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The Length-Weight Relationship and Condition Factors of Twelve Fish Species, with Special Reference to Cichlid species from the Mediterranean Manzala Lagoon, Egypt

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ABSTRACT

The length-weight relationship of fish is one of the most studied biological characteristics of fish biology. The relationship between the length and weight of fish species can provide additional insights into its morphology, life history, environmental conditions, growth pattern, and general health. In the current study, the length-weight relationship and condition factors of 12 different fish species were assessed mainly during dredging operations in Manzala Lagoon. In addition, the length distribution was analyzed for cichlid species. A total of 6375 samples of fish species were collected between November 2019 and October 2021 from several sites covering the lagoon's water body using different fishing gear and methods. The studied species were found to belong to six families, namely Cichlidae, Clariidae, Bagridae, Mugilidae, Moronidae, and Anguillidae. The results of the present study recorded that half of the species had isometric growth, and the other half showed allometric growth. The (*b*) values of pooled data obtained from the twelve species ranged from 2.83 to 3.34. The findings of this study showed that the condition factor (K) of the studied fish was in good condition except for *A. anguilla, C. gariepinus, C. auratus,* and *B. bayad* (0.2199, 0.7287, 0.8109, and 0.8306, respectively). *A. anguilla* (0.2199) had the lowest condition factor, while *C. zillii* (1.901) recorded the highest. The values of both parameters (*b* and K) indicate the good well-being of fish in the lagoon. Intensive studies are recommended on Manzala Lagoon after the completion of the dredging operations. The data provided in the current study can be utilized as a basis for the effective management of these species' fishery in Manzala Lagoon.

INTRODUCTION

Lake Manzala is the largest Mediterranean lagoon in Egypt, with an area of approximately 572.41km^2 in 2020 **(Abd Ellah, 2021)**. It is one of the most important sources of inland fisheries in Egypt since it represents more than 40% of the total fish production of the northern natural lakes in Egypt **(GAFRD, 2022)**. Lake Manzala is greatly important, locally and internationally, since it is the largest brackish coastal lake adjoining the Nile Delta **(Dumont & El-Shabrawy, 2007)**; consequently, it has a high value for the biodiversity in the Mediterranean region **(Ali & El-Magd, 2016; Abd**

Ellah, 2021; Mahmoud *et al*., 2022). Due to its size and economic activity, Manzala Lake is a highly influential lake in Egypt **(El-Fadaly *et al*., 2019)**. It is expected to have a role in relieving the effects of climate change, and it plays a key role in protecting coastal cities from floods and storm inundation **(Ali & El-Magd, 2016**; **Mahmoud *et al*., 2022)**.

The Egyptian government has started the implementation of a national project to develop the Egyptian lakes, with a major focus on the Manzala Lake. Recently, a national project for the purification and dredging of Lake Manzala (since May 2017) aimed to clean up and develop Lake Manzala. The clearing and development of Lake Manzala have taken important steps toward restoring the lake's natural state being one of the largest lakes in northern Egypt.

The length-weight relationship of fish is one of the most studied biological characteristics of fish biology. In fisheries science, length-weight relationships (LWRs) are significantly important. Fisheries studies usually involve length and weight measurements since these variables constitute the foundation for more study and management evaluation in the field of fisheries sciences **(Masoumi *et al*., 2023)**. The relationship between a fish individual's length and weight can provide additional information on its morphology, life history, environmental conditions, growth pattern, and general health **(Froese, 2006; Tesch, 1986; Ricker, 1975; Geraci *et al*., 2018)**. Eminently, the condition factor (K) is a parameter of the state of well-being of fish based on the hypothesis that heavier fish of a particular length is in a better physiological condition **(Bagenal, 1978)**. Additionally, factor K can also be used as an index to assess the status of the aquatic ecosystem **(Edah *et al*., 2010)**.

This study provided information on the LWRs of twelve fish species from Manzala Lake that will be useful in their fisheries and conservation management. It is marked that the family Cichlidae dominates fish biodiversity in Lake Manzala **(Shalloof *et al*., 2023)**. Moreover, its production constitutes about 50% of the total production of the lagoon **(GAFRD, 2022)**. The present work aimed mainly to provide a preliminary assessment of the conditions of different fish species, with special reference to four cichlid species (*Oreochromis niloticus, O. aureus, Coptodon zillii,* and *Sarotherodon galilaeus*) during dredging operations to provide more effective management of this vital water body. This research could be the first step in assessing the impact of dredging operations on some biological aspects of different fish species.

