



Comparison of Length and Weight Characteristics of *O. niloticus* and *O. aureus* from Garmat Ali River, Iraq

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Cichlid species invaded the Iraqi waters in the mid-2000s and are now dominant fish species. The present study was carried out to investigate the age and growth of two cichlid species, *Oreochromis niloticus* and *O. aureus* in Garmat Ali River, Iraq from October 2019 to September 2020. A total of 2707 specimens of *O. niloticus* ranging from 7.0 to 25.5 cm and 1664 of *O. aureus* varying from 7.0 to 26.3 cm were examined which were captured by various fishing gears. The length-frequency distributions revealed that fish lengths (13.0-18.0 cm) formed 64.1% of the total catch of *O. niloticus* and 67.2% of *O. aureus*. The length-weight relationships were $W=0.012*L^{3.109}$ for *O. niloticus* and $W=0.015*L^{3.075}$ for *O. aureus*, and both species indicated positive allometric growth. The highest values of the relative condition factor were obtained during spring and the values decrease when length of two species increase. Seven age groups were determined for *O. niloticus*: 9.9, 12.9, 15.6, 17.9, 19.4, 20.4 and 22.2 cm, and for *O. aureus*: 9.3, 12.5, 15.2, 18.0, 19.4, 21.3 and 22.2 cm. The theoretical maximum length (L_{∞}) was 29.2 cm for *O. niloticus* and 28.6 cm for *O. aureus*. These results can assist in fisheries management and conservation of the fish species in Iraqi waters.

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Keywords: *O. niloticus* and *O. aureus*; relative condition factor; age and growth; Garmat Ali River; Iraq.

1. INTRODUCTION

Cichlidae family is originally found in Africa and the south-western Middle East but can today be found in several other waters around the world. It inhabits a variety of fresh and brackish water habitats, from shallow streams and ponds through the rivers, lakes and estuaries [1]. This family is comprised of 250 genera, 2288 available species whereas 1728 are recognized valid species [2]. It is represented by three species in the Iraqi waters namely Nile tilapia *Oreochromis niloticus*, Blue tilapia *O. aureus* and Redbelly tilapia *Coptodon zillii* which have invaded these waters during the last decade. Now, the tilapia species were found in different waters of the country [3-12]. The total landing of tilapia species by the inland artisanal fisheries of Basrah Governorate was 864,700 kg during 2017-2019 and came in the third rank with 15.4% of the total fish landings during this period [13].

The age and growth of *O. niloticus* and *O. aureus* have been studied by researchers in different natural water bodies the world over especially in Egypt and Iraq using fish scales [14] in the Wadi El-Raiyan Lakes, Egypt; [15] in the Abu-Zabal Lake, Egypt; [16] in the Rosetta branch of the Nile River, Egypt; [17] in the River Nile at BeniSuef, Egypt; [18] in the NozhaHydrodrome, Egypt; [19] in the El-Bahr El-Faraouny Canal, Egypt; [20] in the Euphrates River, Al-Hindyah, Iraq; [21] in the Tigris River, Baghdad, Iraq; [22] in two Nilotic canals, Egypt and [12] in AL-Rumaitha River, Iraq. However, Jiménez [23] studied the age and growth of *O. aureus* in the Infiernillo Reservoir, Mexico using scales and opercular bones, while Bwanika, et al. [24] relied on the otoliths for determination the age and growth of *O. niloticus* in lakes Nabugabo and Wamala, Uganda.

In the present study, the length-frequency distribution, length-weight relationship, age and growth of *O. niloticus* and *O. aureus* in Garmat Ali River, north of Basrah were described to provide the basis for proper management of these cichlid species.

2. MATERIALS AND METHODS

Samples of *O. niloticus* and *O. aureus* were collected from the Garmat Ali River (30° 34' to 30° 35' N and 47° 43' to 47° 46' E) during October 2019 to September 2020. The river is a waterway

that connects the East Hammar marsh to the Shatt Al-Arab River, located in the north of Basrah city (Fig. 1). Its length is about 6 km with a width of 280 m and an average depth of 9 m. The river is affected by the tidal current of the Arabian Gulf through the Shatt Al-Arab River. The water temperature of the river varied from 13.5°C in January to 32.4°C in July, and salinity values ranged from 1.2 gL⁻¹ in April to 9.9 gL⁻¹ in October. The predominant vegetation on both banks of the river comprise mainly reed, *Phragmites australis* and cattail, *Typhadomingensis*, whereas hornwort, *Ceratophyllum demersum* was dominant in the deeper areas.

Fish sampling was carried out using gill nets (200 m long) of varying mesh size (15-35 mm), cast net (9 m diameter, with 15*15 mm, mesh size) and boat electrofishing (D.C. at 300-400 V, 10 A). Specimens were stored in ice and were transported to the laboratory for analysis.

The total length (L) and weight (W) of the fish were recorded to the nearest 1 mm and 0.1 g, respectively. The length-weight relationship was calculated using the formula of $W = a \cdot L^b$, and (a) and (b) are constants [25]. The type of growth for each species was determined by Student's t-test. The relative condition factor (K_n) was determined using the following formula, $K_n = W'/W$ [25], where W' = the observed weight and W = the calculated weight. All the calculations were done by using Microsoft Office Excel 2010.

