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Length-Weight Relationship and Condition Factor of *Synodontis schall* (Bloch & Schneider, 1801), from Roseires Reservoir, Sudan

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Authors' contributions

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

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ABSTRACT

This study was carried out to investigate the length-weight relationship and condition factor of the Mochokid catfish *S. schall*, a commercially important fish species in the Roseires reservoir on the Blue Nile, Sudan. A total of 643 specimens were collected using the multi-filament gillnets of mesh

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sizes (4.0, 8.0, 10.0, and 12.0 cm) and twine (No. 2 and 12) during the period from November 2015 to October 2016; Samples were collected from four sites namely: Awal Bab, Elregiba, Kirma, and Wad El Mahi.; The length and weight of sampled fish were measured and recorded on the sampling sites and used to determine a length-weight relationship. The growth coefficient (*b*) ranged from 1.196 to 2.649, with moderate to high correlations (*r*) between 0.437 and 0.798. Values of (*b*) were less than 3 indicating a negative allometric growth pattern, whereas weight increased at a lower rate than length. The condition factor (K) ranged from 1.966 ± 0.696 to 3.856 ± 3.856, suggesting the fish were in good health condition throughout the sampling sites. The findings of this study provide valuable insights into the biological aspects of *S. schall*, which can form the basis of sustainable management and conservation policy for the fishery resource of this economically important fish species in the Roseires reservoir.

Keywords: Synodontis schall; Roseires dam reservoir; length-weight relationship; condition factor.

1. INTRODUCTION

The Sudan inland fisheries are located primarily around the Nile and its tributaries, major man-made lakes (Nubia and Merowe) and dam reservoirs, like Jebel Aulia, Roseires, Sinnar, Khashm El-Girba, Upper Atbara and Sittit Dams. The Roseires Dam, established in 1966 on the Blue Nile River at Ad Damazin town, is one of the most important dams in Sudan which was originally built to store water for irrigation purposes and hydropower generation, [1,2]. The height of Roseires Dam was increased by 10.0 meters during the period 2006-2012, allowing greater water storage, and creating a 75 km long lake, forming an important fishing ground with a maximum sustainable production of 1,000 tons/year [2].

The expansion of Roseires Dam reservoir is expected to change the fish abundance and distribution, alter primary productivity of the water, promote individual growth rates of fishes, and increase overall fish production. Additionally, it is anticipated that the significant increase in the volume of water in Lake Roseires will lead to a corresponding increase in fish production from the reservoir [3], and future changes in the fisheries sector, which can achieve positive changes in the socioeconomic status and livelihood of people inhabiting the region [2].

Approximately 112 species of the genus Synodontis were recorded in the Nile River and Eastern Rift Valley Lakes (i.e. Egypt, Ethiopia, Sudan), and across West African countries (i.e. Ivory Coast, Ghana, Guinea, Guinea Bissau, Liberia, Niger, Nigeria, Senegal, Sierra Leone, [4,5].

Studies on length-weight relationships are of considerable importance for proper fishery management of the stocks and biomass estimation of any fish species [6-8]. LWR can be used to predict the weight of a fish when its length is known (or vice versa), for assessing fishery yields [9-11], and provide information on the fish growth pattern [12-17]. LWR has also been widely used in local and inter-regional morphological comparison of populations [18,10], as well as estimating weight at age, and assessing age structure and function of fish populations [19,16,20,21,11]. Moreover, LWR is used to evaluate the index of well-being of the fish population and obtain information on the condition of fishes in order to determine whether somatic growth is isometric or allometric [22,23].

The condition factor (K) of a fish (also known as Fulton's condition factor) is an important biological parameter that indicates the suitability of a specific body of water for growth of fish, and as an index of species average size; It also reflects the physico-chemical and biological factors, and interactions of feeding conditions, parasitic infections and physiological factors [24]. In addition, it indicates the changes in food reserves in the water body, and an indicator of the general health condition, and an expression of the relative fatness of the fish [10].

Therefore, understanding the condition factor ('K') is important in fishery assessment and management of fish populations, as it gives us clear knowledge regarding maturity, spawning and life cycle of fish at different body lengths during their life span, availability of food in a water body, and environmental factors affecting growth of a fish [25,22,20].

Analysis of LWRs and condition factors has evolved from log-transformed mean weights to non-linear fitting approaches that leverage modern statistical software and computing power, allowing for a more accurate

representation of the relationship between fish length and weight [26-30].

The present study aims to provide the baseline information on the length-weight relationships and condition factor of the commercially important Mochokid catfish, *S. schall* in Roseires Dam reservoir on the Blue Nile, Sudan. The study's results will be useful in the sustainable management and exploitation of this species' fishery and the protection of its natural habitats.

