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Length-weight relationship, condition factor and feeding habits of *Synodontis schall* (Bloch and Schneider, 1801) In river Benue at Makurdi, Nigeria

Akombo P.M, Akange E.T, Adikwu I.A, Araoye P.A

Akombo P.M
Department of Biological Sciences, Benue State University, PMB 102119 Makurdi, Nigeria.

Akange E.T
Department of Fisheries and Aquaculture, University of Agriculture, PMB 2373, Makurdi, Benue State, Nigeria.
Email: akangeter@gmail.com;
Tel: +2347037157305

Adikwu I.A.
Department of Biological Sciences, Benue State University, PMB 102119 Makurdi, Nigeria.
Email: Adikwukate@yahoo.com
Tel: +2348033848761

Araoye P.A
Department of Biological Sciences, Benue State University, PMB 102119 Makurdi, Nigeria.
Email: debaraoye@gmail.com;
Tel: +2348035897463

Correspondence:
Akombo P.M
Department of Biological Sciences, Benue State University, PMB 102119 Makurdi, Nigeria.
Email: mbakaanpauline@yahoo.com
Tel: +2347038141372

ABSTRACT
The Length-Weight relationship (LWR), condition factor and feeding habits of *Synodontis schall* (Bloch and Schneider, 1801) were studied over a 24-month period from January, 2009 to December, 2010. A total number of 635 specimens comprising of 329 males and 306 females with the size range of 6.1-30.40 cm and the mean of 12.04 ± 0.11cm were studied. The weight ranged from 53.0-864g with the mean of 57.71 ± 2.26g. The LWRs for the females, males and combined sexes had r-values of 0.9333, 0.9308 and 0.9411respectively. The mean condition factor K was 2.874, 2.838 and 2.855; regression coefficient **b** 2.5290, 2.4977 and 2.6749 for the females, males and combined sexes respectively. Out of the 635 stomachs examined for food items, 153 (24.09%) were empty while 482 (75.91%) contained wide range and varying quantities of food items indicating that *S.schall* in River Benue is Omnivorous.

Keywords: *Synodontis schall*, length-weight relationship, condition factor, feeding habits, River Benue

1. Introduction
The genus *Synodontis* (Cuvier, 1816) [7] commonly known as the up-side-down catfish belongs to the family Mochokidae. The Family comprises three genera-*Mochochus*, *Synodontis* and *Chiloglanis* (Reed *et al*., 1967, Holden and Reed, 1972, Araoye, 1999)[9, 24, 38]. *Synodontis* is the largest genus of the catfishes, Siluriformes and most widely distributed (Friel and Vigliotta, 2006) [21]. The genus is commercially important in the inland waters of West Africa and in River Benue at Makurdi. *S. schall* is one of the species that can be seen in the fish markets throughout the year.

A lot of studies have been carried out on *S. schall* in different water bodies by many authors but not much has been done on the species in River Benue at Makurdi. These works include those of Araoye, (1997, 1999) [8, 9] and Araoye *etal*. (2002) [11] all in Asa Lake at Ilorin, Kwara State, Nigeria. Bishai and Abu Gideiri (1968) [18] in the Nile River, Egypt, Halim and Guma'a in the Nile waters at khartoun in Sudan, Luff and Bailey (2000) [30] in River Nile at El-Minya, Egypt. Laléyé *et al*., (2006) [29] in Ouémé River Benin. Mekkawy and Hassan, (2011) [23] from river Nile, Egypt and Midhat *et al;* (2012) [32] also from River Nile at Gizza. The only work at Makurdi is that of Akombo *et al.,* (2011) [7].
This study is therefore aimed at determining the length-weight relationship, condition factor and feeding habits of *S.schall* in Rive Benue at Makurdi.

2. Materials and Methods
The study was carried out in the Lower Benue River at Makurdi, Nigeria. The Lower Benue River is the portion of the Benue River that is contained within the Benue and Kogi States of Nigeria (Reid and Sydenhan, 1979) [39]. River Benue originates from the Adamawa Mountains of Cameroun and flows west across East-Central Nigeria (Nedeco, 1959) [33]. It is the largest tributary of the Niger which it joins at Lokoja in Kogi State, Nigeria.

The River has extensive alluvial plain stretching for many kilometers, which covers a distance of approximately 187 kilometers. The extensive flood plain forms breeding grounds for many fish species (Beadle, 1974) [17]. The highest water levels are in August to September and the Lowest are in March to April.

