Length-weight relationships and condition factor of three commercially important fish species from Roseires reservoir, Blue Nile, Sudan.

Abstract:

This study aimed to investigate the length-weight relationship and condition factor of three commercially important fish species in Roseires Reservoir on the Blue Nile, Sudan. A total number of 387 specimens of *Labeo senegalensis*, 285 of *Alestes dentex*, and 318 *Oreochromis niloticus*) were collected from four sampling sites on the ~~Reservoir, using gillnets with different mesh sizes during the period Nov. 2015 to Oct.~~ reservoir, using gillnets with varying mesh sizes from November 2015 to October 2016. The results showed that the three species exhibited negative allometric growth ($b < 3$) in all sites, except *L. senegalensis* at the Wad El Mahi site, which displayed positive allometric growth (*b*' value 3.182)~~,~~ and moderate to high correlation coefficient ($r = 0.442 - 0.998$) The condition factor displayed average values ranged from 1.963- 3.751 (*L. senegalensis*) to 2.080 - 3.287 (*A. dentex*) and 2.336 - 3.287 (*O. niloticus*), thus indicating good health conditions and wellbeing of the three species in the study area. The results of this investigation provide baseline data and valuable information on the growth pattern and health status of three fish species in the Roseires reservoir and can used as a basis for effective management measures of the three fish species in the Reservoir.

Keywords: *Alestes dentex Labeo senegalensis, Oreochromis niloticus,* Length-weight relationship, Fulton condition factor, Roseires reservoir.

Introduction

The Nile tilapia (*Oreochromis niloticus*, Linnaeus 1758), the Nile Robber (*Alestes dentex* Linnaeus, 1758), and the African Carp (*Labeo senegalensis*, Valenciennes 1842) are commercially ~~important~~ crucial native fish in the freshwaters of Sudan. They are regularly exploited in the small-scale freshwater fisheries sector, as they provide ~~an important~~, essential ~~source of livelihood, income, and a~~ and income and a and income, and income, substantial, crucial, essential source of income, and nutritive source of protein required by human health. During the past few decades, ~~the artisanal freshwater fisheries have been heavily exploited, in the major~~major significant ~~African rivers, lakes, and reservoirs leading to a serious decline in the richness of the~~ artisanal freshwater fisheries have been heavily exploited in the major significant African rivers, lakes, and

reservoirs in significant African rivers, lakes, and reservoirs, leading to a serious severe decline in severe decline in the richness of commercial fish species [1 and 2].

The length-weight relationship (LWR) and Fulton's condition factor (FCF) are two vital tools in fishery management used to determine a fish population's growth patterns and well-being. They are widely used to provide information on the growth and condition of fish and give insight into the health of fishes and their community [3; 4 and 5]. Length-weight relationships of fishes are based on the assumption that growth patterns could be isometric when length and weight increase at identical growth rates, or allometric when the two morphometric traits increase at different rates [6; 7 or allometric when the two morphometric traits increase at different rates [6, 7, and 8]. Moreover, knowledge of fish length-weight relationships supports fishery stock assessment and management [9], fish population dynamics, distribution, mortality, and morphology of the fish species [10; 11; 12, 11, 12, and 13].

On the other hand, the condition factor indicates the fish's well-being, overall good health, and physiological status. It is influenced by food availability [14], environmental factors, sex, maturity stage, ecological health of the habitats, and discharges from various industries, which could alter water quality and bring about changes inchanges in exchange growth patterns [15]. The condition factor is based on the assumption that heavier fish of a given length are in better condition [16]. Different fish species usually exhibit varying values of condition factorcondition factor values, which can indicate their adaptation and health in specific habitats. Understanding Fulton's condition factor is also crucial for assessing the physiological condition and fitness of fish fish's physiological condition and fitness in different ecosystems. Condition factors higher than 1.0 indicate good health conditions of the fish and good adaptation to the environment.

