



Study of Some Biological Aspects of the Nile Carp, *Labeo niloticus* (Pisces, Cyprinidae) from Khashm El-Girba Reservoir and Atbara River, Sudan: I Abundance; Sex Ratio; Gonado-somatic Index and Breeding Season

Mutasim Yousif Mohamed Abdalla^{1*}, Abuelgasim Ibrahim Abdelhalim²
and Ahmed El Bedawi Adam³

¹*Khashm El-Girba Fisheries Research Station, Fish and Aquatics Research Centre, Animals Resources Research Corporation, Sudan.*

²*Department of Zoology, Faculty of Science, University of Khartoum, Sudan.*

³*Fisheries and Aquaculture Consultant, Ministry of Animal Resources and Fisheries, Khartoum State, Sudan.*

Authors' contributions

This work was carried out in collaboration among all authors. Author MYMA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AIA managed the analyses of the study. Author AEBA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this study is to investigate some biological aspects of the Nile carp, *Labeo niloticus*, in Khashm El-Girba reservoir and Atbara River, Sudan. The study was conducted during December 2015 to November 2016. Samples were collected bi-monthly from three localities, namely; Um Aswad (Atbara River), El-Remila and El-Monaba (Khashm El-Girba reservoir), using beach seine nets of 1.2 cm 4.0 cm and 7.0 cm stretched mesh. A total number of 1,190 specimens of *L. niloticus* were collected from the three sampling sites. Two peaks of abundance were observed for

*Corresponding author: Email: mutasim.emy@gmail.com;

L. niloticus at all sampling sites (February- March and September- October). Sex ratio was 1:1, except in downstream areas, where females were more dominant than males. Gonado-somatic index showed one peak of increase, and ranged from 1.28 - 1.79 and 0.50 – 1.701 for females and males respectively, indicating one spawning season.

Keywords: Abundance; Gonado-somatic index; *Labeo niloticus*; sex ratio; spawning season.

1. INTRODUCTION

The main fresh water fisheries activities in Sudan are centered on the River Nile, its tributaries and major reservoirs. In Sudan, man-made lakes cover about 3,075 km². Total sustainable yield of capture fisheries production was estimated at about 34,000 tonnes [1].

Khashm El-Girba dam was constructed in 1964 across Atbara River. The Lake covers a maximum area of about 125 km² and extends for about 80.0 km downstream. The dam was originally constructed for irrigation and agricultural purposes to provide a source of livelihood for the population displaced by the rising water of Nubia Lake. It was designed to store about 1.3 billion m³. However, it is currently operating at a capacity of only about 600 million m³. The reservoir has been flushed annually since 1970 to remove the accumulated silt [2] and [1]. The Lake created by the construction of the dam supports a seasonal fishery (October – July) for a group of fishermen who combine fishing with rain-fed agriculture [3].

In Africa, species of the genus *Labeo* contribute significantly to subsistence fisheries [4]. In Sudan, Family Cyprinidae is represented by eighteen species in six genera [5]. Of these only four species of the genus *Labeo* are of commercial importance i.e. *L. niloticus* Forskal, 1775, which is according to [5] is the commonest fish between the mouth of the Nile and Lake Nubia (southern part of Lake Nasser). *Labeo horie* Heckel, 1846 and *Labeo coubie* Riippell, 1832 are rare in the lower Nile and are found mainly in the Blue and White Niles, and *Labeo forskalii* Riippel, 1835 which is very rare and occurs mainly in rocky or stony places. All species are capable of growing to a considerable size, and the first three species are fairly common at Khartoum fish market.

In northern part of Jebel Aulia (White Nile), most of the recorded fish species showed seasonal fluctuation of population abundance. *L. niloticus* constituted about 10.5% and about 4.4% of the

total catch in Jebel Aulia and Al-Gietina sampling sites respectively [6].

In Sudan, Cyprinid fishes exhibit a relatively high abundance during the summer season and lowest abundance in winter. They were the third most common fishes in Jebel Aulia reservoir and constituted 12.10% of total catch [7]. Babiker (1984) [8], studied the seasonal abundance of *L. niloticus* in Jebel Aulia Reservoir, and concluded that the lowest levels of abundance of this species occurred in the summer (February to June), and the highest levels of abundance occurred in October and early November in the White Nile.

