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Biological aspects of an invasive species of *Oreochromis niloticus* in the Garmat Ali River, Basrah, Iraq

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Abstract: *The biological characteristics of invaded species, Nile tilapia (Oreochromis niloticus L.) in Garmat Ali River, Iraq, including length compositions, age, growth, reproduction, and food habit were studied and compared with those of other populations. Samples were collected monthly by different fishing gears from September 2018 to August 2019. The lengths of individuals of the species ranged from 6.9 to 23.2 cm, and the length groups10.0-20.0 cm have predominated the fish population (93.8%).The length-weight relationship was* $W= 0.014\ L^{3.077}$ *indicating positive allometric growth.The mean values of the relative condition factor for males and females were 0.99 and 0.98, respectively. The growth model parameters were* $L\infty= 27.5$ *cm, K= 0.195,* $t_o= 1.055$ *and the growth performance index (Ø) was 2.169.The overall sex ratio was 1:0.97 (M:F). The length at first maturity was determined as 8.0 and7.0 cm for females and males, respectively. Two peaks of the gonado-somatic index were exhibited, the highest one in July for both sexes and others in March for males and in April for females. Fecundity ranged from 420 to 977 eggs for fish of 13.0-20.3 cm. The fecundity of O. niloticus increased in proportion to the 1.58 power of total length, and 0.46 power of body weight. The overall major food items of the species were detritus (45.0%), diatoms (25.0%), algae (19.7%) and macrophytes (8.1%).The results highlighted basic biological features on invasion fish species which can assist in fisheries management and conservation of the fish species in Iraqi waters.*

Key Words: *Nile tilapia, growth, reproduction, food habit, Garmat Ali River, Iraq*

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I. Introduction

Tilapia are native to northern and western Africa, the Middle East, central and south America, and southern India (William, 2015).This family represented 250 genera and 1720 valid species (Froese and Pauly, 2019). There are three major taxonomic groups of tilapia, namely *Oreochromis, Sarotherodon* and *Coptodon* (*Tilapia*), each includes many species including nile tilapia *Oreochromis niloticus,* blue tilapia *O. aureus,* gililean tilapia (*Sarotherodon galilaeus*) and redbelly tilapia *Coptodon zillii* (McAndrews, 2000).Tilapia are substrate brooders that deposit their eggs in nests excavated in the sediment. Species of the genus *Oreochromis* are maternal mouthbrooders, e.g., the females incubate the eggs in their mouths. Species of the genus *Sarotherdon* are maternal and paternal mouthbrooders (Teichert-Coddington *et al.* 1997). Tilapias are the second most widely farmed fish in the world after carps, with a global production of6.3 million tons in 2018 (FAO, 2019).

The Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) is a cichlid fish and is native to the Nile River basin, western and eastern Africa, and the south-western Middle East. It has been widely introduced elsewhere, both in Africa and other continents, including tens of countries in Asia, Europe, North America, Central America and South America (Snoeks *et al*., 2018). *O. niloticus* is well-suited to aquaculture production because they are fast-growing and tolerant of a range of environmental conditions, and the escapement and replacement from aquaculture facilities to natural waters are common (Canonico *et al*., 2005). The annual total production of *O. niloticus* increased from 2,537 tons in 2010 to 4,200 tons in 2016, accounted for 8% of fish farmed production in the world (FAO, 2018).

Tilapia species are exotic fish to Iraqi waters and early records show that *Tilapia* (*Coptodon*) *zillii* was caught from the Euphrates River near Musaib City, Centre of Iraq(Al-Sa'adi, 2007; Saleh, 2007). Later, *O. niloticus* was first recorded in the Shatt Al-Arab River by Al-Faisal and Mutlak (2015) and became widely distributed in different natural waters of the country, such as in Euphrates River at Al-Hindia Barrier (Abulheni and Abbas, 2017), in the Tigris River, southern Baghdad (Khalifa, 2017), in the Shatt Al-Arab River (Mohamed and Abood, 2017), in the Garmat Ali River (Mohamed *et al*., 2017), in the middle part of Shatt Al-Arab River, Iraq (Mohamed and Hameed, 2019); in AL-Rumaitha River, Al-Muthanna province, southern Iraq (Negaud, 2019).

Several biological studies have been conducted on *O. niloticus* in different natural waters in the world. Some authors have described the length-weight relationship of the species such as Marx *et al*. (2014) in Barur Reservoir, Krishnakri District, India; Raj *et al*. (2016) in lentic habitats of Palakkad district, Kerala, India; Moslen and Miebaka (2017) in a Tidal creek in the Niger Delta, Nigeria; Teame *et al.* (2018) in Tekeze Reservoir, Ethiopia; and Yongo *et al.* (2018) in Lake Victoria, Kenya. Bwanika *et al*. (2007) concentrated on the growth of *O. niloticus* in lakes Nabugabo and Wamala, Uganda. Food and feeding habits of *O. niloticus* have been studied by Shalloof *et al.* (2009) in Damietta Branch of the River Nile, Egypt, and Alam *et al*. (2015) in the River Yamuna, India. Other studies have been concentrated on the reproductive biology of *O. niloticus* from Lake Edku, Egypt (Bakhoum, 2002), and from Tekeze Reservoir, Ethiopia (Teame *et al.,* 2018).

