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ASSESSMENT OF FAMILY CICHLIDAE INHABITING LAKE MANZALA, EGYPT

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ABSTRACT

The age and growth of cichlid fishes inhabiting Lake Manzala were studied during the peried from August 2000 to September 2001, based on the length-frequency bF samples collected by the surrounding nets. Analysis of the data using (FiSAT) computer program returned the estimate of the von Bertalanffy's growth curve parameters as: L_∞ = 28.88 cm (total length); k = 0.53 year^{-1} for *Oreochromis niloticus*; L_∞ = 21.53 cm; k = 0.59 yr^{-1} for *aureus*; L_∞ = 23.63 cm; k = 0.27 yr^{-1} for *Sarotherodon galilaeus*; and L_∞ = 18.38 cm, K=0.55 year^{-1} for *Tilapia zillii*. The respective values of the total mortality coefficient "Z" were found to be 3.38, 2.94, 1.02 and 2.26 yr^{-1}. Moreover, their respective natural mortality coefficients "M" were 1.04, 1.21, 0.71 and 1.21 yr^{-1}. The estimated exploitation rates "E" were 0.69, 0.59, 0.31 and 0.47 in respective for the mentioned species. Their relative yield and relative biomass per recruit showed that the stock of *O. niloticus* and *O. aureus* were over the exploited. To obtain the maximum relative yield per recruit; the present level of exploitation rate should be reduced by about 20 % for *O. niloticus* and 10 % for *O. aureus*. The stocks of *S. galilaeus* and *T. zillii* were under the exploitation level.

INTRODUCTION

Lake Manzala is the largest Nile Delta Lake and is the most important source of inland fishery production in Egypt contributing about 48% of the northern Nile Delta lakes (GAFRD, 2004). Its area has been reduced to 1200 km^2 by 1980 (Meininger & Mullie, 1981).

Four Tilapia species are identified in Lake Manzala; *Oreochromis niloticus*, *Oreochromis aureus*, *Sarotherodon galilaeus* and *Tilapia zillii*. These species form the basis of the important artisan fisheries in most areas of the lake. The main artisan fishing gears used in the lake are; the surrounding net which is widely used in most areas of the lake and is known locally as (El-Tara), the seine/hand-catching combination

(El-Laffa), the trammel net (El-Daba), the basket traps (Gawabi) and the bottom trawls (El-Kerba) as described by El-Bokhty (2004).

Various aspects of the biology of cichlids of commercial importance have been studied in Egypt (Hosny, 1987;Yamaguchi *et al*., 1990 ; El-Shazly, 1993 ; Khalil, 1994; Abd-Alla, 1995; Shenouda *et al*., 1995; Khalifa *et al*., 2000 ; Abd-Alla and Talaat, 2000; Khallaf *et al*.,2000; Khallaf, 2002). There is a considerable exploitation pressure of the different species of tilapia by the different gears. For a sustainable management of the cichlid fish, information on the dynamics of the stocks and biology of the species is essential. The present study is an endeavor to estimate the population parameters of the stocks in Lake Manzala using the length frequency data in a predictive analysis.

MATERIALS AND METHODS

The length frequency data of different cichlid species were collected seasonally from the surrounding gears in Lake Manzala during August 2000 to September 2001. After sorting the fish sample to the different species, the total length of each individual fish was measured to the nearest 0.1 cm and weighed to the nearest 0.5 gm to estimate the size composition as well as the length-weight relationship by using the power equation $W=aL^b$ (W is the total weight, L is the total length, a & b are constants). The length frequency distributions were analyzed using the appropriate routines and subroutines of the "FiSAT" computer program (Gayanilo *et al.,* 1997). An estimate of the asymptotic length (L_∞) and the growth coefficient (K) were obtained by the method of Wetherall (1986). The parameters were then used as seed values in ELEFAN I routine (Pauly, 1984 a &b) for estimating the best combination of L_∞ and K. The Phi-prime index Φ (Munro and Pauly, 1983; Moreau *et al*., 1986) for the species concerned was used to estimate the growth performance index as $\Phi = \log K + 2 \log L_\infty$.

