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Morphometric, Meristic and Conditional Factor Characterization of Redbelly Tilapia (*Coptodon zillii*) in Lake Komadugu, Yobe State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This research was carried out to study the morphological characteristics of *Coptodon zillii* from Lake Komadugu in Yobe State, Nigeria using morphometric measurements, meristic counts and length-weight relationship. A total of 60 specimens of *Coptodon zillii* were purchased from the fisher folks at landing site in Lake Komadugu, examined and analyzed for morphometric and meristic characterization. The results revealed that all the morphometric characters of *C. zillii* in Lake Komadugu varied whereas some meristic characters including mean number of rays on pectoral fin (8.00 ± 0.00), pelvic fin ray (5.00 ± 0.00), anal fin spine (3.00 ± 0.00), pelvic fin spine (1.00 ± 0.00) and number of lateral line (2.00 ± 0.00) were constant. A significant linear relationship was established and represented by the equation: $W = 0.008SL^{2.097}$ (r =0.6410 d.f. = 58) for male, $W = 0.001SL^{3.013}$ (r = 0.9600 d.f. = 58) for female. Mean condition factor which was not significantly different (p>0.05) showed that male *C. zillii* had 1.80 ± 0.27, female (1.92± 0.26) and pooled sex (1.86 ± 0.25). Findings of this study implies that *C. zillii* from Lake

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Komadugu are in good health. In conclusion, these findings are very useful in stock assessment, population dynamics, sustainable management and conservative measures of *C. zillii* in Lake Komadugu.

Keywords: Coptodon zillii; Lake Komadugu; meristic counts; morphometric character.

1. INTRODUCTION

Tilapia which belongs to the family Cichlidae is the common name applied to three genera (*Sarotherodon*; *Oreochromis* and *Tilapia*) including about 70 species [1]. The Redbelly tilapia (*Coptodon zillii*), is one of the most valued and predominant African native fish species with the highest number of catches in Northeast Nigeria [2,3]. It is a cheap source of highly nutritive protein and is widely acceptable due to its high fillet quality and good taste. It is also an important food fish that can be cultured in either fresh or salt water in tropical and subtropical climates [4].

C. zillii are successful species in the aquaculture industry for several reasons such as resistance to diseases, high stocking density of fish, hardiness, tolerance to poor water quality including low dissolved oxygen level and high tolerance to salinity in wide range [5]. In addition, the biology of *C. zillii* has shown that they are prolific breeders which grow and survive in a wide range of natural and artificial conditions. As a good aquaculture species, *C. zillii* accepts artificial feeds with a better food conversion ratio, fast grow rate with a high yield potential and wide acceptability by fish consumers. Additionally, other cultivable characteristics exhibited by tilapia include high market value, high meat quality and good taste [6]. Tilapia can be grown in a variety of culture systems ranging from simple systems with little infrastructure to more intensive and complex systems [7,8]. The study on meristic and morphometric characters in fishes is very important because they are useful in spotting the differences between fish population and in differentiation of taxonomic units. Morphometric measurement and meristic count which have been widely used to identify fish stocks remains the simplest and most direct way among methods of species identification, source of information for taxonomic and evolutionary studies [9]. Morphometric and meristic studies of animals are part of the vigorous tools for measuring discreteness of the same species [10]. Morphology, which is the study of form and structure of organisms, is very important in biology. These traits reveal the inter-relations between the various body parameters like length, weight, fecundity etc. Meristic traits are the countable structures occurring in series in fish such as myomeres, vertebrate, fin rays etc. These characters are among those most commonly used for differentiation, identification of species populations and establishing evolutionary relationships [11,12]. In fisheries science, morphometric analysis helps in understanding the relationship between body parts [13] and to know the origin of stock, separation of stocks, or identification of the commercially-important species of fishes [14,15,16]. Studies on morphological variations in fish populations are also useful in phylogenetics and in providing information for subsequent studies on the genetic improvement of stocks. Morphological variation between populations can provide a basis for population structure, and may be applicable for studying short-term, environmentally induced variation geared towards successful fisheries management [17,18]. According to Goncalves et al., [19], Froese and Pauly [20], Mohammed [21] and Mwanja et al., [22], morphological change and divergence within species are expected to take place when fishes are exposed to new developmental and evolutionary forces that determine their body forms. In Nigeria, reports on morphological diversity of fishes within populations of the same species includes studies by Omoniyi and Agbon [23]; Solomon et al. [24]; Oladimeji et al. [25]; Ukenye et al. [26] etc. Length-weight relationship is a crucial growth index used by fishery biologists as a tool for sustainable fisheries management [27]. Length-weight relationship is used in estimating growth rate [28], estimating the average weight of fish from a known length group [29], converting growth in-length equations to growth-in-weight in stock assessment models [30], estimating length and age structures [31] and biomass estimation from length frequency distributions [32]. The importance of condition factor is widely related to the well-being or health status, growth and feeding intensity in different fish species [33]. The hypothesis stating that heavier fish of a given length are in better condition is used in interpreting condition factor in fish [34]. Condition factor also indicates the degree of food availability, suitability and health status and a specific water body and state of sexual maturity [35]. The Redbelly tilapia (*C. zillii*) is one of the common and important food fish species in the catches of fishers in Lake Komadugu. However, it is observed that the decrease of *C. zillii* in the catches of fishers is tremendous coupled with the paucity of information on some important aspects of the biology of this species which indicates need to study and document information on the morphometry of *C. zillii* in order to help in planning of conservation and management strategies of this fish species. This study was therefore carried out to assess the population of *Coptodon zillii* from Komadugu Lake in Yobe State, Northeast, Nigeria through their morphometric characteristics, meristic traits, length-weight relationship and condition factor.