For age determination, four to six scales were removed from the left side of each fish between the lateral line and the dorsal fin base. Scales were cleaned and mounted dry between two glass slides [26]. Scale reading was carried out at magnification of 10X using a slide projector. From the magnified image of the scale, total scale radius and the distance between the focus and their respective annuli were measured. The relationship between fish length (L) and the radius of scale (S) was calculated from the equation: $L = a + b S$ [27], where "a" is the intercept (correction factor) and "b" is the slope of the regression line. For the back-calculation of the body length at the end of each year of life, the following formula, $L_n = a + S_n / S(L - a)$ [27] was depended, where L_n is the length of the fish at age 'n', a is the correction factor, S_n is the radius of the annulus 'n', S the scale radius and L is the length at the time of capture.

The value of L_{∞} for the von Bertalanffy equation was calculated following the Beverton and Holt method using the back-calculated mean lengths for each age of the species [28].

3. RESULTS

3.1 Length-Frequency Distributions

The seasonal length-frequency distributions of 2707 organisms of *O. niloticus* and 1664 organisms of *O. aureus* are illustrated in Fig. 2. The smallest fish length was 7.0 cm for both species during winter, while the largest one was 25.5 cm for *O. niloticus* during autumn, winter and summer, and 26.3 cm for *O. aureus* during autumn. The histograms at Fig.2 showed a unimodal distribution of length for both species in all season except in winter which exhibited bimodal distribution.

Fishes of <10cm length of *O. niloticus* appeared during autumn, winter, and spring, while large fishes (>23cm) were obtained during winter and summer. Two peaks were noticed during winter, the highest one at length 9.0 cm (14.7%) and the second at length 17.0 cm (12.5%). The fish lengths (14.0-17.0 cm) were dominant in the catch in all seasons, except winter. The overall length-frequency distribution of *O. niloticus* from monthly samples revealed that the length group of 16.0 cm was prevailing and formed 15.2%, followed by the length group of 9.0 cm, comprising 7.9% of the total catch. The fish at length groups 13.0 to 18.0 cm formed 64.1% of the total catch.

The size fish (<10cm) of *O. aureus* were appeared in the catch around the year, while the large fish (>23cm) were caught in autumn and winter. The main size group (14.0-17.0 cm) was prevailing in the catch during autumn and summer, while 9.0-14.0 cm during spring. In winter, two modes were observed, the highest one at length 9.0 cm (16.8%) and the second at length 16.0 cm (10.9%). The length group of 16.0 cm was prevailing the overall length-frequency distribution of *O. aureus* forming 16.3%, followed by the length group of 9.0 cm, comprising 8.7% of the total catch. The fish at length groups 13.0 to 18.0 cm formed 67.2% of the total catch.

3.2 Length-Weight Relationships

Based on 2050 specimens of *O. niloticus* their total lengths varied from 7.0 to 25.5 cm and their weights ranged between 8.0 and 325.0 g and the total length of 1622 specimens of *O. aureus*

varied from 7.5 to 26.3 cm and their weights ranged between 6.0 and 356.0 g, the length-weight relationship was calculated for both species (Fig. 3) and the equations obtained are $W=0.012*L^{3.109}$ for *O. niloticus* ($r^2= 0.969$) and $W=0.015*L^{3.075}$ for *O. aureus* ($r^2= 0.963$). The slopes of the weight-length relationship for both species were subjected to t-test, which revealed that these species exhibited positive allometric growth since their 'b' values significantly differed from the theoretical value of 3 ($t= 9.02$ for *O. niloticus* and $t= 4.97$ for *O. aureus*).

3.3 Relative Condition Factor

Monthly variations in the mean relative condition factor (K_n) of *O. niloticus* and *O. aureus* are presented in Fig. 4. The lowest values of K_n for both species were reported in February which was 1.06 for *O. niloticus* and 1.03 for *O. aureus*, while the highest values were 1.22 and 1.11 observed in May for both species, respectively. The overall values of K_n were 0.98 for *O. niloticus* and 1.0 for *O. aureus*. Table 1 explains the values of the mean relative condition factor (K_n) of *O. niloticus* and *O. aureus* for each 2 cm length interval. It shows a somewhat decline in K_n values with the larger size for both species.

3.4 Age and Growth

The scatter diagrams denote the straight-line relationship between fish length (L) and scale radius (S) for both species and presented in Fig.5. The estimated relationships were: $L= 3.132 + 5.069 S$ ($r^2= 0.957$) for *O. niloticus* and $L= 2.232 + 5.403 S$ ($r^2= 0.897$) for *O. aureus*. The results of age determination showed that the maximum life span for each species was seven years.