The instantaneous rate of total mortality (Z) was derived from the length converted catch curve method described by Pauly (1983). The instantaneous rate of natural mortality (M) was computed from the empirical equation of Pauly (1980) considering the mean annual temperature of the lake as 20.75°C (El-Bokhty, 1996). The instantaneous rate of fishing mortality (F) was extracted as F=Z–M. The exploitation ratio was calculated as E = F/Z. (Gulland , 1972) The length at first capture "L_c" was determined from the catch curve according to Pauly (1984a & b).

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 the FiSat software package as follows;

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

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

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,

$m = (1-E)/ (M/K) = K/Z$, and $U = 1 - (L_c / L_\infty)$.

RESULTS AND DISCUSSION

1- Catch characteristics

The total annual catch of Tilapia from Lake Manzala during the period 1995-2004 (GAFRD, 1995-2004) fluctuated between a maximum catch of 40.05 X 10^3 ton in 1998 and a minimum catch of 26.882 X10^3 ton in 2004 with an average of 34.32 ton showing a tendency of oscillation with a decreasing trend (Table 1 & Fig. 1)

Tilapia fish formed the majority of fish catch from the lake (62.62, and 63.12 % in years 1996 and 1997 respectively). Recently, signs of a decline in the landed tilapia catch had been observed in the last few years as it contributed only by 42.15 % in 2004. It was followed by mullets (23.54 %) and catfish especially *Clarias gariepinus* (15.13 %) as recorded by GAFRD (2004). Unfortunately, the species constituents of tilapia fish were not identified. It was found that *Oreochromis niloticus* and *O. aureus* dominated the catch of the surrounding net (El-Tara), seine/hand catching combination (El-Laffa), hand catching (Gatis), frame net (El-Gerba), trammel net (El-Daba) and basket traps (Gawabi) according to El-Bokhty (2004). Therefore, it can be concluded that *O. niloticus* and *O. aureus* dominate tilapia fish populations in Lake Manzala.

The abundance of the different fish species was quite variable among the catch of the surrounding net (El-Tara). From a total of 5265 fish (weighing 202.9 kg.), it was found that *O. niloticus* was the most dominant species contributing by 52.4 & 61.4 % in number and weight respectively. *O. aureus* ranked the second order by 40.9 & 32.7 % in respective. *T. zillii* and *S. galilaeus* were the least frequent species contributing only by 5.9, 1.3 % numerically and 3.3, 2.5 % by weight respectively (El-Bokhty, 2004)

2- Length – weight relationship

A total of 248 specimens of *Oreochromis niloticus* were used to estimate the length-weight relationship. Their total lengths ranged between 6.5 and 27.5 cm with an annual average length of 12.84 ± 0.08 cm, while their total weight varied between 5 and 422 g. with an average of 45.23g. The computed length – weight relationships were as following:

$W = 0.01539\ L^{3.06216}$ (r = 0.9936) for males

$W = 0.01572\ L^{3.05629}$ (r = 0.9902) for females,

$W = 0.01745\ L^{3.01043}$ (r = 0.9661) for combined sexes

The value of exponent "b" was found close to 3 for the combined sexes which indicated that the fish grows symmetrically, while it was slightly larger for males than females indicating that males grow with heavier weights than females. Shalloof (1991) found that the exponent b=2.783 for males and b=2.711 for females showing an isometric growth for males and allometric growth for the females in the middle region of the Lake Manzala. The isometric growth may return to the nature of the fishing process which depends on lifting fish for a period of time before being harvested. This enables fish to feed freely on the filamentous, planktonic algae and succulent higher plants (Pompa and Masser, 1999).