MATERIALS AND METHODS

Study area

Lake Manzala is located between latitudes 31°05'N and 31°25'N, and longitudes 31°47'E and 32°17'E (Fig.1). The lagoon is surrounded by Dakahlia Province from the South, the Mediterranean Sea from the North and Northeast, the Suez Canal from the East, and the Damietta Branch of the Nile from the West **(Hossen & Negm, 2016)**. Narrow channels connect the lagoon with the Mediterranean Sea; the two main channels are El-Gamil and the New El-Gamil. El-Qabouti Canal, located a few kilometers south of Port Said City, connecting the lagoon to the Suez Canal. The Enanya Canal links the lagoon's western area to the Nile's Damietta Branch **(Sallam & Elsayed, 2018)**.

Sampling

Five surveys have been conducted during dredging operations between 2019 and 2021 in Lake Manzala (Fig.1). The sampling sites were selected to cover and represent the whole water body of the lake. Fish samples were collected from the commercial fishing gears and methods employed in the lagoon regions. Trammel nets (*Balla* and *Kaffaya*), basket traps (*Gawabi*), spiral traps (*Tahaweet- Dorra*), trawl nets, noodling (i.e. fishing with bare hands) (*Kadamat*) & longlines (*Sinnar*) were the most common fishing gear and methods implemented in Lake Manzala during dredging operations **(Shalloof *et al.*, 2022)**. From different locations in Lake Manzala, a total of 6375 specimens (2708 of *Oreochromis niloticus*, 1911 of *O. aureus*, 642 of *Coptodon zillii*, 351 of *Sarotherodon galilaeus*, 77 of *Clarias gariepinus*, 55 of *Bagrus bayad*, 269 of *Chelon ramada*, 135 of *Chelon auratus*, 57 of *Mugil cephalus,* 80 of *Dicentrarchus labrax*, 35 of *D. punctatus*, and 55 of *A. anguilla*) were collected.

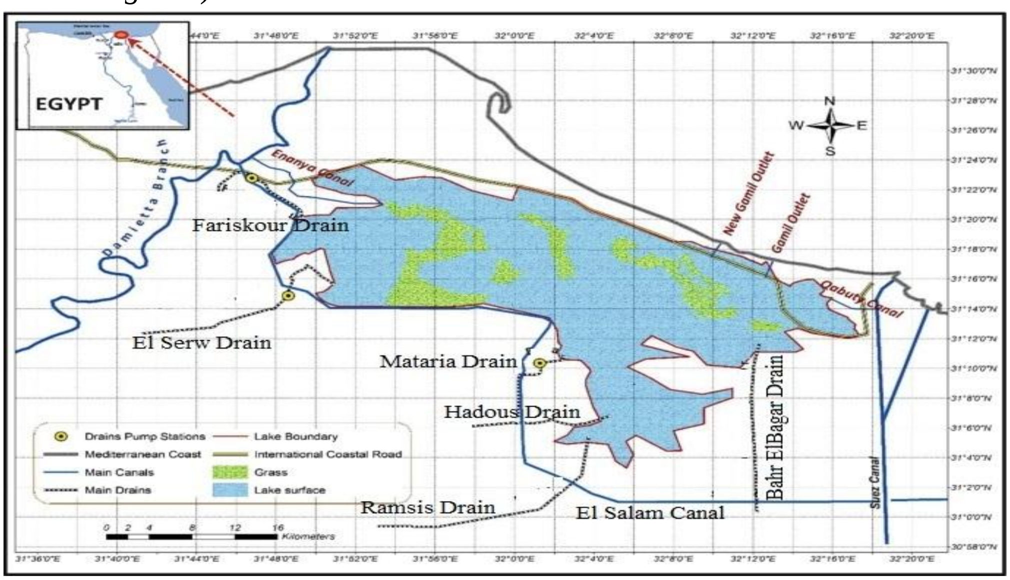

Fig. 1. A map showing Manzala Lagoon

Data analysis

Each fish's total length and total body weight was measured to the nearest 0.1cm and 0.1g, respectively. The length-weight relationship of the studied fish species was estimated for the pooled samples and during different seasons using the formula:

$W = aL^{b}$ **(Ricker, 1975)**

Where, W = Weight of fish (g); L = Total Length of fish (cm), and *a* and *b* are constants.