This study aims to investigate the length-weight relationship and condition factor of three important crucial food fish species that are regularly captured in Roseires Dam Reservoir on the Blue Nile, Sudan, in order to provide baseline data and usefulto provide baseline data and useful, valuable information for effective fisheries management of the three fish species in Roseires Dam Reservoir.

Materials and Methods:

The study was conducted…..area give latitude and longitude.

Explain the season

Explain catch method

Explain number of fish sampled in each case

Laboratory work details with location.

These datas almost 9 year old?

Is it possible to get any new data?

Map of the study area

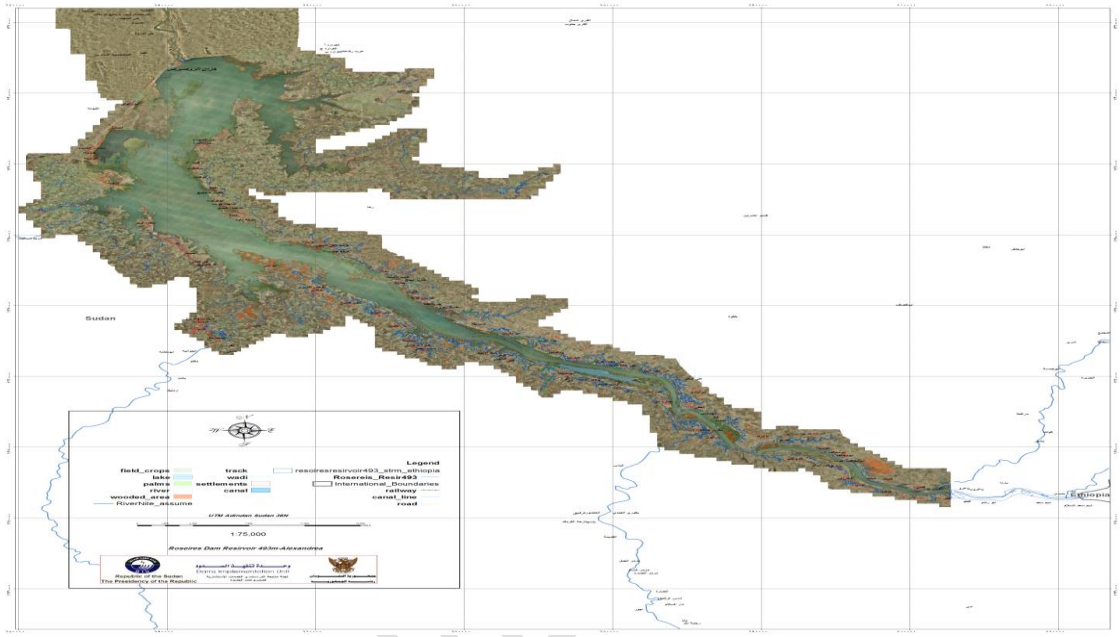


Fig. 1: Roseires Dam reservoir area (Blue Nile, Sudan) before and after the heightening of the Dam.

Fish Sampling ~~sites~~Sites**:** Fish samples were collected from four sampling sites in Roseires Reservoir, as shown in Table 1.

Table 1. Shows the coordinates of the fish sampling sites in Roseires Reservoir (Blue Nile, Sudan) and the distance from Damazin city.

Site	Distance (km)	Coordinate	Elevation (m)
Awal Bab	4	11°45'14"N 34°21'51"E	487
EL Regiba	16	11°38'39"N 34°20'51"E	497
Kirma	43	11°41'09"N 34°30'35"E	507
Wad ELmahi	80	11°25'27"N 34°40'17"E	507

Collection of fish samples:

Fish samples were collected monthly ~~during the period~~ from November 2015 to October 2016. A total number of 287, 285~~, and 318 specimens of *L. senegalensis*, *A. dentex*, and *O. niloticus*~~, and 318 specimens of L. senegalensis, A. dentex, and O. niloticus, respectively, were collected from the four sampling sites, using multi-filament gill nets of various mesh sizes and twine numbers, as shown in Table 2.

