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Population Dynamics of Two Cichlids, *Oreochromis aureus* and *Tilapia zilli*, from Wadi El-Raiyan Lakes, Egypt

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ديناميكية العشائر لنوعين من أسماك البلطى الأوريا والزيللى فى بحيرات وادى الريان – مصر

سحر مهنا

خلاصة: تمت دراسة كل من العمر ومعدلات النمو وحساب معاملات النفوق والانتاج لكل جيل لنوعين من أسماك البلطى (الأوريا والزيللى) فى بحيرات وادى الريان – مصر. تم جمع عينات الدراسة خلال الفترة من أغسطس ٢٠٠٠ الى يوليو ٢٠٠١. تم تحديد عمر هذه الأسماك عن طريق قراءة القشور ووجد أن أقصى عمر لأسماك الأوريا هو ثلاث سنوات بينما كان أربع سنوات لأسماك الزيللى. اشتملت الدراسة أيضا على تعيين معاملات النمو لنموذج برتلانفى والتى استخدمت بدورها فى حساب معاملات النفوق الكلى والطبيعى والناتج عن عملية الصيد كما تم حساب معدلات الاستغلال لهذه الأسماك ووجد أنه أعلى من المعدل الأمثل. بتحليل الانتاج لكل جيل وحساب الكتلة البيولوجية التى تضمن بقاء ٥٠% من مخزون هذه الأسماك لعملية التبويض وانتاج جيل جديد وجد أنه يجب خفض معدلات الاستغلال بنسبة ٥٣% لأسماك الأوريا و ٥٥% لأسماك الزيللى للحفاظ على انتاجية هذه الأسماك.

ABSTRACT: Age, growth, mortality, relative yield-per-recruit and relative biomass-per-recruit of *Oreochromis aureus* and *Tilapia zilli* collected from Wadi El-Raiyan lakes during the period from August 2000 until July 2001 have been estimated. Age was determined from scale readings and the results showed that the maximum life spans of *O. aureus* and *T. zilli* were three and four years, respectively. The von Bertalanffy growth equations were $L_t = 27.15\ (1-e^{-0.56(t+0.32)})$ for *O. aureus* and $L_t = 33.5\ (1-e^{-0.49(t+0.15)})$ for *T. zilli*. The instantaneous annual rates of total, natural and fishing mortality were calculated as 1.69, 0.25 and 1.44, respectively for *O. aureus* and 1.1, 0.2 and 0.9, respectively for *T. zilli*. Exploitation rate was estimated as 0.85 and 0.82 for *O. aureus* and *T. zilli*, respectively. Relative yield-per-recruit and relative biomass-per-recruit analysis indicated that the stocks of *O. aureus* and *T. zilli* were overexploited and that the current exploitation rate should be reduced by about 53% for *O. aureus* and 55% for *T. zilli* to ensure that at least 50% of the individuals could be maintained for spawning and recruitment.

Keywords: *Oreochromis aureus*, *Tilapia zilli*, Wadi El- Raiyan lakes, population dynamics.

Cichlids, particularly tilapias, are the most popular table fish in Egypt and occur in the Nile River and its tributaries, Lake Nasser, Lake Qarun, Wadi El-Raiyan lakes and the Delta lakes (Manzalah, Borollus, Edku and Mariut lakes). They are represented by four species in the Wadi El- Raiyan lakes namely: *Oreochromis niloticus, Oreochromis aureus, Sarotherodon galilaeus* and *Tilapia zilli*. Tilapia are the most important component of the Wadi El-Raiyan lakes production where they constitute about 50% of the total catch (according to fisheries statistics collected from the General Authority for Development of Fisheries Resources). They are collected by trammel nets (Bolti nets) from oar-powered boats; mesh size varies between 2.8 and 3.6 cm (aperture) and the net length varies from 250 to 300 m with a depth of 1.5 – 2.0 m.

Because of the economic importance of tilapias, their biology in different Egyptian water bodies has been extensively studied (Latif *et al.*, 1988; El-Sehamy, 1993; El-Shazly, 1993; Bakhoum and Faltas, 1994; Faltas, 1995; Abdalla and Talaat, 2000). However, despite the importance of tilapias in Wadi El-Raiyan lakes, few studies have been undertaken on the biology and dynamics of these cichlid species there (Solliman, 1981; Khalifa, 2000).

The present study is the first to estimate growth, mortality and exploitation rates, relative yield-per-recruit and relative biomass-per-recruit of *O. aureus*

and *T. zilli* from the Wadi El-Raiyan lakes. It also contributes to the development of an appropriate management plan to maintain these valuable fish resources.

Materials and Methods

Wadi El-Raiyan is a natural depression approximately 90 km southwest of Cairo, between Latitudes 28° 15` and 29° 17` N, and Longitudes 20° 68` and 31° 23` E. The Wadi El-Raiyan depression consists of two main lakes connected by a swampy channel (Fig. 1).

