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Causes of stunting in *Coptodon zilli* in Iraq

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Abstract

This study is an attempt to find out the most important reasons behind stunting phenomenon of the *Coptodon zillii* fish and some factors that lead to this phenomenon derived from four C.zilllii fish population from four province in Iraq starting from Baghdad province and other three ones situated in the south of Iraq such as Babylon or Babil , Wasit , and Maysan. It is suggested in the current study to specify four morphometric features of the C.zilllii fish as the total length , standard length , head length and weight of fish .The highest averages of such the morphometric features have been recorded by Maysan province, total length (16.59±0.61cm), standard length (12.99±0.52cm), head length(4.30±0.24cm), and weight (97.19±10.05 gm) of total length respectively. While, Babylon province has recorded the less averages for morphometric features of the C.zilllii fish population as Total length(14.87±0.33cm),Standard length(11.70±0.28cm) , Head length (3.80±0.21cm) , and Weight (72.68±8.66 gm) respectively .On the other hand , both Baghdad and Wasit provinces have recorded equal averages of the morphometric features. It has been noticed that there are statistically significant differences ($p < 0.05$) in the total and standard length as well as head length in Maysan province sample .Results showed that the total length was between (14.1 and 19.1 cm) and (70%) of the four Iraqi provinces which their length was 17cm .This indicates there are stunting existed in C.zilllii population that was very clear in Babylon province and among male fish more than among female ones .The stunting phenomenon can be due to the increasing population of C.zilllii to the early sexual growth of such fish and also to the bad quality of water at these areas surveyed by this study .Moreover, it has been noticed that there are positive correlations between all morphometric features studied $P < 0.01$) .

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Introduction

Tilapia fish is an African fish that is widely cultivated, especially in Asia and the Middle East (Yakubu, 2012). Being a good and affordable source of protein tilapia fish is at least farmed in 85 countries that make it the most extensively farmed fish worldwide (Al-Zaidy 2013). *Tilapia zilli* is an important as a food fish and for aquaculture. Recently the name of *Tilapia zilli* has been changed in to *Coptodon zillii* by Dunz and Schliewen (2013). In 2007 *C. zillii* was first recorded in Iraq by Al-Saadi *et al.* (2012) and Saleh (2007) from two locations along Euphrates River. This specie considered the most tilapia species found in Iraq.

Stunting phenomenon is a drastically reduced growth rate or a reduction in maximum size in relation to the ecological potential for an entire population of a species (Heath and Roff, 1996; Ylikarjula *et al.,* 1999). Stunting or growth retardation is commonly observed in *Centrarchidae* (Roff 1993; Aday *et al.* 2002), *Salmonidae* (L'Abée-Lund *et al.,* 1990; Roff, 1993), and *Percidae* (Jansen, 1996; Heibo *et al.,* 2005).

Numerous studies suggested many explanatory factors of stunting phenomenon in fish which mainly include intraspecific competition due to overcrowding (Sandheinrich and Hubert, 1984; Roff, 1993), food scarcity or low food availability (Eschmeyer, 1937; Linfield, 1980; Rask, 1983; Post and McQueen, 2011), increase in survival rate (Roff, 1993) and disappearance of top predators (Grimaldi and Leduc, 1973). In addition to environmental factors as well as indirect factors such as early sexual maturity which led to produce smaller individuals -common in mix sex population of tilapia species- (Loya and Flshelson, 1969; Phelps and Popma, 2000).

Indeed growth rates in fish rapidly respond to environmental changes, so this phenomenon occurs as plastic phenotypic responses to environmental change, rather than requiring genetic changes for their alteration (Roff, 1993; Linløkken and Seeland, 1996). Stunted yellow perch individuals showed normal growth after taken to optimal laboratory conditions; concluding that stunting is a result of environmental variation and not of genetic differentiation (Heath and Roff, 1996).

Based on the previous mentioned works it obviously that populations of same species found in different conditions shows different morphology and/or growth rates. The objective of this study was to define the characteristics of a stunted population of *C.zillii* in four different location of Iraq and investigate the possible factors that contribute to this condition.

Materials and Methods

A total of 160 specimens of red belly tilapia (*C.zillii*) were collected from four different Iraqi provinces with 40 fish specimens from each province. Specimens were obtained from Baghdad, Babylon, Wasit and Maysan provinces during January and February 2018. After collection, the fishes were brought to the Iraq Natural History Research Center and Museum-University of Baghdad for further analysis.