Table 2. Specifications of gillnets used ~~for collection of~~of collect fish samples during the study period (Nov. 2015 to Oct. 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

Measurements of length and weight*:*

~~The total length and standard length of each fish~~ Each fish's total length and standard length were measured to the nearest 1.0 mm~~,~~ using a standard measuring board. The body weight of sampled fish was taken to the nearest 1.0 gm~~,~~ using a digital weighing balance, version FRUIT 2000B.

Length-weight relationship:

The relationship between the total weight and the standard length of the fish was computed using the power function according to the [17], as follows:

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

The LWR was also tested using the linear regression equation~~;~~; Log TW = Log a + b Log SL, where: TW=Total weight (g), ~~SL=standard~~standard length (cm), a =constant representing the intercept on the "y" axis, and b = constant of the relationship, representing the slope of the regression line.

Excel package was used to plot ~~the curve of the relationship~~relationship relationship curve between the standard length and total weight of the three fish species, and the liner equation was then obtained from logarithm transformation.

Condition Factor (CF) or (Fulton's condition factor) (FCF):

The condition factor is usually used ~~for comparing~~to compare the condition, fatness, or well-being of fish. It is calculated according to the [16] formula:

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

Where W is the weight of the fish~~;~~ ; L is the total length of the fish, and 'b' is constant.

Statistical Analysis

Statistical analysis is performed using a personal computer and the advanced computer Excel program.

Results and Discussion:

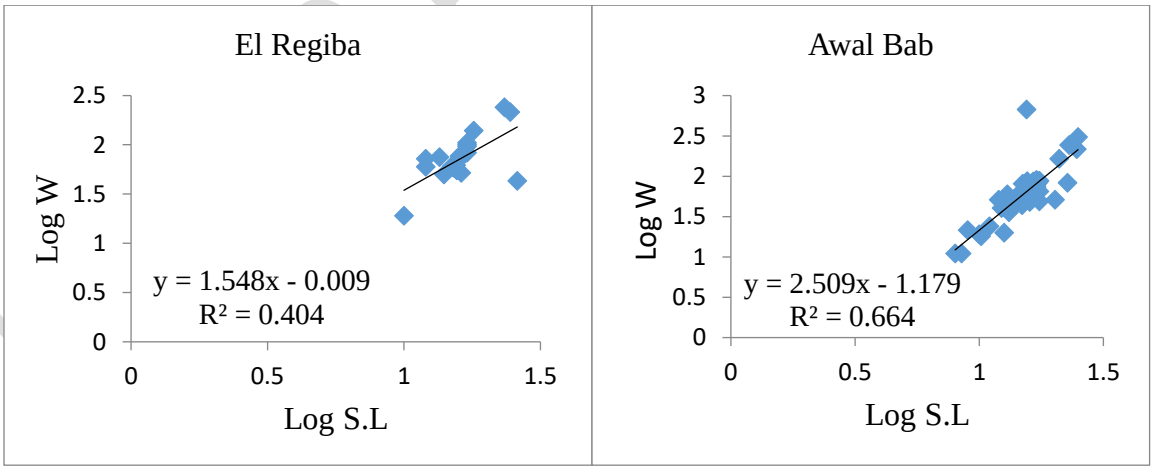
A total ~~investigation period, and~~ 287 specimens of L. senegalensis were reviewed during the investigation period. The results showed that the fish exhibited a negative allometric growth pattern with growth coefficient '*b"* ranging from 1.528 to 2.508 to 2,796 in El Regiba, Awal Bab and Kirma sampling sites respectively, with moderate to high correlation *r* = 0.404 - 0.928, except Wad El Mahi site which showed positive allometric pattern (*b* = 3.18 with *r*= 0.998), as shown in (Fig. 2 and Table 3). This result is in agreement with those obtained for LWR of *L. senegalensis* in Lake Maabo, Central Africa); Khashm El-Girba reservoir, Atbara River, and Upper Atbara and Settit dam complex (Sudan) with growth exponent '*b'* ranged between 2.178 to 2.940 [18; 19; 20 and 21]. Although, [22] reported an isometric growth pattern for of *'b'* = '*b*' 3.043~~;~~ and a high correlation (*r*=0.8315 – 0.968 *L. senegalensis* in Dadin- Kowa lake, Nigeria~~;~~ , yet, [23] in Oguta Lake, Nigeria, found positive allometric growth pattern for the same species, with '*b*' = 3.840 and a high correlation *r*= 0.928; These variations in growth parameters may be due to food availability, changes in environmental factors, the ecological status of the habitats and fishing gear used in sampling.

