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A comparative biological study on *Oreochromis niloticus* from two Nilotic Canals in the Delta of Egypt

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ABSTRACT

Bahr Shebeen canal (BSC) and Khadraweya canal (KHC) are two Nilotic canals, the first is less polluted and the second is polluted. Oreochromis niloticus is the major fish species in the Nile and its branches, and consequently, this study is carried out on their biological parameters are studied to investigate the effect of pollution in those habitats. These included: various parameters of growth, mortality, survival rates, stomach-somatic index, gonado-somatic index, and hepato-somatic index. It was found that there is a significant decline in those parameters in the fish of KHC, as compared to BSC, which could be tied to pollution in that canal.

INTRODUCTION

Compounds present in polluted water are capable of causing biological alterations that can affect particular populations (Rajaguru *et al.*, 2003). Globally, freshwater fishes are the most threatened group of species, due to human impacts within watersheds that change hydrology, water quality, and water availability and climate changes that affect precipitation and runoff, water temperature, and water chemistry (Arthington *et al.*, 2016; Lacy *et al.*, 2017). Also, the diversity, distribution and the population size as well as the state of health in fishes are affected mainly by the water quality (Arimoro *et al.*, 2007).

Fish are an integral component of the aquatic ecosystems. In addition to being a source of protein to humans, they are one of the most indicative species in freshwater systems because they respond with great sensitivity to any change of their surroundings. Fish are usually considered as organisms of choice for assessing the effects of environmental changes and they are used as bio-indicators in monitoring the water pollution of the aquatic ecosystem (Borković *et al.*, 2008; Mohamed *et al.*, 2017). For this reason, the utility of fish for assessing environmental conditions in aquatic ecosystems has gained prominence in previous years (Khallaf *et al.*, 1998, 2003; Yilmaz, 2003; Budambula and Mwachiro, 2006; Adeniyi *et al.*, 2008; Authman, 2008; Authman *et al.*, 2008; Palaniappan *et al.*, 2010; Authman *et al.*, 2012, 2013a, b, 2015; Abdel-Tawwab *et al.*, 2016).

A commonly used fish species in environmental studies are the Nile tilapia, *Oreochromis niloticus*, is one of the most common freshwater fish used in fundamental field and laboratory research and toxicological studies (Rashed, 2001; Authman, 2008; Authman *et al.*, 2012, 2013a; AbouelFad *et al.*, 2016), Moreover, *Oreochromis niloticus* presents a number of characteristics that may make it an appropriate model that can be used as an indicator species in biomonitoring programmers (Gadagbui *et al.*, 1996). The Nile tilapia is a native fish species of Egypt that has become a popular species worldwide; mainly as a valuable fish, easy to breed and grow in a variety of aquaculture systems (Peterson *et al.*, 2004; Peña-Mendoza *et al.*, 2005; El-Sayed, 2006; Authman *et al.*, 2013a).

The growth of fish is responsive to various environmental factors, such as physico-chemical factors and fishing (Ricker, 1975; Khallaf *et al.*, 2016). In this respect, less polluted Bahr She been (BSC), and polluted Khadraweya (KHC) Nilotic canals represent a challenge to research and assess each canal condition on fish. Therefore, in this study, the various biological parameters of *O. niloticus* in BSC and KHC were assessed to show changes that would be related to the conditions prevailing in each canal.

MATERIALS AND METHODS

Study Area

Bahr Shebeen Canal (BSC) (Fig. 1) is an irrigation canal with a depth of 3-5 meters and about 30 m wide, and extends about 80 kms through three different governorates in the Delta of Egypt (Khallaf and Alne-na-ei, 1987; Khallaf *et al.*, 2016). It is surrounded by two major cities, various villages, and cultivable lands, while shore plants are rare due to human interference, especially in town’s vicinity because of shore protection works, during water closure in winter (15 January to 15 February), no submerged plants are noticed. However, macrophytes are common on those shores. Throughout this period, fish survive in left out pools or deeper spots, before reopening the stream again (Khallaf, 2002).

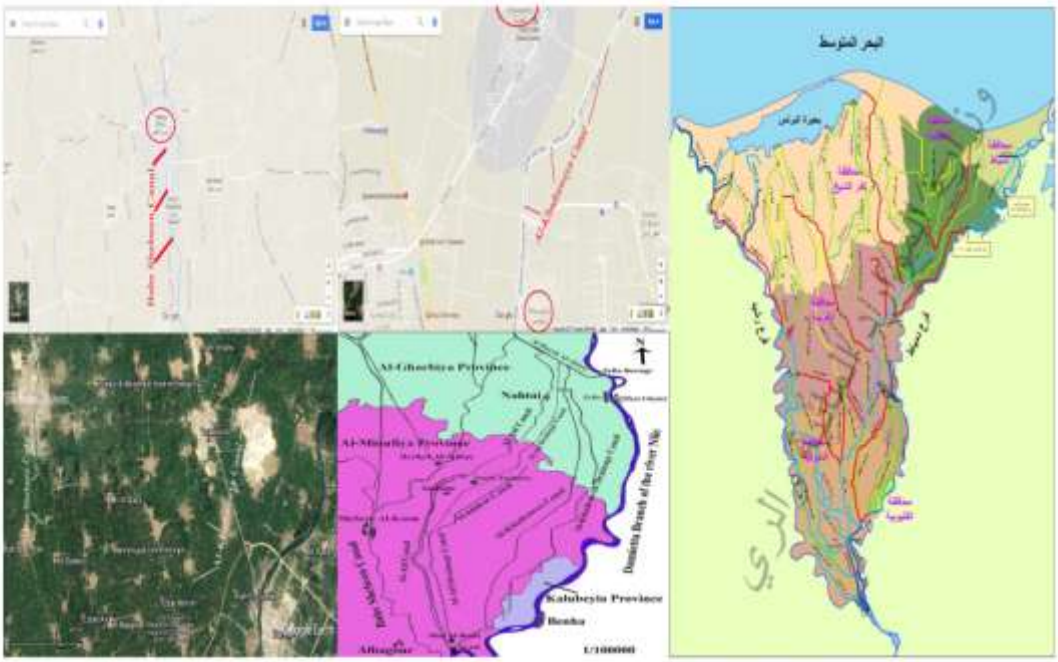

Fig. 1: Map of BHC and KHC Canals, Egypt.

Al-Khadraweya Canal (KHC) (Fig. 1), 3-5 meters in depth, about 10 m wide, and 37.5 Km in length, is an irrigation freshwater canal originates from the end of Meet Berah Canal, which originates from Al-Rayah Al Menoufy which is diverting from the Rossetta branch of the River Nile. KHC extends throughout two governorates, where its whole length is, from which 16.45 km located inside Quesna Center (Minofia Governorate) and the rest located inside Zefta Center (El-Gharbia Governorate).

Although BHC and KHC are considered canals belonging to the River Nile system, but KHC receives agricultural drainage from the surrounding fields, illegal domestic sewage effluents from the surrounding villages, and industrial wastes from the city of Quesna, besides the factory of refuse recycling at Sharanis village. Each channel is considered a semi-independent ecosystem (Khallaf *et al.*, 2016).

Sampling sites

Two sites were chosen to represent (1) non-polluted site from BHC (along 10 km length inside Shebeen Alkoom City) and (2) polluted sites from KHC (along 10 km length between Qwesna El-Balad and Sharanis villages).

