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Evaluation of biological characters of the invasive species, *Coptodon zillii* in the Garmat Ali River, Basrah, Iraq

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Abstract
The age, growth, reproductive biology and food habit of the invasive Redbelly tilapia (*Coptodon zillii*) from Garmat Ali River, Iraq. The length-weight relationship was $W= 0.009*L^{3.237}$ for fish of 7-22 cm, indicates positive allometric growth. The mean values of the relative condition factor were 1.01 and 1.02 for males and females, respectively, indicate a healthy condition of fish. Five age groups were obtained, and their lengths were 9.0, 12.0, 14.6, 16.6 and 18.5 cm, respectively. The growth model parameters were $L\infty$= 28.4 cm, K= 0.168 and to= -1.279, and the growth performance index (Φ) was 2.13. Sex ratio (male: female) was 1:0.81, which deviates from the normal ratio. Length at maturity was 8.2 cm (males) and 8.4 cm (females). Gonadosomatic index (GSI) values ranged between 0.06 in August and 1.89 in July for males and 0.04 in July and 5.35 in April for females indicate that the spawning season extended from April to June. Fecundity varied from 1635 to 3072 eggs for fish of 11.2-17.1 cm. The fecundity (F) can be estimated with the formula $F= 75.89 * L^{1.26}$ or $F=424.24 * W^{0.41}$ (L= total length and W= body weight). Feeding intensity and activity of *C. zillii* were high during spring and summer, respectively. The species fed mainly on detritus (44.6%), algae (19.9%), macrophytes (19.7%) and diatoms (13.3%). These results can assist in fisheries management and conservation of the fish species in Iraqi waters.

Keywords: *Coptodon zillii*, age and growth, reproduction, food habit, Garmat Ali River

1. Introduction

Tilapias are a group of subtropical to tropical freshwater fish of the family Cichlidae that are native to Africa and the south-western Middle East. Tilapia inhabits a variety of fresh and less commonly brackish water habitats, from shallow streams and ponds through the rivers, lakes and estuaries [1]. This family represented 250 genera and 1725 valid species [2]. Tilapias are grouped into three major taxonomic groups according to parental care patterns: *Oreochromis* (arena-spawning maternal mouthbrooders), *Sarotherodon* (paternal or biparental mouthbrooders), and *Coptodon* (*Tilapia*) (substrate spawners). Since the 1930s, many tilapia species have been intentionally dispersed almost worldwide [3]. Tilapia is the second most important fish in fish farming in the world after carps, with a production of 6.3 million tons in 2018 [4].

The redbelly tilapia, *Coptodon zillii* (Gervais, 1848), known previously as *Tilapia zilli*, is widely distributed extending from West Africa through Chad basin to the Nile, Lake Albert and Lake Turkana into Jordan valley [5]. It is economically and ecologically important as food fish, for aquaculture, commercial aquarium trade, aquatic vegetation control and recreational fishery in its native range and in many countries it has been introduced [6]. El-Sayed [7] mentioned that *C. zillii* is known to be one of the most salinity-tolerant tilapia species and can grow, survive, and reproduce at 10 to 30%, depending on the species, size and sex.

In Iraq, tilapia species are invading fish and early records show that *C. zillii* was caught from the Euphrates River near Musaib City, middle of Iraq [8, 9]. Later, *C. zillii* was recorded in the main outfall drain, south Iraq during 2009 by Mutlak and Al-Faisal [10] and became widely distributed in different natural waters of the country, such as in the Shatt Al-Arab River [11, 12], in the Al-Tharthar Lake, Iraq [13], in East Hammar marsh, Iraq [14], in the Garmat Ali River [15], in Al-Diwaniya River, Iraq [16], in the Al-Swaib River, a tributary of Shatt Al-Arab River [17] and in the middle part of Shatt Al-Arab River, Iraq [18].

Various authors have investigated the biology of *C. zillii* in different natural waters in the world [19-32].

The biological studies on *C. zillii* were little in the natural waters of Iraqi. Qadoory [33] studied the reproductive biology of *C. zillii* in Al-Swaib and Al-Ghatra marshes, while Wahab [34] described the food habit of *C. zillii* in the Tharthar Arm, Tigris, respectively. Shakir [35] studied the age and growth of *C. zillii* in Euphrates River passing through Al-Qadisiyah and Al-Muthanna provinces.
The present 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 *C. zillii* in the Garmat Ali River, Basrah, Iraq.

2. Materials and Methods

2.1. Fish collection

Fish were collected monthly between September 2018 to August 2019 from the Garmat Ali River, Iraq (Fig. 1) using drifted and fixed gill nets, cast net and electro-fishing [36]. Samples were preserved in an icebox and taken to the laboratory for further analysis.