Water quality parameters of four locations including temperature, pH and dissolved oxygen were determined. Water transparency, total dissolved solids (TDS), total alkalinity (carbonate hardness-KH), total hardness (GH) and ammonia concentration were also estimated.

Morphological measurements were taken for each specimen using callipers to the nearest 1 mm. Total length (TL), standard length (SL) and head length (HL) of fish specimens were determined. Body weight (W) was measured by balance with 0.1 mg readability.

The sex of the specimens was also identified depending on fish appearance (external sexual organs) and macroscopic examination of gonads.

Length-frequency distributions were used to assess the size structure of *C.zillii* population; fish samples were grouped by 1-cm TL classes and a length frequency histogram was constructed.

Data were presented as mean ± SD. Statistical calculations were performed using SPSS 20 (IBM SPSS Inc.) Significant differences among means were determined using Duncan test at $p<0.05$ level. Correlation analysed between the parameters was also determined using SPPS Version 20.

Results and discussion

Water quality varied between provinces, especially in transparency TDS and general hardness. For ectothermal animals-which include fish-temperature is a critical environmental factor that strongly influences feeding and growth (Summerfelt, 2000).

Tilapia species have been reported to have wide range of temperature, salinity and pH adaptation (Chervinski and Hering, 1973; Chervinski and Zorn, 1974; Anthoni *et al.,* 1990; Cnaani *et al.,* 2000). According to Wohlfarth and Hulata (1983) temperature for optimum growth of tilapia species is (25-28°C), and die when temperatures are less than (10°C) (Summerfelt, 2000).

Table 1. Water quality parameters.

Water parameters	Baghdad	Babylon	Wasit	Maysan
Temperature (°C)	29	26	26.5	28
pH	8.2	7.2	7.8	7
Transparency (cm)	142	350	540	150
TDS (ppm)	520	550	320	450
Dissolved oxygen (mg/L)	18	20	22	22.5
KH (ppm)	143.2	143.2	143.2	143.2
GH (ppm)	451	451	340.1	322.2
NH_3(mg/L)	0.25	0.25	0.25	0.0

The water temperature in studied provinces varied between 26 and 29°C (Table 1) which is considered standard temperature for optimum growth of *C.zilli*. On the other hand, the general requirements of dissolved oxygen for aquaculture should be greater than 5 mg/L in order to maintain growth of warm water fish. It is important to mention the complicated relationship between these factors. While temperature controls the solubility of gases in water and the reaction rate of chemicals; pH value affects toxicity of some compounds to fish, especially ammonia and chlorine (Summerfelt, 2000).

Table 2. Range and mean of morphometric characters of *C.zilli* collected from Iraqi provinces.

Provence	Total Length (cm)		Standard Length (cm)		Head Length (cm)		Weight (g)	
	Mean±SD*	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Baghdad	15.76±0.72^{b}	14.8-17.3	12.41±0.36^{b}	12.0-13.3	4.10±0.24^{b}	3.6-4.5	85.55±4.69^{b}	77.0-96.0
Babylon	14.87±0.33^{c}	14.1-15.5	11.70±0.28^{c}	11.2-12.2	3.80±0.21^{c}	3.5-4.2	72.68±8.66^{c}	46.0-86.0
Wasit	16.35±1.29^{a}	14.5-19.1	12.87±0.90^{a}	11.5-15.0	4.21±0.37^{ab}	3.5-5.0	86.00±13.05^{b}	64.0-127.0
Maysan	16.59±0.61^{a}	15.0-18.0	12.99±0.52^{a}	12.0-14.5	4.30±0.24^{a}	3.8-4.6	97.19±10.05^{a}	81.0-127.0

Means within columns followed by different letters are significantly different ($P<0.05$).

*SD: standard deviation.

