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FISHERIES MANAGEMENT OF SAROTHERODON GALILAEUS (CICHLIDAE) AT WADI EL-RAIYAN LAKES

BY

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ABSTRACT

A study of the age and growth of Sarotherodon galilaeus collected from the Wadi El- Raiyan lakes was carried out by examining the growth increment in their otoliths. The maximum life span of S. galilaeus was found to be seven years in the first lake and three years in the second one. The growth parameters according to the von Bertalanffy growth model were estimated as K=0.29 and L_∞ = 46.64 cm in the first lake and K=0.53 and L_∞ = 27.89 cm in the second one. The total mortality coefficient "Z" was found to be 0.8 year^{-1} in the first lake and 1.39 year^{-1} in the second one. Natural mortality coefficient "M" was estimated as 0.13 year^{-1} in the first lake and 0.22 year^{-1} in the second one. Exploitation rate "E" was computed as 0.84 in both lakes. The relative yield per recruit and relative biomass per recruit analysis showed that the stock of S. galilaeus in Wadi El- Raiyan lakes is overexploited and the present level of exploitation rate should be reduced by about 25% in the first lake and 20% in the second lake to obtain the maximum relative yield per recruit.

INTRODUCTION

Wadi El- Raiyan is a natural depression at about 90 Km southwest of Cairo. It consists of two main lakes connected by swampy channel (Fig. 1). The first one has an area of about 63 Km^2 and the second of about 110 Km^2. The connecting area between the two lakes is shallow and covered by emerged aquatic macrophytes leading to swamp formation. The first lake is completely filled with water and is surrounded by dense vegetation. The area of the second lake is mostly increase as new flooded areas are added from time to time to the southwestern side of it (Khalifa, 2000).

