Department of Zoology,
Fac. of Science, Assiut University,
Head of Dept. Prof. Dr.

STUDY OF THE EFFECT OF LAKE NASSER IMPOUNDMENT ON GROWTH AND AGE COMPOSITION OF *SAROTHERODON GALILAEUS*

(With 12 Tables and 8 Figures)

By

I.A.A. MEKKAWY* and S.H. MOHAMAD**

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دراسة تأثير التخزين ببحيرة ناصر علىالنموو التركيب العمرى للبلطى الجليلى

إمام مكاوى ، سامية محمد

فىهذا البحث كانت العلاقة بين الوزن والطول أيزومترية فىذكور وانـاث البلطىالجليلى مـن بحيرةناصر بينما كانت الومترية فىالجنس الخليط . والذكور كانت اثقل وزنا من الاناث باعتبار وحـدة الطـول .معامل الحالة لهذا النوع اظهر تغيرات شهرية وجنسية ولم يظهر اى ميل نحو الزيادة والنقصان مع الزيادة فـى الطول .يقع وقت تكوين اقل زيادة فى الحلقات فى شهر يناير للذكور ومايو للاناث والجنس الخليط .لقد سجلت الاختلافات الذكرية الانثوية فى الزيادات السنوية للطول والوزن. اظهرت المقارنات مع نتائج مؤلفين اخرين من مناطق مختلفة تغيرات جغرافية ومن عام لعام .واشارت مثل هذه المقارنات الى شيخوخة بحيرة ناصر والى تأثير التلوث والتخزين - الذى سجله العديد من البـاحثين بدراسـاتهم الفيزيائيـة الكيميائيـة- علـى النمـو والـتركيب العمـرى للبلطى الجليلى فـى البحـيرات المصريـة والـى ان بحـيرة نـاصر رغـم شيخوختها افضل حالا من هذه البحيرات .

SUMMARY

The length-weight relationships of male and female *Sarotherodon galilaeus* of Lake Nasser ,Egypt were found to be isometric, whereas that of the combined sexes was allometric. Males were heavier per unit length than females. The condition factor revealed monthly variations and sexual dimorphism, but did not show any particular trend with the increase of fish size. The time of minimum increment of the annulus formation was found to be in January for males and in May for females and combined sexes. Male/female differences were recorded in the annual increments of length and weight. Comparisons of the results of the present work with those of other authors in different localities and times revealed year-to-year and geographical variations. Such comparisons also emphasized on the effect of eutrophication and pollution on the growth and age composition of S. *galilaeus* in some of the Egyptian lakes.

Keywords: *Growth, age composition , pollution, impoundment, Lake Nasser.*

* Department of Zoology, Faculty of Science, Assiut University, Assiut, Egypt.
** Department of Zoology, Faculty of Education, Suez Canal University, Al-Arish,Egypt.

INTRODUCTION

Any sudden change in water temperature, level, salinity, pH and other physico-chemical factors of water may stop the spawning process of ishes .Accordingly, the mature gametes in their gonads are esorbed.Also , the breeding cycle of those fishes may result in a gradual decrease in their culture in a given area. *HUSSEIN (1984)* reported this phenomenon in Nile fishes after the High Dam construction; it was due to the loss of the old irrigation system "Hiadd" in upper Egypt. Such a system served as ideal basins for fish spawning and for early growth of 0 group fish.

LATIF & KHALLAF (1976), *LATIF (1978)*, *EL-OTIFY (1985)*, *ELEWA & AZAZY (1986)* and *KHALLAF (1988)*, studied the effect of impoundment and dam closure in 1968 on the conversion of a fluviatile ecosystem to a lacustrine one in terms of structural and physico-chemical changes which consequently affect the biota. The latter authors quantified the microbial content and chemical characteristics of the lake water during 1974-1984 period as affected by drought period, started since 1980, which lowered the water level from 178 m to 157 m above sea level. *AGAYPI (1993)* referred to the correlation between fish landings , especially tilapiines ,and water level in Lake Nasser. Similar correlations were recorded by *WILLIAMS (1972)* in several African fisheries and *DAVIDOFF (1986)* in Lake Kinneret (Lake Tiberias).

The present work aims to study the effect of impoundment and aging of Lake Nasser in terms of growth and age characteristics of *Sarotherodon galilaeus* (L.) in comparison with those of *ABDEL-AZIM (1974)* for the same species in the same lake in the early years of its formation (1965-1970) .

MATERIAL and METHODS

The present investigation is based on the examination of 978 specimens of *S. galilaeus* (130-700 mm in total length (TL)) which were collected from Lake Nasser marketing center, Lake Nasser, Aswan, Egypt from December 1988 to March 1990 . For each fish, the total length was measured to the nearest millimeter and the body weight (W) was recorded to the nearest gram.

The length-weight relationships for males, females and combined sexes were described by the general power function equation: $W = cTL^n$ where W is the weight of fish in g, TL is the total length of fish in cm and c and n are constants whose values were estimated by the least square method.

The condition factor (K), which measures the well-being of fish was calculated from the following equations as proposed by *BAGENAL* and *TESCH (L978)*:

$$K1 = Wx10^5/TL^n \quad \text{and}$$
$$K2 = Wx10^5/TL^3$$

Also the correlation coefficients between K1 (Rk_1) & K2 (Rk_2) and total length were calculated.

The scales of 926 specimens, taken from behind the pectoral fin just below the upper lateral line, were used for age determination. Examination and measurements of growth annuli on the anterior scale radius were carried out by a scale projector.

To clarify the time of annulus formation, monthly measurements of the distance between the last annulus and the margin of the scale were made. The relationship between the scale radius (S) and the total length was studied to find out the necessary correction factor for the direct proportion calculated length. On the basis of the scatter diagrams, such a relationship was represented by the following linear equation:

$TL = a + bS$

where a (the correction factor) and b are constants which were estimated by the least squares method.

Growth in length was determined by the back calculations using the following formula (*LEE, 1920*):

$TL_n = Sn/S\ (TL-a)$

where TL_n is the calculated length at the end of nth year, TL is the total length of fish at capture, Sn is the scale radius corresponding to nth year., S is the scale radius at time of capture and a is the correction factor.Growth in weight was determined by applying the length-weight equation to the calculated length of different individuals of different age groups.

The age distribution was determined and an age-length key was constructed. From such a key and the length distribution, the number of fishes belonging to each age group could be determined. Moreover, the number of fishes belonging to each age group per kilogram was determined by making use of age-length key and length-weight relationship. Mortality and survival rates were estimated from age distribution according to *RICKER* (1958) and *MEKKAWY (1990)*.