A total 199 fish of *O. aureus* varying between 5.5 and 20.5 cm in total length (with an annual average of 11.81 ± 2.24 cm) were used to estimate the length-weight relationship. Their weight varied between 3 and 173.67g. with an average of 31.27g. The length-weight relationships were computed as;

$W = 0.01528\ L^{3.03918}$ (r = 0.9869) for males

$W = 0.01613\ L^{3.0225}$ (r = 0.9829) for females

$W = 0.01332\ L^{3.0939}$ (r = 0.9882) for combined sexes

Moreover, the computed regressions of weight-based length relationship of 95 fish of *Tilapia zillii* which ranged between 5.5 and 17.5 cm in total length (Av. 9.87 ± 1.84 cm) and weighing between 3 and 114 g (Av. 21.17 g) were as follows;

$W = 0.01243\ L^{3.19669}$ (r = 0.9852) for males

$W = 0.013405L^{3.17689}$ (r = 0.9917) for females

$W = 0.01427\ L^{3.14596}$ (r = 0.9847) for combined sexes

For *S. galilaeus*, a total of 89 fish ranging between 9.5 and 22.5 cm in total length (Av. 14.99 ± 0.91 cm) and varying in weight between 14 and 202 g (Av. 74.67 g) were used to estimate the following relationships;

$W = 0.01967\ L^{2.9966}$ (r = 0.9892) for males
$W = 0.019083\ L^{3.00225}$ (r = 0.9899) for females
$W = 0.01642\ L^{3.05982}$ (r = 0.99916) for combined sexes

In case of *S. galilaeus*, males grow less slightly than females. Similar results were given by El-Ghobashy (1990) and Shaloof (1991).

3- Age composition

It's well known that otoliths, scales or other hard parts can be used for determination of Fish age. Moreover some authors have used the length frequency to predict age components (El-Ganainy & Mehana, 2003; Sabrah, 2006; Sabrah *et al*., 2006). In the present study aging of fish was based on the length frequency distribution in an attempt to be compared with those obtained by other authors from scale reading methods. In the present method a succession of modes may be treated as belonging to successive year classes (Peterson, 1892). Age cohorts were separated by using Battacharya method (1967) and are shown in Table 2. Five cohort components can be successively separated from the length frequency distribution for *O. niloticus*, which indicates that its life span may reach five years. Four cohorts were identified for both *O. aureus* and *S. galilaeus*, while three components were separated for *T. zillii*.

On comparing the mean lengths of cohort components of the pooled data with those of the mean total lengths at capture as measured by different authors (Table 3), it could be found that, these lengths don't deviate so much from those of the other authors who worked on Lake Manzala. Therefore, length frequency could be considered as simple method for aging fish beside reading of otoliths, scales and other hard parts.

4- Growth and mortality estimates

Estimation of growth and mortality parameters are used to characterize the state of various fish populations and as input variables for bio-demographic models like those of Beverton and Holt (1957) and Pet *et al*. (1996). These models are applied to predict consequences of management measures, like changes in effort and mesh size, on the yield. The estimated vital population parameters of the four cichlid species are summarized in Table 3 and are compared with those given by different authors in other localities for *O. niloticus*.

A- Growth performance index

The value of the growth performance index (Φ) of *Oreochromis niloticus* was estimated to be 2.65. This value may reflect the high adaptability of *O. niloticus* to tolerate a wide range of pH, low levels of dissolved oxygen and feeds on a variety of food items (Njiru, 1999). Φ values for *O. aureus*, *T. zillii* and *S. galilaeus* were estimated as 2.44, 2.27 and 2.18 respectively. These low values suggest slow growing rates of these species. Abdel-Aziz *et al*. (1990) found that the growth rate of *O.niloticus* was the lowest in Lake Manzala compared with other regions, like Lake Nubia, White Nile and Lake Nasser. This difference is perhaps a manifestation of the observations that similar species experience different growth rates in different habitats (Lowe-McConnell, 1982).