2. MATERIALS AND METHODS

2.1 Study Area

Fish (*S. schall*) samples were collected from the following sites:

Awal bab sampling site: This is one of the biggest fishing sites on the western bank of the Blue Nile. It lies about 4 km southeast of Ad Damazin town.

EL-Regayba sampling site: is located on the western bank of the Blue Nile about 16 km southeast of Ad Damazin town.

Kirma sampling site: is located on the eastern bank of the Blue Nile, and lies about 43 Km east of Ad Damazin town.

Wed-ELmahi sampling site: located on the eastern bank of the Blue Nile, about 80 km south of Roseires city on the end of the Dam lake.

The study extended 12 months (November 2015 - October 2016). Sampling of fish took place monthly. During each sampling, samples of fish representing different sizes were randomly selected from the catch.

2.2 Sample Collection

During the study period, about 643 specimens of *Synodontis schall* were collected from the four sampling sites, using four multi-filament gill nets of various mesh sizes and twine numbers as shown Table 1.

2.3 Measurements of Length and Weight

The total length (tip of snout to tip end of caudal fin) and standard length (tip of snout to base of

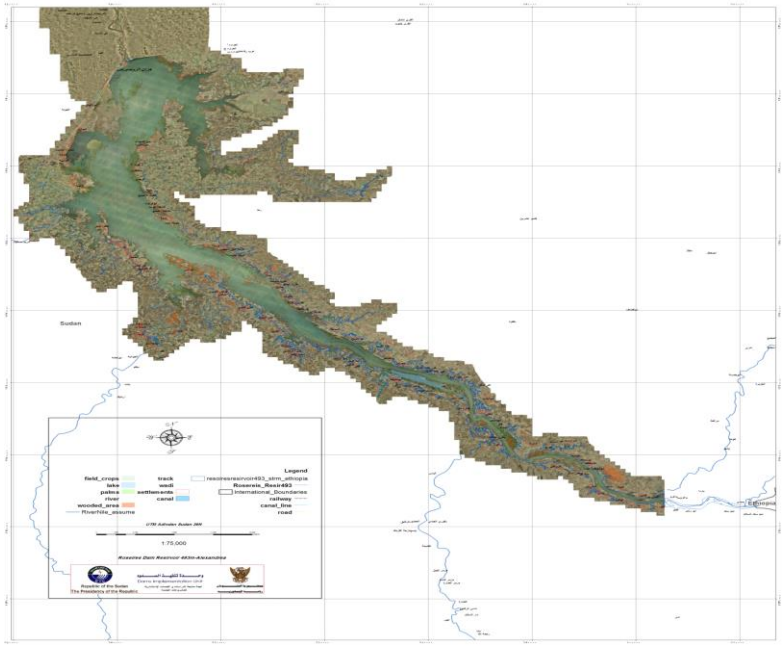

Fig. 1. Roseires reservoir area before and after the heightening of the Dam

Table 1. Specifications of gillnets used for collection of fish samples during the study period, October 2015 to September 2016

Twine No.	Length (m)	Depth (m)	Mesh size (cm)
2	50	2	4
12	90	4	8
12	95	4	10
12	100	4.5	12

caudal fin) of each fish were measured to the nearest 0.01 mm. using a standard measuring board. The body weight of sampled fish was taken to the nearest gm., using a digital weighing balance, version FRUIT 2000B.

2.4 Length-Weight Relationship

Excel package was used to plot the curve of the relationship between the standard length and weight of *S. schall*, and the liner equation was then obtained from logarithm transformation. Values of the constants 'a' and 'b' for the fish were obtained from the length-weight relationship according to [17], using the equation:

$$W = a\,L^{b}$$

Where:

W = total weight in grams
L = total length in cm
b = a constant of the relationship representing the slope of the equation.
a = a constant of the relationship representing the intercept on the "y" axis

2.5 Condition Factor (CF) or (Fulton's Factor) (FCF)

The well-being of *S. schall* was calculated according to [17], according to the following formula:

$$FCF = \frac{w}{L^{b}} \times 100$$

Where W: weight of fish; L: standard length of fish, and 'b': constant.

2.6 Statistical Analysis

Statistical analysis was made by using a personal computer and the advanced computer Excel program.

3. RESULTS AND DISCUSSION

The genus Synodontis comprises several commercially important species, contributing up to 40% of the total landing weight in some regions of Africa [30]. The length-weight relationship in fishes is not constant throughout the year and is affected by factors such as the availability of food, rate of feeding, development of gonads, and spawning season [31,32].