The values of the exponent (*b*) provide information on fish growth. The (*b*) ideal value is 3, which represents isometric growth. When $b < 3$, fish are slimmer with an increasing length, and growth is negative allometric. Fish with $b > 3$ are heavier show positive allometric growth. The null hypothesis of the isometric growth (H_0: b = 3) was tested by *t-test*, using the equation:

$$t_s = (b-3)/S_b,$$

Where, t_s is the student's *t-test*; b is the slope, and S_b is the standard error of the slope for α = 0.05 for testing significant differences among slopes (b) between two regressions for the same species **(Sokal & Rohlf, 1987; Morey *et al*., 2003; Zar, 2010)**.
The condition factor was calculated using the formula:
$K = 100\ W/ L^3$ **(Pauly, 1993)**
Where, K = Condition factor; L =Total length (cm), and W = Total weight (g).

RESULTS

Length-frequency distribution of cichlid species

With respect to the total number (T.no.) of samples, the length of *O. niloticus* (T.no. 2708) ranged from 4– 28cm, whereas that of *O. aureus* (T.no. 1911) ranged from 5– 25cm. The length range of *S. galilaeus* (T. no. 351) was 7– 23cm. While in *C. zillii* (T. no. 642), the length ranged from 3– 16cm. The most frequent lengths were 14– 15cm (13 and 14%, respectively); 15cm (19.1%), 7- 9cm (18–20%), and 14– 15cm (12.8 and 13.6%) for *O. niloticus, O. aureus, C. zillii*, and *S. galilaeus*, respectively (Fig. 2).

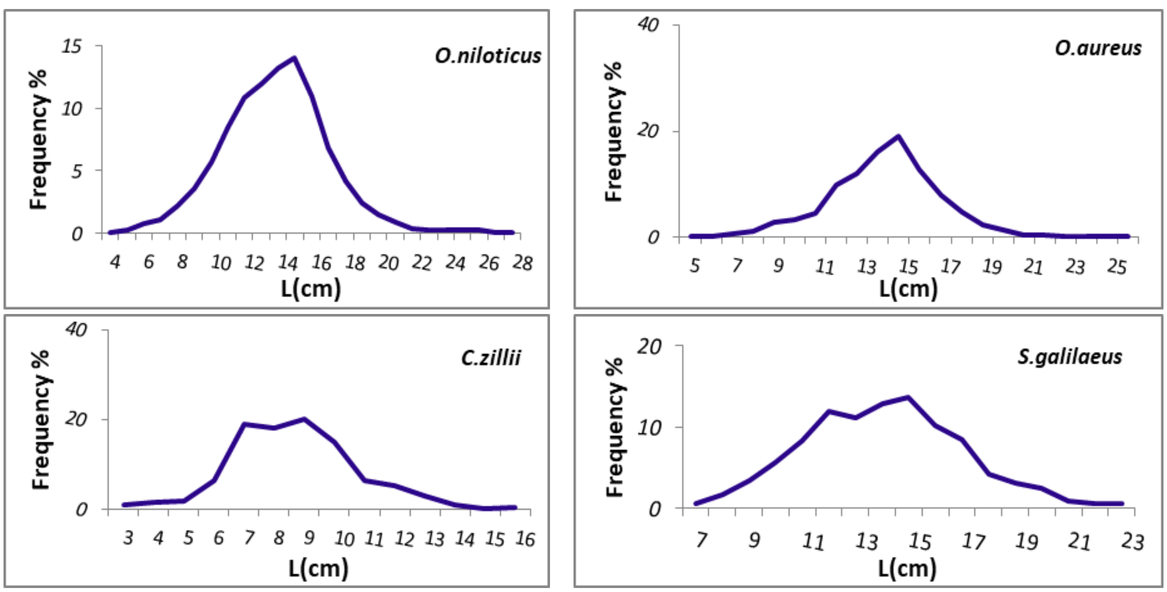

Fig. 2. Length- frequency distribution of different cichlid fish species collected from Manzala Lagoon during the study period

Length- weight relationship

The length-weight relationship of 3078 specimens, comprising 1374 *O. niloticus*, 763 *O. aureus*, 143 *C. zillii*, 350 *S. galilaeus*, 182 *C. ramada*, 38 *C. auratus*, 51 *D. labrax*, 42 *D. punctatus*, 58 *C. gariepinus*, 53 *A. anguilla*, 14 *B. bayad*, and 10 *M. cephalus*, and its parameters of pooled data for the different studied 12 species are given in Table (1). All twelve species' R^2 values were greater than 0.90, and the range of *b* values ranged between 2.83 and 3.34.

