

ORIGINAL ARTICLE

Biometric indices of Atlantic Mudskipper, *Periophthalmus barbarus* (Linnaeus, 1766), from the Old Bakana Creek, Rivers State, Nigeria

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Abstract

Length-frequency distributions (LFDs), length-weight relationships (LWRs), length-length relationships (LLRs), and condition factors of *Periophthalmus barbarus* were studied from the Old Bakana Creek, Rivers State, Nigeria. This research was conducted from June to November 2023 at three sampling sites using the purposive sampling technique. A total of 267 specimens of *P. barbarus* were collected for this investigation. Results revealed that the length frequency distribution (LFD) of *P. barbarus* exhibited a unimodal type distribution with a mean value of 8.74 ± 1.505 . The mean total length ranged from 9.01 ± 1.42 to 12.06 ± 0.84 cm. The mean weight ranged from 7.18 ± 3.03 to 13.89 ± 3.48 g. The b value ($b = 2.07$) for the *P. barbarus* population in the LWR specified negative allometric growth. All LLRs were highly correlated with coefficient of determination values ≥ 0.90 , and the b value ranged from 0.81 to 0.87. The mean Fulton's condition factors values varied between 0.64 ± 0.16 and 0.94 ± 0.11 . The relationships of condition factors with total length of *P. barbarus* were statistically significant from September to November, while condition factors recorded for July and August were found statistically significant with the body weight ($P < 0.01$). Thus, the aforementioned findings provide some valuable information for policymakers in the move towards restoration, species conservation, and effectively management of *P. barbarus* natural stock.

Keywords: Allometric growth, Condition factor, Old Bakana Creek, *Periophthalmus barbarus*

INTRODUCTION

The Atlantic mudskipper (*Periophthalmus barbarus*) is a species of mudskipper native to fresh, marine, and brackish waters of the tropical Atlantic coasts of Africa, including most offshore islands, through the Indian Ocean and into the western Pacific Ocean to Guam. It is the only species of the family Oxudercidae in the Gulf of Guinea, which includes estuaries and lagoons of the West African coast (FAO 1990). Oxudercidae comprises 42 species belonging to 10 genera globally, e.g., *Boleophthalmus boddarti*, *Scartelaos histophorus*, *Periophthalmodon septemradiatus*, *P. schlosseri*, *Periophthalmus chrysopilos* (Fricke et al. 2022). *Periophthalmus* species belongs to the class Actinopterygii, order Perciformes, family Gobiidae, and the subfamily Oxudercinae includes 10 genera and 40 species (Fishbase 2018). Mudskippers are amphibious euryhaline fish that prefer semi-terrestrial habitats

such as mangroves, mudflats, and estuaries (Kumaraguru et al., 2020). The tidal flats created by river estuaries and the floor of the mangrove forest ecosystem are the natural habitats of mudskippers (Shirani et al. 2012). These areas are known as the most degraded habitat types on the earth since they are continuously exposed to heavy metal pollution either from anthropogenic practices (Ferreira et al. 2019) or from naturally occurring pollution due to sedimentation and flooding (Zhang et al. 2019). *P. barbarus* is an economically important fish species due to the medicinal properties found in the fish because of its aphrodisiac values (Etim et al. 2002). It gains commercial value either through food consumption or as traditional medicine by humans (Kanejiya et al. 2017). Sometimes they are even used as bait for catching prey (Gadhavi et al. 2017). The high fishing pressure and anthropogenic activities on this fish species ecosystem could lead to a decline of

fish populations.

Fisheries management acknowledges biometric studies as a key parameter that can be used to assess the biomass and stock condition of fish species alongside other aspects of the population (Zargar et al. 2012). Biometric indices such as size, age, growth rate, and conditions are recognized as underlying variables that can be used to explain and forecast how various species respond to stressors such as exploitation, climate change, and so on (Hasan et al. 2021). Standing stock, yield, and biomass are frequently estimated from length frequency data converted with length-weight relationships (LWRs), and length-length relationships (LLRs) are useful for standardization of length type when data are summarized.

