integrity Research Journals

Global Journal of Fisheries Science
Volume 3(2), pages 7-14, June 2021
Article Number: BD4D0B4D1
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2021.024
https://integrityresjournals.org/journal/GJFS

Full Length Research

Study of some biological aspects of the Nile Carp, *Labeo niloticus* (Pisces, Cyprinidae) from Khashm El-Girba Reservoir and Atbara River; Eastern Sudan: II, length-weight relationship, condition factor and age structure

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Received 15th May, 2021; Accepted 14th June, 2021

ABSTRACT: This study was undertaken to assess the length-weight relationship, condition factor and age structure, of the Nile carp, *Labeo niloticus*, in Khashm El-Girba reservoir and Atbara River, Sudan, from December 2015 to November 2016. Samples of fish were collected bi-monthly from three locations, namely; Um Aswad (Atbara River), El-Remila and El-Monaba (Khashm El-Girba reservoir), using beach seine nets of 1.2, 4.0 and 7.0 cm stretched mesh. Out of a total number of 1,190 specimens of *L. niloticus* collected from the three sampling sites, 189 specimens were randomly selected to determine age. The relationship between length and weight indicated negative allometric growth pattern in all three locations, where the slope (b) of the (LWR) was highly significant ($p<0.001$) and ranged from 2.178 to 2.885. The mean condition factor (K) varied monthly in the three locations with values ranging from 1.671 in Um Aswad (Atbara River) to 2.548 in El-Monaba (reservoir). Although the age of *L. niloticus* ranged from 0+ and 3+ years, yet, most of the studied fish are between age 0 + and 1+.

Keywords: Age structure, Atbara River, condition factor, Khashm El-Girba reservoir, *Labeo niloticus*, length-weight relationship.

INTRODUCTION

The main freshwater fisheries in Sudan are located in the River Nile and its tributaries, major dam reservoirs and man-made lakes. The Atbara River forms one of the five sub-basins of the Nile system within Sudan borders. Lake Khashm El Girba was formed on the eastern part of Sudan as a result of the construction of Khashm El Girba Dam across the Atbara River in 1964, creating a lake that supports a seasonal artisanal fishery (October – July) (Salih 1995 and FAO, 2014).

Four commercial species of genus Labeo occur in the Sudan; viz. *L. niloticus* Forskal, 1775, *Labeo horie* Heckel, 1846, *Labeo coubie* Riippell, 1832, and *Labeo forskalii* Riippel, 1835, which is a rare species and occurs mainly on rocky places. The four species are capable of growing to about 2.0 feet standard length and over 4.0 kg in weight (Abu Gideiri, 1984).

Knowledge of length-weight relationship (LWR) is an important tool in the management of the resource and determining the exact age of reproduction, growth, rate, over fishing and under fishing (El-Azrag, 1981). Moreover, it can provide information about the, general health of the fish, habitat conditions, life history, fish fatness and wellbeing and morphological characteristics of the fish (Schneider et al., 2000, Froese, 2006). The successful

management of small- scale fisheries requires the use of biometric data collected in the field, in order to transform them into suitable indicators. Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes more slender as it increase in weight, while positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Riedel et al., 2007). However, the growth process of freshwater fishes can differ in the same species dwelling over diverse locations, influenced by numerous biotic and abiotic factors.

An additional important biometric tool is the relative condition factor (K) which can be derived from the length-weight relationship (Le Cren, 1951). Condition factor shows the degree of wellbeing of the fish in their habitat, and measures the deviation of an organism from the average weight in a given sample. It assess the suitability of a specific water environment for growth of fish (Yilmaz et al., 2012, Mensah, 2015). An overall fitness for fish species is assumed when (K) values are equal or close to one. When the value of condition factor is higher, it means that the fish has attained a better condition. Ahmed et al. (2011) used the condition factor (K) of *L. niloticus* in Khashm El-Girba reservoir to assess the fatness of this species, and found that it ranged from 1.595 ±0.912 to 2.536 ±0.070. Obeida (2010) reported that the condition factor of *L. niloticus* ranged between 2.401 to 1.268± 1.871 in El hashaba, and 3.495 to 1.302 ±1.951 in Kosti, and 3.856 to 1.112 ±1.836 in El Nuzul. While Karar et al. (2017) recorded mean condition factor for *L. niloticus* of 1.4216, indicating good physiological condition of the fish. However, the condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of food, and water quality parameters (Khallaf et al., 2003).

