Asian Journal of Biology

Volume 17, Issue 2, Page 1-20, 2023; Article no.AJOB.95916
ISSN: 2456-7124

Size Structures, Length-Weight Relationships and Condition Factors of *Synodontis obesus* (Boulenger, 1898: Siluriformes, Mochokidae) in the Lower Cross River, Nigeria

Ukpatu, John Etitigwun [a*], Udoidiong, Okon Micheal [b] and Nkanta, Glory [c]

[a] Department of Fisheries and Aquaculture, Faculty of Agriculture, Akwa Ibom State University, Obio Akpa Campus, Nigeria.
[b] Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Uyo, Nigeria.
[c] Department of Zoology, Faculty of Biological Sciences, Akwa Ibom State University, Ikot Akpeden Campus, Nigeria.

Authors' contributions

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

Article Information

DOI: 10.9734/AJOB/2023/v17i2317

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95916

Original Research Article

Received: 22/11/2022
Accepted: 27/01/2023
Published: 09/02/2023

ABSTRACT

Size Structures, Length-Weight Relationships and Condition Factors of *Synodontis obesus* ((Boulenger, 1898: Siluiformes, Mochokidae) were carried out with standard methods in the Lower Cross River, Nigeria to assess the population dynamics of the rarely studied but commercially

**Corresponding author: E-mail: etitigwun@yahoo.com;*

important species. A total of 241 specimens (124: wet season and 117: dry season) were collected at Ayadehe Head Bridge fishing port in Itu Local Government Area, Akwa Ibom State, Nigeria from August 2020 to January 2021. The overall abundance showed high size variability within months and between seasons. The total biomass of the specimens collected was heavier in the wet season (12020.33g =12.02Kg) than in the dry season (10709.3g =10.7Kg) with an overall biomass of (22729.63g =22.7Kg). The overall size structures were: 15.0 – 28.30 cm, mean: 21.5±2.44 cm TL; 12.0 – 20.5 cm, mean: 15.88±1.6 cm SL and 13.20 – 21.50 cm, mean: 16.88±1.64 cm FL. The total weight of the species varied from 42.30 – 166.0g with overall mean value of 94.31±2.603g. The length and body weight of fish samples caught for both wet and dry season were significantly different ($p<0.05$).The length composition of the species exhibits unimodal, bimodal and trimodal growth patterns. The species had heterogeneous groups or cohorts (1+, 2+ and 3+) with variation in body weight. The length-at-first maturity of *S. obesus* was 20.85 cm mid length. Growth coefficient (b) varied between (2.497) for the wet season and (2.617) for the dry season respectively with the mean growth coefficient (b=2.532) in the LWR ($W= aL^b$). The species exhibited negative allometric growth pattern with an increase in length resulting to increase in weight of the fish. The condition factor (K) decreased with increased in the size of fish and ranged from 2.17-2.57 (Mean: 2.35) in both wet and dry seasons. The average condition factor (K) (2.35±0.15) was > 1.0 for both seasons revealing that the species was in good physiological state of well-being. The condition factor (K) of *S. obesus* by size category showed K-values for recruits > sexually mature fish > aged fish. Thus fish size is an exponential index of condition factor. The results of this study constitute valuable fisheries data that would enhance the availability, conservation, valorization, exploitation and sustainability of *S. obesus* in the Lower Cross River, Nigeria.

Keywords: LWR; population dynamics; growth indices; condition factor; management implication.

1. INTRODUCTION

The Coas synodontis (*Synodontis obesus,* fat species*)* is a fresh water cat fish found mostly in creeks, ponds, streams, lakes, rivers and coastal drainages of Cameroon, Nigeria, Ghana, Togo and other Central and West African countries. The species was first described by British – Belgian Zoologist George Albert Boulenger in 1898 as an upside-down catfish with strong, bony head capsule that extends back as far as the first spine of the dorsal fin [1,2] This fish has whisker like organs on their head called barbels which relate to touch, the colour of their skin, the skull bone and number of length of teeth.

Length frequency distribution is one of the methods that are used to estimate the relative growth of the species. The Length-Weight Relationship (LWR) is a mathematical model that allows for the conversion of length into weight, and weight into length in stock assessment models, as well as the estimation of biomass from the length frequency distribution and are useful for a wide number of studies, such as estimating growth rates, age structure and other aspects of fish/shrimps population dynamics [3-5].

In fisheries science, condition factor is used in order to compare the "condition", "fatness" or wellbeing of fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to access the status of the aquatic ecosystem in which fish live. It is a useful index for monitoring of feeding intensity, age and growth rates in fish species and family.

The family Mochokidae comprises three genera-*Mochochus*, *Chiloglanis* and *Synodontis* (the largest genus of the catfishes). The *Synodontis* species has contributed significantly to the dietary protein intake of human population mostly in Northern part of Nigeria. Across the globe, several studies had been carried out on the Mochokidae family. Outside Nigeria, the genus *Synodontis* had been studied by Entsua-Mensah et al. [6] in Votta River, Ghana; Konan et al. [7] in coastal Rivers, Southeast of Ivory coast; Midhat et al. [8] in River Nile at Gizza.

In different parts of Nigeria especially in the Northern part, studies had centered on the length frequency distribution, LWR and condition factor of *S. schall, S. robbianis, S. resupinatus, S. clarias, S. sorex* and *S. frontosus* in different water bodies and the works include those of Araoye, [8,10] and Araoye et al. [3] for *Synodontis schall* (Teleostei: Mochokidae) all in Asa Lake Ilorin, Nigeria; Adeyemi [4] on *Synodontis resupinatus*_in Idah Area of River Niger, Nigeria; Akombo et al. [11] in Lower River

Benue; Azua and Akaahan, [12] in Lower River Benue, Makurdi, Nigeria, Sidi Imorou et al*. [13]* in Okpara Stream, Nigeria all on *S. schall* and works of Arame et al*.* [5] who studied the fishes of Mochokidae family in Niger River, Northern Nigeria. In the western part of Nigeria, few works also were carried out on *Synodontis* species. They include the works of Abdul [14] in Ogun State coastal estuary, Nigeria. However, little or no information exists on the species *Synodontis obesus* in the Southeast Nigeria except the work of Offem et al*;* 2009 on forty-six important fishes which only include *Synodontis schall* of tropical flood river and Essien-Ibok et al; 2015 on the biology of Mochokidae in the lower Cross River, Akwa Ibom State. *S. obesus is* rarely studied but commercially important species in the Lower Cross River, Nigeria. Knowledge of the biology, population structures, length frequency distribution, length-weight relationships and condition factors of *S. obesus* would enhance the success of good scientific planning and management of the species in the Lower Cross River, Nigeria. Thus, this study was carried out to fill the gaps in knowledge of the length frequency distribution, length-weight relationships and the condition factor of *S. obesus* of the Lower Cross River System in order to provide useful tools for fishery assessment and sustainable management of the species in Nigeria.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

This study was conducted in the lower Cross River were samples are landed at Ayadehe Head Bridge fishing port in Itu Local Government Area, Akwa Ibom State, Nigeria. The lower Cross River is situated in the South East of Nigeria and has an area of about 1500km^2. The area is located between longitude 8^0 30ˈE and latitude 4^0 32^1 and 5^0 12N [15]. The cross river estuary is connected with the neighboring estuarine water in the south west of Cameroon [16] (Fig. 1).

2.2 Climate

The lower Cross River shares the climatic conditions that prevail in the rain forest zone of southern Nigeria where the weather is permanently wet with an annual rainfall of up to 4000m. The mean annual temperature for the area is about 27^0C with mean maximum of approximately 30^0C recorded in the month of January, with a narrow range of about 3^0C. The narrow range is attributed to the nearness of the area of the sea, which tends to prevent extreme fluctuation of temperature. The main factor influencing the climate is movement of inter – tropical front which gives rise to two seasons, the wet and dry season. The wet season is characterized by high rainfall, relative humidity and heavy clouds from April to mid - November. The dry season during which harmattan occurs begins in mid-November and ends in March.

2.3 Activities on the Lower Cross River

Some activities carried out include timber cutting, fishing, farming, trading and exchanging of goods which take place below and around the head bridge.

2.4 Collection to Fish Samples

The fishes were caught by the local fishermen using wooden canoes and speed boats. They made use of gill nets and traps. The samples were gotten directly from the fishermen on early arrival at cheaper prices or most times bought from the market women. Specimens were collected for six months (August, 2020 to January, 2021).

2.5 Measurement of the Samples

The total length was taken by the measuring distance from the tip of the snout to the end of the caudal fin. The standard length was obtained by measuring the length of the fish from the tip of snout to the end of the caudal peduncle using a measuring board. The weight was measured using balance. The samples were preserved in 10% formalin.