However, the biological studies on *O. niloticus* in the natural waters of Iraqi are scarce, among them the study of Khalefa (2017) on some biological characteristics of *O. niloticus* from Tigris River, southern Baghdad, Iraq, and the work of Negaud (2019) on some biological aspects of *O. niloticus* L. in AL-Rumaitha River, Iraq. Therefore, this study describes the length-frequency distribution, length-weight relationship, relative condition factor, age, growth rate, sex ratio, gonado-somatic index, fecundity and food habit of *O. niloticus* in the Garmat Ali River, Basrah, Iraq.

II. Materials and Methods

The study was conducted in the Garmat Ali River, a waterway that connects the East Hammar marsh to the Shatt Al-Arab River, situated in the north of Basrah city (Fig. 1). The river has a length of 6 km with a width of 280 m and mean depth of 9 m. It is affected by the tidal current of the Arabian Gulf through the Shatt Al-Arab River. The shoreline vegetation of the river is typically associated with characteristic emergent macrophytes comprising a majority of *Phragmites australis* and *Typha domingensis,* as well as floating species like *Ceratophyllum demersum.*

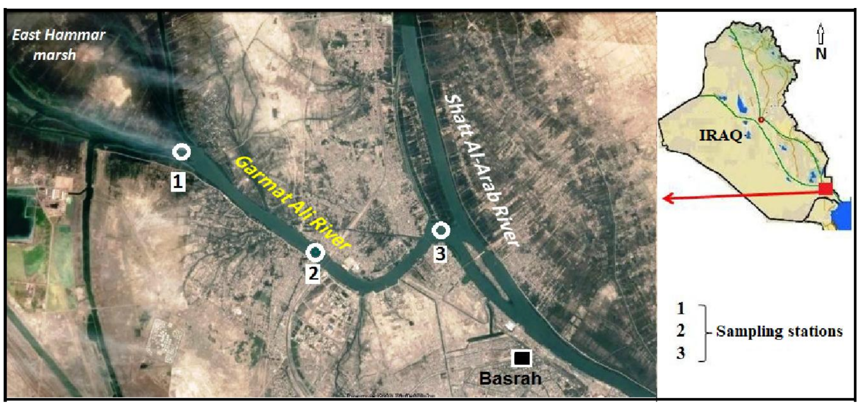

Fig. 1. Map of the Garmat Ali River with locations of study sites.

Fish specimens were collected at monthly intervals from the river between September 2018 to August 2019 using drifted gill nets (200-500 m long, with 15x35 mm, mesh size), fixed gill nets (100-300 m long, with 15x35 mm, mesh size), cast net (9 m diameter, with 15x15 mm, mesh size) and electro-fishing by generator engine (providing 300-400V and 10A). After capture, the fish were preserved in an icebox for subsequent analysis.

The total length and body weight were measured for each individual *O. niloticus* to the nearest 0.1 cm and 0.1 g, respectively. The length-weight relationship was calculated by the least square method on the logarithmically transformed data using the formula of $W=\alpha L^b$, where W is the individual fish weight (g), L is the total length (cm), α is intercepted and b is the slope of the regression line (Le Cren, 1951).Standard error was calculated for the slope (b): the hypothesis of isometric growth (b=3) was tested through the Student's *t*-test (Ricker, 1975).The relative condition factor (Kn) was calculated as the ratio of observed and calculated weights for each length and the averages of different months (Le Cren, 1951).

Three to six scales from the left side of the fish, above the lateral line, near the dorsal fin were removed,cleaned and mounted dry between two slides for age estimation by a micro-projector (magnification 20X) to age determination, and to measure the total scale radius and the distance from the focus to each annulus. The body-scale relationship was best described by the linear equation L= a + bS, where L is the total fish length in cm, S is the scale radius in cm and a is the intercept on the y-axis and b the slope of the regression line. Hence, the lengths were back-calculated with the equation $L_n = a + S_n / S (L-a)$ (Schneider *et al*.,2000), where L_n

is the length of the fish at age 'n', a is the intercept with the axis of the abscissa of the previous regression, S_n is the radius of the annulus 'n', S is the scale radius at capture and L is the length at capture.

The theoretical growth in length was described by the von Bertalanffy growth equation: $L_t= L_\infty(1-e^{-K(t-to)})$, where L_t is total length at age t, L_∞ is asymptotic length, K is the growth coefficient and t_o is hypothetical time at which the length is zero, using Beverton and Holt method (Ricker, 1975).

The growth performance index (Ø) was computed, according to the method of Pauly and Munro,1984) as follows: Ø= $\log_{10} K + 2 \log_{10} L_\infty$.

Each fish was then dissected, the stomach removed and gives the degree of fullness, and then opened in Petri dish to examine different food items. The stomachs were scored 0, 5, 10, 15 and 20 points according to its fullness as described by Hynes (1950). Feeding intensity and feeding activity for each monthly sample were calculated after Dipper *et al*., (1977) and Gordon (1977), respectively.

Each stomach was opened and the contents were examined using a research microscope and the food items were identified as far as content groups according to Hadi *et al.* (1977) and Al-Saboonchi *et al.* (1986). The index of relative importance (%IRI) proposed by Stergion (1988), based on the percentage of points (P%) and frequency of occurrence (O%) methods (Hyslop, 1980) was used to assess the most important food items:

$$IRI= O\% \times P\% \text{ and } IRI \%= IRI / \Sigma IRI * 100$$

Gonads were subsequently removed from the body cavity, weighed and examined macroscopically for sex identification. The ratio of the number of male to female specimens was determined monthly for only those fish whose gonads were identifiable as male and female. The sex ratio was tested by the chi-square ($\chi 2$) method. Thus: $\chi^2= \Sigma(O - E)^2/E$, where, O = Observable and E = Expected.

