THE BIOLOGY OF *OREOCHROMIS NILOTICUS* IN A POLLUTED CANAL

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Abstract

In the present investigation, some biological aspects (length-weight relationship, condition factor, age, growth, mortality, gonadosomatic index and fecundity) of *Oreochromis niloticus* population from Shanawan drainage canal, Al-Minufiya Province, Egypt, were studied. This was carried out on 162 fish samples collected during the period from April 1992 to May 1993. *Oreochromis niloticus* was found to mature earlier (8-9 cm), more fecund (18126 eggs/year) and has high mortality rates. A comparison of the various parameters of *Oreochromis niloticus* from Shanawan drainage canal with those of other authors in different localities and times in Egypt revealed year-to-year and geographical significant differences in relation to variation in weight with length, condition, fecundity, growth and mortality rates. These differences were discussed and found to be attributed to the effect of eutrophicaton and pollution on the growth, age and other biological aspects of *Oreochromis niloticus*. However, multiple regression analysis showed that only female gonadosomatic index correlated significantly with pesticides and heavy metals.

Introduction

Over the last years, in many African countries a considerable population growth has taken place, accompanied by a steep increase in urbanization, industrial and agricultural land use. This has entailed a tremendous increase in discharge of a wide diversity of pollutants to receiving water bodies and has

caused undesirable effects on the different components of the aquatic environment and on fisheries (FAO, 1992 and Authman, 1998). Furthermore, modern agricultural activities have introduced several polluting substances such as organic matter, chemical fertilizers, insecticides, herbicides, etc., into the River Nile and drainage systems.

Of the 5.5 billion cubic meters (bcm) of water released from the Aswan High Dam, about 50 percent ends up in the drainage system where Egypt possesses approximately 50000 Km of irrigation and drainage canals (Redding & Midlen, 1990). Drainage water above the Delta is returned to the Nile River, recycled downstream and reused.

Drainage water, however, consists not only of irrigation return water but in many cases industrial and domestic wastewater where huge volumes of untreated wastewater are discharged into agricultural drains daily. Drainage water is therefore contaminated with salts, agricultural chemicals (Pesticides & Heavy metals) and other pollutants as pathogens from domestic sewage and industrial discharge.

In spite of the intensive studies conducted on the biology of *Oreochromis niloticus* in River Nile and Egyptian lakes (e.g. Al-Zahaby *et al*., 1981; Khallaf *et al*., 1986 and Ezzat *et al.,* 1990), it was found that the biological studies on this species in drainage canals were neglected and our knowledge about this is deficient. Therefore, for the first time, this work is introduced to study some biological aspects of *Oreochromis niloticus* in Shanawan drainage canal located in the Delta region, Al-Minufiya Province, Egypt. In this canal, pollution by various concentrations of pesticides and heavy metals in water as well as in *Oreochromis niloticus* were identified earlier by Khallaf *et al*. (1994, 1995 and 1998).

Material And Methods

Study Area

Shanawan drainage canal extends about 8 km from Manshat Shanawan village through Almay village near Shebeen Al-Koom city, into another big drainage canal in Menouf city, called Sabal drainage canal which is connected to it at

Shoubrapass village and which finally drains into the Rossetta Branch of the River Nile.

Shanawan drainage canal is very shallow, where its depth ranges between 1 - 1.5 m, and narrow, where its width in the first 1.5 Km of its length ranges between 2.5 - 3.5 m, while the width of the remaining part averages up to 6.5 m.

Oreochromis niloticus specimens were caught by bottom trap (Gobiah) nets by fishermen during the night between 5 pm and 6 am, at different localities in Shanawan drainage canal within a 5 km length, during consecutive months between April 1992 to May 1993. The present study is based on a total of 162 *Oreochromis niloticus*; 87 males and 75 females. Measurements of fish scales, length, weight and gonad were carried out in the laboratory after collection of the fish.

Statistical analyses were carried out at the 5 % level of significance. Statistical analysis followed those of Sokal & Rohlf (1981) and Dixon & Massey (1983). Statistical tests of the difference between regression coefficients and multiple regressions were carried out using STATGRAPH (Ver. 5) computer program.