Table 2 shows the mean back-calculated lengths at the end of the different years of the life of *O. niloticus* and *O. aureus*. The lengths corresponding to the various ages of *O. niloticus* were 9.9, 12.9, 15.6, 17.9, 19.4, 20.4 and 22.2 cm, while of *O. aureus* were 9.3, 12.5, 15.2, 18.0, 19.4, 21.3 and 22.2 cm. It was obvious that the growth in length is more rapid in earlier age groups. The highest estimated length increment was attained in the first year of life, which was 9.9 cm for *O. niloticus* and 9.3 cm for *O. aureus*. The percentage annual increment varied from 44.6% during the first year of life to 4.5% during the 6th year of life for *O. niloticus* and from 42.0% during the first year to 4.1% during the 7th year for *O. aureus* (Table 2).

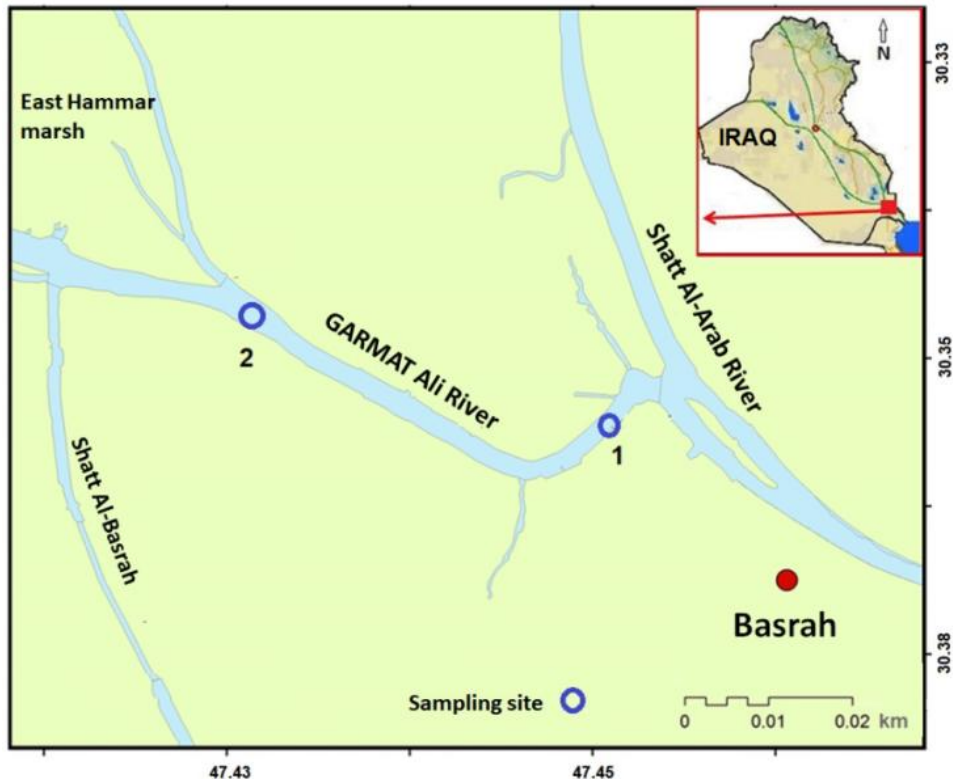


Fig. 1. Map of Garmat Ali River with locations of study sites

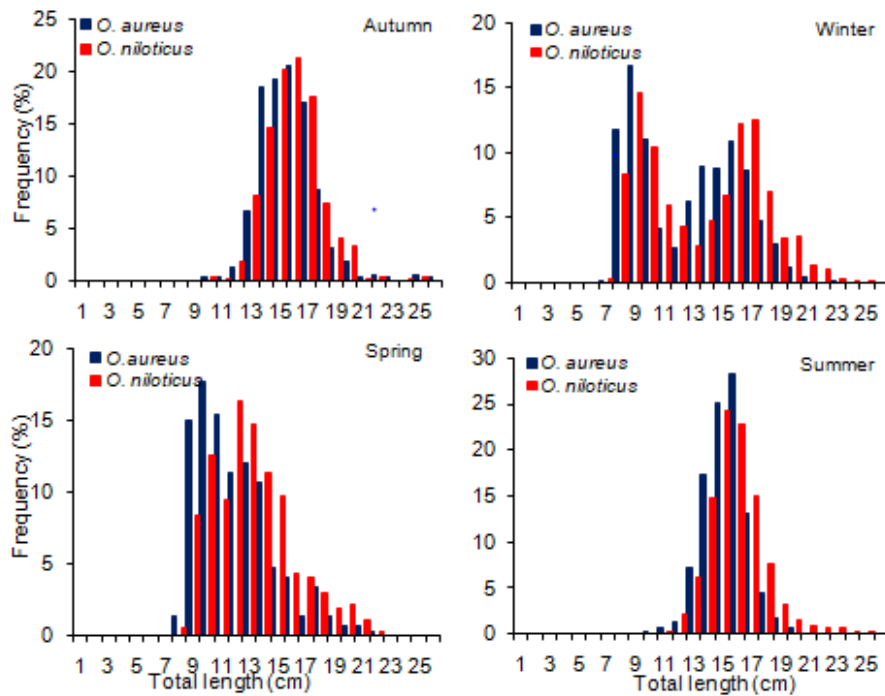


Fig. 2. Seasonal length-frequency distributions of *O. niloticus* and *O. aureus*