Several investigators studied the habitat, food and feeding, age and growth and some aspects of the population dynamics of *L. niloticus* in Jebel Aulia dam reservoir, Khashm El-Girba reservoir and Atbara River and the River Nile in Sudan (Ahmed, 1978; El-Moghraby et al., 1993; Bailey, 1994; El- Kasheif et al., 2007, Salih, 1995; Abdalla, 2018; Abdalla et al., 2020). Nin (1992) studied age and growth of fish to show changes in fish population and body size caused by fishing mortality rate.

Thus, the aim of this study was investigate the length-weigh relationship condition factor and age structure of *Labeo niloticus* from Atbara River and Khashm El-Girba reservoir in order to assess its growth pattern, fitness and well-being, and consider seasonal variations of age of this species in the study area.

MATERIAL AND METHODS

Study area

The study area comprised three sampling sites, one site in Atbara River (downstream) and two sites in Khashm El-Girba reservoir (upstream). Sampling sites were located according to the coordinates determined by using GPS (Garmin 62sc), as shown in Table1 and Figure 1.

Collection of samples

Samples of *L. niloticus* were collected bi-monthly during the period December 2015 to November 2016. Three beach seine nets were used with stretched mesh size of 1.2, 4.0 and 7.0 cm; of length 32.0. 78.0 and 88.0 m, and of depth 1.7, 2.2 and 4.7 m respectively. Fish were identified to the species level according to Abu Gideiri (1984) and Bailey (1994).

Morphometric measurements

Total length (TL) of fish was measured to the nearest 0.1 cm from the tip of snout to end of the upper lobe of the caudal fin, and standard length (SL) from the tip of the snout to the flexure between caudal peduncle and caudal fin, using a measuring board. Body weight (BW) was recorded to the nearest 0.1g using a digital balance (SF-400A). All measurements of the collected samples of *L. niloticus* were taken at the sampling sites.

Biological studies

Length-weight relationship

The relationship between length and weight of *L. niloticus* was calculated according to the equation W = a Lb (Bagenal and Tesch, 1978).

Where: W= total weight of fish (g), L= standard length of fish (cm), a = constant and b = the regression coefficient, estimated by converting the logarithmic linear regression of the transformed equation according to Sparre and Venema (1992) as follows:

Log (W) = log (a) + b log L

Data analysis was carried out using Past Statistical Package version 3.14.

Condition factor (Fulton's factor) (FCF)

Condition factor (K), is calculated according to the formula:

$$\mathrm{K} = \frac{W}{Lb} \times 100$$

Where; W = total weight of the fish in grams and L = the standard length of the fish in cm.

The value of (b) usually ranges from 2.5 to 4.0 for mature freshwater fish.

Table 1. Estimated distance and coordinates of sampling sites in relation to Khashm El-Girba Fisheries Research Station.

Site	location	Distance (km)	Coordinate (GPS)	Elevation (ft.)
Um Aswad	Downstream	2.77	14°85´23.03´´ N - 35°45´48.86´´ E	1440
El-Remila	Upstream	6.57	14°45´3.89´´ N - 35°52´42.69´´ E	1549
Al-Monaba	Upstream	10.10	14°51´85.17´´ N - 35°52´37.27´´ E	1550