RESULTS

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR

The weight of S. *galilaeus* increased as the fish length increased (Correlation coefficient for untransformed data, R=0.82, 0.86 & 0.87 for males, females and combined sexes respectively). Males were heavier than females in the younger fishes and the reverse was the case in the older ones (Table 1). The length - weight relationship was best described by a general power function equation . The logW-log TL relationships (R=0.87, 0.86 &0.88 for males, females and combined sexes respectively) were linear .

Using the least squares method, the estimates of the parameters of the power function equation were considered (Table 2). As the value of the allometric coefficient, n, did not differ significantly from 3 for males and females, it was concluded that the growth in weight relative to fish size was isometric through the period of investigation. On the other hand, the growth in weight of the combined sexes was allometric.

The condition factor of S. *galilaeus* (Table 3) did not vary significantly with length increase (Rk_1 = -0.12, 0.07 & -0.11; Rk_2 = -0.04, -0.06 & -0.02 for males, females and combined sexes respectively). Significant monthly and yearly variations in the condition factor (Table 4) were detected (Rk_1= -0.41, -0.53 & -0.34; Rk_2 = -0.42, -0.50 & -0.35 for males, females and combined sexes respectively). Using the cube equation, the condition factor (K_2) of males was higher than that of females, whereas the condition factor (K_1) calculated by the power equation had failed to some extent to reveal such a trend of sexual dimorphism (Table 4). It is worthy noting that K_1 values did not vary significantly from K_2 values because the allometric coefficients of males and females used in the estimation of K_1 were equal statistically to 3; i.e. the two sexes had isometric growth.

AGE DETERMINATION AND GROWTH

TIME OF ANNULUS FORMATION

There was no particular trend toward increase or decrease in the marginal increments of scales of S. *galilaeus* (Fig.1).The maximal increments were found in December for males and in November for females and combined sexes, whereas the minimal increments were found in January for males, and in May for females and combined sexes respectively. Accordingly, annulus formation of scales of S. *galilaeus* began and became complete at different times of the year in Lake Nasser.

BODY-SCALE RELATIONSHIP

The total length (TL)- scale radius (S) relationships of S. *galilaeus* were linear with high correlations. Such relationships were best described, according to the least squares method, by the following equations:

Males TL = 8.504 + 35.923 S R=0.79 N=309

Females TL = 8.023 + 37.273 S R=0.78 N=194

Combined sexes TL = 9.211 + 35.590 S R=0.78 N=926

The intercepts of the aforementioned equations were used as correction factors in the back calculations of length at the end of each year of life. The equations of back calculations were found to be:

Males TL_n = 8.504 + Sn/S (TL-8.504)

Females TL_n = 8.023 + Sn/S (TL-8.023)

Combined sexes TL_n= 9.211 + Sn/S (TL-9.211)

CALCULATED GROWTH IN LENGTH AND WEIGHT

In all age groups of S. *galilaeus* the calculated lengths nearly coincided with the observed ones (Table5). Except for age group I, The average calculated lengths of females were higher than those of males in all age groups. S. *galilaeus* attained its greatest length in age group I after which the growth increment in length markedly decreased (Table 5).

Except for age group IV, males were heavier than females of the same age group (Table 6). This sexual differences in weights slightly decreased as age group increased until age group IV where the reverse was the case. Table 6 shows that males attained annual increments greater than those of females until age group IV where the reverse was true. Also, it can be concluded that S.*galilaeus* attains the greatest part of its weight in the first (males) and in the third, fourth and fifth (females) years of life.

SURVIVAL RATE DERIVED FROM AGE COMPOSITION

To estimate the survival rate as well as the instantaneous total mortality rate from age composition the logarithms of the percentage frequency of successive ages were plotted against the corresponding age (Fig.2). The descending limbs of the curves of Fig. 2 form almost straight lines. The slopes and the intercepts of such lines were estimated by the least square method and the following equations were obtained:

Males: log(% frequency)= 5.3598 - 1.19256 Age

Females: log(% frequency)= 4.8666 - 1.0164 Age

Combined sexes: log(% frequency)= 6.0242 -1.3828 Age

Making use of these equations, the instantaneous total mortality rates were 2.747, 2.355 and 3.185 for males, females and combined sexes respectively after age group III. On the other hand, the survival rates were 0.064, 0.095 and 0.041 for males, females and combined sexes respectively.

AGE-LENGTH KEY AND AGE DISTRIBUTION

Tabulation of frequency of fish specimens of S. *galilaeus* in different age groups showed an overlapping between age groups (Table7). The majority of fishes were found to belong to age groups II -III in both sexes;age group III had the highest frequency.

Making use of the length-weight relationship and age-length key, fish specimens used in such relationship were distributed among age groups I-V and the frequency and its percentage of males, females and combined sexes were estimated (Table 8). Age groups III of males and combined sexes and age group IV of females exhibited the high ratios. Table 8 shows also sexual dimorphism of S. *galilaeus* in terms of total weight, percentage weight and number of fish per kilogram in each of the age groups considered.

LENGTH DISTRIBUTION

Length distribution of S. *galilaeus* varied with the variation of sexes (Table 1). Analysis of such distributions showd two modes only in males , females and combined sexes, whereas age distributions referred to the presence of four age groups in males and five ones in females and combined sexes. This means that age groups deduced from length distributions of Table 1 do not coincide with those derived from scale reading data. When the number of classes of length distributions increased into 25 classes, three, six and two modes in males females and combined sexes respectively were derived (Fig. 3). These results almost conform with those of scale reading. The length distribution of 25 classes was used for estimation of the instantaneous total mortality (3.481, 3.409 & 3.368 for males, females and combined sexes respectively) and survival (0.031, 0.033 & 0.034 for males, females and combined sexes respectively) rates of S.*galilaeus*. These survival rates were smaller than those derived from age distribution of males and females .

DISCUSSION

In the present work, over a wide range of length, the growth in weight of *Sarotherodon galilaeus* relative to length was best described by the power function equation.

Such growth was isometric for males and females but allometric for the combined sexes. *AGAYPI* (1992) recorded allometric growth in the combined sexes of S. *galilaeus* of Lake Nasser (in 1982).