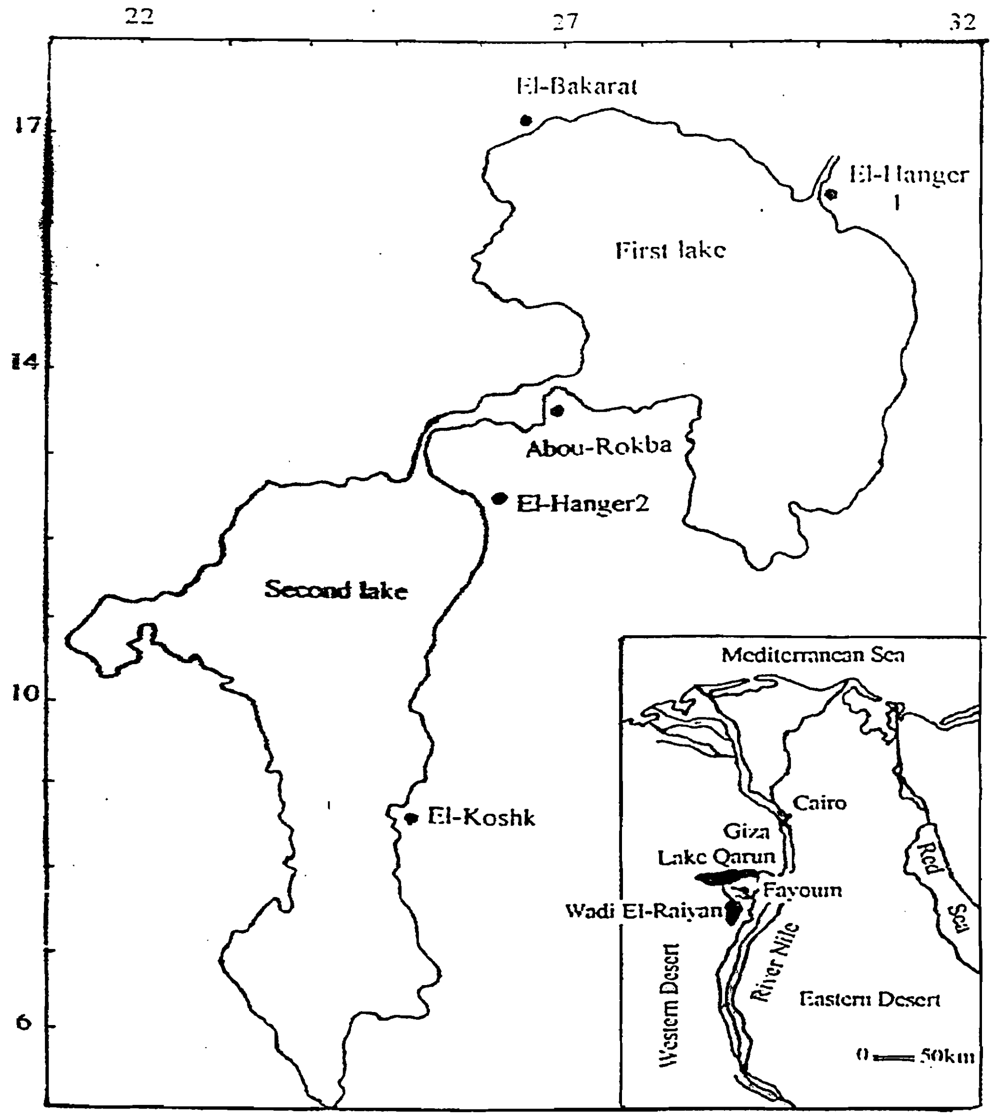


Fig. 1 : Map of Wadi El-Raiyan Lakes.

The annual catch of the first lake contributed about 74% of the total fish production of Wadi El-Raiyan while the second lake contributed about 26% of the total fish production (throughout the fishing seasons from 1988/89 to 1999/00). The most economically important fish species represented in the catch of the Wadi El-Raiyan lakes are: Tilapias, Mullet, Nile Perch, Carp and Bayad. In addition, other group which contains fish species of small catches or those appear occasionally.

Tilapias, are the most popular fish in Egypt distributed along Nile River and its branches, lake Nasser, lake Qarun and Delta lakes (Manzala, Borollus, Edku and Mariut) They are represented by four species in Wadi El- Raiyan lakes namely; *Oreochromis niloticus, Oreochromis aureus, Sarotherodon galilaeus* and *Tilapia zilli*. These species are the most abundant species at Wadi El- Raiyan lakes, where they constitute about 50% of the total catch in the first lake and about 44% of the total catch in the second lake as indicated from the present study (Fig. 2).

Intensive studies were undertaken concerning the biology of tilapia in different water bodies in Egypt (Hosny, 1987; Bayoumi and Khalil, 1988; Yamaguchi *et al.*, 1990; El-Shazly, 1993; Khalil, 1994; Adam, 1994; Abdalla, 1995; Shenouda *et al.*, 1995; Khalifa *et al.*, 2000; Abdalla and Talaat, 2000).

Despite the great importance of tilapia in Wadi El- Raiyan lakes, there are very few studies that deal with the biology and dynamics of some tilapia's species in Wadi El-Raiyan lakes (Soliman, 1981 and Khalifa, 2000).

The present study is concerned with the age and growth, mortality and exploitation rates, relative yield per recruit and relative biomass per recruit of *Sarotherodon galilaeus* in Wadi El-Raiyan lakes to assess this valuable fish resource.