These parameters can be identified by measuring the length-weight relationship (LWRs) of fish in order to estimate the biomass of certain fish stocks and to manage fisheries resources (Shalloof & El-Far 2017) and as an indicator of fish condition (Froese 2006). The LLRs and LWRs are also widely acknowledged as the most effective framework for evaluating fish stocks inside the environment (Saha et al. 2019, 2021). Fish condition factors (K) may be used as an indicator of a fish's overall well-being and condition in regard to its surroundings, reflecting how strong or fairly deep-bodied the fish are (Froese 2006) and physiological status (Rahman et al. 2020).

Although *P. barbarus* was assessed as 'least concern' (Froese & Pauly 2024), the study of the biometry of *P. barbarus* is meager in Nigeria, particularly in Old Bakana Creek, and forms the basis of the present study. Therefore, the present study was conducted to broaden the knowledge of important biological features of *P. barbarus*, i.e., length frequency distribution, growth patterns based on length-length and length-weight relationship, and condition factors of this species from the Old Bakana Creek, which is situated in the southern part of Rivers State, which is part of the larger Niger Delta region, and has faced environmental challenges such as pollution from oil spills and industrial waste.

MATERIALS AND METHODS

Study site: Old Bakana Creek is a significant waterway located in the Degema Local Government Area of Rivers State, Nigeria. Situated in the Niger. It lies between longitude 4.8833°N and latitudes 6.9833°E. It is a distributary of the Benue River, which flows through the Niger Delta region (Fig. 1). It is a relatively small creek, with a width of about 100-200 meters and a depth of 5-10 meters. The creek is characterized by slow-moving water and mud sediment.

Sampling and sample handling: Samples of *P. barbarus* were collected from local fishermen using traditional fishing gear, such as basket traps with a length of 30cm and a diameter of 5cm and local drum traps with a mesh size of 3 to 9mm. A total of 267 specimens were sampled biweekly for each month from June to November 2023 (rainy season) from the fishermen in the study area (Fig. 2). The biological parameters of the fish were measured, including total lengths (TLs) and standard lengths (SLs), with a precision of 0.01cm using a measuring board of 0.01cm, and the weight of the fish was taken by means of an electronic precision balance of 0.1g at the Fisheries Laboratory, University of Port Harcourt.

The growth pattern of *P. barbarus* was inferred from the length-weight relationships. The LWR was calculated as $W = a \times L^b$ (a is the regression intercept and b is the regression slope) (Ricker 1973) W is fish body weight (g), and L is fish total length (cm). Length-length relationship analysis was performed using $Y = a + bX$, (Alam et al. 2012) Where, Y= total length, X= Standard length, a= constant of proportionality and b= coefficient of regression. 95% confidence limits (95% CL) of parameters a and b were also determined. Fulton's condition factor (K) was calculated based on Blackwell et al. (2000) as follows: $KF = 100 \times (W/L^3)$. Where K is Fulton's condition factor, W is fish body weight (g), and L is fish total length (cm) and 100 is a factor to bring the value of K near unity.

Statistical analysis: The Spearman rank-correlation test was used to evaluate the association of condition factors with total length (TL) and bodyweight (BW),