2.1 Sampling method:
The *S. schall* specimens were purchased from the fish sellers at Wadata Market, Makurdi, which is one of the landing sites on the bank of River Benue. The fishes were procured fortnightly for 24 months and transported to the Biology Laboratory in Benue State University for identification and measurements. Identification was done using the keys of Reed *et al*., (1967) Holden and Reed (1972), Babatunde and Raji (1998) and Idodo-Umeh (2003) [14, 24, 25, 38].

2.2 Length-Weight Measurements:
The standard lengths (SL) of the fish sample were measured using a measuring board. The anterior tip of the fish was placed against a stop at the beginning of the measuring scale with its mouth closed. SL was taken as the length from the tip of the fish's mouth to the hidden base of the tail fin rays and this was measured to the nearest 0.1 centimeter. The total weight (TWT) was measured using a digital electronic weighing balance (Adam AFP 4100L). This was read to the nearest 0.1 gramme.

2.3 Sex determination:
The different sexes of *Synodontis* species can only be identified after dissection. Thus the fishes were dissected and the gonads were inspected using the keys of Nikolsky (1963) [34]. In the young males, testes were thin, thread like with very small projections, whitish in colour and extend to about 1/3 of the abdominal cavity. In adult males, the testes were creamy in colour with very conspicuous granules. The young females had thin, pink to white tubular structures occupying about 1/5 of the abdominal cavity. In adult females, that were about to spawn eggs were readily discernable in the ovaries which increased in size and filled most of the abdominal cavity (Bagenal, 1978; Halim and Guma'a, 1989) [15, 22].

2.4 Length-Weight relationship (LWR):
The LWR of the fishes were calculated using the equation

$$W = aL^b \text{ - - - - - - - - - (1)}$$

Where W = the observed total weights of the fishes.
L = the observed standard lengths.
a and **b** are constants.
b is the slope usually between 2 and 4 and ***a*** is the intercept on the length axis (Bagenal, 1978) [15]. The logarithmic transformation of the equation (1) gives a straight line relationship.

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

When $\mathbf{Log_{10}W}$ is plotted against $\mathbf{Log_{10}L}$, the regression coefficient is **b**, and **Log a** is the intercept on the Y axis.

2.5 The Condition Factor (K)
The condition factor (K) was computed from the equation:

$$K = \frac{100W}{L^b} \text{ - - - - - - - - - - (2)}$$

Where W = the observed total weight for each fish.
L = the observed standard length for each fish.
K= the Condition Factor.

2.6 Food and Feeding:
The fishes were dissected and the stomachs were removed and preserved immediately in 4% formalin for subsequent examination of the food items. The stomachs were scored 0, ¼, ½, ¾, or full according to their fullness as described by Olatunde (1978) [36]. Each stomach sample was then opened and the content emptied in a petri dish. Some food items such as grains and insect parts were identified with the naked eye, while others were identified with the aid of a microscope. Slide preparation were made and examined under the light microscope using the X10 and X40 objectives. The stomach contents were analysed using:

i. Frequency of Occurrence method which is as follows:

$$\% \text{ Food Sample} = \frac{\text{No of Stomachs with a food Sample}}{\text{Total No of Stomachs with food}} X100$$

ii. Point Method

$$\% \text{ Points} = \frac{\text{Points allotted to a food Sample}}{\text{Total Points allotted}} X100$$

3. Results
Length–Weight Relationship
Figures 1-3 below show the log-transformed Length–Weight relationship of *S. Schall* females, males and combined sexes respectively. All the three relationships were positively correlated at 0.05% level. ($p<0.05\%$).

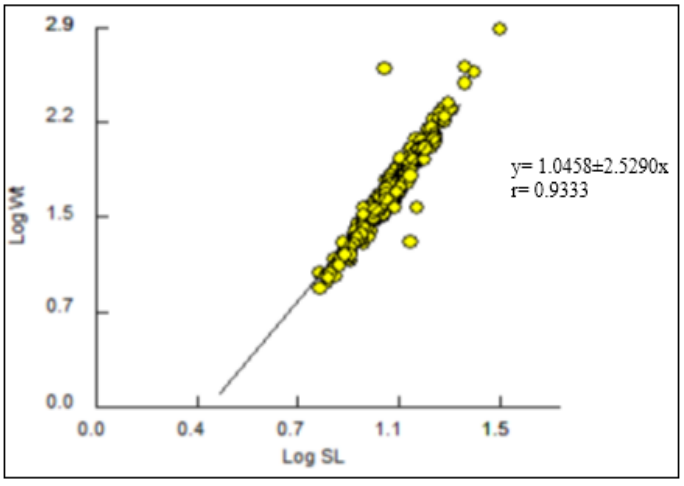

Fig 1: Length-Weight Relationship of *S. schall*-Females.

