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Biometric Evaluations and Condition Factor of the Mudskipper, *Periophthalmus barbarous* (Linnaeus, 1766) From Ibaka Mangrove Swamp, Nigeria

Enenwan Precious Udoinyang[1] • Aniefiokmkpong O. Okon[1] • Victoria Folakemi Akinjogunla[2]✉ • Itoro J. Archibong[1] • Unwana J. Effiong[1] • Emmanuel A. Essien[1]

[1] University of Uyo, Faculty of Science, Department of Animal and Environmental Biology, Uyo, Akwa Ibom State, Nigeria, everjewel2002@yahoo.co.uk, aniefiokmkpongo@gmail.com, itoroarchibong@uniuyo.edu.ng, vicakin@yahoo.com, emeritusessien49@gmail.com

[2] Bayero University, Faculty of Agriculture, Department of Fisheries and Aquaculture, Kano, Kano State, Nigeria, vfakinjogunla.faq@buk.edu.ng

✉ Corresponding Author: vfakinjogunla.faq@buk.edu.ng

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ABSTRACT

The length-weight relationship and Fulton condition factor (K) of 404 samples of the mudskipper, *Periophthalmus barbarus* from Ibaka mangrove swamp were investigated for six months (January to June 2022) using standard methods to accommodate both the dry and wet seasons. For the 404 samples, the mean total length was 11.22±0.11 cm while the mean body weight was 16.4±0.48 g. Other biometric data collected includes percentage eye diameter (ED%) ranging between 5.07 and 8.26 cm for May and February, respectively. Percentage head length (HL%) values were between 20.9 and 28.12 cm for May and January, respectively. For percentage body depth (BD%), the least was recorded in April (19.49 cm) while the highest was observed in February (24.55 cm). The Fulton condition factor (K) determined for most of the sampled months showed that the values were above unity (K>1), indicating good living conditions on account of food availability, absence of parasites/predators, and absence of disease. However, K was less than unity (K<1) in February and June, indicating a possible decline in food availability and other factors responsible for growth. The values of the length-weight relationship (b) were greater than 3 (b>3) in almost all the months except in April, having a value of 2.895, indicating that the species exhibited a positive allometric growth pattern. This implied that as the length of the fish increased, there was also a corresponding increase in the weight of *P. barbarus* from the Ibaka Mangrove Swamp.

INTRODUCTION

The Cross River Estuary is an aquatic ecosystem which inhabits diverse life forms of fauna which includes silver catfish, tilapias, mudfishes, mudskippers, shrimps, oysters, plants and wildlife. The water found in this region is brackish salty water at the upper and lower stretch of the estuary. It is also a useful medium for the sustenance of livelihood and economic enhancement (Bisong et al., 2007). Mudskipper, *Periophthalmus barbarus* belonging to order Gobiiformes and family Oxudercidae is the only species of genus in West Africa (Abiaobo & Udo, 2017).

It inhabits the warmer and muddy part of the estuary and spends most of its life out of the water using large, specialized pectoral fins to walk on land. They burrow during high tide to protect themselves from predators as they are morphologically and physiologically adapted to live both on land (ability to walk on land and climb trees) and in water (Bob-Manuel, 2011; Ravi, 2013). Mudskippers occupy a salient ecological niche and is a valued component of some artisanal catches being exploited either for use as baits in hook and line fisheries, for human consumption or for use in traditional medicinal preparations where aphrodisiac properties are attributed to its flesh (Clayton, 1993).

The study of the relationship of length-weight is an important diagnostic indication of the wellbeing of fish species under investigation to measure the variations from the expected weight or length of individual fish or groups of fishes. The investigating and managing of the fisheries species most of the time entails the utilization of fundamental tools and biometric interactions (length, width and weight) to convert data collected in the field into appropriate indexes for evaluation purposes such as indication of fatness, gonadial development and stock biomass assessment (Froese & Pauly, 2015; Akinjogunla & Moruf, 2019; Akinjogunla & Soyinka, 2022).

Morphometric activities depend majorly on the stage of growth, reproductive organs and ecological parameters (food quantity and quality, water temperature and salinity) (Dall et al., 1991). In the aspect of fish morphometry, species of similar sizes can be compared when dealing with characteristics that alter in size. Eye diameter, (ED), head length (HL), body depth (BD), and total length (TL) are some of the common data observed for morphological features of fish samples under any investigation of biometric studies (Pradhan et al., 2017).