Results and Discussion

(1) The length - weight relationship :

In this study, the values of the weight-length exponent are : n = 2.65052, 2.70562 and 2.70308 for male, female and combined sexes, respectively; of the standard length-weight relationships of *Oreochromis niloticus* in Shanawan drainage canal. However, comparing the weights of the different lengths of both sexes shows that the female is generally heavier or more robust than male. On a seasonal basis, *Oreochromis niloticus* from Shanawan drainage canal attained its highest average weight in winter (86.9 gm), autumn (75.6 gm) and spring (72.6 gm), while the lowest one was observed in summer (58.0 gm).

As shown in Table 1, there was a significant difference ($F = 10.08$ & $P < 0.05$) between the regression coefficients (n) of the length-weight relationship of the fish.

The weight at total length of *Oreochromis niloticus*, in Shanawan drainage canal, is heavier when compared to those from other Egyptian localities, with the exception of fishes of length groups 11, 16 and 19 cm compared with those of Bahr Shebeen Canal 1986 and length groups 21 and 23 cm compared with those of Lake Nasser 1994 (Table 2). The difference in weight becomes wider with increase in length, reaching its maximum of 56.7 gm at 17 cm length. The higher weight at some length intervals of fishes of Bahr Shebeen than those of Shanawan drainage canal may be explained by the running water effect, low salinity, low nitrogenous load and favourable content of dissolved oxygen of the fluvial Bahr Shebeen (Authman, 1990; Elewa & Authman, 1991), i.e. clear water (free from pollution). However, food availability is high in Shanawan drainage canal due to the high content of phytoplankton, water plants and zooplankton and the high amounts of organic matter. Also, higher values of pesticides and heavy metals in water and different organs of the fish of Shanawan drainage canal (Khallaf *et al.*, 1994, 1995 & 1998) cause enlargement of these organs leading to increase in their weight.

However, the lower value of condition factor of *O. niloticus* in Shanawan drainage canal compared to the values of the same species in Bahr Shebeen, Lake Manzalah and Lake Nasser means that there is a general stress on the fish population of that species in this canal. In accordance, in earlier studies, similar results were also attributed to the high levels of pollution (Sindermann, 1979 & 1990; Lowe-McConnell, 1975 & 1987).

The comparison of growth in length was carried out and shown in table (3). It was found that the maximum growth in total length of *Oreochromis niloticus* from Shanawan drainage canal occurred during the first year of life (50.3 %), followed by a decrease in the second year (49.7 %). These results indicated that, the growth in length of fishes of Shanawan drainage canal was higher than those of other waters with the exception of the fishes of age-group I from the River Nile.

However, growth increment in weight at the end of the first year is very small (14.9 %), then it sharply increased during the second year of life (85.1 %). Again, these differences may be attributed to the size of fish and ecological conditions (as pollution) of different localities. It was mentioned by many authors (Hosny, 1987; Akel, 1989; Bakhoum & Faltas, 1994) that the growth of fish decreased in the polluted water. Akel (1989) and Bakhoum & Faltas (1994) reported that *O. aureus* (a very closely related species) in a non polluted region

of Lake Mariut grew faster and had better growth performance index than those of a polluted region of the lake.

(2) Survival and mortality rates :

The annual survival rates of male and female *O. niloticus* from Shanawan drainage canal were 0.09 and 0.06, respectively. This indicates that females suffer higher mortality than males. However, these values are lower than those of *Oreochromis niloticus* from other Egyptian localities (Table 4). Equally, the annual mortality rate (0.92) and instantaneous mortality rate (2.56) of the studied fish were higher than those of other localities. This may be attributed to the highly increased eutrophication and pollution of the water of Shanawan drainage canal. Saleh (1980) and Dethlefsen & Tiews (1985) mentioned that pollution increased the susceptibility of fish to diseases and increased the mortality rates. Hasan & Thomas (1993) mentioned that the acute pollution condition of the Lake Mariut proper water has now come to be the main factor causing the remarkable decrease in catch.