2.6 Data Analysis

Length-weight relationship was done using the formula $W=aL^b$ [17] which was transformed into natural logarithmic form in W=Log a + b Log L, where W = body weight (g), L = Total Length (cm), a = constant, b = growth exponent. Condition factor (K) was computed using the formula $K = 100\ W/SL^3$, where W=Fish weight (g), SL = Fish Standard Length (cm). All the analyses were performed with FAO-ICLARM Stock Assessment Tool (FiSAT II, version 1.2.2)- [18] and computer-based SPSS package, version 20. Significant differences in fish growth were tested with student's t-test according to the method of Sokal and Rohlf, [19].

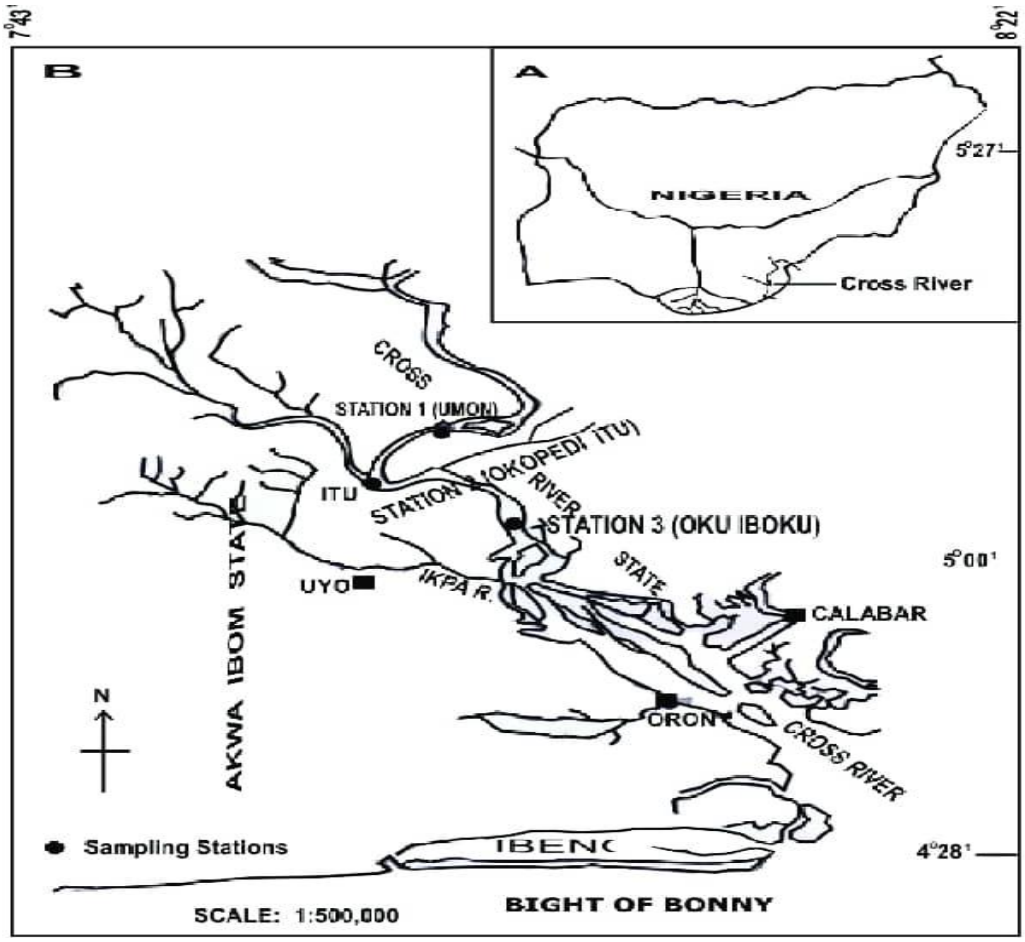


Fig. 1. Map of Lower Cross River showing the sampling stations

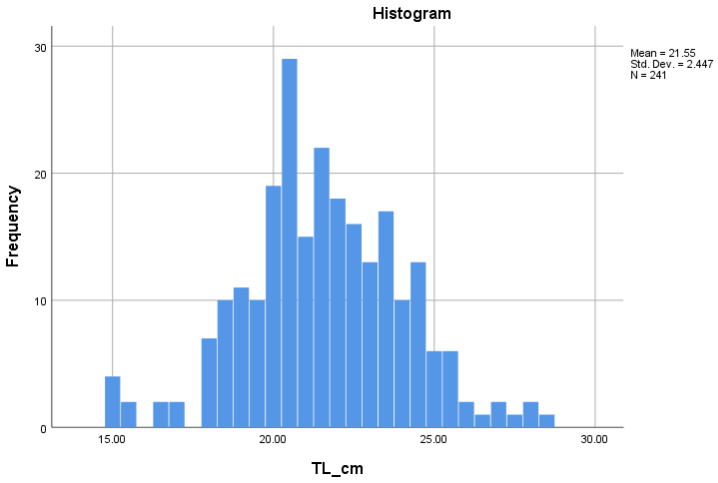
3. RESULTS

3.1 Length Frequency Distribution of *Synodontis obesus*

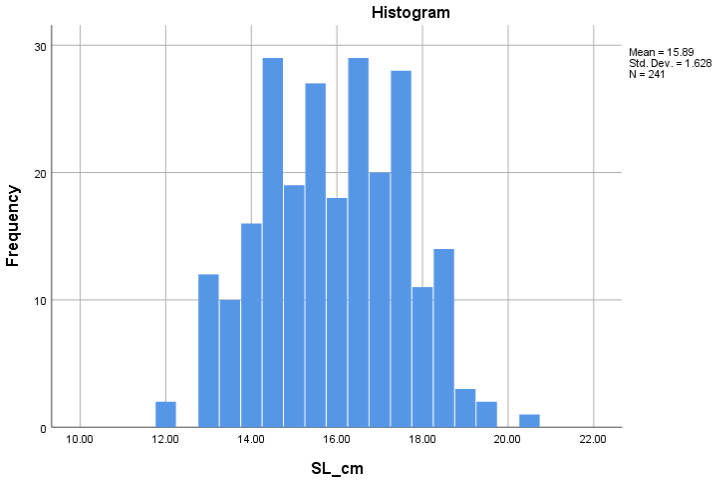
The total length, standard length and fork length distribution of *Synodontis obesus* in the Lower Cross River, Nigeria are displayed in Fig. 2 (a-c). There were variations in the sizes of *S. obesus* landed at Ayadehe Head Bridge fishing port in Itu Local Government Area, Akwa Ibom State, Nigeria from August 2020 to January 2021. The total biomass of the specimens collected was bigger in the wet season than in the dry season. The maximum total length (L_{max}) was 28.30 cm while the minimum total length was 15.0cm with a mean value of 21.55cmTL. The standard length ranged from 12.0cm to 20.5cm with mean value of 15.88cm. The fork length varied from 13.20-21.50 cm with a mean value of 16.89cm. Total length, standard length, fork length and total weight showed significant seasonal variation ($p<0.05$). Length distribution followed a normal frequency curve (Fig. 2 a-c).

3.2 Determination of Age and Growth of *S. obesus*

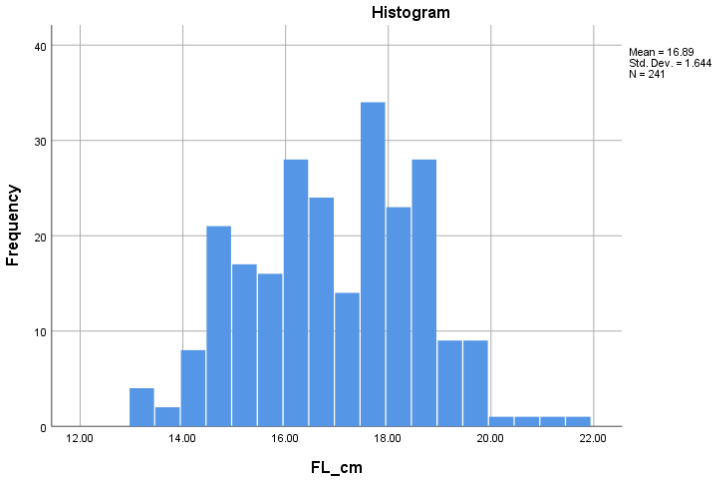
The length composition of the species exhibits unimodal, bimodal and trimodal growth pattern namely: modal length of the first few age groups (recruits or infants), modal length of the active population (sexually mature age) and the aged fish. This is an indication that the population of the species in the Lower Cross River had heterogeneous groups or cohorts (1+, 2+ and 3+) with variation in body weight. The size groups (active population, 20.0- 25.0 cm) were numerically dominant comprising 54% of the sampled population, while size groups (juvenile, 15.0 -19.5 cm) produced 28 % and the length class aged fish (25.10-28.50 cm) TL contributed 18%. This mean infant mortality is < 30%, adult mortality is > 55% while death by senescence account for 5% (Fig. 3).