The mean size at first maturity was taken as that at which 50% of individuals were mature.The Gonadosomatic Index (GSI) of the fish was expressed as GSI=(Gonad weight/ Body weight) * 100 (King, 1995).

The ovaries were separated by keeping fully mature gravid ovaries into Gilson's solution during March-April 2019. The fecundity was estimated by using the gravimetric method (Bagenal and Braum, 1978).The eggs were counted from each subsample and the mean number of eggs was calculated and then multiplied by total ovarian weight which gives the absolute fecundity. Total length and body weight were estimated to establish a mathematical relationship with fecundity (Beganal and Braum, 1978) as $F= aX^b$, where F is fecundity, X is the total length (cm) or body weight (g), α and b are constant. The obtained data were analysed using the computer programmed Microsoft Excel, ver., 2010.

III. Results

Length-frequency distributions

A total of 2042 individuals of *O. niloticus* ranging in length from 6.9 to 23.2 cm, were sampled in this study. The seasonal length-frequency distributions of the species in the river are presented in figure 2. The number of individuals collected during autumn was 306 fish ranging in length from 8.0 to 22.0 cm, and the most dominant length group observed was 18.0 cm, accounted 22.9% of the catch. Lengths of fish during winter ranged between 6.9 to 22.0 cm, and the most dominant length groups recorded were those of 10 and 16 cm, represented 16.9 and 11.4% of the catch, respectively. The sample composed of 337 specimens was caught during spring, ranged from 8.0 to 21.0 cm, and the most frequent length group was 12 cm, accounted 15.1% of the catch during this season. The small fish caught during summer was 12.0 cm and the large one was 23.2 cm, and the most frequent length group was 18.0 cm comprised 19.8% of the catch. The most dominant length groups of the overall lengths of *O. niloticus* observed were those of 10.0 to 20.0 cm representing 93.8% of the total catch.

Length-weight relationship

Comparison between regressions did not reveal any statistically significant difference between sexes ($t= 0.335$, $p<0.05$), therefore the relationship between body weight and total length for *O. niloticus* was calculated on the entire sample (1342 specimens), ranging in total length from 7.7 to 23.2 cm and in weight from 5.0 to 144.0g. Body weight exponentially increased with total length by the following relationship (Fig. 3): $W= 0.014 L^{3.077}$, ($r^2= 0.956$).

The regression coefficient (b) of the relationship proved to be statistically significantly different from the value 3 in the *t*-test ($t= 4.270$, $P>0.05$), indicating positive allometric growth. Also, the corresponding significant correlation coefficient (r^2) indicating a length-weight relationship (in log scale) strongly linear.

Relative condition factor

The monthly variation of the relative condition factor (K_n) of *O. niloticus* showed similar trends in both sexes (Fig. 3). The range of K_n for males was 0.91 in February to 1.09 in April, while for females varied from 0.88 in February to 1.06 in May. However, there is another peak for the relative condition factor observed in

December for both sexes. The mean values of K_n for males and females were 0.99±0.04 and 0.98±0.05, respectively.

