World Journal of Fish and Marine Sciences 2 (5): 357-375, 2010
ISSN 2078-4589

Some Biological Aspects of the Nile Mormyrid Fish, (*Mormyrus kannume*, Forsskål, 1775), from Bahr Shebeen Nilotic Canal, Egypt

[1]*Elsayed A.H. Khallaf and* [2]*Mohammad M.N. Authman*

[1]Department of Zoology, Faculty of Science, Minufiya University, Shebeen Alkoom, Egypt
[2]Department of Hydrobiology, National Research Center, Dokki, Giza, Egypt

Abstract: This study was carried out to investigate the population characteristics of the low abundant *Mormyrus kannume*, in order to improve their role in biodiversity of Bahr Shebeen Nilotic Canal, as well as their fishery management. The length-weight relationship was found to be: log W (g) = -2.156 + 3.0330 log TL (cm) and the average condition coefficient (K) was 0.70. Age determination using annual rings on fish vertebrae, indicated that the longevity of this species reaches 8 years. Back calculation was determined by using Lee's equation. The maximum increase in length was noted among the first and second age-groups. The von Bertalanffy growth equation was computed as: $L_t = 77.19\{1 - e^{-0.1287(t + 0.9095)}\}$ and the asymptotic length (L_∞) = 77.19 cm. The population parameters (L_∞, W_∞, K, t_0, Z and M) were estimated. The study revealed that the instantaneous total and natural mortality rates were 51 and 32%, respectively. The body length at first sexual maturity (Lm_{50}) and mean selection length (L_c) were equal to 30 and 24.8 cm, corresponding to age of 2.75 and 2.10 years, respectively. Those preceded estimates should indicate overfishing, but on the contrary, survival rate of 60%, exploitation ratio of 0.37 and expected behavioral feeding and spawning habits, indicated that the fish escape full recruitment of the intended fishing gears which are essentially used for catching tilapias. If fishing rates are to increase, protective measures should be taken to increase mesh sizes of the fishing gears, to permit mormyrids to spawn before being subject to recruitment.

Key words: Age · Growth · Mortality · Population dynamics · *Mormyrus kannume* · Nilotic Canal · Egypt

INTRODUCTION

Bahr Shebeen Canal (BSC, Fig. 1), is an important water and fishery resource throughout three governorates in the Egyptian delta [1]. It is a semi-independent water ecosystem from the Nile, but connected to it by Alrayah Almenoufi near the Barrage [2], is a shallow [ca. 2-3 m] and narrow [ca. 30 m] irrigation canal [3]. It runs for more than 80 km through the Egyptian Delta, surrounded by two major cities, various villages and cultivable lands, while shore plants are rare due to human interference, especially in towns vicinity because of shore protection works, during water closure in winter [15 January to 15 February], no submerged plants are noticed [4]. However, macrophytes are common on those shores. Throughout this period, fish survive in left out pools or deeper spots, before reopening the stream again [5]. The physico-chemical characteristics of this canal are indicating favorable conditions for the aquatic fauna [6]. Although sporadic or intentional pollution may be expected at certain locations along the canal, but the effect of dilution and water current are minimizing the effects of pollution [5]. BSC was to be considered eutrophic because electric conductivity was higher than 200 μmhos and has good water quality since total dissolved solids were less than 420 mg/liter [6]. There is a continuous successful fishery in this canal; however, accurate estimate of catch statistics is not available, due to the uncontrolled illegal fishing activities of the numerous fishermen without effective control.

In spite of the favorability of this canal for the fish fauna, the main catch is composed of tilapias (*Oreochromis niloticus* and *Tilapia zillii*). This is due to the used fishing gears which are mainly directed to fishing tilapias.

The mormyrid species *Mormyrus kannume* [7]; Elephant-snout fish (Fig. 2); was reported to be distributed in Egypt in the River Nile and Lake Nasser and

Corresponding Author: Mohammad M.N. Authman, Department of Hydrobiology, National Research Center, Dokki 12622, Giza, Egypt, E-mail: mmauthman@yahoo.com.

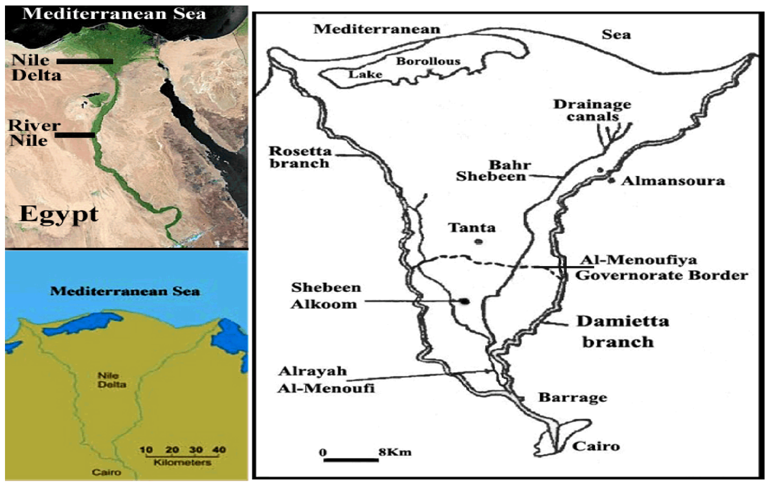

Fig. 1: Map of Bahr Shebeen Canal (BSC).

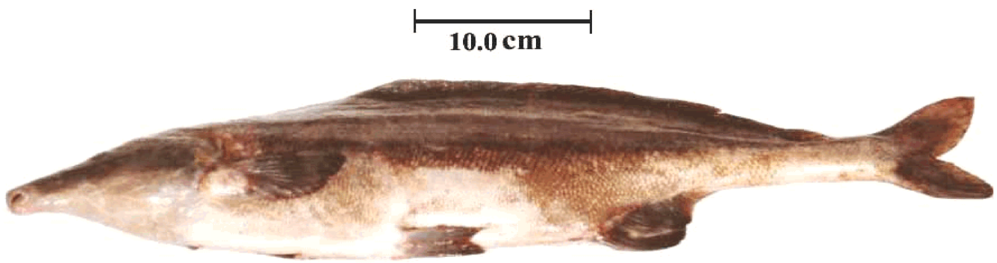

Fig. 2: *M. kannume*, 57.9 cm total length.

it was described as a common species, but its numbers were to be decreasing [8]. This species belongs to Class: *Actinopterygii* (ray-finned fishes), Order: *Osteoglossiformes* (bony tongues), Suborder: *Mormyroidei*, Family: *Mormyridae* (Elephantfishes) and Genus *Mormyrus* [8, 9]. *M. kannume* has a wide distribution in Africa, found in Uganda [10], Nigeria, Blue Nile and Lake Victoria, Lake Kyoga; Lake Albert, Lakes Edward and George, Tana River, Athi River and Northern Guaso Nyiro River [8, 11], but apparently more frequent in Lake Nubia whereas the largest specimen caught reached 130 cm in length [12].

This fish is commonly caught in rapidly flowing water of the River Nile mainly by trammel nets [12]. Its local name is Boweza or Anooma (Anomah Umm Baouez) among which the former denotes the presence of elongated and curved downwards snout [8, 12, 13]. The fish is brownish or olive above, white beneath and possess an elongated fusiform more or less compressed body [14] which is covered with very small cycloid scales [11] and the eye is tiny; they possess a high and long soft dorsal fin [12], narrow caudal peduncle [9] and pointed deeply forked tail [9, 11, 13].

M. kannume spends the day on the bottom, but after nightfall it becomes very active, searching for food, i.e. nocturnal, associated with rocks [8]. It feeds on insects, particularly chironomid larvae, shrimp, earthworms, annelid worms and bottom animals [8, 12, 14]. It has a curious habit of swimming backwards and attains a maximum length of 1 m [8]. It possesses electric organs lying on either side of the terminal portion of the tail [11, 14] and well grown fish can give quite an electrical shock [8, 13]. From a reproductive perspective, males outnumbered the females in the catch and only left ovary or testis is present [8, 12]. This fish spawns over rocks, emerging from the mud in deep water [11].

M. kannume is a rare species in the commercial catch from BSC, but relatively more abundant during June and July. It occupies the lowest commercial importance relative to major dominant species in the catch.

In spite of the intensive studies conducted on the biology of several Nile fishes, it was found that the biological studies on *M. kannume* in Egyptian water [15-18] were very scarce.

In this study, the biology and population dynamics of *M. kannume*, in BSC, were investigated for understanding their role in biodiversity, as well as their fishery development in Egypt.

MATERIALS AND METHODS

Sampling: Fish specimens were collected monthly from commercial fishing with trammel nets at various localities within 25 km length of BSC during consecutive months between January 2005 and January 2006. Fish samples (134 males and 116 females) were collected with records on date of capture, standard and total lengths (to the nearest 0.1 cm), body weight (to the nearest 0.1 g), sex, maturity stages [19] and gonads weight. Fish scales (10-20 from each specimen) were taken from the left side of each fish from the region behind the pectoral fin between the dorsal fin and lateral line [20]. Also, the first five vertebrae, just behind the skull and right below the dorsal fin were obtained from each fish. The scales were placed in solution of 10% of NH_4OH for 24 hours, then washed with distilled water, dried with filter paper and mounted between two glass slides and examined for annuli reading and measurements. Age determination was based on the examination of the scales through a binuclear microscope at *X* 10 magnification and annuli were distinguished [21]. Vertebrae of each fish were cleaned from tissue and examined for annuli reading; to the nearest mm; using an occular micrometer under a light microscope at *X* 4 magnification.

