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BIOLOGY AND FISHERIES MANAGEMENT OF TILAPIA SPECIES IN ROSETTA BRANCH OF THE NILE RIVER, EGYPT.

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ABSTRACT

Cichlids were absolutely the most common fish group (96.99%) in the commercial catch of Kafr El-Zayyat and Desook sectors of the Rosetta branch of the Nile River during the year 2006. It is represented by four species namely *Oreochromis niloticus* (51.29%), *Tilapia zillii* (36.24%), *Oreochromis aureus* (5.59%) and *Sarotherodon galilaeus* (3.87%). Age was determined by using body scales readings. The parameters of Von Bertalanffy growth model were estimated as K= 0.39 year^{-1}, L_∞= 28.5 cm and t_o= -0.32 year for *O. niloticus;* K = 0.50 year^{-1}, L_∞= 16.5 cm and t_o = -0.15 year for *T. zillii*; K= 0.40 year^{-1}, L_∞= 26.4 cm and t_o = -0.21 year for *O. aureus* and K = 0.42 year^{-1}, L_∞= 20.3 cm and t_o = -0.24 year for *S. galilaeus*. It was found that; *O. niloticus* has the highest rate of growth followed by *O. aureus* and *S. galilaeus* while *T. zillii* has the lowest one. The coefficients of total mortality (Z), natural mortality (M) and fishing mortality (F) were 1.62, 0.8 and 0.82 year^{-1} respectively for *O. niloticus*; 2.41, 1.09 and 1.32 year^{-1} for *T. zillii*; 2.13, 0.83 and 1.3 year^{-1} for *O. aureus* and 2.47, 0.92 and 1.55 year^{-1} respectively for *S. galilaeus*. The Exploitation rate (E) was 0.51, 0.55, 0.61 and 0.63 year^{-1} for *O. niloticus, T. zillii, O. aureus* and *S. galilaeus* respectively. The yield per recruit and the biomass per recruit analysis showed that, the actual values of both the yield per recruit and the fishing mortality of the four under study species were very close to the maximum sustainable yield per recruit and the optimum fishing mortality of each species. This means that, the present level of exploitation rate of these species is optimum; and for management purposes it is recommended not to increase the fishing activities in the area of study.

1. INTRODUCTION

The most important natural feature of the Nile River in Egypt is both its agriculture fertility and productive fisheries. Rosetta branch is one of the two main branches of the Nile River (Fig.1). It is about 220 km in length with an average width of 180 m. and depth varying between 2 and 4 m (Abd el-Sattar and Elewa 2001). It ends at Idfina Barrage which releases excess water to the Mediterranean Sea. Several studies had been done on Rosetta branch by Massoud and Mahdi (1985 – a & b), Bakry (1996), Abbassy *et. al.* (1999), Abdo (2002), Donia, *et. al.* (2003), AbdAllah, *et. al.* (2006).

Tilapia is the generic name of a group of cichlids endemic to Africa. The group consists of three important genera namely *Oreochromis, Sarotherodon* and *Tilapia*. Genus Tilapia contains more than 70 species (Meyer, 2002) and is originally found in Africa and parts of the Middle East but can today be found in a number of other waters around the world. Due to their importance in the Egyptian inland waters, many studies on their biology and fisheries were done such as follows. Abdel Azim (1974), Talaat (1979), Ishac *et. al.* (1985), Bayoumi and Khalil (1988), Akel (1989), Dowidar *et. al.* (1990), Abdel-Baky and El-Serafy (1990), Abdel-Aziz *et. al.* (1990), El-haweet (1991), El-Shazly (1993), Bakhoum (1994, 1995 & 2002), Essa and Faltas (1997), Abd-Alla and Talaat (2000), Al-Sayes *et. al.* (2002), Adam (2004), Eskander (2004), Abaza (2004)**,** Mehanna (2005)**,** El-sayed (2006), El-Sayed and Moharram (2007) and Njiru, *et. al.* (2008).

The objectives of this study are to assess the fishery status of tilapia species in Rosetta branch and to obtain the basic information required for managing this important fish resource.