Table 4 shows the results of the condition factor of the three fish species in Roseires Reservoir during the period. It can be observed that the average value of condition factor (K) of *L. senegalensis.* ~~ranged~~ Ranged from 1.963 (Wad El Mahi) to 3.752 (Awal bab), revealing ~~the good condition and health status of this species~~ this species' good condition and health status in Roseires Reservoir during the study period. This may be due to the abundance of food items and good water quality conditions of the species. The obtained value of (K) agrees with those recorded by [21] from Khashm El-Girba reservoir and Atbara River, Sudan (K= 1.595 (River) and 2.536 (Reservoir); Similar results were obtained by [23] in Lake Oguta, Nigeria, (K between 1.20 – 3.92), and [18] in Lake Maabo, Central Africa, (K = 2.341). However, [19], working in the Upper Atbara and Sittit complex dam, Sudan recorded a good condition value of K = of 3.121 for *L. senegalensis*~~,~~ ~~while~~. At the same time [24], in Mono basin Benin and Togo, West Africa, obtained a low average

condition factor of (0.085) of the same species. This may be attributed to poor water quality and environmental and geographical differentiation of the different water bodies.

Table 3. shows the linear fit of the length-weight relationship of the three fish species studied ~~during the period~~ (November 2015 – October 2016).

Site	Fish species	*b*	*a*	*r*
Awal Bab	*L. senegalensis*	2.509	-1.179	0.664
	A. dentex	1.477	-0.166	0.442
	O. niloticus	2.154	-0.553	0.788
El Regiba	*L. senegalensis*	1.528	-0.009	0.404
	A. dentex	2.007	-0.705	0.848
	O. niloticus	2.285	-0.710	0.808
Kirma	*L. senegalensis*	2.796	-1.457	0.928
	A. dentex	2.393	-1.807	0.931
	O. niloticus	2.648	-1.108	0.837
Wad El Mahi	*L. senegalensis*	3.182	-1.897	0.998
	A. dentex	2.656	-1.311	0.967
	O. niloticus	2.445	-0.789	0.755