B- Mortality Rates

An estimate of the total mortality coefficient (Z) for *O. niloticus* from the descending portion of catch curve (Fig. 2-a) was found to be 3.38yr $^{-1}$. This value is higher than that estimated by Dowidar *et al*. (1990) (2.2 yr $^{-1}$) from Lake Manzala and is confirming that the species is subjected to high mortality levels. Meanwhile, the natural mortality (M) was computed as 1.04 yr $^{-1}$ and the fishing mortality (F) was computed as 2.34 yr $^{-1}$ for *O. niloticus*.

The total mortality coefficients (Z) of other fish species were estimated as 2.94 yr^{-1}, 2.26 yr^{-1} and 1.02 yr^{-1} for *O. aureus*, *T. zillii* and *S. galilaeus* respectively (Figs. 2 b, c & d). The instantaneous rates of natural mortality as determined from Pauly's equation (1980) were 1.21yr^{-1}, 1.21yr^{-1} and 0.71yr^{-1} for the later three cichlid species respectively. In addition; their respective fishing mortality rates were calculated as 1.73 yr^{-1}, 1.06 yr^{-1} and 0.32 yr^{-1}. These findings indicate that *O. niloticus* is subjected to the highest fishing mortality.

C- Exploitation Rate

The exploitation rates (E) For *O. aureus*, *O. niloticus*, *T. zillii* and *S. galilaeus* estimated were found to be 0.69, 0.59, 0.47 and 0.31 respectively. The result indicated that the stock of *O. niloticus* and *O. aureus* were overexploited, while that of *S. galilaeus* and *T. zillii* were under the optimum exploitation rate (E = 0.5). Dowidar *et al.* (1990) mentioned that *O. niloticus* and *S. galilaeus* are highly exploited compared to the other two species.

5- Length at first capture (L_c)

The size at which the fish reaches its first sexual maturation is very important to maintain and keep the spawning of the fish population. L_c at which 50% of the fish that become vulnerable to capture were estimated to be 7.07, 6.33, 5.80 and 10.21cm for *O. niloticus*, *O. aureus*, *T. zillii* and *S. galilaeus* respectively. This means that the first two species were caught before being given the chance to grow even to their first size at maturing.

Shawky (1999) recorded that the male and female lengths of tilapia fish at their first sexual maturity were 10.6, 11.4 cm for *S. galilaeus*, 9.9, 9.8 cm for *T. zillii* ; 10.8, 12 cm for *O. niloticus* and 11.8, 12 cm for *O. aureus* in respective, Therefore, it is recommended to increase L_c values to at least these minimum lengths by using wider mesh-sized nets for conservation of the stock and Moreover to raise the sustainable yields of the different fish caught by the surrounding net at Lake Manzala.

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

As shown in Figures 2 & 3a to d, the relative yield per recruit and relative biomass per recruit of *O. niloticus* were estimated at different exploitation rates. It was found that the present level of exploitation rate (0.69) was higher than that producing the maximum relative yield per recruit (0.47) by about 22% for *O. niloticus*. Both of $E_{0.1}$ (the level of exploitation at which the increase in relative yield per recruit is one tenth of its value) and $E_{0.5}$ (the exploitation level under which the stock become reduced to half of its unexploited biomass) were found to be 0.40 and 0.29 respectively. Therefore, the exploitation rate of *O.niloticus* should be reduced from 0.69 to 0.47 (nearly 22%) to get the maximum yield/recruit. Similarly, *O. aureus* exploitation rate should be reduced from 0.59 by about 10 % to reach its optimum level to get the maximum (Y/R) and (B/R) rate. While *S. galilaeus* and *T. zillii*, with their current exploitation rates are still under the optimum level of exphitation (E=0.5) that can produce this maximum sustainable (Y/R) and (B/R).