He also reported that the growth in length of that species showed local variations within the different areas of the lake. Similar results were obtained by Agaypi (1992) and *MEKKAWY et al.*(1995) for *O.niloticus*. Comparing the parameters of the power function equation estimated by different authors in different localities and years (Table 9), one can conclude that the general well-being of S. *galilaeus* populations varies with sexual, geographical and year-to-year variations. The allometric coefficients of *BISHARA* (1973) (for males of 1968 & 1969 and females of 1969) were only inside the confidence limits of the allometric coefficient of the combined sexes of S. *galilaeus* of the present work.

The condition factor measures the variations in fish weight which are not associated with fish length. *BISHARA*'s (1973) results referred to the fact that the trend of increase or decrease of S. *galilaeus* of Lake Manzalah with length may vary seasonally. *SHOUGY* (1991) recorded that in the middle region of that lake, the condition factor of that species increased with the increase of length.

In the present work, no correlation between the condition factor of that species and fish size in Lake Nasser was recorded. Similar results were obtained by *EL-BOLOCK* and *KOURA* (1961), and *ABDEL-AZIM* (1974) working on S. *galilaeus* of Lake Tiberias, and Lake Nasser respectively. This means that S. *galilaeus* has a constant condition for younger and older fishes in these regions; a result which may be due to the prolonged spawning seasons.

According to the results of the present work and those of *EL-BOLOCK* and *KOURA* (1961), *BISHARA* (1973), *ABDEL-AZIM* (1974) and *SHOUGY* (1991) sexual dimorphism and monthly, yearly, seasonal and geographical variations were revealed by the condition factor of S.*galilaeus* . Comparisons (Table 10) of the present results with those of *ABDEL-AZIM* (1974) working on the same species of the same locality, Lake Nasser, in the early years of its formation (1965, 1970) refer to the recent unsuitable physico-chemical characteristics of lake water that control the growth of S. *galilaeus*; i.e. there is a general stress on fish population of that species in Lake Nasser. Similarly, the aforementioned variations in the condition factors may be due to variations in the reproductive activity (spawning and brooding), which cause erratic feeding patterns and depletion of bodily reserves, particularly for females.

In the present work , annulus formation of S. *galilaeus* from Lake Nasser took place from January to May. *BISHARA* (1973) recorded late March to be the time of annulus formation of S. *galilaeus*.The prolonged time of annulus formation may be due to the prolonged period of spawning of S. *galilaeus* and new growth on the scales of different individuals begins and becomes complete at different times; a similar situation was recorded by *MEKKAWY* (1990) and *MEKKAWY et al* (1995) on

Alestes nurse and *O. niloticus* of Aswan locality and Lake Nasser respectively.

In the present work, sexual dimorphism in annual increments in length and weight of S.*galilaeus* of Lake Nasser was recorded; females grew in length faster than males and the reverse was the case for weight until age group IV. *BEN-TUVIA* (1959), *FRYER* and *ILES* (1972), *JOHNSON* (1974), *TREWAVAS* (1983) and *BEN-TUVIA et al.* (1992) stated that the growth in length of males was slightly faster than that of females. Also, geographical, and year-to- year variations in the growth rates of that species can be revealed if the results of the present work are compared with those of *JENSEN* (1958), *BEN-TUVIA* (1959), *EL-BOLOCK* and *KOURA* (1961), *BLACHE et al.*(1964), *BISHARA* (1973), *ABDEL AZIM* (1974), *TREWAVAS* (1983) and *BAYOUMI* and *KHALIL* (1988) (Figs.4-7). *AL SHAZLY* (1993) recorded weak growth rates in length of that species in Lake Mariut. He emphasized on that the growth rates of *O. niloticus* were higher than those of S.*galilaeus*; similar results were recorded by the present authors (Fig.8) and *SHOUGY* (1991) in Lake Nasser and Lake Manzalah respectively.

Survival and instantaneous total mortality rates of certain Nile fishes ,which are considered of primary importance for fishery management, were investigated by many authors including *MAHDI et al.* (1973), *MEKKAWY* (1990), *YOAKIM et al.* (1993a,b) and *MEKKAWY et al.*(1995). In the present work, the two parameters were estimated for comparisons between S. *galilaeus* populations collected from different localities at different times (Tables 11&12). Such estimates revealed year-to-year and geographical variations which depended upon age groups with maximum number of fishes, i.e. age group that suffered high selective mortality which caused a fishingup effect. Generally, one can conclude that fish stock decreases in the Egyptian lakes .These findings coincide with the amount of pollution recorded in such lakes.

Although tilapiines remain the basis of the Lake Nasser fishery , their biological characteristics, as reflected by S. *galilaeus* of the present work, were significantly different if compared with those (*ABDEL-AZIM*, 1974) reflected by the same species in the early years of lake formation (1965- 1970 period). Similar observations on the effect of impoundment on the diversity and biological characteristics of cichlids had been made for Lake Kainji (*LELEK*, 1973; *BALOGUN*, 1986), Lake Kariba (BALON, 1972), Lake Kamburu (*DADZIE*, 1980), Lake Itezhitezhi (*KAPASA* and *COWX*, 1991) and Lake Nubia (*ALI*, 1984). There-fore, on the bases of the results of the present work and those of *EL-HAWEET* (1991), *SHOUGY* (1991), *AL-SHAZLY* (1993) and *MEKKAWY* *et al.* (1995), one can conclude that the cichlids, especially S. *galilaeus*, *O. niloticus* and *O.aureus*, have a great ability, as reflected by their post impoundment prominence in the normal and dry condition in the aged lakes, to adapt to the new lacustrine habitat, to feed on different items and to spawn successfully in a balanced equilibrium with the ecological and biological conditions. Moreover, among the tilapiine fishes, S.*galilaeus* were able to adapt to special environmental factors and to predominate (*BEN-TUVIA et al.*,1992) in Lake Kinneret (Lake Tiberias) in the time at which *O.niloticus* declined (*BEN-TUVIA*, 1959) and disappeared completely from that lake (*BEN-TUVIA et al.*, 992). Generally, in the Egyptian lakes *O. niloticus* grow to a greater length than S.*galilaeus*, whereas in Lake Tiberias (*BEN- TUVIA*, 1959) the reverse is the case (Fig.8).