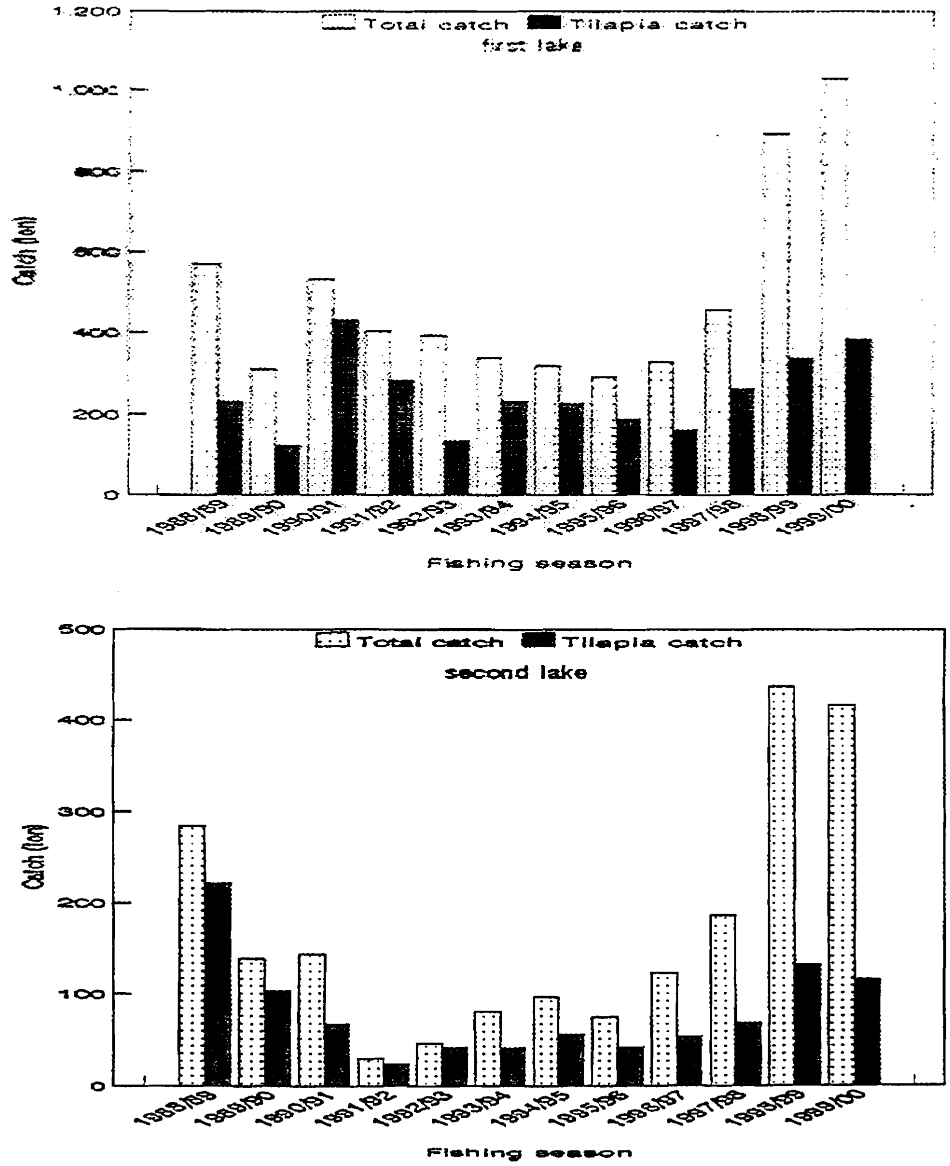


Fig. 2 : Total catch and tilapia catch (ton) from Wadi El-Raiyan lakes during the period from 1988/89 to 1999/00.

MATERIALS AND METHODS

Random samples of *Sarotherodon galilaeus* were collected from the Wadi El-Raiyan lakes (first and second lakes) during the period from August 2000 until July 2001. Fish samples were obtained from landing sites during all months except July and August where fish samples were collected by means of experimental fishing gears due to closed season. Total length to the nearest millimeter, total weight to the nearest 0.1 gram, sex and otoliths were taken for each individual specimen.

Annual rings on otoliths were counted using optical system consisting of Nikon Zoom-Stereomicroscope and Heidenhain's electronic bidirectional read out system V R X 182, under transmitted light. The total radius of the otolith "S" and the distance between the focus of the otolith and the successive annuli were measured to the nearest 0.001mm. The lengths of the previous ages were back - calculated using Lee's equation (1920) as follows:

$$L_n = (L - a)\ S_n/S + a$$

where L_n is the calculated length at the end of n^{th} year

L is the length at capture

S_n is the scale radius to n^{th} annulus

S is the total scale radius.

and a is the intercept of the regression line with the Y-axis.

The relation between length (L) and weight (W) was computed using the formula $W = a\ L^b$ where a and b are constants whose values were estimated by the least square method.

Based on the length frequency data of *S. galilaeus* collected from Wadi El-Raiyan lakes, an estimation of the population parameters was performed using FAO-ICLARM Fish Stock Assessment Tools (FiSAT) software of Gayanilo *et al.*, 1997. The growth parameters (L_∞ and K) were estimated using Gulland and Holt (1959) plot. The growth performance index was computed according to the formula of Pauly and Munro (1984) as $\phi = \text{Log } K + 2 \text{ Log } L_\infty$. Total mortality coefficient "Z" was estimated by the analysis of catch curve based on length frequency data using the method of Pauly (1983a). The length at first capture "L_c" was estimated by the analysis of catch curve using the method of Pauly (1984a&b). The

Natural mortality coefficient "M" was estimated by using Ursin (1967) formula as $M = W^{-1/3}$ where W is the total weight of fish. Exploitation rate "E" was computed using the formula of Gulland (1971) as E = F/Z.

The relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)' were estimated by using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in FiSAT software package. This model is defined by:

$$(Y/R)' = E\,U^{M/K}\,[1 - (3U/1+m) + (3U^2/1+2m) - (U^3/1+3m)]$$

$$(B/R)' = (Y/R)'/F$$

where (Y/R)' is the relative yield per recruit

(B/R)' is the relative biomass per recruit

M is the natural mortality coefficient

F is the fishing mortality coefficient

K is the growth parameter

E is the exploitation rate or the fraction of deaths caused by fishing

$m = (1-E)/(M/K) = (K/Z)$

$U = 1 - (L_c/L_\infty)$

RESULTS AND DISCUSSION

Age Determination

Otoliths were used for age determination of *Sarotherodon galilaeus.* The use of otoliths for age determination of tilapias has been well documented by many authors (Beamish and McFarlane, 1983&1987; Karakiri and Hammer, 1989; Yamagushi *et al.*, 1990; Fenton and Short, 1992; Morales-Nin, 1992; Zhang, 1992).

The results show that the maximum life span of *S. galilaeus* in Wadi El-Raiyan lakes was found to be seven years in the first lake and three years in the second one.

Growth in Length

Body Length - Otolith Radius Relationship

The otolith's measurements of 366 *S. galilaeus* from the first lake and 236 ones from the second lake were used to describe the relationship between the total length and the otolith radius. This relationship was found to be linear and can be represented by the following equation:

In the first lake $L = 3.903 + 3.104\ S$ $(r = 0.98)$

In the second lake $L = 1.713 + 5.673\ S$ $(r = 0.97)$

where L is the total length in centimeter,

S is the scale radius in millimeter

and r is the correlation coefficient.

Back - Calculations

The total lengths at the end of each year of life were back-calculated using Lee's equation (1920) as follows:

In the first lake $L_n = (L - 3.903)\ S_n/S + 3.9031$

In the second lake $L_n = (L - 1.713)\ S_n/S + 1.7133$

where L_n is the length at the end of n^{th} year in cm,

S_n is the radius of scale to n^{th} annulus in mm,

S is the total radius of scale

and L is the total length at capture

Tables 1 and 2 show the back - calculated lengths at the end of each year of life *S. galilaeus* collected from the first and second lakes, respectively. It is found that in both lakes, the maximum growth in length was recorded by the end of the first year of life after which a decrease in growth rate was noticed by the increase of age. It was also found that the growth in length of *S. galilaeus* in the first lake is higher than that in the second one.

Table 1: Average back-calculated lengths (cm) of *Sarotherodon galilaeus* from the first lake of Wadi El-Raiyan.

Age group	No. of fish	Empirical length	Back-calculated lengths at the end of each year of life						
			1	2	3	4	5	6	7
I	91	15.22	**14.19**						
II	105	23.79	14.32	**22.86**					
III	80	29.09	14.24	22.81	**28.29**				
IV	52	33.98	14.18	22.65	28.22	**33.15**			
V	24	37.12	14.13	22.58	28.19	33.13	**36.56**		
VI	9	40.08	14.15	22.49	28.09	33.07	36.46	**39.13**	
VII	5	41.92	14.17	22.38	28.10	33.05	36.32	39.05	**41.20**
Growth increment			14.19	8.67	5.43	4.86	3.41	2.57	2.07

Table 2: Average back-calculated lengths (cm) of *Sarotherodon galilaeus* from the second lake of Wadi El-Raiyan.

Age group	No. of fish	Empirical length	Back-calculated lengths at the end of each year of life		
			1	2	3
I	108	15.20	**14.15**		
II	104	20.45	14.11	**19.88**	
III	24	24.05	14.03	19.71	**23.22**
Growth increment			14.15	5.73	3.34

Length – Weight Relationship

In the first lake, the total length of *S. galilaeus* varied between 12 and 43cm, while the total weight of a fish varied between 42 and 1554g. In the second lake the total length ranged between 12 and 24.3 cm, while the total weight varied between 37 and 256g. The computed length-weight equations were as follows:

$W = 0.0275\ L^{2.9030}$ $(r = 0.99)$ in the first lake

$W = 0.0305\ L^{2.8669}$ $(r = 0.98)$ in the second lake

Growth in Weight

The weights at the end of each year of life and the annual increment of *S. galilaeus* were estimated and the results are given in Tables 3 and 4. The results indicated that the annual increment in weight for *S. galilaeus* in both lakes was very slow by the end of the first year of life and reached its maximum value at age of four years in the first lake and two years in the second one.

Table 3: Calculated weights (g) of *Sarotherodon galilaeus* from the first lake of Wadi El- Raiyan.