The condition factor which shows the degree or state of wellbeing of the fish species in their natural environment is expressed by using the 'coefficient of condition'. The co-efficient of the condition is a measure of various ecological and biological factors such as gonad stages, degree of fitness and suitability of the environment with regards to the feeding condition (Gomiero & Braga, 2005; Akinjogunla & Soyinka, 2022).

Due to the importance of this estuarine fauna worldwide, a great effort to study their biology (length-weight, sex ratio, condition factor, food and feeding, nutrients composition, etc.) has been undertaken in recent years (Clayton, 1993; King, 1996; Lawson, 2010; Kumolu-Johnson & Ndimele, 2010; Manoharan et al., 2013, Naminata et al., 2014; Yapi et al., 2017; Akinjogunla et al., 2017, 2021; Akinjogunla & Moruf, 2018, 2019; Solitoke et al., 2020; Udoinyang et al., 2022; Akinjogunla & Soyinka, 2022).

The study of morphometry (length, weight and health status) of species is considered to be important in the determination of the size-length relationships between sexes of the species and the connection that occurs between the various size groups of the sampled population while the relationship between condition factor and Length-weight values are linked to growth performances (Isometric, positive or negative allometric) of the species. Yet, little is known about the morphometric changes, length-weight relationship and condition factor in the mudskipper from Ibaka mangrove swamp off Cross River Estuary. The increasing demand of aquatic products as food in southern Nigeria and the dearth of information on growth dimensions of *P. barbarus* in Nigeria has prompted this study. Therefore, this research aimed to evaluate the morphometry relationship (length-weight relationship and condition factor) of *P. barbarus* from Ibaka mangrove swamp, Cross River

Estuary, Nigeria. This study would serve as baseline information for other research on the topic currently under investigation. This baseline information will help to pose an optimal and efficient management of stock available.

MATERIAL AND METHODS

Study Area

Ibaka is the biggest, most dynamic, and strategically located fishing community in Mbo Local Government Area of Akwa Ibom State, Nigeria, compared to the adjourning fishing communities in Cross River State (Udoinyang et al., 2022). The study site lies between latitude 4.6478°N and longitude 8.2979°E in the southern part of Nigeria which alternates between the wet and dry seasons. Ibaka has a long stretch that opens into Gulf of Guinea and the water is brackish and highly saline. It is a good nursery ground for cultivation of blue crabs and breeding of different fish and sea food species for fishermen.

Sampling

Monthly samples of *P. barbarus* (Figure 1) were obtained at Ibaka mangrove swamp, off Cross River Estuary, Nigeria. A total of 404 samples were collected for six months (from January to June 2022) with the help of the local fishermen who used traditional fishing gears such as cast nets with 10-40 mm as mesh size along with periwinkle baits. The sampling was done using a randomized sampling techniques i.e., collection was done at random using sampling net and traps in the swamp at different points. The samples were transported with the aid of a robust container with lid to the wet laboratory in the Department of Animal Environmental Biology, University of Uyo, Uyo where the biometric data were collected.

Figure 1. *Periophthalmus barbarus* from Ibaka Mangrove Swamp (X 25 mag)

Laboratory Analysis

The samples on reaching the laboratory were preserved under iced condition in a refrigerator awaiting morphometric measurements. At each measurement period, the samples were brought out of the refrigerator and allowed to defrost under the laboratory working bench. Four measurable morphometric characters (total length, standard length, body weight and body depth) were used in this study. These morphometric characters were measured and recorded in proformas for each mudskipper (Shamsa et al., 2016). The length and width were measured in centimeters (cm) with the aid of graduated meter rule while the body weights, gut weights and liver weight were measured to the nearest 0.1 in gram (g) using the electronic weighting scale Camry (Model EHA1).

Growth patterns of *P. barbarus*

Length–Weight Frequency Distributions

The statistical length-weight relationships were established using the linear regression:

$$W = aL^b \quad \text{(Ricker, 1975b) (1)}$$

where W and L are the independent and dependent variables of allometric parameters, respectively. W is total weight in grams (g); L is length in centimeters (cm); ais rate of change of weight with length (intercept); and b is weight at unit length (slope). The equation (1) above and data obtained were transformed into natural logarithms and this gave a linear (straight line) relationship as given in equation (2):

$$\log W = \log a + b(\log L) \quad \text{(Parsons, 1988) (2)}$$

Fulton Condition Factor (K)

The Fulton condition factor of the fish indicates the state of general wellness of the fish and was estimated from the relation. The Fulton condition factor of the *P. barbarus* was determined using the formula given in equation (3):

$$K = \frac{W}{L^3} \times 100 \quad \text{(Ricker, 1975a) (3)}$$

where *K*: condition factor; *L*: length of the species (cm); *W*: body weight (g).