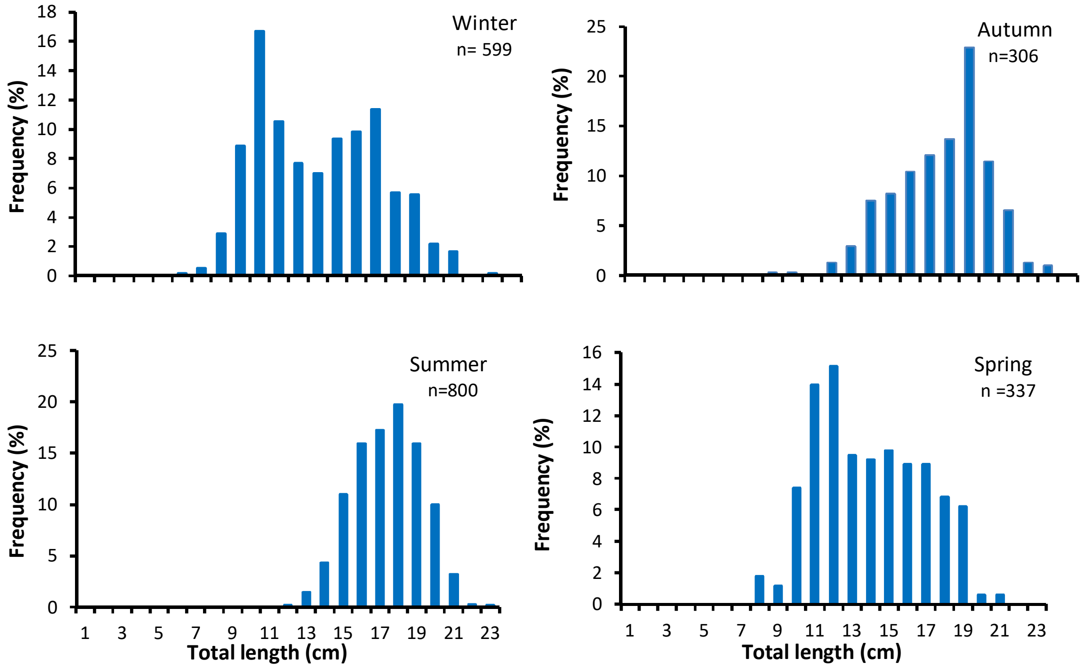

Fig. 2. Seasonal length-frequency distributions of *O. niloticus*

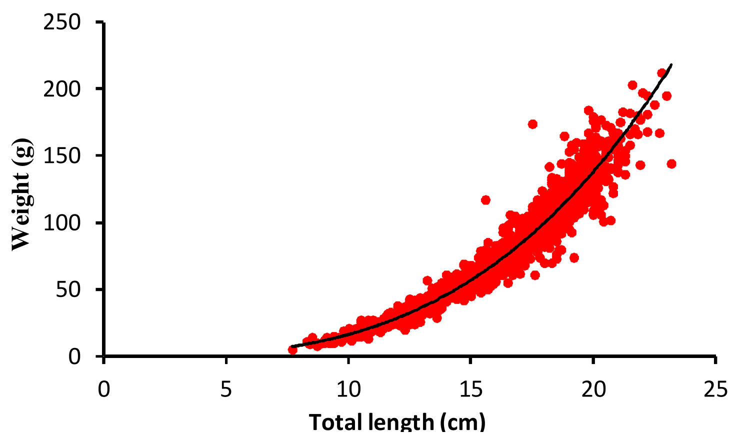

Fig. 3. The length-weight relationship of *O. niloticus*

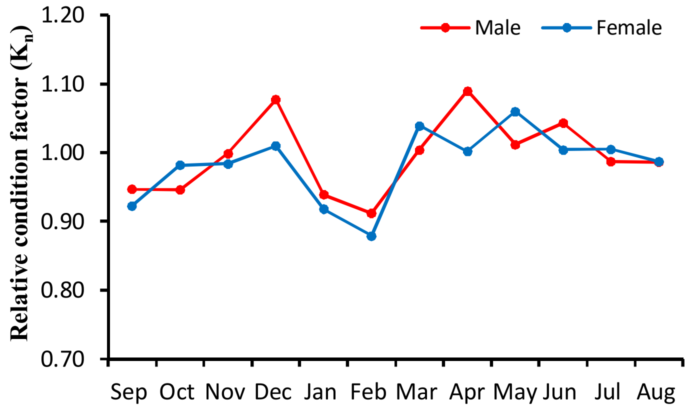

Fig. 4. Monthly variations in relative condition factor of *O. niloticus*

Age composition and growth rate

Age determination based on scale readings of 118 fish recognized five age classes in the population of *O. niloticus*. Age 1 was the most numerous (29.7%), followed by age 4 (28.0%), age 2 (23.7%), age 3 (14.4%) and age 5 (4.2%). Linear relationship (Fig. 5) has been observed between total fish length (L) and scale radius (S), which reflects the high degree of correlation between these two parameters, which was L= 2.369+5.590 S, r^2= 0.976. The mean size of fish at the time of formation of the first annulus was TL= 2.4 cm.

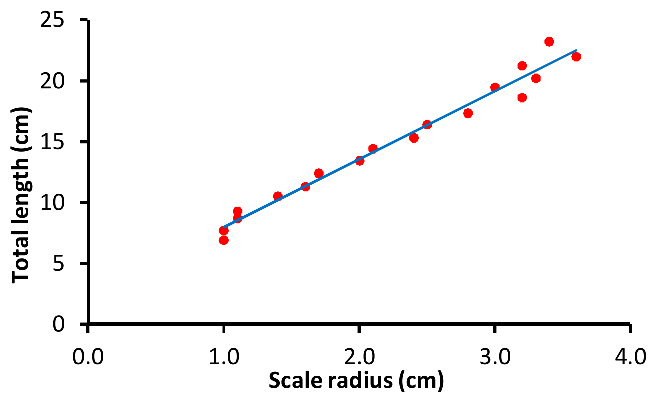

Fig. 5. The relationship between fish length and scale radius of *O. niloticus*

The mean back-calculated lengths at various ages were determined for the overall sample of *O. niloticus* (Table 2). The mean lengths estimated at ages 1 to 5 years were found to be 9.2, 12.4, 15.0, 17.5 and 19.1 cm, respectively. The maximum annual increment in length was found to occur in the first year of life (46.7%), in subsequent years decrease in the annual increment with the increase in age has been recorded.

Table 1. Mean back-calculated total lengths at age of *O. niloticus*

Age	Length at age (cm)					No. of fish
	1	**2**	**3**	**4**	**5**	
1	9.4					35
2	9.6	13.2				28
3	9.8	12.8	15.9			17
4	8.9	12.2	15.0	18.3		33
5	8.2	11.3	14.2	16.6	19.1	5
Mean length (cm)	9.2	12.4	15.0	17.5	19.1	
Annual increment (cm)	8.7	3.2	2.7	2.4	1.7	
% Growth increment	46.7	17.2	14.3	13.0	8.9	

The growth of *O. niloticus* was described by the von Bertalanffy model based on the back-calculated length at various ages. The estimated growth parameters were $L\infty$= 27.5 cm, K= 0.195, t_o= -1.055, and the growth performance index (Ø) of the species was calculated as 2.169.

Reproduction

Of 1,342 fish analysed, 683 (50.9%) were males and 659 (49.1%) females. The overall sex ratio was 0.97:1 (female: male) and did not differ significantly from the expected ratio1:1 (χ^2=0.02,P=0.05). Females of *O. niloticus* dominated the catch from September to April, whereas males more abundant from May to October. The smallest female specimen with mature ovary had a length of 8.0 cm, while the least size of male recorded with mature gonads was 7.0 cm.

Monthly mean values of gonad-somatic index for females and males of *O. niloticus* with the 95% confidence limits are shown in Figure 6. The maximum peaks of gonad-somatic index (GSI), both males and females were observed in July, constituting 1.48 and 2.79, respectively (Fig. 6). However, the minimum value of GSI for males was 0.07 recorded in January, while for females was 0.16 observed in December. Moreover, there are other smaller peaks in GSI for both sexes were shown in March for males and in April for females (Fig. 6).