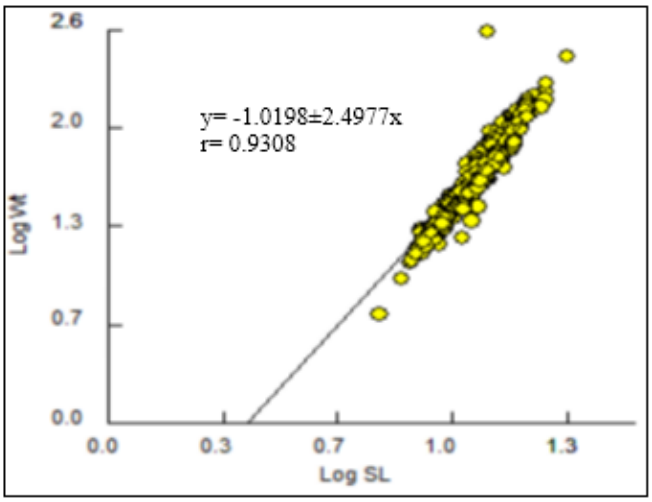

Fig 2: Length-Weight Relationship of *S. schall*-Males

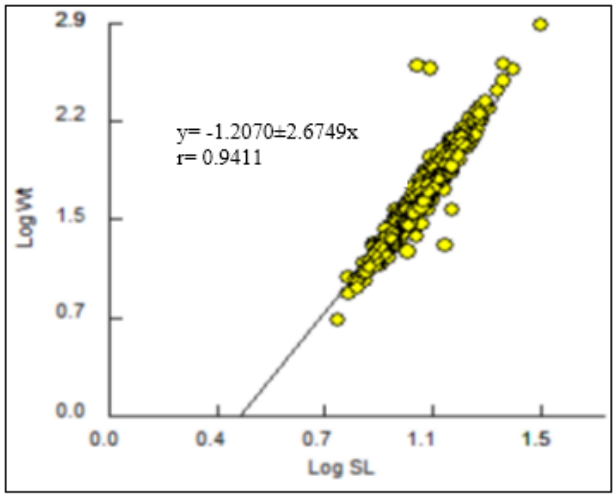

Fig 3: Length-Weight Relationship of *S. schall*-Combined Sexes

The Regressive Equations for the graphs

♀ Logw =Log - 1.0458 +2.5290 LogL

♂ Logw = log - 1.0198 + 2.4977 LogL

Combined Sex LogW = Log -1.2072 + 2.6749 LogL

Table 1: Morphometric Parameters of *S.schall* in the Lower River Benue at Makurdi.

Parameter	Sex		
	♀	♂	**Combined Sex**
No.	306	329	635
Length Range (cm)	6.6 – 30.4	6.1 – 21.5	6.1 – 30.4
Mean Length (cm) ± SE	12.29 ± 0.175	11.81 ± 0.134	12.04 ± 0.110
Weight Range (g)	8.4 – 864.5	5.3 – 406.9	5.3 – 864.5
Mean Weight (g) ± SE	63.37 ± 4.04	52.36 ± 2.14	57.71 ± 2.26
a	-1.0458	-1.0198	-1.2072
b	2.5290	2.4979	2.6749
r	0.9333	0.9308	0.9411
K	2.874	2.838	2.855

a = intercept on x-axis, b = slope, r = Coefficient of Regression, K = Condition Factor.

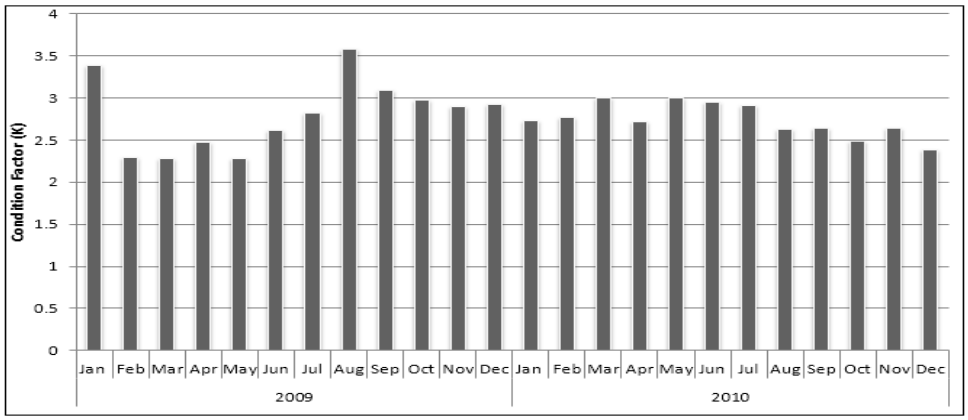

Fig 4: Condition Factor of *S.schall* from January, 2009 to December, 2010.