Data Analysis

Data generated were presented as descriptive statistics, it was carried out and the results presented as mean ± standard error (SE), maximum and minimum using analysis of variance (ANOVA) and Statistical Package for Social Sciences (SPSS version 21) while co-efficient of determination (r^2) was used to determine the linear regression. Lines and scattered graphs were used to depict trends in the distribution and relationships between length, width and weights of *P. barbarus* using Minitab 14.

RESULTS

A total of 404 samples of *P. barbarus* were measured, the mean total length was 11.22±0.11 cm and mean body weight was 16.4±0.48 g.

Morphometric Characteristics

Table 1 shows the measurement of the morphometric parameters of the samples as range and mean±SE within the six months of sampling. The least mean total length and mean body weight were recorded in the month of May (6.35±1.13 and 13.85±0.94, respectively) while the highest value for the mean total length was recorded in the month of June (12.22±1.34 cm). The month of April had the highest mean body weight (17.11±0.98 g). For body depth, May had the least mean value of 1.78±0.08 cm while the highest was observed in February (2.20±0.07 cm) and March (2.20±0.08 cm); for head length (hl), the least was in the month of May (1.11±0.07 cm) while the highest was in March (2.57±0.55 cm); for eye diameter (ED), the least mean value was in May (0.44±0.02 cm) and the highest was in March (0.77±0.35 cm); for eye diameter (ED), the least mean value was in May (0.27 cm) and the highest

Table 1. Biometric characteristics of *Periophthalmus barbarus* for January-June 2022

Biometrics (min - max)	**January**	**February**	**March**	**April**	**May**	**June**
TL (cm)	7.5 - 16.5	7.8 - 17.4	8.5 - 18.2	8.5 - 15.4	4.0 - 10.6	8.6 - 18.3
Mean TL	**10.4±1.17**	**11.95±1.24**	**11.52±0.49**	**11.49±0.21**	**6.35±1.13**	**12.22±1.34**
SL (cm)	6.3-11.6	6.8-14.3	7.0-14.7	7.6-12.9	6.9-14.0	6.3-14.6
Mean SL	**8.57±0.86**	**8.96±1.09**	**9.37±0.98**	**9.75±0.80**	**5.32±0.97**	**8.91±1.03**
ED (cm)	0.4 - 1.5	0.3 - 1.9	0.5 - 1.8	0.3 - 1.0	0.1 - 1.0	0.1 - 1.0
Mean ED	**0.65±0.15**	**0.74±0.38**	**0.77±0.35**	**0.62±0.02**	**0.44±0.02**	**0.45±0.02**
BD (cm)	0.7 - 3.2	1.2 - 4.2	1.2 - 3.8	1.3 - 3.0	0.5 - 3.0	1.4 - 3.70
Mean BD	**1.83±0.09**	**2.20±0.07**	**2.20±0.08**	**1.90±0.05**	**1.78±0.08**	**1.98±0.08**
SWT (g)	2.0 - 36.0	2.0 - 26.0	2.0 - 41.0	3.0 - 34.0	4.0 - 39.0	3.0 - 39.0
LWT (g)	0.1 - 0.5	0.1 - 0.5	0.1 - 0.5	0.1 - 0.5	0.1 - 0.5	0.1 - 0.6
BWT (cm)	5.0 - 48.0	5.0 - 54.0	5.0 - 47.0	6.0 - 44.0	1.0 - 44.0	1.7 - 48.0
Mean BWT	**17.07±1.09**	**14.61±0.98**	**14.71±0.98**	**17.11±0.98**	**13.85±0.94**	**15.99±1.14**
HL (cm)	0.7 - 4.3	1.5 - 3.4	1.2 - 10.0	1.4 - 3.0	0.8 - 12.0	1.0 - 3.2
Mean HL	**2.41±0.09**	**2.30±0.78**	**2.57±0.55**	**1.42±0.04**	**1.11±0.07**	**1.87±0.05**
GWT (cm)	0.1 - 0.7	0.1 - 0.6	0.1 - 0.6	0.1 - 0.4	0.1 - 0.5	0.1 - 0.5
Mean GWT	**0.28±0.03**	**0.25±0.04**	**0.28±0.04**	**0.18±0.05**	**0.10±0.06**	**0.24±0.05**
% ED of SL	7.60	8.26	8.21	6.36	5.07	7.72
% HL of SL	28.12	25.70	27.4	24.80	20.90	20.39
% BD of SL	21.35	24.55	23.48	19.49	19.92	21.06