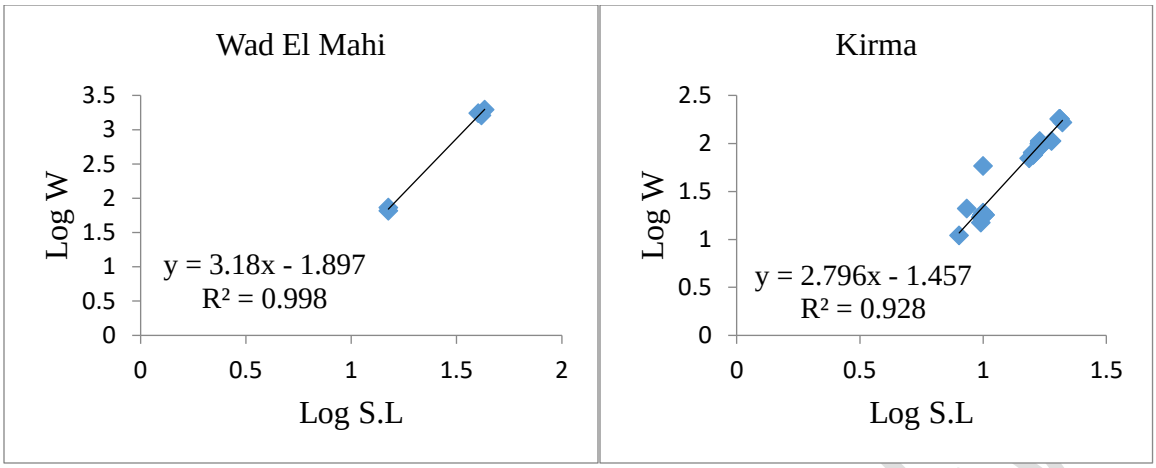


Fig.2: Linear fit of the length-weight relationship of *L. senegalensis* during