Previous studies of *Synodontis schall* reported '*b*' values (the exponent in the length-weight relationship) ranging from 2.4977 to 3.522, indicating both allometric and isometric growth patterns [31-36].

The results of the current study indicated a negative allometric growth pattern of *S. schall* in all sample sites. The values of the exponent (*b*) were found to be 2.649, 1.196, 2.156, and 2.426, with high to moderate correlation (*r* = 0.798, 0.437, 0.539, and 0.626) in Awal Bab, Elregiba, Kirma, and Wad El-Mahi, respectively (Figs. 2-5 and Table 2). These results agree with previous findings in the Lower Ogun River (Nigeria), Okpara Stream (Benin), Khashm El Girba reservoir and Atbara River, Upper Atbara and Sittit dam complex, and the River Benue (Nigeria) [32,31,1,35].

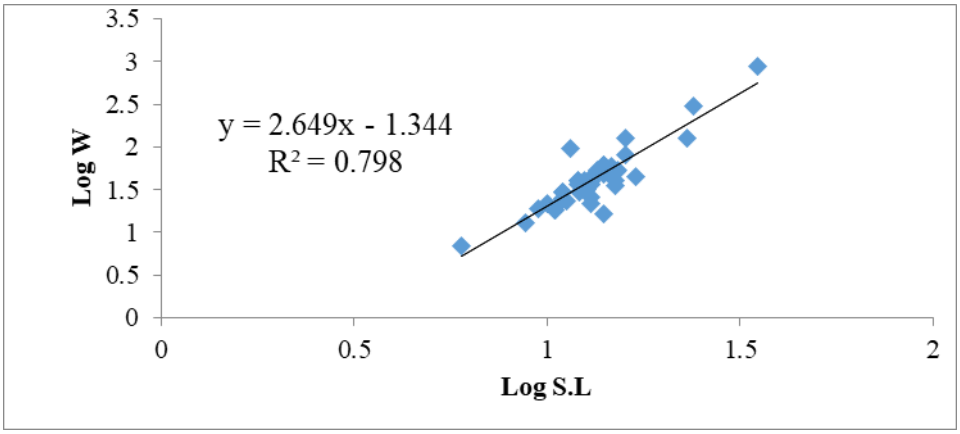

Fig. 2. Linear fit of the length-weight relationship of *S. schall* in Awal Bab site during the study period (2015/2016)

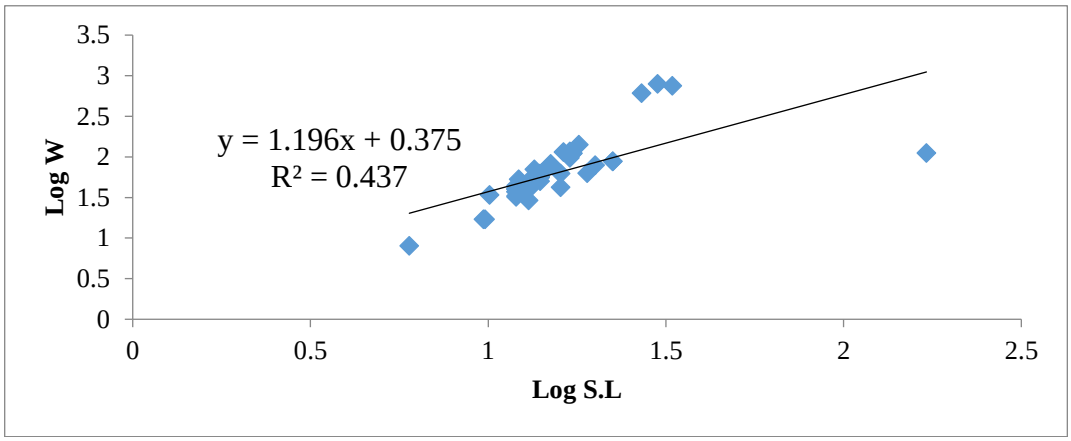

Fig. 3. Linear fit of the length-weight relationship of *S. schall* in Elregiba site during the study period (2015/2016)