Age group	No. of fish	Calculated weights at the end of each year of life						
		1	2	3	4	5	6	7
I	91	**60.75**						
II	105	62.38	**242.51**					
III	80	61.37	240.97	**450.22**				
IV	52	60.62	236.10	446.99	**713.34**			
V	24	60.01	233.99	445.61	712.09	**947.85**		
VI	9	60.25	231.29	441.04	708.35	940.34	**1154.49**	
VII	5	60.50	228.02	441.50	707.11	929.90	1147.65	**1340.85**
Increment		60.75	181.76	207.71	263.12	234.51	206.64	186.36

Table 4: Calculated weights (g) of *Sarotherodon galilaeus* from the second lake of Wadi El- Raiyan.

Age group	No. of fish	Calculated weights at the end of each year of life		
		1	2	3
I	108	**60.73**		
II	104	60.23	**160.96**	
III	24	59.26	157.05	**251.24**
Increment		60.73	100.23	90.28

Growth Parameters

The von Bertalanffy growth parameters (L_∞, K and t_o) were estimated and the obtained equations were as follows:

$L_t = 46.64\,(1 - e^{-0.29\,(t+0.22)})$ in the first lake

$L_t = 27.89\,(1 - e^{-0.53\,(t+0.31)})$ in the second lake

Growth performance index

The obtained results indicate that the growth performance index (ø) of *S. galilaeus* was found to be higher in the first lake (ø = 2.80) than that in the second one (ø = 2.61).

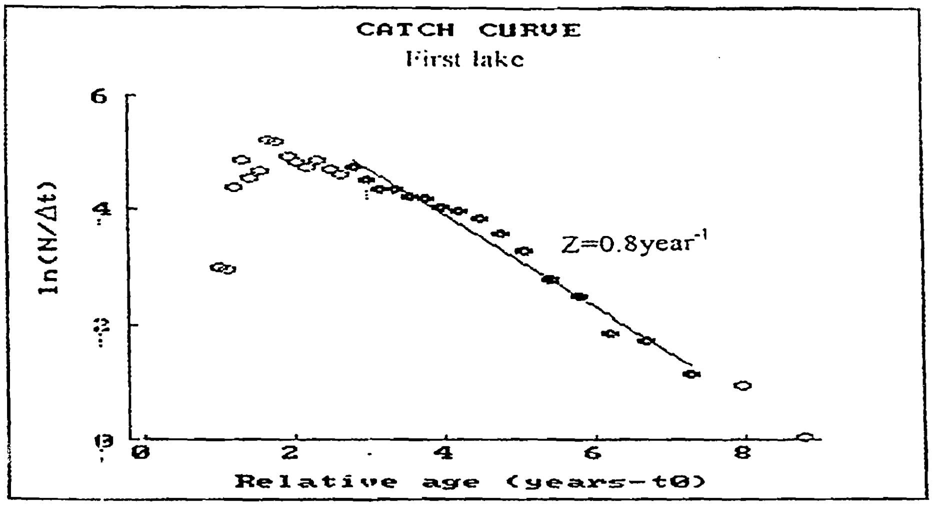
A comparison of the growth parameters and growth performance index (ø) of *S. galilaeus* with those of the same species in different water bodies is given in Table 5.

Mortality Rates

Total mortality coefficient "Z" was estimated as 0.8 $year^{-1}$ in the first lake and 1.39 $year^{-1}$ in the second one (Fig. 3). Natural mortality coefficient "M" was estimated as 0.13 $year^{-1}$ in the first lake and 0.22 $year^{-1}$ in the second one while fishing mortality coefficient "F" was estimated as 0.67 $year^{-1}$ in the first lake and 1.17 $year^{-1}$ in the second one

Table 5: Growth parameters and growth performance index (ø) of *Sarotherodon galilaeus* from different water bodies in Egypt.

Locality	L_∞	K	ø	Author
Lake Manzala	30.08	0.24	2.33	Hosny, 1987
Lake Manzala	19.75	0.39	2.19	Bayoumi & Khalil, 1988
Lake Nasser				Yamaguchi, *et al.*, 1990
Males	27.29	0.68	2.70	
Females	28.82	0.52	2.64	
Lake Mariut	90.70	0.07	2.75	El-Shazly, 1993
Lake Edkuo	25.26	0.26	2.22	Khalil, 1994
Lake Nasser	31.46	0.50	2.69	Adam, 1994
Lake Edku	28.10	0.27	2.33	Abdalla & Talaat, 2000
Wadi El-Raiyan (first lake)	36.16	0.45	2.77	Khalifa, 2000
Wadi El-Raiyan (second lake)	25.96	0.39	2.42	
Wadi El-Raiyan (first lake)	46.64	0.29	2.80	The present study
Wadi El-Raiyan (second lake)	27.89	0.53	2.61	