Conclusion

Results of the present study indicated that the stocks of *O. niloticus* and *O. aureus* using surrounding nets in Lake Manzala were overexploited. For fishery management of this resource the fishing pressure and the present level of exploitation should be reduced to the optimum level. The use of illegal mesh sizes and other destructive fishing methods need to be urgently addressed by the authorities concerned. The entry to the fishery should be controlled; the registration of boats and the licensing of nets should be introduced to help in monitoring the effort exerted on the fishery.

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Table (1): Tilapia fish landed from Lake Manzala during 1995 - 2004

Year	Total Catch(ton)
1995	35503
1996	32881
1997	39826
1998	40050
1999	33929
2000	39573
2001	34767
2002	29703
2003	30054
2004	26882
Av. Catch	34316.8

Table (2): Mean lengths of components as identified by Bhattacharya analysis for Cichlid fish species in Lake Manzala.

	Age Groups				
Season	1	2	3	4	5
Oreochromis niloticus					
winter	10.66	13.54	18.5	22	
(S.D.)	1.11	1.69	1.48	0.72	
(S.I.)		2.06	3.13	3.18	
spring	11.34	14.78	19.33		
(S.D.)	1.57	1.48	1.07		
(S.I.)		2.26	3.57		
summer	9.28	13.15	17.54	20.72	24
(S.D.)	1	1.87	1.1.79	0.84	1.63
(S.I.)		2.7	2.4	2.42	2.66
fall	10.28	13.57	19.22		
(S.D.)	1.08	1.79	1.08		
(S.I.)		2.29	3.94		
pooled data	10.27	13.34	16.57	19.1	
(S.D.)	1.22	1.33	0.75	1.12	
(S.I.)		2.41	3.11	2.71	
Oreochromis aureus					
winter	8.69	12.07	16.27		
(S.D.)	1.44	1.93	0.85		
(S.I.)		2	3.01		
spring	11.38	13.83	16.46	19.02	
(S.D.)	1.04	0.92	0.64	1.19	
(S.I.)		2.5	3.38	2.79	
summer	8.82	12.51	15.43		
(S.D.)	0.89	1.01	1.63		
(S.I.)		3.87	2.21		
fall	9.76	12.75	15.8		
(S.D.)	1.49	1.49	0.72		
(S.I.)		2.01	2.75		
pooled data	8.84	12	15.3	19.67	
(S.D.)	1.22	1.58	1.31	0.9	
(S.I.)		2.26	2.28	3.96	

Table (2 cont.): Mean lengths of components as identified by Bhattacharya analysis for Cichlid fish species in Lake Manzala.

	Age Groups				
Season	**1**	**2**	**3**	**4**	**5**
Sarotherodon galilaeus					
winter (S.D.) (S.I.)	11 0.95	14.52 0.73 4.19	16.99 1.67 2.06		
spring (S.D.) (S.I.)	not determined				
summer (S.D.) (S.I.)	10 0.85	13 1 2.93	16.78 0.37 4.81	20 1.2 4.1	
fall (S.D.) (S.I.)	11 1.2	13.96 0.26 4.07			
pooled data (S.D.) (S.I.)	11.12 0.95	14.04 0.99 3.01	17.24 0.98 3.25	19 0.91 1.86	
Tilapia zillii					
winter (S.D.) (S.I.)	9.36 1.45	11.07 1.39 1.2			
spring (S.D.) (S.I.)	9.75 0.93	13.55 0.8 4.39			
summer (S.D.) (S.I.)	8.13 0.84	10.74 1.02 2.81	14 0.49 4.31		
fall (S.D.) (S.I.)	9.76 1.49	12.75 1.49 2.01	15.8 0.72 2.75		
pooled data (S.D.) (S.I.)	9.85 1.72	12.32 0.61 2.12	14.2 0.58 3.61	17 0.96 3.64	