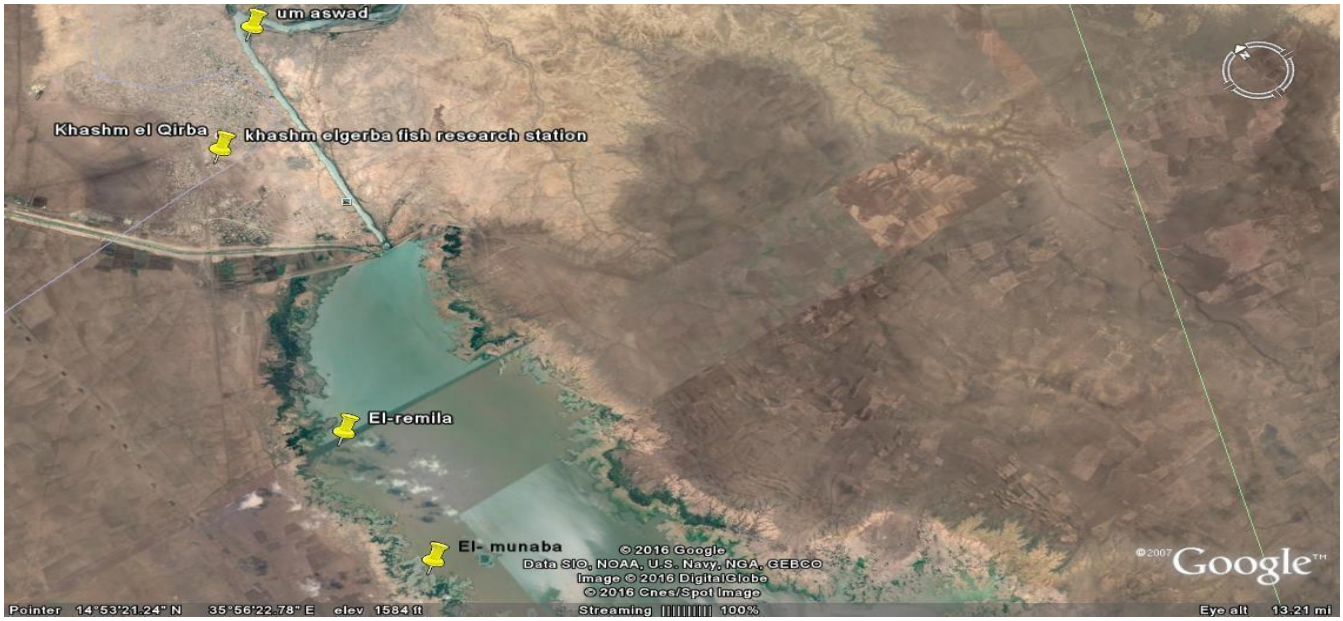

Figure 1. Map of sampling sites at Khashm El-Girba reservoir and Atbara River (source Google earth programme, 2016).

Age

Age of *L. niloticus* was estimated by dissecting the five anterior- most vertebrae of the fish, as they are best developed in freshwater fishes. The vertebrae were then removed, boiled and cleaned using a plastic brush, dried for 3 days, and kept in paper envelopes, with date of capture, area of collection, total and standard length and weight. Age of fish was read with the help of a magnifying lens (Nin, 1992).

Data analysis

Data was analyzed using the statistical package (Past statistical package version 3.14) to obtain liner regression and correlation and Microsoft office Excel 2007 to calculate average and standard deviation.

RESULTS

Length - weight relationship

In the present study, the plot of standard length of *L. niloticus* against the corresponding weight yielded logistic curve, which was straightened by logarithmic transformation of data. The slope (b) of the length-weight relationship of *L. niloticus* was highly significant ($p<0.001$), indicating negative allometric growth pattern which ranged from 2.178 to 2.885 in the study area (Figure 2, Table 2).

Condition factor

The average condition factor calculated for *L. niloticus* recorded values of 1.671 ±0.273, 1.953 ±0.644 and 2.548 ±0.516 in Um Aswad, El- Remila and El-Monaba sampling sites respectively. Relatively high values of condition factor were recorded during April to July (2.038±0.775 - 2.333±0.640) at El-Remila site (upstream). High values of condition factor were also recorded at El-Monaba site (upstream) during February to June (2.205±0.431-2.601±0.481) as well as during periods from July to October, indicating good growth of this species upstream of Khashm El-Girba reservoir. However, the overall mean condition factor (K) ranged from 1.671 to 2.548, 1.953±0.644 and 2.548±0.516 in Um Aswad, El-Remila and El-Monaba sampling sites respectively (Table 3).