Note: TL: Total length; SL: Standard length; ED: Eye diameter; BD: Body depth; HL: Head length; GWT: Gut weight; SWT: Somatic weight; LWT: Liver weight; min: Minimum; max: Maximum.

was in March (0.77 cm); for gut weight (GWT), the least was in May (0.10±0.06 g) while the highest was in January (0.28±0.03 g) and March (0.28±0.04 g).

Length-Weight Relationship of *P. barbarus*

The monthly functional equations for total length-weight relationships for *P. barbarous* are shown in Table 2. There was a positive correlation in the relationship as indicated in the r^2 values across the six months. There was a variation in the 'r^2' values recorded across the month for the length-weight relationship for *P. barbarus* (0.6482-0.8976 cm). The least value of 0.6482cm was calculated for January while the highest value of 0.8976 cm was in the month of March. Figures 2a–f show the plot of the monthly relationship that existed between total length and body weight of *P. barbarus*.

Fulton Condition Factor (K)

In this study, Figure 3 summarizes the monthly variation in the condition factor for *P. barbarus*. The Condition Factor (K) ranged from 0.91 to 1.94. The minimum condition factor was reported in the month of June (0.91), while the maximum condition factor was in the month of May (1.94). A value of 0.97 was recorded in February, 1.01 in March, 1.21 in April and 1.34 was recorded in January.

Table 2. Functional equations for the total length–weight relationship of *Periophthalmus barbarus*

Month	Relationship	a	b	r^2	Functional equation
January	W vs TL	- 0.5436	1.6238	0.6482	W =1.6238TL - 0.5436
February	W vs TL	- 1.749	2.7742	0.8656	W = 2.7742TL - 1.749
March	W vs TL	- 1.7278	2.7154	0.8976	W = 2.7154TL - 1.7278
April	W vs TL	- 1.9662	3.0077	0.8893	W = 3.0077TL - 1.9662
May	W vs TL	- 1.4517	2.5289	0.8111	W = 2.5289TL - 1.4517
June	W vs TL	-0.9162	2.0407	0.6791	W = 2.0407TL - 0.9162

Note: W: Weight; TL: Total length; a: Slope; b: Intercept; r^2: Regression.

Table 3. Correlation matrix of body composition of *Periophthalmus barbarous*

	TL	SL	ED	BD	HL	SWT	GWT
TL	1	0.933*	0.894*	0.879*	0.622	0.835*	0.605
SL		1	0.837*	0.853*	0.770	0.877*	0.511
ED			1	0.968*	0.802*	0.542	0.864*
BD				1	0.831*	0.591	0.742
HL					1	0.438	0.658
SWT						1	0.104
GWT							1

Note: TL: Total length; SL: Standard length; ED: Eye diameter; BD: Body depth; HL: Head length; SWT: Somatic weight; GWT: Gut weight. The values with the asterisk (*) indicate significant difference.