Age and Growth: The length-weight is determined by using the general parabola: $W = a L^n$, or $\log W = \log a + n \log L$, whereas W is weight (g), L is total length (cm), a is constant and n is exponent value [22, 23]. Fish condition was determined using the formula proposed by Bagenal and Tesch [24]: $K = 100 \times W / L^n$ [25], whereas W is fish weight (g); L is fish total length (cm) and n is the exponent of the general length-weight equation. Age determinations were based on the examination of fish vertebrae; due to the difficulty of determining the age of the fish by bony scale determination, whereas many scales were found as regenerated scales in which the characteristic structure of central area of normal scales has been abolished. The Linear length-vertebra relationships were established by using the formula of Lee [26]: $L = a + b V$, where L is fish total length at capture (cm), a and b are constants and V is vertebra radius (mm). The lengths of the previous ages were back - calculated using the equation of Lee [26] as follows: $L_n = a + (L_c - a)/V_c \times V_n$, whereas, L_n is the calculated fish total length in cm at annulus n, V_n is the vertebra radius at annulus n, V_c is the vertebra radius at capture, L_c is the total length of fish at capture and a is the y-intercept of Lee formula. The estimation of general growth in length was based on the grand average of back-calculated lengths and the growth in weight was studied from calculated weights corresponding to back-calculated lengths attained at the end of each year of life, by the length-weight relationship equation. Relative growth (*h*) and instantaneous growth (*G*) for length or weight were calculated as given by Ricker [23] as follows: $h_L = (L_{j+1} - L_j)/L_j$ and $h_W = (W_{j+1} - W_j)/W_j$, $G_L = \ln(h_L + 1)$ and $G_W = \ln(h_W + 1)$, whereas h_L and h_W = relative growth in length and weight at age-groups j and j+1 and G_L and G_W = instantaneous growth rates in length and weight.

Von Bertalanffy growth in length; the theoretical growth in length; was determined by the equation of von Bertalanffy [27] as mentioned by different authors [23, 28, 29]. The common forms of this equation were as follows:

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

Whereas, L_t is the total length of fish in cm at age t, 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_0 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. 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 [23]; into: $W_t = W_\infty \{1 - e^{-k(t-t_0)}\}^n$, with, W_t = weight at time *t*, W_∞ = asymptotic weight, n = is exponent value of length-weight relationship.

Population Dynamics: 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) [23, 30]. The plot of $\log_e$ of frequency at different age-groups and using the straight part of it to calculate a straight line for which the slope would be - Z. Hence, the survival and mortality rates would be calculated as follows: $S = e^{-z} = 1 - A$, whereas: S = Annual survival rate, A = Annual mortality rate and Z = Instantaneous mortality rate. Instantaneous natural mortality rate (M) was used in this study according to

Pauly [31]; who made a regression analysis of M (per year) on K (per year), L_∞ (cm) and T (average annual temperature of water column in degrees centigrade); as follows:

$$\ln M = -0.0152 - 0.279*\ln L_\infty + 0.6543*\ln K + 0.463*\ln T$$

Whereas L_∞, K are von Bertalanffy equation constants and T = average annual of water column temperature in centigrade which equals to 22.33°C [6, 32]. The fishing mortality (F) was calculated as F = Z - M [28]. The expectation of death due to fishing or what is known as exploitation ratio (E = F / Z) was calculated [31, 33, 34], whereas Z and F are the total and fishing mortality coefficients, respectively. The mean selection length (L_c) which considered by many authors as the length at first capture was estimated using the length selection catch curve method [35]. The corresponding age (t_c) was obtained by converting L_c using the von Bertalanffy growth equation [$t_c = - 1 / K^* \ln (1 - L_c /L_\infty) + t_0$] [30]. Maximum age ($t_{max}$), the longevity of the fish species, was calculated from the relation: $t_{max} = 3/k+t_o$ [34], whereas K and t_0 are von Bertalanffy equation constants.

To compare the overall growth performance of the fish species, growth performance index (ϕ) [36, 37], has been used as follows: $\phi_L = \log_{10} k + 2 \log_{10} L_\infty$, for length and $\phi_W = \log_{10} k + 2/3 \log_{10} W_\infty$ for weight, where K, L_∞ and $W_\infty$are von Bertalanffy equation parameters.

Length at recruitment (L_r) was estimated according to Beverton and Holt [38] by the equation: $L_r= L' - (k (L_\infty - L_0) / Z)$, whereas L' is the mean length and L_0 is the length for which all fish of that length and longer are under run exploitation. The corresponding age at recruitment (t_r) was calculated by the following equation: $t_r = - 1 / K^* \ln (1 - L_r /L_\infty) + t_0$] [30]. Yield per recruit model (Y/R) was estimated by Beverton and Holt [28] method using the current growth parameters. Such a model is in principle a "steady state model" [39] and can be written according to Gulland [29] in the following form:

$$Y/R=F*Exp^{-M(T_c-T_r)}*W_\infty[(1/Z)-(3S/(Z+K))+(3S^2/(Z+2K))-S^3/(Z+3K)],$$

Where: $S = e^{-k(T_c - T_0)}$.

Beverton and Holt's Biomass per recruit (B/R) was also calculated by the equation: (B/R) = (Y/R)/F. Fishery managers can control the two parameters "F" and "T_c". Therefore the model allows the authors to calculate Y/R with varying inputs of different values of T_c and F and then assess which effect the various input values have on Y/R of the *M. kannume*. The relative yield-per-recruit (Y/R)' and relative biomass-per-recruit (B/R)' were estimated by applying the model of Beverton and Holt [40] as modified by Pauly and Soriano [41] which is incorporated into the FiSAT software package [42].

Reproduction Characteristics: The gonadosomatic index (GSI); to evaluate the state of maturity of the gonads; was calculated [43, 44] for each specimen using the following equation:

$$G.S.I. = \text{weight of gonads (g)} \times 100 / \text{total body weight of fish (g)}$$

The length at first maturity (L_{m50}) was determined; taking into account the distribution of mature and immature fish within the different length classes; from the plot of cumulative percentage of maturation against the corresponding lengths [30]. The age at first maturity (t_{m50}), the age when 50% of the population becomes mature (also called the age of massive maturation) was obtained by converting L_{m50} using von Bertalanffy equation [$t_{m50} = - 1 / K^* \ln (1 - L_{m50} / L_\infty) + t_0$], where L_∞, t_0 and K are von Bertalanffy growth parameters [30].

Statistics: All statistical analyses were calculated, using the computer program of SPSS Inc. (version 14.0 for Windows) at the 0.05 level of significance.

RESULTS

Age and Growth: Analysis of variance indicated that there is no significant difference between either variances or slopes of this relationship for males and females. Consequently, the data were pooled irrespective of sex (Table 1 and Fig. 3) and one relationship was predicted as follows:

$$\log W = -2.156 + 3.0330 \log L \text{ or } W = 0.00698 L^{3.0330}$$

(r^2 = 0.998; Standard error of "n" = 0.0094), whereas, w = fish weight in grams; L = its total length in cm. The high value of the correlation coefficient (r^2) performs a good measure for the strength of this equation and closeness of observed and calculated values of fish weight.

When condition factor (K) (Table 1) was computed for each length interval, irrespective of sex, it was clear that the values of K ranged from 0.62 to 0.75 with a grand average mean of 0.70. Also, irregularity was found in this parameter. In spite of that, there is an overall increase in K as the fish increase in length. The values of condition factor (K) of *M. kannume* revealed a significant monthly variation (F=3.608, P <0.01). As indicated in Fig. 4, females have better condition than males allover the year round.

Table 1: Total length-weight relationship and condition factor of *M. kannume* from Bahr Shebeen Nilotic Canal.

Total length (cm)	No. of fishes	Weight (g) Actual Range	Mean±SD	Calculated	Advantage of weight	Condition factor K
15	11	29.7–37.9	33.0±2.65	33.4	- 0.4	0.69
17	2	35.6–42.2	38.9±4.67	43.7	- 4.8	0.62
19	7	43.0–75.0	63.4±14.32	64.1	- 0.7	0.68
21	60	60.0–100.0	81.1±9.23	80.9	+ 0.2	0.70
23	39	85.0–143.0	105.2±11.86	103.4	+ 1.8	0.71
25	34	120.0–170.0	140.5±13.48	136.6	+ 3.9	0.72
27	16	133.0–195.0	165.6±16.49	168.8	- 3.2	0.68
29	9	175.0–213.0	197.7±13.82	202.2	- 4.5	0.68
31	9	250.0–292.0	268.9±20.27	249.6	+ 19.3	0.75
33	8	260.0–338.0	320.8±25.02	301.9	+ 18.9	0.74
35	3	364.0–375.0	371.3±6.35	359.6	+ 11.7	0.72
37	9	387.0–455.0	423.2±28.85	425.7	- 2.5	0.69
39	9	431.0–498.0	477.3±26.58	511.1	- 33.8	0.65
41	8	535.0–720.0	566.0±63.99	597.0	- 31.0	0.66
43	4	603.0–893.0	711.3±125.92	661.3	+ 50.0	0.75
45	6	630.0–759.0	674.7±61.78	737.8	- 63.1	0.64
47	3	784.0–954.0	866.7±85.10	852.0	+ 14.7	0.71
49	5	769.0–1150.0	984.2±137.04	990.6	- 6.4	0.69
51	4	1075.0–1486.0	1229.0±188.93	1135.2	+ 93.8	0.75
55	3	1272.0–1346.0	1296.7±42.72	1387.6	- 90.9	0.65
57	1	1613.0–1613.0	1613.0±0.00	1549.0	+ 64.0	0.73
Total	250	29.7–1613.0	250.5±287.87	250.9	*Average*	0.70
F-value			685.47	4970.96		2.14
(Sig.)			(0.000)	(0.000)		(0.004)

K = W / L ^{n} X 100. n = 3.033. (Sig.) = significance level.