(3) Gonadosomatic Index (GSI) and fecundity :

In comparison to other localities, fecundity ranged between 1234 to about 3893 eggs for fishes ranging in standard length from 9 cm (= 12 cm TL) to 18 cm (= 23 cm TL) as compared to 482 to 3982 eggs for the fish ranging in total length from 11 to 22 cm in Bahr Shebeen Canal (Alne-na-ei, 1986), 290 to 924 eggs of the fish ranging in total length from 13 to 18 cm in the middle region of Lake Manzalah (Shalloof, 1991), 453 to 1383 eggs of the fish ranging in total length from 9 to 22 cm in Lake Mariut (El-Shazly, 1993) and 547 to 3670 eggs of the fish ranging in total length from 12 to 27 cm in the River Nile (Tharwat, 1995). However, the higher fecundity of *O. niloticus* in Shanawan drainage canal as compared to the same species in other localities is due to the response to drastic conditions concerning various pollutants recorded in the studied area (Khallaf *et al.*, 1994, 1995 & 1998; Authman, 1998). In accordance, Bagenal (1960 a & b), Nikolsky (1963) and Lagler *et al.* (1977) stated that enormous fecundity in fishes is related to enormous mortality., They also reported that an increase in fecundity of an individual within the population represents an adaptive response of the population to environmental changes where an increase in the fecundity ensures the preservation, and not the extermination, of the species; it ensures its relative stability both in space and in time, in the event of fairly wide fluctuations in the environmental conditions. The

hypothesis that fecundity showed increase with increasing environmental harshness could be fully proved in this study. Thus, GSI and fecundity in this study correlated significantly with pollutants such as nitrates, phosphates, silicates and organic matter. In addition to those, GSI correlated positively with heavy metals and pesticides (Table 5).

Oreochromis niloticus fish in Shanawan drainage canal mature earlier (8 & 9 cm), were more fecund (18126 eggs/year) and have an extended spawning season (September-May) and high mortality rates. In accordance, Balon (1979 & 1981), Noakes & Balon (1982), and James & Bruton (1992) stated that increasing environmental harshness leads to earlier sexual maturity at a smaller size, extended spawning season, increased fecundity and high mortality.

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Table (1) : Comparison of the regression coefficient (n) of the total length-weight relationship of *Oreochromis niloticus* from Shanawan Draiange Canal (present study) with those of *Oreochromis niloticus* from different localities : Bahr Shebeen Canal (Alne-na-ei, 1986), Lake Manzalah (Shalloof, 1991), Lake Mariut (El-Shazly, 1993; Bakhoum, 1994), Lake Nasser (Mekkawy *et al.*, 1994) and River Nile (Tharwat, 1995).

	Source of variation	Sum of squars	*df*	Mean squares	F ratio
Shanawan Drainage Canal X Bahr Shebeen Canal	Among n's	0.000046	1	0.000046	0.4613
	Both regressions	0.0043	31	0.0001	
Shanawan Drainage Canal X Lake Manzalah	Among n's	0.0005	1	0.0005	0.5464
	Both regressions	0.0241	26	0.0009	
Shanawan Drainage Canal X Lake Mariut (1993)	Among n's	0.0212	1	0.0212	107.31 *
	Both regressions	0.0074	32	0.0002	
Shanawan Drainage Canal X Lake Mariut (1994) [Southeast basin]	Among n's	0.0042	1	0.0042	20.69 *
	Both regressions	0.0040	22	0.0002	
Shanawan Drainage Canal X Lake Mariut (1994) [Lake proper]	Among n's	0.0104	1	0.0104	34.59 *
	Both regressions	0.0064	22	0.0003	
Shanawan Drainage Canal X Lake Nasser	Among n's	0.0158	1	0.0108	5.44 *
	Both regressions	0.1461	51	0.0029	
Shanawan Drainage Canal X River Nile	Among n's	0.0143	1	0.0143	141.80 *
	Both regressions	0.0028	29	0.0001	

* Significant Difference ($\alpha = 0.95$).