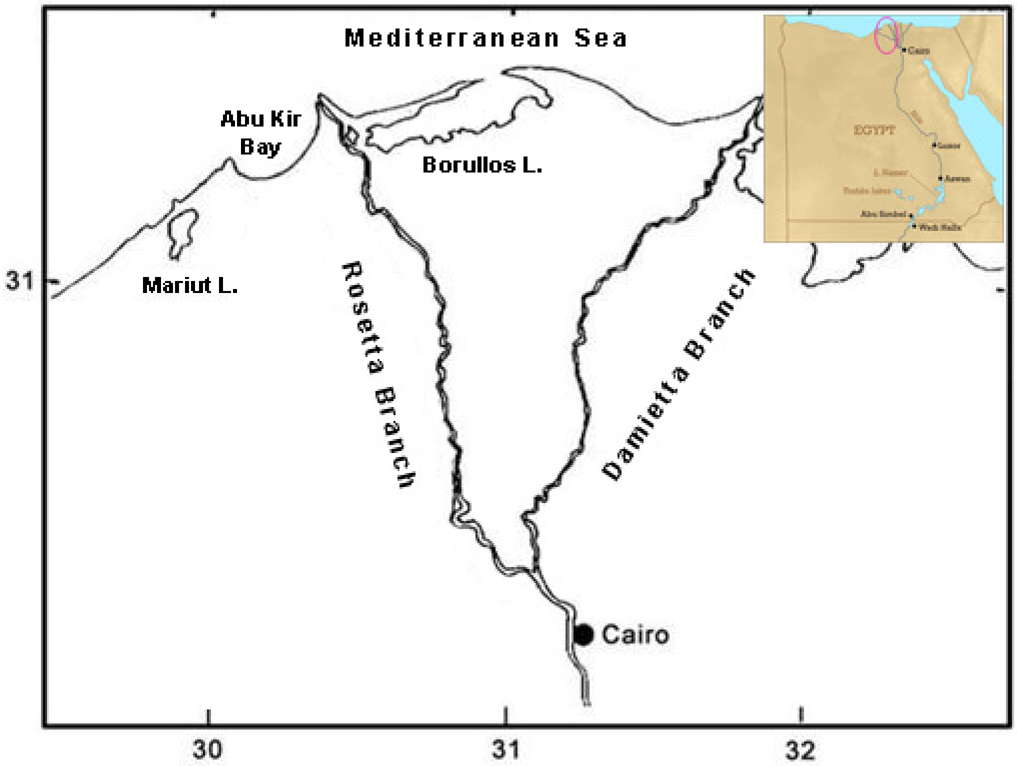

Fig. (1): Location of the Nile Delta (Rosetta branch).

2. MATERIALS AND METHODS

Monthly random samples (About 2330 fish) were collected from commercial fishing boats landing in the two main landing centers of Rosetta branch (Kafr Elzyat and Desok) and from some minor fishing cites from January 2006 to January 2007.

The fish samples were identified; total length and total weight were recorded to the nearest centimeter and gram respectively. Length-weight relationship was estimated using the power equation $W = aL^b$ (Le Cren, 1951) where a and b are constants. Condition factor was calculated according to the formula $K = (W / L^3) \times 100$ (Hile, 1936) where W is the total weight in g. and L is the total length in cm.

Scales were removed from the area below the lateral line behind the pectoral fin of the left side of the fish. They were kept in special envelops with full information for further reading. Scales were washed with distilled water and mounted dry between two glass slides. They were examined under a binocular microscope (X25) to measure the total scale radius and the distance from the focus to each annulus using an eye piece micrometer.

The relationship between the scale radius and the fish total length was found to be represented by the linear equation L = a + bS where, L is the total fish length in cm, S is the scale radius in cm and a & b are constant.

The lengths at different ages were back calculated using lee‘s method (1920) as:

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

where L_n is the calculated length at the end of the n^{th} year of life in cm. L is the total length at capture in cm, S_n is the scale radius related to age (n) year in mm, S is the total scale radius in mm and (a) is the intercept on the Y axis of the length scale relationship.

The growth parameters of the Von Bertalanffy growth model (L_∞ and K) were computed by fitting the Gulland and Holt (1959) plot. While t_o was estimated by the equation:

$$t_o = t + (1/K) (L_n (L_\infty - L_t) / L_\infty)$$

According to Moreau *et. al.* (1986), the following equations were adopted to estimate the growth performance of length and weight for the four species under study:

$$ø_L = \text{Log } K + 2 \text{ Log } L_\infty$$

$$ø_{wt} = \text{Log } K + 2/3 \text{ Log } W_\infty$$

The value of (t_{max}) was obtained according to the following equation:

$$T_{max} = (-1 / K) \text{ Ln } (1 – (0.95 L_\infty) / L_\infty)$$

The total mortality coefficient (Z) was estimated by using Beverton and Holt’s (1956) equation $Z = K ((L_\infty - L^-) / (L_\infty – L^{'}))$ where Z is the instantaneous total mortality coefficient, L^- is the mean length and $L^{'}$ is the length for which all fish of that length and longer are under full exploitation. Natural mortality coefficient (M) was calculated by using Pauly empirical formula (1980):

$$\text{Log } M = -0.0066 – 0.279 \text{ Log } L_\infty + 0.6543 \text{ Log } K + 0.4634 \text{ Log } T$$

where T is the annual mean temperature. The fishing mortality coefficient (F) was computed as F = Z – M.