Monthly fish samples were collected from the Wadi El-Raiyan lakes during the period from August 2000 until July 2001. Samples were obtained from landing sites during all months except August 2000 and July 2001, when fish samples were collected by means of experimental fishing because of the closed fishing season. Experimental fishing was carried out using the same techniques as the fishermen from whom samples were bought. Throughout the period 575 fish were collected, 278 *O. aureus* and 297 *T. zilli*. Total length to the nearest millimeter, whole weight to the nearest 0.1 gram and scales were taken for each individual specimen. Scales from the left side of the fish were removed from an area just below the lateral line and behind the pectoral fin. Each scale was washed in distilled water, dried and mounted between two glass slides. The scales were examined using a measuring projector " LEITZ TP 300 " connected to an electronic reversible counter LEITZ VRZ U. The total scale radius and the radius of each annulus were measured to the nearest 0.001 mm. The total radius of each scale was plotted against the total fish length to determine the body length - scale radius relationship. The total lengths of the previous ages were back - calculated using Lee's (1920) equation:

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

where L_n is the back-calculated total length at the end of the n^{th} year, L is the total length at capture, S_n is the scale radius of the n^{th} annulus, S is the total scale radius and a is the intercept of the linear regression line.

The relation between length and weight was computed using the formula $W = aL^b$ where W is the total weight in gram, L is the total length in cm and a and b are constants whose values were estimated by least squares regression analysis.

FAO-ICLARM Fish Stock Assessment Tools (FiSAT) software of Gayanilo *et al.* (1997) was used to estimate the growth parameters (K, L_∞ and t_o) using a Gulland and Holt (1959) plot, the growth performance index (ø) using the formula of Pauly and Munro (1984) as $ø = \text{Log } K + 2 \text{ Log } L_\infty$, and the instantaneous total

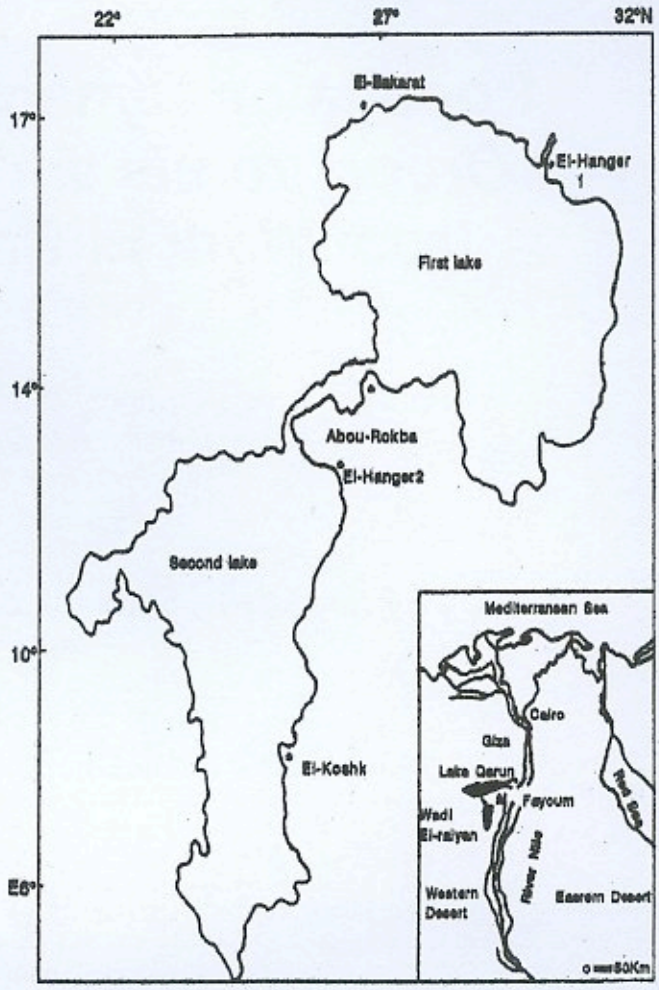

Figure 1. Wadi El-Raiyan lakes where the study was undertaken.

mortality coefficient "Z" by the analysis of catch curves based on length frequency data using the method of Pauly (1983). The length at first capture, L_c, was estimated using the method of Pauly (1984 a,b). The instantaneous natural mortality coefficient M was estimated by using Ursin's (1967) formula where $M = W^{-1/3}$, where W is the mean weight of all fish investigated. 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 applying the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) which is incorporated into the FiSAT software package.

Results and Discussion

AGE AND GROWTH: Scales were used for age determination of *O. aureus* and *T. zilli* from Wadi El-Raiyan lakes. The use of scales for age determination and growth studies of cichlids has been shown to be valid (El-Zarka, 1961a for *T. zilli* in Egyptian lakes; Payne and Collinson, 1983, for *O. niloticus* and *O. aureus* in Mariut and Manzalah lakes; Beamish and McFarlane, 1983 and 1987; Carlander, 1987; Lai *et al.*, 1996). The use of scales as a reliable and valid method for ageing *O. aureus* and *T. zilli* has been established.

Body length – scale radius relationships (Fig. 2) showed strong correlations. Also, the increase of fish size is accompanied by an increase in the number of annuli on the scales. On the other hand, back - calculated lengths accord with the observed lengths for the different age groups. Moreover, marginal increment indicated that the annulus is formed once a year.