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Table 1: Mean weight(W) and frequency (F) of *Sarotherodon galilaeus* in different length groups during the period of investigtion (December 1988-March 1990)

Length groups	Males		Females		Combined sexes	
cm	F	W	F	W	F	W
13	2	40.000	1	25.000	3	35.000
14	2	40.000	2	50.000	4	45.000
15	4	51.250	1	60.000	5	53.000
16	2	67.500	1	60.000	3	65.000
20	2	172.500	-	-	3	160.000
21	2	160.000	4	207.500	12	212.500
22	19	235.263	9	203.889	57	232.281
23	26	263.654	12	239.667	82	271.720
24	33	291.364	16	289.375	107	299.486
25	40	322.975	24	280.417	127	324.283
26	35	367.486	24	363.750	111	378.802
27	41	415.976	22	368.818	97	408.804
28	30	424.833	26	448.808	92	449.065
29	29	468.448	22	498.545	74	490.851
30	24	516.958	19	547.000	71	536.620
31	15	574.200	17	583.353	58	600.345
32	10	621.100	3	646.667	28	662.536
33	6	631.333	3	655.000	17	671.059
34	5	726.000	4	820.000	15	753.000
35			1	840.000	5	903.000
36			2	972.500	3	986.667
37			1	990.000	1	990.000
38					1	1040.000
43	1	2500.00			1	2500.000
44			1	1605.000	1	1605.000
Total	328	30.000 820.000	215		978	
Range	1-41		1-26	25.00-1605.00	1-127	25.000-1605.00

Table 2 : Estimates of the parameters (c & n) of the power equation which describes the length-weight relationship of *Sarotherodon galilaeus*. Also confidene limits (L_1 & L_2) of n are given at 0.05 level of significance.

Estimates of parameters	Males	Females	Combined sexes
c	0.02979	0.00947	0.03145
n	2.87397*	3.21528*	2.86874**
L_1	3.0502	3.4659	2.9638
L_2	2.6977	2.9647	2.7736

* Isometric growth.

** Allometric growth.

Table 3: The condition factor of *Sarotherodon galilaeus* derived from the power (K_1) and cube (K_2) equations in different length groups.

Length groups (class mark)	Males			Females			Combined sexes		
	N	K_1	K_2	N	K_1	K_2	N	K_1	K_2
13	2	1.837	2.537	1	1.087	0.624	3	1.587	2.222
14	2	1.506	2.097	2	1.768	1.000	4	1.637	2.315
15	4	1.570	2.205	1	1.889	1.059	5	1.634	2.327
16	2	1.760	2.490	1	1.550	0.857	3	1.690	2.426
20	2	1.961	2.865	-	-	-	3	2.004	2.969
21	2	1.812	2.661	4	2.299	1.196	12	2.276	3.395
22	19	2.224	3.283	9	1.894	0.973	57	2.179	3.269
23	26	2.143	3.183	12	1.969	1.003	82	2.205	3.329
24	33	2.117	3.160	16	2.093	1.056	107	2.167	3.289
25	40	2.074	3.112	24	1.822	0.912	127	2.089	3.186
26	35	2.117	3.190	24	2.078	1.031	111	2.182	3.345
27	41	2.117	3.207	22	1.901	0.936	97	2.088	3.217
28	30	1.933	2.942	26	2.067	1.010	92	2.056	3.184
29	29	1.938	2.961	22	2.060	0.998	74	2.024	3.148
30	24	1.944	2.982	19	2.030	0.976	71	2.006	3.133
31	15	1.963	3.024	17	1.974	0.943	58	2.036	3.194
32	10	1.894	2.931	3	1.924	0.911	28	2.019	3.182
33	6	1.782	2.767	3	1.851	0.873	17	1.894	2.996
34	5	1.901	2.961	4	2.118	0.992	15	1.952	3.099
35				1	2.046	0.954	5	2.082	3.325
36				2	2.076	0.960	3	2.128	3.405
37				1	1.923	0.883	1	1.923	3.091
38							1	1.910	3.078
43	1	3.140	5.130				1	3.140	5.130
44				1	1.936	0.859	1	1.936	3.179

Table 4 : Monthly variations in the condition factor of *Sarotherodon galilaeus* derived from the power (K_1) and cube (K_2) equations.

Months	Males			Females			Combined sexes		
	F	K_1	K_2	F	K_1	K_2	F	K_1	K_2
December 1988	2	2.427	3.646	1	2.470	1.208	3	2.441	3.745
January 1989	4	2.457	3.725	3	2.475	1.211	13	2.532	3.891
February	2	2.235	3.352	2	2.905	1.448	4	2.407	3.674
March	5	2.685	4.051	6	2.518	1.261	11	2.666	4.094
April	30	2.227	3.364	28	2.315	1.134	57	2.225	4.420
May	49	1.967	2.970	25	1.619	0.902	82	1.819	2.793
June	44	1.511	2.292	38	1.574	0.774	86	1.556	2.397
July	28	2.139	3.234	11	2.041	0.991	39	2.127	3.282
August	39	2.042	3.105	23	2.166	1.065	51	2.076	3.212
September	29	2.169	3.259	18	2.026	0.999	48	2.144	3.299
October	18	2.085	3.137	11	1.921	0.955	51	2.054	3.134
November	17	2.202	3.313	12	2.237	1.090	61	2.125	3.276
December	17	2.166	3.259	8	2.222	1.113	60	2.206	3.387
January 1990	15	2.146	3.228	12	2.078	1.017	72	2.224	3.400
February	15	2.171	3.301	11	2.009	0.982	168	2.194	3.367
March 1990	14	1.879	2.785	6	1.741	0.925	172	2.145	3.283

Table 5 : Annual increment of growth in length of *Sarotherodon galilaeus.*

Age groups	Males					Females					Combined sexes				
	No. of fish	Length at capture	calcu-lated length	Annual increment (cm)	Annual increment %	No. of fish	Length at capture	calcu-lated length	Annual increment (cm)	Annual increment %	No. of fish	Length at capture	calcu-lated length	Annual increment (cm)	Annual increment %
I	7	11.64	14.73	14.73	69.91	3	13.67	14.70	14.70	56.32	13	13.06	15.13	15.13	57.97
II	103	18.12	17.61	2.88	13.67	65	18.09	17.68	2.98	11.42	288	18.23	17.78	2.65	10.15
III	187	20.61	20.16	2.55	12.10	111	21.03	20.56	2.88	11.03	583	20.60	20.26	2.48	9.50
IV	12	21.30	21.07	0.91	4.31	14	23.65	23.15	2.59	9.92	41	23.31	23.05	2.79	10.68
V	-	-	-	-	-	1	25.10	26.10	2.95	11.30	1	26.10	26.10	3.05	11.69

Table 6 : Annual increment of growth in weight of *Sarotherodon galilaeus.*

Age groups	Males					Females					Combined sexes				
	No. of fish	Length at capture	Calcu-lated weight	Annual increment (g)	Annual increment %	No. of fish	Length at capture	Calcu-lated weight	Annual increment (g)	Annual increment %	No. of fish	Length at capture	Calcu-lated weight	Annual increment (g)	Annual increment %
I	7	11.64	70.54	70.54	36.59	3	13.67	55.84	55.84	16.44	13	13.06	78.41	78.41	21.52
II	103	18.12	117.64	47.10	24.43	65	18.09	100.38	44.54	13.11	288	18.23	124.68	46.27	12.69
III	187	20.61	171.19	53.55	27.78	111	21.03	162.75	62.37	18.36	583	20.60	181.13	56.45	15.49
IV	12	21.30	192.77	21.58	11.19	14	23.65	242.05	79.30	23.35	41	23.31	264.22	83.09	22.80
V						1	26.10	339.65	97.60	28.74	1	26.10	364.45	100.23	27.50

Table 7 : Age-length key of *Sarotherodon galilaeus* (the total number (F) and the number of fish belonging to each age group are given).