3.1 Condition Factor

Figure 4 below shows the mean monthly Condition Factors of the species from January, 2009 to December, 2010. The monthly condition factors were observed to be higher in the rainy season months than the dry season. This means that the fishes were in better condition in the rainy season than the dry season. The highest value of 3.580 was observed in August, 2009, while the lowest value of 2.275 was observed in May, also in 2009. The mean condition for the females, males and combined sex were 2.874, 2.838 and 2.855 respectively for the period of study showing that the fishes were in good condition throughout the period (table I).

The regression coefficient the **b** values were 2.5290, 2.4977 and 2.6749 for the females, males and combined sexes respectively indicating negative allometric growth pattern.

3.2 Food and Feeding

The results of the stomach content analysis of *S.schall*

examined from January, 2009 to December, 2010 revealed that the fish is an omnivore feeding on a variety of food items comprising of different types of algae, plant materials, insects parts and larvae, fish parts and scales, worms, molluscs, (bivalves and gastropods), diatoms, crustaceans, artificial corn meal, different types of grains (rice, maize, guinea corn, etc) detritus, mud and many unidentified food items. The number of empty stomach and occurrence of artificial corn meal were observed to be more in 2010 than 2009.

Table 2 below shows the stomach content analyses of *S.schall* by frequency of occurrence and point methods, while table 3 shows the stomach fullness of the fishes. The analysis of the stomach fullness revealed that 24.09% of the stomachs were empty while 75.91% had varied quantities of food. Stomachs with 50% fullness (23.78%) were more than those with 100% fullness (14.66%).

Table 2: Stomach Content Analysis of *S. schall* by Frequency of Occurrence and Point Methods.

Food Item	Frequency of Occurrence Method	Point Method
Plant:		
Plant materials	85.48	10.43
Seeds/grain	42.49	3.20
Corn meal (artificial)	80.71	8.89
Algae:		
Filamentous	31.54	4.20
Colonial	43.90	6.39
Diatoms	62.13	16.12
Insects:		
Insect parts	38.12	5.36
Chironomid larvae	22.90	4.06
Coleopteran larvae	20.94	2.48
Molluscs		
Bivalves	50.43	2.39
Gastropods	11.62	1.16
Crustaceans:		
Crayfish	11.41	1.17
Prawns	12.03	1.31
Copepods	17.84	1.16
Water Mites	32.45	1.22
Fish:		
Fish parts	33.69	2.13
Scales	25.93	2.10
Protozoa:		
Paramecia	24.67	1.27
Amoebae	31.22	0.22
Worms:		
Roundworms	15.77	1.56
Detritus/Mud	76.46	9.46
Sand particles	33.65	6.28
Unidentified food items	63.36	7.44

Table 3: Stomach Fullness of *S.schall* in Lower River Benue at Makurdi

Stomach Fullness	No of fishes	% Fullness
0 (ES)	153	24.09
¼	101	15.91
½	151	23.78
¾	137	21.57
Full	93	14.66
Total	**635**	**100**

4. Discussion

The high positive correlation in the length-weight relationship of *S.schall* in lower River Benue at Makurdi agrees with many researchers of length-weight relationships such as Ayuba (1997) [13] on *Synodontis* species in River Benue at Yola; Abubakar and Ishaya (2000) [6] on *O.niloticus* in Geriyo lake, Yola; Abubakar and Edward (2002) [5] on the catfish *Synodontis* in upper Benue River basin Yola; Abowei and Hart (2009) [2] on ten finfish species from the lower Num River, Delta State and Akombo *et al*., (2011) [7] on four species of Synodontis from Lower Benue River at Makurdi.

The Length-weight relationship of fish also known as growth index is an important fishery management tool. It is vital in estimating the average weight at a given length group (Abowei and Davies, 2009; Abowei, 2010). Jomabo *et al.,* (2009) [1, 2, 27] reported that LWRs of fishes are important in fisheries biology and population dynamics where many stock assessment models require the use of LWR parameters.