the study period (2015/2016).

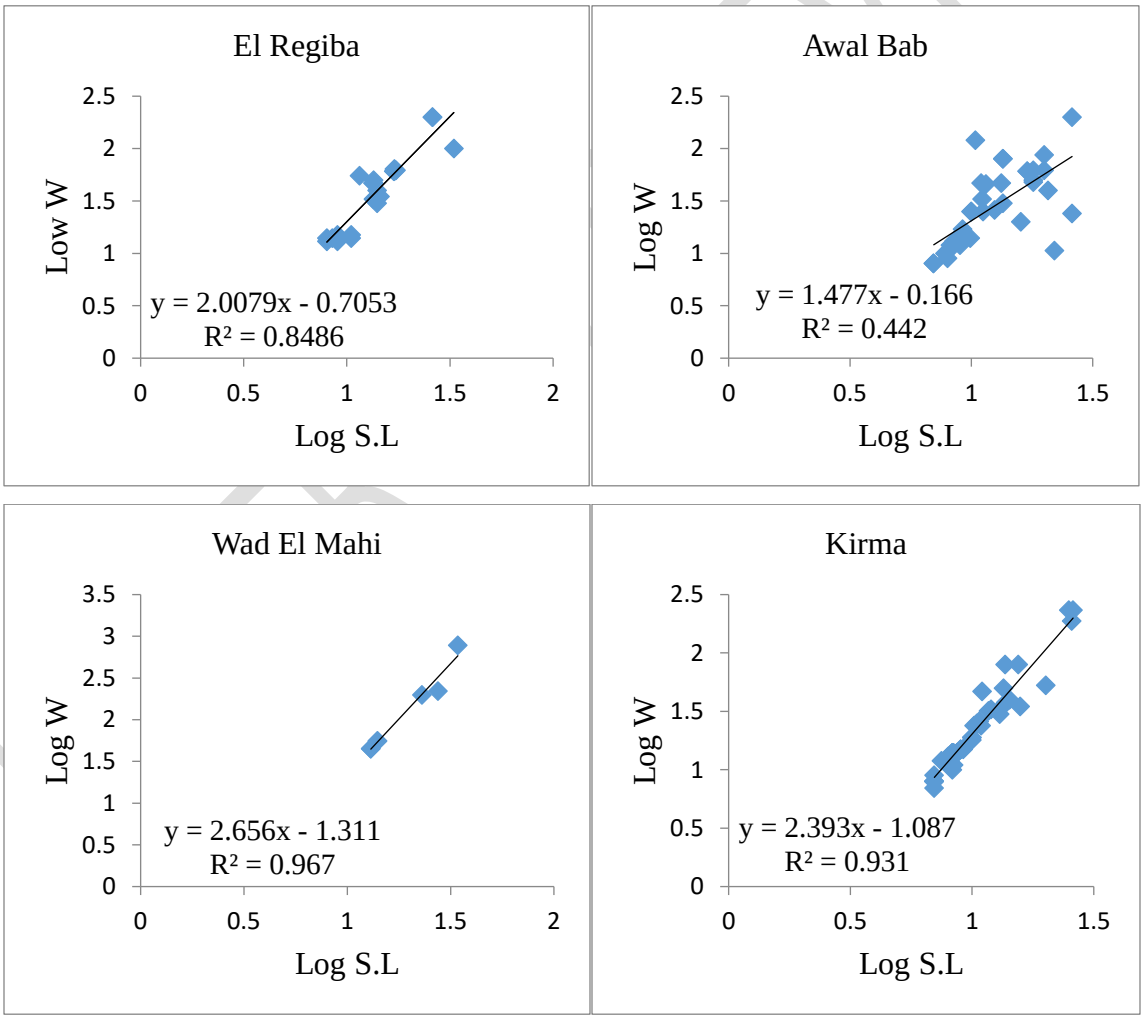
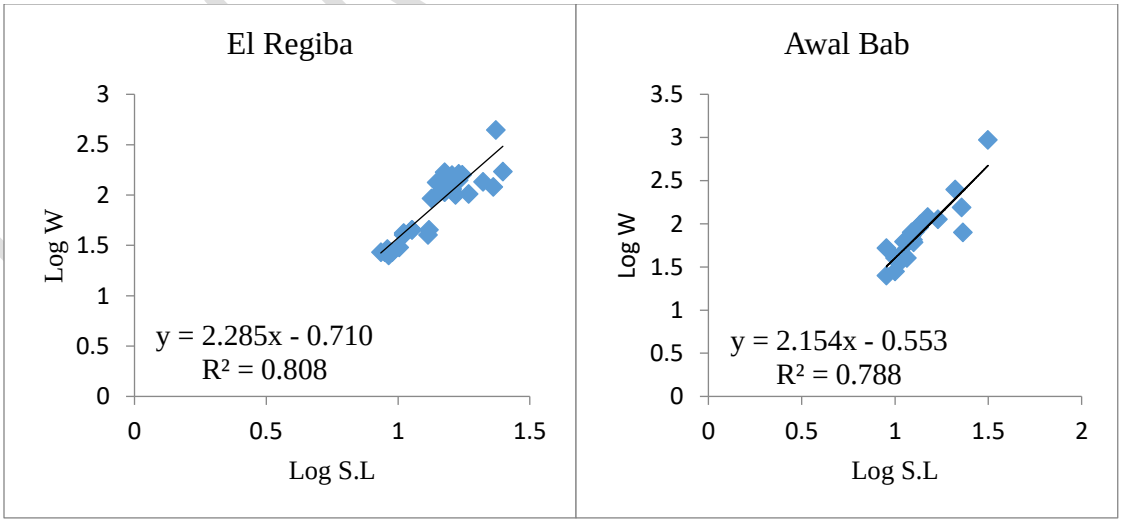