The oldest fish examined was three years old for *O. aureus* and four years old for *T. zilli* (Fig. 3). These results are similar to other studies (El-Zarka, 1961b; Latif *et al.*, 1988; Bayoumi and Khalil, 1988; Khalil, 1994; Faltas, 1995 and Abdalla and Talaat, 2000).

The back–calculated lengths at the end of each year of life of *O. aureus* and *T. zilli* are given in Tables 1 and 2. Age readings indicated that both *O. aureus* and *T. zilli* attain their highest growth rate in length during the first year of life, after which a gradual decrease in growth increment was observed with further increase in age.

LENGTH-WEIGHT RELATIONSHIPS: The total length of 278 specimens of *O. aureus* ranged between 8 and 23.9 cm with weight varying from 7 to 265 g while the total length of 297 specimens of *T. zilli* varied from 8 to 30.5 cm with weight ranging between 9 and 600g. The length - weight relationships for the two species are shown in Figure 4. The length – weight equations were estimated as:

O. aureus $W = 0.0122\ L^{3.109}$

T. zilli $W = 0.0160\ L^{3.088}$

It was found that growth in weight is very slow during the first year in both species and thereafter growth in weight increases with age until it reaches its maximum value at age group II for *O. aureus* and group III for *T. zilli*.

GROWTH PARAMETERS: The back - calculated lengths were applied to a Gulland and Holt (1959) plot to estimate the von Bertalanffy growth parameters (L_∞ and K) (Fig. 5) while t_o was estimated from the equation:

$$-\ln [(L_\infty - L_t) / L_\infty] = -Kt_o + Kt$$

where L_t is the length at age t.

The VBGF for growth in length (cm) and weight (g) were as follows (Fig. 5):

O. aureus

$L_t = 27.15\ (1 - e^{-0.56\ (t\ +0.32)})$ For growth in length

$W_t = 349.90\ (1 - e^{-0.56\ (t\ +32)})^{3.109}$ For growth in weight

T. zilli

$L_t = 33.50\ (1 - e^{-0.49\ (t\ +0.15)})$ For growth in length

$W_t = 819.33\ (1 - e^{-0.49\ (t\ +0.15)})^{3.088}$ For growth in weight

where L_t and W_t are the length and weight at age t.

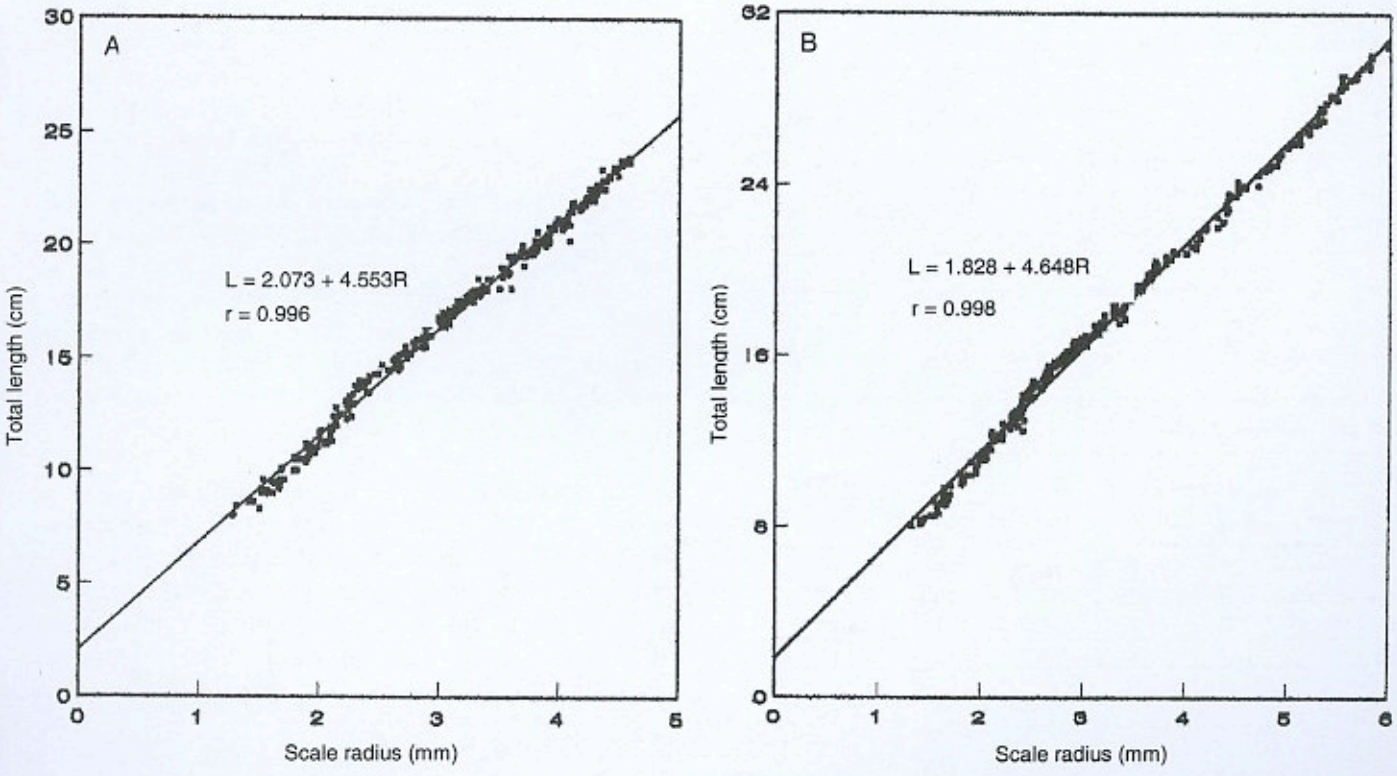

Figure 2. Total length-scale radius relationship of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