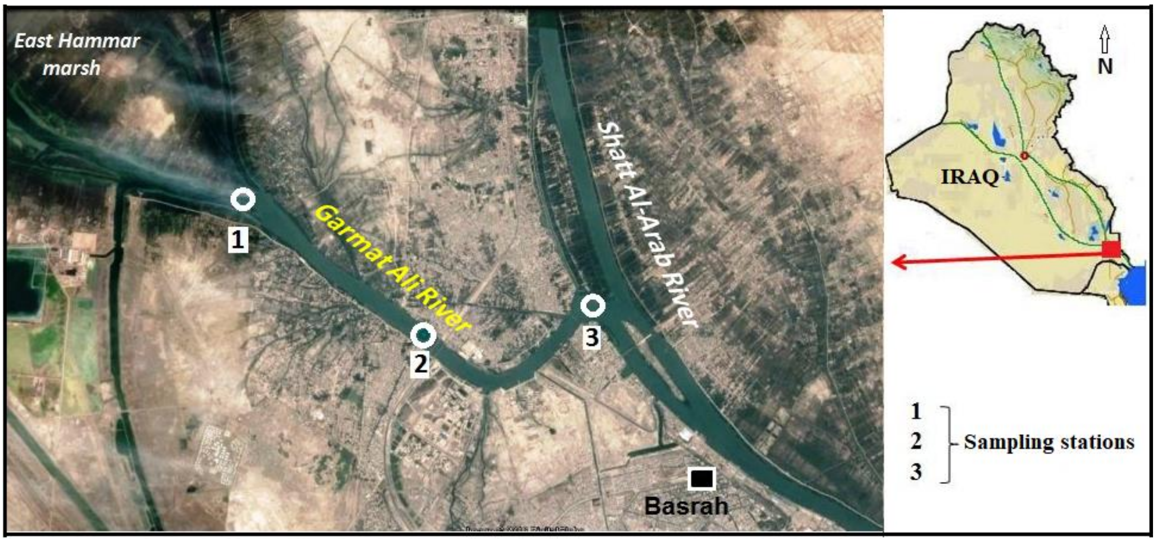

Fig 1: Map of the Garmat Ali River with locations of study sites.

2.2. Laboratory analyses

In the laboratory, each fish was measured for total length (TL) to the nearest 0.1 cm and weighed (W) to the nearest 0.1 g. Scales were removed from the area below the dorsal fin and above the lateral line, cleaned and mounted dry between two glass slides. They were examined by a micro-projector (X20) to age determination and to measure the total scale radius and the radius of each annulus. Each specimen was dissected, stomach removed and preserved in 4% formaldehyde. Gonads were removed, weighed and observed to determine the sex. Ovaries with visible eggs were preserved in Gilson fluid for the estimation of fecundity.

2.3. Data and statistical analysis

To establish the length-weight relationship, the commonly used relationship $W=aL^b$ was applied [37], where a and b are constants. The growth coefficient (b) was tested from isometric growth (b= 3). The relative condition factor (K_n) was calculated for the species using the following formula, $K_n= W'/W$ [37], where W′ is the total body weight (g) and W is the expected weight.
The total radius of each scale was plotted against the fish length to determine the body length-scale radius relationship. The lengths at different ages were back-calculated using the equation $L_n= a + S_n /S (L-a)$ [38], where L_n is the back-calculated length at age 'n', a is the intercept of the linear regression line (correction factor), S_n is the scale radius of the annulus 'n', S is the scale radius and L is the length at capture. The growth parameters of the von Bertalanffy growth model (L_∞, K and t_o) were computed using Beverton and Holt method [39]. The growth performance index (Ø) was computed, according to the method of Pauly and Munro [40] as follows: $Ø= \log_{10} K +2 \log_{10} L_\infty$.
Stomach fullness was examined and donated scores 0, 5, 10, 15 and 20 points according to its fullness [41]. Feeding intensity and feeding activity for each monthly sample were calculated after Dipper *et al.* [42] and Gordon [43], respectively. The food items were identified as far as content groups according to Hadi *et al.* [44] and Al-Saboonchi *et al.* [45]. The index of relative importance (IRI%) proposed by Stergion [46], based on the percentage of points (P%) and frequency of occurrence (O%) methods [47] was used to assess the most important food items:

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

A Chi-squared goodness of fit test was used to test for a difference in the sex ratio from a 1:1 ratio. 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 [48]. The estimation of fecundity was based on the gravimetric method [49]. The relationship between fecundity and total length and body weight was estimated 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.

3. Results

3.1. Length-frequency distributions

The seasonal length-frequency distributions of *C. zillii* in the river are presented in Figure 2. The number of individuals collected during autumn was 118 individuals ranging in length from 11 to 21 cm, and the highest frequency of catch belonged to the length group 16 cm constituting 17.8%, while the length groups from 13 to 19 cm formed the main catch (94.1%). Sizes of *C. zillii* during winter ranged from 8 to 20 cm, and the dominant length group was 13 cm formed 19.7% of the catch in this season, while the length groups 10 to 16 cm constituted 89.8%. Lengths of fish during spring ranged between 8 to 21 cm, and the most dominant length group recorded was 12 cm, represented 15.1% of the catch. The sample composed of 106 specimens was caught during summer, ranged from 11 to 21 cm, and the most frequent length group was 15 cm, accounted for 26.4% of the catch during this season. The overall sample of *C. zillii* composed of 702 specimens, ranged from 7 to 22 cm in total length, the most dominant length groups of the overall lengths observed were 14 to 19 cm representing 58.8% of the total catch.