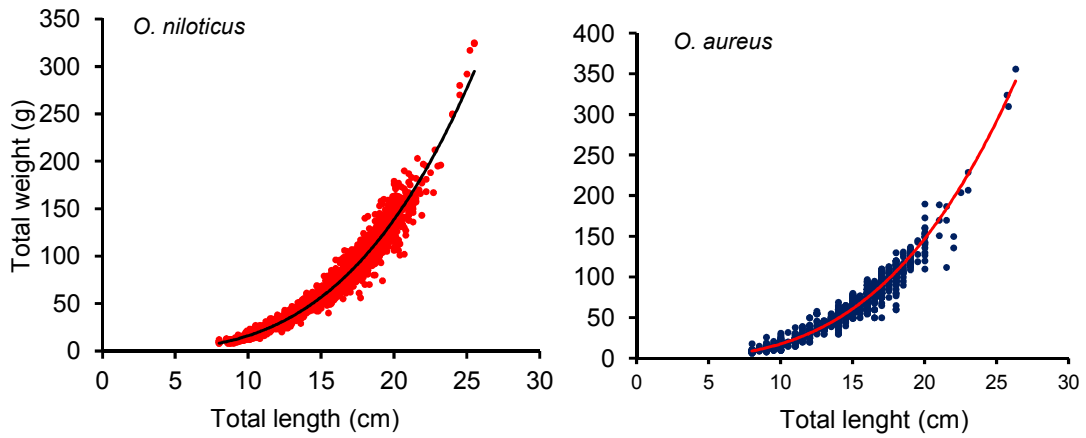


Fig. 3. The length-weight relationships of *O. niloticus* and *O. aureus*

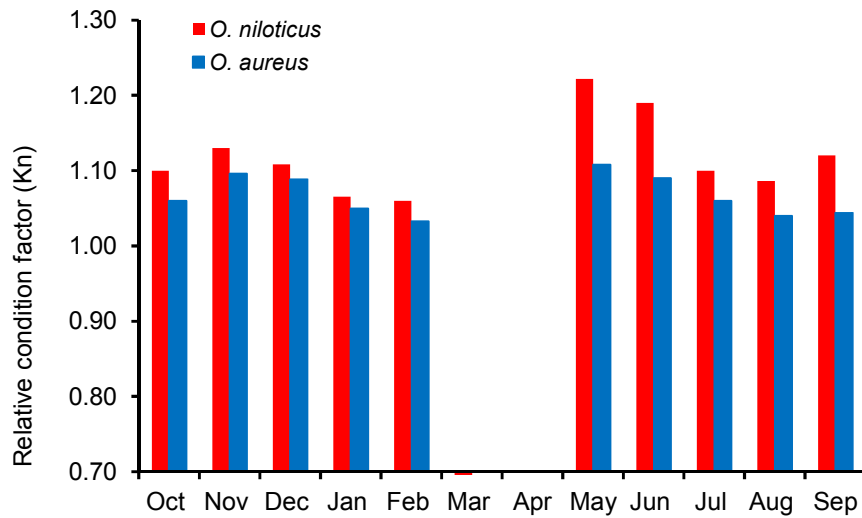


Fig. 4. Monthly variations in relative condition factor of *O. niloticus* and *O. aureus*

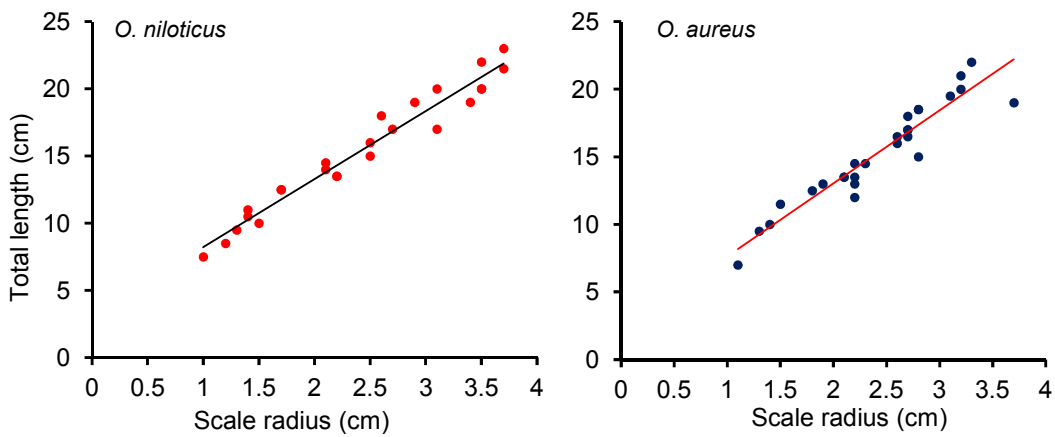


Fig. 5. The relationships between fish length and scale radius of *O. niloticus* and *O. aureus*