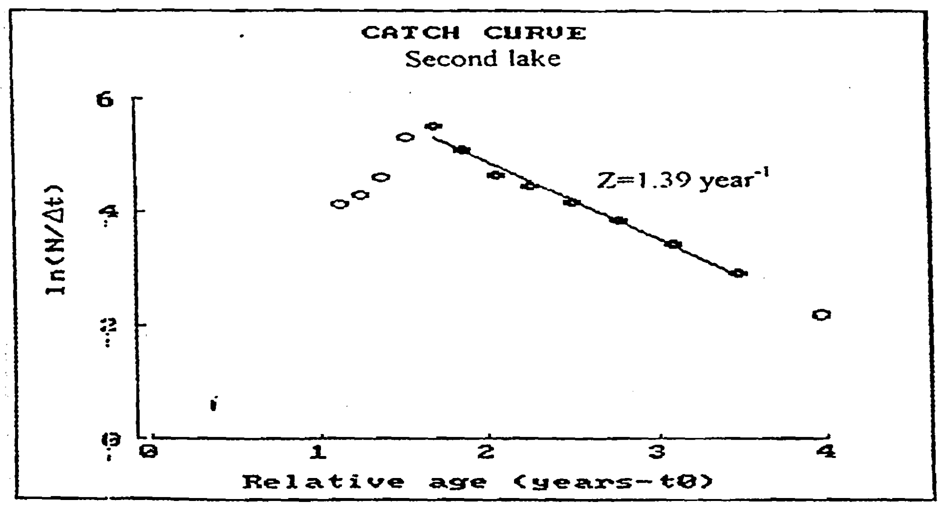


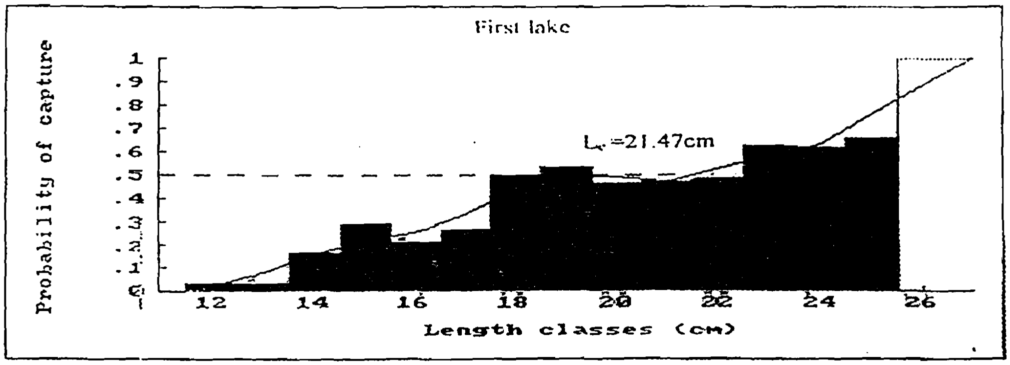
Fig. 3 : Estimation of total mortality coefficient "%" of *Sarotherodon galilaens* from Wadi El-Raiyan lakes

Exploitation Rate "E"

Exploitation rate "E" was computed using the formula of Gulland, 1971 and the obtained E was 0.84 in both lakes. Gulland suggested that the optimum exploitation rate should be about 0.5, so the high value of the present exploitation rate indicates that the stock of *S. galilaeus* in Wadi El-Raiyan lakes is overexploited.

Length at first capture "L_c"

The length at first capture (the length at which 50% of the fish at that size are vulnerable to capture) was estimated as a component of the length converted catch curve analysis (FiSAT). The value obtained was $L_{50\%}$ = 21.47 cm in the first lake and 14.84 cm in the second one (Fig. 4).



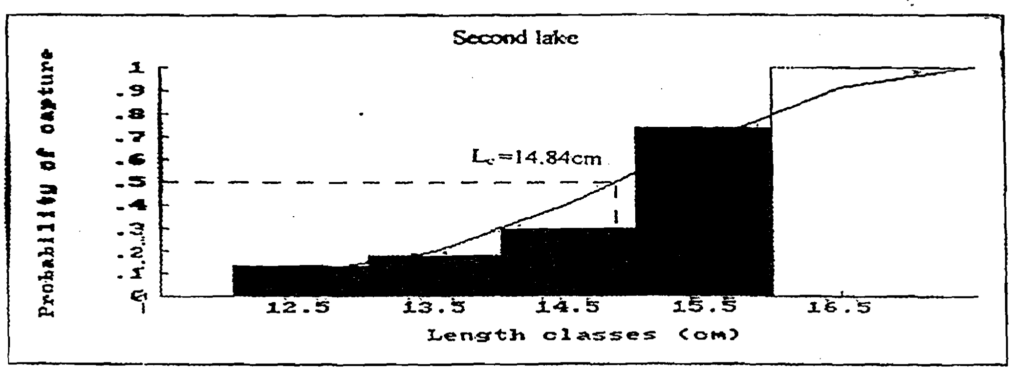


Fig. 4: Estimation of length at first capture "L_c" of *Sarotherodon galilaens* from Wadi El-Raiyan lakes

