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Length-Weight Relationship and Condition Factor of *Tillapia zilli* in River Yobe, Northeast, Nigeria

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ABSTRACT This study examined the length-weight relation and condition factor of *Tillapia zilli* in River Yobe, Northeast, Nigeria. Three hundred fifty fish species were collected from commercial fishers at selected landing sites within the study area between June and November 2020. The morphometric and meristic characteristics examined varies due to environmental variations such as water temperature, stress, food availability, spawning ground, fishing intensity, and sex. The mean condition factor shows no significant difference ($P < 0.05$) throughout the sampling period. A linear relationship was established W = 0.4667 L1.1279 and significant at $P < 0.01$ with b value indicating a negative allometric growth pattern. The correlation coefficient (r2 = 0.5212) indicated that LWR model is reliable. This study provides baselines on length-weight relation and condition factor of *Tillapia zilli* in River Yobe. Thus further research should be encouraged on the water body for sustainable utilization, decision making, and policy formulation.

Keywords: Condition factor; length-weight relationship; River Yobe; *Tillapia zilli*

INTRODUCTION

Fish from inland waters such as *Tilapia zilli* is an extremely demanding, treasured, and essential source of protein to man, and not only that, it also contributes significantly to the gross domestic product (GDP) of the country (Bolarinwa, 2015). It is a low-cost source of highly nutritious protein, which is highly suitable due to its excellent fillet quality and good taste (Oladimeji & Olaosebikan, 2017). To manage this fisheries resource, relevant knowledge of fish biology is essential. The biological parameters include length-weight relationship (LWR), condition factor, age and growth, duration of spawning season, etc. (Birkeland & Dayton, 2005). In biology, the study of the structure and form of organisms is called morphology. It is crucial in population studies because it differentiates species taxonomically and creates evolutionary interactions (Oladimeji & Olaosebikan, 2017). Morphometric and meristic are vital tools for assessing the discreteness of the same species (Oladimeji & Olaosebikan, 2017). Morphometry quantifies form, shape, and size, while meristic means sequential body counts.

To identify or foretell the growth form of fish, LWR is an essential fishery management device that can be used (Ajagbe *et al*., 2016). Similarly, Alex *et al*. (2012) opine that understanding some measurable features such as LWR is essential in studying fish biology. LWR can also forecast weight from length dimensions made in the yield evaluation (Pauly, 1993). There are different types of growth that fish can reach, such as positive allometric growth, negative allometric growth, or isometric growth. Isometric denotes an increase in the growth of an organism, but there is no variation of body shape. Negative allometric growth indicates that as fish increases in weight, the fish becomes slim, while positive allometric growth shows that as the length of the fish increases, it becomes moderately bolder or deeper-bodied (Alex *et al*., 2012). The length-weight factor stated as 'coefficient of condition' shows the fish's well-being grade in their environment. This factor measures numerous biological and ecological factors such as gonad development, degree of fitness, and environmental appropriateness concerning the feeding condition (Alex *et al*., 2012). The condition factor must be higher for a fish to attain an enhanced state. Fish condition factors can be affected by several factors such as sex, feed availability, stress, other water quality parameters, and season (Khallaf *et al*., 2003).

According to Olurin & Aderibigbe (2006), Tilapias are flexible in nature because their maximum attainable size and growth can be highly subjective by their habitat's biological and physical composition. *Tilapia zilli* is one freshwater species that form the more significant part of the food protein of many Nigerians (Hetch, 2010; Azubuike, 2016). Even though the species has been well researched, very little is known about the ecology of *T. zilli* populations in River Yobe, Northeast Nigeria.

In Africa, *T. zilli* provides over 70% of fish production. However, *T. zilli* is one of the significant Cichlid families found in Nigeria. Ecology study of this fish species will help fishers design an approach for its management for advanced production in aquaculture. Moreover, Nigeria has faced considerable difficulty controlling aquatic weed invasion of dams. Based on this study, *T. zilli*, a *macrophytic feeder*, will be recommended to regulate aquatic weeds. Therefore, a wide-ranging assessment of the ecology of fish species in the water body is vital. Information collected will be beneficial to formulate an approach for the sustainable conservation and management of the water body. Hence, this study becomes vital due to larger households that rely on the water body for their source of livelihood.

MATERIALS AND METHODS

Study area

The study was carried out in River Yobe, Northeast, Nigeria. River Yobe (Figure 1) is the only perennial water that flows into Lake Chad from Nigeria. The water body is located between Latitude 10º30"N – 13º5"N and Longitude 8º20"E – 15º5"E, with a catchment area of almost 32.900 km2 (Bukar *et al.*, 2018).