(a)



(b)



(c)

Fig. 2 (a-c). Length frequency distributions of *Synodontis obesus* in the Lower Cross River, Nigeria (TL = total length; SL = standard length; FL = fork length)

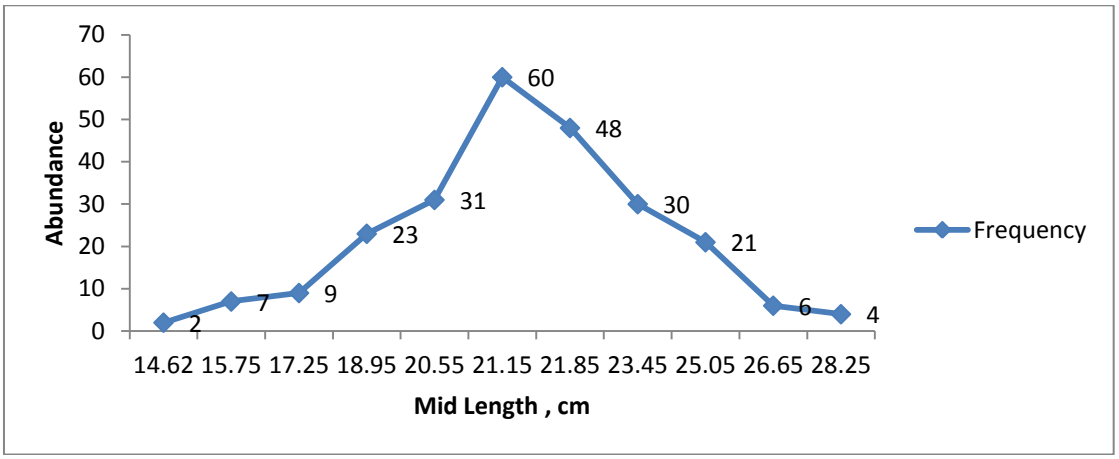


Fig. 3a. Length class and numerical abundance of *Synodontis obesus* in the Lower Cross River

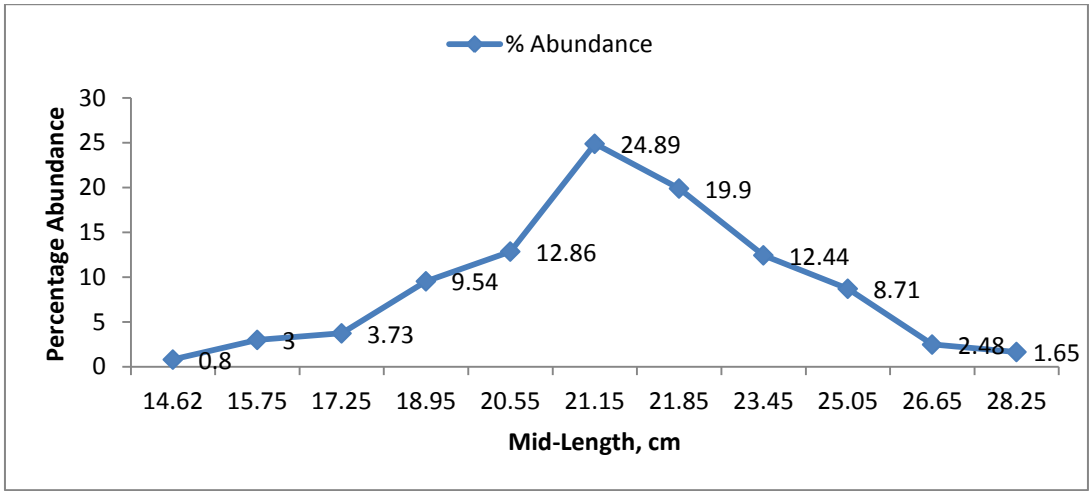


Fig. 3b. Length class and percentage abundance of *Synodontis obesus* in the Lower Cross River

3.3 Length -at -first Maturity of *Synodontis obesus*

The length –at-first maturity is the length at which the species attend sexual maturity detected at 50% from Ogive. The predicted mean-length-at age curve displayed in Fig. 4, revealed that the length-at-first maturity of *S. obesus* was 20.85 cm ML. The sexually mature specimens account for about 25% of the population (Fig. 4).

3.4 Numerical Abundance

A total of 241 individuals of *Synodontis obesus* (Mochokidae), 124 (wet season) and 117 (dry season) were collected at Ayadehe Head Bridge fishing port and used for this study. Numerical abundance varied from month to month with a peak in October. The overall abundance showed high size variability within months and between seasons (Table 1). The fish biomass was heavier in the wet season (12020.33g =12.02Kg) than in the dry season (10709.3g =10.7Kg) with an overall biomass of (22729.63g =22.7Kg).

3.5 Monthly and Seasonal Size Structures

The monthly size structures of *S.obesus* in Lower Cross River are displayed in Table 1. In the wet season, the maximum size (TL, SL and TW) were recorded in September, while maximum sizes in the dry season were recorded in January. Seasonal variation in size showed higher values in the wet season than in the dry season (Table 2). The total length ranged from 15.0-28.30 cm, mean: 21.95±2.66 (wet season)

and 15.0-26.90 cm, mean: 21.14±2.12 (dry season). Standard length fluctuated from 12.90-20.5 cm, mean: 16.25±1.64 (wet season) and 12.00-19.00 cm, mean: 15.50±1.51 (dry season). Fork length oscillated between 13.20-21.50 cm, mean: 17.23±1.69 (wet season) and 13.20-19.60 cm, mean: 16.52±1.51 (dry season). The total body weight varied from 43.55-166.0g, mean: 96.93±28.8 (wet season) and 42.30-144.16g, mean: 91.68±23.29 (dry season). The overall size structures were: 15.0 – 28.30 cm, mean: 21.5 ± 2.44 cm TL; 12.0 – 20.5 cm, mean: 15.88±1.6 cm SL and 13.20 – 21.50 cm, mean: 16.88±1.64 cm FL. The population structure of *S. obesus* revealed TL>FL>SL. The total weight of the species varied from 42.30 – 166.0g with overall mean value of 94.31±2603g TW (Table 2). The length and body weight of fish samples caught in both wet and dry seasons were significantly different ($p<0.05$).

There were significant positive relationships between total length-standard length ($r=0.842$, $p<0.05$); total length- fork length ($r=0.883$, $p<0.05$); total length- total weight ($r= 0.757, p<0.05$); standard length-fork length ($r= 0.953, p<0.05$); standard length-total weight ($r=0.850$, $p<0.05$) and fork length –total weight ($r= 0.815, p<0.05$). Generally, the results showed strong correlation between length-weight relationships ($p<0.05$).

3.6 Length-weight Distribution

The log-transformed length–weight relationship and the linear growth graphs as shown in Fig. 5 (a &b) revealed positive correlation ($p<0.05$) between length and weight of the species.

The straight line graph implied that as the length of the fish increased, the weight also increased, while the logarithmic curve showed that the weight of the fish increased in respect to the cubic length of the fish. Table 3 shows regression parameters of length-weight relationship of *Synodontis obesus* of Lower Cross River, Nigeria. The relationship shows that the length increased as the weight increased as shown by the positive "a" value and high coefficient of determination (r^2).

3.7 Monthly Length-weight Relationship Parameters of *Synodontis obesus* Caught in the Lower Cross River

Length-weight relationships (LWRs), Allometric coefficient (b), intercept (a), Correlation coefficient (r), Coefficient of Determination (R^2), growth trends and p-values of of *Synodontis obesus* caught in the Lower Cross River (August, 2020-January, 2021) are summarized in Table 3.