Length groups (class mark)	Males						Females						Combined sexes					
	F	I	II	III	IV	V	F	I	II	III	IV	V	F	I	II	III	IV	V
10	2	2					1		1				3	2	1			
11	3	3					3	2	1				6	5	1			
12	4	1	3				1		1				5	1	4			
13	1	-	1										1	-	1			
15	-	-											2	1	1			
16	16	-	13	3			8		8				42	2	31	9		
17	37	1	28	8			15		13	2			91	1	60	30		
18	46		21	23	2		25		15	10			153	-	70	81	2	
19	44		18	26	-		27	1	10	15	1		153	1	62	88	2	
20	35		8	26	1		26		8	18	-		102		26	75	1	
21	44		6	36	2		30		4	23	3		114		17	91	6	
22	36		2	30	4		15		3	11	1		85		7	71	7	
23	22		-	19	3		22		1	19	2		80		3	72	5	
24	10		2	8			10			10	-		42		3	37	2	
25	4		-	4			4			-	4		23			16	7	
26	4			4			3			2	-	1	13			10	2	1
27							1			-	1		5			1	4	
28							2			1	1		3			2	1	
29							1				1		2				2	
37	1		1										1		1			
Sum	309	7	103	187	12		194	3	65	111	14	1	926	13	288	583	41	1

Table 8 : Age distribution showing the relation between the age groups in number and weight when the observed weight was used. Also, the number of fish belonging to each age group per a kilogram is given.

Items	I	II	III	IV	V
Frequency					
Males	-	12.01	143.18	5.80	-
Females	-	3.88	65.03	83.09	8.00
Combined sexes	2.64	26.68	482.57	253.57	8.54
% Frequency					
Males	-	7.46	88.93	3.61	-
Females	-	2.42	40.64	51.93	5.00
Combined sexes	0.34	3.45	62.35	32.76	1.10
Weight in KG					
Males	-	2481.67	43663.07	1456.18	-
Females	-	668.39	20750.29	32113.25	2910.00
Combined sexes	141.79	6088.85	158239.30	104968.10	3234.38
% Weight					
Males	-	52.13	917.27	30.59	-
Females	-	11.84	367.64	568.96	51.56
Combined sexes	0.52	22.33	580.33	384.96	11.86
No. of fishes in each kilogram					
Males	-	0.25	3.01	0.12	-
Females	-	0.07	1.15	1.47	0.14
Combined sexes	0.01	0.10	1.77	0.93	0.03

Table 9: Length-weight equations of *Sarotherodon galilaeus* from different localities in different times.

Author	Location	Sex	Length-weight equations
Ben-Tuvia (1959)	Lake Tiberias	Combined sexes	$W=1.687x10^{-5}\ L^{3.087}$ *
El-Bolock & Koura (1961)	Lake Tiberias	Combined sexes	$W=1.282x10^{-5}\ L^{3.1023}$ *
El-Zarka *et al.*, (1970)	Lake Mariut	Combined sexes	$W=7.153x10^{-6}\ L^{3.1838}$ *
Bishara (1973)	Lake Manzalah	Males }1968	$W=1.698x10^{-2}\ L^{3.0715}$
		Females }1968	$W=2.175x10^{-3}\ L^{3.8042}$
		Males }1969	$W=3.282x10^{-2}\ L^{2.7937}$
		Females }1969	$W=3.62x10^{-2}\ L^{2.7683}$
Bayomi & Khalil (1988)	Lake Manzalah	Combined sexes	$W=2.332x10^{-2}\ L^{2.9393}$
Abdel-Azim (1974)	Lake Nasser	Combined sexes	$W=1.622x10^{-2}\ L^{3.1240}$
		Males	$W=1.883x10^{-2}\ L^{3.0674}$
		Females	$W=1.173x10^{-2}\ L^{3.2106}$
Agaypi (1992)	Lake Nasser (in 1982)	Combined sexes	$W=0.165\ L^{2.60}$
Present work	Lake Nasser	Combined sexes	$W=3.145x10^{-2}\ L^{2.8687}$
		Males	$W=2.979x10^{-2}\ L^{2.8740}$
		Females	$W=0.947x10^{-2}\ L^{3.2153}$
Mikhail (1979)	Cairo	Combined sexes	$W=1.088x10^{-5}\ L^{3.111}$ *
	Beni-Suef	,, ,,	$W=9.497x10^{-6}\ L^{3.1400}$ *
	El-Minya	,, ,,	$W=9.016x10^{-6}\ L^{3.1534}$ *
	Assiut	,, ,,	$W=8.898x10^{-6}\ L^{3.1568}$ *
	Total area(from Cairo to Assiut)	,, ,,	$W=8.273x10^{-6}\ L^{3.1693}$ *

* Length in mm

Table 10: Comparison of condition factor of *Sarotherodon galilaeus* of the present work with that of Abdel-Azim (1974).

	Abdel-Azim (1974)		Present work	
	N	K	N	K
13	3	3.05	3	1.59
14	3	3.00	4	1.64
15	4	3.02	5	1.63
16	3	3.15	3	1.69
17	11	2.67		
18	12	2.36		
19	18	2.17		
20	30	2.22	3	2.00
21	25	2.18	12	2.28
22	23	2.03	57	2.18
23	23	2.28	82	2.21
24	23	2.31	107	2.17
25	38	2.33	127	2.09
26	31	2.50	111	2.18
27	37	2.57	97	2.09
28	48	2.54	92	2.06
29	41	2.57	74	2.02
30	68	2.56	71	2.01
31	65	2.53	58	2.04
32	71	2.43	28	2.02
33	75	2.44	17	1.89
34	63	2.44	15	1.95
35	48	2.40	5	2.08
36	35	2.34	3	2.13
37	24	2.28	1	1.92
38	19	2.32	1	1.91
39	4	2.21	-	-
40	7	2.23	-	-
Total	852		976	

Table 11: Survival rates of *Sarothcrodon galilacus* estimated according to age composition (S1) and length distribution (S2) for different localities.