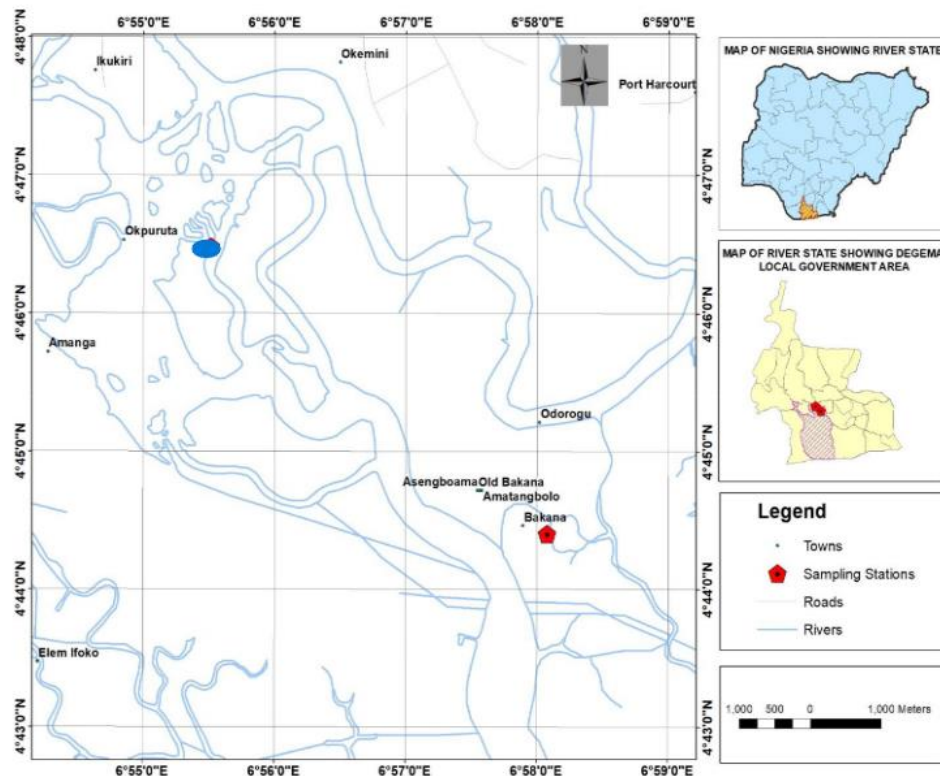


Fig.1. Map of the study area in old Bakana Creek.

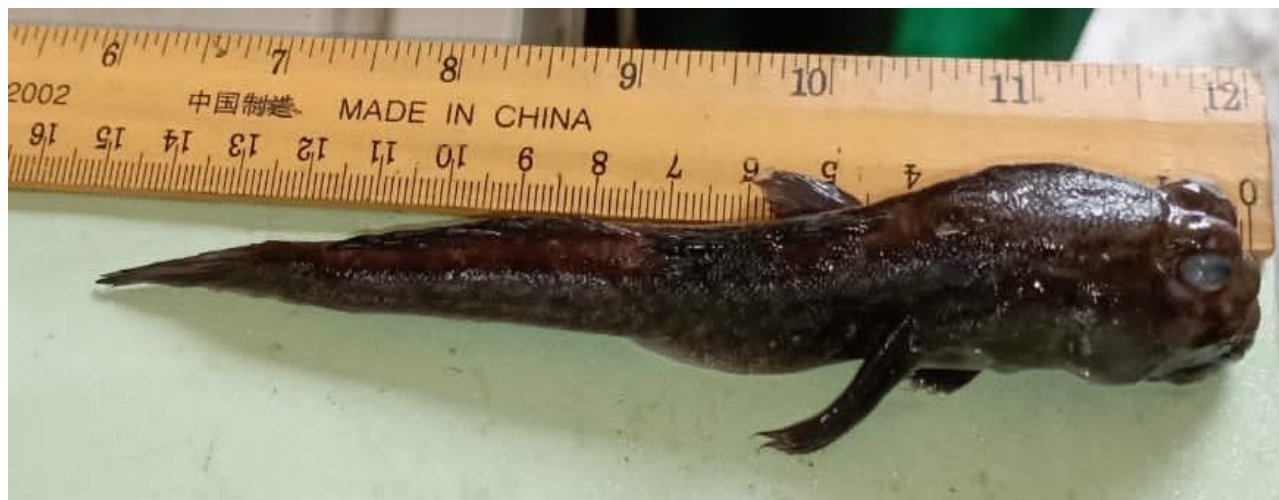


Fig.2. (*Periophthalmus barbarus*) species of mudskipper.

and all the statistical analyses were performed at 5% ($P < 0.05$) level of significance.

RESULTS

A total of 267 specimens of *P. barbarus* were collected for this investigation. Figure 3 presents histograms of the length-frequency distribution of *P. barbarus* from Woji Creek. The length frequency distribution (LFD) of *P. barbarus* exhibited a unimodal type distribution

with a mean value of 8.74 ± 1.505 . They were grouped into 21 classes based on total length and frequency. The group with the length size range of 11-11.50 cm had the highest percentage compared to the other group size ranges; the majority of fish caught were small (5.9 to 14.7 cm).