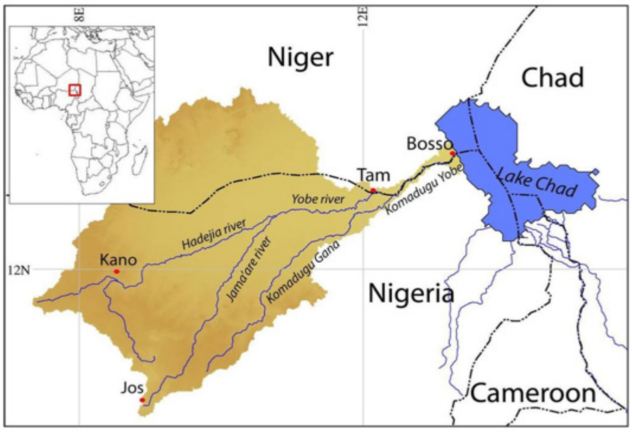

Figure 1. Map of study area.

Sample collection

350 *Tillapia zilli* were purchased from commercial fishers in River Yobe. The sampling duration was six months (June and November), covering the dry and rainy seasons. Gillnets caught fish species cast nets and traps. The fish were transported to the Department of Fisheries and Aquaculture Laboratory, Federal University, Gashua, Yobe State, in an ice chest to avert post-harvest spoilage. Fish specimens were sorted and identified to the species level in the laboratory using the Nigerian freshwater fisheries field guide by Olaosebikan & Raji (2004). Sampling was done bi-monthly at the early hours between 06:00 and 10:00hours (GMT +1).

Measurement of morphometric characteristics and meristic features

Morphometric characteristics such as total length, standard length, body weight, body depth, head length, head depth, snout length, dorsal fin length, anal fin length, eye diameter, caudal peduncle length, caudal peduncle depth, and pelvic fin were measured according to Olaosebikan & Raji (2004). This was done within 24 hours after catch using a digital Vernier calliper and a measuring board to the nearest centimetre (cm). The bodyweight of each fish sample was measured with an electronic chemical balance of 0.1 g precision. According to Turan (2004), the meristic count was carried out, including several dorsal fin rays, anal-fin ray, pectoral fin ray, caudal fin ray, pelvic fin ray, anal fin spine, and pelvic fin spine.

Length-weight relationship

The length-weight relationship was estimated using the length-weight equation given by (Panase & Mengumphan, 2015) as follows:

$$W = aL^b$$

Where: W = bodyweight of fish (g), L = total length of fish (cm), a = scaling constant determined empirically and b = growth coefficient/pattern. If b=3, the growth is referred to as isometric, and if b≠3 is referred to as allometric, which can either be positive (b > 3) or negative (b < 3) (Imam *et al.*, 2010; Famoofo & Abdul, 2020). The point at which the regression line intercepts along the y-axis and the slope of the regression line is known as "a and b," respectively. The above equation was logarithmically transformed to make a linear straight-line equation (Abdul *et al.*, 2016) to obtain Log10 W = Log_{10} a + b Log_{10} L.

Condition factor

The condition factor, which is generally referred to as the well-being of fish, was determined using the formula described by Le Cren (Famoofo & Abdul, 2020). It is an essential index for evaluating feeding intensity, age, and growth rates also used to assess the status of an aquatic ecosystem where fish lives but is widely influenced by both the biotic and abiotic environmental variables.

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

Where: k = condition factor, W = body weight of fish (g), L = total length of fish (cm).

Data analysis

Data collected were processed using Microsoft Office Excel software 2013 to estimate the intercept and slope. The data were further subjected to basic descriptive statistics, including minimum and maximum value, means, standard deviation, and Duncan Multiple Range Test to separate the means at 95% probability level using Statistical Package for Social Sciences (SPSS) version 23.

RESULTS AND DISCUCCIONS

Morphometric characteristics and meristic features of Tillapia zilli

Table 1 shows the morphometric characteristics and meristic features of *T. zilli* from River Yobe. The total weight ranged between 32.56-82.0 g with a mean value of 55.59±12.25 g. Total length ranged between 11-16.3 cm, with a mean value of 13.378±1.29 cm. Standard length ranged from 9.8 cm to 14.2 cm with a mean value of 11.17±1.15. Body depth ranged from 3.1 to 8.1 cm with a mean value of 5.33±0.91. The mean head length value was 3.58±0.70, snout length 0.91 ± 0.38 cm, dorsal fin length 7.24±1.25 cm, and anal fin length was 3.14±0.43 cm. The meristic features are the countable features. The dorsal ray ranged between 25-31 with the mean of 28.04±1.32, the anal fin ray and caudal fin ray ranged between 10-19 (14.55±1.93) and 13-24 (19.75±2.99), respectively. At the same time, the pectoral fin ray, anal-fin ray, and pelvic fin ray had a constant value of 8, 3, and 1, respectively.