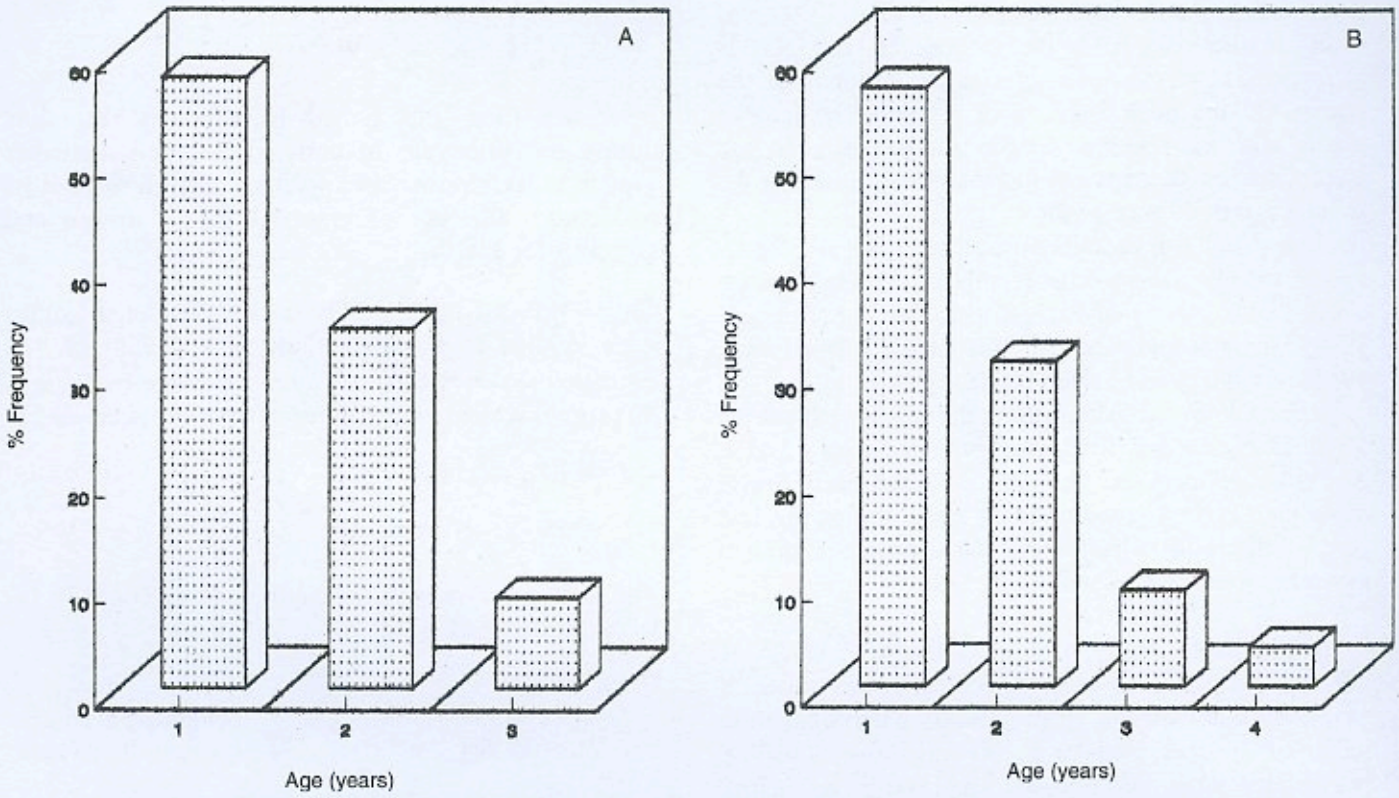

Figure 3. Age composition of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

TABLE 1

Average back-calculated lengths (cm) of* Oreochromis aureus *from Wadi El-Raiyan lakes.

Age Group	No. of Fish	Empirical Length	Back-calculated Lengths at the end of each year of life		
			1	2	3
I	160	15.60	**14.53**		
II	94	20.91	14.41	**20.08**	
III	24	23.75	14.39	19.88	**23.19**
Total	278				

TABLE 2

Average back-calculated lengths (cm) of* Tilapia zilli *from Wadi El-Raiyan lakes.

Age Group	No. of Fish	Empirical Length	Back-calculated Lengths at the end of each year of life			
			1	2	3	4
I	168	15.81	**14.75**			
II	91	23.05	14.71	**22.18**		
III	27	27.25	14.63	22.07	**26.69**	
IV	11	30.14	14.57	21.95	26.58	**29.38**
Total	297					

The values of growth parameters in the present study are compared with those from other studies in Table 3.