Locality	S1 Surv- ival rate	After length group	After age group	S2 Total survival rate	After length group
L. Tiberias (El-Bolock & Koura, 1961)	0.478		0	0.680	
L. Manzalah (Bishara, 1973)	0.281	116	2	0.221	193
L. Mariut (El-Zarka *et al.*, 1970)				0.134	118
L. Nasser (Abdel-Azim, 1974)	0.126	305	2		
L. Nasser (Present work)	0.041	200.5	3	0.034	219.6

Table 12: Mortality rates of *Sarotherodon galilaeus* estimated according to age composition (I1) and length distribution (I2) for different localities.

Locality	I1 Mort- ality rate	After length group	After age group	I2 Total mortality rate	After length group
L. Tiberias (El-Boloch & Koura, 1961)	0.738	<99	0	0.386	164
L. Manzalah (Bishara, 1973)	1.269	116	2	1.509	193
L. Mariut (El-Zarka *et al.*, 1970)				2.010	118
L. Nasser (Abdel-Azim, 1974)	2.074	305	2		
L. Nasser (Present work)	3.185	200.5	3	3.368	219.6

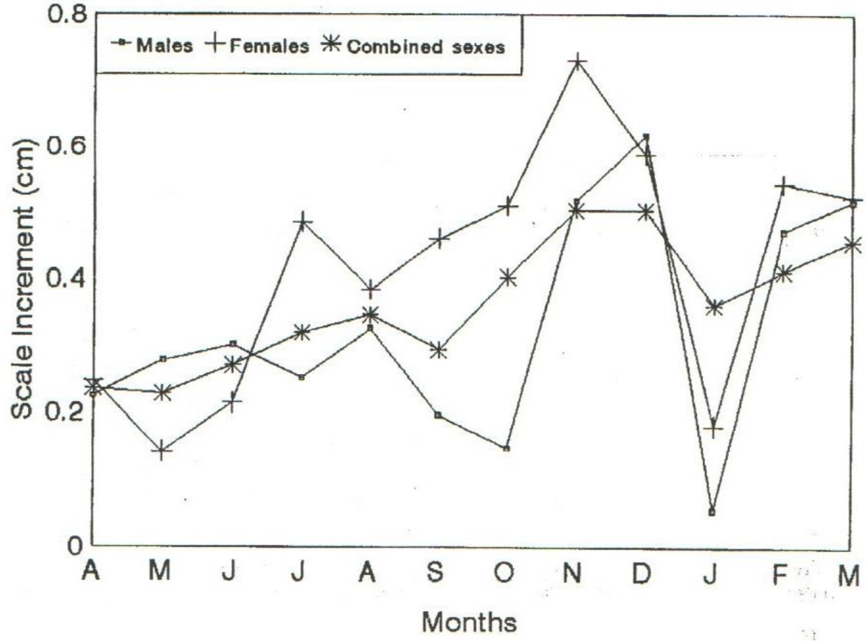

Fig.1 :Averages of scale increments of *Sarotherodon galilaeus* of age group III in different months of capture(1989-1990).

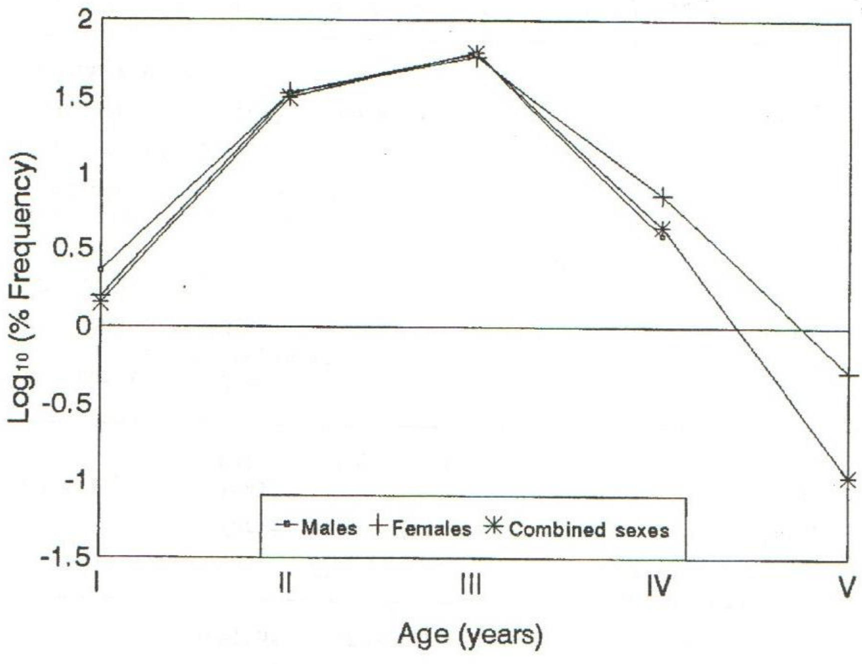

Fig. 2:The relationship between age groups of *Sarotherodon galilaeus* and the logarithms of the percentage of frequency of such groups.

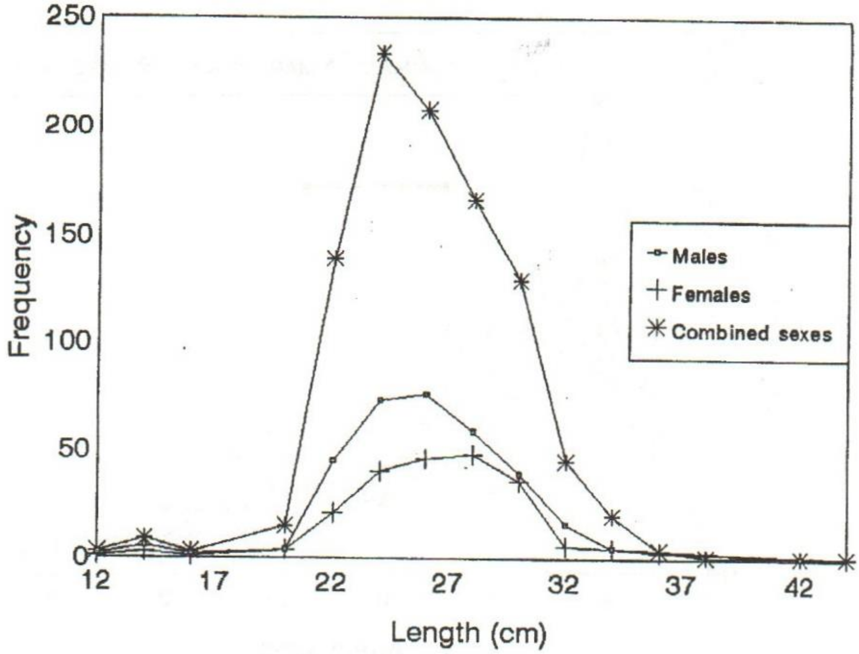

Fig.3: Length distribution of *Sarotherodon galilaeus* of Lake Nasser during the period of investigation.