The survival rates (S) was simply estimated according to Ricker (1975) equation $S = e^{-Z}$, while the exploitation rate (E) was computed from the ratio F / Z (Gulland, 1971).

Length at first capture (L_c) was investigated from the equation of Beverton and Holt (1956) $L_c = L^- - (K (L_\infty - L^-)) / Z$ and the corresponding age at first capture (t_c) were calculated by the following equation:

$$t_c = (-1 / K) (\text{Ln } ((1 – (L_c / L_\infty)) + t_o)$$

while length at recruitment (L_r) was estimated also in the same manner by the equation:

$$L_r = L^- - (K (L_\infty - L’)) / Z$$

The corresponding age at recruitment (t_r) was calculated by the same equation of age at first capture by using the length at recruitment $t_r = (-1 / K) (\text{Ln } ((1 – (L_r / L_\infty)) + t_o)$ where L^- is the mean length of the catch, K, L_∞ and t_o are the constants of Von Bertalanffy equation, Z is the instantaneous total mortality coefficient and L’ is the length for which all fish of that length and longer are under full exploitation.

Yield per recruit model was estimated by Beverton and Holt (1957) and written in the form suggested by Gulland (1969) as follows

$$Y/R = F.\ e^{-M(tc-tr)}.W_{\infty}.[(1/Z) - (3S/(Z+K)) + (3S^2/ (Z+2K)) - (S^3/(Z+3K))]$$

Where W_{∞} is the asymptotic body weight and $S = e^{[-K(tc-to)]}$. Biomass per recruit was calculated by the equation:

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

3. RESULTS AND DISCUSSION

3.1. Catch composition

Tilapia species are the most common fish group in the commercial catch of the Rosetta branch of the Nile River. The landed catch was represented mainly by *Oreochromis niloticus* (51.29%), *Tilapia zillii* (36.24%), *O. aureus* (5.59%) and *Sarotherodon galilaeus* (3.87%). and the rest about 3.01% are composed of *Bagrus bajad*, *Alestes baremoze*, *Clarias gariepinus*, *Labeo niloticus*, *Cyprinus carpio* and *Latus niloticus*.

3.2. Length weight relationship

The total length of *O. niloticus* varied between 9.5 and 25.5 cm with mean length 13.2 cm and the total weight ranged between 16.97 and 281.77 gm., and the total length of *T. zillii* varied between 7.5 and 15.5 cm with mean length 10.05 cm, and the total weight ranged between 8.43 and 59.97 gm. While the total length of *O. aureus* lies between 10.5 and 24.5 cm with mean length 13.02 cm, and the total weight ranged between 21.88 and 288.72 gm, and the total length of *S. galilaeus* varied between 8.5 and 18.5 cm with mean length 10.22 cm, and the total weight ranged between 13.55 and 123.60 gm. The obtained length weight relationships equations were:

$$W = 0.0184L^{3.0082} \quad (r^2 = 0.9631)$$

for *O. niloticus*

$$W = 0.0171\ L^{3.0524} \quad (r^2 = 0.9850)$$

for *T. zillii*

$$W = 0.0253\ L^{2.8724} \quad (r^2 = 0.9825)$$

for *O. aureus*

$$W = 0.0277\ L^{2.8785} \quad (r^2 = 0.9943)$$

for *S. galilaeus*

The most frequent length group percentage of *O. niloticus* was (21.04%) corresponding to length group 11.5 cm and it was (33.10%) for *T. zillii* corresponding to length group 8.5 cm, and for *O. aureus* it was (23.08%) corresponding to length group 14.5 cm, while it was (33.33%) corresponding to length group 9.5 cm for *S. galilaeus*.