GROWTH PERFORMANCE INDEX: The growth performance index values for *O. aureus* and *T. zilli* were 2.62 and 2.74, respectively. These values are higher than those reported for the same species in other Egyptian lakes (Table 3) indicating high growth rates of these two species in Wadi El-Raiyan lakes.

MORTALITY RATES: The instantaneous total mortality coefficient was estimated as 1.69 $year^{-1}$ for *O. aureus* and 1.1 $year^{-1}$ for *T. zilli* (Fig. 6).

The natural mortality coefficient was estimated as 0.25 $year^{-1}$ and 0.2 $year^{-1}$ for *O. aureus* and *T. zilli* respectively, while the fishing mortality coefficient "F" was estimated as F = Z - M and found to be 1.44 $year^{-1}$ and 0.9 $year^{-1}$ for *O. aureus* and *T. zilli*, respectively.

EXPLOITATION RATE: Exploitation rate was computed as 0.85 and 0.82 for *O. aureus* and *T. zilli*, respectively. Gulland (1971) suggested that the optimum exploitation rate for any fish stock was about 0.5, so the high values of the present exploitation rate indicate that the stocks of *O. aureus* and *T. zilli* in Wadi El-Raiyan lakes are probably overexploited.

LENGTH AT FIRST CAPTURE: The length at first capture (the length at which 50% of the fish are vulnerable to capture) was estimated as a component of the length

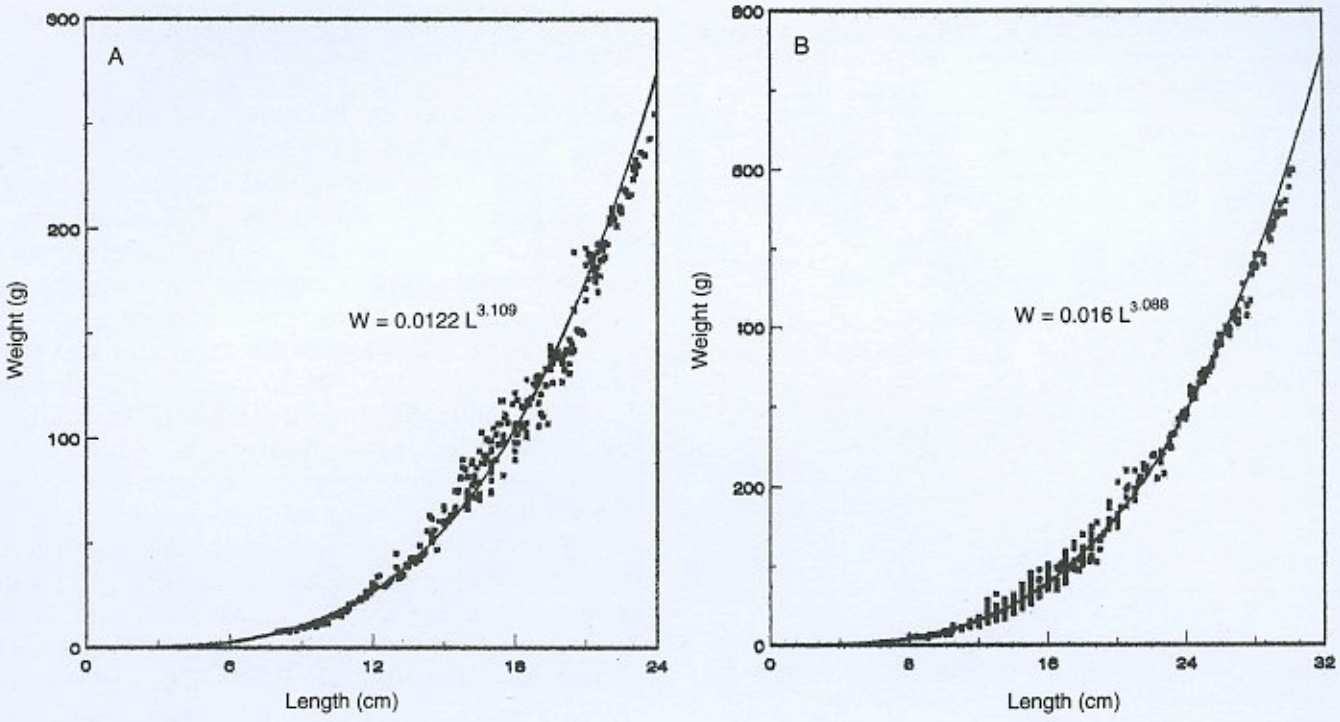

Figure 4. Length-weight relationship of *Oreochormis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