Table 1. The relative condition factor (K_n) of *O. niloticus* and *O. aureus*

| Total length (cm) | | No. of fish | Mean weight (g) | | K_n | |
|----------------------------|------|-------------|-----------------|------------|-------|--------------|
| Range | Mean | | Observed | Calculated | Mean | SD (\pm) |
| <i>O. niloticus</i> | | | | | | |
| 8-9.9 | 9.2 | 86 | 11.97 | 12.18 | 0.98 | 0.17 |
| 10-11.9 | 10.9 | 239 | 21.12 | 20.98 | 1.00 | 0.15 |
| 12-13.9 | 13.0 | 217 | 37.27 | 36.07 | 1.03 | 0.13 |
| 14-15.9 | 15.1 | 359 | 58.08 | 57.41 | 1.01 | 0.11 |
| 16-17.9 | 16.9 | 507 | 82.70 | 82.00 | 1.01 | 0.11 |
| 18-19.9 | 18.8 | 481 | 115.67 | 114.73 | 1.01 | 0.11 |
| 20-21.9 | 20.5 | 144 | 146.35 | 150.22 | 0.98 | 0.12 |
| 22-23.9 | 22.5 | 9 | 188.78 | 200.85 | 0.94 | 0.08 |
| 24-25.9 | 24.8 | 8 | 288.38 | 281.96 | 1.02 | 0.04 |
| Overall | | | | | 1.00 | 0.03 |
| <i>O. aureus</i> | | | | | | |
| 7-8.9 | 8.1 | 75 | 9.21 | 9.23 | 1.00 | 0.18 |
| 9-10.9 | 9.5 | 265 | 15.25 | 15.21 | 1.00 | 0.20 |
| 11-12.9 | 11.6 | 136 | 29.55 | 27.74 | 1.05 | 0.23 |
| 13-14.9 | 13.8 | 344 | 49.06 | 47.64 | 1.03 | 0.12 |
| 15-16.9 | 15.6 | 475 | 69.49 | 69.05 | 1.01 | 0.12 |
| 17-18.9 | 17.4 | 255 | 95.41 | 96.67 | 0.99 | 0.11 |
| 19-20.9 | 19.3 | 58 | 131.97 | 133.05 | 0.99 | 0.09 |
| 21-22.9 | 21.6 | 9 | 163.22 | 185.56 | 0.88 | 0.16 |
| 23-24.9 | 23.0 | 2 | 218.00 | 226.13 | 0.96 | 0.07 |
| 25-26.9 | 25.9 | 3 | 330.00 | 327.18 | 1.00 | 0.04 |
| Overall | | | | | 0.99 | 0.05 |

Table 2. Back-calculated lengths (cm) at the end of the different years of the life of both Species

| Age | No of fish | Calculated lengths (cm) at age | | | | | | |
|----------------------------|------------|--------------------------------|------|------|------|------|------|------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| <i>O. niloticus</i> | | | | | | | | |
| 1 | 26 | 9.5 | | | | | | |
| 2 | 18 | 10 | 13.9 | | | | | |
| 3 | 20 | 10.5 | 13.1 | 16.1 | | | | |
| 4 | 14 | 10.1 | 12.9 | 15.9 | 18.8 | | | |
| 5 | 4 | 9.5 | 12.5 | 15.5 | 16.9 | 19.4 | | |
| 6 | 3 | 9.4 | 12.4 | 15.6 | 17.1 | 19.5 | 20.5 | |
| 7 | 2 | 9.3 | 12.3 | 15.1 | 17 | 19.3 | 20.3 | 22.2 |
| Mean length (cm) | | 9.9 | 12.9 | 15.6 | 17.9 | 19.4 | 20.4 | 22.2 |
| Annual increment (cm) | | 9.9 | 3.0 | 2.7 | 2.3 | 1.5 | 1 | 1.8 |
| % Growth increment | | 44.6 | 13.5 | 12.2 | 10.4 | 6.8 | 4.5 | 8.1 |
| <i>O. aureus</i> | | | | | | | | |
| 1 | 14 | 9.5 | | | | | | |
| 2 | 15 | 10 | 13.1 | | | | | |
| 3 | 19 | 8.6 | 12.4 | 15.2 | | | | |
| 4 | 10 | 10 | 13.7 | 16.1 | 19.5 | | | |
| 5 | 8 | 8.7 | 11.8 | 14.7 | 16.5 | 19.1 | | |
| 6 | 3 | 9.4 | 12.2 | 15.3 | 18.1 | 19.7 | 21.4 | |
| 7 | 2 | 9.2 | 12 | 14.9 | 17.9 | 19.3 | 21.3 | 22.3 |
| Mean length (cm) | | 9.3 | 12.5 | 15.2 | 18.0 | 19.4 | 21.3 | 22.3 |
| Annual increment (cm) | | 9.3 | 3.2 | 2.7 | 2.8 | 1.4 | 1.9 | 1.0 |
| % Growth increment | | 41.7 | 14.3 | 12.1 | 12.4 | 6.3 | 8.5 | 4.5 |

The means of calculated weight in the different years of the life of the two species were estimated, by applying the corresponding length-weight equations to the back-calculated lengths and given in Table 3. The growth in weight was slow in earlier ages and then increased in the following years of life. The highest percentage annual increment in the weight for *O. niloticus* was at the 7th year (23.2%), and the lowest one was 7.6% at the end of the first year, while for *O. aureus* was 7.0% at the first year and 22.6% at the end of 6th year. The values of L_{∞} for the von Bertalanffy growth model of *O. niloticus* and *O. aureus* were 29.2 and 28.6 cm, respectively.