2. MATERIALS AND METHODS

2.1 Study Area

The sampling was conducted at the Komadugu Lake, Yobe River basin in Yobe State, Nigeria (Fig. 1). The Komadugu Lake is geographically located between Latitude 10º30"N – 13 º5"N and Longitude 8º20"E – 15º5"E, which has a catchment area of approximately 32,900 Km^2 (Bukar et al., 2018).

2.2 Collection of Fish Samples

A total number of sixty (60) freshly caught samples of *C. zillii* were randomly selected and bought from commercial fishermen at the landing site of Komadugu Lake between January and February, 2020. The fishermen used a wide range of fishing gears such as cast nets, gillnets, and non-return (gura trap) to catch fish, and an outboard engine canoe to convey the fish to the landing site. Fish samples were immediately immersed in 10% formalin and transported to the laboratory of Department of Fisheries and Aquaculture, Faculty of Marine Environmental Management, Nigeria Maritime University, Delta State, where the fish samples were identified by using keys and works provided by [36].

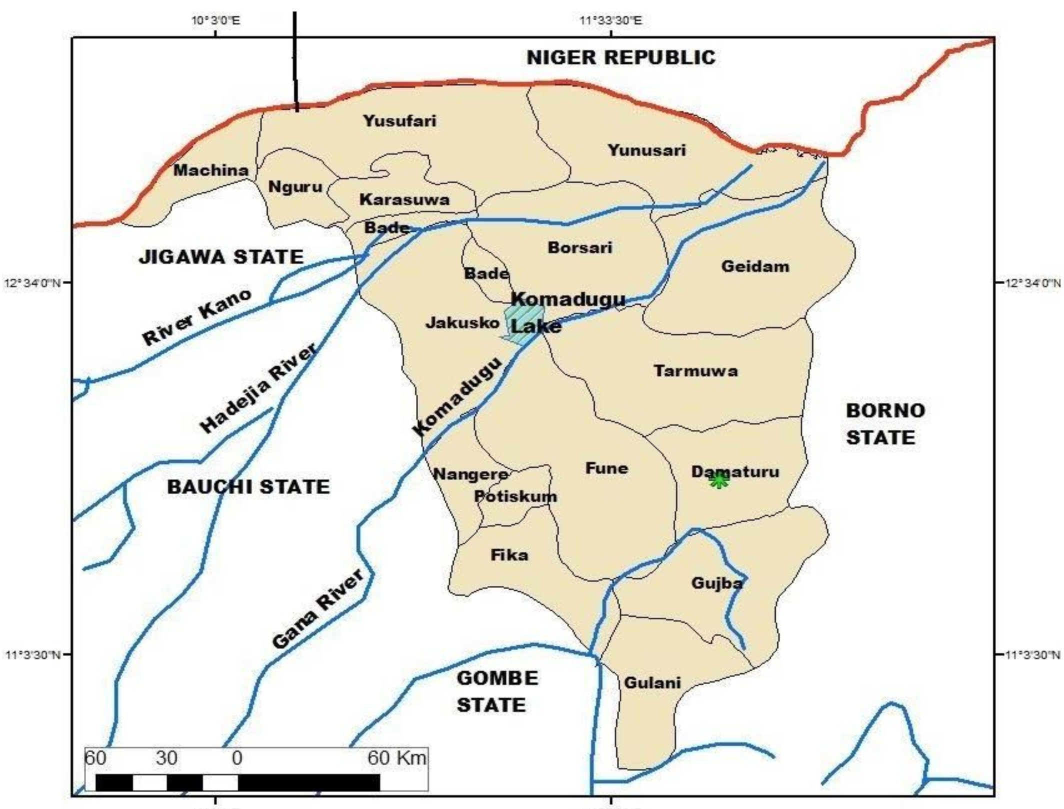

Fig. 1. Map showing the study area

2.3 Measurement of Morphometric Characters

Data on morphometric characters such as standard length, total length, mouth diameter, anal fin length, pelvic fin length, eye diameter, dorsal fin length, head length, caudal fin length, pectoral fin length, body depth (plate 1) and body weight were measured according to Olaosebikan and Raji [37] within 24 hours using a digital Vernier calliper and a measuring board to the nearest cm. Total body weight, measured with a sensitive Sartorius balance (Model, EB3) to the nearest 0.1 g. The description of the morphometric characters measured are as follows:

Standard length (SL-cm): Distance from the tip of the snout to the end of hypural plate.

Total length (TL-cm): The distance from tip of the snout to the tip of longest caudal fin ray. Gape Width (GW-cm): Distance between corners of mouth gap.

Anal fin length (AFL-cm): Length of the longest anal fin ray. Pelvic fin length (PFL-cm): Length of the longest pelvic fin ray.

Eye diameter (ED-cm): Distance from the posterior to the anterior eye rims in the longitudinalaxis