Collection of samples

Fish samples were collected monthly from November 2014 to October 2015, from BSC and KHC, and brought to the laboratory, at Faculty of Science, Minufeya University, Shebeen Alkoom, Egypt, for analyses. Data of date, place of capture, length to the nearest cm, weight to the nearest 0.1 g, were recorded. Fish scales (10 - 15) were taken from the left side of the fish below the lateral line and behind the pectoral fin as suggested by Rounsefell and Everhart (1953). Certain numbers of fish vertebrae were kept for subsequent examination to validate scale reading.

Growth measurements:

Length-Weight relationship

In fishes, the conventional length - weight equation is a curvilinear one and can usually or always be best expressed by the equation (Le Cren, 1951):

$$W = a L^n$$

The data then transformed into logarithmic form to give a straight line as follows:

$$\text{Log } W = \log a + n \log L$$

Where W is body weight (g) of fish, L is total length (cm) of fish, a is constant and n is exponent value (Le Cren, 1951; Ricker, 1975). These constants can be evaluated empirically from the available data by applying an appropriate statistical method. The most widely used are the least square method.

The value $n = 3$ indicates that the fish grows symmetrically or isometrically (provided its specific gravity remains constant).Values other than 3 indicate allometric growth: if $n > 3$, the fish becomes "heavier for its length" as it grows larger (Ricker, 1971). If the fish gets relatively thinner, n will be less than 3. The exponent n is found to range between 2.5 and 4.0. If that exponent is 3.0 or close to it, growth is said to be isometric, while values of n less than, or more than, 3.0 describes an allometric growth (Ricker, 1975).

Condition factor (Coefficient of condition)

The condition factor "K" [or Fulton's (1902) condition factor] describes the condition of the fish based on the following relationship after Le Cren (1951) and Ricker (1975):

$$K = W / L^3 \times 100$$

Where W is fish body weight (g) and L is fish total length (cm).

Fish in good condition will have higher values of K than those in poor condition.

Age determination

After being cleaned and mounted dry oh glass slides, fish scales were examined for annuli reading and counting. Age determination was based on the examination of the best three scales from each fish by naked eye and through a binuclear microscope at X10 magnification. Each scale was read twice and annuli were distinguished according to Lagler (1956). The annulus was considered as a year-ring when it appeared complete on the scale. The age was determined by counting the number of completely developed annual rings on scales. Year-rings were verified by examining annuli in fish vertebrae which showed no deviation from ageing using the fish scales. The fish were classified into age groups according to the numbers of completed years of life.

Growth in length and weight

The growth in length and weight study of the fish was made by determining the actual growth in length and weight at the time of capture and classified on the basis of annuli in different age groups.

Von Bertalanffy growth in length

The growth parameters of the von Bertalanffy (1938) growth model equation (L_∞, K and t_o) were computed according to Gulland (1969) and Ricker (1975) by fitting the Ford (1933)-Walford (1946) plot. The common forms of this equation were as follows:

$$L_t = L_\infty \{1 - e^{-k(t-t_0)}\}$$

$$L_{t+1} = L_\infty (1 - e^{-k}) + L_t e^{-k}$$

where, L_t is the total length of fish in cm at age t, L_{t+1} is the length of fish in cm at age t+l, L_∞ is the maximum asymptotic length i.e. the theoretical length beyond which the fish would not grow; K is the Brody’s coefficient of growth constant, t is the age in years; t_o is the theoretical time at which the fish would have been of zero size if it had always grown according to the equation and e is the logarithmic constant.

Following Gulland (1969), the plot of length increment against initial length (L_t) followed a straight line, which could be described by the following equation:

$$\text{Incr.} = a + b L_t$$

Where, Incr. is the length increment in cm, and L_t is the fish initial length in cm, a and b are constants. The x-axis intercept of this equation could be estimated exactly by the equation -a/b. This would give the asymptotic length (L_∞) of the fish. On the other hand, the relationship between Ln (L_∞ - L_t/ L_∞) against time (t) in years by the following equation:

$$\text{Ln}(L_\infty - L_t/ L_\infty) = a + b\, t$$

Where, L_∞ = asymptotic length (cm), L_t = total length of fish (cm) at age t, t = age in years, Ln = the natural logarithm, a and b are constants.

Consequently, t_0, the time at which the fish form scale, equal -a/b, and the slope of that line equal -K, the Brody's coefficient of growth.

While the growth in weight was studied from calculated weights corresponding to calculated lengths attained at the end of each year of life, by the length-weight relationship equation ($W = a L^n$). Consequently, the von Bertalanffy equation is transformed (Following Ricker, 1975) into:

$$W_t = W_\infty \{1 - e^{-k(t-t_0)}\}^n$$

With, W_t is weight (g.) at time t, W_∞ is asymptotic weight (g.), K, t_0 are von Bertalanffy equation constants, and n is exponent value of length-weight relationship.

Mortality rates

The total instantaneous mortality rates (Z) were calculated by least squares regression of the natural log (Ln) of the numbers in age groups on age (Catch curve) (Ricker, 1975; Pauly, 1983; Sparre *et al.*, 1989).

The survival and mortality rates would be calculated as follows:

$$S = e^{-z} = 1 - A$$

Where: S = Annual survival rate, A = Annual mortality rate, and Z = Instantaneous mortality rate.

Growth performance index (Ø) in length and weight

To compare the overall growth performance of the fish species, growth performance (Ø) (Pauly and Munro, 1984; Moreau *et al.*, 1986), has been used as follows: $Ø_L = \log_{10} K + 2 \log_{10} L_\infty$, for length and $Ø_W = \log_{10} K + 2/3 \log_{10} W_\infty$, for weight, where K, L_∞ and W_∞ are von Bertalanffy equation constants.

The maximum age (t_{max})

Maximum age (t_{max}), the longevity of the fish species was calculated from the relation: $t_{max} = 3/K + t_0$ (Pauly, 1983), where K and t_0 are von Bertalanffy equation constants.

Reproduction

The Gonado-Somatic Index (GSI)

The maturity coefficient or gonado-somatic index (GSI); used as an indicator parameter for reproduction; was calculated for each specimen as the percentage of gonad weight to that of the fish weight using the following equation (Khallaf and Authman, 2010):

GSI = Gonad weight (g) / Whole body weight (g) x 100

The Stomach Somatic Index (SSI)

Weight of the stomach was divided by the fish weight and multiplied by a hundred, and the average per month, length or age-group were used as a measure of feeding activity of the fish (Khallaf and Alne-na-ei, 1987; Khallaf and Authman, 1992). Stomach fullness index (SI) was calculated as follows:

SSI= Weight of stomach (g) / Weight of fish (g) x 100

Hepatosomatic Index (HSI)

The hepatosomatic index (HSI) was expressed as the weight of liver divided by the fish weight and multiplied by a hundred (Jangaard *et al.*, 1967; El-Maghraby *et al.*, 1972; Khallaf and Authman, 1991), and was calculated as follows:

HSI = Weight of liver (g) / Whole body weight (g) x 100

Statistical Analysis

All statistical analyses (Regression and Anova) were done using the computer program of SPSS Inc. (version 17.0 for Windows) at the 0.05 level of significance.