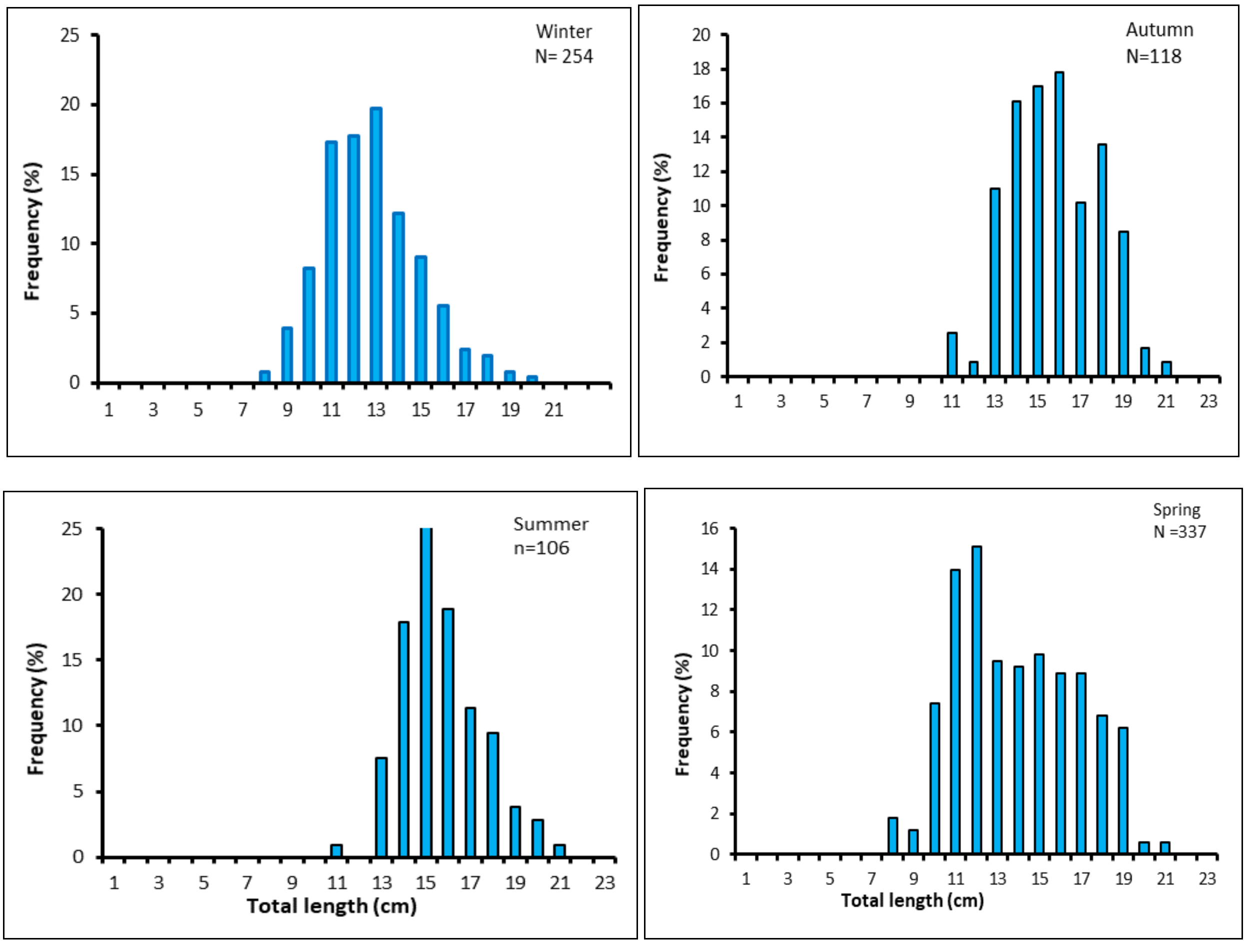

Fig 2: Seasonal length-frequency distributions of *C. zillii*

3.2. Length-weight relationship

The statistical test between sexes revealed no significant difference between them (t= 0.176, p<0.05), hence the length-weight relationship for *C. zillii* derived from pooled data (1342 specimens) in the size range of 7.7-23.2 cm (5.0-144.0 g weight). The relationship was estimated by the least square method and the regression equation was: $W= 0.009\ L^{3.237}$, r^2= 0.954 (Fig. 3). In terms of growth type, *C. zillii* revealed positive allometric growth (t= 8.798, P>0.05). Also, the corresponding significant correlation coefficients (r^2) indicating a length-weight relationship (in log scale) strongly linear.

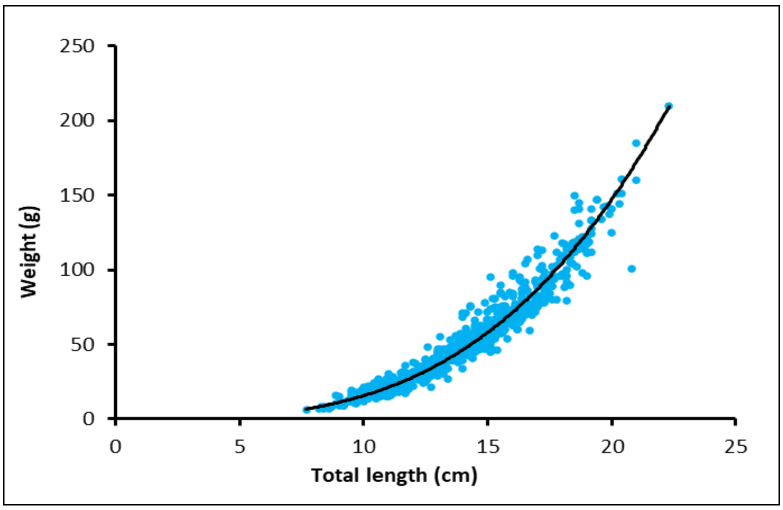

Fig 3: The length-weight relationship of *C. zillii*

3.3. Relative condition factor

The relative condition factor (K_n) of *C. zillii* showed monthly fluctuations in both sexes (Fig. 4), but there was no significant difference in K_n values between them (t= 0.27, p>0.05).