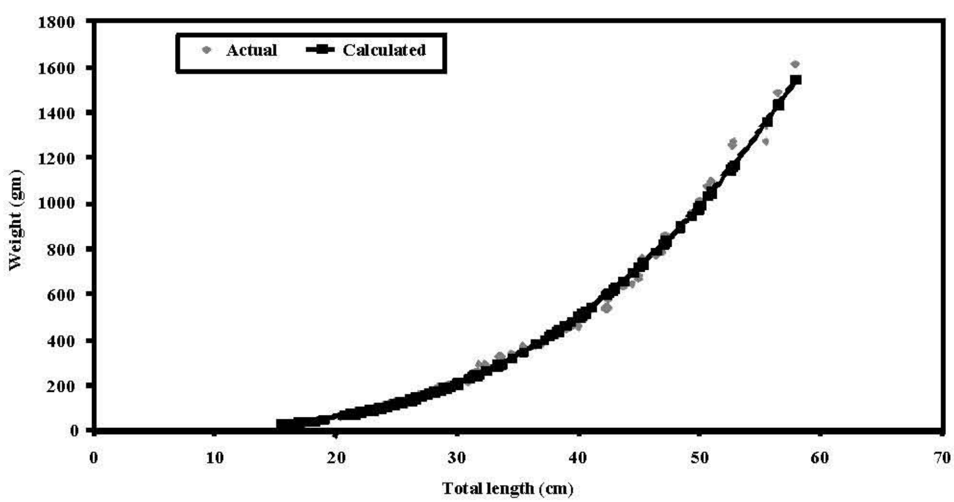

Fig. 3: Total length-Weight relationship of *M. kannume* (combined sexes) from Bahr Shebeen Nilotic Canal.

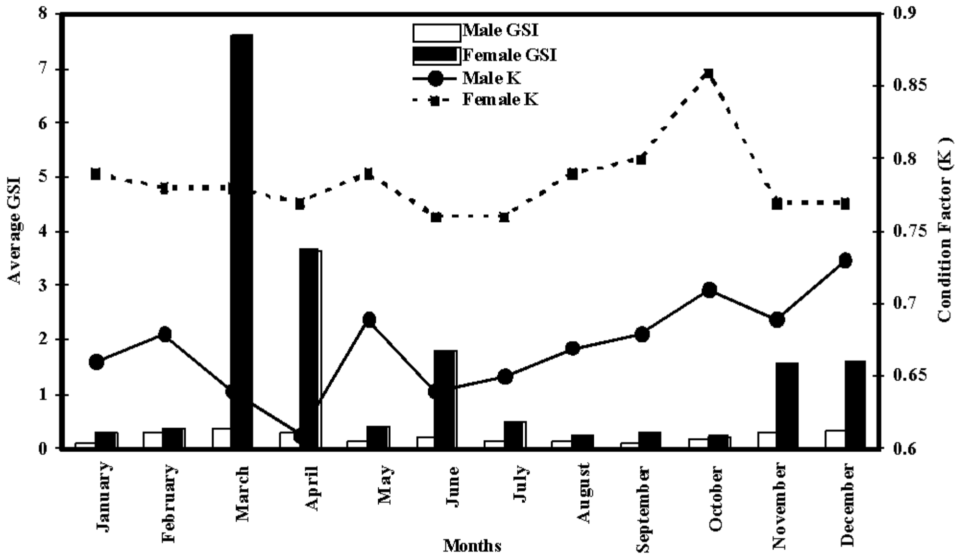

Fig. 4: Monthly variations of condition factor (K_n) and gonadosomatic index (GSI) of male and female *M. kannume* from Bahr Shebeen Nilotic Canal.

The total length-vertebra radius relationship was established by using the formula: L = a + b VR, whereas the constant "a" is a correction factor and the constant "b" is the slope and the formula; irrespective of sex; is found to follow a straight line as follow:

$$TL = 3.7813 + 15.1583\ VR,\ (r^2 = 0.986,\ \text{standard error of "b"} = 0.1288)$$

Whereas, TL is the fish total length (cm) and VR is the vertebra radius (mm). The following equation was adopted for back-calculation of length at different vertebra annuli:

$$L_n = 3.781 + (L_c - 3.781) / V_c \times V_n$$

Whereas, L_n is the calculated fish length in cm at annulus n, V_n is the vertebra radius at annulus n, V_c is the vertebra radius at capture, L_c is the length of fish at capture and a is the y-intercept. Accordingly, for combined sexes, the Y-intercept (correction factor) was considered as 3.781 cm (Fig. 5).

The longevity of *M. kannume* from BSC was estimated to be 8 and 7 years for males and females, respectively, using the readings of its vertebrae (annual growth rings). As seen from table 2, the increase in length, among the observed mean lengths at different age-groups, was irregular.

The back–calculated lengths at the end of each year of life of combined sexes are given in table 2 and fig. 6. Age readings indicated that *M. kannume* attain their highest growth rate in length during the first year of life, after which a gradual decrease in growth increment was observed with further increase in age. On the other hand, in respect to the growth increment in back-calculated weights (Table 2 and Fig. 6), the minimum annual increment is noticed during the first year of life then the annual increment increases with the increase in age to reach the maximum value at the six year of life and then there is a conspicuous drop in these values at age-groups VII and VIII.

Based on these values, the relative and instantaneous rates of growth in length and in weight were calculated and represented in table 3. Thus, the maximum growth in length and weight was noticed during the first year, but declined fast in the following years of life as the fish gets older.

Back calculated lengths of *M. kannume*, at the end of each year of life were used to fit the von Bertalanffy growth model, to describe the theoretical growth. The plot of length increment against initial length (L_t) followed a straight line, which could be described by the following equation:

$$\text{Increment (cm)} = 9.136 - 0.118\ L_t\ \text{(cm)},\ (r^2 = 0.907,\ \text{standard error of "b"} = 0.017)$$

The x-axis intercept of this equation could be estimated exactly by the equation -a/b. This would give the asymptotic length (L_∞) of combined sexes which is equal to 77.19 cm. On the other hand, the relationship between Ln (L_∞ - L_t/ L_∞) against time in years gave the following equation:

Table 2: Average total length (cm) and weight (g) at capture and calculated total length (cm) and calculated weight (gm) at the end of each year of life and percentage of annual increments of *M. kannume*, irrespective of sex, from Bahr Shebeen Nilotic Canal.

			Mean back calculated length at the end of the year							
Age Group	No. of Fish	Average total length at capture (cm)	1	2	3	4	5	6	7	8
0	12	16.40								
I	126	21.54	16.61							
II	48	26.93	16.73	23.44						
III	26	32.41	16.86	24.46	28.79					
IV	15	38.61	16.97	23.88	31.24	35.18				
V	10	44.36	17.75	23.85	31.15	35.97	41.35			
VI	5	49.52	16.93	24.95	29.05	36.14	41.58	46.02		
VII	5	52.66	17.78	23.97	29.13	36.23	41.09	45.81	49.35	
VIII	3	55.22	17.49	21.91	31.06	36.18	41.42	46.47	49.55	52.23
Total	250									
Grand average of length			17.14	23.78	30.07	35.94	41.36	46.10	49.45	52.23
Average annual increment			17.14	6.64	6.29	5.87	5.42	4.74	3.35	2.78
% annual increment			32.82	12.71	12.04	11.24	10.38	9.08	6.41	5.32

			Mean back calculated weight at the end of the year							
Age Group	No. of Fish	Average weight at capture (g)	1	2	3	4	5	6	7	8
0	12	33.20								
I	126	107.10	35.09							
II	48	135.80	35.87	99.76						
III	26	233.06	36.72	113.51	186.10					
IV	15	609.83	37.45	105.54	238.40	341.80				
V	10	697.20	42.92	105.14	236.33	365.61	557.99			
VI	5	790.75	37.19	120.55	191.24	370.88	567.46	771.92		
VII	5	827.63	43.14	106.76	192.84	373.69	547.42	761.29	954.10	
VIII	3	1218.40	41.04	81.29	234.26	372.13	560.86	795.04	965.88	1133.20
Total	250									
Grand average of weight			38.68	104.65	213.19	364.82	558.43	776.08	959.99	1133.20
Average annual increment			38.68	65.97	108.55	151.63	193.61	217.65	183.91	173.21
% annual increment			3.41	5.82	9.58	13.38	17.09	19.21	16.23	15.28

Table 3: Relative growth rates (*h*), instantaneous growth rates (*G*) of calculated total lengths and weights and calculated von Bertalanffy lengths and weights at different age-groups; irrespective of sex; and comparison between the computed actual and back-calculated von Bertalanffy total lengths of *M kannume* from Bahr Shebeen Canal.

		Age group (years)							
		I	II	III	IV	V	VI	VII	VIII
Calculated Total length (cm)									
	h		0.387	0.265	0.195	0.151	0.115	0.073	0.056
	G		0.327	0.235	0.178	0.140	0.108	0.070	0.055
Calculated Weight (g)									
	h		1.706	1.037	0.711	0.531	0.390	0.237	0.180
	G		0.995	0.712	0.537	0.426	0.329	0.213	0.166
Von Bertalanffy lengths									
	Length	16.97	24.31	30.76	36.42	41.39	45.75	49.58	52.95
	Increment		7.34	6.45	5.66	4.97	4.36	3.83	3.37
Von Bertalanffy weights									
	Weight	37.45	111.44	227.45	379.68	559.69	758.59	968.21	1181.59
	Increment		73.99	116.01	152.23	180.01	198.91	209.62	213.38

Comparison between the computed actual and back-calculated von Bertalanffy total lengths

	Paired-Samples T-Test		
	df	*t*	Sig. (2-tailed)
Male	7	7.871	0.000
Female	7	11.153	0.000
Combined sexes	7	18.093	0.000

df = degree of freedom. *t* = T- value. Sig. = Significance level ($\alpha = 0.05$).

$$Ln\,(L_\infty - L_t/\,L_\infty) = -\,0.1170 - 0.1287\,t,\ (r^2 = 0.999,\ \text{standard error of "b"} = 0.002)$$

Whereas, t = age in years. Consequently, t_0 of combined sexes equal -a/b=-0.9095 year. The slope of this line equal – K=0.1287 year^{-1}, the Brody's coefficient of growth. Accordingly, the growth of *M. kannume* was described by the following von Bertalanffy growth equation:

$$L_t = 77.19\{1 - e^{-0.1287(t+0.9095)}\}\ \text{and}\ L_{t+1} = 9.32 + 0.879\,L_t$$

The application of the first form of that equation gave the first length at different ages of combined sexes (Table 3). The equation of theoretical growth in weight was obtained by applying the length-weight relationship equation to the growth in length equation as follows:

$$W_t = 3706.6\,[1 - e^{-0.1287(t+0.9095)}]^{3.0330}$$

Von Bertalanffy growth functions were also fit to the actual total length at capture of *M. kannume*; irrespective of sex; and the following equations were obtained:

Increment (cm) = 8.2773 – 0.0912 L_t(cm), (r^2 = 0.584, standard error of "b" = 0.034)

$Ln\,(L_\infty - L_t/\,L_\infty) = -\,0.1603 - 0.1001\,t$, ($r^2$ = 0.995, standard error of "b" = 0.003).