Table 2. Linear fit of length –weight relationship of *L. niloticus* at Khashm El-Girba reservoir and Atbara River during the study period (Dec 2015- Nov 2016).

Site	Equation	No.	Value of (b)	Value of (a)	*r*
Um Aswad	log(W)= 1.496+2.824 log SL	574	2.824	1.496	0.920
El-Remila	log(W)= 1.567+2.885 log SL	376	2.885	1.567	0.974
El- Monaba	log(W)= 0.649+2.178 log SL	240	2.178	0.649	0.527

Where: (b) is the slope, and (a) is intercept of linear regression, r correlation coefficient.

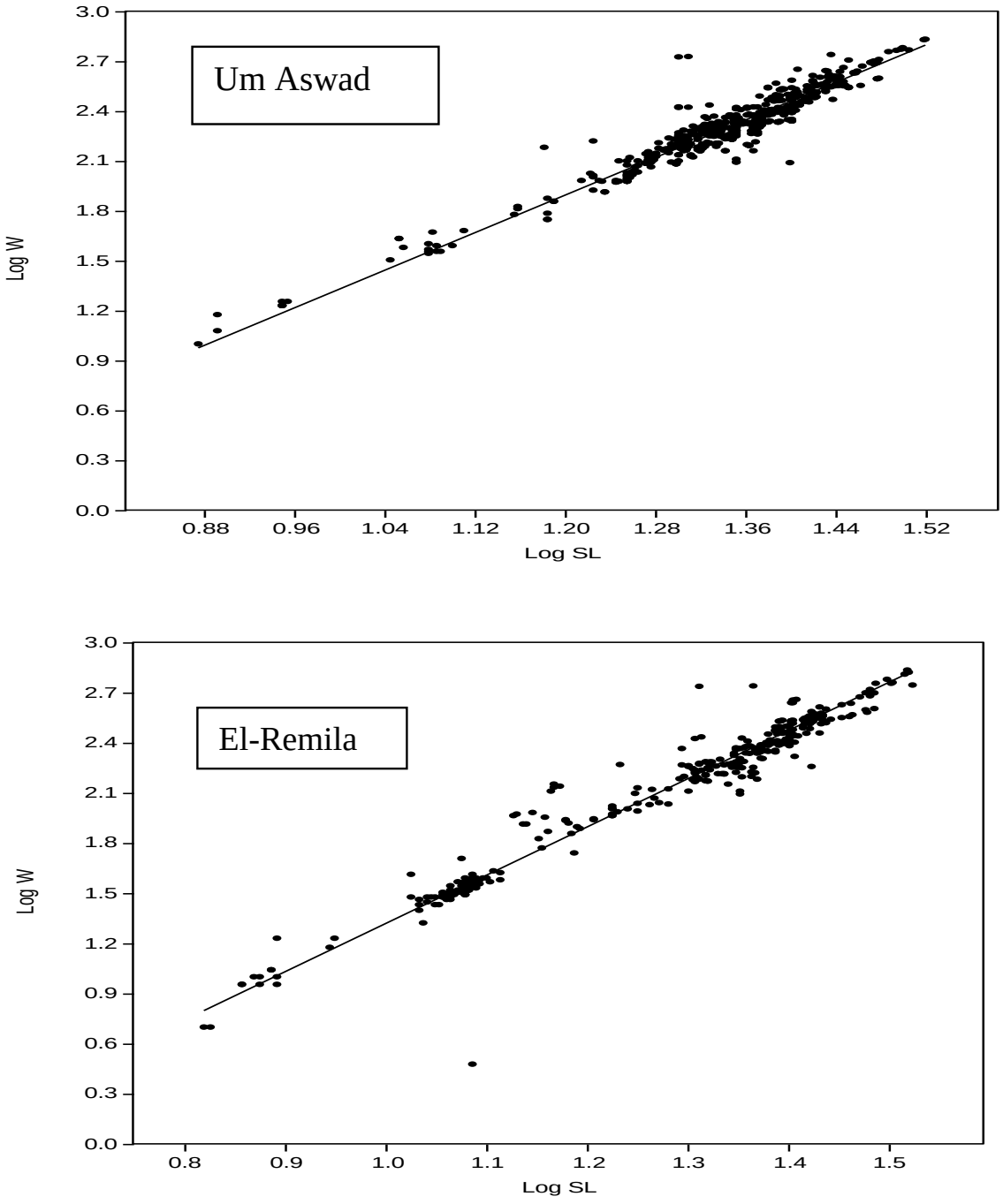

Figure 2. Linear fit of length–weight relationship of *L. niloticus* in Um Aswad (Atbara River) and El-Remila and El-Monaba (reservoir).