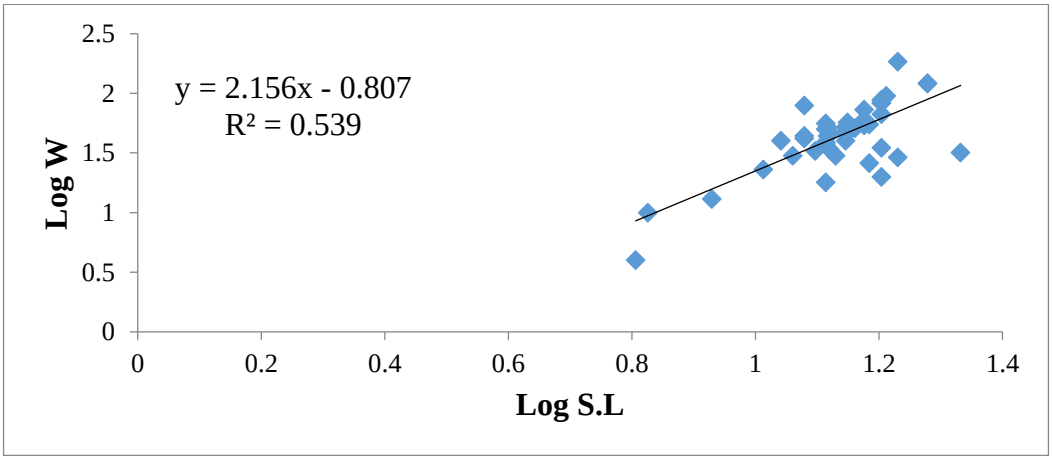

Fig. 4. Linear fit of the length-weight relationship of *S. schall* in Kirma site during the study period (2015/2016)

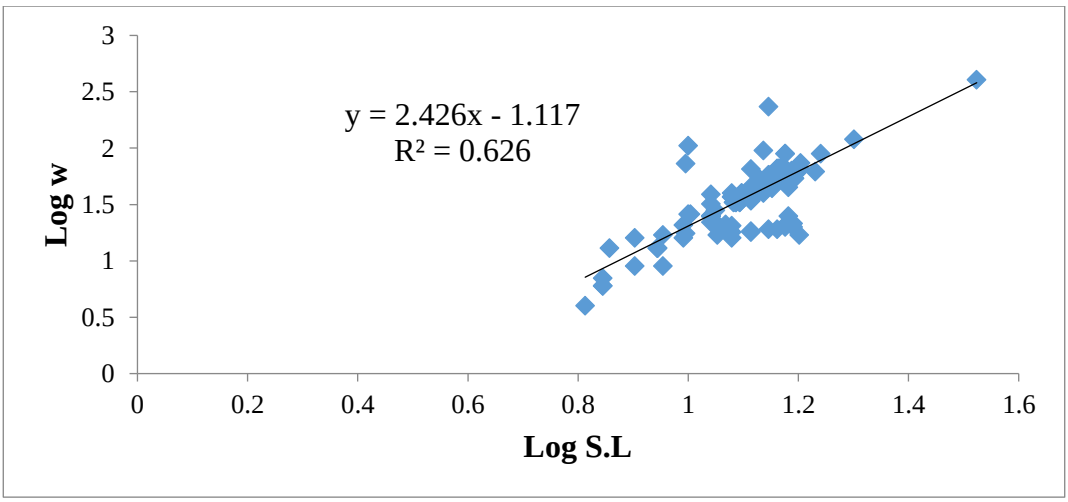

Fig. 5. Linear fit of the length-weight relationship of *S. schall* in Wad ELmahi site during the study period (2015/2016)

Table 2. Shows linear fit of length-weight relationship *S. schall* during the study period (2015/2016)

Site	*b*	a	*r*
Awal Bab	2.649	-1.344	0.798
Elregiba	1.196	-0.375	0.437
Kirma	2.156	-0.807	0.539
Wad El Mahi	2.426	-1.117	0.626

Table 3. Shows condition factor (C.F) of *S. schall* in Awal Bab, Elregiba, Kirma and Wad El-Mahi during the study period (2015/2016)

Month	Awal bab	Elregiba	Kirma	Wad El-Mahi
Dec-15	3.455 ± 0.048	1.535 ± 0.549	0 ± 0.000	2.302 ± 0.476
Jan-16	3.760 ± 0.000	1.890 ± 0.201	2.030 ± 0.707	3.082 ± 1.408
Feb-16	3.521 ± 1.287	2.491 ± 0.268	1.690 ± 0.268	1.962 ± 0.416
Mar-16	3.398 ± 0.331	2.349 ± 0.081	1.758 ± 0.000	2.072 ± 1.251
Apr-16	3.029 ± 0.679	2.414 ± 0.507	2.074 ± 0.000	1.970 ± 0.744
May-16	3.549 ± 0.000	2.586 ± 0.253	3.127 ± 0.121	1.912 ± 0.154
Jun-16	3.902 ± 0.694	2.700 ± 0.662	1.979 ± 0.000	1.914 ± 0.504
Jul-16	3.108 ± 0.108	2.666 ± 1.124	1.850 ± 0.470	1.828 ± 0.166
Aug-16	3.002 ± 0.975	2.245 ± 0.905	2.417 ± 0.845	1.969 ± 0.594
Sep-16	3.808 ± 0.800	2.573 ± 0.000	2.080 ± 0.415	1.733 ± 0.257
Oct-16	3.957 ± 0.242	2.627 ± 1.185	1.619 ± 0.246	1.871 ± 0.597
Nov-16	0.812 ± 0.983	2.129 ± 0.120	1.865 ± 0.399	2.228 ± 0.760
Average	3.856 ± 3.856	2.428 ± 0.738	1.982 ± 0.614	1.966 ± 0.696