Table (3) : Comparison of calculated total lengths (cm) and weights (gm) of *Oreochromis niloticus* at different localities : Shanawan Drainage Canal (present study), Bahr Shebeen Canal (Alne-na-ei, 1986), Lake Manzalah (Shalloof, 1991), Lake Mariut (El-Shazly, 1993), Lake Nasser (Mekkawy *et al.*, 1994) and River Nile (Tharwat, 1995).

Locality		Age-groups					
		I	II	III	IV	V	VI
Shanawan Drainage Canal	T.L.	9.1	18.1				
	Incr.	9.1	9.0				
	% incr.	50.3	49.7				
	W	19.4	130.3				
	Incr.	19.4	110.9				
	% incr.	14.9	85.1				
Bahr Shebeen Canal	T.L.	7.1	12.5	17.0	19.7		
	Incr.	7.1	5.4	4.5	2.7		
	% incr.	36.1	27.4	22.8	13.7		
	W	9.6	46.6	109.9	165.7		
	Incr.	9.6	37.0	63.3	55.8		
	% incr.	5.8	22.3	38.2	33.7		
Lake Manzalah	T.L.	6.8	10.0	13.0	17.6		
	Incr.	6.8	3.2	3.0	4.6		
	% incr.	38.6	18.2	17.1	26.1		
	W	8.4	23.1	46.6	107.2		
	Incr.	8.4	14.7	23.5	60.6		
	% incr.	7.8	13.7	21.9	56.6		

Table 3 Continued

		I	II	III	IV	V	VI
Lake Mariut	T.L.	8.4	14.2	18.8	24.2		
	Incr.	8.4	5.8	4.6	5.4		
	% incr.	34.7	24.0	19.0	22.3		
	W	9.6	48.4	116.5	256.6		
	Incr.	9.6	38.8	68.1	140.1		
	% incr.	3.8	15.1	26.5	54.6		
Lake Nasser	T.L.	14.9	19.4	23.7	29.4	33.5	37.8
	Incr.	14.9	4.5	4.3	5.7	4.1	4.3
	% incr.	39.4	11.9	11.4	15.1	10.8	11.4
	W	71.5	153.6	277.6	517.8	759.1	1036.8
	Incr.	71.5	82.1	124.0	240.2	241.3	277.7
	% incr.	6.9	7.9	12.0	23.2	23.3	26.7
River Nile	T.L.	13.0	19.1	22.6	25.1		
	Incr.	13.0	6.1	3.5	2.5		
	% incr.	51.8	24.3	13.9	10.0		
	W	41.7	138.7	233.1	320.5		
	Incr.	41.7	97.0	94.4	87.4		
	% incr.	13.0	30.3	29.4	27.3		

T.L. = total length (cm).
W = weight (gm).
Incr. = increment.

Table (4) : Comparison of the survival and mortality rates of *Oreochromis niloticus* from Shanawan Drainage Canal (present study) and those from different localities.

Locality	Author		Annual Survival rate (S)	Annual Mortality rate (A)	Instanta-neous Mortality Rate (Z)
Lake Tiberias	El-Bolock & Koura (1961)		0.24	0.76	1.42
Lake Mariut	El-Zarka *et al.* (1970)		0.24	0.76	1.44
	El-Shazly (1993)		0.17	0.73	1.78
Lake Manzalah	Bishara (1973)		0.38	0.62	0.97
	Shalloof (1991)		0.45	0.55	0.80
Jebel-Aulia (Sudan)	Mahdi *et al.* (1973)		0.08	0.92	2.49
Wadi El-Rayan	Soliman (1981)		0.76	0.24	0.27
Lake Nasser	Azim (1974)	(1965 – 1970)	0.31	0.69	1.18
	Latif & Khallaf (1987)	(1984) (1985)	0.35 0.31	0.65 0.69	1.06 1.16
	Mekkawy *et al.* (1994)		0.11	0.89	2.25
Bahr Shebeen	Alne-na-ei (1986)		0.25	0.75	1.40
	Latif *et al.* (1989)		0.25	0.75	1.40
	Khallaf 1992)		0.22	0.78	1.52
River Nile	Tharwat (1995)		0.33	0.67	1.12
Shanawan Drainage Canal	Present study		0.08	0.92	2.56

Table 2. Comparison of average observed weight (gm) at different total lengths (cm) of *Oreochromis niloticus* from different localities : Shanawan Drainage Canal (present study), Bahr Shebeen Canal (Alne-na-ei, 1986), Lake Manzalah (Shalloof, 1991), Lake Mariut (El-Shazly, 1993; Bakhoum, 1994), Lake Nasser (Mekkawy *et al.*, 1994) and River Nile (Tharwat, 1995).