RESULTS

Growth

Length-Weight relationship

BSC

The total length of *O. niloticus* fish samples, that collected from BSC (non-polluted site), varied between 11.00-30.00 cm whereas the total body weight varied between 26.00-472.00 g. The data were pooled irrespective of sex (Table 1) and one relationship for 313 specimens is found to be as follows:

$$\text{Log } W = -1.70906 + 2.99931 \log L, \quad \text{or} \quad W = 0.01954\, L^{2.99931}$$

($r^2 = 0.9993$ SE (n) = 0.033 *F-value* = 8167.221)

Where:

W = fish body weight in grams; L = its total length in cm; r = correlation coefficient, SE (n) = Standard error of "n" and Sig. = Significance level.

Table 1: Total length-weight relationship and condition factor (K) of *O. niloticus* fish (irrespective of sex) from BSC, Egypt.

Total Length (cm)	No. of fishes	Weight (g)		Condition factor (K)
		Observed	Calculated	
11	15	30.733	25.965	2.309
12	22	35.727	33.707	2.068
13	22	45.318	42.853	2.063
14	20	61.800	53.520	2.252
15	45	73.444	65.824	2.176
16	60	85.733	79.883	2.093
17	39	99.359	95.813	2.022
18	26	121.154	113.730	2.077
19	29	142.793	133.753	2.082
20	13	173.077	155.997	2.163
21	9	187.222	180.580	2.022
22	3	252.333	207.619	2.370
23	3	220.333	237.229	1.811
24	2	259.000	269.529	1.874
25	3	333.000	304.635	2.131
26	1	363.000	342.664	2.065
30	1	472.000	526.343	1.748
Total	313	98.403		2.130

KHC

The total length of *O. niloticus* fish samples, that collected from KHC (polluted site), varied between 9.50-23.50 cm whereas the total body weight varied between 17.00-237.00 g. The data were pooled irrespective of sex (Table 2) and one relationship for 319 specimens is found to be as follows:

$$\text{Log W} = -1.22841 + 2.55857 \log L, \quad \text{or} \quad W = 0.059100\, L^{2.55857}$$

$$(r^2 = 0.9053 \qquad SE\ (n) = 0.046 \qquad \textit{F-value} = 3029.767)$$

Where:

W = fish body weight in grams; L = its total length in cm; r = correlation coefficient, SE (n) = Standard error of "n" and Sig. = Significance level.

Table 2: Total length-weight relationship and condition factor (K) of *O. niloticus* fish (irrespective of sex) from KHC, Egypt.

Total length (cm)	No. of fishes	Weight (g)		Condition factor (K)
		Observed	Calculated	
9	1	17.000	16.334	2.332
10	5	23.800	21.387	2.380
11	3	29.000	27.294	2.179
12	10	37.600	34.100	2.176
13	30	49.867	41.849	2.270
14	53	54.792	50.587	1.997
15	63	65.556	60.353	1.942
16	63	73.873	71.189	1.804
17	42	85.810	83.134	1.747
18	23	102.783	96.225	1.762
19	14	111.214	110.501	1.621
20	5	132.600	125.998	1.658
21	4	150.500	142.751	1.625
22	–	–	–	–
23	3	217.333	180.162	1.786
Total	319	72.806		1.850

Generally, there is a close agreement between the observed and calculated weights of fish in both canals. Also, the high values of the correlation coefficient (r) perform a good measure for the strength of the length-weight equations and closeness of observed and calculated values of fish weights.

Condition factor (Coefficient of condition)

Monthly variations of condition factor (K)

When the monthly variation of the coefficient of condition for both canals is considered, some irregularities found to appear as shown in Table (3). The fish of BSC were indicated to have better K during April, July, and November. In KHC, the K value peaked in January, March, June, and September-November period.

Table 3: Monthly variations of condition factor (K) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

Months	BSC	KHC
	K	K
January	2.20	2.29
February	2.27	1.90
March	2.07	1.98
April	2.35	1.73
May	2.10	1.52
June	1.94	1.90
July	2.09	1.75
August	1.92	1.77
September	1.90	1.90
October	2.16	1.93
November	2.43	1.85
December	2.17	1.67
Average	2.13	1.85

Seasonal variations of condition factor (K)

The seasonal changes in the mean values of the condition factor, of *O. niloticus* (Table 4) indicate that the values of "K" were higher in fish of BSC than in KHC during all seasons. These results confirmed by the observed significant (P<0.05) differences in "K" values of *O. niloticus*, in polluted area (KHC) during all seasons in comparison with the non- polluted site (BSC), as shown by independent-samples *T*-test results.

Table 4: Seasonal variations of condition factor (K) of *O. niloticus* from BSC and KHC, Egypt.

Sites	Seasons											
	Spring			Summer			Autumn			Winter		
	Mean	±	SE	Mean	±	SE	Mean	±	SE	Mean	±	SE
BSC	2.17	±	0.021	1.98	±	0.017	2.16	±	0.040	2.20	±	0.018
KSC	1.74	±	0.025*	1.81	±	0.018*	1.89	±	0.027*	1.01	±	0.028*

SE = standard error.

(*) Significant difference (P<0.05) as compared to BSC.

Variations of condition factor (K) with total length (TL)

On considering variation in total length as a basis for comparing the fish condition (K) (Tables 1 & 2), irregularity is found in this parameter. Higher values of K are noticed for lengths of 11, 14, 15, 20, 22 and 25 cm in BHC and for lengths of 9, 10, 11, 12 and 13 cm in KHC. Generally, K decreased with the increase of total length. The correlation coefficient (r) for the condition factor and total length relationships, for BSC and KHC values, is: 0.55 in BSC, while it is 0.9084 for KHC.

Age determination and age composition

In the present study scales were used for age determination of *O. niloticus*, from BSC and KHC, and by using the readings of its annual growth rings, it was found that the longevity of *O. niloticus* attained four years in both canals (Table 5). It was found also that, fish of age-group I was dominant in the catch and constitute about 50.80% and 48.90% for BSC and KHC *O. niloticus* fish, respectively, while the frequency of fishes of age-groups O and IV is the least and contributed about 2.88 and 0.94% for BSC and KHC *O. niloticus* fish, respectively.

Table 5: Age composition, average total length (cm) and weights (g), annual increments (Incr.) and percentage of annual increments at different age-groups of *O. niloticus* (irrespective of sex) from BSC and KHC, Egypt.

BSC								
Age-groups (years)	No. of fishes	%	Total length (cm)			Weight (g)		
			Mean	Incr.	%	Mean	Incr.	%
0	9	2.88	11.36			29.89		
I	159	50.80	14.67	14.67	59.24	64.40	64.40	21.69
II	78	24.92	17.51	2.84	11.46	103.68	39.28	13.23
III	56	17.89	20.00	2.50	10.09	159.63	55.95	18.84
IV	11	3.51	24.76	4.76	19.21	296.91	137.28	46.24
Total	313							
KHC								
Age-groups (years)	No. of fishes	%	Total length (cm)			Weight (g)		
			Mean	Incr.	%	Mean	Incr.	%
0	11	3.45	10.95			26.91		
I	156	48.90	14.58	14.58	62.92	57.57	57.57	26.49
II	94	29.47	16.64	2.06	8.89	77.32	19.75	9.09
III	55	17.24	18.84	2.20	9.50	109.60	32.28	14.85
IV	3	0.94	23.17	4.33	18.69	217.33	107.73	49.57
Total	319							

Growth in length and weight

Growth in observed length and weight

As seen from Table (5), the increase in length and weight, among the observed mean lengths and weights at different age-groups, is irregular. Age readings indicated that *O. niloticus* in both BSC and KHC attain their highest growth rate in length during the first year of life, after which a decrease in growth increment was observed with increase in age until ages III and II for fish in BSC and KHC, respectively, and then the annual increment increases again with the increase in age. On the other hand, it was found that, the minimum annual increment in weight is noticed during the first year of life whereas the maximum annual increment in weight is noticed during the fourth year of life. There is a conspicuous drop in annual increment in weight values at age-groups II and III for *O. niloticus* fish in both BSC and KHC.