4. DISCUSSION

The length range of *O. niloticus* was compared with those obtained by the various authors in different geographic localities (Table4). The length range of *O. niloticus* in the present study was comparable with those documented by several authors [29, 16, 30-32, 7, 33, 12, 34]. Conversely, other authors recorded higher values of length for this species in other waters [35, 24, 36, 17, 37, 19, 38, 39, 40]. Also, the middle-sized fish (13.0-18.0 cm long) was the most abundance representing 64.1% of the total catch. Mahmoud and Mazrouh [16] found that the length group 11.5 cm dominated the catch of *O. niloticus* (21.04%) in the Rosetta branch, Nile River, Egypt. Njiru et al. [41] stated that the

lengths of *O. niloticus* (<24 cm) dominated the catches of *O. niloticus*(60.5%) in Lake Victoria, Kenyan. Nyakuni [42] found that the sizes range ≤ 22 cm formed the greatest proportion (67.3%) of *O. niloticus* in Albert Nile, Uganda. Sixty per cent of *O. niloticus* catches was below 30 cm in Lake Victoria, Kenya [43].

On the other hand, the length range of *O. aureus* in the current study was wider than those obtained for the species by some authors in different geographic localities (Table 4) such as Mehanna [14], Mahmoud and Mazrouh [16], Jawad et al. [44] and Alwan and Mohamed [45].

Conversely, this length range was smaller than those reported by Jiménez [23], Messina et al. [46], and Mahmoud et al. [18] in some other waters. The length groups 13.0 to 18.0 cm constituted 67.2% of the total catch of *O. aureus* in this study. Mahmoud and Mazrouh [16] found that the length group (14.5 cm) formed 23.1% of *O. aureus* population in the Rosetta branch, Nile River, Egypt. Mahmoud et al. [18] indicated that the most dominant length group (15.5 cm) constituted 20.1% of the catch of *O. aureus* in the Nozha Hydrodrome, Egypt. Water condition, food supply, population density, fishing pressure, possibly using different gears, and the levels of intraspecific competition may be related to these differences in fish sizes among habitats [47-49].

Table 3. Calculated weights (g) at the end of the different years of life for both species

| Age | No of fish | Calculated weights (g) at age | | | | | | |
|----------------------------|------------|-------------------------------|------|------|-------|-------|-------|-------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| <i>O. niloticus</i> | | | | | | | | |
| 1 | 26 | 13.7 | | | | | | |
| 2 | 18 | 16.1 | 44.8 | | | | | |
| 3 | 20 | 18.7 | 37.3 | 70.8 | | | | |
| 4 | 14 | 16.6 | 35.5 | 68.1 | 114.7 | | | |
| 5 | 4 | 13.7 | 32.2 | 62.9 | 82.3 | 126.4 | | |
| 6 | 3 | 13.3 | 31.4 | 64.2 | 85.4 | 128.5 | 150.1 | |
| 7 | 2 | 12.8 | 30.6 | 58.0 | 83.8 | 124.4 | 145.6 | 192.3 |
| Annual increment (g) | | 14.6 | 20.3 | 29.5 | 26.8 | 34.9 | 21.4 | 44.4 |
| % Growth increment | | 7.6 | 10.6 | 15.4 | 13.9 | 18.2 | 11.1 | 23.2 |
| <i>O. aureus</i> | | | | | | | | |
| 1 | 14 | 15.2 | | | | | | |
| 2 | 15 | 17.8 | 40.9 | | | | | |
| 3 | 19 | 11.2 | 34.5 | 64.6 | | | | |
| 4 | 10 | 17.8 | 46.9 | 77.1 | 139.0 | | | |
| 5 | 8 | 11.6 | 29.7 | 58.3 | 83.1 | 130.4 | | |
| 6 | 3 | 14.7 | 32.9 | 65.9 | 110.5 | 143.4 | 185.0 | |
| 7 | 2 | 13.8 | 31.2 | 60.8 | 106.8 | 134.6 | 182.3 | 210.0 |
| Annual increment (g) | | 14.6 | 21.4 | 29.3 | 44.5 | 26.3 | 47.5 | 26.3 |
| % Growth increment | | 7.0 | 10.2 | 14.0 | 21.2 | 12.5 | 22.6 | 12.5 |

The growth coefficient (b) of the length-weight relationship provides valuable information on fish growth, which is isometric when $b = 3$, has positive allometry when $b > 3$, and has negative allometry, when $b < 3$ [50, 49]. This coefficient (b) is different among various geographic localities for the same species as presented in Table 2. It is evidently from the table that the values of (b) for both species exhibited a different type of growth (isometric and negative or positive allometric) in various of these locations, it was ranged from 2.001 in the Pharaoh Sea Canal, Egypt to 3.210 in the Rumaitha River, Iraq for *O. niloticus*, while for *O. aureus* varied from 2.510 in the Aguamilpa Reservoir, Mexico to 3.283 in the Garmat Ali River. Both species in the present study exhibited a positive allometric pattern of growth that means large fish have grown more in weight than in length and robustness of large-sized specimens were in good nutritional

environments [51]. Moreover, Riedel et al. [49] stated that this type of growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length. The length-weight relationship in fish can be affected by various factors such as habitat, season, stage of maturity, sex, food supply, stomach fullness, health, stress and sampling methodology [28,27, 52,51,40].