Total length(cm)	Shanawan Drainagean al	Bahr Shebeen Canal			Lake Manzalah (middle region)			Lake Mariut 1993		
	Weight	W	D	% D	W	D	% D	W	D	% D
9	19.7	—	—	—	15.1	+ 4.6	23.35	11.7	+ 8.0	40.61
10	24.8	24.1	+ 0.7	2.82	22.4	+ 2.4	9.68	17.8	+ 7.0	28.23
11	33.4	34.1	- 0.7	2.10	31.6	+ 1.8	5.39	22.0	+ 11.4	34.13
12	40.3	42.5	- 2.2	5.46	38.2	+ 2.1	5.21	30.2	+ 10.1	25.06
13	51.1	53.1	- 2.0	3.91	46.2	+ 4.9	9.59	36.8	+ 14.3	27.98
14	63.8	64.5	- 0.7	1.10	52.5	+ 11.3	17.71	46.0	+ 17.8	27.90
15	75.5	78.1	- 2.6	3.44	71.5	+ 4.0	5.30	59.7	+ 17.6	23.31
16	91.5	93.5	- 2.0	2.19	80.0	+ 11.5	12.57	70.6	+ 20.9	22.84
17	110.2	108.6	+ 1.6	1.45	91.8	+ 18.4	16.70	86.5	+ 23.7	21.51
18	130.6	125.0	+ 5.6	4.29	118.0	+ 12.6	9.65	98.8	+ 31.8	24.35
19	145.3	147.2	- 1.9	1.31	138.0	+ 7.3	5.02	117.6	+ 27.7	19.06
20	179.0	168.5	+ 10.5	5.87	—	—	—	140.9	+ 38.1	21.28
21	194.6	194.0	+ 0.6	0.31	155.0	+ 39.6	20.35	161.0	+ 33.6	17.27
22	—	220.2	—	—	—	—	—	179.2	—	—
23	257.5	255.0	+ 2.5	0.97	250.0	+ 7.5	2.91	221.9	+ 35.6	13.38

W = Weight (gm).
D = difference.
% D = % difference.

Table 2 Continued

Total length(cm)	Lake Mariut 1994 Southeast basin (non-polluted)			Lake Mariut 1994 Lake Proper (polluted)			Lake Nasser			River Nile (Cairo sector)		
	W	D	% D	W	D	% D	W	D	% D	W	D	% D
9	12.6	+ 7.1	36.04	11.3	+ 8.4	42.64	—	—	—	16.4	+ 3.3	16.75
10	16.9	+ 7.9	31.85	13.0	+ 11.8	47.58	20.0	+ 4.8	19.35	21.3	+ 3.5	14.11
11	22.1	+ 11.3	33.83	20.7	+ 12.7	38.02	—	—	—	27.7	+ 5.7	17.07
12	27.7	+ 12.6	31.27	26.8	+ 13.5	33.40	—	—	—	36.6	+ 3.7	9.18
13	35.9	+ 15.2	29.75	34.2	+ 16.9	33.07	36.7	+ 14.4	28.18	46.1	+ 5.0	9.78
14	44.5	+ 19.3	30.25	43.6	+ 20.2	31.66	46.7	+ 17.1	26.80	56.4	+ 7.4	11.60
15	52.0	+ 23.5	31.13	54.6	+ 20.9	27.68	51.9	+ 23.6	31.26	71.0	+ 4.5	5.96
16	70.2	+ 21.3	23.28	64.6	+ 26.9	29.40	57.5	+ 34.0	37.16	85.1	+ 6.4	6.99
17	83.5	+ 26.7	24.23	77.5	+ 32.7	29.67	53.5	+ 56.7	51.45	97.7	+ 12.5	11.34
18	96.7	+ 33.9	25.96	93.0	+ 37.6	28.79	75.0	+ 55.6	42.57	121.7	+ 8.9	6.81
19	117.0	+ 28.3	19.48	108.0	+ 37.3	25.67	—	—	—	141.8	+ 3.5	2.41
20	133.7	+ 45.3	25.31	128.0	+ 51.0	28.49	167.5	+ 11.5	6.42	175.1	+ 3.9	2.18
21	—	—	—	—	—	—	202.5	- 7.9	4.06	192.9	+ 1.7	0.87
22	—	—	—	—	—	—	227.5	—	—	220.4	—	—
23	—	—	—	—	—	—	284.4	- 26.9	10.45	253.2	+ 4.3	1.67