Von Bertalanffy growth in length and weight

The growth pattern was described by computing the equation of von Bertalanffy using the observed total length at capture of *O. niloticus* in BSC and KHC (Table 6). Because of the differences in growth rates of fish observed lengths mentioned previously, the different fitting methods (e.g., Ford-Walford graph (L_{t+1} on L_t), Gulland (Increment against initial length, L_t)…etc.) could not be applied to predict the asymptotic length (L_∞). However, the following modification (after Khallaf *et al.*, 1993) was used. The inverse of age-lengths when plotted against initial length, irrespective of sex, gave a straight line. The predicted equations for these relationships were used for calculating L_∞ as follows:

In BSC:

$$100 \text{ x } (L)^{-1} = 10.58436 - 0.26996 \text{ L } (r^2 = 0.97280)$$

In KHC:

$$100 \text{ x } (L)^{-1} = 10.93274 - 0.29003 \text{ L } (r^2 = 0.97999)$$

Where, L = total length in cm.

Accordingly, the values of L_∞ (asymptotic length) are calculated by dividing the quantity of "-a/b" of these regression equations to get the line cut at the X-axis giving L_∞. The latter is found to be 39.21 and 37.70 cm for *O. niloticus* in BSC and KHC, respectively. This value of L_∞ is used to predict the value of t_0 in both canals. Consequently, t_0 (age at which length is nil) and k (the Brody's coefficient of growth) constants of von Bertalanffy equations are calculated from the relationship between Ln $(L_\infty - L_t)/L_\infty$ against the time (t) in years as follows:

In BSC:

$$\text{Ln } (L_\infty - L_t)/L_\infty = -0.26516 - 0.17119 \text{ t } (r^2 = 0.94889)$$

In KHC:

$$\text{Ln } (L_\infty - L_t)/L_\infty = -0.30347 - 0.15035 \text{ t } (r^2 = 0.93462)$$

Where, t = age in years.

Table 6: Calculated von Bertalanffy total lengths and weights at different age-groups of *O. niloticus* from BSC and KHC, Egypt.

von Bertalanffy lengths (cm)					
Age group (years)					
		I	II	III	IV
BSC	Length	13.86	17.85	21.21	24.04
	Increment		3.99	3.36	2.83
KHC	Length	13.75	17.09	19.97	22.44
	Increment		3.34	2.88	2.47
von Bertalanffy weights (g)					
Age group (years)					
		I	II	III	IV
BSC	Weight	51.98	110.95	186.10	271.00
	Increment		58.97	75.16	84.89
KHC	Weight	48.32	84.31	125.51	169.23
	Increment		35.99	41.20	43.72

Consequently, t_0 equal -a/b = -1.549 and -2.018 year, in BSC and KHC, respectively. The slopes of these lines equal – K = 0.171 and 0.150 year^{-1} in BSC and KHC, respectively.

Therefore, the von Bertalanffy equations for *O. niloticus* fish in BSC and KHC are found to be as follows:

In BSC:

$$L_t = 39.21\{1 - e^{-0.171 (t + 1.549)}\}$$

$$\text{and} \quad L_{t+1} = 6.1690 + 0.8427 \, L_t$$

In KHC:

$$L_t = 37.70\{1 - e^{-0.150 (t + 2.018)}\}$$

$$\text{and} \quad L_{t+1} = 5.2620 + 0.8604 \, L_t$$

The equations of theoretical growth in weight were obtained by applying the length-weight relationship equations to the growth in length equations as follows:

In BSC:

$$W_t = 1174.72 \, [1 - e^{-0.171 (t + 1.549)}\}]^{\,2.99931}$$

In KHC:

$$W_t = 637.70\ [1 - e^{-0.150\ (t + 2.018)}\}]^{\ 2.55857}$$

The application of the von Bertalanffy growth equations gave the length and weight at different age-groups (Table 6) of *O. niloticus* in BSC and KHC.

Mortality rates

Survival rates (S) were calculated for *O. niloticus* fish in BSC and KHC using the catch curve method. The descending limb of this curve for fishes in both canals followed a straight line between age-groups I to IV (Fig. 2), and consequently was used for the calculation of survival rate throughout the predicted regression equations as follows:

In BSC:

Ln Frequency = 6.04831- 0.83444 age (years) (r = -0.95323)

In KHC:

Ln Frequency = 6.77220 - 1.23897 age (years) (r = -0.90398)

Therefore, the instantaneous total mortality rate Z = (-b) = 0.83 and 1.24 for BSC and KHC, respectively. Consequently $S = e^{-Z}$ = 0.43 and 0.29, while the mortality rate A will be 0.57 and 0.71 for BSC and KHC, respectively.

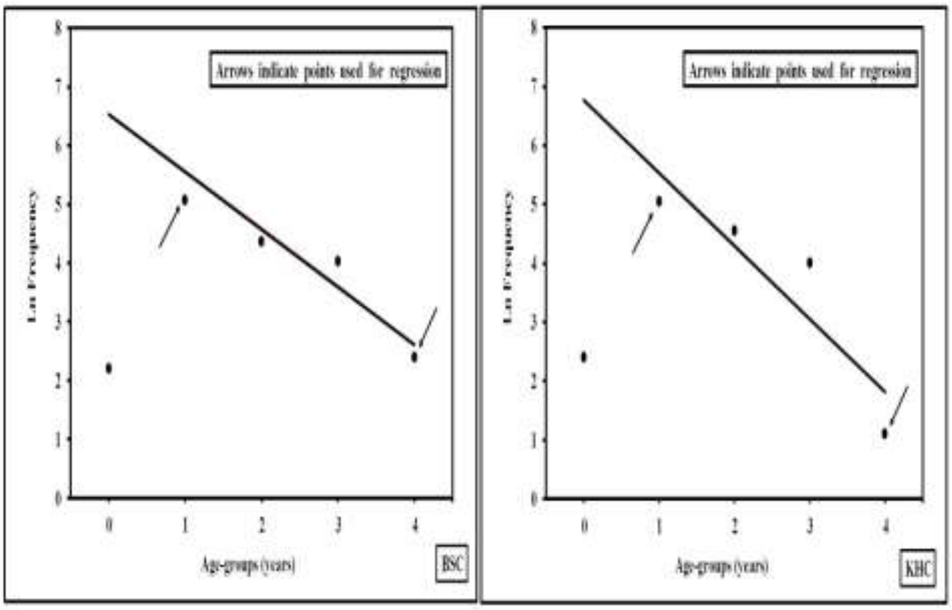

Fig. 2: Catch curve of *O. niloticus* in BSC and KHC, Egypt.