Dorsal fin length (DFL-cm): Length of the longest dorsal fin ray.

Head length (HL-cm): The distance from tip of the snout to the posterior point of opercular membrane.

Caudal fin length (CFL-cm): Length of the longest caudal fin ray. Pectoral fin length (PFL): Length of the longest pectoral fin ray.

Body depth (BD-cm): The distance from the ventral surface of the fish at deepest part to theanterior end of first dorsal fin.

Body weight (BW-g): this is the total weight of the fish measured in grams.

2.4 Measurement of Meristic Features

The meristic counts were carried out within 24 hours of sample collection following the method of Turan et al., [38] by counting the number of lateral lines, number of spine in anal fin, number of spines on dorsal fin, number of spines on pelvic fin, number of anal fin ray, number of dorsal fin ray and number of pectoral fin ray.

2.5 Determination of Length-Weight Relationship

The length- weight relationship of males, females and pooled (combined) sex of *C. zillii* from Komadugu Lake was estimated using the equation given by Froese [39] as follows:

$W = aL^b$

Where W is the total weight in grams (TW - g), a is the intercept, L is the standard length (SL-cm) and b is the slope.

Linear regression model of Microsoft Office Excel in PC windows (2013) was used to estimate the parameters a (intercept) and b (slope) based on logarithms according to Akanse and Eyo [27] as follows:

Log (W) = Log (a) + b Log (L)

where W = total weight (TW - g) and L = standard length (TL - cm).

Deviation from isometry (b = 3) for the exponents (b value) of the length-weight relationship was tested using a t-statistic function according to Pauly [40] as follows:

$$t = \frac{\mathrm{s.d.(x)}}{\mathrm{s.d.(y)}} \frac{\sqrt{b} - 3}{2\sqrt{1 - r2}} \sqrt{n} - 2$$

Where

s.d. (x) is the standard deviation of the Log L values`

s.d. (y) is the standard deviation of Log W values
n is the number of specimens

b is the exponent of the Length-weight relationship

r2 is the correlation coefficient of the Length-weight relationship.

If t calculated is greater than the tabulated t value for the degree of freedom (n – 2), it implies that the b value is significantly different from 3 [40].