Relative yield per recruit (Y/R)' and relative biomass-per recruit (B/R)'

The relative yield per recruit and relative biomass per recruit of *S. galilaeus* from the first and second lakes were estimated (Figs. 5 and 6). The present level of exploitation rate of *S. galilaeus* in the first lake (E= 0.84) is higher than that produces the maximum relative yield per recruit by about 25%. Both of $E_{0.1}$ (the level of exploitation at which the marginal increase in relative yield per recruit is $1/10^{th}$ its value at E=0) and $E_{0.5}$ (the exploitation level under which the stock has been reduced to 50% of its unexploited biomass) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.62 and 0.39 respectively. The results indicated that the present levels of E and F were higher than those which give the maximum (Y/R)'. Also the present level of exploitation rate (E = 0.84) is higher than the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass. For management purpose, the exploitation rate of *S. galilaeus* should be reduced from 0.84 to 0.39 (53.6%) to maintain a sufficient spawning biomass.

The exploitation rate of *S. galilaeus* in the second lake was found to be E= 0.84. This rate of exploitation is higher than that produces the maximum relative yield per recruit (E_{max}= 0.67) and relative biomass per recruit ($E_{0.5}$= 0.40) by 20.2% and 52.4%, respectively.

In conclusion, the present results indicate that the two stocks of *S. galilaeus* in both lakes under study are overexploited. To maintain this resource, the present fishing pressure should be decreased as well as the length at first capture should be increased and the present level of exploitation rate should be reduced under the optimum level.