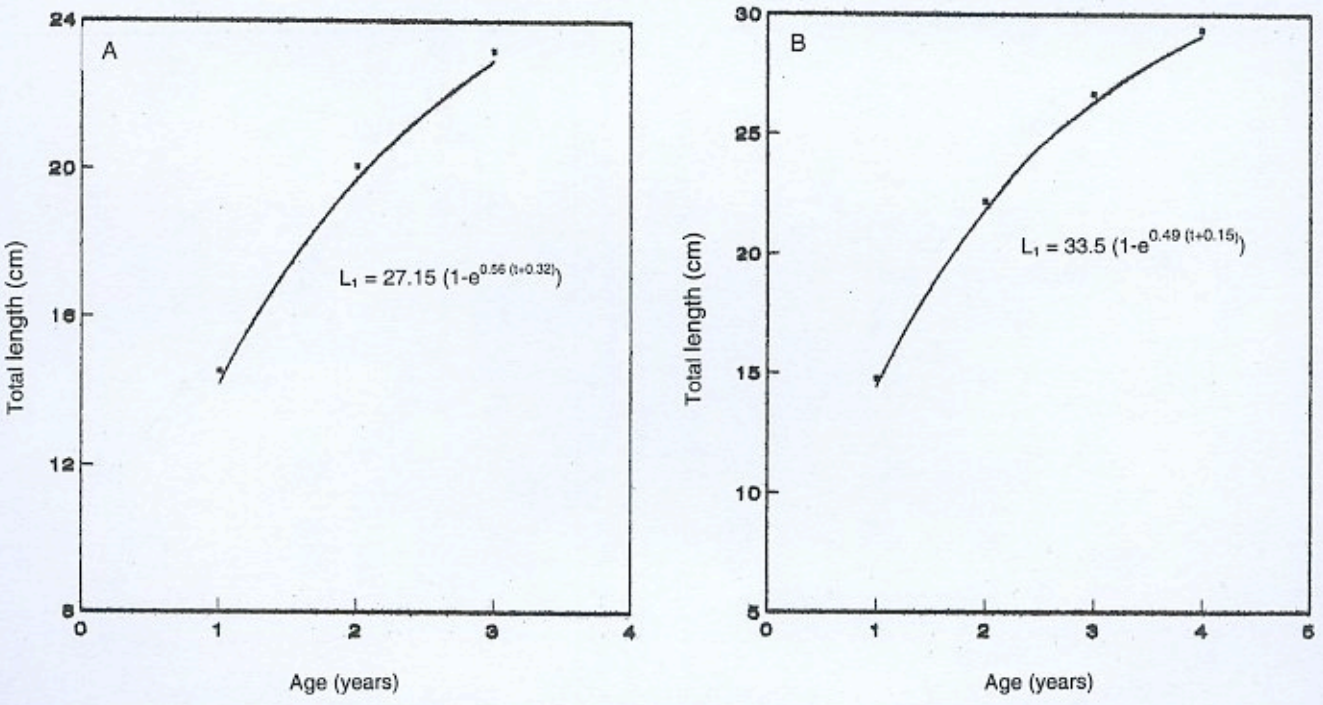

Figure 5. Growth curve of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

TABLE 3

Growth parameters (L_∞ and K) and growth performance index (ø) of* Oreochromis aureus *and* Tilapia zilli *from different water bodies in Egypt.

Species and Locality	L_∞	K	ø	Author	Method
T. zilli (Bahr Shebeen)	19.50	0.49	2.27*	Latif *et al.*, 1988	Scales**
T. zilli (Bahr Shebeen)	21.56	0.27	2.10*	El-Sehamy, 1993	Scales**
O. aureus (Lake Mariut)	30.40	0.23	2.34	Bakhoum & Faltas, 1994	Scales**
T. zilli (Lake Qarun)	20.96	0.35	2.19*	Faltas, 1995	Scales**
O. aureus (Lake Edku)	27.40	0.21	2.20		
Wadi El-Raiyan				The present study	Scales**
O. aureus	27.15	0.56	2.62		
T. zilli	33.50	0.49	2.74		

*ø was calculated by the present author.

** von Bertalanffy growth parameters were estimated using the back-calculated lengths from scale readings.

converted catch curve analysis involved in FiSAT software. The values obtained were 15.28 cm for *O. aureus* and 11.54 cm for *T. zilli* (Fig. 7).

RELATIVE YIELD PER RECRUIT AND BIOMASS PER RECRUIT: The model of Beverton and Holt (1966) was used to estimate the relative yield-per-recruit (Y/R)'and relative biomass-per-recruit (B/R)' of *O. aureus* and *T. zilli* in Wadi El-Raiyan lakes. This model allows a relative prediction of the long term catch weights and stock biomass under different exploitation rates.