Accordingly, the von Bertalanffy growth formula, of actual total length at capture, was expressed by the following equation:

$$L_t = 90.76\,\{1 - e^{-0.1001(t+1.6020)}\}\ \text{and}\ L_{t+1} = 8.65 + 0.905\,L_t$$

The application of the first form of that equation gave the first length at different ages for age groups I to VIII and it was found to be: 20.79, 27.45, 33.48, 38.93, 43.86, 48.32, 52.36 and 56.02 cm of combined sexes.

Age composition data (Fig. 7) revealed that age group VIII is the least and contributed about 2.24 and 1.20% for males and sexes combined, respectively. While for females, it was found that age groups VI and VII are the least and contributed about 1.72%. While the frequency of fishes of age groups I and II are dominant in the catch and constitute about 46.27 and 16.42, 55.17 and 22.41 and 50.40 and 19.20% for males, females and sexes combined, respectively.

Population Dynamics: The total instantaneous mortality rate [Z] of *M. Kannume*; irrespective of sex; was calculated by catch curve. The descending right portion of this curve followed a straight line over age-groups from I to VIII with the calculated equation:

$$Log_e\,(N) = 4.9559 - 0.5098\,T,\ (r^2 = 0.963,\ \text{standard error of "b"} = 0.041,\ n = 8)$$

Whereas: N = frequency, T = age in years. Therefore, the instantaneous mortality rate [Z], the survival rate [S] and the annual mortality rate [A] could be calculated for combined sexes as follows: Z= 0.51 year^{-1}, S= 0.60 and A= 0.40. The used catch-curve of combined sexes was shown in Fig. (8). Inserting the growth parameters of von Bertalanffy equation (L_∞, k) and annual water temperature of the area under study (average, 22.33°C) in the equation of natural mortality (M), we obtained its value for combined sexes as follows: M= 0.32 year^{-1}. The fishing mortality coefficient "F" of *M. Kannume* was estimated as F = Z - M and found to be 0.19 year^{-1} whereas the exploitation rate was found to be 0.37. The mean selection length (L_c) of *M. kannume*, the size at which 50% of the fish are retained by the gear, was found to be 24.8 cm for combined sexes (Fig. 9). The corresponding mean

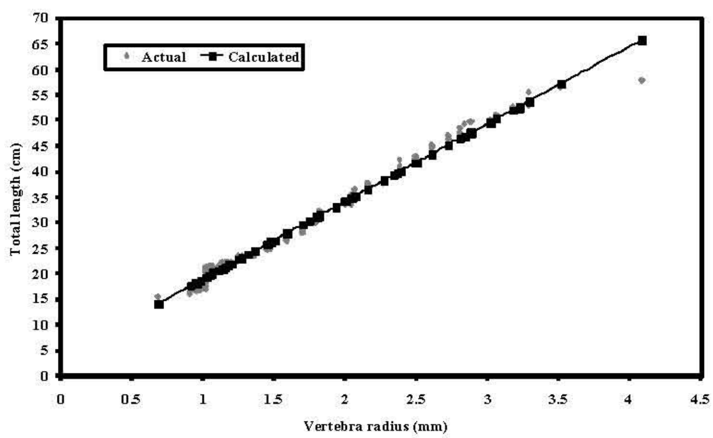

Fig. 5: Total length-vertebra radius relationship of *M. kannume* (irrespective of sex or time) from Bahr Shebeen Nilotic Canal.

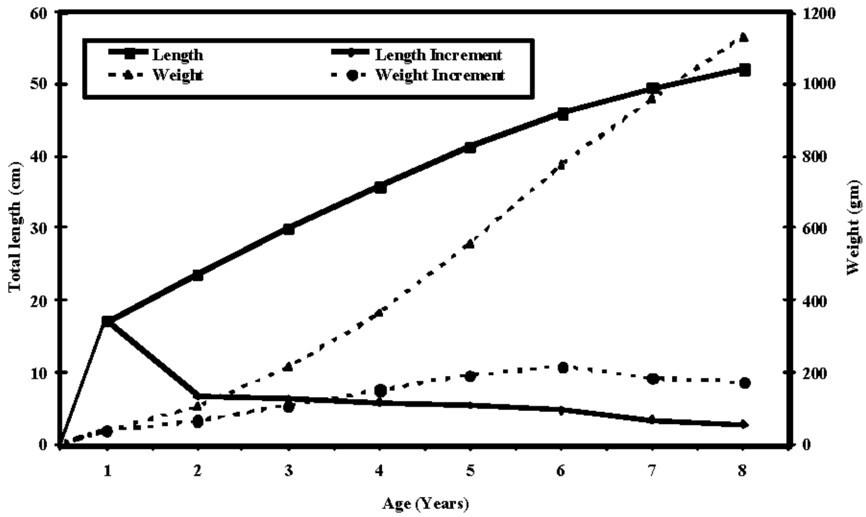

Fig. 6: Back-calculated length and weight and increments of *M. kannume* (combined sexes) from Bahr Shebeen Nilotic Canal.

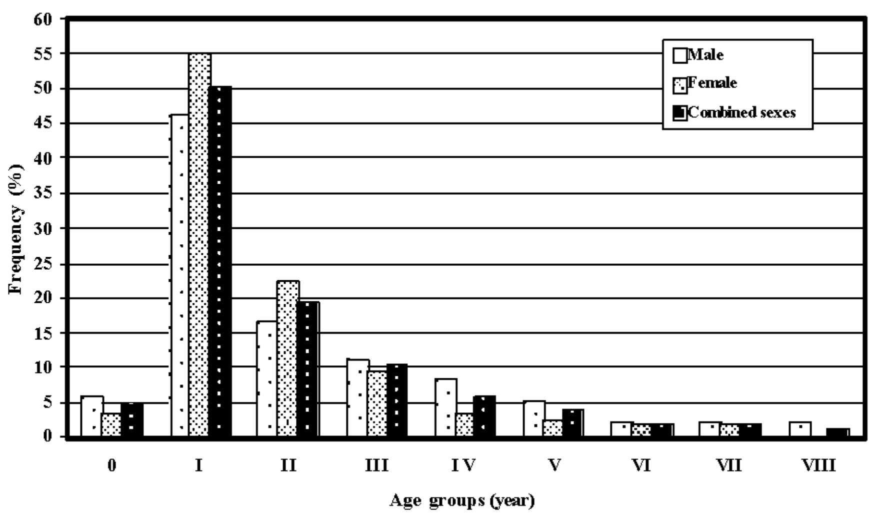

Fig. 7: Percentage of age composition of *M. kannume* from Bahr Shebeen Nilotic Canal.

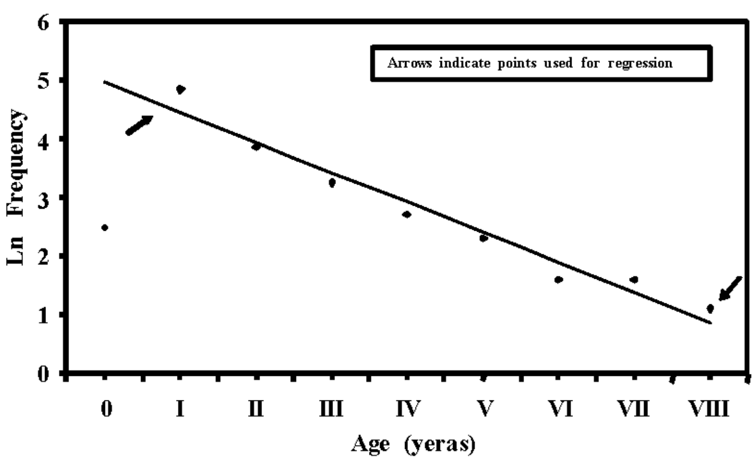

Fig. 8: Catch curve of *M. kannume* from Bahr Shebeen Nilotic Canal.

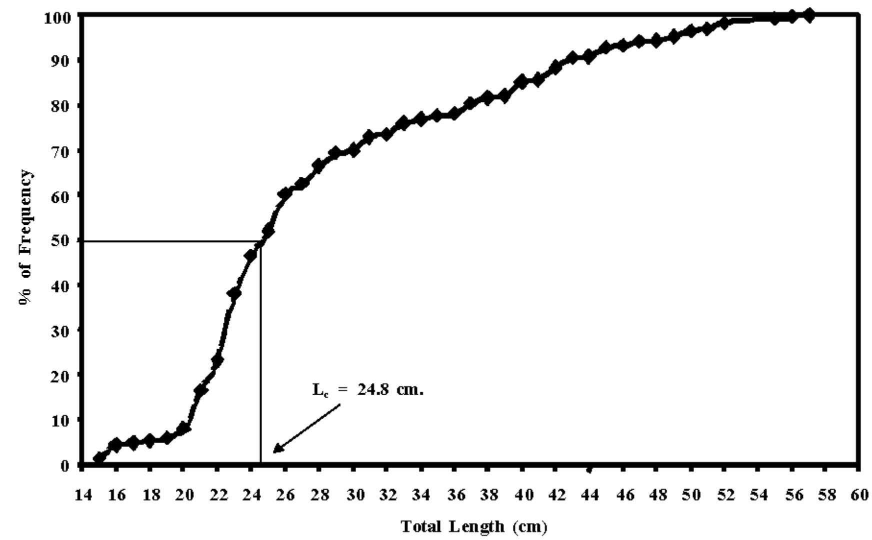

Fig. 9: Cumulative length selection (Gear selection) curve of *M. Kannume* (Combined sexes) from Bahr Shebeen Nilotic Canal showing the mean selection length (L_c).