Growth performance index (Ø) in length and weight

The growth performance indices (Ø) of *O. niloticus* fish were found to be 2.42 and 2.33 of growth performance in length ($Ø_L$) and 1.28 and 1.05 of growth performance in weight ($Ø_W$) in BSC and KHC, respectively.

The maximum age (t_{max})

The values of maximum age (t_{max}) of *O. niloticus* fish were found to be 15.98 and 17.93 years in BSC and KHC, respectively.

It was seen from sex distribution in Table (7) that the two sexes did not occur in the same proportion during different seasons in BSC and KHC. It was found that males were more numerous than females with the exception of autumn in BSC whereas in KHC males outnumbered females during all seasons. Statistical analysis by Chi-square (X^2) test indicated that sex ratio was highly significantly (P<0.01) different from the expected ratio of 1:1 during different seasons with the exception of winter in BSC. While in KHC, the statistical analysis by Chi-square (X^2) test indicated that ex ratio was insignificantly (P>0.05) different from the expected ratio of 1:1 during different seasons. Overall, the sex ratio (male: female) of *O. niloticus* in BSC and KHC was 1:0.64 and 1:0.72, respectively, which deviate significantly (X^2 = 15.211 and X^2 = 8.806, P<0.01, respectively) from the hypothetical distribution of 1:1 (Table 7).

Reproduction

Sex ratio (X^2):

Table 7: Seasonal variations of sex ratio of *O. niloticus* from BSC and KHC, Egypt.

BSC							
Seasons	Male (M)		Female (F)		Total No. of samples	Sex ratio M:F	Chi-square (X^2)
	No.	%	No.	%			
Spring (Mar-May)	58	68.24	27	31.76	85	1:0.47	11.306**
Summer (Jun-Aug)	66	76.74	20	23.26	86	1:0.30	24.605**
Autumn (Sep-Nov)	17	30.91	38	69.09	55	1:2.24	8.018**
Winter (Dec-Feb)	50	57.47	37	42.53	87	1:0.74	1.943
Total	191	61.02	122	38.98	313	1:0.64	15.211**
KHC							
Seasons	Male (M)		Female (F)		Total No. of samples	Sex ratio M:F	Chi-square (X^2)
	No.	%	No.	%			
Spring (Mar-May)	46	52.87	41	47.13	87	1:0.89	0.287
Summer (Jun-Aug)	53	61.63	33	38.37	86	1:0.62	4.651
Autumn (Sep-Nov)	36	61.02	23	38.98	59	1:0.64	2.864
Winter (Dec-Feb)	51	58.62	36	41.38	87	1:0.71	2.586
Total	186	58.31	133	41.69	319	1:0.72	8.806**

** = highly significance (P = 6.635 at α = 0.01, df = 1).

The gonado-somatic index (GSI)

The results show that the gonado-somatic indexes (GSI) values are higher in *O. niloticus* fishes of KHC than in BSC during all months of the year with the exception of February, September and October (Table 8; Fig. 3). Seasonally, GSI of fish in KHC are higher than in BSC during all seasons (Table 9). Also, the results showed significant differences (P<0.05) in GSI values in polluted area (KHC) during spring in comparison with the non- polluted site (BSC), as shown by independent-samples T-test results.

Table 8: Monthly variations of gonado-somatic index (GSI) and stomach somatic index (SSI) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

Months	BSC		KHC	
	GSI	SSI	GSI	SSI
January	0.645	0.942	1.132	0.458
February	1.075	2.850	0.811	0.573
March	0.575	1.600	2.350	1.231
April	0.903	1.870	1.533	1.166
May	0.816	0.654	1.324	0.356
June	0.329	0.661	0.556	0.507
July	0.490	0.482	0.737	0.245
August	0.516	0.116	0.617	0.456
September	0.728	0.469	0.658	0.952
October	0.690	0.620	0.430	0.820
November	0.684	0.706	1.255	0.594
December	0.640	0.759	0.737	0.599

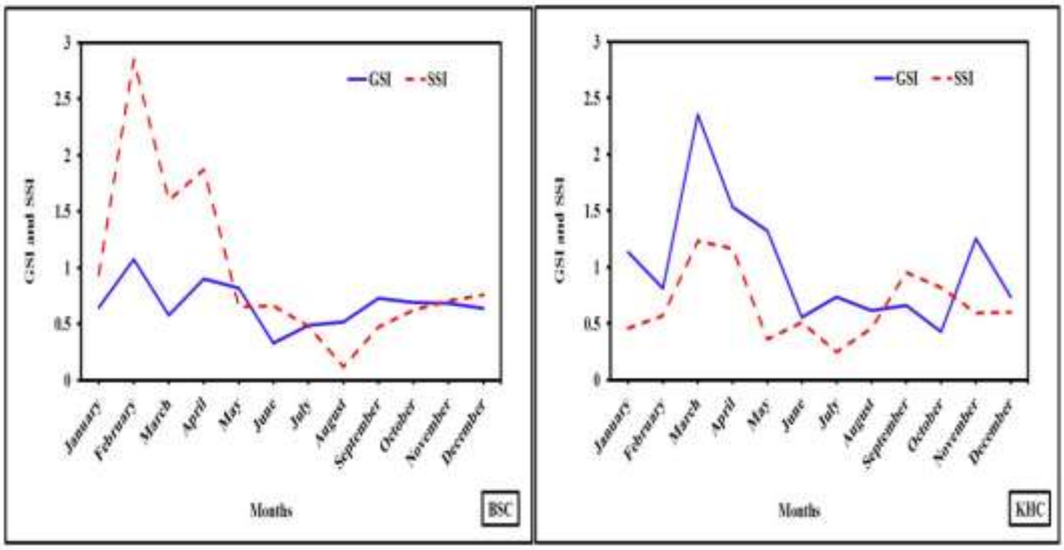

Fig. 3: Monthly variation of GSI (Solid line) and SSI (Dashed line) of *O. niloticus* in BSC and KHC, Egypt.

The Stomach Somatic Index (SSI)

The results show that the stomach somatic index (SSI) values are higher in *O. niloticus* fishes of BSC than in KHC during all months of the year with the exception of August, September and October (Table 8; Fig. 3). Seasonally, SSI of fish in BSC is higher than in KHC during all seasons (Table 9). Also, the results showed significant differences (P<0.05) in SSI values in polluted area (KHC) during summer and winter in comparison with the non- polluted site (BSC), as shown by independent-samples *T*-test results.

The SSI and GSI for BSC and for KHC (Fig. 3) showed changes which can be related to multiple spawning nature of *O. niloticus*, and variation in physicochemical parameters. The difference in variation of those parameters can be related to such activity. However, more effects are interfering with this biological process.

Table 9: Seasonal variations of gonado-somatic index (GSI) and stomach somatic index (SSI) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

GSI												
Sites	Seasons											
	Spring			Summer			Autumn			Winter		
	Mean	±	SE	Mean	±	SE	Mean	±	SE	Mean	±	SE
BSC	0.826	±	0.156	0.430	±	0.101	0.765	±	0.153	0.784	±	0.123
KSC	1.831	±	0.185*	0.681	±	0.108	1.036	±	0.263	0.874	±	0.112
SSI												
Sites	Seasons											
	Spring			Summer			Autumn			Winter		
	Mean	±	SE	Mean	±	SE	Mean	±	SE	Mean	±	SE
BSC	1.147	±	0.119	0.739	±	0.066	0.614	±	0.053	1.024	±	0.082
KSC	0.926	±	0.114	0.231	±	0.044*	0.556	±	0.081	0.542	±	0.046*

SE = standard error.
(*) Significant difference (P<0.05) as compared to BSC.