The results (Fig. 8) show that the maximum (Y/R)' was obtained at E= 0.69 for *O. aureus* and E= 0.59 for *T. zilli*. As the exploitation rate increases beyond these values, (Y/R)' decreased. Both the $E_{0.1}$ (the level of exploitation at which the marginal increase in (Y/R)' reaches 1/10 of the marginal increase computed at a very low value of E) and $E_{0.5}$ (the exploitation level which reduces the unexploited biomass to 50%) were estimated. The $E_{0.1}$ and $E_{0.5}$ estimates were 0.67 and 0.40, respectively, for *O. aureus* and 0.57 and 0.37, respectively, for *T. zilli*. The results indicated that the current E and F values were higher than those which

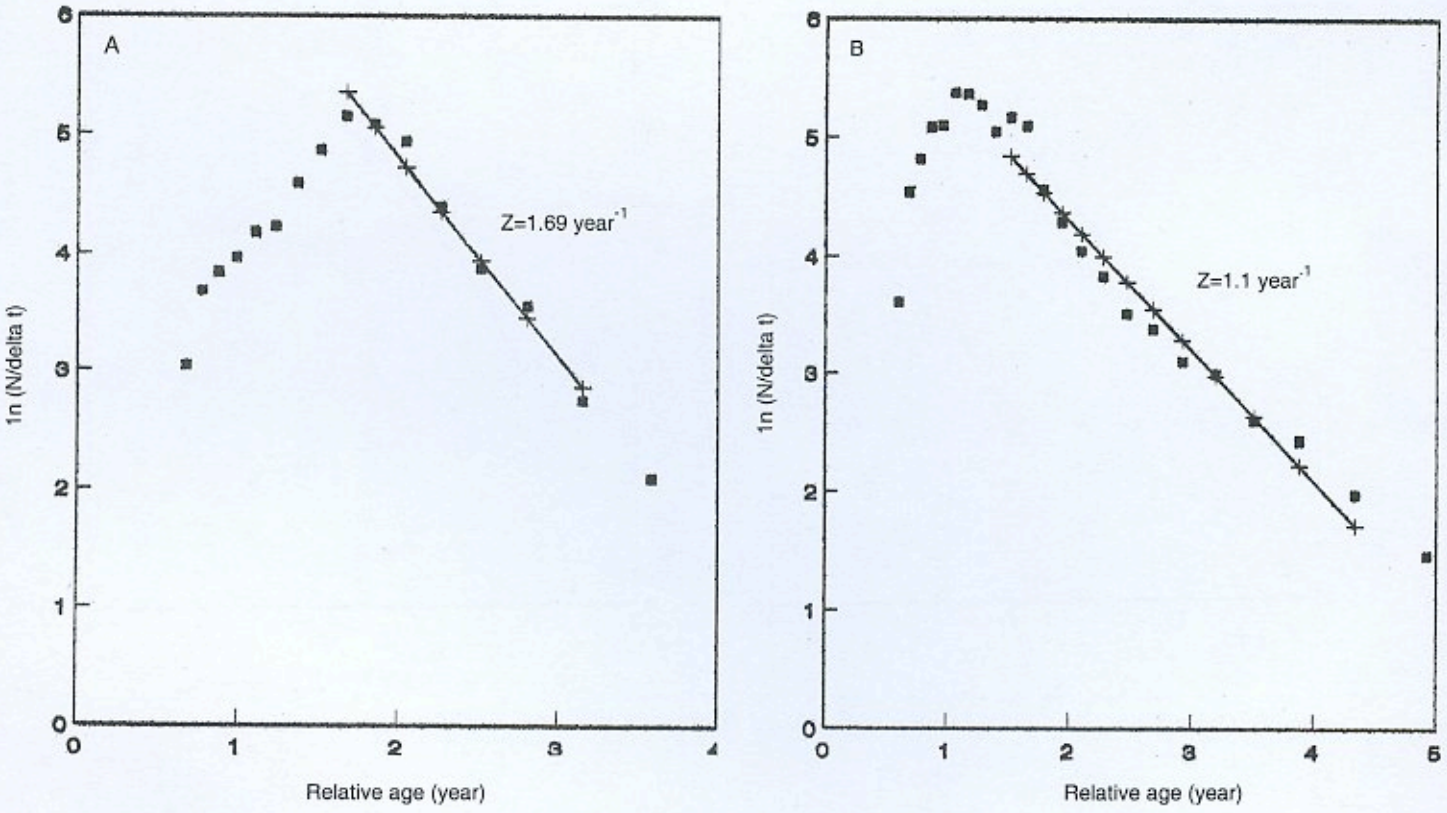

Figure 6. Total mortality coefficient (Z) of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