The overall sex ratio of *C.zillii* population in Iraqi provinces was F:M (1:1.5). The female percentage was the highest in Baghdad and followed by Babylon, Wasit and Maysan (62.5, 50, 25 and 20%, respectively) (Fig.1). The differences in sex ratio between provinces may belong to environmental conditions. Literature contains numerous observations on tilapia of sex ratios deviation from

the norm of a1:1 these are explained on the basis of autosomal or polygenic effects (Calhoun and Shelton, 1983; Majumdar, 1983; Mair *et al.*, 1997). Additionally Abucay *et al.* (1999) demonstrated the effect of environmental conditions during the period of sex differentiation on the sex ratio of the tilapia. They reported that high temperature can influence sex ratio of tilapia specie in the direction of both male and female with a genetic basis.

Table 3. Morphometric characters' means of male and female individuals of *C.zilli*.

Gender	Total Length (cm)	Standard Length (cm)	Head Length (cm)	Weight (g)
Male	15.75±0.79 [b]	12.38±0.63 [b]	4.01±0.32 [b]	84.18±13.00 [b]
Female	16.11±1.33 [a]	12.66±0.91 [a]	4.25±0.29 [a]	87.16±12.60 [a]

Means within columns followed by different letters are significantly different (P<0.05).

Statistical analysis showed significant differences between provinces in all studied morphometric parameters (TL, SL, HL and weight) of *C.zillii*. Fish samples that collected from Maysan had the highest total length, standard length, head length and weight followed by samples from Wasit. The specimens of Babylon provinces were significantly lower than other provinces in all studied parameters (Table 2). Similarly Jawad *et al.* (2018) reported that *C. zillii* samples that collected from three different locations along the Shatt al-Arab River; showed significant differences in some morphometric traits.

Table 4. Morphometric characters of *C.zilli* collected from Iraqi provinces.

Provence	Gender	Total Length (cm)	Standard Length (cm)	Head Length (cm)	Weight (g)
Baghdad	Male	15.45±0.53	12.22±0.29	3.89±0.15	84.27±5.06
	Female	15.94±0.76	12.52±0.36	4.23±0.19	86.32±4.37
Babylon	Male	14.92±0.37	11.62±0.27	3.61±0.10	70.20±9.86
	Female	14.82±0.27	11.79±0.27	3.99±0.07	75.15±6.62
Wasit	Male	15.72±0.63	12.44±0.49	4.08±0.29	80.60±7.29
	Female	18.24±0.80	14.16±0.57	4.60±0.32	102.20±13.33
Maysan	Male	16.44±0.59	12.88±0.52	4.25±0.23	96.23±10.68
	Female	17.19±0.16	13.45±0.20	4.51±0.06	101.00±6.02
Total	Male	15.75±0.79	12.38±0.63	4.01±0.32	84.18±13.00
	Female	16.11±1.33	12.66±0.91	4.25±0.29	87.16±12.60

The difference in the results between the four provinces could be due to differentiation at environmental and genetic factors.

In addition significant differences between male and female individuals observed in morphometric parameters. Interestingly females showed higher values in all morphometric traits (Table 3). In contrast *C. zillii* samples collected from Shatt al-Arab River did not reveal significant differences between genders (Jawad *et al.*, 2018). Effect of interaction between location and gender factors on morphometric characters is shown in Fig. 2. The interactions between these two factors were significant at p<0.01. The result demonstrate that female individuals from Wasit province showed the highest values while the Babylon province's males showed the lowest values in studied morphometric parameters (Fig.2).

The morphologic traits of *C.zillii* populations collected from Iraqi provinces showed variation depending on gender and location (Table 4). In general total length, standard length, head length and

weight of *C.zillii* populations ranged from 14.1 to 19.1 cm, 11.2 to 15.0 cm, 3.5 to 5.0 cm and 46 to 127 g, respectively.

The Fig. 3 clearly shows that most specimens were more frequent in the 15cm, 16cm and 17cm classes with the absence of the 18cm and 19cm classes in most provinces. However, 50% of individuals from Baghdad were grouped into 15cm class and more than 80% of samples from Babylon classified in to the same group. Individuals of Wasit and Maysan provinces which showed higher average of TL were more frequent in 16cm class and account for 35% and 55%, respectively. Generally the total length of most (70%) *C.zilli* samples that collected from Iraqi provinces was below 17cm.

Table 5. Correlation between morphometric parameters of *C.zilli* collected from Iraqi provinces.

