E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(1): 173-177

www.fisheriesjournal.com
Received: 27-11-2016
Accepted: 28-12-2016

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Seasonal variation in the length-weight relationships and condition factor of *Synodontis schall* (Bloch and Schneider, 1801) (Siluriformes: Mochokidae) in man-made Lake Ayamé 2 (Côte d'Ivoire)

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Abstract
Length-weight relationship (LWR) and condition factor (K) of *Synodontis schall* (Bloch and Schneider, 1801) were studied in man-made Lake Ayamé 2. Samples of *S. schall* were collected from catches of artisanal fisheries using various mesh size of gill nets from May 2015 to April 2016. Length-weight data were analyzed and length-weight relationship graphs were plotted for the dry and rainy seasons of the sampling years. The b values in the LWR ($W= aL^b$) varied between 2.5163-2.7857 for the dry seasons and 3.0008-3.001 for the rainy season indicating that the growth pattern of *S. schall* had negative allometric and isometric in the seasons respectively. The average condition factor (K) were less than 1 (Mean: 0.315-0.647) during the dry season revealing that this fish species was not in good physiological sate of well-being. However, it was in better condition (K-values were greater than 1; Mean: 1.0375-1.357) during the rainy season.

Keywords: *Synodontis schall*, length-weight relationship, condition factor, man-made Lake Ayamé 2, Côte d'Ivoire

1. Introduction
The genus *Synodontis* (Cuvier, 1816) commonly known as the up-side-down catfish belongs to the family Mochokidae [1]. The Family comprises three genera-*Mochochus*, *Synodontis* and *Chiloglanis* [2-4]. *Synodontis* species are currently restricted to freshwaters of Africa, occurring mostly in Central and West Africa [5] and throughout Africa except in the southern-most parts [6].

This genus is widely distributed in inland waters of West Africa [7] particularly and in man-made Lake Ayamé 2. *Synodontis schall*, Shield-head catfish, is important ecologically. Indeed, it plays silent roles in determining the dynamics and structure of the aquatic ecosystem. This fish represents a relatively cheap source of animal protein and other essential nutrient required in human diet [8]. Apart from its utilization as a food fish, it is important economic and commercial species as it occurs in both subsistence and artisanal fisheries landings.

Knowledge of some quantitative aspects such as length-weight relationship is important in studying fish biology. Length and weight relationships are of great importance in fisheries research because they provide information on population parameters [9-11]. In fact, a change in length and weight tells the age and year-classes of fishes, which is important in fishery. The data can also be used to estimate the mortality rate, and furthermore they can be used to assess the sustaining power of the fishery stock. In addition, the data on length and weight can also provide important clues to climatic and environmental changes, and the change in human subsistence practices [12, 13]. At the same time, the relationship of length-weight estimates condition factor of the fish species and fish biomass through the frequency. In fisheries science, the condition factor is used in order to compare the "condition", "fatness" or wellbeing of fish. And it is based on the hypothesis that heavier fish of a particular length are in a better physiological condition [14]. Condition factor is also a useful index for the monitoring of feeding intensity, age, and growth rates in fish [15]. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live.

In Côte d'Ivoire, few studies [16-18] have been conducted on length-weight relationship of *Synodontis schall* in the tropical freshwater environment. However, no information is available on fish population biology such as, length-weight relationship (LWRs) and condition factor of *S. schall* from the man-made Lake Ayamé 2 located between two hydroelectric dams. Therefore, to remedy this deficiency, the aim of the present study is to assess growth patterns and physical or heath conditions of *S. schall* during the seasons of the year.

2. Materials and Methods

2.1 Study area

Lake Ayamé 2 is located in South-East Côte d'Ivoire (5^0 34'- 5^0 37' N and 3^0 09'- 3^0 10' W), and is the second oldest hydroelectric dam in the country (Figure 1). It was built in 1963 on the river Bia and has an average surface of 7 Km^2 [19]. It rises in Sui (Ghana) and enters Aby lagoon (Côte d'Ivoire). This aquatic ecosystem is localized in a region under the influence of equatorial transition climate characterized by an equatorial transition zone, with two rainy seasons separated by a short dry period from August to September, and a more pronounced one from December to March [20]. This lake is at certain times of the year fully covered by a floating plant slick viz *Pistia stratiotes* and *Eichhornia crassipes*.