3.3. Condition factor (K):

The average values of the condition factor for each length group of the four species under study were calculated. The values of (K) of the four under study species were higher in small lengths than in big lengths. By comparing the annual average values of (K) for the four species it appears that, the condition factor of *S. galilaeus* had the highest value (2.06), while the condition factor of both *O. niloticus* and *T. zillii* was the same (1.84), and *O. aureus* had the smallest value (1.79).

3.4. Age determination

Age determination in fish is one of the most important tools in the study of fish populations. In fact it is the basis for further studies on growth, mortality, recruitment and management. In the present study scales were used for age determination. *O. niloticus*, *O. aureus* and *S. galilaeus* were reached five age groups while *T. zillii* was represented by only four age groups.

Age group I was the most dominant age group for all the species under study. It was (67.48%) for *O. niloticus* and it ranges from 9.5 cm to 14.5 cm, for *T. zillii* (69.04%) ranges from 7.5 cm to 9.5 cm, *O. aureus* (79.23%) ranges from 10.5 cm to 15.5 cm and *S. galilaeus* (56.67%) ranges from 8.5 cm to 10.5 cm. These indicate that, the small sized fish dominate the catch of tilapia species in the area of study.

The Length distribution percentages within each age group of the four species under study are shown in Fig. (2), there are obvious length overlapping between the different age groups of these four under study species especially for small age groups.

3.5. The body length – scale radius relationship

The scale radius relationships of the four under study species were found to be linear and can be represented by the following equations:

$$L = 2.97 + 2.08\ S \quad (r^2 = 0.9923)$$

for *O. niloticus*

$$L = 2.11 + 4.12\ S \quad (r^2 = 0.9899)$$

for *T. zillii*

$$L = 2.78 + 2.96\ S \quad (r^2 = 0.9892)$$

for *O. aureus*

$$L = 2.34 + 3.54\ S \quad (r^2 = 0.9881)$$

for *S. galilaeus*

3.6. Back calculations and growth in length

The back calculation of length at the end of different years of life was calculated for the four under study species, it is noticed that, all the species attained their highest growth rates in length during the first year of life, after which a gradual decrease was noticed with further increase in age.

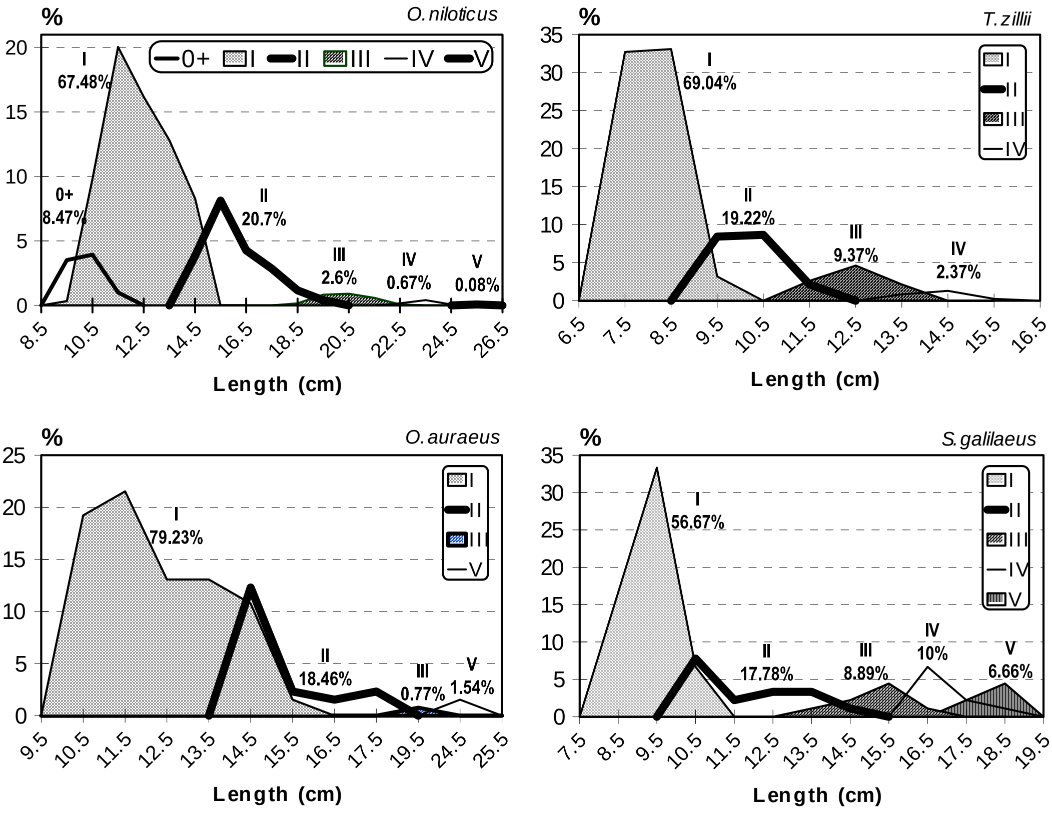

Fig. (2): Length distribution percentage within each age group of the four under study species.