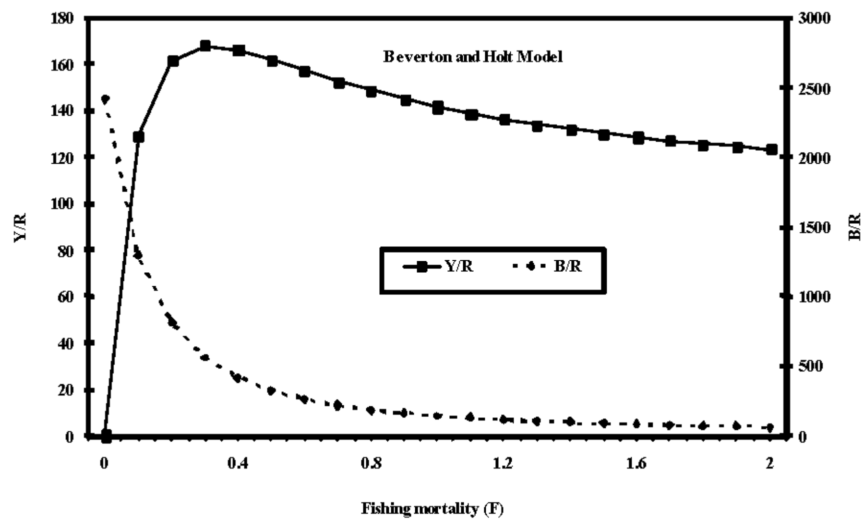

Fig. 10: Yield per recruit (Y/R) and biomass per recruit (B/R) of *M. Kannume* from Bahr Shebeen Nilotic Canal (Based on actual standard length data).

selection age t_c was calculated as 2.10 yrs. The corresponding mean selection weight W_{t_c} was calculated as 118.41 gm. The value of maximum age (t_{max}) was found to be 22.4 years for combined sexes. The obtained results indicated that the growth performance index (ϕ) were found to be 2.89 of growth performance in length (ϕ_L) and 1.49 of growth performance in weight (ϕ_W) for combined sexes.

Based on actual standard length (cm) data; in order to compare with other authors; table (7) shows that the calculated yield per recruit (Y/R) was 156.70 g. On the other hand, the biomass per recruit (B/R) was 652.9166 g.

Figure (10) shows the yield per recruit (Y/R) and the biomass per recruit (B/R) of *M. kannume*; irrespective of sex; as a function of fishing mortality by various F values. The results show that, the estimated yield per recruit (Y/R) increases continuously with the increase of fishing mortality reaching its climax at maximum sustainable yield (MSY) then it remained more or less constant or decreased. It appears that, the maximum sustainable yield per recruit (MSY/R) was 167.7794 g whereas the corresponding optimum fishing mortality value was 0.30 year^{-1} (Table 7). It was found that, the maximum sustainable biomass per recruit (MSB/R) was 559.2645 g.

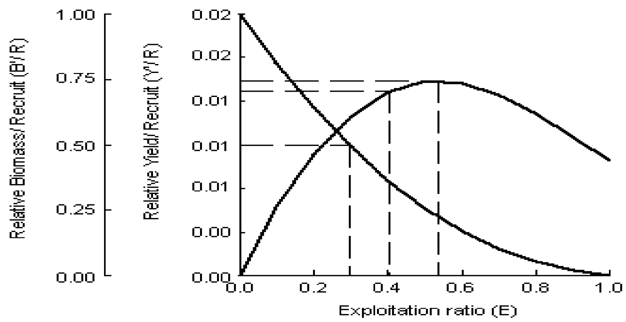

Fig. 11: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' against exploitation rate (E) of *M. kannume* from Bahr Shebeen Nilotic Canal (Based on actual standard length data).

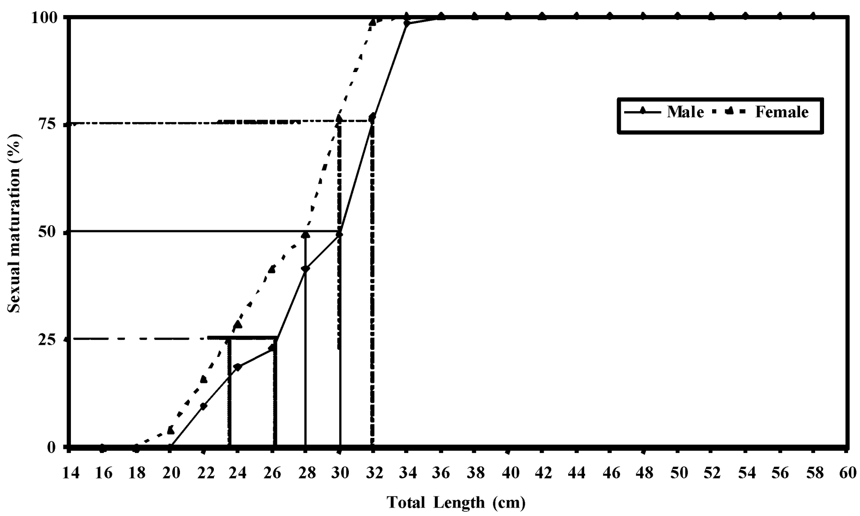

Fig. 12: Size at first sexual maturity of male and female of *M. kannume* from Bahr Shebeen Nilotic Canal.

Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)' plot in relative yield per recruit (Y/R)' and biomass per recruit (B/R)' against exploitation rate (E); incorporated in FiSAT program (Fig. 11); indicated that the maximum (Y/R)' was obtained at E= 0.54. As the exploitation rate increases beyond this value, (Y/R)' decreased. Both the $E_{0.1}$ (the level of exploitation at which the marginal increase in (Y/R)' reaches 1/10 of the marginal increase computed at a very low value of E) and $E_{0.5}$ (the exploitation level which reduces the unexploited biomass to 50%) were estimated. The $E_{0.1}$ and $E_{0.5}$ estimates were 0.40 and 0.29, respectively (Table 7).

Reproduction Characteristics: Males were slightly more numerous than females and sex ratio of 1:0.87 between males (134) and females (116) was obtained. The gonado-somatic indexes (G.S.I.) for both sexes of *M. kannume* were graphically represented in Figure 4. The results show that the values are higher in females than in males during all months of the year. It was found that, females mature earlier than males and all females and males longer than 34 and 36 cm, respectively, are sexually mature. Figure 12 shows that the length at first sexual maturity (Lm_{50}) is 28 and 30 cm in total length corresponding to 174.35 and 207.14 g in total weight and 2.33 and 2.75 years for females and males, respectively.

DISCUSSION

The *Mormyridae* is one of the largest families of fishes endemic to Africa with an estimated 208 species belonging to 18 genera [45-47].

The limited abundance of *M. kannume* in the River Nile and its tributaries (i.e. BSC) may be attributed to three reasons: (l) the loss of flood clay or silt after building the Aswan High Dam. The construction of a dam created a lacustrine environment behind it and may have created a zone of turbulent tailwaters immediately below it [48].

These changes cause alternations in the composition of the fish assemblages [49]. In this context, when the Volta River in West Africa was dammed to form the Volta Lake, bottom-feeding mormyrids declined, but herbivorous cichlids and pelagic clupeids abundantly increased [50]. (2) Pollution by domestic sewage and agro-chemicals was and still is a real problem in delta area [5]. The above two reasons were considered as factors influencing fresh water fish yield in Egypt [51]. (3) The high numbers of fishermen and boats in BSC exploiting the canal without official permission and regular control [52]. This leads to decline in the landings as well as the size of fish as indicated by Khallaf [53]. Very narrow-mesh nets used by some fishermen for catching tilapias less than 7 cm length before reaching sexual maturity length which is 15 ± 2 cm [3]. While other fishermen use poisonous substances [54] or even electric shocks [55] to catch fishes in illegal ways. For *M. kannume* in BSC, the length-weight relationship is well-described by the equation:

$$\log W = -2.156 + 3.0330 \log TL \text{ or } W = 0.00698\ TL^{3.0330}$$

The value of the exponent (n = 3.0330) shows that weight of *M. kannume* in BSC increases to a power greater than the cube of the length and this indicates that the shape changes rapidly as the fish grows in length, i.e. the fish grows heavier for its length as indicated by Wootton [49]. When this value was compared (Table 4) with those from River Nile at Sohag [17], a non-significant difference occurred among the regression coefficients of the total length-weight relationship of fishes in comparison. When comparison to other localities was considered (Table 4); according to standard length; a significant difference was found to occur among the regression coefficients of these relationships.

The weight at length of *M. kannume* from BSC was heavier when compared (according to total and standard lengths) to those form other localities (Table 5) with the exception of fishes of different length groups of those of River Nile at Sohag [17], from length groups of 15 to 30 cm of those of Lake Nasser [15] and from length groups of 15 to 35 cm of those of River Nile at Assiut [18]. The difference in weight becomes wider with increase in length reaching its maximum of 333.1 gm at 55 cm standard length. The higher weight of BSC than those of Lake Nasser [15], High Dam reservoir [16] and River Nile at Assiut [18] may be due to the riverine effect of BSC. On the other hand, food availability in the fluvial BSC is rich since it passes through cultivated lands rich with various aquatic and terrestrial plant forms. Moreover, this

Table 4: Comparison of the condition factor (K_c and K_n) and the regression of length (*L.* cm) and weight (*W.* gm) relationships of *M. kannume* from different localities.