Hepatosomatic Index (HSI)

The monthly variation of hepatosomatic index of *O. niloticus* fish samples collected from BSC and KHC were clearly obvious in Table (10) and illustrated graphically in Fig. (4). The results show that the hepatosomatic index (HSI) values are higher in *O. niloticus* fishes of KHC than in BSC during all months of the year with the exception of April and May. On considering the seasonal variations, HSI values of *O. niloticus* fish, which collected from BSC and KHC were tabulated in Table (11) and represented graphically in Fig. (4). These results showed that HSI of fish in KHC is higher than in BSC during all seasons. Also, the results showed significant difference (P<0.05) in the fish collected from polluted area (KHC) during summer, autumn and winter in comparison with the non-polluted site (BSC), as shown by independent-samples T-test results.

Table 10: Monthly variations of hepatosomatic index (HSI) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

Months	BSC	KHC
	HSI	HSI
January	2.350	2.449
February	1.875	2.393
March	1.365	2.191
April	1.612	1.440
May	1.032	0.981
June	0.711	0.775
July	0.558	0.986
August	0.482	1.075
September	0.633	1.158
October	0.551	0.732
November	1.490	2.629
December	2.067	2.504

Table 11: Seasonal variations of hepatosomatic index (HSI) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

HSI												
Sites	Seasons											
	Spring			Summer			Autumn			Winter		
	Mean	±	SE	Mean	±	SE	Mean	±	SE	Mean	±	SE
BSC	1.340	±	0.077	0.584	±	0.029	1.054	±	0.080	2.103	±	0.068
KSC	1.529	±	0.075	0.929	±	0.046*	1.918	±	0.145*	2.448	±	0.080*

SE = standard error.
(*) Significant difference (P<0.05) as compared to BSC.

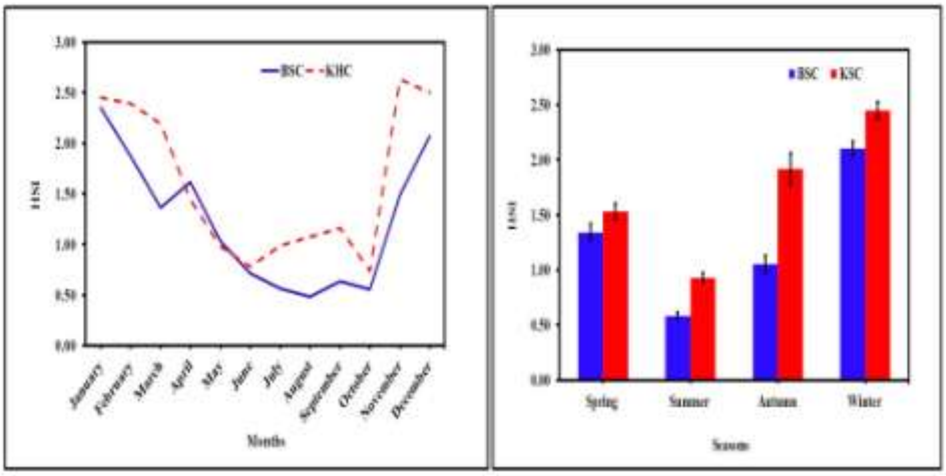

Fig. 4: Monthly and seasonally variations of hepatosomatic index (HSI) of *O. niloticus* fish (irrespective of sex) from BSC and KHC, Egypt.

DISCUSSION

Having good water quality is important for a healthy river, as it affects the humans, animals and plants that utilize the water (Sutadian *et al.*, 2018). Due to the vital importance of water resources to human health and natural ecosystems, their qualitative and quantitative monitoring overtime would be of utmost importance (Tavakol *et al.*, 2017). The environmental impacts in any aquatic ecosystems can be assessed and monitored by physical and chemical techniques and also by biological methods (Foil, 1989; Chae *et al.*, 2000; Bream *et al.*, 2017).

Length-weight relationship is a useful tool in a wide range of applications such as estimation of biomass from length data, estimation of a species condition factor and comparisons among life history and morphologic differentiations of the same species in other aquatic systems (Binohlan and Pauly, 2000; Keyombe *et al.*, 2017). Length-weight relationship measurement is also a useful tool that provides important information concerning the structure and function of fish populations in any aquatic systems (Anderson and Neumann, 1996).

It is well established by many authors (Le Cren, 1951; Ricker, 1975) that the slope of the length-weight relationship is an indicator of the variation in fish condition and health. In addition, it may vary with species, sex, or geographical areas. Slope of the length–weight relationship for KHC is less than that of BSC. This indicates that the health of fish is better in BSC than that of KHC. This can be quantified by dividing the two slope values as follows:

KHC/BSC: 2.5586/ 2.9993 = 0.853.

This result indicates a deficiency of 14.7 % in health of *O. niloticus* in KHC than in BSC. In concomitance, if the average monthly K for the two canals, a comparable result is predicted: 0.868. In other words, the difference in water quality between the two canals ranges between 13.2 to 14.7%. This may be attributed to the worse ecological conditions of the KHC as a result of a progressive accumulation of pollutants. Bedajit Singh *et al.* (2012) mentioned that the actual relationship between length and weight may depart from the cubic value 3 and this may be due environmental condition in which the animal lives and also due to the physiological condition of the animal. The values of (n) in the present study are in accordance with that estimated by some authors working on the same species and differ from others (Table 12). This may reflect the impact of pollution of KHC causing stress load on fish. Pollution was seen to affect the condition of *O. niloticus* in Lake Marriut, Egypt (Bakhoum, 1994), that there were highly significant variations of L-W relationships of both species in polluted and non-polluted parts of the lake. Similarly Khallaf *et al.* (2003) reported differences in L-W relationships of *O. niloticus* in a polluted canal compared with those of other authors in different localities and times. These differences were attributed to the effect of eutrophication and pollution on growth and other biological aspects of *O. niloticus* (El-Kasheif *et al.*, 2015).