Based on the *t*-test results of *b*-values, six species showed an allometric growth ($P< 0.05$), and four of them had positive allometric growth (*O. niloticus*, *C. gariepinus*, *A. anguilla*, and *C. auratus*), while the other two species showed a negative allometric growth (*C. zillii* and *O. aureus*). On the other hand, the remaining six species (*S. galilaeus*, *B. bayad*, *C. ramada*, *M. cephalus*, *D. labrax*, and *D. punctatus*) exhibited isometric growth ($P> 0.05$) (Table 1).

Table 1. Different parameters of length-weight relationships of different 12 fish species from Manzala Lagoon during the period of study

Species	N	*a*	*b*	S_b	R^2	P	GT
O. niloticus	1374	0.0166	3.0256	0.013	0.9767	0.0430	(+)A
O. aureus	763	0.0187	2.9612	0.018	0.9712	0.0361	(-)A
C. zillii	143	0.0237	2.8948	0.043	0.9693	0.0166	(-)A
S. galilaeus	350	0.0203	2.9457	0.033	0.9572	0.2004	I
C. gariepinus	58	0.0042	3.1584	0.041	0.9906	0.0003	(+)A
B. bayad	14	0.0181	2.7824	0.210	0.9361	0.3186	I
C. ramada	182	0.0095	2.9717	0.040	0.9689	0.4769	I
C. auratus	38	0.0032	3.3394	0.068	0.9852	1.6×10^{-05}	(+)A
M. cephlalus	10	0.0125	2.9522	0.048	0.9979	0.3485	I
D. labrax	51	0.0116	2.9631	0.046	0.9882	0.4292	I
D. punctatus	42	0.0154	2.8321	0.088	0.9630	0.0628	I
A. anguilla	53	0.0006	3.3365	0.111	0.9470	0.0037	(+)A

N: Number of examined specimens. S_b: Standard error of the slope (b) with 95% confidence interval (*t*-test). R^2: Coefficient of determination. P: Significance level of b versus 3 for length-weight relationship. GT: The growth type (I: Isometry, (–) A: Negative allometry, (+) A: Positive allometry).

In addition, seasonal variations in maximum, minimum, average length, weight, and different parameters of the length-weight relationship of different cichlid species are shown in Table (2).

Table (2) shows that *O. niloticus* and *O. aureus* had the maximum average lengths of 14.47– 16.47cm and weights of 61.18– 104.42g throughout all seasons, respectively, whereas *C. zillii* exhibited the minimum average lengths of 9.79– 10.73cm and weights of 18.93- 29.39g. The maximum lengths and weights of *O. niloticus* and *O. aureus* were recorded in the autumn season (25.7- 28 & 22- 25.9cm; -284.8- 408.5 & 199.6- 295g, respectively), whereas the maximum lengths and weights of *C. zillii* were recorded in the winter and autumn seasons (16.0- 16.5cm & 78- 87g, respectively).

The average values of *b* for the cichlid species during different seasons ranged from 2.8178 to 3.2075 for *O. aureus* and *S. galilaeus* during the winter and summer seasons, respectively. The "*b*" values for *O. niloticus*, *O. aureus*, and *S. galilaeus* that were noted in the autumn were greater than 3 (3.02, 3.01, and 3.02, respectively) (Table 2).

Table 2. The maximum, minimum, average length (cm), weight (g), and different parameters of the length-weight relationship of different cichlid species during different seasons at Manzala Lagoon throughout dredging operations