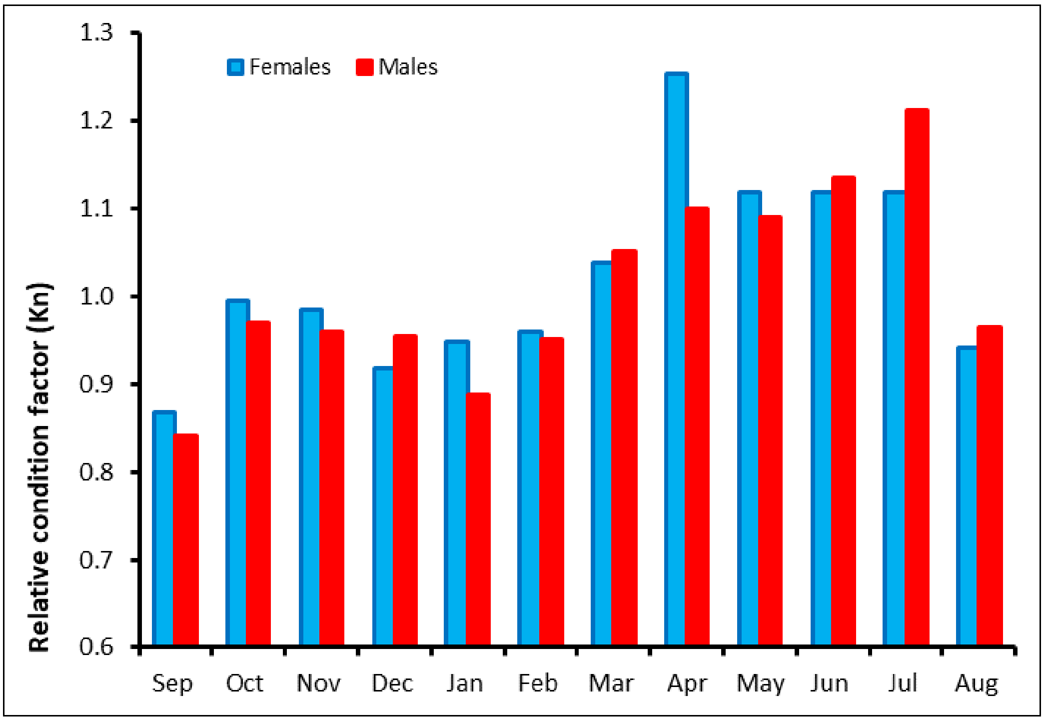

Fig 4: Monthly variations in relative condition factor of *C. zillii*

The mean values of K_n for males and females were 1.01± 0.10 and 1.03± 0.11, respectively. K_n values for males fluctuated from 0.84 in September to 1.21 in July, while for females from 0.87 in September to 1.25 in April. However, there are other smaller peaks for K_n observed in October for both sexes. The mean values of K_n for males and females were 1.01±0.11 and 1.02±0.11, respectively.

3.4. Age composition and growth rate

In the present study, the scale was used for age determination and five age groups were obtained for *C. zillii*. The relationship between the fish length (L) and the scale radius (S) was linear, as shown in Figure 5, and can be represented by the following equation: L= 2.535+5.467 S, r^2 = 0.923. The mean size of fish at the time of the formation of scales on the fish body (correction factor) was 2.535 cm. The following equation was adopted for back-calculation of length at different scale annuli: Ln = Sn / S (L + 2.535) + 2.535. The mean back-calculated lengths at the end of each year of life are given in Table 1. The mean lengths estimated at ages 1 to 5 years were found to be 9.0, 12.0, 14.6, 16.6 and 18.5 cm, respectively. The highest growth takes place in the first year of life (46.7%), after which the annual increment gradually and progressively decreases with further increase in age.

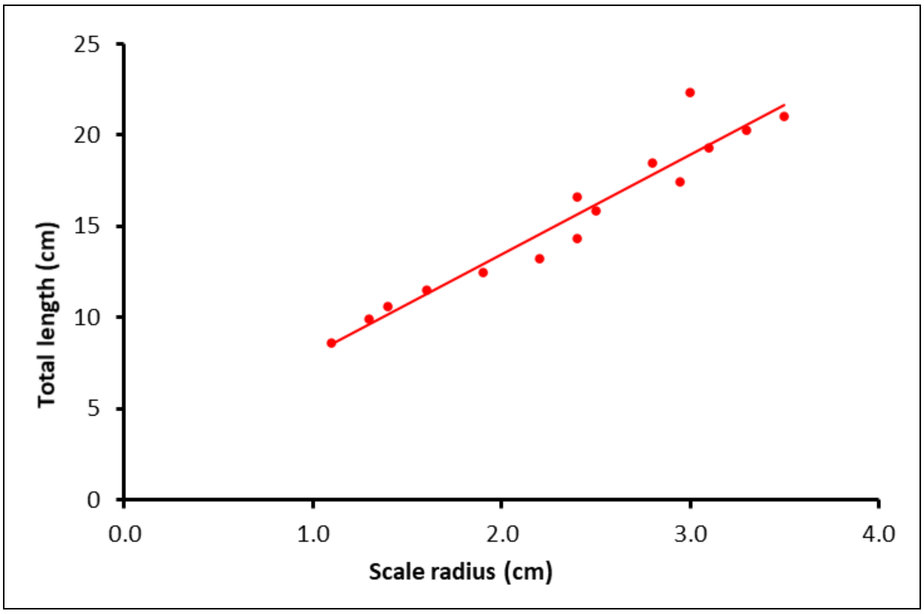

Fig 5: The relationship between fish length and scale radius of *C. zillii*

Table 1: Mean back-calculated total lengths at the end of different years of the life of *C. zillii*