The seasonal variation of K_n during different months indicated that the lowest values for *O. niloticus* and *O. aureus* were observed during winter, while the highest values were during spring. Similar observations were reported by Al-Wan and Mohamed [45] and Mohamed and Al-Wan [34] in their biological studies on both species in the same river and related these to the feeding activity and the development of the gonads of these species. Messina et al. [46]

Table 4. Comparative data for length ranges and growth coefficient (b) of the length-weight relationship of *O. niloticus* and *O. aureus* in different ecosystems

| Authors | Length range (cm) | (b) | Region |
|----------------------------|-------------------|-------|------------------------------------|
| <i>O. niloticus</i> | | | |
| Ahmed et al. [35] | 15.0-53.0 | 2.844 | Kaptai Reservoir, Bangladesh |
| El-Bokhty [29] | 6.9-27.5 | 3.010 | Lake Manzala, Egypt |
| Bwanika et al. [24] | 3.7-52.5 | 3.117 | lakes Nabugabo & Wamala, Uganda |
| Mahmoud and Mazrouh [16] | 9.5-25.5 | 3.008 | Rosetta branch, Nile River, Egypt |
| Shalloof and El-Far [30] | 12.0-22.0 | 2.403 | Abu-Zaabal lakes, Egypt |
| Hirpo [31] | 8.0-25.0 | 2.690 | Lake Beseka, Ethiopia |
| Hassan and El-Kasheif [17] | 4.0-33.9 | 2.792 | River Nile, Beni Suef, Egypt |
| Mortuza and Al-Misned [32] | 6.9-27.3 | 3.080 | Wadi Hanifah, Saudi Arabia |
| Kembenya et al. [37] | 8.0-33.0 | 3.080 | Lake Baringo, Kenya |
| El-Kasheif et al. [19] | 4.8-33.6 | 2.001 | El-Bahr El-Faraouny Canal, Egypt |
| Khalifa [7] | 6.8-27.9 | 2.010 | Tigris River, south Baghdad, Iraq |
| Shalloof and El-Far [33] | 8.3-28.6 | 2.726 | Rosetta branch, River Nile, Egypt |
| = | 10.8-26.1 | 3.063 | Damietta branch, River Nile, Egypt |
| Teameet et al. [38] | 6.0-37.0 | 2.917 | Tekeze Reservoir, Ethiopia |
| Enawgaw and Lemma [39] | 2.5-30.9 | 2.900 | Lake Tinishu Abaya, Ethiopia |
| Cuadrado et al. [40] | 11.4-36.1 | 3.138 | Lakes of Esperanza, Philippines |
| Negaud [12] | 4.5-26.0 | 3.210 | AL-Rumaitha River, Iraq |
| Mohamed and Al-Wan [34] | 6.9-23.2 | 3.077 | Garmat Ali River, Iraq |
| Present study | 8.0-25.5 | 3.032 | Garmat Ali River, Iraq |
| <i>O. aureus</i> | | | |
| Mehanna [14] | 8.0-23.9 | 3.109 | Wadi El-Raiyan Lakes, Egypt |
| Jiménez [23] | 20.5-40.9 | 2.870 | Infiernillo Reservoir, Mexico |
| Mahmoud and Mazrouh [16] | 10.5-24.5 | 2.872 | Rosetta branch, Nile River, Egypt |
| Shalloof and El-Far [30] | 11.0-19.0 | 2.108 | Abu-Zaabal lakes, Egypt |
| Messina et al. [46] | 13.9-53.8 | 2.510 | Aguamilpa Reservoir, Mexico |
| Mahmoud et al. [18] | 12.5-31.5 | 2.973 | Nozha Hydrodrome, Egypt |
| Jawad et al. [44] | 10-21.5 | - | Shatt Al-Arab River, Iraq |
| Al-Wan and Mohamed [45] | 6.6-22.9 | 3.283 | Garmat Ali River, Iraq |
| Present study | 7.5-26.3 | 3.032 | Garmat Ali River, Iraq |