Season	Species	Max. L.	Min. L.	Av. L.	Max. wt.	Min. Wt.	Av. wt.	*a*	*b*	R^2
Winter	*O. niloticus*	26	9	16.47	355	12	104.42	0.0216	2.9615	0.9816
	O. aureus	25	5	15.78	263	3	84.23	0.0292	2.8178	0.9919
	C. zillii	16	5.1	10.36	78	3	29.09	0.0229	2.921	0.9889
	S. galilaeus	23	7.9	14.44	219	7	59.83	0.0217	2.9238	0.9653
Spring	*O. niloticus*	26.5	7.2	14.47	340	5.7	61.18	0.0161	3.0325	0.9703
	O. aureus	22	10	15.2	199.6	17.4	68.8	0.0182	2.990	0.958
	C. zillii	15	9	10.73	60.4	13.4	29.39	0.0283	2.860	0.9935
	S. galilaeus	-	-	-	-	-	-	-	-	
Summer	*O. niloticus*	25.7	7	15.79	284.8	6.6	76.59	0.0176	2.996	0.9840
	O. aureus	24.8	9.9	15.40	265	15.5	64.66	0.0174	2.975	0.9542
	C. zillii	14.1	3.0	9.797	48	0.6	18.93	0.0193	2.951	0.9894
	S. galilaeus	19	10.8	14.37	125	20.1	54.35	0.0098	3.2075	0.9633
Autumn	*O. niloticus*	28	4	15.03	408.5	2.1	75.60	0.0168	3.0289	0.9782
	O. aureus	25.9	5	15.03	295	2.4	67.14	0.0166	3.0114	0.979
	C. zillii	16.5	3	9.97	87	1.2	26.02	0.0292	2.8503	0.9661
	S. galilaeus	7	23	14.05	240.3	7	69.61	0.0200	3.0152	0.9766

(-): Did not appear or showing with very few individuals in the sample.

Condition factor

The condition factor (K) of the studied fish species ranged from 0.2199 to 1.9008, indicating that most of the fish species were in good condition, except for *A. anguilla*, *C. gariepinus*, *C. auratus*, and *B. bayad* (K = 0.2199, 0.7257, 0.8109, and 0.8306, respectively). The highest condition factor was recorded for *C. zillii*, followed by *S. galilaeus* and *O. niloticus* (1.901, 1.8240, and 1.7885, respectively) (Table 3). The lowest value of K was recorded for *A. anguilla* (0.21985). The K value of most studied species was greater than 1, which indicates that the well-being of different fish species was good.

Table 3. The mean (±SD), maximum (Max.) and minimum (Min.) condition factor (K) of different 12 fish species collected from Manzala Lagoon

Species	Max. K	Min. K	Mean K±SD
O. niloticus	3.3	0.91	1.7885±0.21
O. aureus	2.71	0.95	1.6911±0.20
C. zillii	4.44	1.27	1.9008±0.37
S. galilaeus	2.8	1.24	1.8240±0.24
C. gariepinus	0.99	0.58	0.72^7±0.08
B. bayad	0.97	0.67	0.8306±0.11
C. ramada	1.40	0.45	1.7523±0.12
C. auratus	0.98	0.61	0.8109±0.08
M. cephlalus	1.14	0.92	1.0684±0.07
D. labrax	1.43	0.81	1.0485±0.12
D. punctatus	1.45	0.74	1.0039±0.15
A. anguilla	0.29	0.16	0.2199±0.03

Seasonal variations in the condition factor of different cichlid species (Table 4) show that the mean best condition of *O. niloticus* and *O. aureus* was higher in the winter season (1.96 and 1.80, respectively) compared to the other seasons. In addition, the mean best condition factor (K) of *C. zillii* was recorded in both the spring and autumn seasons (2.13). The maximum values of K of *O. niloticus* were recorded in the winter and autumn seasons (3.3 and 3.28, respectively),while *O. aureus* and *C. zillii* were detected in autumn (2.7 and 4.44, respectively) and *S. galilaeus* in the winter season (2.8) (Table 4).

Table 4. The mean seasonal values, maximum (Max.) and minimum (Min.) of the condition factor (K) of different cichlid fish species collected from Manzala Lagoon

Season	Species	Mean K± SD	Max. K	Min. K
Winter	*O. niloticus*	1.96±0.23	3.3	1.62
	O. aureus	1.80 ±0.19	2.4	1.39
	C. zillii	1.93±0.24	2.3	1.59
	S. galilaeus	1.78±0.22	2.8	1.37
Spring	*O. niloticus*	1.76±0.21	2.63	0.91
	O. aureus	1.79±0.21	2.20	1.47
	C. zillii	2.13±0.42	3.32	1.79
	S. galilaeus	-	-	-
Summer	*O. niloticus*	1.75±0.14	2.39	1.35
	O. aureus	1.63±0.17	2.16	1.20
	C. zillii	1.73±0.16	2.31	1.42
	S. galilaeus	1.71±0.16	2.10	1.38
Autumn	*O. niloticus*	1.83±0.24	3.28	0.91
	O. aureus	1.72±0.20	2.71	1.27
	C. zillii	2.13±0.49	4.44	1.27
	S. galilaeus	2.09±0.25	2.62	1.24

DISCUSSION

The Egyptian government launched an extensive program for the development of Egyptian wetlands, with the maintenance of the aquatic basin of Manzala Lagoon given a high priority. After these efforts, the total lake area of Manzala Lake extended gradually to 572.41km^2 in 2020, with the open water area increasing to about 75% of the total lake area. The dredging operations, especially in front of the sea-lagoon connection channels, were conducted to increase the flow of seawater into the lagoon **(Abd Ellah, 2021; Mahmoud *et al*., 2022)**.