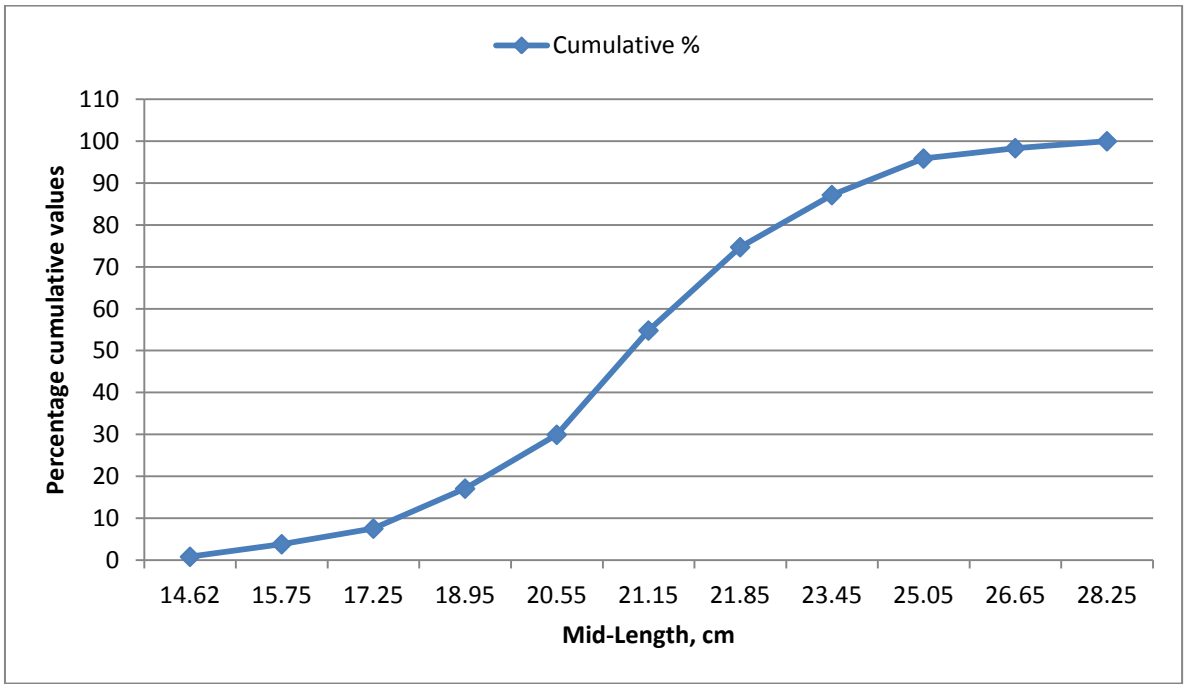


Fig. 4. Length -at -first maturity of *Synodontis obesus* in the Lower Cross River, Nigeria

Table 1. Monthly Size structures of *Synodontis obesus* in the wet season months (August, 2020-October, 2020) and in the dry season months (November, 2020 – January, 2021)

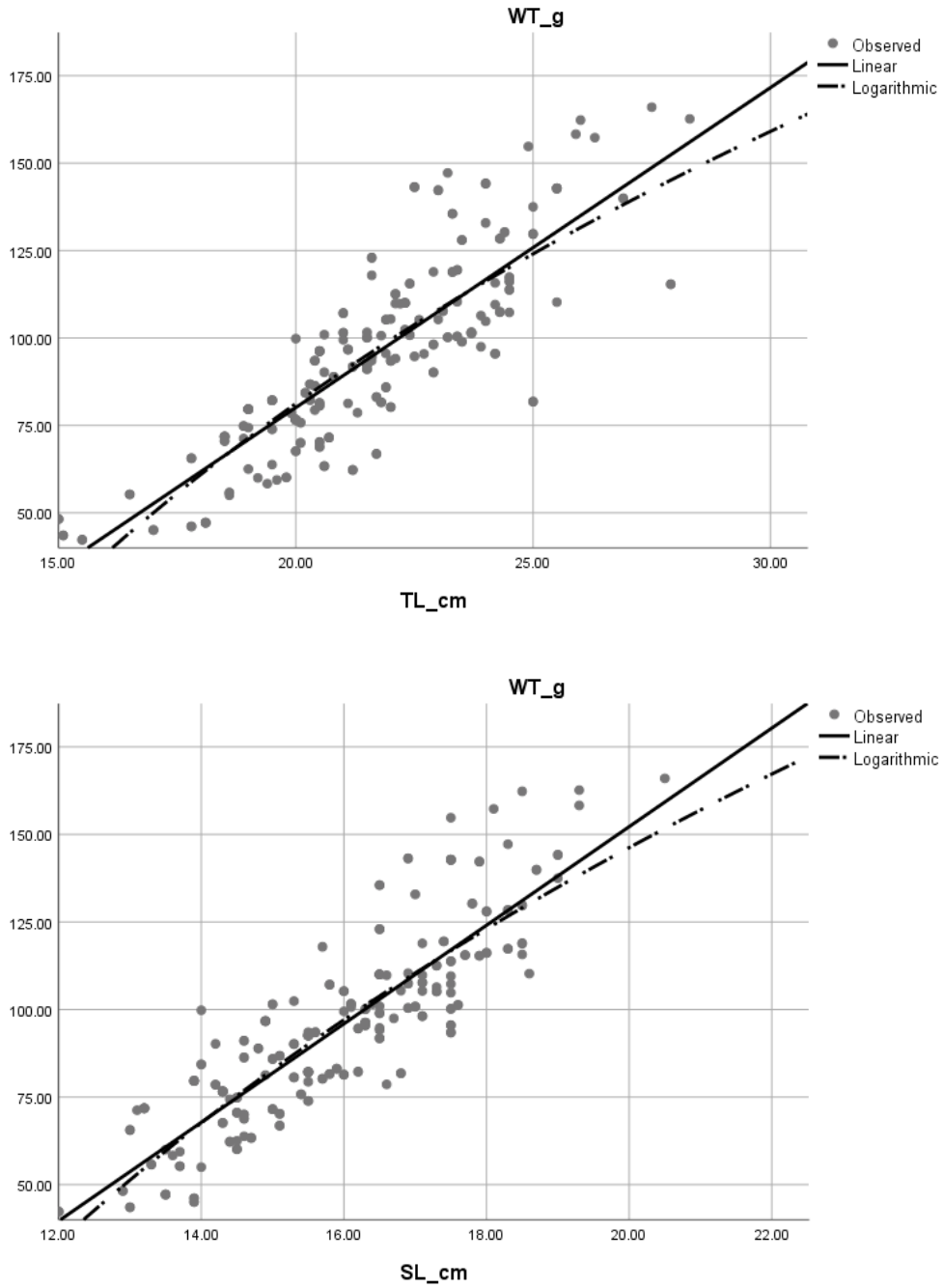
Wet Season									
		Aug			**Sep**			**Oct**	
Parameters	**N**	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**
Total Length (cm)	40	19.00-27.90	22.83±1.92	39	15.00-28.30	21.77±3.04	45	15.10-27.90	21.33±2.72
Standard Length (cm)	40	13.70-19.30	16.73±1.36	39	12.90-20.50	16.32±1.76	45	13.00-19.30	15.76±1.67
Fork Length (cm)	40	14.90-21.10	17.73±1.404	39	13.20-21.50	17.26±1.83	45	13.70-20.60	16.76±1.70
Total Weight (g)	40	59.40-162.65	102.67±24.87	39	43.55-166.00	94.70±30.47	45	43.55-162.31	93.78±30.51
Monthly biomass		4106.9 (4.1Kg)			3693.33 (3.6Kg)			4220.1 (4.2Kg)	
Total biomass (wet season)	**124**	**12020.33(12.02Kg)**							
Dry Season									
		Nov			**Dec**			**Jan**	
	N	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**
Total Length (cm)	40	15.50-25.50	20.46±1.74	43	15.50-25.50	21.23±2.02	34	15.00- 26.90	21.76±2.45
Standard Length (cm)	40	12.00-17.50	14.92±1.24	43	12.00-18.50	15.68±1.49	34	12.90-19.00	15.93±1.66
Fork Length (cm)	40	13.30-18.80	16.00±1.30	43	13.30-19.50	16.69±1.46	34	13.20-19.60	16.87±1.65
Total Weight (g)	40	42.30-142.80	85.66±20.19	43	42.30-143.16	93.34±23.10	34	47.18-144.16	96.14±26.13
Monthly biomass		3426.66 (3.4Kg)			4013.72 (4.0Kg)			3268.9 (3.2Kg)	
Total biomass (dry season)	**117**	**10709.3 (10.7Kg)**							
Wet+Dry season	**241**	**22729.63 (22.7Kg)**							

N = Number of specimen, SD = standard deviation, Range (Minimum-Maximum values)

Table 2. Seasonal Size structures of Synodontis obesus in the wet season months (August, 2020-October, 2020) and in the dry season months (November, 2020 – January, 2021)

	Wet Season			Dry season			Combined season		
Parameters	**N**	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**	**N**	**Range**	**Mean±SD**	**Sig level**
Total Length (cm)	124	15.00-28.30	21.95±2.66	117	15.00-26.90	21.14±2.12	241	15.00-28.30	21.55±2.44	F=3.946, p=.0021, p<0.05
Standard Length (cm)	124	12.90-20.50	16.25±1.64	117	12.00-19.00	15.50±1.51	241	12.00-20.50	15.88±1.62	F=7.075; p=0.001; p<0.05
Fork Length (cm)	124	13.20-21.50	17.23±1.69	117	13.20-19.60	16.52±1.51	241	13.20-21.50	16.88±1.64	F=6.376;p=0.002;p<0.05
Total Weight (g)	124	43.55-166.00	96.93±28.84	117	42.30-144.16	91.68±23.37	241	42.30-166.00	94.31±26.39	F=1.481;p=0.229; p<0.05

N = Number of specimens, SD = standard deviation, Range (Minimum-Maximum values); p< 0.05 = significant; p>0.05 = not significant



Fig, 5. Linear and logarithmic relationships between: (a) total length (TL, cm) and total weight (TW, g); (b) Standard length (SL, cm) and total weight (TW, g) of *S. obesus* collected in Lower Cross River, Nigeria (vertical axis = total weight in grams)

3.7.1 Growth Coefficient (b)

Seasonal exponential growth coefficient (b) varied between 2.497 (wet season) - 2.617(dry season) with a mean value of 2.532. The mean value of (b) was less than the theoretical cubic value of 3.0. In both seasons, t-value revealed significant difference between calculated **b**. Evaluation of the plumpness of *S. obesus* showed the fish exhibits significant negative allometric growth (b= 2.35 < 3.0, $p<0.05$) which signifies that the fish grows thinner with age.