2.2 Data collection and analysis procedure

Fish samples were collected monthly from May 2015 to April 2016 using two batteries of gillnet (06 to 60 mm stretched mesh). Fishes captured were identified following [21]. The Standard Length (SL) of the fish was measured to nearest 1mm on a measuring board. The total weight was measured using a digital electronic weighing balance (model SF-400) with 0.1 g accuracy and sex was registered.

The Length-weight relationships (LWR) regression coefficients of both sexes were determined by the formula: $W = aSL^b$. The value of constants ''a'' or intercept and ''b'' or slope [12] were computed from the transformed logarithm values of length and weight using the equation Log W = Log a + b Log SL; where W = weight of fishes (g) and SL=standard length of fishes (cm).

The condition factor (K) was calculated using the formula: $K = 100W/SL^3$ [22], where K = condition factor, W = weight (g) and SL = standard length (cm). Significance of differences in fish growth was tested with the Student's t-test.

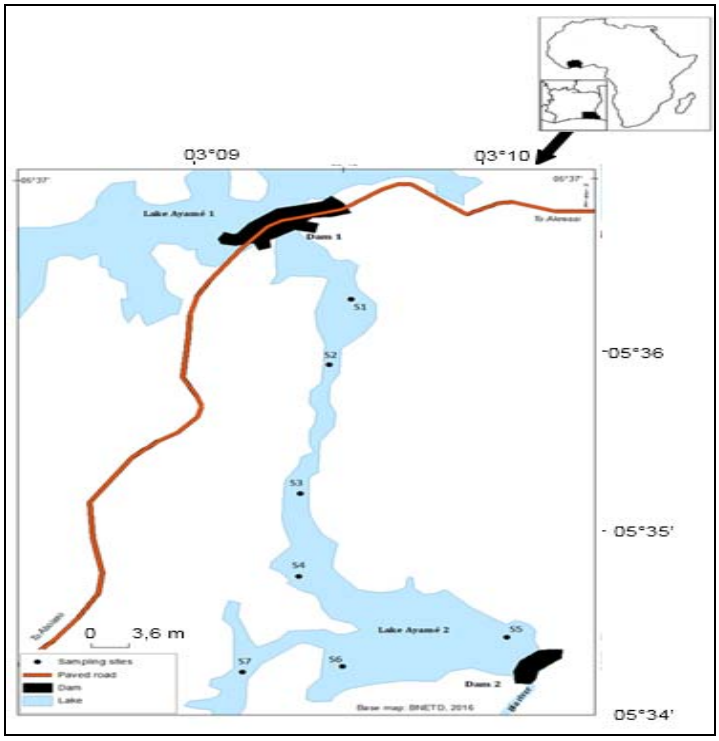

Fig 1: Map of the study area and the sampling stations (**S**) in man-made Lake Ayamé 2 (Côte d'Ivoire).

3. Results

3.1 Length –weight relationships

The standard length and mean body weight of *Synodontis schall* in man-made Lake Ayamé 2 for the sampling period are presented in table 1. For females, length ranged from 12.6 cm to 20.7 cm, weight varies between 38 g and 202 g with a mean of 104.64 ± 35.29 g in the rainy season while length ranged from 9.8 cm to 19 cm and weight ranged between 29 g and 197 g with a mean of 90.73 ± 32.54 g in the dry season. The Student showed a significant difference in length and body weight for both seasons ($p<0.05$). For males, length ranged from 12.2 cm to 20.4 cm, weight varies between 40 g and 201 g with a mean of 85.78 ± 29.33 g in rainy season while length ranged between 8 cm and 18 cm, weight varies between 22 g and 199 g with a mean of 73.04 ± 36.59 g in the dry season. Both length and body weight of fish samples caught for rainy and dry seasons were significantly different respectively (Student t-test, $p<0.05$).

Length-weight relationship parameters of *S. schall* in man-made Lake Ayamé 2 for both dry and rainy season is presented in table 2. For females, in the rainy season, length-weight relationships was $W = 0.0095SL^{3.0008}$ with a significant correlation (r = 0.8499, $p<0.05$) whereas in the dry season this relation was $W = 0.015SL^{2.7857}$. The allometric indices b was 3.008 and 2.7857 during the rainy and dry season respectively. In males, the corresponding relationship between length-weight was $W = 0.0094SL^{3.0001}$ (r = 0.8607, $p<0.05$) in the rainy season and was $W = 0.0275SL^{2.5163}$ (r =

0.7243, $p<0.05$) in the dry season. The allometric indices b was 3.0001 during rainy season and 2.5163 during dry season. In both season, *t*-value test revealed significant difference between calculated b. In female and male sexes of the fish species, the exponent b-values were less than 3.0 (theorical cubic value) in the dry season and greater than 3.0 in the rainy season. The test results revealed that *Synodontis schall* exhibited negative allometric growth type for dry season which means they tend to become thinner as they grow larger. However, in rainy season, the fish species had isometric growth pattern indicating that the fish becomes fatter as it grows.