	Comparison according to Total length (cm)							
Locality	K_c	K_n	a	n	S.E.(n)	r	r^2	Author
Bahr Shebeen	0.78	0.70	0.006982	3.0330	0.009	0.999	0.998	present study
River Nile at Sohag	0.97	1.22	0.011957	2.933162	0.14735	0. 936	0.998	[17]

	Test of Equality			
Source of variation	*df*	*Sum of squares*	*Mean squares*	*F*, α = 0.05.
Among *n's* (variation among regression)	1	0.0042	0.0042	1.6907
Average variation within regression	212	0.526	0.0025	

	Comparison according to Standard length (cm)							
Locality	K_c	K_n	a	n	S.E.(n)	r	r^2	Author
Bahr Shebeen	1.14	0.91	0.009528	3.0520	0.021	0.994	0.988	present study
High Dam reservoir	1.07	0.96	0.012672	2.9382	0.052	0.996	0.992	[16]
River Nile at Assiut	0.99*	3.02**	0.0197	2.8023	0.022	0.994	0.989	[18]

	Test of Equality			
Source of variation	*df*	*Sum of squares*	*Mean squares*	*F*, α = 0.05, + = Significant
Among *n's* (variation among regression)	2	0.01758	0.00879	4.62599^{+}
Average variation within regression	225	0.42749	0.0019	

Locality	K_c	K_n	a	n	S.E.(n)	r	r^2	Author
Lake Nasser	1.52	-	0.037325	2.655	-	-	-	[15]

$K_c = W / L^3 \times 100$. $K_n = W / L^n \times 100$. $^{*}K_c = W / L^3 \times 10^5$. $^{**}K_n = W / L^n \times 10^5$. *S.E. (n)* = standard error of regression coefficient. r = correlation coefficient. r^2 = coefficient of determination.

Table 5: Comparison of average calculated weight (gm) at different lengths of *M. kannume* from different localities.

Comparison according to total length					Comparison according to standard length										
	1	2				1	3			4			5		
TL (cm)	W	W	D	%	SL (cm)	W	W	D	%	W	D	%	W	D	%
15	25.8	-	-	-	15	31.9	41.5	-9.6	30.09	-	-	-	38.9	-7.02	22.02
20	45.6	58.5	-12.9	28.29	20	68.1	81.4	-13.3	19.53	62.9	+5.2	7.64	87.2	-19.07	28.00
25	95.3	119.2	-23.9	25.08	25	137.9	155.2	-17.3	12.55	128.4	+9.5	6.89	162.9	-25.00	18.13
30	172.4	211.5	-39.1	22.68	30	246.2	261.0	-14.8	6.01	228.1	+18.1	7.37	271.5	-25.32	10.28
35	283.2	341.7	-58.5	20.66	35	416.1	403.1	+13.0	3.12	368.8	+47.3	11.37	418.2	-2.12	0.51
40	433.8	516.2	-82.4	18.99	40	628.0	585.7	+42.3	6.74	557.6	+70.4	11.21	608.0	+19.98	3.18
45	630.6	741.1	-110.5	17.52	45	905.1	812.6	+92.5	10.22	801.1	+104.0	11.49	845.8	+59.31	6.55
50	879.8	929.8	-50.0	5.68	50	1325.3	1087.7	+237.6	17.93	1106.1	+219.2	16.54	1136.3	+189.01	14.26
55	1187.6	-	-	-	55	1747.7	1414.6	+333.1	19.06	1479.2	+268.5	15.36	-	-	-
60	1560.5	-	-	-	60	-	1796.7	-	-	1927.2	-	-	-	-	-
65	-	-	-	-	65	-	2237.3	-	-	2456.6	-	-	-	-	-
70	-	-	-	-	70	-	2739.8	-	-	3074.0	-	-	-	-	-
75	-	-	-	-	75	-	3307.3	-	-	3785.9	-	-	-	-	-
80	-	-	-	-	80	-	3943.0	-	-	4598.8	-	-	-	-	-
85	-	-	-	-	85	-	4649.7	-	-	-	-	-	-	-	-

1. Bahr Shebeen (This study). 2. River Nile at Sohag Governorate [17]. 3. Lake Nasser [15]. 4. High Dam Reservoir [16]. 5. River Nile at Assiut Governorate [18]. W = Weight. D = Difference. % = Percent of Difference. TL= Total length. SL= Standard length

variation could be attributed to different stages in ontogenetic development as well as to differences in age, maturity and sex. Geographic location and associated environmental conditions, such as season (date and time of capture), disease and parasite can also affect the value of (n) [56]. This may indicate that the ecological conditions in BSC are suitable for the growth of the *M. kannume* during the period of this study. Also, this may show that fish weight can be used as a guide to the effect of different ecological factors on the growth of fish.

The coefficient of condition (K) is considered as a measure of the "fitness" of the fish in a population and 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 [57].

The condition coefficient "K" of *M. kannume* in BSC is showed that the value of "K" increased with increasing fish length with some irregularity. This was in contrast to other authors [15-17], who mentioned that there is decrease in "K" with increase in length. The condition factor of *M. kannume* in River Nile at Assiut showed no particular trend as mentioned by Ahmed [18]. By comparing the condition factor of *M. kannume* in different regions (Table 4), we can see that the condition factor (k_c) is clearly lower in fishes of BSC region than that in other regions with the exception of K_c of fishes of High Dam reservoir and River Nile at Assiut (based on standard length comparison). This verifies the above mentioned finding that *M. kannume* in BSC region is heavier rather than High Dam reservoir data of Aly [16] and River Nile at Assiut data of Ahmed [18].

M. kannume from BSC has a relatively higher longevity, as they attained 8 years. Similarly, they reached 6 years in River Nile at Assiut [18], 7 years in High Dam reservoir [16] and 10 years in Lake Nasser [15]. These significant variations are due to the changes in the fishing effort and exploitation rate of different fishery resources. The abundance of zero groups for *M. kannume* from BSC indicated that the fish are subject to accidental fishing early in life; as fishing is mainly concentrated on tilapias which are relatively smaller in size.

The maximum growth in length occurred during the first and second years of life, followed by a marked decrease as the fish got older (Table 2). Apparently this happens because the fish gets nearer to its asymptotic length and consequently weight, whereas theoretically cessation of growth may occur. This is also represented by the relative and instantaneous rates of growth in total length or weight (Table 3). The same trend is also noticed for mormyrids of Lake Nasser [15] and River Nile at Assiut [18], while those from High Dam reservoir [16] attained their highest growth in length during the fifth and sixth years of life (Table 6).

Table 6: A comparison of average actual and back-calculated standard length (cm) and weight (g) at the end of different years of life of *M. kannume* at different localities.

		Actual standard length										
Age group (year)		I	II	III	IV	V	VI	VII	VIII	IX	X	Author
Bahr Shebeen	Length	19.10	23.82	28.61	34.04	39.07	43.58	46.33	48.57	-	-	Present study
	Increment		4.72	4.79	5.42	5.03	4.51	2.75	2.24	-	-	
Lake Nasser	Length	19.88	25.64	34.20	40.71	47.89	57.00	62.00	68.00	70.00	76.00	[15]
	Increment		5.76	8.56	6.51	7.18	9.11	5.00	6.00	2.00	6.00	
High Dam reservoir	Length	15.8	22.91	31.35	39.34	48.95	58.77	64.07	-	-	-	[16]
	Increment		7.11	8.44	7.99	9.61	9.82	5.30	-	-	-	
River Nile at Assiut	Length	18.15	20.82	27.76	34.74	38.90	45.33	-	-	-	-	[18]
	Increment		2.67	6.94	6.98	4.16	6.43	-	-	-	-	
		Back-calculated standard length										
Age group (year)		I	II	III	IV	V	VI	VII	VIII	IX	X	Author
Bahr Shebeen	Length	15.25	21.06	26.57	31.70	36.44	40.59	43.52	45.95	-	-	Present study
	Increment		5.81	5.50	5.13	4.74	4.15	2.93	2.43	-	-	
Lake Nasser	Length	14.94	24.45	33.38	40.60	46.80	53.15	58.75	63.00	67.40	71.50	[15]
	Increment		9.51	8.93	7.22	6.20	6.35	5.60	4.25	4.40	4.10	
High Dam reservoir	Length	10.30	18.97	27.94	36.16	46.08	57.25	61.99	-	-	-	[16]
	Increment		8.67	8.97	8.22	9.92	11.17	4.74	-	-	-	
River Nile at Assiut	Length	15.17	20.76	27.09	32.03	36.95	41.99	-	-	-	-	[18]
	Increment		5.59	6.33	4.94	4.92	5.04	-	-	-	-	
		Actual weight										
Age group (year)		I	II	III	IV	V	VI	VII	VIII	IX	X	Author
Bahr Shebeen	Weight	107.10	135.80	233.06	609.83	697.20	790.75	827.63	1218.40	-	-	Present study
	Increment		28.70	97.26	376.77	87.37	93.55	36.88	390.77	-	-	
Lake Nasser	Weight	-	-	-	-	-	-	-	-	-	-	[15]
	Increment		-	-	-	-	-	-	-	-	-	
High Dam reservoir	Weight	69.00	138.62	347.99	641.73	1237.78	2265.00	2779.29	-	-	-	[16]
	Increment		69.62	209.37	293.74	596.05	1027.22	514.29	-	-	-	
River Nile at Assiut	Weight	58.85	91.76	223.10	404.62	557.41	695.00	-	-	-	-	[18]
	Increment		32.91	131.34	181.52	152.79	137.59	-	-	-	-	
		Back-calculated weight										
Age group (year)		I	II	III	IV	V	VI	VII	VIII	IX	X	Author
Bahr Shebeen	Weight	38.92	104.17	211.51	362.69	554.95	771.01	953.79	1125.93	-	-	Present study
	Increment		65.25	107.34	151.17	192.26	216.07	182.77	172.15	-	-	
Lake Nasser	Weight	49.0	181.1	413.9	696.0	1015.1	1423.0	1856.6	2234.9	2673.6	3127.4	[15]
	Increment		132.12	232.78	282.18	319.04	407.93	433.57	378.26	438.72	453.82	
High Dam reservoir	Weight	11.00	68.00	219.00	477.00	990.50	1905.60	2422.00	-	-	-	[16]
	Increment		57.00	151.00	258.00	513.50	915.10	516.40	-	-	-	
River Nile at Assiut	Weight	39.82	96.75	158.95	318.38	475.27	674.58	-	-	-	-	[18]
	Increment		56.93	62.20	159.43	156.89	199.31	-	-	-	-	

Back calculated weight-at-length indicated that *M. kannume* from BSC region were heavier during first years of life than those having the same lengths from other Egyptian localities (Table 6) with the exception of the fishes of Lake Nasser [15]. The variation of weights at different lengths among different regions are mainly attributed to water temperature which can affect fish growth directly by affecting the physiology of the fish [58, 59] and food availability in these areas [60, 61]. Also, this may be due to the interaction of a complex of genotype, body size and physiological conditions of the fish and environmental conditions [62].