Morphometric characters and meristic features of T. zillii expressed as a percentage of standard length (SL-cm)

Morphometric characters of *T. zilli* expressed as a percentage of standard length (Table 2) showed that body weight (494.23±74.14 %) had the highest percentage, followed by total length (120.07±8.32 %) while snout length had the minuscule percentage (8.17±2.94 %). Meristic features of *T. zillii* expressed as a percentage of standard length (Table 3) showed that dorsal fin ray had the highest percentage (253.38±26.26 %), followed by caudal fin ray (179.85±37.47%), while several pelvic fin rays had a minor percentage (55.50±5.76 %).

Table 1. Morphometric characteristics and meristic features of *Tillapia zilli*.

Character	Minimum	Maximum	Mean
Body Weight (g)	32.56	82.00	55.59±12.25
Total Length (cm)	11.00	16.30	13.378±1.29
Standard Length (cm)	9.8	14.2	11.17±1.15
Body Depth (cm)	3.1	8.1	5.33±0.91
Head Length (cm)	2.7	6.0	3.58±0.70
Snout Length (cm)	0.5	2.3	0.91±0.38
Dorsal Fin Length (cm)	3.0	9.0	7.24±1.25
Anal Fin Length (cm)	2.0	4.0	3.14±0.43
Eye Diameter (cm)	0.8	2.6	1.55±0.45
Caudal Peduncle Length (cm)	1.5	2.8	2.03±0.25
Caudal Peduncle Depth (cm)	1.5	21.1	2.47±2.72
Pelvic Fin Length (cm)	1.6	4.3	2.89±0.65
Dorsal Fin Ray	25.0	31.0	28.04±1.32
Anal Fin Ray	10.0	19.0	14.55±1.93
Pectoral Fin Ray	8.0	8.0	8.00±0.00
Caudal Fin Ray	13.0	24.0	19.75±2.99
Pelvic Fin Ray	6.0	6.0	6.00±0.00
Anal fin spine	3.0	3.0	1.0±0.00
Pelvic fin spine	1.0	1.0	1.00±0.00

Table 2. Morphometric characters of *T. zillii* are expressed as a percentage of standard length (SL-cm).

Morphometric character	Percentage of standard length
Total length	120.07±8.32
Body depth	47.768±6.70
Head length	31.86±3.73
Snout length	8.17±2.94
Dorsal fin length	65.07±11.35
Anal fin length	28.24±4.16
Eye diameter	13.89±3.94
Bodyweight	494.23±74.14
Caudal peduncle length	18.26±2.54
Caudal peduncle depth	21.71±21.42
Pelvic fin length	26.01±5.93

Table 3. Meristic features of *T. zillii* are expressed as a percentage of standard length (SL-cm).

Meristic Character	Percentage of standard Length (SL-cm)
Dorsal fin ray	253.38±26.26
Anal fin ray	130.93±17.47
Pectoral fin ray	137.71±30.42
Caudal fin ray	179.85±37.47
Pelvic fin ray	55.50±5.76

Length-weight relationship and condition factor (K) of T. zillii

LWR and condition factor (K) of *T. zillii* were estimated for 350 samples for six (6) months. Figure 2 showed the relationship between Log of body weight (g) against Log of total length (cm) in wish a significant linear relationship was established W = 0.4667L$^{1.127}$9 (r^2 = 0.5212) and significant at $P < 0.01$. Estimates from the condition factor showed no significant difference ($P > 0.05$) in the mean condition factor of sampled fish throughout the sampling period.

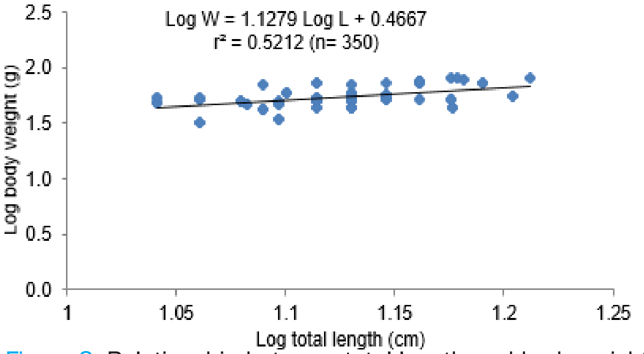

Figure 2. Relationship between total length and body weight of *T. zilli*.