2.6 Calculation of Condition Factor (K)

The Fulton's condition factor (K) of males, females and pooled (combined) sex of *C. zillii* from Komadugu Lake was estimated using the equation given by Froese [39] as follows:

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

Where K is the condition factor, W is the total weight in grams (TW - g), L is the standard length in centimeters (SL - cm) and 3 is a constant.

2.7 Statistical Analysis

Basic descriptive statistics including minimum value, maximum value, mean, and standard deviation were computed for the morphometric measurements and meristic counts. To standardize the differences in the overall body size among *C. zillii* samples, all the morphometric measurement and meristic count data were divided by standard length (SL) following the method of [41] and presented as ratio.

3. RESULTS

3.1 Morphometric Characters of *C. zillii* from Lake Komadugu

A total of sixty (60) *C. zillii* was obtained from Lake Komadugu and used for morphometric studies. The total weight ranged from 20 to 390g with the mean value of 193.37 ± 88.78 g. Total length ranged from 10 cm to 36.5 cm with the mean value of 21.98 ± 3.88 cm. Standard length ranged from 8.50 cm to 30 cm with a mean value of 20.45 ± 3.53 cm. results for other morphometric characters are presented in Table 1.

3.2 Meristic Characters of *C. zillii* from Lake Komadugu

The meristic characters of 60 *C. zillii* samples obtained from Lake Komadugu is shown in Table 2. In all the characters counted, mean number of dorsal fin ray was 11.87 ± 0.85, anal fin ray (9.40 ± 0.49), dorsal fin spine (14.60 ± 0.36) and number of scale along the lateral line (21.00 ± 1.59). Mean number of rays on pectoral fin (8.00 ± 0.00), pelvic fin ray (5.00 ± 0.00), anal fin spine (3.00 ± 0.00), pelvic fin spine (1.00 ± 0.00) and number of lateral line (2.00 ± 0.00) were constant.

Table 1. Morphometric characters of *C. zillii* from Lake Komadugu

Characters	Mean ± SD	Minimum	Maximum
Anal Fin Length (cm)	3.37 ± 0.94	1.50	5.00
Body depth (cm)	4.79 ± 0.69	2.00	7.50
Body Weight (g)	193.67 ± 88.78	20.00	390.00
Caudal Peduncle Depth (cm)	2.11 ± 0.70	1.00	4.50
Dorsal Fin Length (cm)	12.62 ± 4.58	1.60	21.50
Eye Diameter (cm)	1.50 ± 0.50	1.00	2.00
Head Length (cm)	3.38 ± 0.31	3.00	4.80
Upper jaw Length (cm)	1.62 ± 0.20	1.40	1.80
Pre Orbital Length (cm)	0.65 ± 0.19	0.50	0.80
Post Orbital Length (cm)	2.54 ± 0.11	2.30	2.70
Pectoral Fin Length (cm)	4.90 ± 1.45	1.50	7.00
Pelvic Fin Length (cm)	2.46 ± 1.02	0.20	6.00
Standard Length (cm)	20.45 ± 3.53	8.50	30.00
Total Length (cm)	21.98 ± 3.88	10.00	36.50

Table 2. Meristic characters of *C. zillii* from Lake Komadugu

Meristic Character	Mean ± SD	Minimum	Maximum
Anal fin ray	9.40 ± 0.49	9.00	10.00
Dorsal fin ray 0.85	11.87 ±	11.00	13.00
Pectoral fin ray	8.00 ± 0.00	8.00	8.00
Pelvic fin ray	5.00 ± 0.00	5.00	5.00
Anal fin spine	3.00 ± 0.00	3.00	3.00
Dorsal fin spine 0.36	14.60 ±	14.00	15.00
Pelvic fin spine	1.00 ± 0.00	1.00	1.00
Number of scale along the lateral line 1.59	21.00 ±	19.00	24.00
Number of lateral line	2.00 ± 0.00	2.00	2.00

3.3 Morphometric Characters of *C. zillii* from Lake Komadugu Expressed as Percentage of Standard Length (SL-cm)

Morphometric characters of *C. zillii* from Lake Komadugu expressed as percentage of standard length (Table 3) showed that total length had the highest percentage (107.49 ± 2.66 %), followed by body weight (94.70 ± 5.78 %) while pre orbital length had the least percentage (3.20 ± 0.24 %).