Abu Gideiri YB. [9] and Baiely RG. [5] studied the morphological feature of *L. niloticus* in Nile system within Sudan. They reported that, this species has an inferior mouth with well-developed lips forming a sucker-like ring enclosing the jaws. [10] studied food and feeding habits of *L. niloticus* in Jebel Aulia dam reservoir, and stated that this species was a bottom feeder, feeding on soft decayed vegetation, organic debris and whatever, and small organisms. [6] reported that *L. niloticus* was encountered throughout the year, and constituted 10.5% and 4.4 % of total catch in Jebel Aulia and Gietina fishing sites respectively. The annual abundance of *L. niloticus* in Lake Nubia was studied by [11]. He found that it ranged from 1.06% - 22.92% during the period 1977- 1984.

In Nubia Lake, [12] stated that, *L. niloticus* was among the five most common species in the Lake, and represented 10.4% of the total catch in the Lake, and that the highest percentage abundance of this species was noted during May-July with a drop in numbers toward August and September.

19 fish species belonging to 10 families in Khashm El-Girba reservoir and Atbara River, and stated that *L. niloticus* was the most abundant species in the catch [13].

Gonado-somatic index is used to follow the seasonal development of the gonads in both

male and female fish. However, the indices usually decrease in running and spent stage of spawning of the fish. Sex ratio, however, is usually determined by the examination of the gonads of the fish. It plays a very important role in determining the onset of spawning and hence the breeding season of the fish. In White Volta, (Ghana), sex ratio of *Labeo senegalensis*, belonging Cyprinidae family was 1: 1.5 [14].

Labeo coubie breeds in July- August, and that its fecundity ranged from 262.880 and 2.640.240 eggs; for females ranging in length from 9 – 85 cm, and added that fecundity increased according to the increase in length [15]. On the other hand, [16], found that the total number of ripe eggs in the ovary of *L. niloticus* ranged from 100075 – 2497360 eggs, with an average number of 393922 eggs, for fish of standard length ranging from 293 - 413 mm and average length of 332 mm. However, [14] working on *Labeo senegalensis*, reported that out of eleven out of the 89 females of total length ranging from 9.5 - 24.6 cm, and body weight ranging from 20 - 212 g, the total number of recorded eggs was 2,385 with a mean value of 217 eggs per gravid female of this species.

Due to the scarcity of biological information on *Labeo niloticus* in Atbara River (the only northern tributary of the Main Nile) and Khashm El-Girba dam reservoir, it is deemed necessary to carry out some observations on the biology of this

species to establish baseline data which can be used as a platform for future studies on the management of this commercially important species.

2. MATERIALS AND METHODS

Three locations were selected for sampling fish of in Khashm El-Girba reservoir and Atbara River. There were; Um Aswad downstream Atbara River and El-Remila and El-Monaba reservoir on Khashm El-Girba reservoir.

2.1 Sample Collection

Samples of *L. niloticus* were collected during the period December 2015 - November 2016. Beach seine nets of 1.2 cm, 4.0 cm and 7.0 cm stretched mesh were used to collect the samples on a bi-monthly basis. Identification of the collected specimens was made following [17], and checked according to [9 and 5]

2.2 Morphometric and Measurement

Total length (TL) and standard length (SL) were measured to the nearest (0.1 cm) using a standard measuring board. Body weight (W) and gonad weight were recorded to the nearest (0.1 g) using a digital balance (SF-400 A). All measurements of *L. niloticus* were taken at the sampling sites.



Plate 1. A map of Khashm El-Girba reservoir, Atbara River and the sampling sites
(Source Google earth programme, 2016)

2.2.1 Abundance

The abundance of *L. niloticus* was estimated by calculating the percentage of the fish from the total monthly catch by using the formula:

$$\text{Abundance} = \frac{\text{Number of specific species}}{\text{Total caught}} \times 100$$

2.2.2 Sex-ratio

Male and female *L. niloticus* were identified on the basis of the genital papilla, and confirmed by dissection. Sex ratio was determined by the following formula

$$\text{Sex ratio} = \frac{\text{number of females}}{\text{number of males}}$$

2.2.3 Gonado-somatic index (GSI)

Gonado- somatic index is determined according to [18], using the following formula:

$$\text{GSI (\%)} = \frac{\text{Gonad weight (g)}}{\text{Body weight (g)}} \times 100$$

2.2.4 Breeding season

Breeding season is determined according to the value of the gonado- somatic index.

2.3 Data Analysis

Data was analyzed using statistical package: past statistical package version 3.14 and Microsoft office Excel 2007.