The ranges of monthly total length (TL), standard length (SL), and body weight (W) are depicted in Table 1. The mean total length ranged from 9.01 ± 1.42

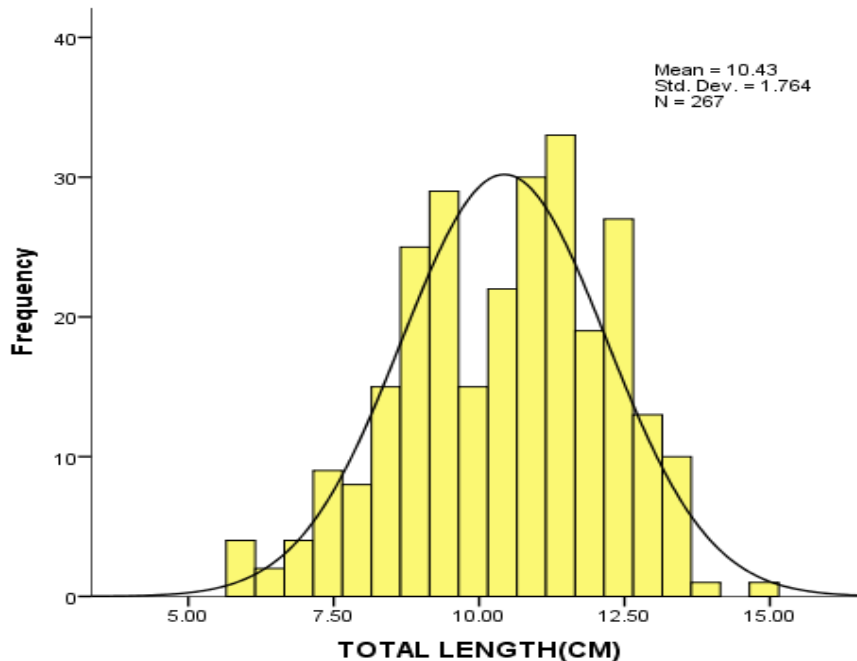


Fig.3. Length (TL) frequency distributions of *P. barbarus* from the Old Bakana Creek.

Table 1. Descriptive statistics of length (cm) and weight (g) of *P. barbarus* from the Old Bakana Creek.

Month	N	Total Length (cm)			Weight(g)			Standard Length(cm)		
		Min	Max	Mean $\pm$ SD	Min	Max	Mean $\pm$ SD	Min	Max	Mean $\pm$ SD
June	30	7.5	14.7	11.07 $\pm$ 1.85	0.3	24	11.09 $\pm$ 5.57	6.5	12.5	9.30 $\pm$ 1.50
July	44	9.6	13.5	11.75 $\pm$ 0.84	8	24	13.89 $\pm$ 3.48	8	11.4	9.83 $\pm$ 0.73
August	20	10	13.3	12.06 $\pm$ 0.84	3	18	11.40 $\pm$ 3.83	8.5	11.3	10.12 $\pm$ 0.75
September	44	8.7	13.2	11.19 $\pm$ 1.23	4	15	10.30 $\pm$ 2.82	7.4	12.2	9.40 $\pm$ 1.13
October	69	5.9	12.6	9.60 $\pm$ 1.55	2	17	8.46 $\pm$ 3.51	5	10.3	8.03 $\pm$ 1.30
November	60	5.9	13.2	9.01 $\pm$ 1.42	2	17	7.18 $\pm$ 3.03	4.8	10.8	7.54 $\pm$ 1.27

to 12.06 $\pm$ 0.84cm, and the mean standard length ranged from 7.54 $\pm$ 1.27 to 10.12 $\pm$ 0.75cm, while the mean body weight varied from 7.18 $\pm$ 3.03 to 13.89 $\pm$ 3.48g.