Fish condition factor (K), which measures physiological well-being of the fish (Wootton, 1994; Lalèyè *et al.*, 2006), is considered as a measure of the "fitness" of the fish in a population. It may also be considered as a rough measure of the state of the fish, whether healthy or unhealthy, starved or well-fed, spawning or spent (Patterson, 1992). It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene, 2005). Fish body condition is known to vary seasonally depending on changes in gonadal development, food availability, and other environmental factors (Pope and Willis, 1996; Keyombe *et al.*, 2017). It is usually influenced by the type of fish species, sex, season, maturity stage among other factors (Anyanwu *et al.*, 2007). The role of the condition indices as stated by Stevenson and Woods (2006) is to quantify the health of individuals in a population or to tell whether a population is healthy relative to other populations. When fish of a given length exhibits higher weight it means they are in better condition (Anwa–Udondiah and Pepple, 2011). As the fish grow in size, it means getting older, and the period of rapid growth or health deteriorate. Thus, decline of K with length of fish, though follow that tendency, but it is conspicuous in KHC than in BSC. KHC has more sources of pollution which in turn means deterioration in the fish health. Such observation was indicated earlier by Knight (1968), Ricker (1975), Nwadiro and Okorie (1985), Khallaf (1992) and Khallaf *et al.* (2003). This is exemplified by the slope of the length-weight relationship, where it is lower for the fish in KHC (2.5587) than that in BSC (2.9993). When the average monthly values of K are taken into account, it gave 1.85 and 2.13 respectively for the two canals. Those finds indicate that KHC is less favorable to the fish health by 13 to 15%. This also was confirmed by the highly significant higher values of "K" of fish in BSC than in KHC during all seasons. By comparing the condition factor for *O. niloticus* in different regions (Table 12), we can see that the grand average values of condition factor of *O. niloticus* in BSC and KHC are in accordance with that estimated by some authors working on the same species and differ from others indicating general stress on fish population of that species in those canals. In accordance, in earlier studies, similar results were also attributed to the high levels of pollution (Lowe-McConnell, 1975; Sindermann, 1979; Lowe-McConnell, 1987; Sindermann, 1990).

The determination of age of fish is of great importance for solving the biological problems of fisheries (El-Kasheif *et al.*, 2015). It was found that; *O. niloticus* from BSC and KHC has a relatively higher longevity, as they attained 4 years. Longevity of *O. niloticus* varies at different regions where *O. niloticus* attained 2 years in Shanawan drainage Canal (Khallaf *et al.*, 2003), 4 years in Bahr Shebeen canal (Alne-na-ei, 1986; Khallaf *et al.*, 2017), 6 years in Damietta branch (Authman *et al.*, 2009) and El-Bahr El-Faraouny Canal (El-Kasheif *et al.*, 2015), 7 years in Lake Nasser (Latif and Khallaf, 1987) and Edku Lake (Abd-Alla and Talaat, 2000).

Table 12: Comparison of the regression of length (cm)-weight (g) relationships and the condition factor (K) irrespective of sex of *O. niloticus* from different Egyptian localities.

Locality	a	n	K	Author
BSC	0.01954	2.99931	2.13	Present study
KHC	0.059100	2.55857	1.85	Present study
Bahr Shebeen Canal	0.040659	2.7889	2.19	Alne-na-ei (1986)
	0.066	2.5948	—	Khallaf *et al.* (2017)
El-Bahr El-Faraouny Canal	0.0366	2.8006	2.13	El-Kasheif *et al.* (2015)
Lake Nasser	0.0571	2.8789	—	Latif and Khallaf (1987)
River Nile	0.014397	3.107633	1.91	Tharwat (1995)
	0.0377	2.7924	1.345	Hassan and El-Kasheif (2013)
Lake Manzalah	0.01745	3.01043	—	El-Bokhty (2006)
Edku Lake	0.01702	3.03264	—	Abd-Alla and Talaat (2000)
Shanawan Drainage Canal	0.042696	2.7707	2.07	Khallaf *et al.* (2003)
Abu-Zabal lakes	0.0282	2.8592	1.86	Ibrahim *et al.* (2008)
	0.0894	2.4034	1.7056	Shalloof and El-Far (2009)
Rosetta branch	0.0184	3.0082	1.84	Mahmoud and Mazrouh (2008)
Damietta branch	0.0165	3.0755	—	Authman *et al.* (2009)
Nozha Hydrodrome	0.0273	2.9093	2.05	Mahmoud *et al.* (2013)

$K = W/L^3 X100$

These significant variations are due to the changes in the fishing efforts and exploitation rate of the fishery resources, as well as, over fishing throughout the past and present times (El-Kasheif *et al.*, 2007; Authman *et al.*, 2009; El-Kasheif *et al.*, 2015).

It was found that, the growth rate in length was rapid during the first year of life, followed by a marked decrease as the fish got older. On the other hand, the growth in weight showed a marked increase as the fish got older. Apparently this happens because the fish gets nearer to its asymptotic length and consequently weight, where theoretically cessation of growth may occur (Khallaf and Authman, 2010). Adding to that, low number of older age groups in the present study may be duo to serious ecological condition of KHC.

The von Bertalanffy growth models accurately estimated theoretical growth in length and weight. Predicted lengths and weights-at-age of von Bertalanffy theoretical growth (Table 6) and observed lengths and weights (Table 5) for *O. niloticus* in BSC and KHC agree nearly closely. *O. niloticus* in BSC and KHC regions characterized by having largest asymptotic length (L_∞) in comparison with other localities with the exception of fishes of Lake Nasser, River Nile at Beni suef and Nozha Hydrodrome (Table 13). This may be attributed to the difference in size of collected sample and the difference in ecological environment of different habitats (Shalloof and El-Far, 2009).

Table 13: Comparison of growth parameters (L_∞, K, t_o and W_∞), growth performance index (Ø), mortality (Z and A) and survival (S) rates of *O. niloticus* from different water bodies in Egypt.

Locality	L_∞	K	t_o	W_∞	$Ø_L$	$Ø_W$	t_{max}	Z	S	A	Author
BSC	39.21	0.171	-1.549	1174.72	2.42	1.28	15.98	0.83	0.43	0.57	Present study
KHC	37.70	0.150	-2.018	637.70	2.33	1.05	17.93	1.24	0.29	0.71	Present study
El-Bahr El-Faraouny Canal	37.265	0.294	0.089	903.5364	2.611	1.439	10.29	1.15	0.3166	0.6834	El-Kasheif *et al.* (2015)
Bahr Shebeen•	28.78	0.292	0.02	980.30*	2.38*	1.46*	10.29*	1.40	0.25	0.75	Alne-na-ei (1986)
	28.9	0.29	0.02	—	2.38*	—	10.36*	1.52	0.22	0.78	Khallaf (1992)
Lake Nasser	53.2	0.34	0.59	5313.28*	2.98*	2.02*	9.41*	1.06	0.35	0.65	Latif and Khallaf (1987)
	54.730	0.270	-0.745	6414 .87	2.91*	1.97*	10.37*	1.21	0.30*	0.70*	Khalifa *et al.* (2000)
River Nile	48.14	0.147	0.2237	1881.79	2.532	1.350*	20.63*	0.97	0.38	0.62	Hassan and El-Kasheif (2013)
Lake Manzalah	28.88	0.53	—	435.33	2.65	1.48*	—	3.38	0.03*	0.97*	El-Bokhty (2006)
Edku Lake	34.5	0.2015	-0.5209	784.53*	2.38	1.23*	14.37*	1.3909	0.2489	0.7511	Abd-Alla and Talaat (2000)
Abu-Zabal lakes	34.59	0.1336	-2.09	446.74*	2.20*	0.89*	20.37*	—	—	—	Shalloof and El-Far (2009)
Rosetta branch	28.5	0.39	-0.32	439.0	2.50	1.36	7.63	1.62	0.20	0.80	Mahmoud and Mazrouh (2008)
Damietta branch	36.3	0.12	-1.12	1064.54	2.20	1.10	23.88	0.64	0.53	0.47	Authman *et al.* (2009)
Nozha Hydrodrome	38.06	0.211	-0.432	1081.94	2.485	1.347	14.23	0.873	0.42	0.58	Mahmoud *et al.* (2013)

• Standard length.
* Calculated by the present authors.