	Total Length (cm)	Standard Length (cm)	Head Length (cm)
Standard Length (cm)	0.926**		
Head Length (cm)	0.735**	0.804**	
Weight (g)	0.751**	0.790**	0.646**

** Correlation is significant at the 0.01 level.

Total length of *Tilapia zillii* that caught in the Oueme River basin varied from 4.0-28cm (Lalèyè, 2006). While according to Konan *et al.* (2007) the standard length ranged from 5.5 to 24cm. On the other hand the weight of *T.zilli* ranged between 20 and 159g (Coulibaly, 2003). *Tilapia zillii* could reach to standard length of 40 cm (SL) and a weight of 300 grams (Et *et al.* 2017).

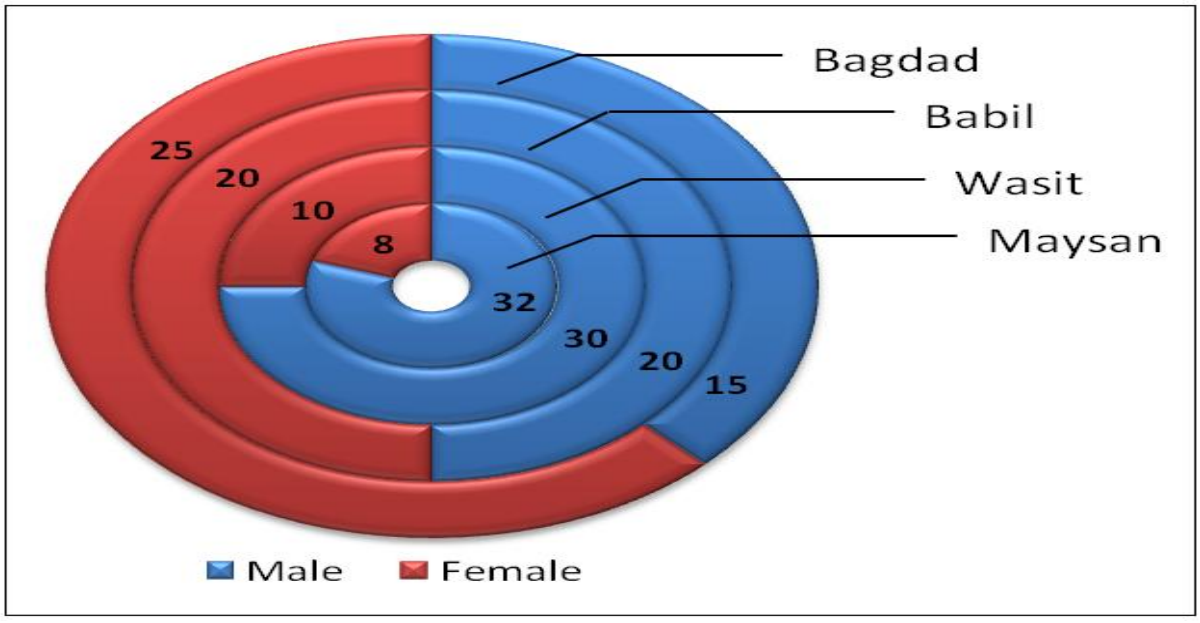

Fig. 1. Male and female count of *C.zillii* in Iraqi provinces.

It is clearly that *C.zillii* samples in our study had lower values in total length, standard length and weight compared with the values observed in the literature. Most of our samples classified in to 15cm and 16cm groups. In addition the maximum TL of samples was 17.3, 15.5, 19.1 and 18.0 cm in Baghdad, Babylon, Wasit and Maysan, respectively. Similarly Jawad *et al.* (2018) reported that samples collected from Qurna, Hartha and Abu Al-Khaseeb, Iraq showed low values of total and standard length 130-170 mm and 110-130mm, respectively. Fish might show different growth patterns due to water quality,

nutrition, habitat, density, sex and time of life stages (Ali *et al.* 2000). Tilapia species under favourable growth conditions will reach maturity within 6–8 month at a size often less than 100 g. They will continue to reproduce under proper conditions, the offspring competing with the initial stock for food, resulting in stunted growth and dwarf individuals. Stunting in tilapia species has been reported by several authors in experimental ponds as well as natural water bodies due to many reasons (Loya and Flshelson, 1969; Bruton and Allanson, 1974; Coward *et al.,* 2005; Takagi, 2009). Overcrowding, low food availability and the absence of top predators have been considered as important stressors which cause many changes in physiological aspects of fish (Eschmeyer, 1937; Echo, 1955; Grimaldi and Leduc, 1973; Sandheinrich and Hubert, 1984).