Family Cichlidae constituted about 50% of the total catch of Manzala Lagoon during 2020, followed by Mugilidae and Clariidae (28 and 17%), respectively **(GAFRD, 2022)**.

Schneider *et al*. (2000) and **Froese (2006)** reported that, the importance of determining length-weight relationships (LWRs) in fish has been cited by fisheries biology studies focusing on environmental factors and the ecology of species (morphological features, health conditions, and habitat conditions). If the value of b = 3, **Ricker (1958)** used the expression "isometric growth", and **Tesch (1986)** used the term "allometric growth" for values other than b = 3.

In the present study, six species showed an allometric growth, four of which had a positive allometric growth (*O. niloticus*, *C. gariepinus*, *A. anguilla*, and *C. auratus*), while the other two species showed a negative allometric growth (*C. zillii* and *O. aureus).* On the other hand, the remaining six species (*S. galilaeus*, *B. bayad*, *C. ramada*, *M. cephalus*, *D. labrax*, and *D. punctatus*) showed an isometric growth pattern. The positive allometric growth indicates that the fish body becomes proportionally stouter or deeper since it increases in length, while the negative allometric growth implies that the fish becomes slenderer since it increases in weight. On the other hand, the isometric growth is associated with no change in the body shape while an organism grows **(Riedel *et al*., 2007; Nehemia *et al*., 2012)**.

The mean *b* value of length-weight relationships based on TL was between 2.83 and 3.34 for all twelve species, being within the expected range of 2 to 4 **(Tesch, 1971)**. Variation in b value in fish might be due to several factors, including habitat, species, season, locality, health, sex, gonad maturity, stomach fullness and preservation techniques **(Le Cren, 1951; Esmaeili, 2001; Sadeghi & Esmaeili, 2018; Eagderi *et al*., 2020; Purrafee Dizaj *et al*., 2020; Al Jufaili *et al*., 2021)**. Differences in the LWRs could be due to the combination of one or more of the above factors. In addition, differences in the exponent (b), which provides information on fish growth, may be ascribed to climate change (especially temperature). The gonad state and feeding intensity may explain the seasonal variations in the value of "b," whether it is allometric or isometric growth. This might also be the reason for the changes detected in K values during the year.

In the present study, *O. niloticus* and *O. aureus* among cichlids had maximum average lengths of 14.47– 16.47cm and weights of 61.18– 104.42g during all seasons, respectively, whereas *C. zillii* showed minimum average lengths of 9.79– 10.73cm and weights of 18.93- 29.39g. This may be attributed to *O. niloticus* having the highest growth rate, while *C. zillii* had the lowest, as recorded by **Ibrahim *et al*. (2008)**.

The K value of most species in the present study was greater than 1, as an evidence of compatibility with the environment to achieve good growth. The best condition factor was recorded for *C. zillii*, followed by *S. galilaeus* and *O. niloticus* (1.901, 1.8240, and 1.78853, respectively). The lowest value of K was recorded for *A. anguilla* (0.21985). Numerous factors, such as sex, age, state of maturity, size, state of stomach, illness, sampling methods, sample sizes, and environmental condition affect fish conditions and the parameters of length-weight relationships in fish **(Ama-Abasi, 2007; Yem *et al*., 2007; Adeyemi *et al*., 2009)**. In addition, the mean values of K of *O. niloticus, O. aureus, S. galilaeus,* and *C. zillii* were considered high when compared to those recorded in the study of **Bakhoum and Abdallah (2002)** conducted on Lake

Manzala. The same observation was recorded for *C. ramada*, compared to the results of by **Krareem *et al*. (2009)** in Manzala Lagoon , and even the eastern Mediterranean **(Jisr *et al*., 2018)** (Table 5).