3. RESULTS

In the present study, two peaks of abundance were observed for *L. niloticus* at all three sampling sites; the first one occurred during February in Um Aswad (Atbara River) and El-Monaba (Khashm El Girba reservoir); and in March at El-Remila (Khashm El Girba reservoir); while the second peak was observed during September- October at Monaba site. The two peaks of seasonal abundance of *L. niloticus* coincided with the periods of low and high water in the River, Fig. 1. It was found that *L. niloticus* was most abundant in downstream and constituted about 24.21% of the fish caught from the downstream. However, it constituted 12.07% and 13.11% of the total catch from upstream (El-Remila and El-Monaba, respectively).

The gonado-somatic index of *L. niloticus* tended to increase as from April onwards and reached a peak during July-September, then started to decrease in October-February. Hence, one breeding season can be assigned to *L. niloticus* as indicated by the high GSI during July-September, and ranged from 1.281 - 1.795 and 0.442 – 0.572 for females and males respectively. It is worth mentioning that this spawning period also coincided with the period of flushing of the reservoir to remove the accumulated silt; Fig. 2.

Sex ratio of *L. niloticus*, on the other hand, recorded almost similar values (1.0: 1.0) throughout the study area, Table 1.

4. DISCUSSION

The occurrence of two peaks of abundance for *L. niloticus* in the three sampling sites (February- March and September- October) can be correlated with the hydrological regime of Atbara River. Thus, during the flood season (July- September) large quantities of nutrients are washed from the Ethiopian plateau and carried downstream into Atbara River, creating favourable condition for the growth of algae and other plant material which form the main food of *L. niloticus*. However, during the low water level in Atbara River (February- May), *L. niloticus* tends to change its feeding strategy to browse on bottom organisms and scrape plant growth off the rocks and stony areas, using its sectorial and protrusible mouth. This opportunistic feeding habit allows this species to feed on whatever food is available rather than preference of particular type of food. Thus, *L. niloticus* constituted about 24.21% of all fish caught downstream, and 12.07% and 13.11% of the total fish caught upstream (El-Remila and El-Monaba, respectively) and became the dominant species in Atbara River and Khashm El-Girba reservoir. The above result agrees, in part, with the findings of [8] who observed a single peak of abundance for *L. niloticus* (July- October), in the Jebel Aulia Dam on the White Nile. This may be attributed to the differences in sampling sites, frequency of sampling, and environmental conditions prevailing in the two fresh water environments. This is further supported by the findings of [13], who reported that *L. niloticus* was the most dominant fish in Khashm El-Girba and Atbara River.