Age	Length (cm) at the end of each year					No. of fish
	1	2	3	4	5	
1	9.9					13
2	9.1	12.6				17
3	8.9	12.4	15.3			14
4	8.8	12.0	15.0	17.6		15
5	8.3	11.0	13.5	15.6	18.5	21
Mean length (cm)	9.0	12.0	14.6	16.6	18.5	
Annual increment (cm)	8.7	3.0	2.6	2.0	1.9	
% Growth increment	47.8	16.5	14.3	11.0	10.4	

The constants of the von Bertalanffy growth model of *C. zillii* were computed as $L\infty$= 28.4 cm, K= 0.168 and t_o= -1.279. Therefore, the growth performance index (Φ) of the species was calculated as 2.13.

3.5. Reproduction

A total of 545 fish analysed, 302 (55.4%) were males and 243 (44.6%) females. The overall sex ratio between males and females was found to be 1:0.81 showing the domination of males in the samples. Statistical analysis by Chi-square ($\chi 2$) test indicated that the sex ratio was significantly different from the expected ratio of 1:1 ($\chi 2$= 6.39, p= 0.05). Also, it was found that males outnumbered females during all months except for September, January, March and August. To find the size at first maturity was calculated for each 1.0 cm class interval separately for the sexes. The smallest mature specimen recorded was 8.2 cm for males and 8.4 cm female.

The gonad-somatic index (GSI) for females and males of *C. zillii* exhibited clear monthly fluctuations in their mean values (Fig. 6). The highest value of GSI for females (5.35) occurred in April and then gradually dropped to the lowest value (0.04) in July, while the highest value for males occurred in July (1.89) and the lower value (0.02) in August. However, there is another small peak in GSI for males was found in May (0.71).

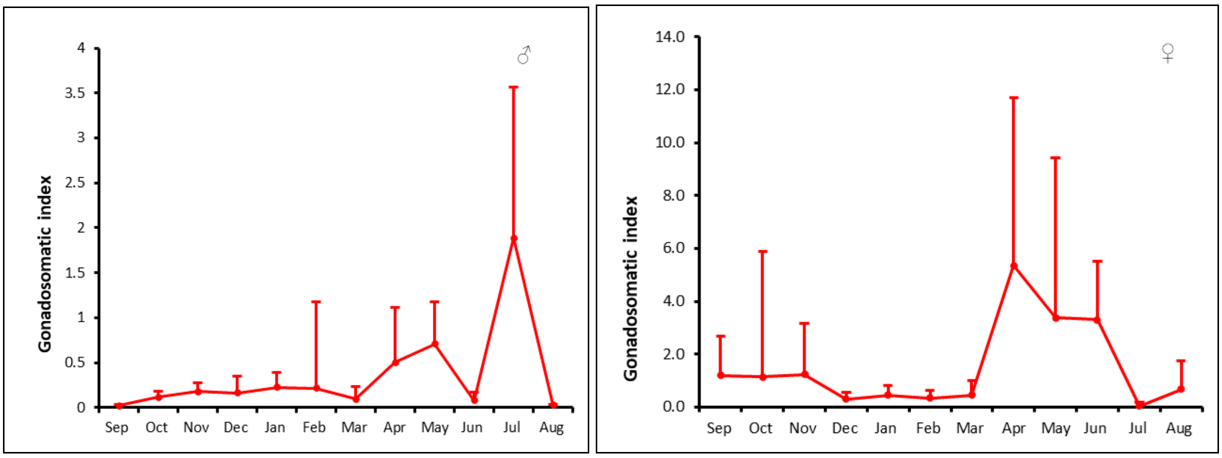

Fig 6: Monthly variations in the GSI of *C. zillii*

The calculated absolute fecundity for *C. zillii* varied from 1635 to 3072 eggs with a mean 2224±534.7 corresponding to fish total length of 11.2-17.1 cm and the total weight of 28-101 g. The relationships of absolute fecundity with total length and total weight were best explained as:

$F= 75.89\ L^{1.26}$, (n= 14, r^2= 0.629).

$F= 424.24\ W^{0.41}$, (n= 14, r^2 = 0.645).

3.6. Food habit

A total of 700 samples of *C. zillii* studied, 408 fish (58.3%) had food items in their stomach, while 292 fish (41.7%) had an empty stomach. The feeding activity of the species fluctuated from 52.3% in January to 87.5% in August, whereas the feeding intensity varied from 4.1 point/fish in October to16.0 point/fish in April (Fig. 7).

