detriment of overfishing through the use of unregulated fishing nets. A study of the range and mean of various morphometric data in the present study showed that *O. aureus* grow markedly larger in size than *C. zillii* and *S. melanotheron*. However, there is little or no significant differences between measured variables in *C. zillii* and *S. melanotheron*. This type of variations in measured variables has been observed by Soyinka *et al.* (2022) in *C. zillii* and *S. melanotheron* from Lagos Lagoon, Nigeria.

## CONCLUSION

The growth pattern of three cichlid species in this study indicate negative allometry with strong association between length and weight. The species enjoy good well-being for growth and survival in Lake Alau. Coefficient of variation values estimated revealed low intra-group variation for all characters in *C. zillii* and *S. melanotheron*, but high in *O. aureus*. The morphometric parameters in *O. aureus* were high compared to *C. zillii* and *S. melanotheron*. The study establishes the growth pattern, condition and morphometry of *C. zillii*, *O. aureus* and *S. melanotheron* in Lake Alau, Nigeria. The negative allometric growth pattern of cichlid populations in this study can be attributed to overfishing, which did not allow for proper growth and development of the stock. Based on this, continuous monitoring and responsible fishing is advocated in the lake through the use of regulated mesh size. Future studies should attempt to understand the influence of the physicochemical variables of the Lakes' water on the growth pattern of these species. This will assist

in conservation and management of these stock for sustainable use of the people.

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#### AUTHOR CONTRIBUTION

OAN design the study, interpret the data and wrote the draft of the manuscript; OKK contribute, reviewed and edited the manuscript, MOA analysed the data and contributed in writing the draft of the manuscript; SE collect the data. All authors approved the manuscript for submission.