The fecundity of *O. niloticus* from the study river varied from 420 to 977 eggs, with a mean value of 645±256.6 for fish of 13.0 to 20.3 cm (mean= 16.7±3.68) and 30 to 154 g (mean= 84.9±37.66). The relationships revealed significant positive correlations, and best represented for both by the following equations:

$F= 7.41\ L^{1.58}$, (n= 25, r^2= 0.797) and $F= 83.54\ W^{0.46}$, (n= 25, r^2 = 0.788).

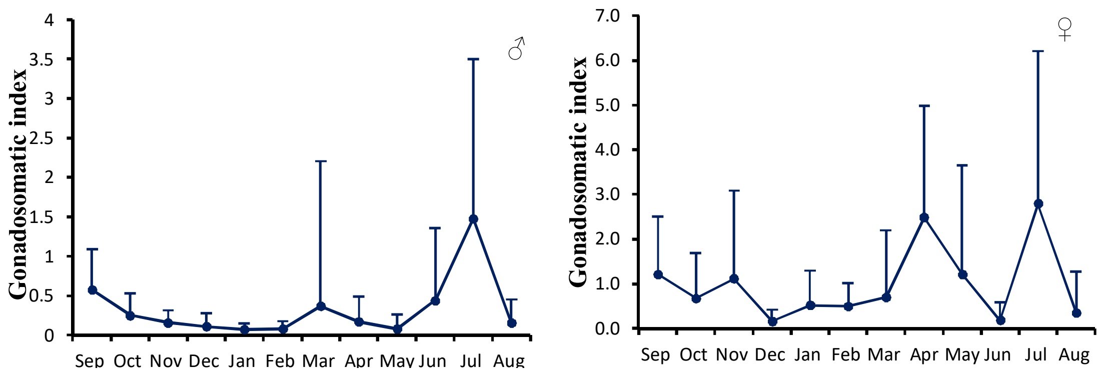

Fig. 6. Monthly variations in the GSI of *O. niloticus*

Food habit

A study on the natural food of *O. niloticus* was made based on the stomach of 700 fish, 408(58.3%) had food in their stomachs whereas the remaining 292 (41.7%) were empty. The size range of fish used for stomach content analysis was 8.4-23.5 cm TL.

Monthly variations in feeding intensity and feeding activity of the species in the river are illustrated in Figure 7. Feeding intensity values varied from 6.1 point/fish to 13.8 point/fish. The highest was recorded in March and the lowest in September, while the lowest value of feeding activity (41.8%) was recorded in August and the maximum activity (86.0%) was encountered in April.

Food of plant origin, namely, detritus, diatoms, algae, and macrophytes constituted the bulk of the food of *O. niloticus,* and was regularly consumed (Fig. 8). Detritus were the main food item at seven months, and their contribution according to the index of relative importance (IRI) ranged from 15.9% in June to 75.0% in August. Diatoms were the dominant food item at three months and comprising 1.3% in October and 55.6% in June. Algae occupied the second position, prevailing for two months and ranged from 4.4% in August to 45.3% in March. Macrophytes, although regularly consumed, formed small proportions of dietary composition, ranged between 0.1% in February and 29.1% in October. The overall major food items of *O. niloticus* from this study were detritus (45.0%), diatoms (25.0%), algae (19.7%) and macrophytes (8.1%). Some other food items were also recorded include fish (1.4%), crustacean (0.4%), zooplankton (0.4%) and aquatic insects (0.1%).