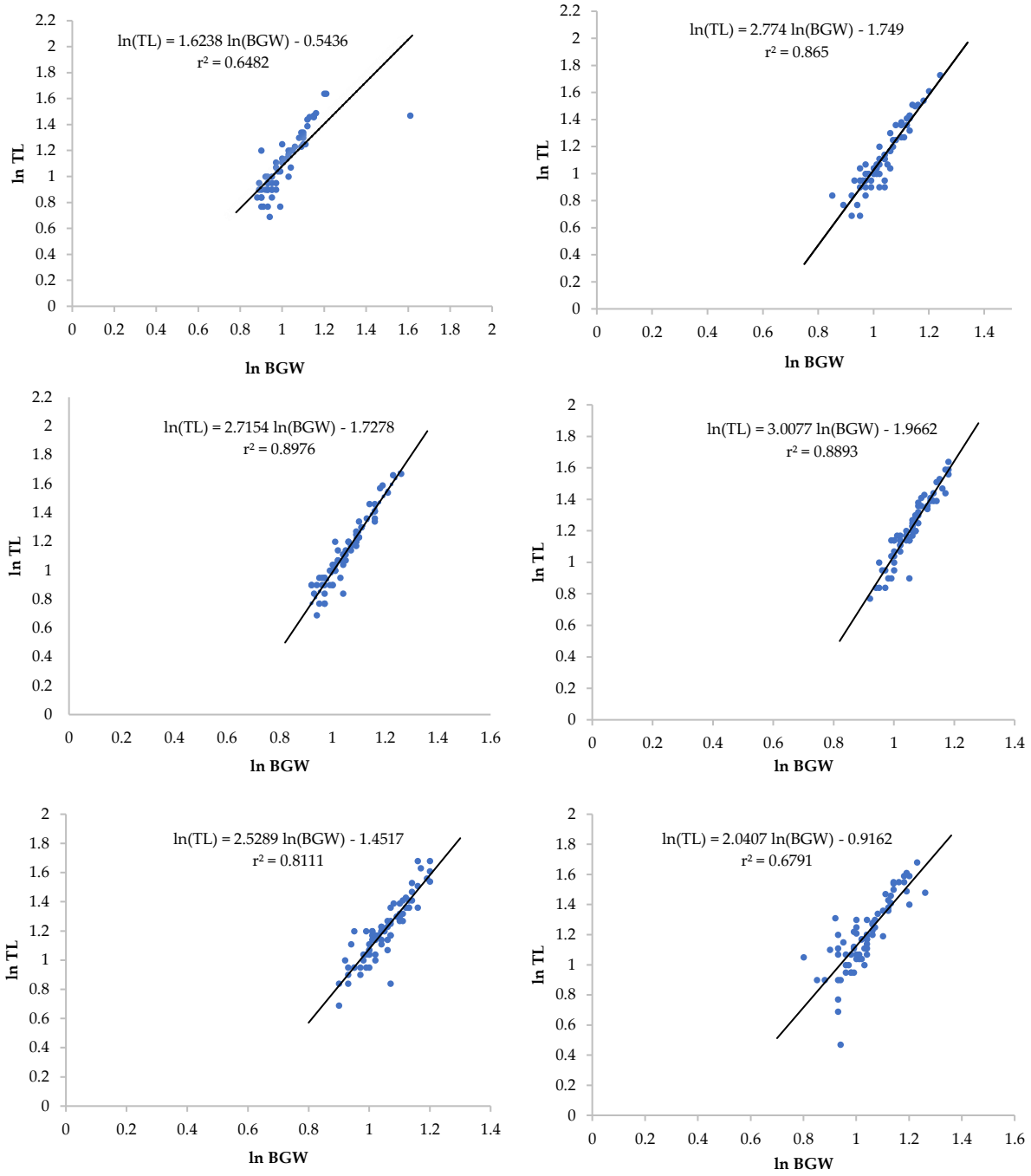

Figure 2. Length and weight relationship of *Periophthalmus barbarous* from a) January to e) June, 2022

DISCUSSION

In this study, specimens with total length between 6.35 and 12.22 cm were examined from the Ibaka mangrove ecosystem. Fish weight is considered to be a function of length (Naminata et al., 2014). For an ideal fish which maintains dimensional equality, the isometric value of '*b*' would be 3.0. Wotton (1990) and Naeem et al. (2010) stated that if the value of $b = 3$, the growth is isometric and allometric if $b \neq 3$ (negative allometric if $b < 3$ and positive allometric if $b > 3$). Positive allometric growths were observed ($b > 3$) during the sampled months except in the month of April where negative allometric growth rate was recorded. The negative allometric growth recorded for April is an indication of a decline in the growth performance of the fish. The sharp decline may be because it falls within the onset of the wet season where there is sharp change in the environmental parameters and the possibility of limited or reduced availability of quality and quantity food in their habitat.