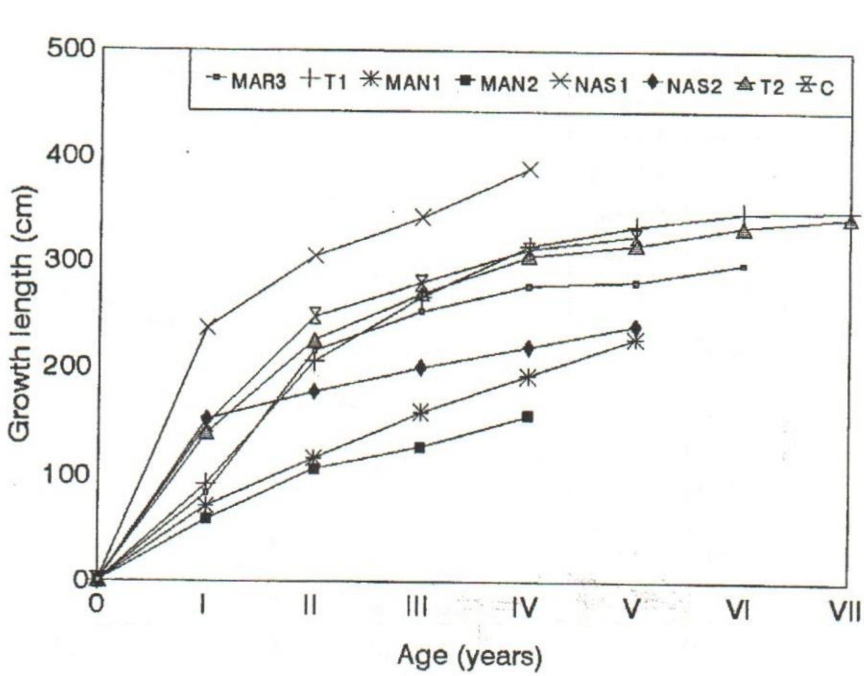

Fig.4 :General growth in length of *Sarotherodon galilaeus* at different localities(MAR3,Mariut57;T1, Tiberias61; MAN1,Manzalah73; MAN2,Manzalah88; NAS1,Nasser74; NAS2, Nasser89-90;T2, Tiberias59;C,Chad).

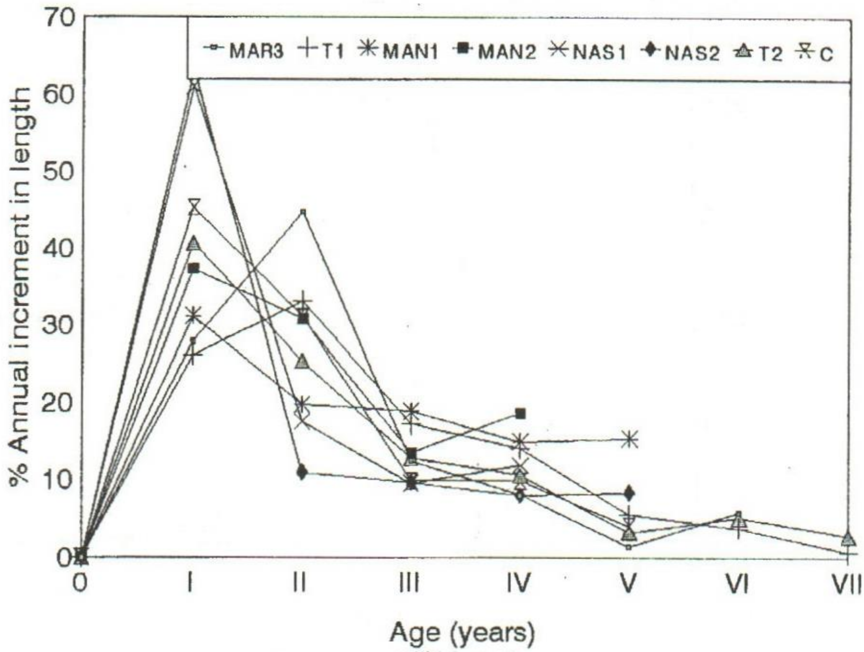

Fig.5 :%annual increment in length of *Sarotherodon galilaeus* at different localities(MAR3, Mariut57; T1,Tiberias61;MAN1,Manzalah73;MAN2,Manzalah88;NAS1, Nasser74; NAS2, Nasser89-90 ;T2, Tiberias59;C,Chad).