S.D. = standard deviation S.I. = separation index

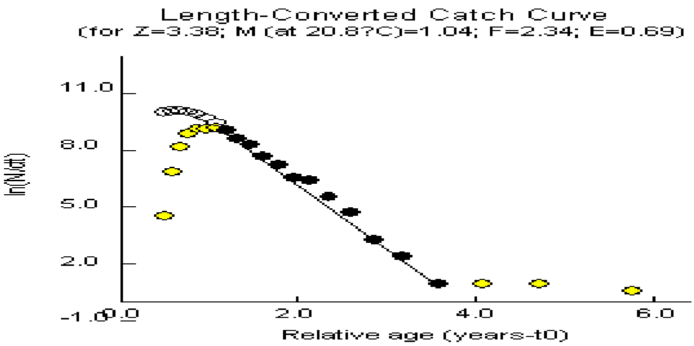
Table (4). Estimated vital population parameters for Tilapia fish inhabiting Lake Manzala.

species	L_∞	K	Φ	Z	M	$C.I._z$	F	E
O. niloticus	28.88	0.53	2.65	3.38	1.04	3.20 – 3.56	2.34	0.69
O. aureus	21.53	0.59	2.44	2.94	1.21	2.73 – 3.14	1.73	0.59
T. zillii	18.38	0.55	2.27	2.26	1.21	1.92 – 3.51	1.06	0.47
S. galilaeus	23.63	0.27	2.18	1.02	0.71	0.73 – 1.32	0.32	0.31

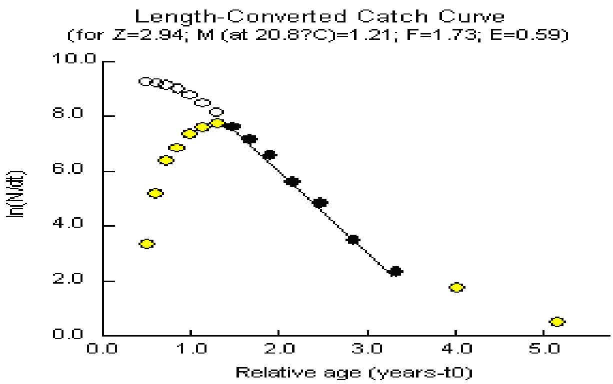
Z: estimated from length converted catch curve, F = Z – M, E = F/ Z
C.I.z: Confidence Interval of Z.

Table (5). Growth parameters, L_∞ , K, $t_\circ$ and growth performance index (Φ) of *Oreochromis niloticus* as recorded by different authors.

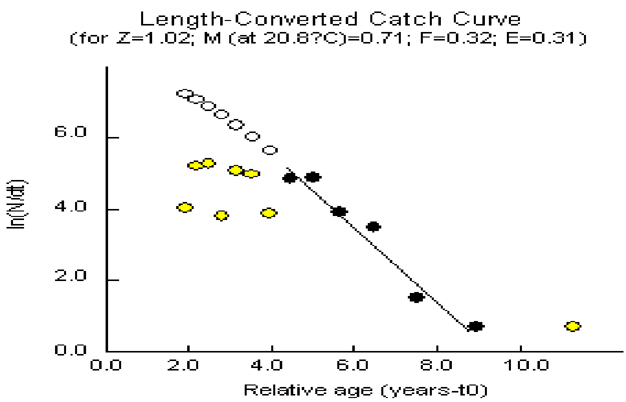
Locality	sex	L_∞	K	$t_\circ$	Φ	Reference
Maruit	combined	29.4	0.594		2.71	El-Zarka *et al.,*1970
Maruit	♂	34.4	0.45		2.73	Payne & Collinson,
	♀	27.1	0.58		2.44	1983
Manzala	combined	29.4	0.294		2.41	″ ″
Manzala	combined	28.01	0.377	-0.199	2.48	Abdel-Aziz e*t al.*,1990
Manzala	combined	36.6	0.266			Dowidar *et al.*,1990
Edku	combined	32.76	0.332	-0.154	2.55	Abdel-Aziz *et al.*, 1990
Edku	combined	34.5	0.2015	-0.52	2.38	Abd-Alla & Talaat, 2000
Coatetelco, Mexico	combined	29.19	0.07			M□árquez, 1998
Manzala	combined	28.88	0.53		2.65	present study