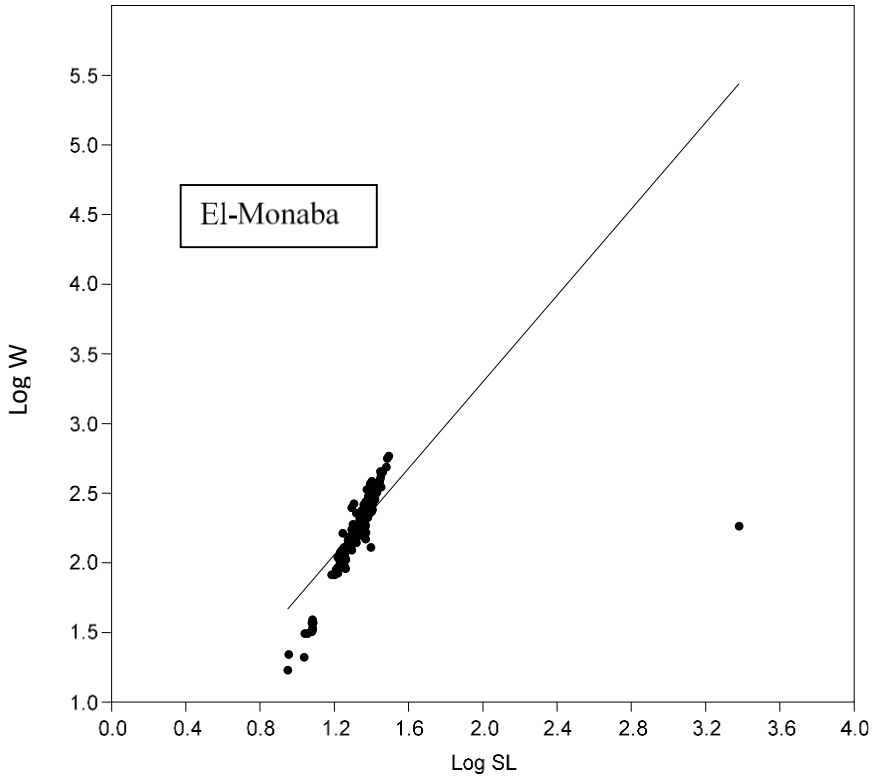

Figure 2. Contd.

Table 3. Average condition factor of *L. niloticus* in the study area during the period (Dec 2015- Nov 2016).

Months	Um Aswad	El-Remila	El-Monaba
Dec-15	1.549±0.193	1.802±0.523	1.155
Jan-16	1.652±0.211	1.860±0.714	1.650
Feb-16	1.742±0.357	1.872±0.750	2.205±0.431
Mar-16	1.689±0.220	1.898±0.746	2.372±0.344
Apr-16	1.699±0.305	2.038±0.775	2.551±0.621
May-16	1.692±0.323	2.083±0.575	2.587±0.545
Jun-16	1.678±0.346	2.204±0.485	2.601±0.481
Jul-16	1.691±0.347	2.333±0.640	2.722±0.543
Aug-16	-	-	-
Sep-16	1.606±0.340	1.389	2.481±0.232
Oct-16	1.557±0.196	1.490±0.289	2.605±0.222
Nov-16	1.678±0.115	1.905±0.640	2.385±0.404
Mean condition factor	1.671±0.273	1.953±0.644	2.548±0.516

Age structure

Age was determined by examining about 189 specimens of *L. niloticus*; fishes of age 0 + and 1+ year were most abundant in in the three sampling sites, with females abundant than males in Um Aswad (Atbara River) and El-Monaba sites (reservoir). Although males of age 1 + were more abundant than females in El-Remila site (reservoir), the two sexes were represented in nearly equal numbers in El- Remila and El-Monaba sites (reservoir). Males and females of age 2+ were few in the three sampled sites, with females dominating males in Um Aswad site, while males dominated females at El- Remila and El- Monaba sites. However, males and females of age 3+ were scarce in the study area especially in the upstream site of El-Monaba (Figure 3).