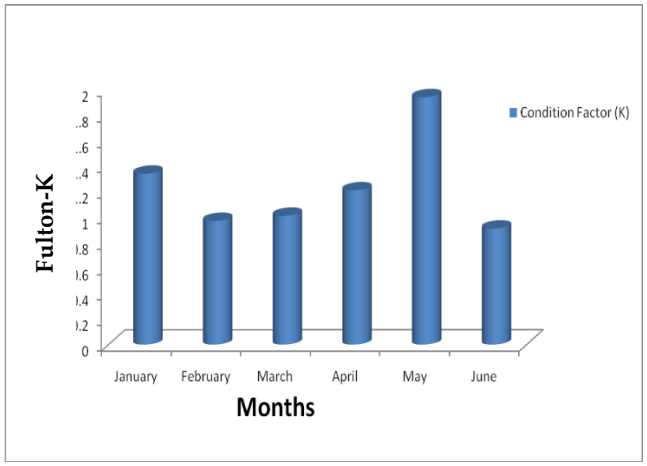

Figure 3. Monthly variation in the Fulton condition factor (K) of *Periophthalmus barbarus* from Ibaka mangrove swamp

The results of length-weight relationship of *Clarias gariepinus* obtained from Ibaka Mangrove Swamp, Nigeria revealed allometric pattern of growth. The average "b" value (2.44) for *Clarias gariepinus* was less than 3.0, which indicated a negative allometric growth increase. This implies that there was a slower rate increased in the weight than the body length. This agrees with the study of Kumolu-Johnson & Ndimele (2011) which reported similar growth for *Clarias gariepinus* in Ologe Lagoon, Lagos. Negative allometric growth pattern in freshwater fishes has also been reported in studies such as Abowei & Ezekiel (2013); Naminata et al., (2014); Akinjogunla & Soyinka (2022). The fish's weight is determined by length's function (Odedeyi et al., 2007). This study was in relation with researches from inland water bodies in Nigeria. This was noticeable among fish length-weight encompasses the outcomes of Peter & Diyaware (2014). Also, the allometric growth pattern experimented observations was similar to evaluation of length-weight relationship of fish species in Ebonyi River (Ude et al., 2011).

The inconsistencies in these results may be attributed to some internal (gonad maturity, sex, fish activities, health, seasonal growth and food habits) and external factors (habitat, temperature and availability of food) (Froese, 2006; Cazorla, 2008; Isa et al., 2010). The condition of fish upon capture such as stomach fullness, health and maturity can affect length-weight relationships (Cherif et al., 2008). The variability in the length-weight relationship can also be as a result of population variability and sampling error (Frosta et al., 2004). From the observation of this study, the rate of increase in length is considered to be directly proportional to increase in weight for *P. barbarus*.

The relative condition factor was studied to determine the general well-being or condition of fish. It can also be referred to as "ponderal index", "coefficient of condition", "condition factor and "length-weight factor" (Williams, 2000). The condition factor (K) for any species will have the value of 1, regardless of the unit measurement. For K value less than 1, it indicates slow growth rate in a fish which may be caused by disease and high population density (Anderson & Neumann 1996). In general, a high condition factor indicates favorable environmental conditions such as habitat and food availability while in contrast, a low condition factor indicates less favorable environmental condition factor (Blackwell et al., 2000).

The underlying hypothesis for this factor is that for a given length, a heavier fish is said to be in a better condition (Sivashanthini & Abeyrami 2003). In this study, the condition factor for *P. barbarus* varies among months of study (January to June). For January, March, April and May, condition factor, K values were 1.34, 1.01, 1.21 and 1.94, respectively, which indicated good favorable conditions of food availability, lack of predation, among other factors necessary for growth were available in those months. However, February and June had the lowest condition factor of 0.97 and 0.91, respectively, which showed that the conditions for optimum living were low in those months.

CONCLUSION

The morphometric features of *P. barbarus* from Ibaka mangrove swamp were investigated for six (6) months (dry season- January, February and March; rainy season – April, May and June) upon which length - weight relationship (LWR) and condition factor (K) were determined. The morphometry analysis carried out included measurement of weight, standard length, total length, length of head, eye diameter. The mean value for length–weight relationship (b) was greater than three (b > 3) across

the months with exception of the month of April that had b value less than 3 (b < 3). The condition factor (K) across the sampled months was found to be greater or equal to unity (≥ 1) especially during the rainy season indicating that the environmental conditions were favorable to the population of *P. barbarus*.

Compliance with Ethical Standards

Authors' Contributions

EPU, AOO, IJA, UJE and EAE: Manuscript design, Conducted the survey, Reviewing and Editing.

VFA: Drafting of manuscript

VFA, UJE and EAE: Data analysis, Editing

VFA and EAE: Reviewing

All authors read and approved the final manuscript.

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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Not applicable.

Data Availability

The data that support the findings of this study are available from the first author, (EPU) upon request.

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