Table 7: Comparison of population parameters of *M. kannume* (irrespective of sex) from Bahr Shebeen canal (Present study) and those from different localities in Egypt [Based on Actual standard length (cm)].

Parameters	Bahr Shebeen (Present study)	Lake Nasser [15][a]	High Dam reservoir [16][b]	River Nile at Assiut [18]
S	0.60	0.60	0.36+	0.34+
A	0.40	0.40	0.64+	0.66+
Z	0.51	0.51**	1.02	1.08
M	0.27	0.16	0.32	0.35
F	0.24	0.35	0.70	0.73
E	0.47	0.68	0.69	0.67
L_c	22.0	37.29***	29.831	32.79
t_c	1.60	3.33	2.56	3.30
Wt_c	119.14	555.36	272.72+	348.36+
K	0.100	0.061	0.147	0.148
t_o	-1.634	-1.137	0.029	-0.836
L_∞	79.669	156.26	96.10	67.94
W_∞	6049.74	24926.76	8481.70+	2683.07+
ϕ_L	2.80	3.17	3.13	2.83
ϕ_W	1.52	1.72	1.79+	1.46+
t_{max}	28.37	49.18	20.41	20.27
L_{m50} male	26.50	-	46.60	31.50
t_{m50} male	2.41	-	4.54+	3.37+
Wt_{m50} male	210.26	-	1011.34+	311.30+
L_{m50} female	24.75	-	31.80	31.70
t_{m50} female	2.09	-	2.76+	3.41+
Wt_{m50} female	170.68	-	329.06+	316.87+
L_r	16.40*	33.10*	24.20	24.10
t_r	0.67	2.77	2.00	2.14
Wt_r	48.61	404.71	147.49+	146.99+
Y/R	156.70	598.73	342.59+	179.71+
Y/R'	0.01385	0.01282	0.02148+	0.02377+
B/R	652.9166	1710.6571	489.4143+	246.1781+
MSY/R	167.7794	671.9918	389.0597	175.9210
MSB/R	559.2645	3359.9590	972.6492	146.6000
F_{msy}	0.30	0.20	0.40	1.20
$E_{maximum}$	0.535	0.492	0.548+	0.825+
$E_{0.1}$	0.403	0.407	0.457+	0.707+
$E_{0.5}$	0.294	0.281	0.304+	0.364+

* Calculated by the equation: $L_r = L' - (k (L_\infty - L_0) / Z)$ [38].

** Calculated by the equation: $Z = k*((L_\infty - L')/(L' - L_0))$ [38].

*** Calculated by the equation: $L_c = L' - (k(L_\infty - L')/Z)$ [38].

[a] Calculated by present authors. [b] after Ahmed [18]. + Calculated by present authors.

The computed von Bertalanffy back-calculated total lengths were compared with the computed von Bertalanffy observed actual total lengths of *M. kannume* from BSC region (Table 3). It was found that, there is a significant difference between lengths in comparison and this indicated that the used fishing gears selectivity was directed towards the larger fishes.

The population parameters of *M. kannume* from different localities (based on actual standard length data) were estimated for comparison (Table 7). Intra-differences between some of such parameters are evident. The patterns of growth (ϕ), the K value of von Bertalanffy model, fishing, natural and total mortality of different populations were different. These findings refer to variability in fisheries characteristics of *M. kannume* population of different localities.

In fishes, the sex ratio varies from one species to another. In accordance to some authors [15, 16, 18] and in contrast others [17], it was found that the number of males exceeded that of females. The present results indicated that *M. kannume* in BSC is a multiple spawner. This is in agreement with that reported by Khallaf and Authman [63] and Authman and Khallaf [64] who found that, *M. Kannume* in BSC is asynchronous fish, which is characterized by having a prolonged spawning season i.e. reproduce during different periods of the year. This was in disagreement with that reported by some authors [15-17] for the same species in Lake Nasser, High Dam reservoir and River Nile at Sohag. Also, Scott [10] showed that, *M. kannume* samples taken at a typical spawning-ground; in Lake Victoria, Uganda; contain ripe fish over a prolonged period, from October to May and possibly June. Breder and Rosen [65] found that *M. kannume*, in Lake Victoria, breed between September and December. However, Okedi [66] mentioned that most mormyrids are anadromous spawners and the stimuli for the annual or twice yearly spawning, being flood-associated factors, including changes in food supply.

Males attained sexual maturity at a slightly greater length and age than females. This is in agreement with Aly [16] who found that females of *M. kannume* in High Dam reservoir mature earlier than males, but at longer length. On the other hand, this is in contrast to Ahmed [18] who found that males of *M. kannume* in River Nile at Assiut mature earlier than females. The big size of *M. kannume* from BSC region at which the fish mature (28-30 cm) requires the protection of immature fish to preserve a spawning stock as a priority in management of the mormyrid fishery. Decline in the value of the condition factor "K" with the increase of fish gonado-somatic index for both sexes of *M. kannume* from BSC (Fig. 4) can be related to the effect of spawning upon feeding activity, whereas fish may be fasting or lowering the food intake during the spawning periods.

Natural mortality coefficient of BSC mormyrids, was higher (0.32) than the average given by Pauly [31] for 175 fish stocks (0.2 and 0.3). The high survival rate here in this study (S = 0.60), means that about 60% of *M. kannume* survive per year, indicating lower fishing. This is farther shown by the exploitation ratio (E) in the present study as 0.37. The high survival rate in this study indicating that the used fishing gears are not effective in catching mormyrids due to the fish behavior peculiarities, which enable them to escape fishing recruitment. In that direction, Daget [67] and Petr [68] emphasized that Mormyrids from Lake Volta, Ghana, prefer quite muddy bottoms for dwelling and indicated that they preferred rocky flooded areas with aquatic plants as their breeding grounds. While, Ahmed [18] indicated that *M. kannume* in the Nile near Assiut, is a bottom feeder, whereas sand, mud and fish remains are present in the fish stomachs. The subsistence of the fish on chironomid larvae and cladocerans are another indication of that behavior.

The mean selection length (25.3 and 24.2 cm for males and females) of the studied fish, which would be critical in eliminating them before spawning. That is apparent from the predicted values for size at maturity of 28 cm and 30 cm, for females and males. However, their behavior prevents or minimizes their full recruitment by the fishing gears, since it is imminent that they escape the fishing gears. Those gears are originally used to catch tilapias and as such are not causing over fishing of mormyrids. The adverse effect of recruiting mormyrids would appear if fishing rate is increased in that canal.

It was concluded that, the high survival rate of 60%, exploitation ratio of 0.37 and expected behavioral feeding and spawning habits of *M. kannume*, indicate that the fish escape full recruitment of the intended fishing gears which are essentially used for catching tilapias. If fishing rates are to increase, protective measures should be taken to increase mesh sizes of the fishing gears, to permit mormyrids to spawn before being subject to recruitment. Also, pollution may not be apparent, but it should be kept at its minimum or completely prohibited in order to prevent deterioration of BSC natural resources.

REFERENCES

1. Khallaf, E.A. and M. Authman, 1991a. Growth and mortality of *Bagrus bayad* (Forskal) in Bahr Shebeen Canal. J. Egypt. Ger. Soc. Zool., 4: 87-109.
2. Khallaf, E.A. and M.N. Authman, 1992. Changes in diet, prey size and feeding habit in *Bagrus bayad* and possible interactions with *B. docmac* in a Nile canal. Environ. Biol. Fish., 34(4): 425-431.
3. Khallaf, E.A. and A.A. Alne-na-ei, 1987. Feeding ecology of *Oreochromis niloticus* (Linnaeus) and *Tilapia zillii* (Gervias) in a Nile canal. Hydrobiologia, 146: 57-62.
4. Khallaf, E.A. and A.A. Alne-na-ei, 1993. Feeding ecology of *Barbus bynni* (Forskal) from Bahr Shebeen Canal. Arch. Hydrobiol., 90(4): 575-587.
5. Khallaf, E.A., 2002. An ecological assessment of Bahr Shebeen Canal (Review paper). J. Union Arab. Biol., Cairo, 17(A): 65-75.
6. Elewa, A.A. and M. Authman, 1991. Limnological Studies on BSC Bahr Shebeen Canal, El-Menoufia Governorate, Egypt. Bull. Fac. Sci., Zagazig Univ., 13(2): 470-480.
7. Forsskål, P., 1775. Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium; quae in itinere orientali observavit Petrus Forsskål. Post mortem auctoris edidit Carsten Niebuhr. Hauniae. Descr. Animalium, 1-20 + i-xxxiv + 1-164.