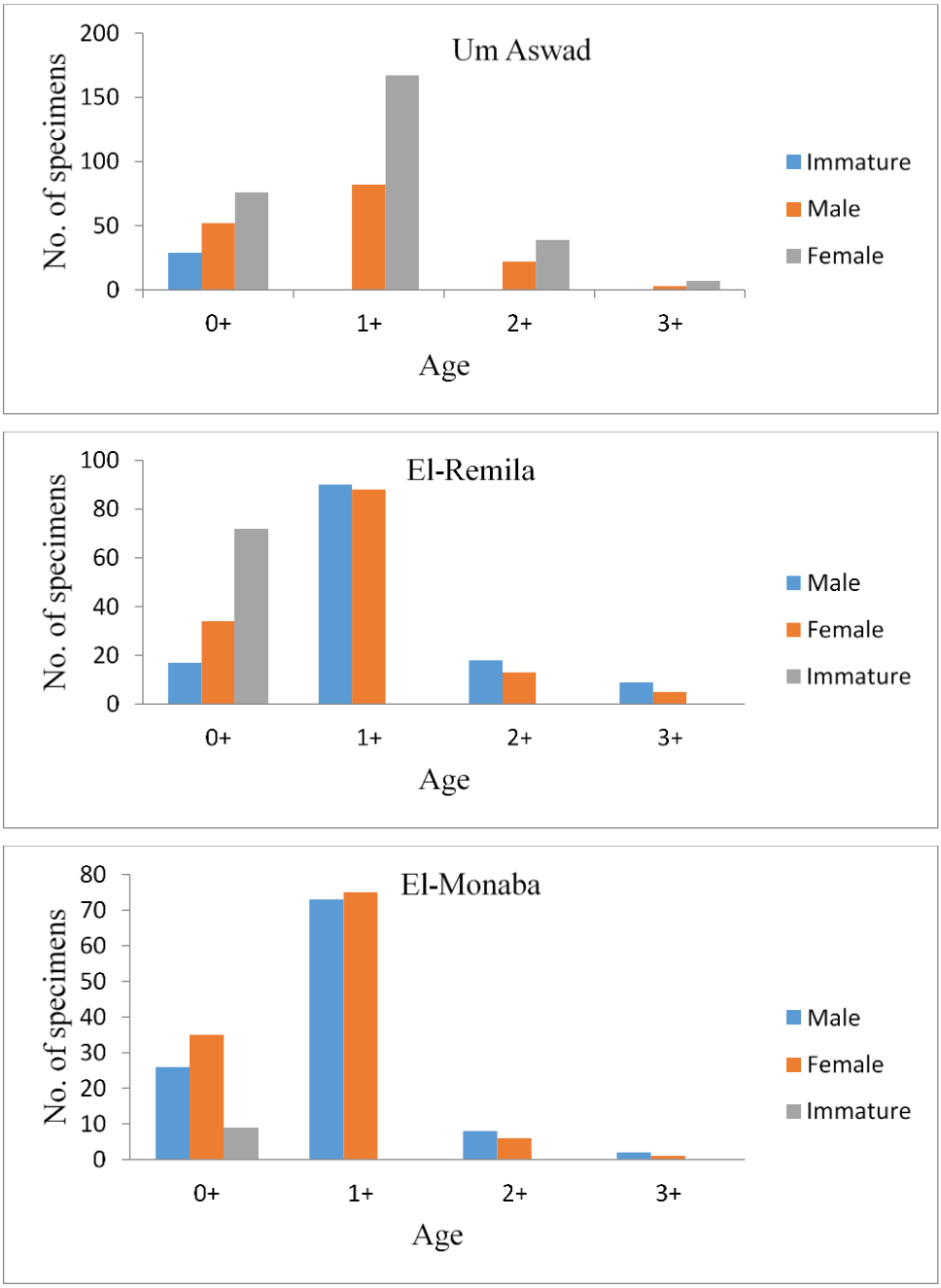

Figure 3. Age structure of *L. niloticus* in Um Aswad (Atbara River) and El-Remila and El-Monaba (reservoir).