Table 3. Monthly Length-weight relationship parameters of *Synodontis obesus* caught in the Lower Cross River (August, 2020-January, 2021)

Months	N	Intercept (a)	Growth exponent (b)	Correlation coefficient (r)	Coefficient of determination (R^2)	Growth	P-value (t-test)	Level of significance
August	40	1.1479	2.9972	0.8953	0.7736	A-	t=7.522, p=0.0001	*
September	39	0.8902	2.3194	0.91917	0.8448	A-	t=14.195, p=0.0001	*
October	45	1.1018	2.591	0.88861	0.78963	A-	t= 12.704, p=0.0001	*
Wet season	**124**	**0.96887**	**2.4973**	**0.87825**	**0.77133**	**A-**	**t=20.286, P=0.0001**	*****
November	40	1.4269	2.9502	0.86628	0.75044	A-	t=10.69, p=0.0001	*
December	43	0.8277	2.6411	0.79568	0.6331	A-	t=8.4112, p=0.0001	*
January	32	0.9263	2.4476	0.8853	0.78375	A-	t= 10.769, p=0.0001	
Dry season	**117**	**0.9688**	**2.6174**	**0.85028**	**0.72298**	**A-**	**t= 17.324, P=0.0001**	*****
Wet+Dry season	**241**	**0.9467**	**2.5320**	**0.86581**	**0.74963**	**A-**	**t=26.751, P=0.0001**	*****

**Significance @p<0.05, A- : negative allometric growth; values in brackets are monthly total biomass in kilograms*

Table 4. Standard length, body weight, and condition factor by season of *Synodontis obesus* captured in Lower Cross River, Nigeria

Season	N	Standard Length (cm)		Total Weight (g)		Condition Factor		P
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	
Wet season	124	12.90-20.50	16.25±1.64	43.55-166.00	96.93±28.84	2.17-2.39	2.25±0.12	
Dry season	117	12.00-19.00	15.50±1.51	42.30-144.16	91.68±23.37	2.37-2.57	2.45±0.01	
Combined seasons	241	12.00-20.50	15.88±1.62	42.30-166.00	94.31±26.39	2.17-2.57	2.35±0.15	p>0.05

N = Number of specimens, SD = standard deviation, Range (Minimum-Maximum values); p< 0.05 = significant; p>0.05 = not significant

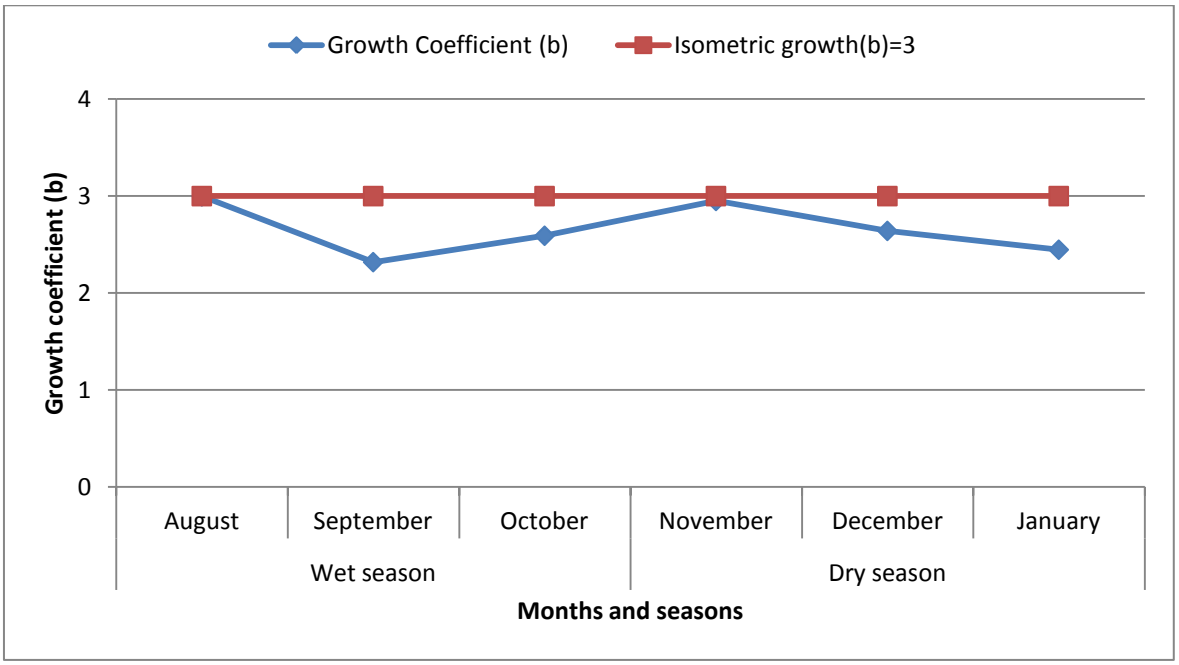
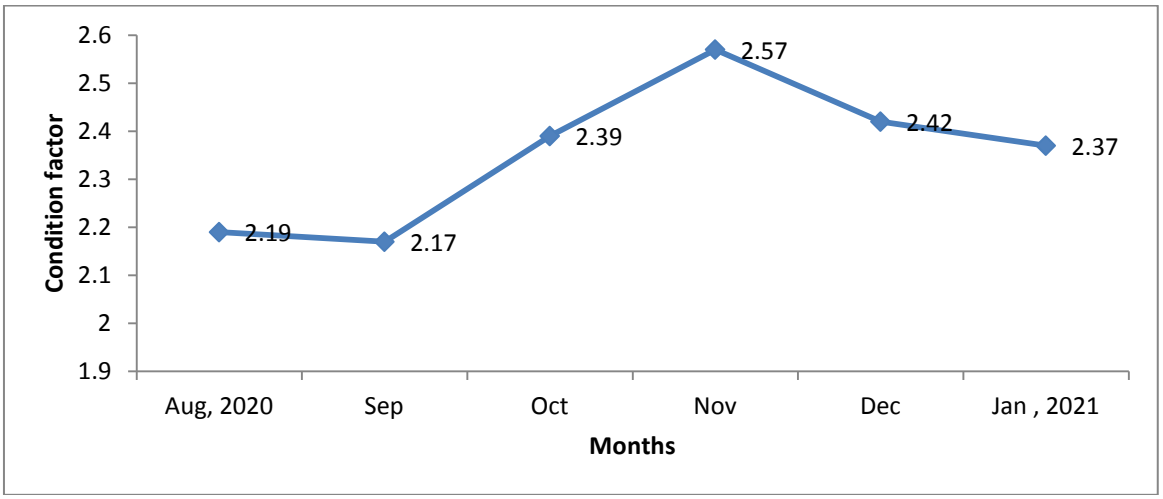


Fig. 6. Monthly Variation of growth coefficient (b) of *Synodontis obesus* caught in the Lower Cross River (August, 2020-January, 2021); the straight line is the standard isometric value = 3.0



(a)

Fig. 7. Monthly variation of condition factor(K) for *Synodontis obesus* from the Lower Cross River during August 2020-January, 2021

3.7.2 Condition factor (K) of *Synodontis obesus*

Value of the condition factor *of Synodontis obesus* showed that in the wet season, K values ranged from 2.17 to 2.39 with an average of 2.35± 0.12 (Fig. 7). In the dry season, value of K ranged between 2.37- 2.57 with a mean value of 2.45±0.06. The overall value of K ranged from 2.17-2.57 with an average value to 2.35±0.15 (Table 4). Thus, the higher values of K were recorded in the dry season months (November, b = 2.57) while lower values were recorded in the wet season (September, b= 2.17). The student's t-test showed no significant difference between the K value of *S. obesus* obtained in the wet season with those obtained in the dry season ($p>0.05$). There was significant difference between the calculated K and the standard value of 1.0.