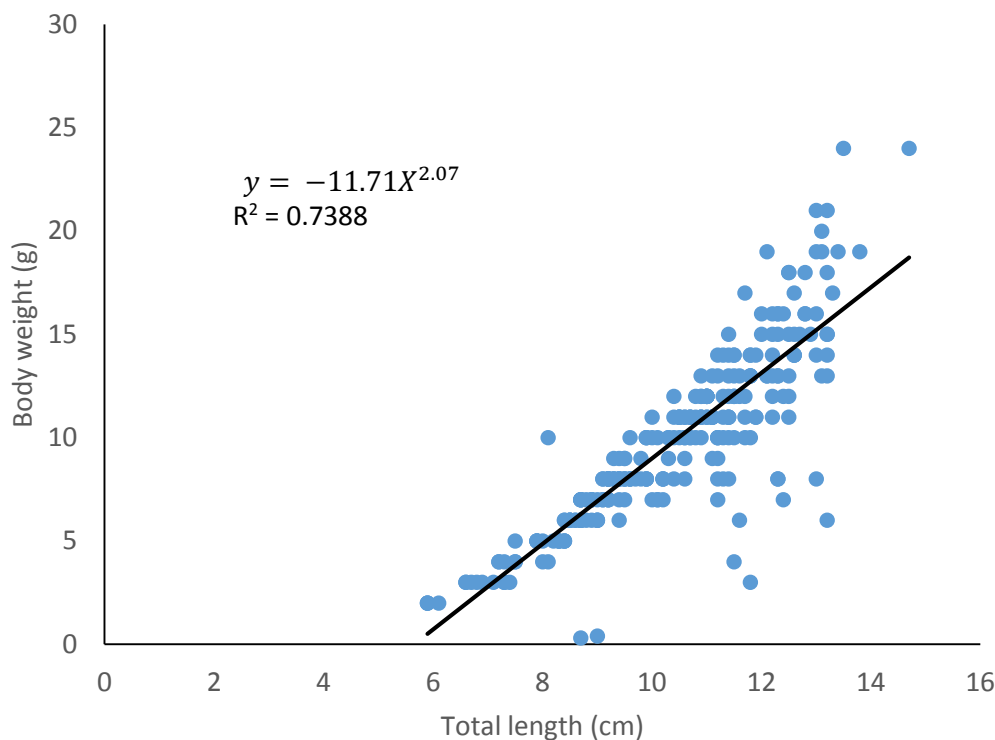
The monthly variances in the “b” value (allometry coefficient) were observed from 2.00 to 3.76 with the correlation coefficient (r^2) of 0.53 to 0.90 in Table 2. The growth coefficient was minimum in November (2) and maximum was observed in July (3.76). The regression parameters a and b of the LWRs, 95% confidence limits, and coefficients of determination (r^2) of *P. barbarus* were presented in Table 2. Overall b value (b= 2.07) for the *P. barbarus* population in the LWR specified negative allometric growth (b<3) (Fig. 4).

The monthly length-length relationship (LLR) with regression parameters a and b and the 95% confidence limit of b with the coefficient of determination (r^2) presented in Table 3 showed that the b value ranged from 0.81 to 0.87. All LLRs were highly correlated with the coefficient of determination values ≥ 0.90 , and the b values were less than 3 (b<3) throughout the sampling period.

Fulton’s condition factor mean values varied between 0.64 $\pm$ 0.16 and 0.94 $\pm$ 0.11 closed to the wellbeing threshold of 1 (Table 4). The highest value was recorded in November with a minimum value of 0.57, a maximum value of 1.07, and a mean value of 0.94 $\pm$ 0.11, while the lowest value was recorded in August with a minimum value of 0.18 and a maximum

Table 2. Descriptive statistics on monthly length-weight relationship and growth patterns of *P. barbarus* from the Old Bakana Creek.

Month	Regression Parameters		95% CL of b		R2	Growth type
	a	b	Min	Max		
June	-19.21	2.74	2.24	3.23	0.82	A-
July	-30.25	3.76	3.21	4.30	0.82	A+
August	-21.29	2.71	1.91	4.52	0.66	A-
September	-11.91	2.09	1.46	2.72	0.53	A-
October	-12.16	2.15	1.97	2.32	0.90	A-
November	-10.86	2.00	1.81	2.20	0.88	A-

**Fig.4.** Length-weight relationship of *P. barbarus* from the Old Bakana Creek.

value of 0.86 with a mean value of 0.64 ± 0.16 .

According to the Spearman rank correlation test in Table 5, it was observed that the relationships of condition factors with total length of *P. barbarus* from September to November were statistically significant, while from June to August they were not significantly different.

Further results revealed the monthly relationship between condition factor and body weight of *P. barbarus* in Table 6. Condition factors recorded for July and August were found statistically significant with the body weight ($P < 0.01$), while the values recorded for June, September, and November were not

significantly different.

DISCUSSION

Fisheries management and research often require the use of biometric relationships in order to transform data collected from the field into appropriate indices (Pathak & Serajuddin 2015), including LFDs, LWRs, LLRs, and condition factor. During this study, the mudskippers size range i.e. the total length ranged from 9.01 ± 1.42 to 12.06 ± 0.84 cm and weighed between 7.18 ± 3.03 and 13.89 ± 3.48 g. Mudskipper reaches 12.6 cm in total length and a maximum lifespan of ~6 years (Tran & Dinh 2020).