Fig.3: Linear fit of the length-weight relationship of *A. dentex* during the study period (2015/2016).

A total ~~number of 285 specimens of *A. dentex* were collected during the period of investigation~~investigation of 285 specimens of A. dentex were collected during the investigation period. The results showed that~~,~~ the *A. dentex* displayed a negative allometric growth pattern, with exponent '*b'* ranging between 1.477 to 2.656, and slight moderate to high correlation (*r* = 0.442 - 0.967), Fig 3, Table 3. Similar results were recorded by [22] with exponent *b*= 2.8926~~,~~ and a high correlation *r*= 0.8215. [25], investigated LWRs of the Characidae family in Jebel Aulia dam and reported growth exponent '*b'* of 2.709, *A. dentex*, indicating isometric (negative) growth patterns of this species~~, while~~. At the same time, [26] in Senegal~~, and [23] Oguta Lake, Nigeria, found isometric allometric growth of *A. dentex* with '*b'* value~~ and [23] Oguta Lake, Nigeria, found isometric allometric growth of A. dentex with 'b' values of 3.26 and 3.0756, with a high correlation *r*= 0.8802.

The condition factor of *Alestes dentex* varied from 2.080 at ~~Wad El Mahi site to 3.287 at Kirma site in the Reservoir displaying good health condition and wellbeing~~the Wad El Mahi site to 3.287 at Kirma site in the Reservoir the Wad El Mahi site to 3.287 at the Kirma site in the Reservoir, displaying good health condition and well-being of the fish (Table 4). Although~~,~~ [27] in Odi River, Niger Delta, Nigeria, and [23], Oguta Lake, Nigeria, obtained low values of (K= 0.83 -1,00)~~,~~ and (K= 0.75) respectively, yet, [25] noted good condition factors of members of family Characidae in Jebel Aulia reservoir with the value of '*b* = 2.7096' for *A. dentex*. This variation in condition factor may be influenced by variations in food abundance, environmental factors, sex, maturity stage, and fishing gear used in sampling procedures.



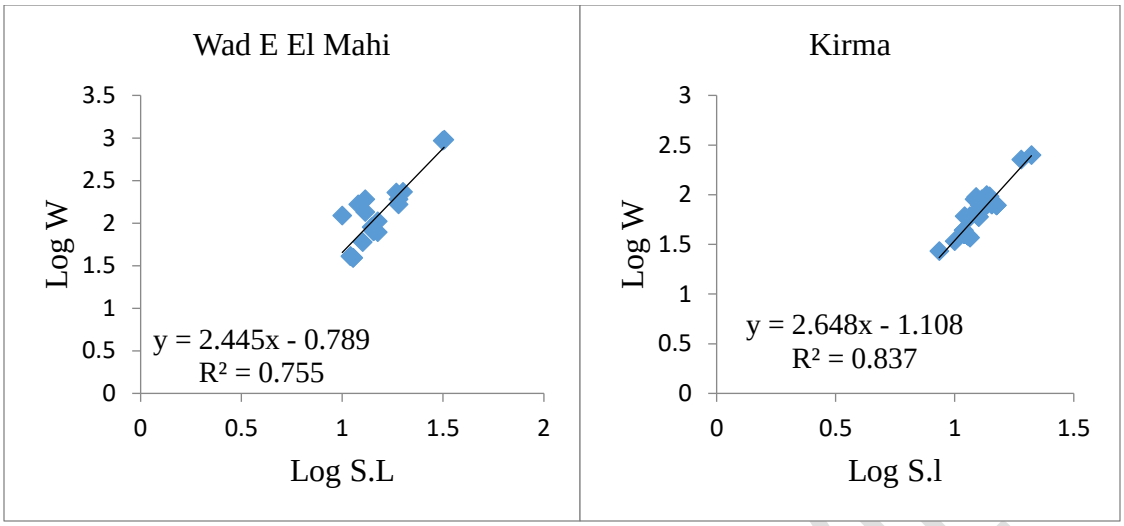


Fig.4: Linear fit of the length-weight relationship of *O. niloticus* during the study period (2015/2016).

Table 4. Condition factor of the three fish species studied in Roseires Reservoir (Blue Nile, Sudan) during the period (Dec. 2015 / Nov. 2016)

Sampling site/fish species	Awal bab	Elregiba	Kirma	Wad El-Mahi
L. senegalensis	2.194±0.519 - 3.962 ±0.329	2.307±1.189 - 3.106±0.001	2.501±0.595 - 3.633±1.069	1.552±0.276 – 2.486±0.235
A. dentex	1.279±0.000 - 3.778±0.674	2.010±0.449 - 2.782±0.479	2.755±0.866 - 3.822±0.639	1.552±0.446 – 2.641±0.437
O. niloticus	2.205±0.007 - 3.601±0.248	2.169 ± 0.213 – 2.700±0.742	2.755±0.287 – 3.822±0.597	2.720±0.990 – 3.769±0.869