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It is clear from Fig. (3) that; *O. niloticus* has the highest rate of growth followed by *O. aureus* and *S. galilaeus* while *T. zillii* has the lowest one. For example, the average lengths at the end of age group I were 11.44 cm for *O. niloticus*, 7.2 cm for *T. zillii*, 10.12 cm for *O. aureus* and 8.32 cm for *S. galilaeus*.

As shown in Table (1) the present results agree with those given by El-Haweet (1991) in Lake Borollus and Abaza (2004) in Lake Mariut, while Abd-Alla and Talaat (2000) found the length at the end of the first year of life of *S. galilaeus* (8.6 cm) is more than that of *O. aureus* (7.4 cm) in Lake Edku.

The parameters of Von Bertalanffy growth model were estimated as K= 0.39 year^{-1}, L_∞ = 28.5 cm and t_o = -0.32 year for *O. niloticus;* K = 0.50 year^{-1}, L∞= 16.5 cm and t_o = -0.15 year for *T. zillii*; K= 0.40 year^{-1}, L∞= 26.4 cm and t_o = -0.21 year for *O. aureus* and K = 0.42 year^{-1}, L∞= 20.3 cm and t_o = -0.24 year for *S. galilaeus*.

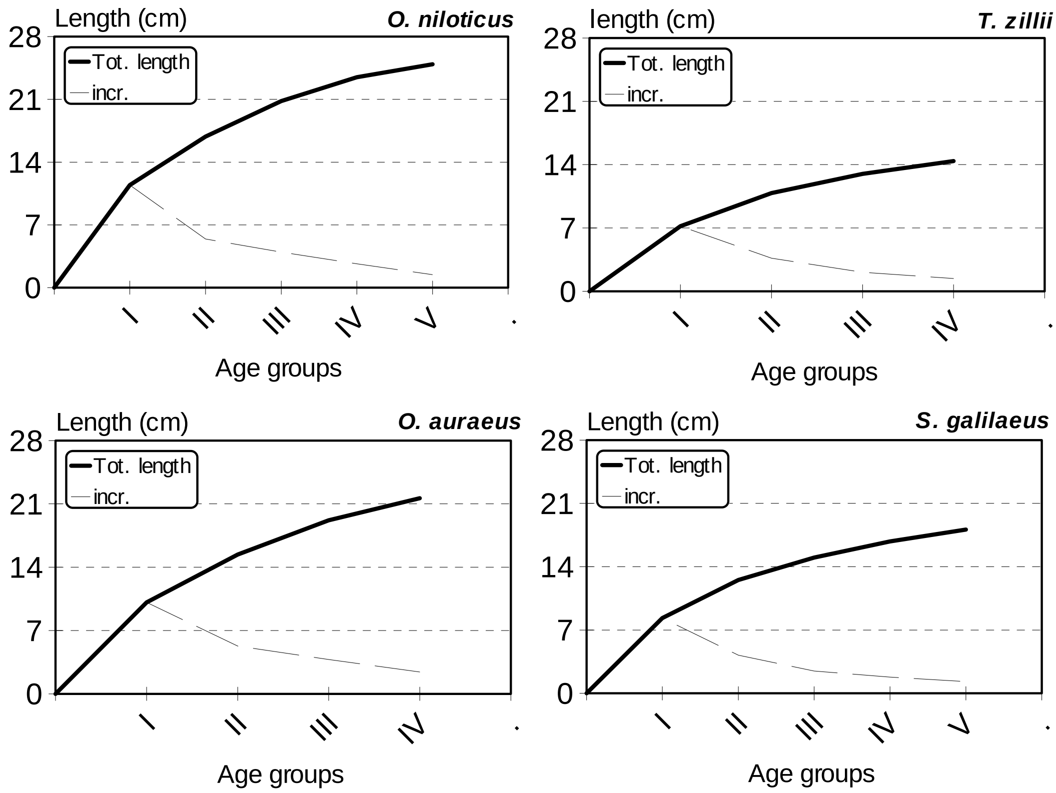

Fig. (3): Back calculated lengths of the four under study species at the end of each year of life.