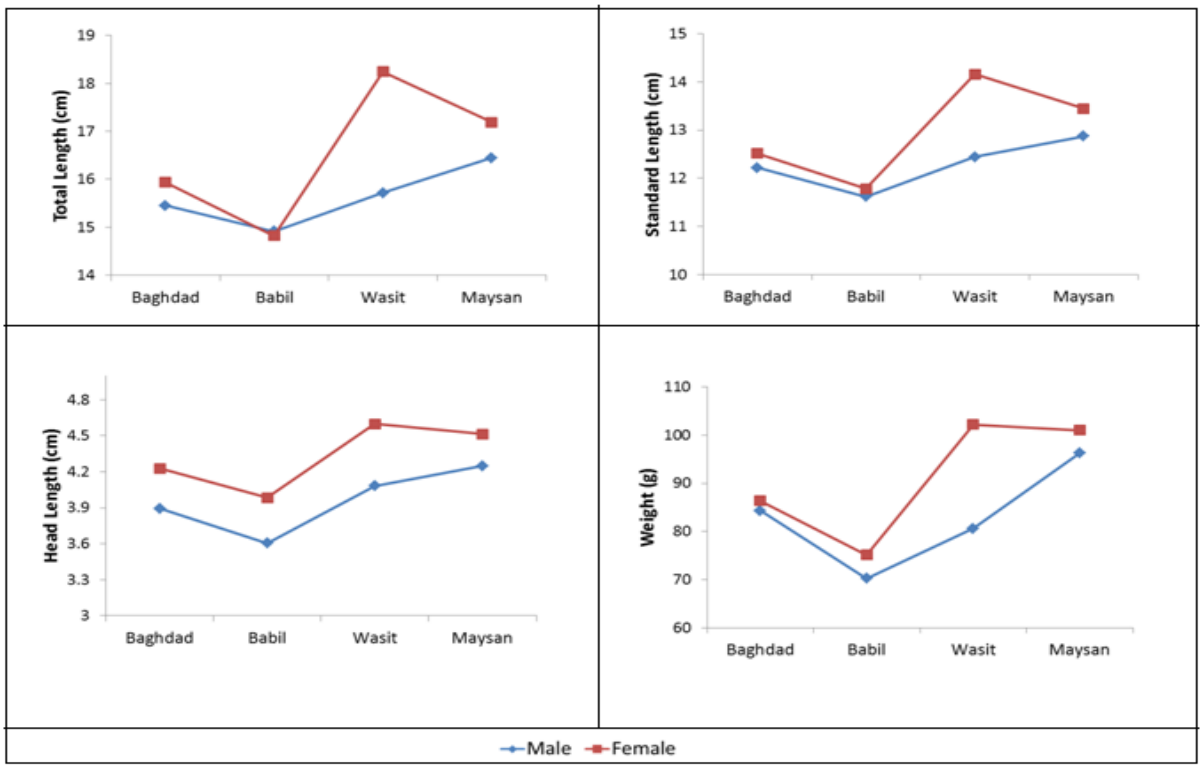

Fig. 2. Gender× location factors interaction.

In addition early sexual maturation that is common in tilapia species distracts energy from growth to reproduction, thus smaller individuals could be seen in mixed sex populations. Swingle (1960) and Verani *et al.* (1983) reported that the average weight of tilapia individuals which harvested from mixed sex tilapia populations was <100g. Therefore various techniques have been developed to control unwanted reproduction, subsequently preventing growth retardation or stunting. Fish growth also could be affected by many environmental factors such as (temperature, salinity, NH_3, etc.). The metabolic rate of ectothermal animals is said to double with each 10°C rise in temperature (Summerfelt, 2000). According to Brown (1957) the growth of *T. zillii* was very slow at 20°C, increases at 25°C and is fastest at 30°C. Achieng (1964) found that in the studied range of temperatures (23, 27 and 31°C), the growth rate of *T. zillii* increased with the rise in temperature. Fish stunting during winter also reported as a common natural phenomenon in temperate regions. On the other hand several limiting factors preventing the fish growth and development could be found in the water such as unionised NH_3 which is highly toxic if the level is higher than 1.0mg.L^{-1} (Shahabuddin *et al.,* 2015).