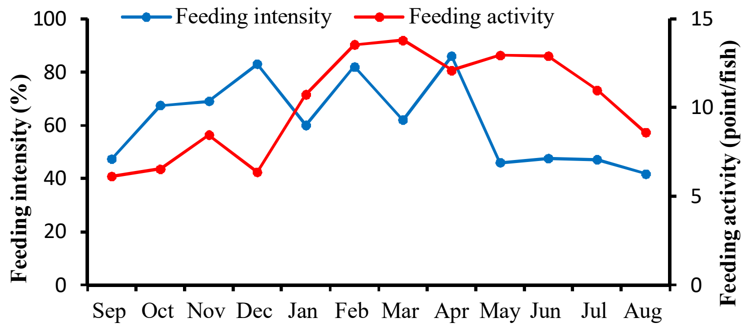

Fig. 7. Monthly variations in feeding intensity and activity of *O. niloticus*

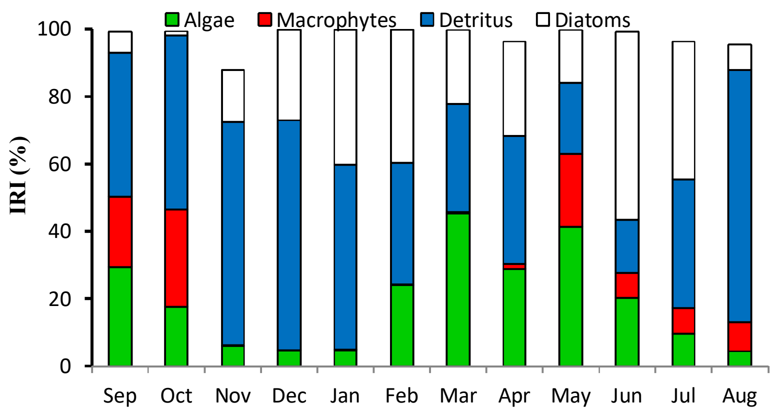

Fig. 8. Monthly changes in IRI% of food items of *O. niloticus*

IV. Discussion

In the present study, the lengths of individuals of *O. niloticus* ranged from 6.9 to 23.2 cm; however, this size of fish was more or less similar to those reported from some other waters, such as 9.5-25.5 cm in Rosetta branch *o*f the Nile River, Egypt (Mahmoud and Mazrouh, 2008), 12-29 cm in Damietta branch of the River Nile, Egypt (Shalloof *et al.*, 2009), 6.9 to 27.3 cm in Wadi Hanifah, Riyadh, Saudi Arabia (Mortuza and Al-Misned, 2013), 13.5-24.5 cm at Aswan region, River Nile, Egypt (El-Bokhty and El-Far, 2014), 19.2-29.2 cm in the Shatt Al-Arab River (Al-Faisal and Mutlak, 2015), 6.8-27.9 cm in the Tigris River, south Baghdad (Khalifa, 2017), and 4.5-26.0 cm in AL-Rumaitha River, Iraq (Negaud, 2019). Conversely, other studies recorded higher lengths for this species in other waters, such as 42 cm in Albert Nile, Uganda (Nyakuni, 2009), 33 cm in Lake Baringo, Kenya (Kembenya, 2014), 33.6 cm in El-Bahr El-Faraouny Canal, Al-Minufiya Province, Egypt (El-Kasheif *et al.*, 2015), 37.0 cm in Tekeze Reservoir, Ethiopia (Teame, *et al.,*2018), 47.5 cm in Lake Victoria, Kenya (Yongo *et al.* 2018), and 36.1 cm SL (standard length) in the two lakes of Esperanza, Philippines (Cuadrado *et al.,* 2019). Also, the population of *O. niloticus* in the present study is dominated by middle-sized fish 10.0–20.0 cm long representing 93.8% of the total catch. Some authors found similar observations. Njiru *et al.* (2007) stated that *O. niloticus*(<30cm) dominated the fish catches (68%) in Lake Victoria, Kenya. The most frequent length group percentage of *O. niloticus* in Rosetta branch of the Nile River, Egypt was (21.04%) corresponding to length group 11.5 cm (Mahmoud and Mazrouh, 2008). Njiru *et al.* (2008) found that *O. niloticus* (<24 cm TL) dominated the bottom trawl catches, comprising 60.47% of the total catch in the Kenyan portion of Lake Victoria. Nyakuni (2009) found that the greatest proportion of *O. niloticus* population in Albert Nile, Uganda was fish of size range 8-24 cm with sizes ≤ 22 cm more abundant in vegetated shore waters (67.3%). Sixty percent of *O. niloticus* in the commercial catches surveyed were below 30 cm TL in Lake Victoria, Kenya (Yongo *et al.* 2018). The reason for these differences may be due to several factors such as water condition, food supply, population density, fishing pressure and possibly using different gears (Nikolsky, 1963).

In the present study, the value of the exponent (b) of the length-weight relationship showed that the growth of *O. niloticus* was found to be positive allometric. This means that the fish becomes relatively stouter or deeper bodied as it increases in length (Riedel *et al.,* 2007). The result reported in this work is also considered to be similar to what several authors reported on the species in other waters, such as b= 3.010 in Lake Manzala, Egypt (El-Bokhty, 2006), 3.08–3.32 for males and 3.07–3.22 for females in Lake Victoria, Kenya (Njiru *et al.*, 2006), 3.117 in lakes Nabugabo and Wamala, Uganda (Bwanika *et al*., 2007), 3.008 in Rosetta branch of the Nile River, Egypt (Mahmoud and Mazrouh, 2008), 3.080 in Lake Baringo, Kenya (Kembenya, 2014), 3.010 in Lake Victoria, Kenya (Yongo *et al.* 2018), 3.138 in the two lakes of Esperanza, Philippines (Cuadrado *et al.,* 2019), and 3.120 in AL-Rumaitha River, Iraq (Negaud, 2019). However, other studies about this species revealed negative allometric growth in other waters, such as 2.924 in Abu-Zabal Lake, Egypt (Ibrahim *et al*., 2008),2.992 in the Mississippi River, USA (Grammer *et al*., 2012), 2.792 in the River Nile at Beni Suef Governorate, Egypt (Hassan and El-Kasheif, 2013), 2.909 in Nozha Hydrodrome, Alexandria (Mahmoud *et al.* 2013), 2.801 in El-Bahr El-Faraouny Canal, Egypt (El-Kasheifn *et al*., 2015) and 2.917 in Tekeze Reservoir, Ethiopia (Teame *et al.,* 2018).The relationship can be influenced by several factors such as sex, gonad maturity, the health of the fish, seasonality of environmental factors, food abundance, degree of stomach fullness, fishing pressures, and fish sizes (Bagenal and Tesch, 1978; Gokce *et al*., 2007; Mir *et al*., 2012; Mili *et al*., 2017). Moreover, Messina *et al.* (2010) stated that allometric growth is often common in species of the genus *Oreochromis*, which may be attributed mainly to problems of food, fish density, and sexual dimorphism and behaviour.