Table 3. Descriptive statistics on the monthly length-length relationship of *P. barbarus* from the Old Bakana Creek.

Month	Regression Parameters		95% CL of b		r ²
	a	b	Min	Max	
June	0.36	0.81	0.77	0.85	0.98
July	-0.03	0.84	0.76	0.92	0.92
August	-0.19	0.85	0.73	0.98	0.92
September	-0.34	0.87	0.78	0.96	0.91
October	0.12	0.83	0.79	0.86	0.97
November	-0.36	0.88	0.84	0.92	0.97

Table 4. Fulton's (KF) condition factors of *P. barbarus* from the Old Bakana Creek.

Month	N	Min	Max	Mean±SD	95% CL
June	30	0.05	1.19	0.76±0.24	0.67 - 0.85
July	44	0.67	1.07	0.84±0.08	0.82 - 0.87
August	20	0.18	0.86	0.64±0.16	0.57 - 0.72
September	44	0.26	1.13	0.76±0.22	0.69 - 0.83
October	69	0.68	1.88	0.91±0.15	0.87 - 0.94
November	60	0.57	1.07	0.94±0.11	0.91 - 0.97

Table 5. Relationships between condition factors and total length of *P. barbarus* from the Old Bakana Creek.

Months	r-value	95.0% Confidence Interval for r		P	Level of Significance
		min	max		
June	-0.08	-3.58	2.34	0.67	NS
July	0.06	-2.53	3.85	0.68	NS
August	-0.01	-2.67	2.59	0.97	NS
September	-0.69	-5.03	-2.56	0.00	**
October	-0.26	-5.14	-0.26	0.03	*
November	-0.39	-8.14	-1.86	0.00	**

r, Spearman rank-correlation values; CL, confidence limit; P, shows the level of significance; ns, not significant; * Significant ($P < 0.05$); ** highly significant ($P < 0.01$).

Table 6. Relationships between condition factors and body weight of *P. barbarus* from the Old Bakana Creek.

Months	r-value	95.0% Confidence Interval for r		P	level of Significance
		min	max		
June	0.29	-1.85	15.28	0.12	NS
July	0.47	8.22	31.64	0.00	**
August	0.79	11.67	26.37	0.00	**
September	0.29	-0.09	7.40	0.06	NS
October	-0.01	-5.88	5.58	0.96	NS
November	-0.11	-10.18	4.27	0.42	NS

r, Spearman rank-correlation values; CL, confidence limit; P, shows the level of significance; ns, not significant; * Significant ($P < 0.05$); ** highly significant ($P < 0.01$).

The different sizes in fishes are influenced by location (King 1994), harvesting season and techniques, genetic and environmental variations, and temperature (Arranz et al. 2021).

Length-frequency histograms show the number or proportion of fish collected in various length categories. In this study, the group with the length size range of 11-11.50cm had the highest percentage compared to the other group size ranges. Variations in fish size (length-frequency) indicated that the fish population ranged from immature specimens to fully matured ones. The growth of a fish is considered as an interaction between the specimen and the environment. The monthly “b” values (growth exponent) indicating the rate of weight gain relative to growth in length or the rate at which weight increases for a given increase in length ranged from 2.00 to 3.76, while the overall estimated b value of the LWR (TL vs. BW) was 2.07, which specified negative allometric growth and was found to be accordant with the expected range (2-4) offered by Tesch (1970). Negative allometric growth patterns were common in the flattened mudskipper (*P. barbarus*) (Moslen & Daka 2017).

The negative allometric growth pattern in this study agrees with the observation of Lawson (2011) from the mangrove swamps of Lagos Lagoon for *Periophthalmus papilio* with b values of 2.55. Sunarni et al. (2019) revealed that negative allometric growth is influenced by the mudskipper (*Boleophthalmus pectinirostris*) swimming activity, thereby causing absorption of nutrients to reduce body weight. The monthly variation in “b” values could be attributed to biological conditions such as food availability and gonad development (Froese 2006). Quang (2016) revealed that seasonal changes and environmental factors had a significant effect on the mudskipper growth. Monthly variations in growth types, with positive allometric growth recorded in July while negative allometric growth in the other five months could be attributed to amphibious behaviours of *P. barbarus*. The mudskipper can adapt to intertidal habitats, and it is very active when out of water for feeding and interacting (Ansari et al. 2014). Muchlisin

et al. (2010) noted that fish behavior could affect the growth pattern besides the environmental factors, as the b value of active fish was lower than that of passive fish.