A total of 318 specimens of *Oreochromis niloticus* were collected during the study period. The results indicated that the fish exhibited a negative allometric growth pattern in all sampling sites, with growth coefficient '*b*' ranging from 2.154 – 2.648, and high correlation '*r*' = 0.755 and 0.837. This result is in agreement with '*b*' values reported for *O. niloticus* by several investigators, including [22] in Dadin-Kowa Reservoir, Nigeria; [23] in Oguta Lake, Nigeria; [18], Lake Maabo, Central Africa; [28] in Tugwi-Muskosi dam reservoir, Zimbabwe; and '*b*' = 1.60 recorded by [29] from Juba fish landing sites, White Nile, South Sudan. However, [30], found an isometric allometric growth pattern of this species from the White Nile within Sudan, with a growth

coefficient '*b*' = 3.070 and a high correlation *r*= 0.981. On the other hand, [31~~; 20 and 21],~~ 20, and 21] noted both negative and positive allometric growth of *O. niloticus* at Khashm El-Girba Dam, Atbara River, Sudan, with '*b*' ranging from 2.288 to 3.648. [32] studied the growth pattern of *O. niloticus* at two fishing sites in the Blue Nile (Sinnar) and the Main Nile (Shendi), Sudan, and found that *O. niloticus* exhibited negative, positive, and isometric growth patterns, with values of '*b*' varying from 1.395 in Shendi (Main Nile), and 3.1167 in Sinnar (Blue Nile). Moreover, [33] investigated the LWRs of *O. niloticus* in selected tropical reservoirs in Southwest Nigeria~~,~~ and reported both allometric and isometric growth patterns with '*b*' ranging between 2.45 to 3.20.

The results obtained for the condition factor of *O. niloticus* exhibited a high value of (K) ranging from 2.336 (El Regiba) and 3.287 (Kirma), demonstrating that the fish enjoyed healthy conditions and well-being throughout the study period. Similar high values of condition factor (K) *O. niloticus* were observed by several investigators, such as [20] for *O. niloticus* in the Khashm El-Girba fish market (mean value of K=3.866); [21] in Khashm El-Girba Reservoir (mean K ranged from 2.441 and 3.415); [23] in Oguta Lake (Nigeria (K = 2.23); [29] in Juba fish market, South Sudan (K = 3.63); and [31] in Khashm El-Girba and Atbara River (K varied between 2.55 to 3.56); [34] in Egypt's Nile (K 1.86 - 2.10); [28] in the Tugwi-Muskosi dam, Zimbabwe, (K value 2.2); and [30], in the White Nile, Sudan, (K=1.558). However, [35]~~, showed that *O. niloticus* exhibited poor condition factor in Lake Beseka,~~ showed that O. niloticus exhibited poor condition factors in Lake Beseka (Ethiopian inland water systems) with an average (K= 0.5), revealing poor health conditions of this species.

Although the condition factor of *O. niloticus* varied in most of the investigated water bodies~~, yet~~, it still lies within the healthy range of the fish, and the '*b*' values still lie within the range frequently recorded for tropical freshwater fish species.

What are your observations?

Inferences?

Explain

Conclusion:

Based on the results of the present investigation, it can be concluded that the three commercially important fish species in Roseires Reservoir, Blue Nile, Sudan, exhibited negative allometric

growth pattern throughout the study period, except *L*abeo *senegalensis* at Wad El-Mahi site, which showed positive growth pattern, with '*b*' = 3.206 ± 0.680, and high correlation coefficient of *r*= 0.998.

The condition factor (K) showed high values of the three fish species during the period of investigation and ranged from 1.963 - 3.751 for *L. senegalensis*~~;~~ ; 2.080 -3.287, for *A. dentex* and 2.336 - 3.287 for *O. niloticus*, reflecting the occurrence of abundant of food items and good water quality of the reservoir.

The finding of this study provides ~~useful~~ valuable information on the growth pattern and health condition of the commercially important fish species in Roseires Reservoir on the Blue Nile. It can inform on effective management measures of the fish population of the Reservoir, particularly after the completion and operation of the Grand Ethiopian Renaissance Dam on the Blue Nile~~, and subsequent changes expected to occur in the water level, water quality parameters~~ and subsequent changes expected to occur in the water level, water quality parameters, and fish population of the Roseires Dam Reservoir.

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