Table 5. Comparison of growth characteristics of *O. niloticus* and *O. aureus* in different ecosystems

| Author | L [∞] | a * | Length (cm) at age | | | | | | | Location |
|----------------------------|----------------|------|--------------------|------|------|------|------|------|------|-----------------------------------|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| <i>O. niloticus</i> | | | | | | | | | | |
| Ibrahim, et al. [15] | - | 3.16 | 10.1 | 14.5 | 18.9 | 23.1 | 26.9 | - | - | Abu-Zabal Lakes, Egypt |
| Mahmoud and Mazrouh [16] | 28.5 | 2.97 | 12.0 | 16 | 21 | 23 | 25.0 | - | - | Rosetta branch, Nile River, Egypt |
| Shalloof and El-Far [30] | 34.6 | 3.20 | 11.7 | 14.6 | 17.0 | 19.3 | - | - | - | Abu-Zabal Lakes, Egypt |
| El-Kasheif et al. [19] | 37.3 | 3.51 | 8.8 | 16.2 | 21.3 | 25.9 | 28.5 | 30.9 | - | El-Bahr El-Faraouny Canal, Egypt |
| Present study | 29.2 | 3.13 | 9.9 | 12.9 | 15.6 | 17.9 | 19.4 | 20.4 | 22.2 | Garmat Ali River |
| <i>O. aureus</i> | | | | | | | | | | |
| Ibrahim, et al. 2008 | - | 4.17 | 10.1 | 13.1 | 16.1 | - | - | - | - | Abu-Zabal Lakes, Egypt |
| Mehanna [14] | 27.2 | 2.07 | 14.4 | 20.0 | 23.2 | - | - | - | - | Wadi El-Raiyan Lakes, Egypt |
| Mahmoud and Mazrouh [16] | 26.4 | 2.78 | 10 | 16 | 19 | 21 | - | - | - | Rosetta branch, Egypt |
| Shalloof and El-Far [30] | 45.2 | 3.47 | 10.3 | 12.3 | 15.1 | - | - | - | - | Abu-Zabal Lakes, Egypt |
| Present study | 28.6 | 2.23 | 9.3 | 12.5 | 15.2 | 18.0 | 19.4 | 21.3 | 22.3 | Garmat Ali River |

*The correction factor of length-scale relationship

found that the highest values of the relative condition factor (K_n) of *O. aureus* in the Aguamilpa Reservoir, Mexico occurred during September 2000 and February and May 2001, which were the months with the largest per cent of spawning and post-spawning females. Hassan and El-Kasheif [17] stated that the minimum value of K_n for *O. niloticus* was during winter and the maximum value was during summer in Nile River, Egypt, while Mahmoud et al. [18] found that the lowest levels of K_n for *O. niloticus* and *O. aureus* happened during winter and the highest levels during spring in NozhaHydrodrome, Egypt. On the other hand, the study showed a somewhat decline in K_n values with the increase of length for both species. Similar observations were reported by Mahmoud and Mazrouh [16] on *O. niloticus* and *O. aureus* in Rosetta branch, Nile River, Egypt, Hassan and El-Kasheif [17] on *O. niloticus* in Nile River, Egypt and El-Kasheif et al. [19] on *O. niloticus* in NozhaHydrodrome, Egypt. The fluctuations in the condition factor of many fish were observed concerning their reproductive cycle, feeding conditions and other environmental and physiological factors [53-56].

The results of growth characteristics for *O. niloticus* and *O. aureus* in the current study and those reported from different geographic locations which were obtained from scales are shown in Table 5. The scales of *O. niloticus* and *O. aureus* have been used in age and growth studies by several investigators in different waters [14-16, 19, 22, 12]. The relationships between fish length and scale radius of both species revealed strong linear correlations. This confirms the validity of using scales for growth assessment [57]. From the table, the values of L_∞ and (a) obtained here are within the range recorded in other populations of *O. niloticus*. Mahmoud and Mazrouh [16] recorded the lowest value of L_∞ (28.5 cm) for the species in the Rosetta branch, Nile River, Egypt, while El-Kasheif et al. [19] found the highest value (37.3 cm) in El-Bahr El-Faraouny Canal, Egypt. The correction factor (a) varied from 2.97 cm in the Rosetta branch of the Nile River, Egypt [16] to 3.51 cm in El-Bahr El-Faraouny Canal, Egypt [19]. On the other hand, the values of L_∞ and (a) attained by *O. aureus* are also within the range noted in other populations of *O. aureus*. L_∞ values varied from 26.4 cm [16] to 45.2 cm [30]. The correction factor (a) values varied from 2.07 cm [14] to 4.17 cm [15]. Moreover, the values of L_∞ for *O. aureus* and *O. niloticus* in the same studied river were 29.9 and 30.5 cm, respectively by using FiSAT II software program [58, 59]. The

growth in length of *O. niloticus* in this study was slower than those reported for the species in the other studies (Table 5), except for the growth in the first year of life when was among the lengths recorded by these studies. While the growth of *O. aureus* was lower than those calculated for ages 1 and 4 years but was within the growth of ages 2 and 3 years in these studies. These differences in the growth of the same species in different locations may depend on several factors, such as environmental differences, habitat, availability of food, metabolic activity, reproductive activity, the genetic constitution of the individual, fishing pressure, non-representative sampling and erroneous methodological applications [47, 60, 23, 53].

5. CONCLUSION

This study revealed that *O. niloticus* and *O. aureus* have positive allometric growth pattern (species become deeper as their length increases) and mean values of relative condition factor (K_n) indicated that both cichlid populations in good condition. Seven ages were determined from the scales, and the theoretical maximum length (L_∞) values were within the range recorded in other populations of both species. These results can assist in fisheries management and conservation of the fish species in Iraqi waters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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