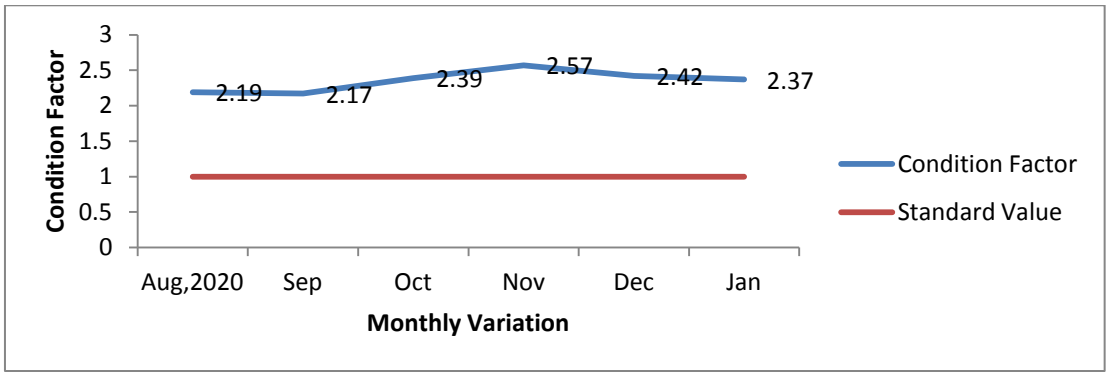


Fig. 8. Monthly variation of condition factor(K) for *Synodontis obesus* from the Lower Cross River during August 2020-January, 2021 (the straight line is the standard value =1)

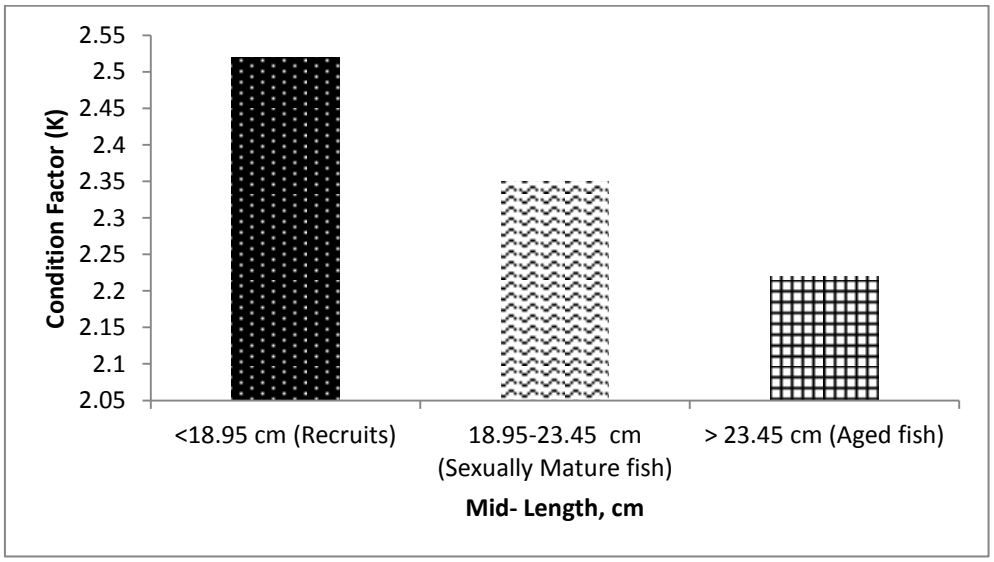


Fig. 9. Condition factor of *S. obesus* by size category in the Lower Cross River, Nigeria

3.7.3 Condition Factor of *S. obesus* by size category from Lower Cross River, Nigeria

The K values decreased with size of *S. obesus.* The recruits ($< 18.95\text{cm}, \text{mid} - \text{class}$) had better and higher condition factor than the sexually mature fish (18.95-23.45cm, mid-class) and larger fish aged > 23.45cm, mid class respectively (Fig. 9). The condition factor (K) of *S. obesus* by size category showed K-values for recruits > sexually mature fish > aged fish. Thus fish size is an exponential index of condition factor (Fig. 9).

3.7.4 Population structures and growth parameters for *Synodontis* species from different localities

The total length (TL, cm), standard length (SL, cm), total weight (TW, g), growth coefficient (b) and condition factor (K) of *Synodontis* species reported from different localities are summarized in Table 5.

4. DISCUSSION

4.1 Size Structures and Maturity

The maximum standard length (SL = 20.5cm) was recorded in this study. The recorded standard length for the species is higher than SL= 19.5 cm reported by Arame et al. [5] for *Synodontis schall* from the Niger River, Northern Benin, Nigeria; (SL = 20.3cm) reported by Sidi Imorou et al. [13] in the Okpara Stream, Nigeria but smaller than (SL= 20.7 cm) reported by Biahoua et al. *[21]* in Man-made Lake, Ayame 2, Cot d'Ivore; (SL = 21.6 cm) reported by Entsua-Mensah et al. [6] for *Synodontis sorex* in the Votta River, Ghana; lower than SL= 22.5cm

Table 5. Growth and other population parameters for Synodontis species from different localities

	TL(cm)	SL (cm)	TW(g)	b	K	Locality	Source
Species							
S. schall		4.5-20.3			0.67±0.08	Okpara Stream, Nigeria	Sidi Imorou et al. [13]
		4.5-20.0	34.0-237.5	2.484	2.732	Niger River, Northern Nigeria	Arame et al. [5]
		22.5				Coastal Rivers, South-east of Ivory Coast	Konan et al. *[7]*
		24.3				SO River Southern Benin, Nigeria	Hazoume et al. [20]
	6.1-30.4 (12.04±0.11)		53.0-86.4 (57.7±2.26)	2.497-2.674	2.874	River Benue, Makurdi, Nigeria	Araoye et al. *[3]*
		8.0-20.7	22.0-202	2.5163-2.7857 dry season; 3.008-3.001 (wet season	0.315-0.647(wet season; 1.0375-1.357 (dry season	Man-Made Lake, Ayame 2, Cot d'Ivoire	Biahoua et al. *[21]*
	28.30-42.90 (36.52)	26.0-40.10 (34.55)	248.40-432.20 (343.12)			Lower River Benue, Makurdi, Nigeria	Azua and Akaahan, [12]
				2.2863		River Nile at Gizza	Midhat et al. [8]
	(12.06±0.2)					Tropical flood River, Nigeria	Offem et al. *[22]*
	6.1-30.4		53.0-864.5 (57.71±2.26)	2.6749	2.885	Lower River Benue	Akombo et al. *[11]*
‘’	6.50-29.5 (13.89)		0.16-228.21	2.55		Lower Cross River, Akwa Ibom State	Essien-Ibok et al. *[23]*
S. resupinatus	11.20-24.20	8.20-16.6	8.75-76.05	3.130	1.03-2.55	Idah Area, River Niger, Nigeria	Adeyemi, S. O [4]
S. clarias		8.5-19.5		3.0859	0.790	Niger River, Northern Nigeria	Arame et al. *[5]*
‘’	(13.0)		(23.55)			Lower Cross River, Akwa Ibom State	Essien-Ibok et al. [23]
S. sorex		7.0-20.0		2.2588	7.276	Niger River, Northern Nigeria	Arame et a. [5]
‘’		21.6				Votta River, Ghana	Entsua-Mensah et al.

	TL(cm)	SL (cm)	TW(g)	b	K	Locality	Source
							[6]
‘’	(11.29)		(24.24)			Lower Cross River, Akwa Ibom State	Essien-Ibok et al. *[23]*
S. frontosus		6.5-14.0			0.409	Niger River, Northern Nigeria	Arame et al. *[5]*
S. obesus	(12.26)		(30.04)	2.64	1.46	Lower Cross River, Akwa Ibom State	Essien-Ibok et al. [23]
S.obesus	15.00-28.30 (21.55)	12.0-20.5(15.88)	42.30-166.00 (94.31)	2.532	2.17-2.57 (2.35)	Lower Cross River, Nigeria	This study

**values in bracket= mean value; Table 5 revealed that S. schall is the most dominant and most studied species of the genus Synodontis. Source: (Author Research, 2021)*

reported by Konan et al. [7] in the Coastal Rivers, South-east of Ivory Coast and equally lower than SL= 24.3cm recorded by Hazoume et al. [20] in the SO River Southern Benin, Nigeria (Table 5). The maximum size attained by *Synodontis* species is location specific. Variations occur in *Synodontis* populations of different localities. The reasons could be: (i) sampling season (ii) type of gear (iii) exploitation rate (iv) genetic makeup (v) prevalent environmental conditions.