Diets of plant origin were made of detritus, algae, macrophytes and diatoms comprised the bulk of the food of *C. zillii* (97.5%), and was regularly consumed (Fig. 8). The maximum contribution of detritus in the diet according to the index of relative importance (IRI) was 83.7% in November and the minimum value was 17.8% in April. Algae occupied the second position and varied from 4.7% in November to 39.7% in March. Macrophytes came to the third position and ranged from 0.05% in February to 65.9% in June. The contribution of diatoms fluctuated from 0.5% in September to 35.9% in February. The overall food composition of the species was comprised of detritus (44.6%), algae (19.9%), macrophytes (19.7%) and diatoms (13.3%). On the other hand, aquatic insects, fish, crustaceans, zooplankton and snails together composed about 2.5% of the diet.

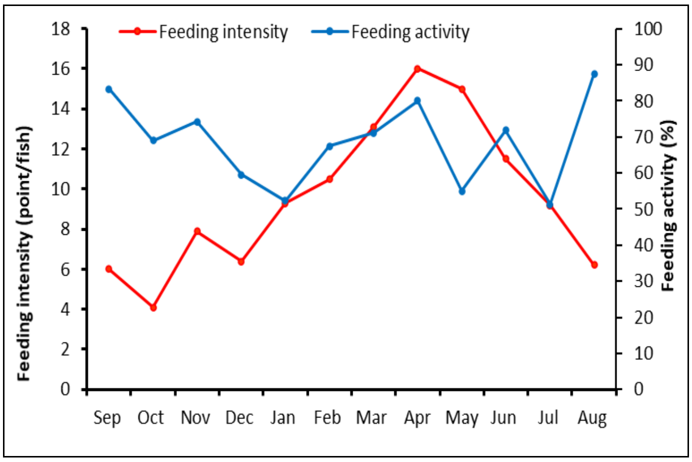

Fig 7: Monthly variations in feeding intensity and activity of *C. zillii*

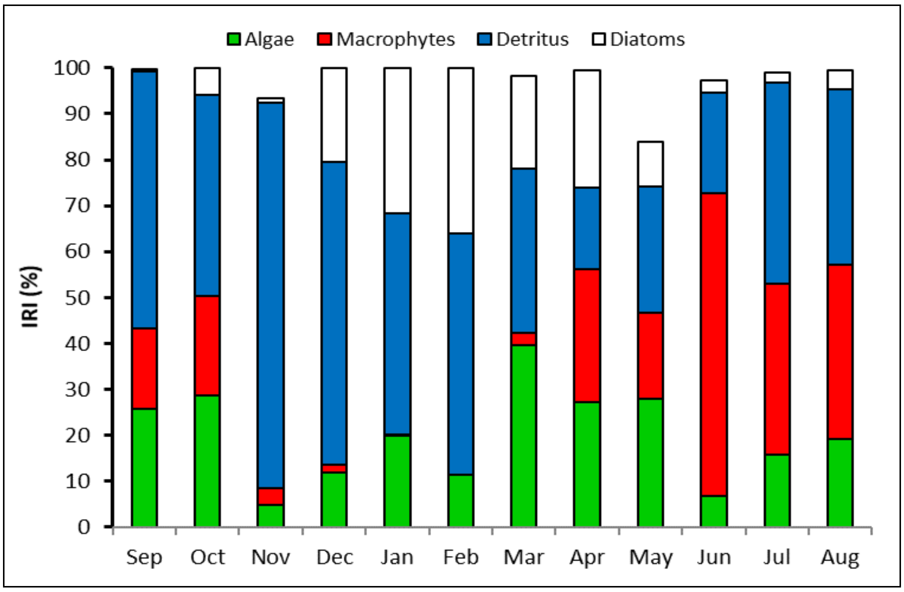

Fig 8: Monthly changes in IRI% of food items of *C. zillii*

4. Discussion

C. zillii can be considered as the first invade species from the family Cichlidae reported in the Iraqi natural waters in 2006 from the Euphrates River near Musaib City, middle of Iraq, then they appeared elsewhere from Iraq in the following years. Some parameters for analysed material given in this paper were compared with the results of the previous studies on *C. zillii* (Table 2).

Table 2: Biological characteristics comparison of *C. zillii* in different ecosystems

Location	Fish length (cm)	Slope (b)	Correction factor (a)	L∞	Φ	Author
Lake Mariut, Egypt	-	3.059	-	-	-	[59]
Lake Zwai, Ethiopia	5.5-32.0	2.981	-	-	-	[51]
Wadi EL-Raiyan Lakes, Egypt	8.0-30.5	3.088	-	33.50	2.74	[6]
Umhfein Lake, Libya	15.0-27.0	3.228	5.168	28.81	2.29	[20]
Abu-Zabal Lake, Egypt	-	2.924	3.767	-	-	[58]
Rosetta branch, Nile River	7.5-15.5	3.052	2.110	16.50	2.13	[21]
Lake Qarun, Egypt	-	2.690	2.222	-	-	[22]
Damietta branch, Nile River, Egypt	10.0-21.0	-	-	-	-	[23]
Gbedikere Lake, Nigeria	-	3.496	-	34.52	2.72	[57]
Lake Timsah, Egypt	6.0-16.0	2.967	Males	22.05	2.19	[25]
			Females	17.83	2.34	
AL-Swaib marsh	6.0-18.0	3.080	-	-	-	[33]
Al-Ghatra marsh, Iraq	7.0-21.1	2.801				
Nozha Hydrodrome, Egypt	14.5-31.5	2.885	0.980	-	2.36	[28]
Cross River basin, Nigeria	6.5-26.8	-	-	27.83	2.55	[52]
Aswan, Nile River, Egypt	12.5-18.5	-	-	19.43	-	[50]
Kanye Dam, Nigeria	6.9-30.0	-	-	-	-	[30]
Crater Lake Nkuruba, Uganda	7.3–28.4	2.970	-	-	-	[52]
Euphrates River, Iraq	-	3.050	-	-	-	[35]
Al-Diwaniya river	7.0-22.0	3.077	2.535	28.40	2.13	Present study