DISCUSSION

The present study was conducted to determine the length-weight relationship, condition factor and age structure of *Labeo niloticus* from Khashm El-Girba reservoir, Sudan. About 1190 specimens of this species were collected from the sampling. Analysis of the regression coefficients obtained indicated negative allometric growth of this species, where the slope (b) of the (LWR) was highly significant ($p<0.001$) and ranged from 2.178 to 2.885, suggesting that the length did not increase with the increase in weight of fish in the study area. This result agrees with the findings of Ahmed (2002) who recorded negative allometric growth for *L. niloticus* from five freshwater species in Atbara River and Khashm El-Girba reservoir. Similarly, several authors who worked on *L. niloticus* from the White Nile, Khashm El-Girba reservoir, Atbara River and River Nile within Sudan, reported

negative allometric growth pattern of this species (Ahmed, 1978; Ibrahim, 2007; Ahmed et al., 2011, Obeida, 2010 and Karar et al., 2017).

The mean condition factor recorded for *L. niloticus* in the study area were 1.671±0.273; 1.953±0.644 and 2.548±0.516 in Um Aswad, El-Remila and El-Monaba sites respectively. Obeida (2010), working on the White Nile, Sudan, reported condition factor (K) mean values of 1.871, 1.951 and 1.836 for *L. niloticus* at El- Hashaba, Kosti and El-Nuzul stations respectively. A similar result was obtained by Ahmed et al. (2011) showing that the condition factor (K) of *L. niloticus* ranged from 1.595±0.912 to 2.536±0.070 in Khasm El-Girba reservoir. On the other hand, Karar et al. (2017) reported that the condition factor for *L. niloticus* in the River Nile was approximately 1.0. The marked difference in the high values of condition factor recorded in Atbara River and Khashm E-Girba areas compared to that recorded in the River Nile may be due to differences in sampling methods, sample size, seasonal variation in water temperature, turbidity, photoperiod and food availability, in the two freshwater ecosystems.

The dominance of specimens of *L. niloticus* of age 0+ and age 1+ in the study area may be due to the use of fishing gear of small mesh size for collecting the fish from the three sampling sites. Soil erosion and heavy siltation of the lentic environment of Khashm El-Girba reservoir during the flood season may have created unfavorable conditions for the growth of large –sized fish. Moreover, the intensive fishing activities carried out before the flushing period of the dam (August) may have resulted in drastic changes in the physical and chemical characteristics of the water, water flow, change in water level and subsequent changes in the food composition of the fish.

Conclusion

The length weight relationship of *Labeo niloticus* from Khashm El-Girba reservoir and River Atbara indicated negative allometric growth of the fish, with (b) ranging from 2.178 to 2.885, while mean condition factor (K) varied between1.671 and 2.548. Most of the fishes collected during the study consisted of immature males and females of age 0+ and 1+. It is recommended that further studies should be conducted on the biology of this commercially important species to provide more detailed information for better understanding, management and exploitation of the fisheries of this species in River Atbara and Khashm El-Girba reservoir.

ACKNOWLEDGEMENT

The authors would like to express their thanks and gratitude to the staff of Zoology Department, Faculty of Science, University of Khartoum; the staff of Khashm El-Girba Fisheries Research Station and Fisheries and Aquatic Research Center. Thanks are also due to Mr. Mohamed Sharif, Mr. Amjad Abd El-Gafar, Mr. Banaga Abdo, Mr. Ahmed Abu Zaid Ahmed, Mr. El-Tag Mohamed Abdalla and Mr. Hassan El-Tayib, for the unlimited assistance they offered during collection of samples.

COMPETING INTERESTS

The authors of this paper declare that competing interests do not exist.

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