Results in this study indicate that there was no variation in the relative condition factor (K_n) for *O. niloticus* between sexes. The low values of K_n for males and females individuals were observed during winter, while the high values were during spring and summer. Moreover, the overall values of K_n for both sexes in this study were near 1.0 suggested that *O. niloticus* individuals were in good condition during the study period. The same finding has been noted by Al-Wan and Mohamed (2019) in their study on the blue tilapia, *O. aureus* from the same river. The result of this study agrees with the findings of the following studies; Njiru *et al.* (2006) stated that the values of K_n for *O. niloticus* in Lake Victoria, Kenya ranged from 0.92 to 1.05 in males and 0.94 to 1.07 in females, the overall value of K_n for *O. niloticus* in Wadi Hanifah, Riyadh, Saudi Arabia was 1.09 for fish 6.9 to 27.3 cm (Mortuza and Al-Misned, 2013). Kembenya (2014) found the K_n value for *O. niloticus* in Lake Baringo, Kenya was ranged from 1.14-1.21. Yongo *et al.* (2018) who reported good condition for *O. niloticus*, K_n equal 1.02 for males and 1.04 for females in Lake Victoria, Kenya. The fluctuations in the condition factor of many fish were observed concerning their reproductive cycle, feeding conditions and other environmental and physiological factors (Wootton, 2011; Datta *et al*., 2013; De Giosa *et al*., 2014).

Several authors used the scales of *O. niloticus* for age determination and growth studies in different waters (Ibrahim *et al.* 2008; Mahmoud and Mazrouh, 2008; El-Kasheif *et al*., 2015; Khalifa, 2017; Negaud, 2019). The total length-scale radius relationship of the species revealed a strong linear correlation (r^2= 0.976). This confirms the validity of using scales for growth assessment (Bagenal and Tesch, 1978). The fish length of *O. niloticus* in the present study at which the scales appear on the body for the first time was a= 2.37 cm TL, this was lower than the values recorded for this species in other waters, such as 3.16 cm in Abu-Zabal Lake, Egypt (Ibrahim *et al*., 2008), 2.97 cm in the Rosetta branch of the Nile River, Egypt (Mahmoud and Mazrouh, 2008), 3.51 cm in El-Bahr El-Faraouny Canal, Egypt (El-Kasheif *et al.*, 2015). The relationship between fish length and scale radius varied between the species and for the same species, depending on sex or diverse habitats (Bagenal and Tesch, 1978).

Asymptotic length ($L\infty$) was calculated for *O. niloticus* in the present study as 27.5 cm. This value of $L\infty$ was more or less similar to those reported from some other waters, such as 28.5 cm in Rosetta branch *o*f the Nile River, Egypt (Mahmoud and Mazrouh, 2008), 25.7 cm at Aswan region, River Nile, Egypt (El-Bokhty and El-Far, 2014), 29.3 cm in the Tigris River, southern Baghdad (Khalifa, 2017), 27.3 cm in AL-Rumaitha River, Iraq (Negaud, 2019). Conversely, other studies recorded higher lengths for this species in other waters, such as 53.9 cm in the Kenyan portion of Lake Victoria (Njiru *et al*., 2008), 33.6 cm in Barra Bonita Reservoir, Brazil (Costa Novaes and Carvalho, 2012), 37.3 cm in El-Bahr El-Faraouny Canal, Egypt (El-Kasheif *et al.*, 2015). Also, the growth performance indexes (ø) of *O. niloticus* in the present study (2.17) was lower than those given by Mahmoud and Mazrouh (2008) and Njiru *et al.* (2008) in the Rosetta branch, Egypt and Kenyan portion of Lake Victoria, respectively. The growth that an individual fish achieves depends on three constraints, the genetic constitution of the individual, the abiotic environment experienced by the fish will set constraints on growth and the biotic environment (Wootton, 2011).

The overall sex ratio was 0.97:1 (female: male) and did not differ significantly from the expected ratio1:1. This was also observed in Lake Edku, Egypt by Bakhoum (2002) who reported a sex ratio of 1:1.07, by Gómez-Márquez *et al*. (2003) in Coatetelco lake, Mexico (1.02:1) and by Mortuza and Al-Misned (2013) in Wadi Hanifah, Saudi Arabia (0.85:1). In other studies, males of *O. niloticus* predominated over females (1.42:1) in Lake Victoria, Kenya (Njiru *et al.,* 2006), and (1.20:1) in Lake Victoria, Kenya (Yongo *et al.* 2018). Some authors have reported the dominance of females such as; Teame *et al.* (2018) in Tekeze Reservoir, Ethiopia (1:1.16), and Negaud (2019) in AL-Rumaitha River, Iraq (1:1.6). The sex ratio of fish population changes based on spawning season, the life stage of the fish, spawning ground, fishing area, and migration (Nikolsky, 1963; Mouine *et al.*, 2011).

In the current study, the length at first maturity was 7.0 cm for males and 8.0 cm for females of *O. niloticus*. These values were more or less similar to those reported by Bakhoum (2002) who stated that the length at first sexual maturity was 9.4cm for males and 10.3 cm for females of the species in Lake Edku, Egypt. Gómez-Márquez *et al.* (2003) found that the smallest mature female was 12.0 cm long and the smallest mature male was 11.7 cm long in Coatetelco lake, Mexico.These results differ from those recorded by Njiru *et al.*, (2008) who recorded 24 cm and 25 cm for male and female fish, respectively in Lake Victoria, Kenyan. Teame *et al.* (2018) reported that the smallest sexually mature male of *O. niloticus* in Tekeze Reservoir was 14 cm whereas the same for females was 12.5 cm. Moreover, Yongo *et al.* (2018) found that the values of L_{M50} of 11.3 cm and 9.9 cm for males and females of *O. niloticus*, respectively in Lake Victoria, Kenya. Bwanika *et al.*, (2007) suggested that *O. niloticus* delays maturation when inhabiting large lakes, and breeds when younger and smaller in small water bodies.