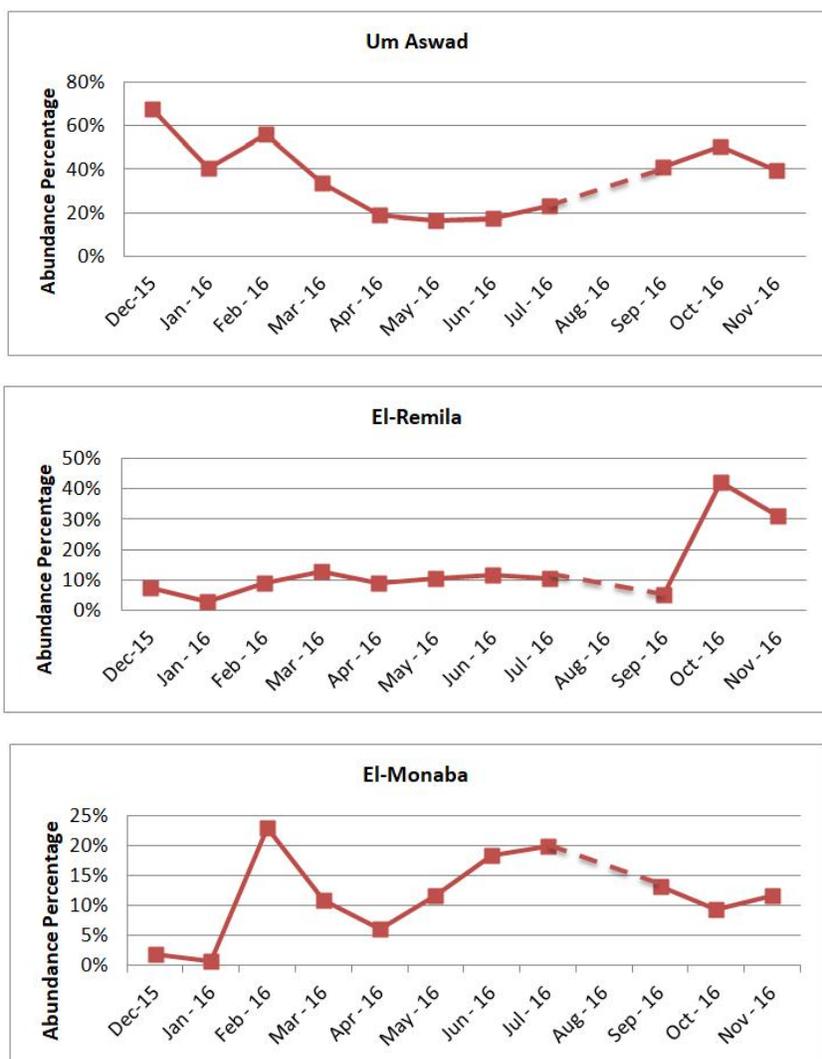


Fig. 1. Abundance of *L. niloticus* at the three sampling sites during the study period

Table 1. Sex ratio of *L. niloticus* in Khashm El-Girba reservoir and Atbara River during the study period

Months	Um Aswad	No. Sample	El-Remila	No. Sample	El-Monaba	No. Sample
Dec-15	1.0 : 1.0	21	0.0:0.0	13	1.0: 0.0	1
Jan-16	1.0 : 1.0	21	1.0 : 1.0	9	0.0 : 1.0	1
Feb-16	1.0 : 1.0	52	1.0 : 1.0	24	1.0 : 1.0	22
Mar-16	1.0 : 1.0	62	1.0 : 1.0	38	1.0 : 1.0	21
Apr-16	1.0 : 1.8	76	1.0 : 1.0	36	1.0 : 1.5	17
May-16	1.0 : 1.0	69	1.0 : 1.0	52	1.0 : 1.0	22
Jun-16	1.0 : 1.0	84	1.0 : 1.0	56	1.0 : 1.0	58
Jul-16	1.0 : 1.0	89	1.0 : 1.0	41	1.0 : 1.0	70
Aug-16	-	0	-	0	-	0
Sep-16	1.0 : 1.0	16	0.0 : 1.0	4	1.0 : 1.0	7
Oct-16	1.0 : 1.0	40	0.0 : 0.0	64	1.0 : 1.0	8
Nov-16	1.0 : 1.0	44	1.0 : 1.0	39	1.0 : 1.0	13
Mean sex ratio	1.0 : 1.0	574	1.0 : 1.0	376	1.0 : 1.0	240