The main causes of mortality in fishes can be either natural or fishing mortality (El-Kasheif *et al.*, 2007; Authman *et al.*, 2009). The present study shows that the low survival rate in KHC (S = 0.29), means that about 29 % of *O. niloticus* survive per year, indicating higher fishing. Also, this may be attributed to the highly increased pollution of the water of KHC. Saleh (1981), Dethlefsen and Tiews (1985) and Khallaf *et al.* (2003) mentioned that, pollution increased the susceptibility of fish to diseases and increased the mortality rates. Adding to that, the older age's groups which represented in small proportion may be reflecting the higher levels of mortality and overexploitation (Abd-Alla and Talaat, 2000) and pollution that tilapias suffer in KHC.

In addition, the annual survival rates of *O. niloticus* from BSC and KHC were 0.43 and 0.29, respectively. This indicates that, *O. niloticus* fish in KHC suffer high mortality than in BSC. However, when the values of survival and mortality rates of *O. niloticus* in BSC and KHC compared with those from other Egyptian localities (Table 13), it was found that, the annual survival rate (0.29) of fishes of KHC was lower than those of fishes from some other localities, while the annual mortality rate (0.71) and instantaneous mortality rate (1.24) of the studied fish were higher than those of some other localities. This may be attributed to the increased eutrophication and pollution of the water of KHC.

It was found that, the values of the patterns of growth ($Ø_L$ and $Ø_W$) of fish in BSC were higher than in KHC and this indicated that KHC is less favorable to the fish health. By comparing the patterns of growth ($Ø_L$ and $Ø_W$) for *O. niloticus* in different regions (Table 13), it is noticed that these values in BSC and KHC are in accordance with those estimated by some authors working on the same species, but in different localities, indicating general stress on fish population of that species in both canals.

The study of reproduction is one of the important items dealt with in fish biology. In fishes, the sex ratio varies from one species to another (Khallaf and Authman, 2010). The sex ratio of most fish species in the wild tends to be 1:1, but deviations can occur and seasonal variations are common (Helfman *et al.*, 2009).

It was found in the present study that the number of *O. niloticus* males exceeded that of females and the overall sex ratio (male: female) of *O. niloticus* in BSC and KHC was 1:0.64 and 1:0.72, respectively, with obvious deviation from the expected ratio (1:1). Nikolsky (1963) and Fryer and Iles (1972) pointed out that, in African water bodies, it is common in the cichlid populations that males dominate because they generally exhibited more growth than females. Also, this observation could be explained by the fact that once the eggs were fertilized, the females hide under vegetations where incubation and protection of the young took place. This activity gives room to the males who then migrate to the feeding zones where they become more vulnerable to catch (Peña-Mendoza *et al.*, 2005; Offem *et al.*, 2007; Shalloof and Salama, 2008; Olele, 2010). In addition, environmental conditions are anticipated to have variable effects on sex differentiation depending on the genetic background and developmental stability of different strains, where it is well known that temperature fluctuations could alter sex-determination pathways and influence the probability that development would be male or female (Devlin and Nagahama, 2002). While low temperature is capable of biasing sex differentiation toward females in many fish species, elevated temperature has been shown to skew sex ratios towards male in some others (Devlin and Nagahama, 2002). The results of the present study confirm this where females of *O. niloticus*, in BSC, increased during autumn where temperature was slightly low, males prevailed during spring and summer where temperatures were high (Table 7). The values of sex ratio in the present study are in accordance with that estimated by some authors for studied species and differ from others. These patterns of variations between *O. niloticus* populations reflect time and locality factors.

The gonadosomatic index (GSI) was used to follow the development of the gonads (Komolafe and Arawomo, 2007). Also, the stomach somatic index (SSI), considered as an appropriate quantitative parameter for feeding activity in fish (Khallaf and Alne-na-ei, 1987; Khallaf and Authman, 1992, 2010). The change in values of GSI and SSI (Fig. 3) did not give a conspicuous trend in either canal. However, the variation in GSI is a simple measure for spawning. BSC values appear more or less at months earlier than those of KHC, which might be attributed to the effect of pollution, which cause delay in sexual maturity. As the fish are not healthy as they should be, they need longer time for the gonads to mature. This was shown earlier by Bakhoum and Faltas (1994) and Khallaf *et al.* (2003). Similar results were also obtained by Barakat (2004) who found that the duration between periods of *O. niloticus* spawning was increased from 30-36 to 55-75 days in control and organic contaminated groups, respectively. *O. niloticus* is known to be a multiple spawner (Khallaf *et al.*, 1986; Shalloof, 1991; Khallaf *et al.*, 2003), but this variation in timing between the two canals might be explained by the prevalent conditions in each specific canal. However, the higher seasonal values of GSI of *O. niloticus* in KHC compared to BSC (Table 9) may be due to the accumulation of heavy metals, pesticides and other pollutants in the fish gonads. As indicated by Khallaf *et al.* (2003), GSI of *O. niloticus* correlated significantly with heavy metals and pesticides. El-Nemaki *et al.* (2008) found higher significant values of GSI in fish which are taken from EL-Abbassa fish farms, Sharkia governorate, that received agriculture drainage water supply.

Hepatosomatic index (HSI) is the biological parameter that helps in studying growth of fish (Weatherley and Gill, 1987). Studying of HSI pointed to the importance of the liver for storage of fat and proteins to be used during the spawning period (Brown, 1957). Also, Oguri (1978) found that the HSI in Osteichthyes is usually about 1 to 2 %, though the index is variable according to fish species and also health condition of fish. So, the HSI could be used as a quick indicator for the level of pollution in the aquatic environment. In the present study, HSI showed significant increase in fish samples collected from KHC during summer, autumn and winter (Table 11) compared to HSI of *O. niloticus* in BSC. This could be due to the accumulation of pesticides which dissolved easily in the lipids and also the accumulation of heavy metals and other pollutants discharged in KHC. These results are in agreement with those of Saleh (1982) who noticed an increase in the liver weight of *Tilapia zillii* living in the polluted water in Lake Mariut due to the accumulation of pollutants. Similarly, Saleh and Hamza (1986) concluded that the liver of *Tilapia zillii* from the polluted Lake Mariut contains considerable amount of pollutants and lipids and give rise to liver vacuoles and leads to a higher HSI. Authman (2011) found that *O. niloticus* fish exposed to higher dose of aluminum sulphate showed significant increase ($P<0.05$) in HSI than the unexposed control fish.

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ARABIC SUMMARY

دراسة بيولوجية مقارنة على سمكة البلطى النيلى *Oreochromis niloticus* من قناتين نيليتين فى دلتا مصر

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تعتبر ترعتا بحر شبين والخضراوية قناتين نيلتين ، والاولى اكثر تلوثا من الثانية. وتمثل اسماك البلطى النيلى *Oreochromis niloticus* النوع الرئيس من الاسماك فى النيل وفروعه، وتم دراسة مدى تاثر عواملها البيولوجية بالتلوث.

اشتملت تلك العوامل : النمو، ومعدلات الحياة والفناء، ومعامل المعدة، ومعامل مناسل وكبد الاسماك. وقد لوحظ تدهور هذه العوامل بدلالة معنوية عالية لتلك الاسماك فى ترعة الخضراوية عنها فى بحر شبين وارجع ذلك لزيادة التلوث فى ترعة الخضراوية.