Few investigations were conducted on the biological characteristics of *D. labrax* and *D. punctatus* in Manzala Lagoon. The K value of *D. labrax* in the present study (1.048) was close to that recorded by **Bakhoum *et al*. (2015)** in the Mediterranean water of Egypt (1.04), but it was less than the estimated value (1.26) of **Shalloof *et al*. (2019)** (Table 5). The K value of *D. punctatus* in the present study was higher than that recorded by **Omar *et al*. (2022)** in Bardawil Lagoon. However, it is considered close to that recorded by **Hassan and El-Feky (2022)** in the Bitter Lakes (1.00). The condition of *C. gariepinus* in Manzala Lagoon (0.73) is more than that recorded by **Keyombe *et al*. (2015)** in Lake Naivasha, Kenya, but nearly the same value (0.76) in Asi River, Turkey **(Şimşek *et al*., 2022)**. Biological studies on *A. anguilla* in Lake Manzala are exceedingly rare. The K value (0.22) recorded for *A. anguilla* in the current study is less than that recorded in the study of **Maric *et al*. (2022)**, who recorded a range of 0.13- 0.25 for the same species in Lake Skadar (Montenegro). On the other hand, an extreme range of 171- 1.98 was recorded in Lake Manzala **(Ezzat *et al*., 1984)** and Um-Hufayan Lagoon, Libya **(Abdelhamid *et al*., 2018)**. These variations may be traced back to the differences in environmental conditions, sampling methods and feeding habits. Furthermore, the dredging activities that have been occurred in Manzala Lagoon may have affected the food chain, availability of small crustaceans, and even the sustainable habitat.

Seasonal variations in the condition factor (K) of the studied cichlid species show that, the maximum values of K of *O. niloticus* were recorded in both the winter and the autumn seasons (3.3 and 3.28, respectively), while *O. aureus* and *C. zillii* values of 2.7 and 4.44, respectively, were recorded in autumn and those for *S. galilaeus* were assessed in winter (2.8). These variations may be due to the feeding intensity in these seasons. In this context, **Shalloof *et al*. (2010)** recorded that feeding intensity and the highest percentage of stomachs containing food of cichlid species in the Rosetta branch of the River Nile occurred during winter.

Table 5. Comparison of length range, parameters of length-weight relationship (a and b) and condition factor (K) of the studied species from Lake Manzala and different localities

	Location		L. range (cm)	a	B	K	Author/s
O. niloticus	Manzala Lake		4-20	0.021	2.98	1.96	**Bayoumi and Khalil (1988)**
				0.015	3.03		**Abdel-Baky and El-Serafy (1990)**
			5-21	0.042	2.7		**Soliman *et al*. (1998)**
		Southwest(A)	8-16	0.07	2.75	1.63	**Bakhoum and Abdallah (2002)**
		Southeast (B)	5-15	0.017	2.95	1.32	
			4–28	**0.017**	**3.026**	**1.789**	**Present study**
au reu	Manzala		3-17	0.023	2.9	1.93	**Bayoumi and Khalil (1988)**