3.4 Meristic Characters of *C. zillii* from Lake Komadugu Expressed as Percentage of Standard length (SL-cm)

Meristic characters of *C. zillii* from Lake Komadugu expressed as percentage of standard length (Table 4) showed that number of scales along the lateral line had the highest percentage (102.60± 4.45 %), followed by number of dorsal fin spine (71.40 ± 3.82 %) while number of pelvic fin spine had the least percentage (4.90 ± 0.50 %).

3.5 Length-weight Relationship of *C. zillii* from Lake Komadugu

Length-weight relationship of *C. zillii* from Lake Komadugu (Table 5) was estimated for 60 specimen. The normal plot of total weight (TW – g) against standard length (SL – cm) for male and female *C. zillii* is shown in Fig. 2 and Fig. 3. A significant linear relationship was established and represented by the equation: $W = 0.008SL^{2.097}$ (r =0.6410 d.f. = 58) for male, $W=0.001SL^{3.013}$ (r = 0.9600 d.f. = 58) for female.

3.6 Condition Factor (K) of *C. zillii* from Lake Komadugu

Results obtained for mean condition factor (Table 6) showed that male *C. zillii* from Lake Komadugu had 1.80 ± 0.27, female (1.92 ± 0.26) and pooled sex (1.86 ± 0.25).

Table 3. Morphometric characters of *C. zillii* from Lake Komadugu expressed as percentage of Standard length (SL-cm)

Morphometric Character	Percentage of Standard Length (%)
Anal Fin Length (cm)	16.48 ± 0.24
Body depth (cm)	23.42 ± 0.59
Body Weight (g)	94.70 ± 5.78
Caudal Peduncle Depth (cm)	10.32 ± 0.36
Dorsal Fin Length (cm)	61.71 ± 0.38
Eye Diameter (cm)	7.33 ± 0.53
Head Length (cm)	16.58 ± 0.45
Upper jaw Length (cm)	7.95 ± 0.30
Pre Orbital Length (cm)	3.20 ± 0.24
Post Orbital Length (cm)	12.44 ± 0.28
Pectoral Fin Length (cm)	23.98 ± 0.38
Pelvic Fin Length (cm)	12.06 ± 0.54
Total Length (cm)	107.49 ± 2.66

Table 4. Meristic characters of *C. zillii* from Lake Komadugu expressed as percentage of standard length (SL-cm)

Meristic characters	Percentage of Standard Length (%)
Anal fin ray	45.97 ± 3.58
Dorsal fin ray	58.04 ± 4.38
Pectoral fin ray	39.12 ± 1.56
Pelvic fin ray	24.45 ± 2.46
Anal fin spine	14.00 ± 2.34
Dorsal fin spine	71.40 ± 3.82
Pelvic fin spine	4.90 ± 0.50
Number of scale along the lateral line	102.60 ± 4.45
Number of lateral line	9.78 ± 3.06

Table 5. Length-weight relationship of *C. zillii* from Lake Komadugu n

	n	a	b	r	r2
Female	60	0.0008	3.013	0.641	0.411
Male	60	0.001	2.097	0.960	0.922

a =intercept or constant, b = slope r = coefficient of correlation, n = Number of fish sample

Table 6. Condition Factor (K) of *C. zillii* from Lake Komadugu

Sex	Condition Factor (K)
Male	1.80 ± 0.27[a]
female	1.92 ± 0.26[a]
Pooled sex	1.86 ± 0.25[a]