Table 4. Condition factor of *Tillapia zilli*.

Month	Minimum	Maximum	Mean ± SD
June	1.28	3.68	2.28±0.60^a
July	1.28	4.06	2.44±0.63^a
August	1.28	3.68	2.38±0.61^a
Sept	1.28	4.06	2.37±0.81^a
October	1.28	4.06	2.41±0.66^a
November	1.28	4.06	2.42±0.72^a
	Total		2.38±0.63

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

Correlation matrix of morphometric characters of T. zilli

Table 5 shows the correlation matrix of morphometric characteristics of *T. zilli*. It was found that all the twelve (12) morphometric characteristics examined in this study show some level (strong and weak) of correlation (positive or negative) although at a different significant level (0.01 and 0.05) except for BD and AFL and ED, SnL and ED & BW, AFL and ED, CPL, CPD & PFL and CPL and CPD which shows no significant relationship.

Table 5. Correlation matrix of morphometric characteristics of *T. zilli* from Nguru-Gashua wetland.

Characters	TL	SL	BD	HL	SnL	DFL	AFL	ED	BW	CPL	CPD	PFL
TL	1											
SL	0.775**	1										
BD	0.315**	0.490**	1									
HL	0.756**	0.842**	0.456**	1								
SnL	0.334**	0.287**	-0.390**	0.217**	1							
DFL	0.322**	0.338**	0.274**	0.275**	0.072	1						
AFL	0.318**	0.297**	0.083	0.308**	0.401**	0.411**	1					
ED	0.164**	0.313**	0.063	0.320**	0.092	0.170*	0.006	1				
BW	0.521**	0.787**	0.639**	0.704**	-0.086	0.320**	0.243**	0.154*	1			
CPL	0.211**	0.255**	0.262**	0.371**	-0.227**	0.161*	0.019	0.327**	0.361**	1		
CPD	0.196**	0.255**	0.286**	0.365**	-0.050	0.201**	0.053	-0.134	0.319**	0.030	1	
PFL	0.194**	0.176*	0.354**	0.312**	-0.311**	0.235**	-0.004	0.128	0.335**	0.585**	0.293**	1

The closer the r value to +1, the stronger the relationship between the morphometric features (Significant at 0.01**and 0.05*.)

Note: TL = Total length, SL = Standard length, BD = Body depth, HL = Head length, SnL = Snout length, DFL = Dorsal fin length, AFL = Anal fin length, ED = Eye diameter, BW = Body weight, CPL = Caudal peduncle length, CPD = Caudal peduncle depth CPD = Caudal peduncle depth, PFL = Pelvic fin length.

Fisheries scientists hypothesized that morphometric characteristics and meristic features are the simplest and most straightforward methods of fish species identification (Hockaday *et al*., 2000) and the most reliable tools in characterizing fish down to species level (Creech,1992; Chambers, 1993). Morphometric characteristics examined in this study include total length, standard length, body depth, head length, head depth, snout length, dorsal fin length, anal fin length, eye diameter, body weight, caudal peduncle length, caudal peduncle depth, caudal peduncle depth, pelvic fin length were within the range reported by Famoofo & Abdul (2020) from Iwopin fre shwater ecotype of Lekki Lagoon, Ogun State, Nigeria. The result from morphometric characteristics was also similar to the study of Ajagbe *et al*. (2016) and Adediji *et al*. (2019), who assessed the morphometric and meristic features of *Tilapia* spp in significant water bodies in Southwest Nigeria. The finding from this work was in line with the study conducted by Jawad *et al*. (2018) in Shatt al-Arab River, Basrah, Iraq. The finding also supports the submission of Idowu *et al*. (2017), who stated that there is no difference in the morphometric characteristics and meristic features of *T. zilli* from inland water bodies from the African continent. Meristic features are the countable structures of importance in fish identification. The features considered in this study were dorsal fin ray, anal-fin ray, pectoral fin ray, caudal fin ray, pelvic fin ray, anal fin spine, and pelvic fin spine. It was observed that some metric features were constant such as pectoral-fin ray, pelvic fin ray, anal fin spine, and pelvic fin spine, while others varied. The finding was in agreement with the study of Stianssy (2000), Idowu *et al*. (2017), Jawad *et al*. (2018), and Adediji *et al*. (2019). Also, Fagbuaro (2015) and Ajagbe *et al*. (2016) assertion that fin rays of the tilapiine group followed the same trend. Slight variation recorded in the morphometric characteristics and meristic features could be attributed to environmental variations such as water temperature, stress, food availability, spawning ground, and sex. This had been highlighted as a reason for morphological variation in fish (Eyo, 2003; Yemi *et al*., 2007; Akinrotimi *et al*., 2019). Both positive and negative relationships ($P < 0.05$ and 0.01) were observed in the correlation matrix of the morphometric characteristics of *T. zilli*. This implies that both direct and inverse relationship/interaction exists between the morphometric characteristics of *T. zilli* in the study area.