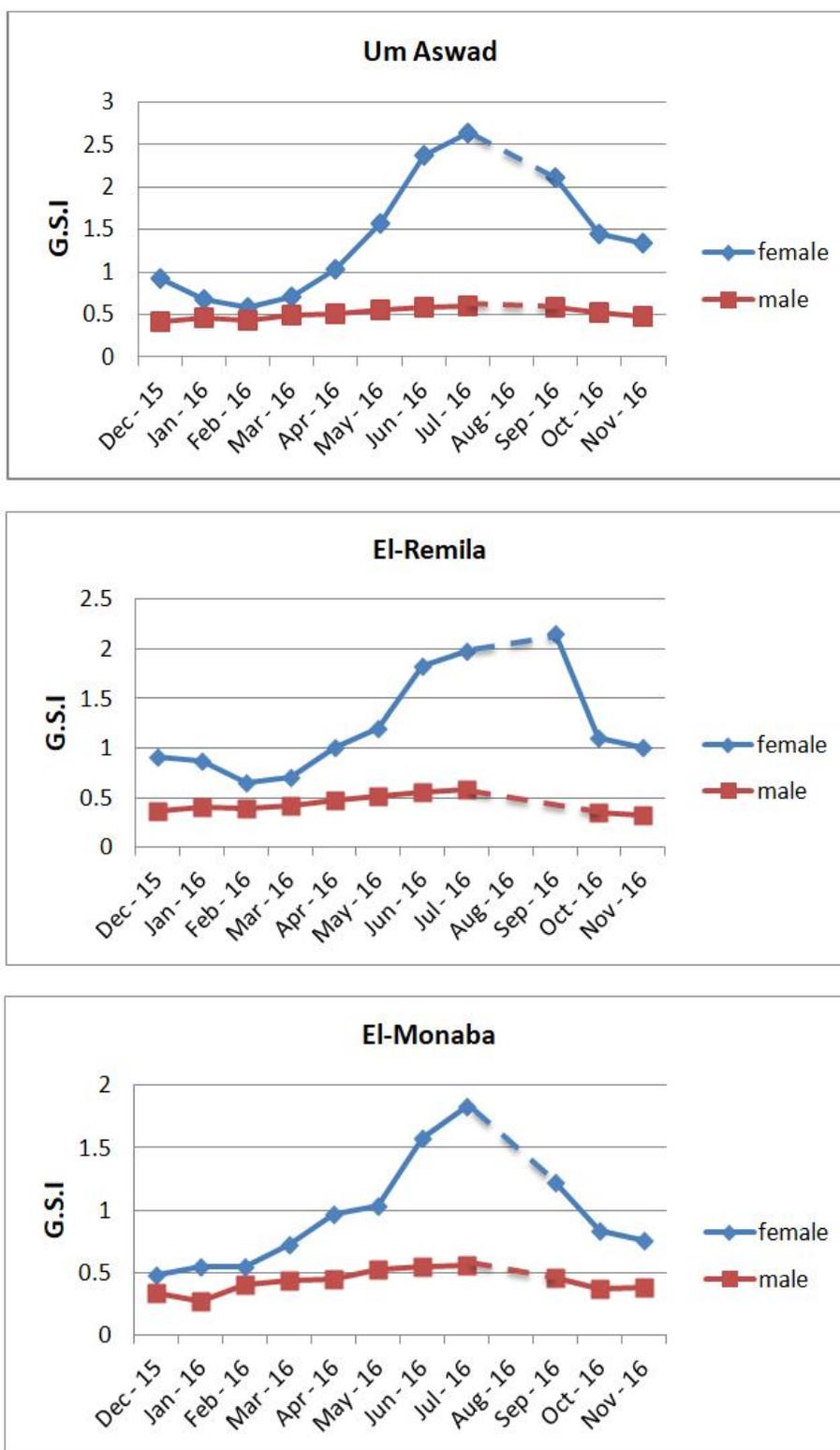


Fig. 2. G.S.I average of male and female of *L. niloticus* monthly, during the study period (2015/2016)

Sex ratio of *L. niloticus*, on the other hand, fluctuated widely on a monthly basis during the study period, but was generally similar at all sampling sites. This is more or less in agreement with the results obtained by [14] for the sex ratio of *Labeo senegalensis*.

High values of Gonado-somatic index (GSI) of females and males of *L. niloticus* was observed during the period July- September, and ranged between 1.281 - 1.795 and 0.442 – 0.572 for females and males respectively Fig. 2, suggesting a single breeding season for *L. niloticus*. This result is in agreement with the findings of [8] who reported that the annual time-sequence of development of the gonads corroborates the observed patterns of abundance in *L. niloticus* in Jebel Aulia reservoir, and that the proportion of ripe females exhibited a single peak during July-August. Similarly, *L. horie*, a closely related species to *L. niloticus*, exhibited a definite breeding season during July and August [7].

It is noteworthy that the breeding activity of *L. niloticus* in Atbara River was followed throughout the study period, except during August (the period of reservoir flushing). Hence, it is possible that the onset of the spawning season of *L. niloticus* occurred during August. This is further supported by the presence of numerous juveniles of *L. niloticus* following the end of the reservoir flushing, as well as the findings of previous authors, such as [3] who worked in Khashm El-Girba reservoir.

However, the slight difference noted in the breeding seasons of *L. niloticus* in other fresh water bodies in Sudan may be attributed to the differences in geographic locations, and environmental factors of the study area.

In the present study, fecundity of *L. niloticus* was not estimated due to the fact that the onset of the spawning season of this species is believed to occur during the annual flushing of Khashm El-Girba reservoir in August. However, [15] found that average fecundity of *L. coubie*, another, closely related species to *L. niloticus*, increased with the increase in length and estimated that fecundity of this species ranged from 262,880 eggs for females of length 38-75 cm, and 2, 640,240 eggs for females ranging in size from 85-90 cm. this result also agrees to a large extent with the findings of [16] and [14] who studied *L. niloticus* in Jebel Aulia (Sudan) and *L.*

senegalensis in White Volta (Ghana), respectively.

5. CONCLUSION

The present study reveals that *L. niloticus* was abundant in Khashm El-Girba reservoir and Atbara River with two peaks in the study area (February- March and September- October). The presence of two peaks of abundance of this species can be correlated with the hydrological regime of Atbara River, as well the feeding strategy of *L. niloticus* which allows it to feed in different parts of the water column, particularly on the bottom where food organism are abundant.

The high values of gonado-somatic index obtained during the study period suggest a single breeding season for *L. niloticus* (July-September) which coincides with the period of annual flushing of Khashm El-Girba reservoir in August (i.e. rain season).

Sex ratio of *L. niloticus* fluctuated widely during the study period, but similar values of sex ratio (1.0:1.0) were generally recorded at all sampling sites.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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