W = Weight (gm).
D = difference.
% D = % difference.

Table (5) : Significant relationships of some biological parameters of *Oreochromis niloticus* from Shanawan Drainage Canal against some physico-chemical parameters, heavy metals and pesticides via the multiple regression analysis.

Interaction			a	b_1	b_2	DF	r^2	F	P
TLc (cm)	VS	Water temperature (°C) and Photoperiod (hrs) *	19.6436	- 0.0488	- 0.3031	2 , 1	0.9951	101.179	0.0692
SLc (cm)	VS	Water temperature (°C) and Photoperiod (hrs) *	14.7720	- 0.0508	- 0.1622	2 , 1	0.9900	49.7483	0.0984
Wtc (gm)	VS	Water temperature (°C) and Photoperiod (hrs) *	154.0001	- 0.7092	- 5.3729	2 , 1	0.9413	8.0108	0.2390
Wtc (gm)	VS	Ammonia (mg/L) and Nitrite (mg/L) *	169.5619	- 3.5756	- 1.5340	2 , 1	0.9902	50.7404	0.0975
GSIm	VS	Organic matter (mg/L) and Nitrate (mg/L) *	- 0. 9298	0.0394	- 0.0063	2 , 1	0.9632	13.0788	0.1893
GSIm	VS	Organic matter (mg/L) and Phosphate (mg/L) *	- 0.7209	0.0291	- 0.0008	2 , 1	0.9820	27.2415	0.1324
GSIm	VS	Organic matter (mg/L) and Silicate (mg/L) *	- 0.9095	0.0277	- 0.0004	2 , 1	0.9648	13.7103	0.1850
GSIm	VS	Nitrate (mg/L) and Phosphate (mg/L) *	- 0.1353	0.0171	- 0.0029	2 , 1	0.9996	1368.81	0.0189
GSIf	VS	Heavy metals (mg/kg) and Pesticides (mg/kg) in gonads only *	6.4625	- 0.0003	0.0028	2 , 1	0.9679	15.0723	0.1767
Fec.	VS	Organic matter (mg/L) and Nitrate (mg/L) *	- 5993.66	257.204	- 43.5197	2 , 1	0.9660	14.1849	0.1820
Fec.	VS	Organic matter (mg/L) and Phosphate (mg/L) *	- 4550.10	185.997	- 5.5758	2 , 1	0.9852	33.3099	0.1200
Fec.	VS	Organic matter (mg/L) and Silicate (mg/L) *	- 5852.70	176.719	- 2.7964	2 , 1	0.9677	14.9654	0.1774
Fec.	VS	Nitrate (mg/L) and Phosphate (mg/L) *	- 805.962	108.923	- 19.0648	2 , 1	0.9989	436.687	0.0334

The multiple regression equation is $Y = a + b_1X_1 + b_2X_2$ ... etc.

where
- Y is the dependent variable.
- X is the independent variable.
- a is the intercept.
- b is the regression coefficient.
- r^2 is the coefficient of determination.
- D is the degree of freedom.
- F
- F is the *F*- ratio.
- P is the probability of accepting or rejecting null hypothesis.

- * = Significant.
- TLc = total length of combined sexes.
- SLc = standard length of combined sexes.
- Wtc = weight of combined sexes.
- GSIm = gonadosomatic index of male.
- GSIf = gonadosomatic index of female.
- Fec. = fecundity.