However, [36] reported that the length-weight relationships of Mochokidae species in the Niger River (Benin) showed both negative and positive allometric growth, with values of '*b'* ranging from 2.236 to 3.380 and high correlations (*r* = 0.87 to 0.99). Regarding *S. schall*, they recorded a negative growth coefficient of *b* = 2.6327. [37] stated that '*b'* value of *S. schall* in Lake Ayamé 2 (Côte d'Ivoire) ranged between 2.516 and 2.785 during the dry season, showing negative allometric growth, but increased to 3.0008 - 3.001 during the rainy season, indicating isometric growth. In contrast, [35] reported that the regression coefficient '*b*' for the length-to-body weight relationship of *S. schall* in the White Nile showed isometric growth, with '*b'* ranging from 2.985 and 3.033.

The results of the current study indicated a negative allometric growth pattern of *S. schall* in all sampling sites. The values of the exponent '*b*' were found to range from 2.649, 1.196, 2.156, and 2.426, with high to moderate correlation (*r* = 0.798, 0.437, 0.539, and 0.626) in Awal Bab, Elregiba, Kirma, and Wad El-Mahi, respectively (Figs. 2-5, and Table 2).

These results agree with previous findings recorded for other tropical African rivers, such as, the Lower Ogun River (Nigeria), Okpara Stream (Benin), Khashm El Girba reservoir and Atbara River, Upper Atbara and Sittit dam complex (Sudan), and the River Benue (Nigeria) [31,30,32, 1,33].

The condition factor (K) is a useful index for assessing the health and general well-being of fish, with values typically ranging from 2.5 to 4, for mature freshwater fish [38,39,29]. Previous values of condition factor reported for *Synodontis schall* ranged from 1,422 to 3.269 [32,33,35-37].

The findings of the current study indicate that the maximum values of condition factor recorded for *S. schall* were 3.957, 2.700, 3.127, and 3.082, while minimum values were 0.812, 1.535, 0.000, and 1.733, for Awal Bab, Elregiba, Kirma, and Wad El-Mahi sites, respectively**.** It is can be inferred from the foregoing data that the high values of condition factor of *S. schall* in Awal Bab and Elregiba sites on the western bank of the Blue Nile, and relatively low values of condition factor recorded in Kirma and Wad El-Mahi sites, on the eastern bank of the Blue Nile, throughout the year (Table 3) This may be due to abundance of food items, and favorable environmental conditions for growths and reproduction which resulted in good health conditions of *S. schall* on the western bank of the Blue Nile.

These findings are consistent with those of [32], who reported good health conditions (K ranging from 0.506 to 3.415) for six species of fish, including *S. schall* (K ranging from 1.422 to 1.844), collected from the Khashm El Girba and Atbara River. Similarly, [40] reported condition factors ranging from 0.443 to 2.191 for 21 species in the Nile within Egypt, including *S. schall* (K = 1.437). Additionally, [1] reported a condition factor of 2.902 for *S. schall* in the Upper Atbara and Sittit dam complex, while [33] recorded mean condition factors of *S. schall* of 2.874, 2.838, and 2.855 for female, male, and combined sexes, respectively. [36] recorded condition factors ranging from 0.409 to 7.276 for *S. frontosus* and *S. sorex*, and 2.732 for *S. schall*. [37] reported good physiological condition for *S. schall* in Lake Ayamé 2 (Côte d'Ivoire), during the rainy season, with 'K' values varying between 1.0375 and 1.357.

4. CONCLUSION

The present study of *Synodontis schall* provides baseline information on the length-weight relationship of one of the economically important fishes in Sudan. It indicated negative allometric growth patterns of the fish in all sampling sites in Roseires Reservoir. On the other hand, condition factor showed high values on the western bank of the Reservoir and relatively lows values on the eastern bank. This may be attributed to anthropogenic influences, physio-chemical and biological changes in the local environment, over-exploitation of this species, and changes in state of the gonadal development of the fish. The results of this study may be useful in the management of the fisheries resources of *S. schall* in Roseires Reservoir.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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