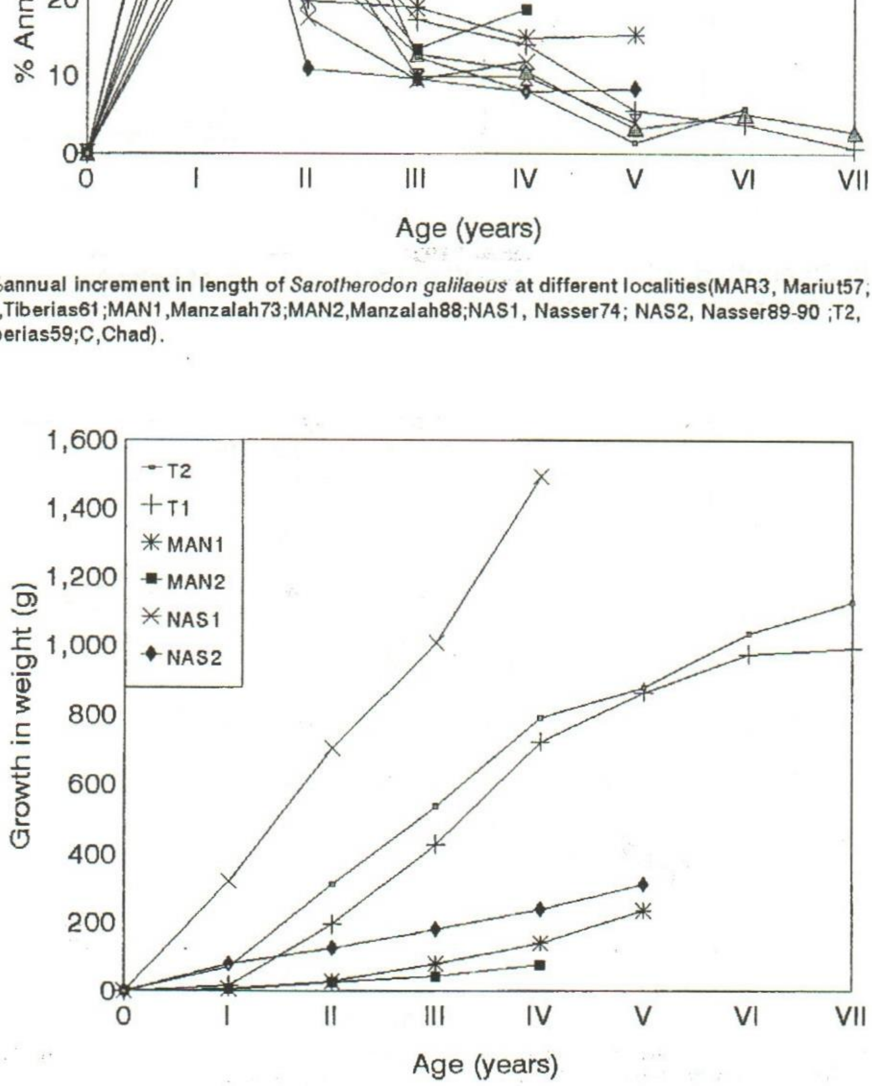

Fig.6 :General growth in weight of *Sarotherodon galilaeus* at different localities(T1,Tiberias61;T2, Tiberias59;MAN1,Manzalah73;MAN2,Manzalah88;NAS1,Nasser74;NAS2,Nasser89-90).

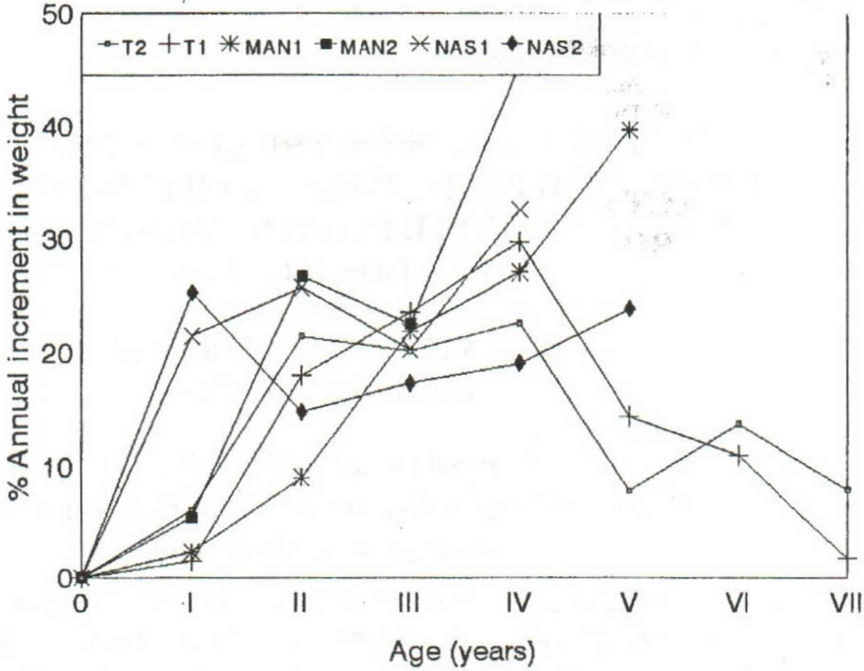

Fig.7:% annual increment in weight of *Sarotherodon galilaeus* at different localities(T1,Tiberias61; T2,Tiberias59;MAN1,Manzalah73;MAN2,Manzalah88;NAS1,Nasser74;NAS2,Nasser89-90).

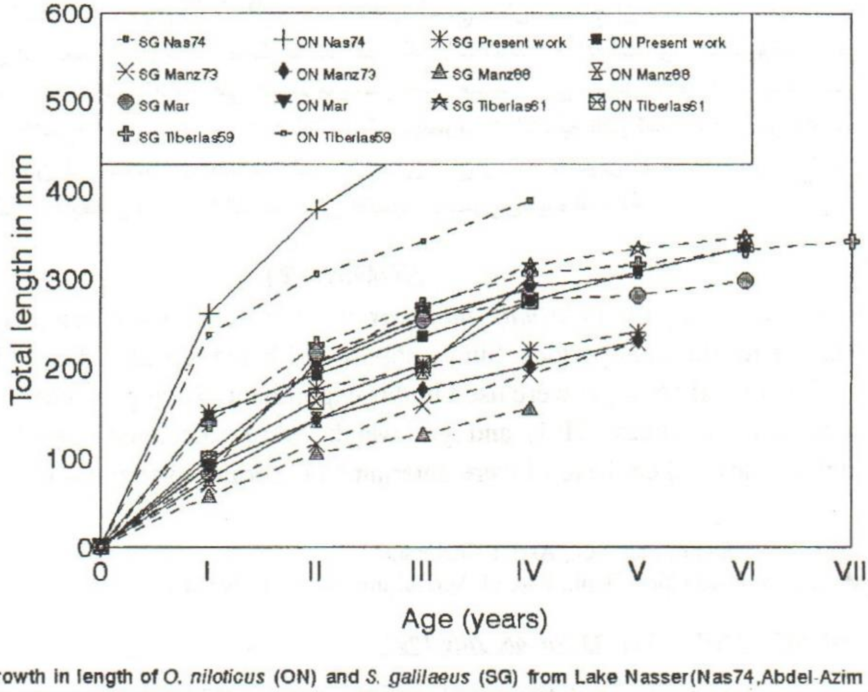

Fig.8 :Growth in length of *O. niloticus* (ON) and *S. galilaeus* (SG) from Lake Nasser(Nas74,Abdel-Azim (1974);Present work),Lake Manzalah(Manz73,Bishara(1973);Manz88,Bayoumi & Khalil(1988)),Lake Mariut(Mar,Jensen(1958)),Lake Tiberias (El-Bolock and Koura,1961; Ben-Tuvia,1959).