LWR is a tool that has been accepted internationally in estimating fish biomass (Abdoli *et al*., 2008; Ferreira *et al*., 2008; Epler *et al*., 2009; Nowak *et al*., 2009; Abdul *et al*., 2016). In evaluating the growth pattern and well-being of fish, LWR is a reliable tool (Eyo & Emeka, 2016) nevertheless this tool is affected by influenced by water pollution, fish population, season, food availability, feeding intensity, sex, age of fish, maturity stage, muscular development and quantity of reserved (Ujjania *et al*., 2012; Abdullahi & Ahmad, 2013; Miller *et al*., 2015; Gupta & Banerjee, 2015; Al Nahdi *et al*., 2016; Famoofo & Abdul, 2020).

Akanse & Eyo (2018) reported that LWR data are used in evaluating the growth pattern and well-being of fish. The regression coefficient (b) value of LWR illustrates the growth pattern, which might be allometric or isometric, which varies between stocks of the same species. The b-value for this study indicates a negative allometric growth pattern. This implies that the rate at which body length increases is not proportional to the increase in body weight, i.e., the fish grow faster in length than in weight. The result of the study was similar to the findings of Ajagbe *et al*. (2016), who reported a negative allometric growth pattern for *T.zilli* in Asejire lake, Southwest, Nigeria. Also, Idowu *et al*. (2017) reported a similar result in her study on Tilapia spp in Oyan Dam, Ogun State, Nigeria. A negative allometric growth pattern was also reported by Taher *et al*. (2018) in their study of LWR and condition factor tilapia in Southern Iraq, but contrary to the findings of Famoofo & Abdul (2020) and Abdul *et al*. (2016), reported a positive allometric growth pattern for *T. zilli* freshwater ecotype of Lekki Lagon and coaster estuary both in Ogun State, Nigeria. According to Enin (1994), whenever the b-value indicates allometric growth, caution must be applied because of violation of the assumption of isometry in the model. Fish commonly show deviation from isometry, which indicates that fish shape changes with growth (Ndome & Eteng, 2010). Gomez & Gomez (1984) reported that a high square correlation (r2) indicates that the LWR model is reliable.

Condition factor (k) is used to define the well-being of fish; it gives general information about the physiological condition of fish concerning its welfare (Gupta & Banerjee, 2015), and growth index and feeding intensity (Ighwela *et al*., 2011). The higher the “k” values, the heavier the fish. Thus, the “k” value is directly proportional to the bodyweight of the fish. But the disparity in the “k” is likened to the environmental condition (Ratnakala *et al*., 2013; Sarkar *et al*., 2013), fluctuation of water temperature (Bolarinwa & Popoola, 2013), breeding season (Abujam & Biswas, 2016), habitat and feeding habit (Nandikeswari *et al*., 2014), spawning season and gonadal development (Henderson, 2005; Obasohan *et al*., 2012). Irom *et al*. (2017) stated that biotic and abiotic factors affect “ k “ values, including food availability, feeding pattern/regime, and gonad development. This assumption was confirmed by Lizama *et al*. (2002) that gonad’s development negatively affects the “k” value due to the transfer of energy to the gonads. The mean “k” value obtained in this study shows no significant difference ($P < 0.05$) but greater than 2. The “k” value recorded in this study was similar to the result of Ajagbe *et al*. (2016), Abdul *et al*. (2016), Idowu *et al*. (2017), Famoofo & Abdul (2020) from a tropical water body in Nigeria.

CONCLUSION

This study used morphometric and metric features, length-weight relationship, and condition factors to assess the population structure of *T. zilli* in River Yobe, Northeast, Nigeria. Although the fish is in good health but not too favourable, *T. zilli* showed a *negative allometric growth pattern with a slightly above two condition factor*. These could be attributed to the stage of gonads development, biotic and abiotic factors, environmental fluctuation, anthropogenic factors, and over-exploitation. Further detailed findings should be encouraged and assessment of other fish species in this water body for sustainable utilization, decision-making, and policy formulation.

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