3.7. Growth in weight

The calculated weights at the end of each year of life of the four under study species (Fig. 4) were estimated by applying the corresponding length-weight equations to the back calculated lengths.

It was found that, the maximum values of annual increments were observed at the end of the third year of life for *O. niloticus*, *T. zillii* and *O. aureus*, while it was observed at the end of the second year of life for *S. galilaeus*. W_∞ was estimated for the four species, it was 439 gm for *O. niloticus*, 87 gm for *T. zillii*, 308 gm for *O. aureus* and 160 gm for *S. galilaeus*.

Table (1): Lengths at the end of the first year of life for the four under study species in the present study as compared to those given by other authors.

Species	Area	L1	Inc. %	Refr.
O. niloticus	Lake Borollus	10.7 cm	38%	El-Haweet (1991)
T. zillii		8.9 cm	47%	
O. aureus		10.3 cm	46%	
S. galilaeus		9.8 cm	45%	
O. niloticus	Lake Edku	9.1 cm	33.7%	Abd-Alla and Talaat (2000)
T. zillii		6.7 cm	39.5%	
O. aureus		7.4 cm	36%	
S. galilaeus		8.6 cm	44.2%	
O. niloticus	Lake Mariut	11.7 cm	51.7%	Abaza (2004)
T. zillii		9.8 cm	61%	
O. aureus		10.9 cm	51%	
S. galilaeus		9.8 cm	62.5%	
O. niloticus	Rosetta Branch	11.44 cm	45.91%	The present study (2008)
T. zillii		7.2 cm	50%	
O. aureus		10.12 cm	43.81%	
S. galilaeus		8.32 cm	45.97%	

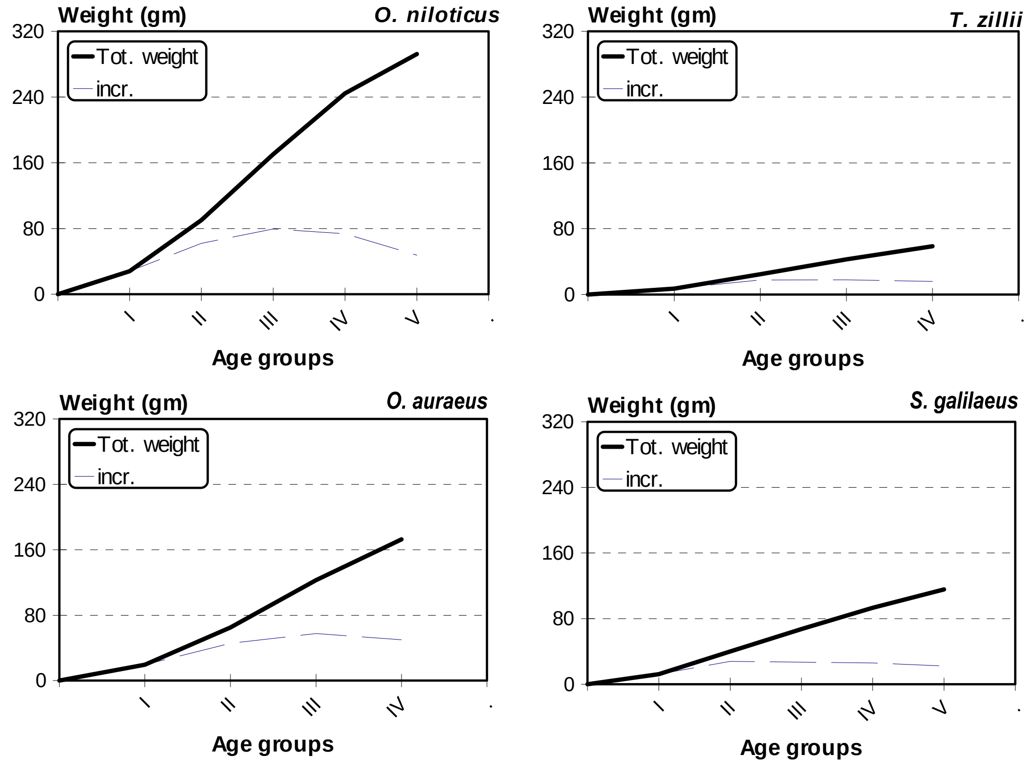

Fig. (4): Back calculated weights of the four under study species at the end of each year of life.