8. Bishai, H.M. and M.T. Khalil (Editors), 1997. Freshwater fishes of Egypt. Egyptian Environmental Affairs Agency (EEAA), Cabinet of Ministers, Egypt, Department of Nature Protection. Publication of National Biodiversity Unit, 9: 229p.
9. Nelson, J.S., 1994. Fishes of the World, 3rd edn., A Wiley- Interscience Publication, John Wiley and Sons, New York, pp: 600.
10. Scott, D.B.C., 1974. The reproductive cycle of *Mormyrus kannume* Forsk. (*Osteoglossomorpha, Mormyriformes*) in Lake Victoria, Uganda. J. Fish Biol., 6(4): 447-454.
11. Hugh Copley, O.B.E., 1958. Common Freshwater Fishes of East Africa. H.F. and G. Witherby Ltd., London, pp: 172.
12. Latif, A.F.A., 1974. Fisheries of Lake Nasser. Aswan Regional Planning, Lake Nasser Development Centre, Aswan, Egypt, pp: 235.
13. Boulenger, G.A., 1907. Zoology of Egypt: The Fishes of the Nile. Published for the Egyptian Government by Hugh Rees Ltd., London, liii+1-578+XCVII.
14. Webb, J.E., J.A. Wallwork and J.H. Elgood, 1981. Guide to living fishes. The American Press LTD, London and Basingstoke, pp: 181.
15. El-Etreby, S.G., 1985. Biological studies on *Mormyrus kannume* Forsk. in Lake Nasser. I. Distribution, Age, Growth and Breeding. First Int. Conf. App. Sci., Zagazig Univ., 30 March- 1 April, 1985, Vol. IV:93-120.
16. Aly, A.M., 1993. Biological studies on mormyrid fishes of the High Dam reservoir. M. Sc. Thesis, Fac. Sci. Aswan, Assiut University, pp: 101.
17. Soliman, F.M., 1994. Studies on some biological aspects of *Mormyrus kannume*, Forskal in the River Nile at Sohag Governorate, Upper Egypt. Bull. Fac. Sci., Assiut Univ., 23(2-E): 83-99.
18. Ahmed, A.A.H., 2007. Studies on population dynamics of two freshwater fish species: *Synodontis schall* and *Mormyrus kannume* from the Nile at Assiut, Egypt. M. Sc. Thesis, Zoology Department, Faculty of Science, Assiut University, Assiut, Egypt, pp: 212.
19. West, G., 1990. Methods of assessing ovarian development in fishes: a review. Aust. J. Mar. Freshwater Res., 41: 199-222.
20. Rounsefell, G.A. and W.H. Everhart, 1953. Fishery Science: its methods and applications. John Wiley and Sons Inc., New York, pp: 444.
21. Lagler, K.F., 1956. Freshwater Fishery Biology. W.M.C. Brown Co. Dubuque, Iowa, USA, pp: 421.
22. Le Cren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol., 20(2): 201-219.
23. Ricker, W.E., 1975. Handbook of computations and interpretations of biological statistics of fish production. Bull. Fish. Res. Bd. Canada, 191: 382P.
24. Bagenal, T.B. and F.W. Tesch, 1978. Age and growth. pp.101–136. *In*: Bagenal TB (ed). Methods for assessment of fish production in fresh waters, 3rd edn., IBP Handbook No. 3, Blackwell Sci. Publ., Oxford.
25. Fulton, T.W., 1902. Rate of growth of Sea fishes. Scient. Invest., Fish Div. Scot. Rep. 20.
26. Lee, R., 1920. A review of the methods of age and growth determination in fishes by means of scales. Min. Agri. and Fish., Invest., second series, London, 2-4(2): 1-32.
27. Von Bertalanffy, L., 1938. A quantitative theory of organic growth. (Inquiries on growth laws. 2). Hum. Boil., 10(2): 181-213.
28. Beverton, R.J.H. and S.J. Holt, 1957. On the dynamics of exploited fish populations. Fish. Invest. Minist. Agric. Fish. Food G.B., London, Ser., 2(19): 533p.
29. Gulland, J.A., 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. FAO Rome Man. Fish Sci., (4): 154p.
30. Sparre, P., E. Ursin and S.C. Venema, 1989. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper, 306: 337p.
31. Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM, 39(3): 175-192.
32. Alne-na-ei, A.A., 1999. Biology of the freshwater fish, *Pollimyrus isidori* (Valenciennes, 1846) (*Teleostei*, *Mormyridae*) in the River Nile Delta. Egypt. J. Aquat. Biol. and Fish., 3(1): 195-222.
33. Gulland, J.A., 1983. Fish stock assessment. FAO Wiley Series, Food and Agriculture, pp: 223.
34. Pauly, D., 1983. Some simple methods for the assessment of fish stocks. FAO Fish. Tech. Pap., 234: 1-52.
35. Pauly, D., 1984. Length-converted catch curves: A powerful tool for fisheries research in the tropics. (Part II). ICLARM Fishbyte, 2(1): 17-19.
36. Pauly, D. and J.L. Munro, 1984. Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte, 2(1): 21.

37. Moreau, J., C. Bambino and D. Pauly, 1986. Indices of overall growth performance of 100 Tilapia (*Cichlidae*) populations. pp.201-206. *In*: Maclean, J.L., L.B. Dizon and L.V. Hosillos (eds). The first Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.
38. Beverton, R.J.H. and S.J. Holt, 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapp. P.V. Réun. Cons. Perm. Int. Explor. Mer., 140(1): 67-83.
39. Sparre, P. and S.C. Venema, 1992. Introduction to tropical fish stock assessment, Part 1 Mannual. FAO Fish. Tech. Pap., 306/1, Rev., 1: 376p.
40. Beverton, R.J.H. and S.J. Holt, 1966. Manual of methods for fish stock assessment. Part 2: Tables of yield functions. FAO Fisheries Technical Paper/ FAO Doc. (38) Rev., 1: 67p.
41. Pauly, D. and M.L. Soriano, 1986. Some practical extensions to Beverton and Holt's relative yield-per-recruit model. pp.491-495. *In*: Maclean, J.L., L.B. Dizon and L.V. Hosillos (eds). The first Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.
42. Gayanilo, F.C.Jr., P. Sparre and D. Pauly, 2005. FAO-ICLARM Stock Assessment Tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8, Revised version. Rome, FAO. pp: 168.
43. Authman, M.M.N., 1990. Studies on some biological aspects of *Bagrus bayad* (Family: *Bagridae*) from Bahr Shebeen Canal. M. Sc. Thesis, Zool. Dept., Fac. Sci., Menoufia Univ., pp: 169.
44. Khallaf, E.A. and M. Authman, 1991b. A study of some reproduction characters of *Bagrus bayad,* Forskal, in Bahr Shebeen Canal. J. Egypt. Ger. Soc. Zool., 4: 123-138.
45. Gosse, J.P., 1984. Mormyridae, Gymnarchidae. pp.:63-124. *In*: Daget J., J.P. Gosse and D.F.E. Thys van den Audenaerde (eds). Checklist of the freshwater fishes of Africa (CLOFFA), ORSTOM, Paris and MRAC, Tervuren, No. 1.
46. Moller, P., 1995. Electric fishes: history and behaviour. Chapman and Hall, New York.
47. Chapman, L.J. and K.G. Hulen, 2001. Implications of hypoxia for the brain size and gill morphometry of mormyrid fishes. J. Zool. Lond., 254(4): 461-472.
48. Neilsen, L.A., R.J. Sheehan and D.J. Orth, 1986. Impacts of navigation on reverine fish production in the United States. Pol. Arch. Hydrobiol., 33: 277-294.
49. Wootton, R.J., 1992. Fish Ecology. Blackie, Glasgow and London, Publ. Chapman and Hall, New York.
50. Lowe-McConnell, R.H., 1987. Ecological Studies in Tropical Fish Communities. Cambridge University Press, Cambridge, pp: 435.
51. Vanden Bossche, J.P. and G.M. Bernacsek, 1991. Source book for the inland fishery resources of Africa: 3. CIFA Technical Paper, No. 18(3), Rome, FAO, pp: 219.
52. Alne-na-ei, A.A., 1996. Fishes of Bahr Shebeen Canal. J. Egypt. Ger. Soc. Zool., 20(B): 147-166.
53. Khallaf, E.A., 1992. Evaluation of the fisheries of *Oreochromis niloticus* at Bahr Shebeen Canal-Nile Delta, Egypt. J. Egypt. Ger. Soc. Zool., 7(B): 27-44.
54. Alne-na-ei, A.A., 1997. Deleterious effects of cyanide compounds used by some fishermen on the economic fishes of Bahr Shebeen Canal, Egyptian Delta. Egypt. J. Aquat. Biol. and Fish., 1(2): 199-231.
55. Alne-na-ei, A.A., 2001. Illegal fishing using electroshockers in different freshwater areas in Almenofiya Province and its effect on fish populations. J. Egypt. Ger. Soc. Zool., 35(B): 1-19.
56. Osman, A.M., 2005. Age and growth of *Lithognathus Mormyrus* (*Teleostei*, *Sparidae*) in Mediterranean waters off Alexandria, Egypt. Egypt. J. Aquat. Res., 31(2): 274-280.
57. Patterson, K.R., 1992. An improved method for studying the condition of fish, with an example using Pacific Sardine *Sardinops sagax* (Jenyns). J. Fish Biol., 40: 821-831.
58. Alliot, E., A. Pastoureaud and H. Thebault, 1983. Influence de la temperature et de la salinite sur la corissance et la composition corporella d'alevin, de *Dicentrarchus labrax*. Aquaculture, 31: 181-194.
59. Weatherley, A.H. and H.S. Gills, 1987. The biology of fish growth. Academic Press, London.
60. Wassef, E. and H. EL-Emary, 1989. Contribution to the biology of bass, *Dicentrarchus labrax* L. in the Egyptian Mediterranean waters off Alexandria. Cybium, 13(4): 327-345.
61. Bruton, M.N., 1990. Trends in the life history styles of vertebrates: an introduction of the second ALHS volume. Environmental Biology of Fishes, 28: 7-16.
62. Wootton, R.J., 1990. Ecology of Teleost fishes. Chapman and Hall, London and New York, Reprinted 1991, pp: 404.
63. Khallaf, E.A. and M.M.N. Authman, 2009. Oogenesis of females of the Nile Mormyrid Fish, *Mormyrus kannume* (Forsskål, 1775) from Bahr Shebeen Canal, Egypt. Egypt. J. Aquat. Biol. and Fish., 13(4): 333-359.

64. Authman, M.M.N. and E.A. Khallaf, 2009. Spermatogenesis of Male *Mormyrus kannume* (Forsskål, 1775) (Teleostei: *Mormyridae*) from Bahr Shebeen Nilotic Canal, Delta, Egypt. Egypt. J. Aquat. Biol. and Fish., 13(4): 361-384.
65. Breder, C.M. and D.E. Rosen, 1966. Modes of reproduction in fishes. T.F.H. Publications, Neptune City, New Jersey, pp: 941.
66. Okedi, J., 1969. Observations on the breeding and growth of certain mormyrid fishes of the Lake Victoria basin. Revue Zool. Bot. Afr., 79: 34-64.
67. Daget, P.S., 1954. Les poisons du Niger Superieur. Mem. L'IFAN. No.36, Dakar.
68. Petr, T., 1967. Fish population changes in the Volta Lake during its first sixteen months. *Hydrobiologia*, 30(2): 193-220.