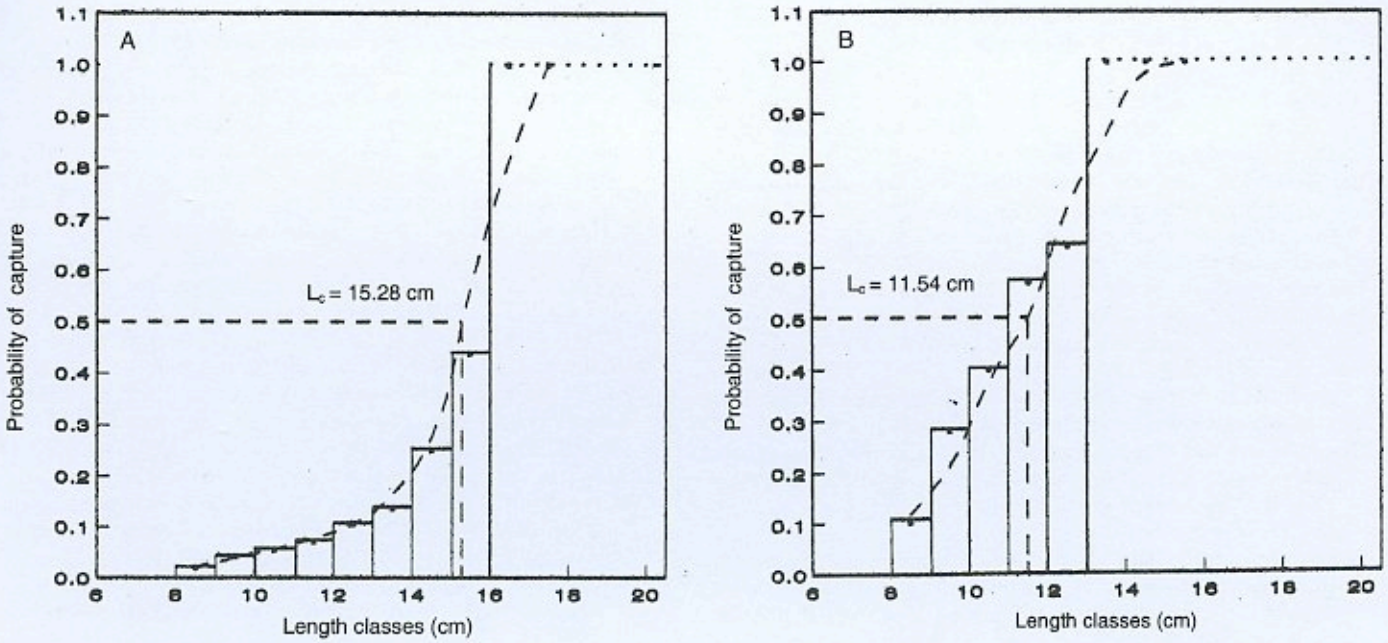

Figure 7. Length at first capture (L_c) of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

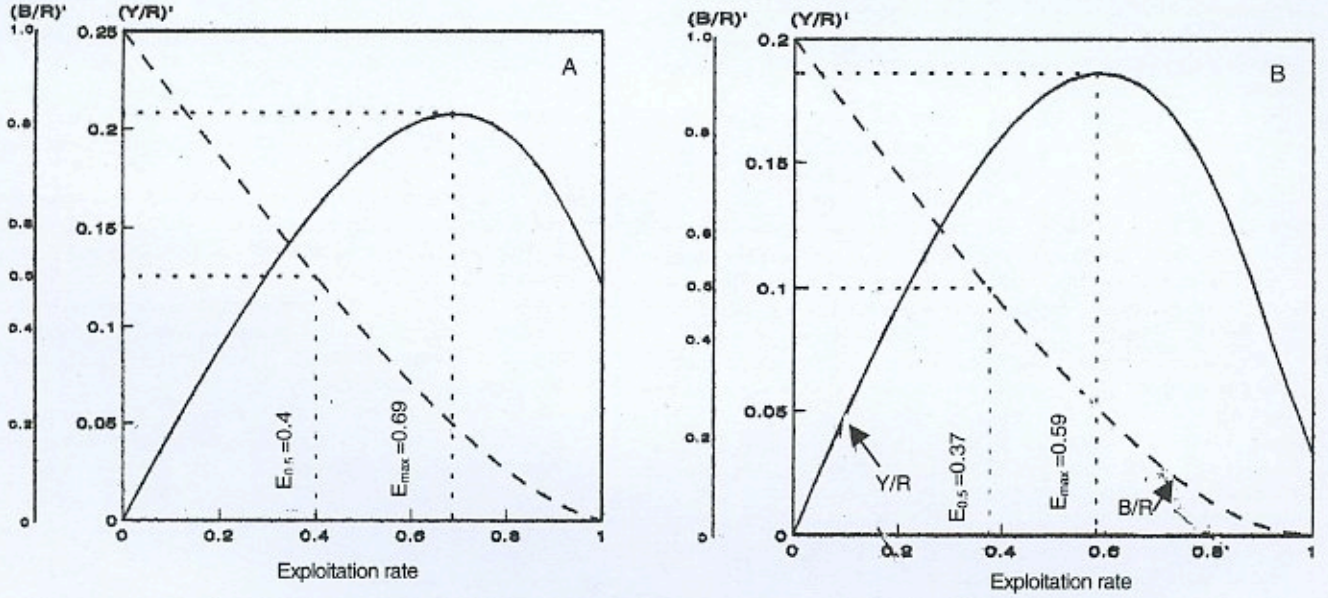

Figure 8. Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R) of *Oreochromis aureus* (A) and *Tilapia zilli* (B) from Wadi El-Raiyan lakes.

gave the maximum (Y/R)'. Also, the present levels of exploitation for both species are higher than the exploitation rate ($E_{0.5}$) which will maintains 50% of the unexploited stock biomass.

For management purpose, the exploitation rate must be reduced from 0.85 to 0.40 (52.9%) for *O. aureus* and from 0.82 to 0.37 (54.9%) for *T. zilli* to maintain a sufficient spawning biomass. This can be achieved by reducing the number of fishing days or the number of fishing trips or increasing the period of the closed season. We can also change the mesh sizes to catch larger fishes to conserve the reproducing part of the population.

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