3.8. Growth performance index

The growth performance indexes (ø) in length and in weight of the four under study species were found to be 2.5 and 1.36 respectively for *O. niloticus*, 2.13 and 0.99 for *T. zillii*, 2.45 and 1.26 for *O. aureus* and for *S. galilaeus* they were 2.24 in length and 1.10 in weight. It is noted that, *O. niloticus* had a higher rate of growth than the other under study species.

3.9. The maximum age

The value of (t_{max}) which is defined as the time required for a fish to reach 95% of the species asymptotic length (L_∞) was estimated for the four under study species, it was found to be 7.63 years for *O. niloticus*, 6.04 years for *T. zillii*, 7.49 years for *O. aureus* and 7.08 years for *S. galilaeus*.

3.10. Instantaneous mortality coefficients

The estimation of mortality coefficients of a fish stock is an essential step for the calculating the optimum yield per recruit and its corresponding fishing effort. Total (Z), natural (M) and fishing (F) mortalities were estimated as 1.62, 0.80 and 0.82 $year^{-1}$ respectively for *O. niloticus***,** 2.41, 1.09 and 1.32 $year^{-1}$ for *T. zillii***,** 2.13, 0.83 and 1.30 $year^{-1}$ for *O. aureus* and 2.47, 0.92 and 1.55 $year^{-1}$ for *S. galilaeus*.

3.11. Survival rates

Ricker (1995) defines the Survival rate as the number of fish alive after a specified time interval divided by the initial number, usually on a yearly basis. The estimation of survival rate (S) for *O. niloticus*, *T. zillii*, *O. aureus* and *S. galilaeus* in Rosseta branch were 0.20, 0.09, 0.12 and 0.08 respectively.

3.12. The exploitation rates

The exploitation rate of *O. niloticus* was found to be 0.51, for *T. zillii* was 0.55, for *O. aureus* was 0.61, while for *S. galilaeus* it was 0.63. Gulland (1971) suggested that, the optimum exploitation rate is around (E = 0.5). Thus it seems that, tilapias suffer from intensive fishing which could be encountered either by minimizing the fishing effort or by regulating the size of the fish caught. However the size regulation is usually preferable since it does not have such drastic effects on the individual fisherman as restricting fishing effort (Gulland, 1978). These high values of exploitation rates of the four under study species in Rosetta branch area during the period of study indicates that, tilapia species are on the optimum exploitation or began to be under an overexploited case.

3.13. Length and age at first capture

Length at first capture (L_c) were estimated for the four under study species in Rosetta branch. The values of L_c were 9.5, 7.5, 10.5 and 8.5 cm, and the values of t_c were 0.71, 1.07, 1.05 and 1.05 year for *O. niloticus*, *T. zillii*, *O. aureus* and *S. galilaeus* respectively.

3.14. Length and age at recruitment

Length at recruitment (L_r) is the youngest length at which the fish maybe vulnerable to fishing. The values of L_r were 8.60, 7.18, 10.03 and 8.21 cm, and the values of t_r were 0.60, 1.00, 0.98 and 0.99 year for *O. niloticus*, *T. zillii*, *O. aureus* and *S. galilaeus* respectively.

3.15. Yield per recruit

Yield per recruit are the most common models used for the prescription of the fisheries state of any fish stock. These models depend upon the yield as a function of age and fishing mortality (Beverton and Holt, 1957). It was 23.5377 g. for *O. niloticus*, 7.7689 g. for *T. zillii* and 22.9833 g. for *O. aureus*, while it was 12.9721 g. for *S. galilaeus*.

3.16. Biomass per recruit

Beverton and Holt biomass per recruit model expresses the annual average biomass of survivors, which is related to the yield per recruit values. It was 28.7806 g. for *O. niloticus*, 5.8663 g. for *T. zillii* and 17.7134 g. for *O. aureus*, while it was 8.3759 g. for *S. galilaeus*. Figure (5) shows the yield per recruit and the biomass per recruit for the four species under study as a function of fishing mortality by testing various F values.

In the case of F = 0, the value of biomass per recruit is considered as the virgin biomass per recruit (The biomass of the unexploited stock). The biomass per recruit curve is decreasing with increasing fishing mortality (which is proportional to the fishing effort).