Based on the obtained results in our study, it is quite clear that the growth of the natural *C.zillii* populations in studied Iraqi provinces is stunted. This

stunting mainly could be due to early sexual maturity -common in tilapia species- which subsequently led to overcrowded population and resources limitation. In addition the poor quality of water in studied area could be considered another reason of stunting. The observed stunting was more evident in Babylon province where the largest individual in population was not bigger than16 cm.

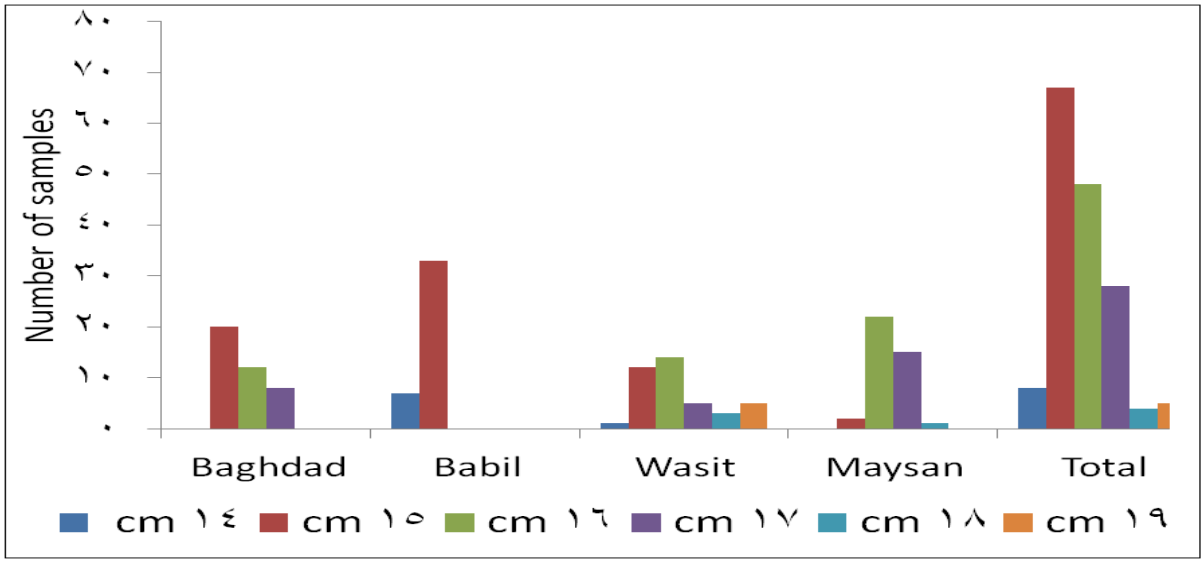

Fig. 3. Length-frequency distribution of *C. zilli* disaggregated by province.

The degree of stunting may also differ according to sex because of the different in somatic and reproductive energy allocations as well as habitat partitioning between the sexes for many fish (Diana and Mackay, 1979; Diana and Salz, 1990; Sandheinrich and Hubert, 2011).

In our study stunting was more evident in males than in females (Table 3, 4 and Fig. 3) and this result is agreed with that obtained by (Ridgway and Chapleau, 1994).

It is worth to mention that stunting is a reversible process caused by exposure of fish to high environmental conditions at an inappropriate stage of development (Björnsson *et al.,* 1988). So. stunted individuals could grow normal when transferred to optimal conditions (Heath and Roff, 1996).

With further data analysis of morphometric characteristics a significant and positive correlation between weight of individual and TL, SL and HL (R=0.75, R=0.79 and R=0.65, respectively) was found, where strong correlation (R=0.93) was found between total length and standard length (Table 5).

Conclusion

It is hoped that this study will be valuable for providing information on some morphometric features of C.zilllii fish population in Iraq .In addition, The current study has shed light on stunting as an exciting phenomenon in such fish population examined by this study ,especially after depended on the results of some morphometric measurements of such type o fish as total length average that was clarified in three-quarter of the sample of the study selected from four Iraqi provinces which was 17cm as a total length .There is a need to conduct more studies on probable reasons of such fish phenomenon .

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