The lengths of individuals of *C. zillii* caught in the present study ranged from 7 to 22 cm. This size of fish was more or less similar to those reported in some waters [33, 23]. However, the present size of the species was better than those found by other authors [21, 25, 33, 50]. Conversely, other studies recorded higher lengths for this species in other waters [51, 6, 20, 28, 52, 30, 53]. Moreover, the most dominant length groups observed in the present study were 14-19 cm representing 58.8% of the total catch. Uneke and Nwani [54] stated that the size groups (11-15cm) were numerically dominant and constituted 67.2% of the population in Cross River basin, Nigeria. 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 [55]. The length-weight relationship of *C. zillii* in this study showed positive allometric growth (Table 2), which indicated that the fish becomes relatively stouter or deeper bodied as it increases in length [56]. Our results are in agreement with Hadi [20] and Adeyemi and Akombo [57]. Negative allometric growth pattern has been reported in *C. zillii* by Negassa and Getahun [51], Ibrahim *et al.* [58], Sholloof [22], Mahmoud *et al*. [25], Qadoory [33], Mahomoud *et al*. [28] and Efitre *et al*. [53]. On the other hand, other studies about this species reported isometric growth [59, 6, 21, 33]. Several factors can be effected on the length-weight relationship in fish, such as sex, gonad maturity, the health of the fish, seasonal effect, degree of stomach fullness, and the difference in the sizes of fish [60-62] .

The relative condition factor (K_n) values in both sexes of *C. zillii* exhibited decreasing trends during winter and contrary tendencies in spring and beginning of summer. These may be attributed to the different state being of a fish, as to the state of the reproductive cycle and the feeding rhythms. Statistical analysis of the generated data reveals there exist significant correlations between the values of K_n and both GSI and feeding intensity in both sexes (r= 0.61-0.77). Many factors can affect the fish condition, such as sex, age, gonad development, feeding condition, illness and environmental condition [37, 63, 64]. Also, the mean K_n values revealed that both males and females of *C. zillii* have a uniform value (1.00), which indicate that both sexes in a good condition and the species inhabiting the aquatic ecosystem is conducive for the optimum growth of this fish. Le Cren [37] stated that K_n values of fish > 1.0 indicated the good state of well-being of the fish, whereas a value < 1.0 is indicative of the reverse nature.

The scales of *C. zillii* have been used in age and growth studies by several workers in different waters [20, 58, 21, 22, 28]. The mean size of *C. zillii* at the time of the formation of scales on the fish body was 2.535 cm (Table 2), this size of fish was higher than the values reported for this species in some waters [21, 22, 28]. Conversely, other studies recorded higher lengths for this species in other waters [20, 58]. The relationship between fish length and scale radius varied between the species and for the same species, depending on sex or diverse habitats [60].

Various authors gave different values for the asymptotic length ($L\infty$) for *C. zillii* among various geographic localities (Table 2). $L\infty$ in this study was similar to those reported from some waters [20, 54]. However, the present size of the species was better than those recorded from some other waters [21, 25, 50]. Conversely, other studies found higher values for this species in other waters [6, 57]. Also, the growth performance indexes (Φ) of *C. zillii* in the present study (2.17) was similar to those given by Mahmoud and Mazrouh [21] and Mahmoud *et al*. [25] in the Rosetta branch, Nile River and Lake Timsah, Egypt, respectively, and lower than other authors in Table 2. 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 [65].

The monthly and yearly percentage of males and females of *C. zillii* in this study showed that the males dominated the natural population over the year, except in four months and the overall sex ratio (M/F) was 1:0.8. This is in the agreement of that recorded for the species in other localities, such as 1:0.9 in Lake Timsah, Egypt [25], 1:0.98 in Damietta branch, Egypt [27] and 1:0.53 in the Euphrates River, Qadisiya province [35]. In other studies, females predominated over males, such as 1:1.05 in Abu qir Bay, Egypt [19], 1:1.19 in Abu-Zabal Lake Egypt [58], 1:1.12 and 1:1.18 in AL-Swaib and Al-Ghatra marshes, respectively [33] and 1:1.4 in Cross River, Nigeria [54]. The sex ratio of fish population related to corresponding differences in spawning season, the life stage of the fish, spawning ground, selectivity in the sampling and migration [55, 66].