The **b** values observed in this study (Table 1) were significantly below 3 which mean that the *S.schall* in River Benue at Makurdi exhibited negative allometric growth pattern. In other words, the fishes became thinner as they grew longer. These observations are in agreement with those of Midhat *et al.,* (2012) [32] who observed the b values of 2.2749, 2.2915 and 2.2863 for *S.schall* females, males and combined sexes in River Nile at Gizza. Other observations of negative allometricgrowth have been made by Lalèyè *et al.,* (2006) [29] for *S. schall* and *S. nigrita* in Ouémé River, Benin; Hassan (2007) [23] for *S.schall* in River Nile at Assiut; Akombo *et al.,* (2011) [7] on four species of *Synodontis* in River Benue at Makurdi. Egbal *et al.,* (2011) [19] reported that most of the fish species (61.1%) investigated in Atbara River and Kashin El-Girba reservoir in Sudan indicated negative allometric growth. Adeyemi (2011) also reported negative allometric growth in *S. robbianus* in River Niger at Idah, Kogi State.

Lagler *et al.,* (1977) [28] stated that the **b** values in the log standard length-log body weight relationship of the linear growth relationship of the linear growth relationships obtained from the transformed lengths fitted over weights indicated the three dimensional growth structures of most fish species. Bagenal and Tesch (1978) [17] reported that the values of **b** for most fish species ranged from 2-4, Fagade (1979) reported the values of 2.9 – 3.4 while Baijot *et al.,* (1997) [16] reported that most fishes had **b** values of 2.5-3.5. When b=3 the fishes grow isometrically i.e all the three dimensions grow at equal rate resulting in ideal shape of fish. Such a value was not obtained throughout the period of study. When the value of b is greater than 3, it means that the fish becomes fatter as it grows (Egbal *et al.*, 2011) [19].

The condition factor reflects the well-being of the fish (Abowei, 2010) [3]. It gives information when comparing two populations living in certain feeding, density, climate and other conditions when determining the period of gonad maturation, and when following up the degree of feeding activity of species to verify if it is making good use of its source (Ighwela *et al.*, 2011) [28]. 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. Condition factor can also be affected by factors like sex, season, age and maturity stages of fish (Edah *et al.*, 2010). It usually decreases as the fish increases in size.

The values of the condition factor in this study were 2.874, 2.838 and 2.855 for the females, males and combined sexes respectively. These values were within the range of 2-4 recommended by Bagenal and Tesch (1978) [15] as suitable for fresh water fishes. This means that *S.schall* in River Benue is in good condition. Even though the female were in a slightly better condition (2.874) than the male (2.838) the difference was not significant ($p>0.05$). Midhat *et al.,* (2012) [32] reported that the males of *S.schall* in River Nile at Gizza had better condition (1.83) than the females (1.64). Oni *et al.,* (1983) [38] reported that condition factor was not constant for a species or population over a time interval and might be influenced by both biotic and abiotic factors like feeding regime and state of gonadal development.

The relative monthly condition factors for the 24 months were higher in the rainy seasons than the dry seasons (figure. 4). This means that the fishes were in better condition in the rainy seasons than the dry seasons, probably due to the availability of more food during the rainy season.

The different varieties of food items found in the stomach of *S.schall* indicate that the species is an omnivore feeding on all types of food available in the environment. Food items such as, detritus, mud, sand, bivalves, crustaceans, fish scales and insect parts show that *S.schall* is an omnivorous bottom feeder. The ventral location of the mouth also indicates bottom feeding. Hassan (2007) [23] observed that *S.schall* in the Nile near Assiut was an omnivorous bottom feeder, where sand, mud and fish remains were present in the stomach. Nnaji *et al.,* (2007) [35] emphasized that *S.schall* usually lived on the bottom feeding on molluscs, crustaceans, annelid worms and to lesser extent on algae, fish scales, mud, sand or anything available. Laléyé *et al.,* (2006) [29] made similar observation on *S.schall* and *S.nigrita* in Ouémé River, Benin. The worms present in the stomachs were parasitic rather than food items.

The analysis of stomach fullness showed that 153 (24.09%) of the stomachs were empty while 482 (75.91%) contained varied quantity of food. Lalèyè *et al.,* (2006) [29] observed 36% empty stomachs in *S.schall* and 35% in *S nigrita* in Ouémé River, Benin. This high number of empty stomachs may be attributed to inadequate food in the river, post-harvest digestion or the method of catching of the specimens. Aramowo (1976) [12] reported more than 67% empty stomachs for *Citharinus* species (Cuvier, 1816) [7] caught with gill nets in Lake Kainji. This he explained might have been due to the food items having been regurgitated or digested as the fish struggled during the catches. The presence of artificial corn meal in the diet is an indication that the fishermen were using corn meal as baits.

5. Conclusion

The findings of this study revealed that the LWRs of *S.schall* in River Benue at Makurdi were positively correlated with the **b** values indicating negative allometric growth pattern. Both males and females of this species were in good condition throughout the study period. The research also revealed that *S.schall* in River Benue is an omnivorous bottom feeder.

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