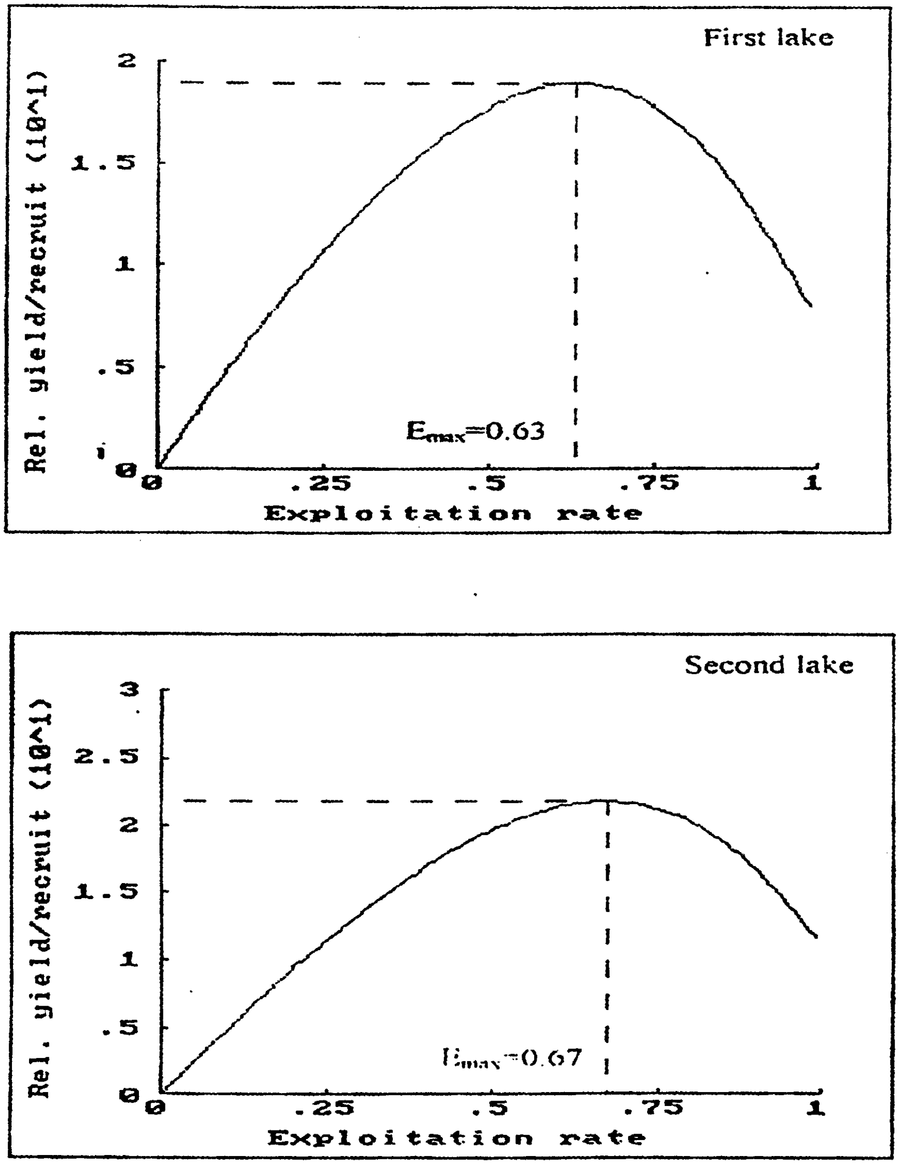
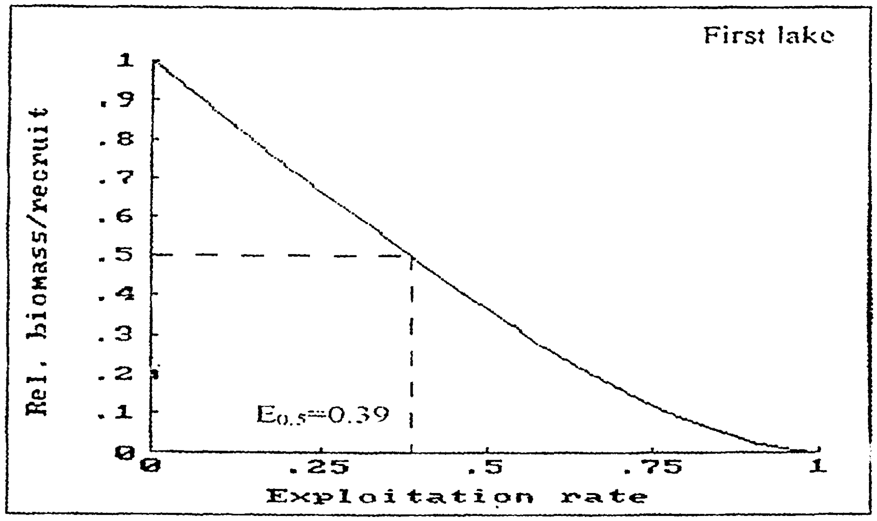


Fig. 5 : Relative yield per recruit $(Y/R)^1$ of *Sarotherodon galilaens* from Wadi El-Raiyan lakes



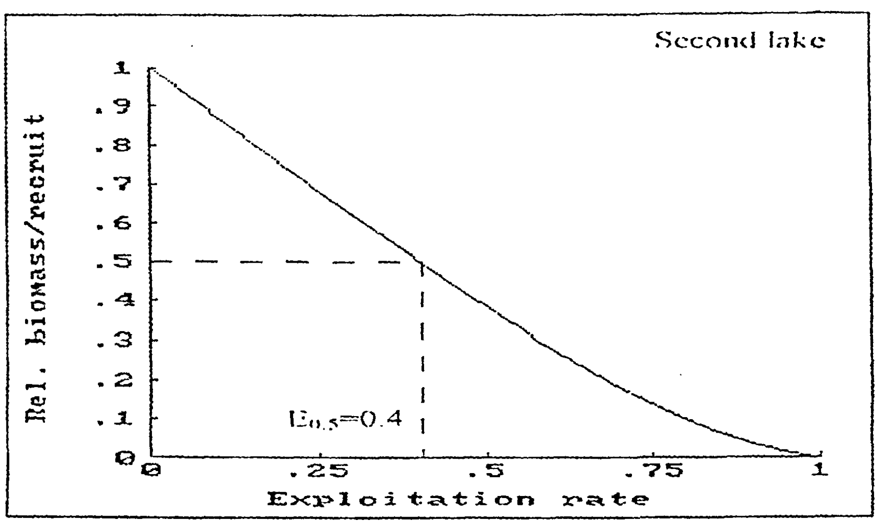


Fig. 6 : Relative biomass per recruit (B/R)' of *Sarotherodon galilaens* from Wadi El-Raiyan lakes

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