The slope (b) of LLRs is close to 1.0; the value ranged from 0.81 to 0.87, indicating that the two-length parameters expand simultaneously as the total length (TL). The length-length relationships (LLRs) were also strongly correlated with (r^2) values that varied between 0.91 and 0.98. The relationship between total length and standard length with body width is closely connected, which reflects a homogenous growth pattern.

Fulton’s condition factor in this study values varied between 0.05-1.88 are within the normal range recommended by Ujanial et al. (2012), who reported condition factor greater than or equal to 1 (≥ 1) is good, indicating a good level of feeding and suitable environmental conditions. The Spearman correlation values (r_s) showed a positive value between total length and condition factors, particularly in September and November, which were highly significant. Siddique et al. (2021) reported that there was a correlation between condition factor and length, and the condition factor decreased with increasing fish length. Body weight versus condition factor values recorded for July and August were highly significant. The higher the “k” values, the heavier the fish. Thus, the “k” value is directly proportional to the bodyweight of the fish. Changes in the condition factor of fish could be used to interpret various biological factors such as fatness, food availability, reproductive activities, and environmental health (Laurat et al. 2019).

CONCLUSION

This study provides reliable length-weight relationships, length-length relationships, and condition factors of *P. barbarus* in the Old Bakana Creek, Rivers State, Nigeria. *P. barbarus* exhibited negative allometric growth with a condition factor very close to 1. The results of the length-length relationship also indicate favorable environmental conditions for the growth of the fish species in the

creek. The findings will serve as a tool for management measures for the conservation of the *P. barbarus* in the Old Bakana Creek, which is very important for the local fishery.

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مقاله کامل

شاخص‌های ریخت‌سنجی ماهی گل‌خورک اقیانوس اطلس، *Periophthalmus barbarus* (Linnaeus, 1766)، از نهر قدیمی باکانا، ایالت ریورز، نیجریه

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چکیده: توزیع فراوانی طول (LFD)، روابط طول-وزن (LWR)، روابط طول-طول (LLR) و فاکتورهای وضعیت ماهی *Periophthalmus barbarus* از نهر قدیمی باکانا، ایالت ریورز، نیجریه مورد مطالعه قرار گرفت. این تحقیق از ژوئن تا نوامبر ۲۰۲۳ در سه محل نمونه‌برداری با استفاده از تکنیک نمونه‌برداری هدفمند انجام شد. در مجموع ۲۶۷ نمونه از گونه *P. barbarus* برای این بررسی جمع‌آوری شد. نتایج نشان داد که توزیع فراوانی طولی (LFD) گونه *P. barbarus* از نوع توزیع تک‌وجهی با میانگین مقدار 8.74 ± 1.50 است. میانگین طول کل از 9.01 ± 1.42 تا 12.06 ± 0.84 سانتی‌متر و میانگین وزن از 7.18 ± 3.03 تا 13.89 ± 3.48 گرم متغیر بود. مقدار b ($b = 2.07$) برای جمعیت *P. barbarus* در رابطه طول-وزن، رشد آلومتریک منفی را نشان داد. تمام روابط طول-طول با مقادیر ضریب تعیین $0.09 \leq$ همبستگی بالایی داشتند و مقدار b از 0.81 تا 0.87 متغیر بود. میانگین مقادیر فاکتورهای وضعیت فولتون بین 0.64 ± 0.16 و 0.94 ± 0.11 متغیر بود. روابط بین فاکتورهای وضعیت با طول کل ماهی *P. barbarus* از سپتامبر تا نوامبر ماه از نظر آماری معنی‌دار بود، در حالی که فاکتورهای وضعیت ثبت شده برای ژولای و آگوست ماه با وزن بدن از نظر آماری معنی‌دار بودند ($P < 0.01$). بنابراین، یافته‌های فوق اطلاعات ارزشمندی را برای سیاست‌گذاران در جهت حرکت به سمت احیا و بازسازی، حفاظت از گونه‌ها و مدیریت مؤثر ذخایر طبیعی *P. barbarus* فراهم می‌کند.

کلمات کلیدی: رشد آلومتریک، شاخص وضعیت، نهر قدیمی باکانا، *Periophthalmus barbarus*