Two peaks of the gonado-somatic index (GSI) for *O. niloticus* were shown in the present study, the highest one in July for both sexes and others in March for males and in April for females. Bakhoum (2002) found the breeding season of the species in Lake Edku, Egypt extended from April to September with a peak of GSI in May. Gómez-Márquez *et al.* (2003) stated that the maximum value of GSI for females *O. niloticus* in Coatetelco lake, Mexico was obtained in June and January, and during December and June for the males.El-Kasheif *et al.* (2015) mentioned that the highest values of GSI for males *O. niloticus* occurred in January-February and May-November periods, while for females happened in February-November period indicating prolonged spawning season for the species in El-Bahr El-Faraouny Canal, Egypt. Teame *et al.* (2018) stated that the mean values of GSI for males of *O. niloticus* in Tekeze Reservoir, Ethiopia was in July whereas for females in August, and in females, two peaks of GSI values were observed during February and August. They found that the main reproductive period for females was July, August, and September which was followed by a reproductively quiescent period between January and February.

The fecundity of *O. niloticus* from the study river different from 420 to 977 eggs for fish of 13.0 to 20.3 cm. Gómez-Márquez *et al.* (2003) stated that the fecundity of *O. niloticus* in Coatetelco lake, Mexico ranged from 104 to 709 eggs for fish of 12.5 to 20.9 cm. Njiru *et al.* (2006) found the fecundity of the species in Lake Victoria, Kenya ranged from 905 to 7619 eggs for fish of 28 to 51cm. Khalifa (2017) mentioned that the fecundity of *O. niloticus* in the Tigris River, southern Baghdad ranged from 372 to 3553 eggs for fish 13.5 to 24.5 cm. Teame *et al.* (2018) indicated that the fecundity of the species in Tekeze Reservoir, Ethiopia changed from 399 to 2129 eggs for fish 14 to 37 cm. Moreover, Nyakuni (2009) stated that the number of eggs for all the broods examined of *O. niloticus* in Albert Nile, Uganda varied from 412 to 2380 eggs for fish 17.6 cm to 42 cm. The absolute fecundity rate of the species in AL-Rumaitha River, Iraq was ranged from 480-1638 eggs for fish 14.5-24.0 cm (Negaud, 2019).

The fecundity of *O. niloticus* in this study increased in proportion to the 1.58 power of total length (TL), and 0.46 power of body weight (BW), which were within the values reported for the same species by Njiru *et al.*(2006) in Lake Victoria, Kenya (b= 1.53 for TL and 0.45 for BW) and Nyakuni (2019) in Albert Nile, Uganda (b= 1.46 for TL and 0.56 for BW). However, Gómez-Márquez *et al.* (2003) found that the fecundity of *O. niloticus* in Coatetelco lake, Mexicoincreased in proportion to the 2.48 power of TL, and 0.81 power of BW. The variation of fecundity is common across fish species, and within the same species because of differences in age, body length, gonadal weight and environmental factors (Lagler *et al*., 1967; Bagenal and Braum, 1978; Jonsson and Jonsson 1999).

The feeding activity of *O. niloticus* was strongly influenced by season since the highest values recorded during spring and then during summer, while feeding decreased during winter due to cold. The species feeds more and digests more while the temperature is suitable with more food and green materials, thus substantiate with present findings. Water temperature is one of the most important environmental variables affecting the distribution and abundance of different species of fish, and the feeding activity and food consumption are affected by temperature due to lower temperatures than ideal limits (Chorbley, 2011).

Food of plant origin, namely, detritus, diatoms, algae, and macrophytes constituted the bulk of the food of *O. niloticus*, and was regularly consumed in the present study. The food items of animal origin comprised small percentages of the stomach contents in this river. The obtained results appear to be broadly similar to that of the species found in other locations around the world, which fed mostly on plant materials originally. Negassa and Prabu (2008) stated that macrophytes, detritus, algae, diatoms constituted foods of plant origin, whereas crustacean, fish eggs, and fish scales constituted foods of animal origin in the stomachs of *O. niloticus* in Lake Zwai, Ethiopia. Also, Shalloof *et al*. (2009) found that the plant origin dominates the diet of the species occurred frequently in more than 60.0% of examined stomachs in the Damietta branch of the River Nile, Egypt. Abdulla (2015) stated that *O. niloticus* in the Shatt Al-Arab River consumed mainly macrophytes (51.1%) and algae (27.5%). Moreover, Khalifa (2017) found that *O. aureus* ingested detritus (61.8%), algae (10.2%), macrophytes (9.1%), diatoms (6.1%), zooplankton (2.4%)and insects (1.8%) in Tigris River, south of Baghdad. Negaud (2019) mentioned that *O. niloticus* in AL-Rumaitha River, Iraq consumed detritus (38.7%), algae (24.8%), macrophytes (10.1%), zooplankton (8.3%), diatoms (5.0%) and insects (1.6%). Contrasting results were obtained by Njiru *et al.* (2008) who stated that algae (57%), insects (24%) and fish (18%) comprising the main portion of the diet of *O. niloticus* in the Kenyan portion of Lake Victoria. *O. niloticus* has been observed to exhibit trophic plasticity according to the environment and the other species they coexist with (Bwanika *et al.* 2007). Alam *et al*. (2015) stated that the stomach contents of *O. niloticus* suggested it to be an opportunistic feeder with the availability of the broader food base.

These results highlighted basic biological features on invasive *O. niloticus* which can assist in fisheries management and conservation of the fish species in Iraqi waters.

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