	Lake		5-20	0.057	2.56		**Soliman *et al*. (1998)**
		Southwest(A)	8-17	0.02	2.87	1.47	**Bakhoum and Abdallah (2002)**
		Southeast (B)	5-18	0.009	3.2	1.45	
			5-26	**0.019**	**2.961**	**1.691**	**Present study**
S. galilaeus	Manzala Lake		3-19	0.023	2.93	2.09	**Bayoumi and Khalil (1988)**
				0.016	3.01		**Abdel-Baky and El-Serafy (1990)**
			6-19	0.027	2.91		**Soliman *et al*. (1998)**
		Southwest(A)	8-14	0.032	2.73	1.75	**Bakhoum and Abdallah (2002)**
		Southeast (B)	5-18	0.011	3.13	1.47	
			8.5-24.5	0.013	3.1		**Makkey (2021)**
			7.5-23	**0.020**	**2.946**	**1.824**	**Present study**
C. zillii	Manzala Lake		2-14	0.021	2.98	2.04	**Bayoumi and Khalil (1988)**
				0.014	3.07		**Abdel-Baky and El-Serafy (1990)**
			5-17	0.051	2.64		**Soliman *et al*. (1998)**
		Southwest(A)	6-14	0.051	2.52	1.65	**Bakhoum and Abdallah (2002)**
		Southeast (B)	6-16	0.013	3.09	1.68	
			3–16	**0.023**	**2.894**	**1.900**	**Present study**
C. ramada	Manzala Lake				2.93		**Fayek (1973)**
					2.95		**Youssef (1973)**
				0.008	3.05	0.75	**Krareem *et al*. (2009)**
	Bardawil Lagoon		11.6-45.8	0.017	2.76		**Dessouky *et al*. (2016)**
			13-41.7	0.0123	2.84	0.77	**Fetouh and El-Far (2023)**
	Lebanon		24-37	0.151	2.17	1	**Jisr *et al*. (2018)**
	Manzala Lake		**11-39**	**0.010**	**2.972**	**1.752**	**Present study**
D. labrax	Bardawil Lagoon		18.1-63.3	0.0109	2.96	0.97	**Fetouh and El-Far (2023)**
			18-62	0.008	3.08		**El-Drawany *et al.* (2022)**
			21-63	0.008	3.04		**Abdalla (2019)**
			18.4-63.3	0.009	3.01	1.26	**Shalloof *et al*. (2019)**
	El-Maadiya		18-38	0.029	2.68	1.04	**Bakhoum *et al*. (2015)**
	Welsh		35-65	0.017	2.87		**Carroll (2014)**
	Greek	Klisova Lagoon	14-34.3	0.008	3.07		**Moutopoulos *et al*. (2011)**
		Papas Lagoon	14-43.3	0.008	3.08		
	Manzala Lake		**10–55.8**	**0.012**	**2.963**	**1.049**	**Present study**
D. punctatus	Bardawil Lagoon		10.1-34.7	0.01	2.99	0.93	**Omar *et al*. (2022)**
	Bitter Lakes		22.5-44.4	0.006	3.13	1	**Hassan and El-Feky (2022)**
	Manzala Lake		**9-22.5**	**0.016**	**2.832**	**1.004**	**Present study**

C. gariepinus	Abu-Zaabal Lakes		26.0-46.0	0.079	2.37	1.14	**Shalloof and El-Far (2009)**
	Nile River		15.0-53.0	♂0.04	2.6		**Tharwat (2000)**
				♀0.02	2.75		
	Lake Naivasha, Kenya		23.0-71.0	0.002	3.23	0.55	**Keyombe *et al*. (2015)**
	Illizi South-East, Algeria		34.0-50.0	0.061	2.42		**Behmene *et al*. (2021)**
	Asi River, Turkey		20.5-62.5	0.009	2.94	0.76	**Şimşek et al. (2022)**
	Manzala Lake		**15–59.2**	**0.004**	**3.159**	**0.726**	**Present study**
C. auratus	Bardawil Lagoon		12.2-30.6	0.0102	2.93	0.81	**Fetouh and El-Far (2023)**
			12.2-33.6	0.007	3.05		**Mrizek *et al*. (2021)**
	Köyceğiz Lagoon, Turkey		6.2-39.3	0.009	2.96	0.56-1.30	**Reis and Ateş (2019)**
	Manzala Lake		**11-.24**	**0.004**	**3.159**	**0.811**	**Present study**
A. anguilla	Manzala Lake		31-66	0.003	3.276	1.96	**Ezzat *et al*.,(1984)**
	Bardawil Lagoon		24.7-55.4	0.0008	3.17	0.15	**Fetouh and El-Far (2023)**
	Um-Hufayan Lagoon, Libya		23.1-44.4	0.016	3.23	1.71-1.98	**Abdalhamid *et al*. (2018)**
	Comacchio Lagoon, Italy		13.5-105	0.001	3.22		**Castaldelli *et al*. (2014)**
	La Albufera de Valencia (Spain)		35.1–85.2	0.001	3.32		**Boulenger *et al*. (2015)**
	Stour (Britain)		33.3–71.0	0.001	3.2		
	Scheldt (Belgium)		35.4–83.7	0.007	2.26		
	Burrishoole (Ireland)		31.8–63.5	0.003	2.86		
	Manzala Lake		**34–74**	**0.0006**	**3.337**	**0.220**	**Present study**

CONCLUSION

The good well-being of the most studied fish species was observed in this lagoon during the period of study. Dredging and cleaning operations in Manzala Lagoon have a positive effect on the condition of the most studied species. We recommend conducting intensive studies on Manzala Lagoon after the completion of dredging operations, especially on the effect of environmental conditions on the biological aspects of fish. In addition, insufficient time had passed to evaluate the long-term impact of dredging operations. Further studies are recommended after the completion of these operations to confirm the impact of dredging on the different biological aspects.

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