**Means with the same superscript are not significantly different (P>0.05)*

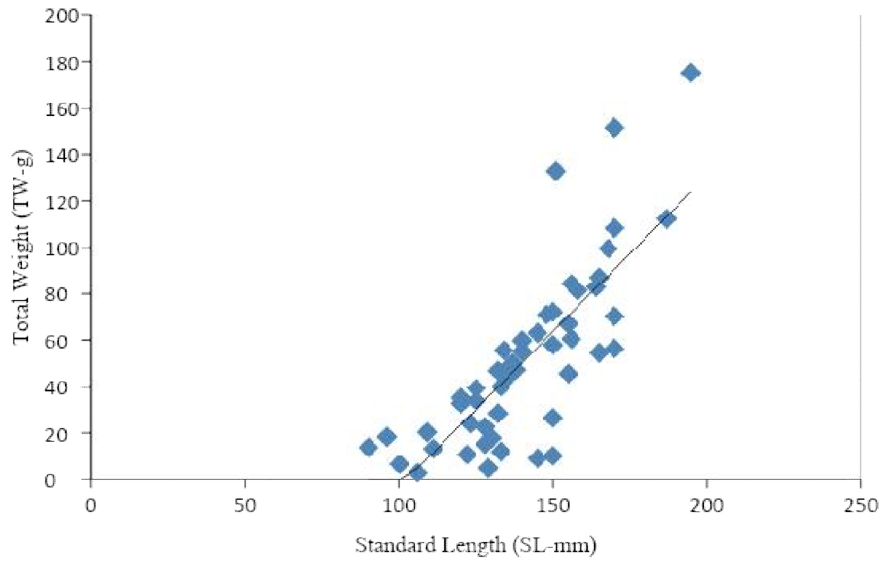

Fig. 2. Length-weight relationship of male *C. zillii* from Lake Komadugu

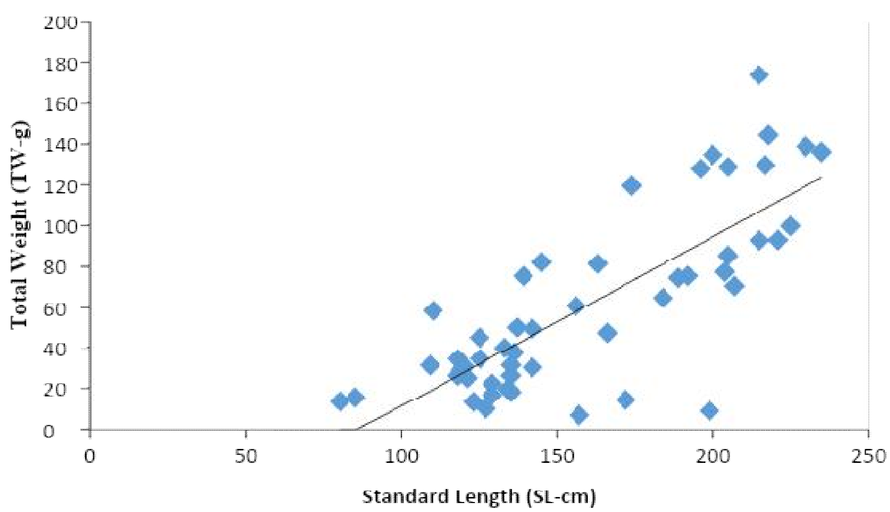

Fig. 3. Length-weight relationship of female *C. zillii* from Lake Komadugu

4. DISCUSSION

The morphometric and meristic methods remain the simplest and most direct way among methods of species identification from previous studies [42,43,44]. Morphometric and meristic characteristics remain dependable tools used on the field to characterize fish species [42,45]. The result obtained from this study showed that morphometric characters of *C. zillii* including total length, standard length, head length, body diameter, eye diameter, mouth diameter, anal fin length, dorsal fin length, pelvic fin length and pectoral fin length were within the range reported by Adediji et al. [46] for the same species from Asejire, Jebba, Kainji, Oyan and Geriyo Lakes in Nigeria. Findings of this study for morphometric characters of *C. zillii* is also similar to report of Idowu et al. [47] who conducted a preliminary study on red belly tilapia *Coptodon zillii* caught from Oyan dam in Nigeria. Our finding is also similar to that of Jawad et al. [48] for *Coptodon zillii* collected from Shatt al-Arab River, Basrah, Iraq. According to Naeem et al. [49], morphometric characters of a fish species indicates if there is any form of disparity between same species from different geographic location. Results of this study agrees with the submission of Idowu et al. [47] that *C. zillii* is not meristically and morphometrically different from the already classified one in Nigerian and other African water bodies. Two possible reasons are given by Jawad et al. [48] for non-homogenization of the populations of any fish species including environmental plasticity and genetic differentiation. Morphometric characters can reveal or expose responses of a fish population to its environment [50]. Meristic characters which are countable such as number of lateral lines, number of spines on anal fin, number of spine on dorsal fin etc. is also useful for identifying fish species. The meristic characters of *C. zillii* counted in this study showed that some characters varied while some were constant. Number of dorsal fin ray, anal fin ray, dorsal fin spine and number of scale along the lateral line varied whereas the number of rays on pectoral fin, pelvic fin ray, anal fin spine, pelvic fin spine and number of lateral line were constant. The constant values of fin rays recorded in this study for *C. zillii* agrees with the findings of Idowu et al., [47], Jawad et al., [48] and Adediji et al., [46], that fin rays of tilapia species do not vary much. Also, report of Fagbuaro [51] and Akinrotimi et al. [52] on fin rays of the tilapiine group followed the same trend. The morphometric and meristic differences observed in this study when compared to other studies could be attributed to environmental fluctuations especially water temperature [52]. Environmental conditions such as w and Akinrotimi et al., [52] on fin rays of the tilapiine group followed the same trend ater temperature, spawning habitat, sex, stress, depth of water and food abundance have been highlighted as the reason for high morphological plasticity in fish [53,54,55]. Beacham [56] also opined that the variation in morphometric and meristic characters among fish populations could be induced by the interaction between ecological and genetic factors. Length-weight relationship data are very reliable in evaluating the relative well-being and growth patterns in fish [27]. The regression coefficient values of length-weight relationship (LWR) shows the growth pattern (allometric or isometric growth pattern) in fish which varies between stocks of same species [33,57,28,58]. The exponent (b = 2.079 for males and 3.013 for females) of the length-weight relationship of *C. zillii* were significantly different from 3 which indicates an allometric growth pattern. Enin, [59] advised that b-values indicating allometric growth must be used with caution because of the violation of the assumption of isometry in the models. Deviation from isometry is commonly observed in fish which indicates that the shape of the fish change as they grow [60]. Taher et al., (2018) reported the exponent 'b' value of 3.1655, 2.9596 and 2.9978 (isometric growth) for cages, pond and wild fish *C. zillii* respectively. This is different from b-values obtained in this study for *C. zillii*. Negative allometric growth has been reported for *C. zillii* in several water bodies in Nigeria [61,62,63]. Variation in growth pattern could be attributed to sex, gonad maturity, species, habitat, season, diet, stomach fullness, health, annual changes in the environmental conditions and preservation methods [60]. Standardizing the differences in the overall body size among the specimens revealed that total length had the highest percentage (107.49 ± 2.66 %) whereas pre orbital length had the least percentage (3.20 ± 0.24 %). For meristic characters, number of scales along the lateral line had the highest percentage (102.60 ± 4.45 %) while number of pelvic fin spine had the least percentage (4.90 ± 0.50 %). Condition factor commonly used in fisheries science to ascertain the well-being of fish and health status of water bodies. When condition factor of fish is one (1) or higher, it indicates that the fish is in a better condition [47]. In this study, the mean condition factor male (1.80 ± 0.27), female (1.92 ± 0.26) and pooled sex (1.86± 0.25) of *C. zillii* from Lake Komadugu were above 1 indicating that the fish were and the lake were in good health status. However, the weight difference in *C. zillii* specimens obtained in this study may be attributed to the individual condition factor, with regards to its relation to well-being and degree of fatness [64]. Mean condition factor values of *C. zillii* reported in this study is similar to values obtained by Idowu et al. [47] for the same species in Oyan lake, Fafioye and Oluajo, [65] Epe Lagoon, Nigeria. Also, similar values were obtained for *C. zillii* in Basra, Southern Iraq (Taher et al., 2018), Lake Qarun, Egypt [66] Abu-Zabal Lake, Egypt [67], a tropical water supply reservoir in Abuja, Nigeria [61] and Ebonyi River, Southeastern Nigeria [68]. Findings of this study disagrees with that of Nehemia et al. [62] who documented condition factor values ranging from 0.53 - 0.74 for *C. zillii* in full strength seawater. Nehemia et al. [62] attributed the differences in condition factor values to different ecological and environmental conditions especially salinity and temperature. According to Khallaf et al. [69], condition factor of fish could be affected by sex, stress, season, food availability, age and water quality.

5. CONCLUSION

The study revealed that some morphometric and meristic features of *C. zillii* in Lake Komadugu varied including total length, dorsal length, body depth and head length while some were constant. Also, *C. zillii* and Lake Komadugu are in good health status with the species exhibiting an allometric growth pattern. Findings of the present study are very useful in stock assessment, population dynamics, sustainable management and conservative measures of *C. zillii* in Lake Komadugu.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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