4.2 Total Length and Total Weight

The fish ranged between 15.00-28.30, mean: 21.55cm for total length and 42.30-166.00, mean: 94.31g) total weight. The mean total length of *S. obesus* (21.55 cm) recorded in this study differs significantly from other reports. The value of 12.06±0.2 cm reported by Offem et al. [22] for *S. schall* in a tropical flood river, Nigeria is lower than this result. The mean total length and mean total weight are higher than the values of mean: 12.26cm TL and mean: 30.04g TW reported by Essien-Ibok et al. [23] for *S. obesus* in the Lower Cross River, Akwa Ibom State. The maximum total length is also higher than 26.2 cm TL reported by Akombo et al. [11] for *S. schall* in Benue River, Nigeria. This means that juvenile exploitation in the Lower Cross River, Nigeria was less severe. Also, the differences in Mochokid sizes from different localities could be as a result of habitat differentiation, environmental degradation, exploitation rate and diet.

The robust weight and increased length of the fish during wet season may be attributed to favourable environmental conditions and the availability of sexually mature population or gravid females during the breeding season of July to October. The <30% recruits, <55% sexually mature age and 18% aged fish is healthy for the fishery. The result indicated that the mortality rate of under-aged fish was low (<30%) while the rate of fishing mortality and decay by senescence were <55% and 18% respectively. This can encourage constant recruitment of juvenile into the fishery and guarantee optimal sustainable yield of the fishery in the Lower Cross River, Nigeria.

4.2.1 Growth coefficient (b)

The growth coefficient (b) signifies the growth pattern of the fish. Growth is isometric when the growth exponent b=3 and allometric when b is greater or less than 3. According to Pervin and Mortuza, [24], the growth coefficient (b) can be classified as b<3: negative allometric, b = 3: isometric and b>3: positive allometric growth. Seasonal growth coefficient (b) recorded in this study varied between 2.497 (wet season) - 2.617(dry season) with a mean value of 2.532. Thus, the overall growth coefficient (b) = 2.532 for *S. obesus* in this study signifies that the fish exhibits negative allometric growth pattern, i.e. the fish grows thinner with age or becomes less rotund as they increase in age. Several authors have reported allometric growth pattern for *Synodontis* species from various water bodies. The mean value of growth coefficient recorded in this study agrees with Adeyemi [4] who also reported negative allometric growth for S. *resupinatus* from Idah Area of River Niger, Nigeria. Similar negative allometric growth pattern was reported by Akombo et al*;* [11] for *S. schall* in the Lower River Benue. Essien-Ibok et al*. [23]* also obtained negative allometric growth pattern for *S. obesus* (b=2.64) from the Lower Cross River, Akwa Ibom State, Nigeria. Also, Arame et al. [5] obtained negative allometric growth pattern b= 2.258 and 2.484 for *S. schall* and *S. sorex* from Niger River, Northern Nigeria.

However, the allometric growth recorded for S. obesus in this study is different from other results. Unlike the results of this study, positive allometric (A+) growth pattern was reported by Konan et al. [7] for *S. schall* from the five coastal rivers of South-east of Cote d'Ivore. Higher positive allometric (A+) growth pattern value was also recorded for *S. robbianis* in Iddah Area River, Kogi State, Nigeria [4]. Other higher positive allometric (A+) growth pattern values were also recorded for *S. schall* and *S. clarias* in Niger River, Northern Nigeria [5].

4.2.2 Correlation coefficient (r)

The correlation coefficient (r) which values ranged from 0.7956 to 0.91917 (Table 3) in the species showed high degree of positive correlation ($p<0.05$) between the TL and TW of *S. obesus*. This indicates that increase in length showed a corresponding increase in weight of the fish. The high positive correlation in the LWR also agrees with other researchers on *Synodontis* species: Akombo et al. [11] who reported a high positive correlation of length-weight relationship between S. schall in the Lower River Benue; Essien-Ibok et al. [23] on *Synodontis* species in lower Cross River, Akwa Ibom State; Azua and Akaahan, 2017 on *Synodontis schall* obtained in the lower River

Benue at Makurdi, Nigeria and Arame et a. [5] on Mochokidae (Pisces: Teleostei: Silurifumes) from Niger River, Northern Nigeria.

4.2.3 Condition factor (K)

The values of K for both seasons were > 1.0 (2.17-2.57). These values were within the range of 2-4 recommended by Bagenal [25] as suitable condition for fresh water fishes. In fishery science, condition factor or body well-being >1.0 is considered good. Datta et al. [26], stated that condition factor (CF) is categorized into three conditions as follows: CF= 1: condition is poor, CF = 1.2: condition is moderate; CF ≥1.40 condition is proportionally good; CF ≥2.0 condition is good. The monthly and overall condition factor recorded for *S. obesus* was generally >2.0. Thus, the overall mean value (K= 2.35) recorded in this study indicates that *S. obesus* in the Lower Cross River is in good condition. Similar good condition for *S, obesus* (K > 1.0) was earlier established by Essien- Ibok et al. [23] for *S. obesus* in the Lower Cross River. Thus, *S. obesus* can survive better even when genetic and environmental conditions are less favourable in Lower Cross River. The good condition for *S. obesus* recorded in this study is comparatively in line with those documented by Adeyemi [4] which condition factor ranged from 1.57 to 3.83 for *Synodontis robbianis* in River Niger, Kogi State, Nigeria.

However, the finding is different from other results. For instance, the condition factor of *S. schall* recorded by Biahona et al. (2017) in man-made Lake Ayame 2, Cot d'Ivoire showed values <1.0. This implies that *S schall* was not in good physiological state of wellbeing in man-made Lake Ayame 2 Cot d'Ivoire. The disparity could be caused by adverse environmental factor in the man-made lake or the differences in lotic and lentic water bodies or the peculiarity and physiological distinction between *S. obesus* and *S. schall* of the same genus. Again, the K-values recorded in this study are quite higher than values reported by Sidi Imorou et al. [13] for *S. schall* (K=0.67+0.08) from Okpara stream and (K= 0.790) for *S. clarias* from River Niger Northern Nigeria [5]. The mean value of K (2.35) recorded in this study is lower than the values of 2.732 and 7.276 for *S. schall* and *S. sorex* respectively reported by Arame et a. [5] in Niger River, Northern Nigeria and *S. sorex* K= 2.885 for *S. schall* from River Benue, Makurdi, Nigeria [11].

4.3 Seasonal Condition Factor

The species showed good condition in both seasons but with peak in the dry season and trough in the wet season and varied according to the size structure of the fish. This means that the fish were in better condition in the dry season than in the wet season and perform well mostly in the dry periods. The results revealed that season influences the plumpness of *S, obesus* in the lower Cross River. Similar performance in the dry season was reported by Arame et al. [5] for *S. sorex* from Niger River, Northern Nigeria. This is different from the results of Akombo et al. [11] who found higher values of condition factor in the wet season months than in the dry season months for *S.schall* in the River Benue, Makurdi, Nigeria. There was no significant difference found in the K ($p>0.05$) of *S. obesus* collected in both wet and dry seasons from the Lower Cross River. This is similar to the results of Biahona et al. [21] who also reported no significant difference ($p>0.05$) in the K- value of *S. schall* collected in both wet and dry seasons from man-made lake of Ayame 2, Cot d'Ivoire.

4.4 Condition Factor of *S. obesus* by Size Category

The condition factor of *S. obesus* in the Lower Cross River decreases as the fish increases in size. Thus, the size of the fish is a determining dynamic or an exponential index of condition factor. According to Oni et al. [27], condition factor is not constant for a species or population over a time interval and might be influenced by size structures, biotic and abiotic factors, and state of gonad development, feeding regimes and seasonal fluctuation in environmental condition.

5. SUMMARY OF FINDINGS

- A total of 241 individuals of *Synodontis obesus* (Mochokidae) , 124 (wet season) and 117 (dry season) were collected at Ayadehe Head Bridge fishing port in Itu Local Government Area, Akwa Ibom State, Lower Cross River, Nigeria and used for this study. Numerical abundance varied from month to month with a peak in October. The overall abundance showed high size variability within months and between seasons.
- The overall size structures were: 15.0 – 28.30 cm, mean: 21.5±2.44 cm TL; 12.0 –

20.5 cm, mean: 15.88 $\pm$ 1.6 cm SL and 13.20 – 21.50 cm, mean: 16.88$\pm$1.64 cm FL. The population structure of *S. obesus* revealed total length (TL) > $fork\ lenght\ (FL)$ > $standard\ lenght\ (SL)$. The total weight of the species varied from 42.30 – 166.0g with overall mean value of 94.31$\pm$2.603g TW.