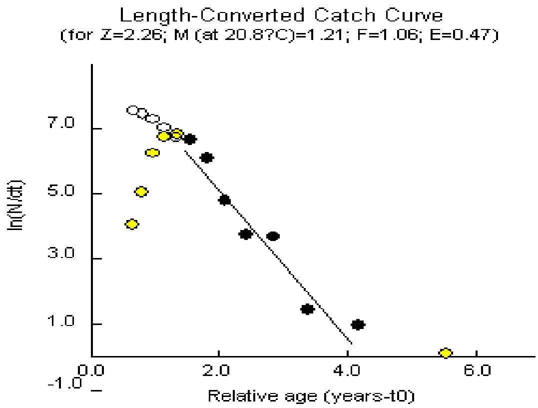
(a) ***O. niloticus***



(b) ***O. aureus***

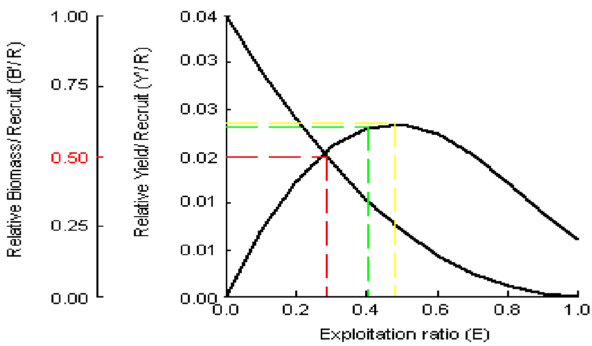


(c) ***S. galilaeus***

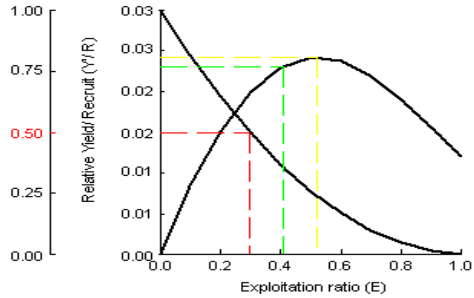


(d) ***T. zillii***

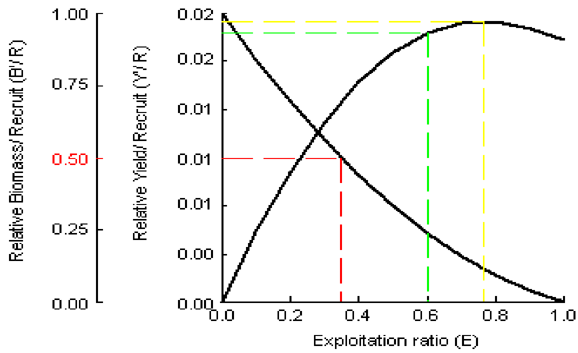
Fig.(2 a-d). Length converted catch curves of *Tilapia* fish, Lake Manzala



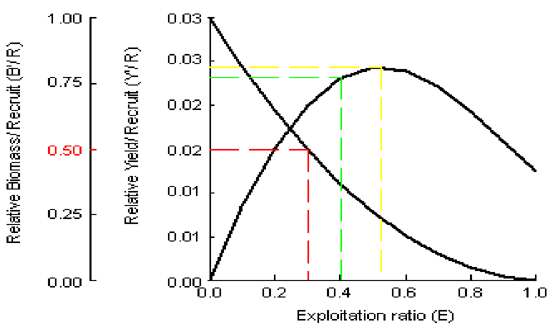
(a) ***O. niloticus***



(b) *O. aureus*



(c) *S. galilaeus*



(d) *T. zillii*

Fig.(3 a-d). Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' of *Tilapia* fish, Lake Manzala