Table 1: Standard length and body weight by sex and by season of *Synodontis schall* captured in the man-made Lake Ayamé 2 during May 2015 to April 2016.

			Standard length (cm)			Weight (g)		
Sex	**Season**	**Number of specimen (n)**	**Min**	**Max**	**Mean ± SD**	**Min**	**Max**	**Mean ± SD**
Females	Rainy season	70	12.6	20.7	158.51±18.21	38	202	104.64±35.29
	Dry season	48	9.8	19	147.85±23.57	29	197	90.73±32.54
Males	Rainy season	60	12.2	20.4	149.7±23.79	40	201	85.78±29.33
	Dry season	52	8	18	137.6±28.56	22	199	73.04±36.59

Min = minimum; Max = maximum and SD = standard deviation

Table 2: Length-weight relationship parameters by sex and by season of *Synodontis schall* caught the man-made Lake Ayamé 2 during May 2015 to April 2016.

Sex	Season	Number of specimen (n)	Intercept (a)	Groxth exponent (b)	Correlation coefficient (r)	Coefficient of determination (R^2)	Level of significance
Females	Rainy season	70	0.0095	3.0008	0.8499	0.92253	*
	Dry season	48	0.015	2.7857	0.700	0.8367	*
Males	Rainy season	60	0.0094	3.001	0.8607	0.9278	*
	Dry season	52	0.0275	2.5163	0.7243	0.85106	*

*Significant at 5%

3.2 Condition factor

Values of the condition factor (K) (Table 3) showed that for females, in the rainy season K ranged from 0.4 to 1.9 with an average of 1.357 ± 0.474. In the dry season, value of K is between 0.35 and 0.8 with a mean of 0.647 ± 0.218. For male's populations, in the rainy season value of K ranged from 0.1 to 1.7 with a mean of 1.0375 ± 0.495. During the dry season, this value of K varies between 0.19 and 0.5 with an average of 0.315 ± 0.102. The Student test showed a significant difference between the K-values of fishes (females and males) observed in the rainy season with those obtained in the dry season ($p<0.05$).

Monthly variation of the Fulton condition (Fig. 2) showed that females had K-values of 1.9 in July and 1.5 in November, whereas males had theirs, 1.7 and 1.1 respectively. However, peak values of 0.7 were observed in September and 0.3 in March for females and 0.3 in September and 0.1 in April for males. No significant difference was found in K ($p>$ 0.05) among season and sexes.

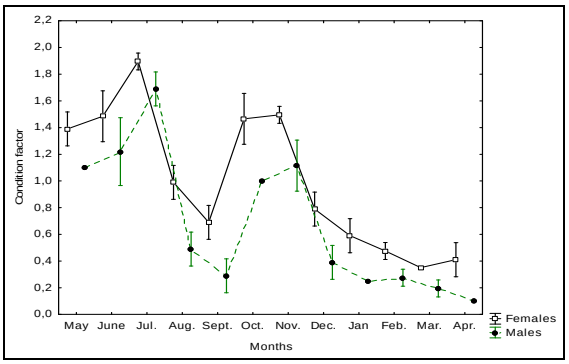

Fig 2: Monthly variation of condition factor K for males and females of *Synodontis schall* from the man-made Lake Ayamé 2 during May 2015 to April 2016.

Table 3: Values of Condition Factor K by sex and by season of *Synodontis schall* caught in the man-made Lake Ayamé 2 during May 2015 to April 2016.