- The length and body weight of fish samples caught for both wet and dry seasons were significantly different ($p<0.05$)
- The results showed high degree of association ($p<0.05$) between length and weight of *S. obesus*
- The maximum total length (L_{max}) was 28.30 cm while the minimum total length was 15.0cm with a mean value of 21.55cmTL.
- The length composition of the species exhibits unimodal, bimodal and trimodal growth pattern namely: modal length of the first few age groups (recruits or infants), modal length of the active population (sexually mature age) and the aged fish.
- The population of the species had heterogeneous groups or cohorts (1+ infant, 2+ mature and 3+aged) with variation in body weight.
- The length-at-first maturity of *S. obesus* was 20.85 cm mid length.
- Monthly growth coefficient varied between 2.319- 2.997 ($b<3.0$)
- Seasonal growth coefficient (b) varied between 2.497 (wet season) - 2.617(dry season) with a mean value of 2.532
- The weight of *S.obesus* progressed at a lesser rate than the cube of the body implying a negative allometric growth pattern.
- The higher value of condition factor (K) was recorded in the dry season months (November) while lower values were recorded in the wet season (September).
- The condition factor (K) of *S.obesus* by size category showed K-values for recruits > sexually mature fish > aged fish.
- Condition factor decreases as the fish increases in size and varied according to season in the Lower Cross River, Nigeria.

6. CONCLUSION

Based on the findings, the following conclusion was reached:

- Length distribution of *S. obesus* followed normal frequency curve
- The population of the species had assorted age groups (1+, 2+, 3+)
- The fish has a robust weight with higher biomass in the wet season
- The fish exhibits significant negative allometric growth and grows thinner with age
- The species is in good physiological state of well-being but time and season influence the plumpness of the fish.
- The size of the fish is a determining dynamic or an exponential index of condition factor.
- Juvenile exploitation in the Lower Cross River, Nigeria was less severe. Thus, the current sustaining power of the fishery stock in the face of human subsistence practices in Lower Cross River, Nigeria is guaranteed.
- The results of this study constitute valuable fisheries data that would enhance the availability, conservation, valorization, exploitation and sustainability of *S. obesus* in the Lower Cross River, Nigeria.
- The result of this study is important for fisheries, biology and environmental scientists concerned with fish stock assessment and policy formations for a sustainable fishery. It provides information about a fish species that has rarely been studied yet commercially important in the Lower Cross River, Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Boulenger GA. Description of a new siluroid fish from West Africa. Annals and Magazine of Natural History (Series 7). 1898;2(11)(art. 49): 415.
2. Froese, Rainer, Pauly, Daniel (eds). Synodonthis obesus" in FishBase, June 2016 version; 2016.
3. Araoye PA, Fagade SO, Jeje CY. Age and growth study of Syndontis schall (Teleostei: Mochokidae) in the environment of Asa Dam, Ilorin, Nigeria. Nigerian Journal of Pure and Applied Sciences. 2002;17:1235-1243.

4. Adeyemi SO. Food and feeding habits of *Synodontis resupinatus* (Boulenger 1904) at Idah area of River Niger, Kogi State, Nigeria. Animal Research International. 2010;7(3):1281-1286.
5. Arame H, Adite A, Adjibade KN, Sidi Imorou R, Sonon PS. Length-weight relationships and condition factors of Mochokidae (Pisces: Teleostei: Silurifumes) from Niger River, Northern Benin. Aquatic Research. 2020;3(2):72-84
6. Entsua-Mensah M, Osei-Abunewa, Alomores P. Length-Weight Relationship of Fishes from Tributaries of the Volta River, Ghana: part 1. Analysis of Pooled Data sets. Naga ICLARM Quarterly. 1995;18(1):36 – 38.
7. Konan AKF, Ouattara M, Ouattara A, Gourène G. Weight-length relationship of 57 fish species of the coastal rivers in south-eastern of Ivory Coast. Ribarstvo. 2007;65(2):49-60. Laleye PA. Length-weight and Lenarterly. 2006;19:53-58.
8. Midhat AEK, Mohammed MNA, Scham AL. Environmental studies on Synodontis schall (Bloch and Schneider, 1801), (Pieces: Mochokidae) in the rive Nile at Gizza sector, Egypt: Biological aspects of population dynamics. Journal of Fisheries and Aquactic Science. 2012;7:104-133.
9. Araoye PA. Bio-Ecology of a Mochokid Synodontis schall (Bloch and Schneider, 1801) in Asa Lake, Ilorin, Nigeria. Ph. D. Thesis, University of Ibadan. 1997;201.
10. Araoye PA. Spatio-temporal distribution of the fish Synodontis schall (Teleostei: Mochokidae) in Asa Dam, Ilorin, Nigeria. Rev Biol Trop. 1999;47(4):1061-1066.
11. Akombo PM, Akange ET, Adikwu IA, Araoye PA. Length-weight relationship, condition factor and feeding habits of Synodontis schall (Bloch and Schneider, 1801) in River Benue at Makurdi, Nigeria. International Journal of Fisheries and Aquatic Studies. 2014;1(3):42-48.
12. Azua ET, Akaahan TJ. Studies in variation in length-weight relationship, condition factor and size distribution of *Orechromis niloticus* and *Synodontis schall* obtained in the ecology lower River Benue at Makurdi, Nigeria. African Journal of Fisheries Science. 2017;5(5):255-259.
13. Sidi Imorou R, Adite A, Sossoukpe E, Abou Y. Length-weight models and condition factors of fishes from Okpara Stream, Oueme River, Northern-Benin. International Journal of Forest Animal and Fisheries Research. 2019;3(3):65-79. DOI:https://doi.org/10.22161/ijfaf.3.3.1
14. Abdul WO. Stock Assessment of Tilapia zilli in the Freshwater Ecotype of Ogun Estuary, Ogun State, Nigeria. Ph.D thesis, University of Agriculture, Abeokuta. 2009;181.
15. Moses BS. The influence of flood regime on fish catch and fish communities of the cross river flood plain ecosystem, Nigeria. Environmental Biology of Fisheries. 1987;18:51-65.
16. Ekanem EM. Climat Characteristics In: Usoro, E. J; Akpan, P. A. (eds), Akwa Ibom State: A geographical perspective. A special publication of the Department of Geography and Regional Planning, University of Uyo, Nigeria. 2010;91-101.
17. Adite A, Tossavi C, Kakpo DBE. Biodiversity, length-weight patterns and condition factors of cichlid fishes (Perciformes: Cichlidae) in brackish water and freshwater lakes of the Mono River, Southern Benin, West Africa. International Journal of Fauna and Biological Studies. 2017;4:26-34.
18. Pauly D. Fish popualtion dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies and Revision. 1984;8:325.
19. Sokal RR, Rohlf FJ. Biometry: the principles and practice of statistics in biological research. 3rd ed. San Francisco: WH Freeman. Sciences. New York: Plenum Publ. 1995;284:321-334.
20. Hazoume RUS, Chikou A, Koudenoukpo CZ, Adite A, Bonou CA, Mensah GA. Length-weight relationships of 30 species of fish of the river Sô in Benin (West Africa). International Journal of Fisheries and Aquatic Studies. 2017;5:514-519. DOI:https://doi.org/10.1007/BF00001173
21. Biahoua KG, Etile RN, Bedia AT, Yao SS, N'Douba V. Seasonal variation in the length-weigth relationships and condition factor of Synodontis schall (Bloch and Schncider, 1801 (Siluriformes: Mockokidae) in Man-made Lake Ayame 2 (Cote d'Ivore). International Journal of Fisheries and Aquactic Studies. 2017;5(1):173-177.
22. Offem OB, Akegbejo-Samsons Y, Omoniyi IT. Length-weight relationship, condition factor and sex ratio of forty six important fishes in a Tropical Flood River. Research

Journal of Fisheries and Hydrobiology. 2009;4(2):65-72.
23. Essien-Ibok MA, Ekpo IE, Bassey HE. Studies on the aspect of the biology of Mochokidae in the Lower Cross River, Akwa Ibom State, Nigeria. Direct Research Journal of Agriculture and Food Science (DRJAFS). 2015;3(11):193-205.
24. Pervin MR, Mortuza MG. Notes on length-weight relationship and condition factor of fresh water fish, Labeo boga (Hamilton) (Cypriniformes: Cyprinidae. University Journal of Zoology Rajshahi University. 2008;27:97-98.
25. Bagenal TB. Methods for assessment of fish production in fresh water. Blackwell Scientific Publication Ltd Oxford. 1978;40-46:165-178.
26. Datta SN, Kaur VI, Dhawan A, Jassal G. Estimation of length –weight relationship and condition factor of spotted snakehead Channa punctate (Bloch) under different feeding regimes. Spring Plus. 2013;2(1):436.
27. Oni SK, Olayemi JY, Adegboye JD. The comparative physiology of three ecologically (pupel), Synodontus schall. Block and Schneider and Tilapia zilli (Gervals). Fish Biol. 1983;22:105-109.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95916