It appears that, for *O. niloticus* the maximum sustainable yield per recruit (MSY/R) was 23.6550 g. while the present yield per recruit value is 23.4005 g., for *T. zillii* (MSY/R) was 8.3199 g. and the present value is 7.7642 g., for *O. aureus* (MSY/R) was 23.1248 g. and the present value is 23.0611 g., and for *S. galilaeus* (MSY/R) was 13.0729 g. and the present value is 12.9721 g.

The corresponding optimum fishing mortality value of *O. niloticus* was 1.045 $year^{-1}$while the present F value is 0.82 $year^{-1}$. For *T. zillii*, the actual F value is 1.32 $year^{-1}$ while the optimum fishing mortality value is 3.20 $year^{-1}$and for *O. aureus*, the actual F value is 1.3 $year^{-1}$while the optimum fishing mortality value is 1.51 year^{1}. Finally for *S. galilaeus*, the actual and optimum F values were 1.55 and 2.05 year^{-1} respectively.

It is clear that, the actual values of both the yield per recruit and the fishing mortality of the four under study species were very close to the maximum sustainable yield per recruit and the optimum fishing mortality of each species. This means that, the present level of exploitation rate of these species is optimum; and for management purposes it is recommended not to increase the fishing activities in the area of study.

These results of the present study in Rosetta branch are agree with the results of Mehanna (2005), who found that the stock of *O. niloticus* at Wadi El-Raiyan Lakes is overexploited. Abd-Alla and Talaat (2000) determined the maximum sustainable yield for the four species of tilapia in Edku Lake and their corresponding ages. They recommended avoiding fishing operation on fish with age less than those mentioned in order to avoid intensive fishing or overexploitation.

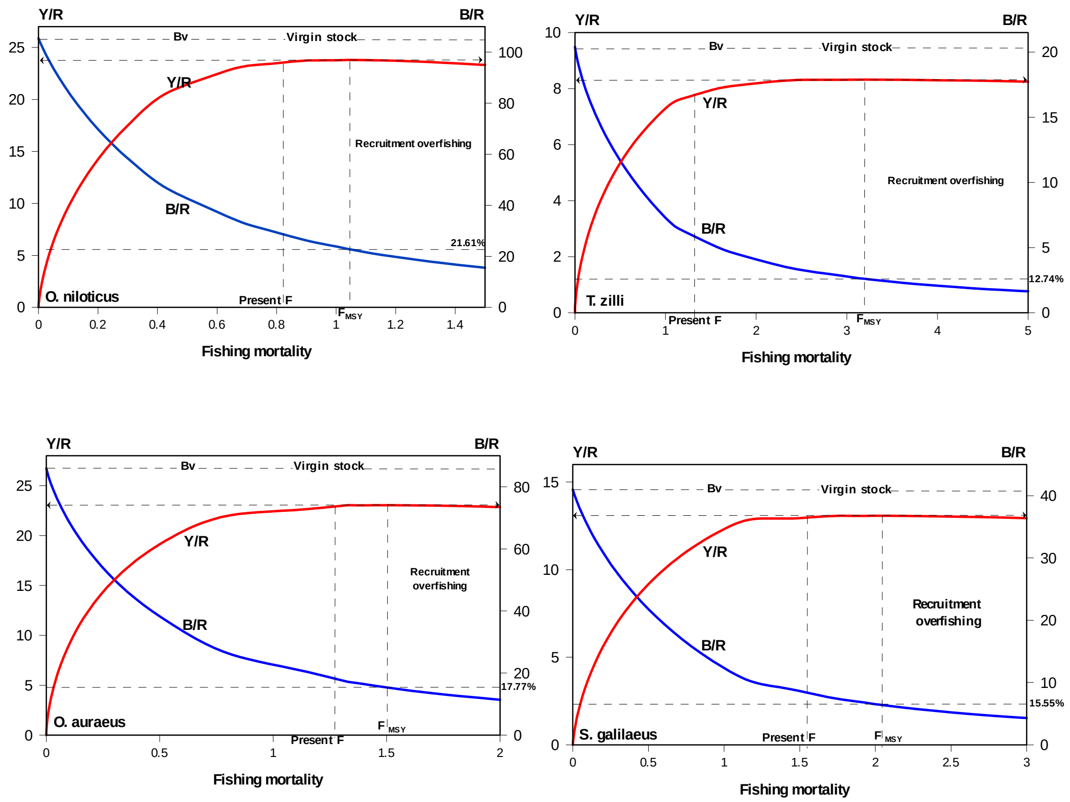

Fig. (5): Yield per recruit and average biomass per recruit of the four under study species as a function of fishing mortality.

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