		Condition factor			
	Seasons	**Min**	**Max**	**Mean**	**SD**
Females	Rainy season	0.4	1.9	1.357	0.474
	Dry season	0.35	0.8	0.647	0.218
Males	Rainy season	0.1	1.7	1.0375	0.495
	Dry season	0.19	0.5	0.315	0.102

Min = minimum; Max = maximum and SD = Standard deviation

4. Discussion

The present study revealed that *Synodontis schall* exhibited negative allometric growth pattern for males and females in dry season, and isometric growth for this population in rainy season, according to the *t*-test. The correlation (r) between length-weight relationships generally occurred high in the each gender and in all season. That also showed that there was a strong connection between length-weight relationships. The implication is that fishes tend to become thinner as they grow larger during dry season and become more robust as they increase in length during rainy season. This may be attributed to the favourable conditions of this aquatic environment during the rainy season (high oxygen content and high nutrient content). These observations are in agreement with those of [23] who observed negative allometric growth for *Gymnarchus niloticus* in Lekki lagoon (Nigeria) for both dry and wet seasons and of [24] who had reported isometric growth on five fish species in Lake Baringo (Kenya) for both dry and wet seasons. However, unlike the results in this study, positive allometric growth pattern was reported for *Synodontis schall* from the five coastal rivers of south-eastern of Côte d'Ivoire [18] and isometric growth pattern was observed for the same fish species in Ayamé and Buyo reservoirs [25]. This difference could be due to physiological growth condition such as gonad development or food availability [26], biological and environmental condition, and geographical, temporal and sampling factor [27, 28]. Indeed, the lotic and lentic environment, polluted and non-polluted

environment would also determine the condition of the fish. Fish tend to be heavier in the lotic and lighter in the lentic environment [29].

In the study, the condition factor of *Synodontis schall* varied significantly between dry (Mean: 0.315-0.647) and rainy (Mean: 1.0375-1.357) seasons. During the dry season, the values of condition factor of this fish species were less than 1 (Mean: 0.315-0.647). In fishery science body well-being ≥ 1.0 is considered as good [30]. The values of mean condition factor of *S. schall* recorded in this study implied that this specie was not in good physiological sate of well-being in man-made Lake Ayamé 2. This could have been caused by adverse environmental factors in this Lake during the dry season. In the Ayamé 2 reservoir, the watershed covered by the invasive plants is equivalent to more than 90% of the whole of the water when the two dam's gates are closed. The plants (the advent of macrophytes) take up a large quantity of nutrients from the water, so that these are locked up within the dam basin rather than being lost by downstream discharge. Consequently, lake water is not constantly renewed and there is depletion in dissolved oxygen characterized by putrid odor of water provoking at massive mortality of the fishes occurred. This result may also be caused by pollutants constant entering man-made Lake Ayamé 2 and imparting negatively on the fish growth pattern. Furthermore, our results could be due to the reduced availability of food and prey items as reported by [30] for *Bagrus docmac* from Lake Akata (Nigeria).

However, during the rainy season, the values of the condition factor were greater than 1 (Mean: 1.0375-1.357). These results suggest that fish species were in better condition. These are consistent with the results of [7] who found that the monthly condition factors of *Synodontis schall* from river Benue (Makurdi, Nigeria) were higher in the rainy season months than the dry season. This could be due to the availability of more food and enhancement during their gonad development in the rainy season [31, 7]. Indeed, during this season, there was an enhancement of the physicochemical variables of the lake water due to the opening of the two dam's gates. Moreover, according to [32] fish condition factor could be influenced by certain extrinsic factor such as changes in temperature and photoperiod.

Current study demonstrated no significant difference in condition factor values between females (mean: 0.647-1.357) and males (mean: 0.315-1.0375), even though the females were in a slightly better conditions than the males. On the contrary, [33] reported that the males of *S. schall* in River Nile at Gizza had better condition (1.83) than the females (1.64). The result could be explained by the fact 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 as reported [15].

5. Conclusion

The results of the length-weight relationships of *Synodontis schall* from man-made Lake Ayamé 2 exhibited negative allometric growth pattern in dry season and isometric in rainy season. The correlation coefficients of the length-weight relationships indicated high degree of positive correlation. The condition factor showed that this fish species was not in good physiological state of well-being in the man-made Lake Ayamé 2 during the dry season, but it was in good state of well-being during the rainy one. This study has therefore provided the basic information which could enhance production potential of *S. schall* and its sustainable development and management in man-made Lake Ayamé 2.

6. Acknowledgement

Authors appreciate the Hydrobiology Laboratory of the Felix Houphouet Boigny Univeristy (Côte d'Ivoire), for approving the use of the laboratory and providing necessary facilities for this study.

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