Data showed that the smallest mature specimen observed during the present study was 8.2 cm for males and 8.4 cm female. These values were more or less similar to those reported by several authors. El-Sayed and Moharram [19] stated that L_{m50} for females and males of *C. zillii* in Abu qir Bay, Egypt was attained at the length of 8.7 cm and 9.7 cm, respectively. Mahomoud *et al.* [25] found that the smallest mature male in Lake Timsah, Egypt was 8.4 cm and the female was 7.5 cm. Qadoory [33] mentioned that the smallest mature male and female in AL-Swaib marsh were 12.4 and 13.2 cm, respectively. The length at first sexual maturity was 9.8 cm for males and 11.0 cm for females of the species in Cross River, Nigeria [54]. These differences may be attributed to differences in genetic and environmental conditions such as food supply, population density and changes in temperature and salinity [25]. Ghazwan [67] pointed out that the phenomenon of early sexual maturity of *C. zillii* might be influenced by such factors during early stages of its lives and it acquires different levels of masculine or feminine hormones such as androgen and estrogen which effect on the genes and genetic control in bodies of this species.

Monthly variations in the gonad-somatic index (GSI) for females and males of *C. zillii* revealed that the spawning season in the study river extended from April to June. Negassa and Getahun [51] declared that *C. zillii* in Lake Zwai, Ethiopia breeds all the year round with peak activities between April and September. Meanwhile, El-Sayed and Moharram [19] stated that GSI of *C. zillii* showed higher values during the period from June to September with a peak in July, while the lower ones occurred during the period from October to February in Abu qir Bay, Egypt. Mahomoud *et al.* [25] found that the period from January to August represented the spawning period of *C. zillii* in Lake Timsah, Egypt. Qadury [33] stated that the spawning season of the species in Al-Swaib marsh, Iraq extended from June to August with a peak of GSI in June, while in the Al-Ghatra marsh prolonged from May to August, with a peak of GSI in April. Uneke and Nwani [54] point out that GSI of *C. zillii* in Cross River, Nigeria showed higher values during the period from May to September with a peak in June, while the lower ones occurred during the period from October to February. Variation in the timing of spawning may be linked to age, size, condition and other factors such as geographic distribution, climatic conditions, and nutritional status of fish [68, 69].

In this study, it was found that the fecundity of *C. zillii* ranged from 1635 to 3072 eggs for fish of 11.2 to 17.1 cm. This result agreed with El-Sayed and Moharram [19] which reported estimate fecundity of the species varied from 1220 to 3124 eggs for fish of size range 8 to 16 cm in Abu qir Bay, Egypt. However, Qadoory [33] stated that the fecundity of the species in Al-Swaib marsh ranged from 3793 to 16762 eggs for fish of 12.4 to 17.1cm and in 2721 to 11767 eggs for length 12.5-16.6 cm in Al-Ghatra marsh. El-Kasheif *et al.* [27] mentioned that the fecundity of *C. zillii* in Damietta Branch of the River Nile, Egypt varied from 1226 to 6184 eggs for fish 8 to 17 cm. Uneke and Nwani [54] found that the fecundity of the species in Cross River basin, Nigeria ranged from 628 to 3631 eggs for fish 12.1 to 25.6 cm. According to this study, it has been found that fecundity was positively correlated with total length (r^2= 0.629) and total weight (r^2= 0.645). It was varied with total length by a factor of 1.26. This agrees with El-Sayed and Moharram [19] who found that the fecundity of *C. zillii* from Abu qir Bay, Egypt increased with total length by a factor of 1.36. However, Uneke and Nwani [54] stated that the fecundity of *C. zillii* from Cross River, Nigeria changed in proportion to the 2.52 power of length, and 1.48 power of body weight. Moreover, Qadoory [33] found that the fecundity of *C. zillii* in Al-Swaib marsh varied with total length and body weight by factors of 4.31 and 1.37, respectively. 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 [70, 49, 71].

In general, the feeding intensity of *C. zillii* was strongly influenced by season, since the highest stomach fullness occurred during spring and lowest during winter, whereas the feeding activity fluctuated throughout the year, but the highest level recorded in August and corresponding with the time of highest temperature. Water temperature is one of the most important environmental factors, which regulates the biogeochemical activities in the aquatic environment as well as all metabolic and physiological activities of fish like feeding activity and food consumption [55, 68].

The major component of the diet of *C. zillii* in this river was food items of plant origin, namely, detritus (44.6%), algae (19.9%), macrophytes (19.7%) and diatoms (13.3%). These items were also reported to be ingested by the species in some waters. Shalloof *et al.* [23] found that *C. zillii* fed on diatoms, algae, plant tissues and organic detritus in Damietta branch of the River Nile, Egypt. Dadebo *et al.* [29] stated that the species is an herbivorous feeding mainly on macrophytes (45.2%), detritus (29.4%) and phytoplankton (16.8%) in Lake Ziway, Ethiopia. This is in contrast with the work of El- Sayed and Moharram [19] who reported that molluscs form a very high proportion of the food of *C. zillii.* Ahmad *et al.* [30] found that *C. zillii* in Kanye Dam, Nigeria consumed algae (32.3%), insects (25.4%), fish parts (17.7%), decayed food particles (16.9%) and unidentifiable materials (7.1%). Adams [72] reported that *C. zillii* fed mostly on green algae (16.9%), higher plants (33.6%), and zooplankton (18.4%), fish (6.3%) and insects (5.3%). Shalloof *et al.* [23] stated that *C. zillii* species did not consume food at random but can select and choose the preferred foodstuff even during different seasons.

In conclusion, it is found that the condition of the species was good, and its sizes and growth rate are better or similar to those recorded in other waters. Sexual maturity was early during the first year of its life, and the species feed on a wide range of food items, and that most of these items are available in high proportions in nature

5. References

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