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AGE, GROWTH AND MORTALITY OF THE RABBIT FISH *Siganus rivulatus* (FORSK., 1775) FROM THE RED SEA

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ABSTRACT

Age, growth and mortality of **Siganus rivulatus** from the Red Sea were studied. Otoliths from 251 fish were used for age determination. Age composition varied among sexes. The oldest females were 5^+ yr. and the oldest males were 4^+ yr. The mean lengths at the end of each year of life for males and females were back-calculated. The Von Bertalanffy equations describing theoretical growth in length and in weight were computed. Survival rate (S), annual mortality rate (A) and instantaneous mortality coefficient (Z) of males and females were estimated by different methods.

INTRODUCTION

Siganid fishes are an important element in shallow coral reef fish community. Recently, they received a great attention as they can be cultivated successivelly with mullets and milk fish. Their growth rate under commercial farming conditions (cages and ponds) was found to be at least 20 times higher than farming in small tanks (Ben-Tuvia 1964, Ben-Tuvia et.al., 1973 and 1983, Popper and Gundermann 1975 and Lichatowich et al, 1984 a and b). However, their biological and dynamical characters are poorly investigated. In this respect, the Egyptian section of the Red Sea is one of the least studied areas. Therefore, the present study is undertaken to throw some light on the biology and dynamics of one of the most abundant species of Siganids from the Red Sea, namely **Siganus rivulatus.**

MATERIALS AND METHODS

Monthly samples of Siganus rivulatus were collected from the neighbourhood of the Marine Biological Station at Ghardaqa from April 1984 through April 1985.

Processing the fish samples involved several steps. The fish was measured to the nearest millimeter of total length and weighted to the nearest gram. Otoliths were removed, cleaned and examined under reflected light in a black-bottomed wacth glass containing glycerin with an optical system consisting of Nikon Zomm stereomicroscope focusing block, Heidenhain's stand and stage with transmitted light, MK II fiber reflected light and Heidenhain's electronic bidirectional read out system VRX 182. The total radius of the otolith as well as the distance from the focus of the otolith to the successive annulii were measured to the nearest 0.001 mm.

The body length-otolith radius relationship was determined by using the least-square regression. the lengths at previous ages were back-calculated from otolith measurements using Lee's equation, (1920).

The general power equation ($W = a L^b$), where, W = weight in gram, L= length in centimeter, a and b are constants, whose values were calculated by the least square regression, is used to describe the general lengthweight relationship.

The parameters of the Von Bertalaffy equations for the theoretical growth in length and in weight (L_∞ K, t_0 and W_∞) were estimated by using the Ford (1933), Walford (1946) methods.

Survival rate (S), annual mortality rate (A) and instantaneous mortality coefficient (Z) were estimated from age-composition using the following methods:

- Champman and Robson method (1960).
- Semilogarithmic regression method (Ricker 1975).
- Coded mean age method (Ricker 1975).

RESULTS AND DISCUSSION

Age Determination:

Otoliths were used for age determination of *S. rivulatus*. The otolith is somewhat oval in shap and laterally compressed. Anteriorly it is deeply biforcated into a long ventral arm and a short dorsal one. The posterior end blunt, round and slightly indented. The outer surface is concave and the inner one is convex, with a deep longitudinal furrow lying between the two ridges. There are alternative widely and narrowly spaced circuli which represent the summer rapid growth and the winter slow growth, respectively.

The validity of otolith for estimating the age and past growth history depends upon the presence of a close direct correlation between the growth of fish and that of the otolith and the periodicity of checks on the otolith.

In the case of S. rivulatus, the present study showed that there is a such close correlation between the total body length and the otolith radius for both sexes. This close correlation satisfied the first criterion for the validation of the otolith of S. rivulatus as an age determination structure.

Investigation the pattern of marginal increment of the otolith, it was found that the least marginal increment was observed in April. After which, a gradual growth of the marginal area took place, reaching its highest value in March of the following year. This indicates that only one true annulus is formed on the otolith yearly, which justifies the use of otolith of S. rivulatus in age determination and growth studies.

Age Composition:

Age composition of S. rivulatus varied among sexes (table 1). The oldest females in the present study were 5^+ yrs and the oldest males were 4^+ yrs. For both sexes age group I dominated the catch and consituted 48.25% and 40.88% for males and females, respectively.

Table (1)
Age composition of S. rivulatus from the Red Sea.

Age group	Males		Females	
	No.	%	No.	%
0	2	1.75	1	0.73
I	55	48.25	56	40.88
II	30	26.32	42	30.66
III	23	20.17	28	20.44
IV	4	3.51	6	4.38
V	-	-	4	2.91
Total	114		137	

Growth in Length:

A- Body Length - Otolith Radius Relationship

The otoliths of 114 males and 137 females of **S. rivulatus** were used to compute the relationship between the total body length and the otolith radius. The following regression equations were obtained:

$$\text{For males } L = 0.1983 + 17.07\, S$$

$$\text{with } r = 0.851464$$

$$\text{For females } L = 0.0415 + 17.61\, S$$

$$\text{with } r = 0.916437$$

where, L = total length in centimeter, S = otolith radius in millimeter and r = correlation coefficient.

B - Back-Calculation

Fish length at the end of each year of life of males and females of **S. rivulatus** were back-claculated using the following equations:

$$\text{For males } L_n = (L - 0.1983)\, S_n / S + 0.1983$$

$$\text{For females } L_n = (L - 0.0415)\, S_n / S + 0.0415$$

where, L_n = calculated length at the end of n th. year,
L = total length at capture,
S_n = otolith radius to nth. annulus, and
S = total otolith radius in millimeter.

The average back-claculated lengths at the end of each year of life of males and females are given in tables 2 & 3. It is clear that, the highest growth rate of males and females takes place in the first year of life, after which the annual increment gradually decreases with further increase of age. It is also evident that, there is no significant differences in the growth rate of both sexes during the first three years of life. In the fourth year of life, females showed a slightly higher growth rate than the males.

Length - Weight Relationship:

The relationship between the total body length and total weight of males and females of **S. rivulatus** were computed using the least square method. These relations were found to be as follow:

$$\text{For males } W = 0.01233\, L^{2.8386907}$$

$$r = 0.992976$$

For females $W = 0.011328\ L^{2.8412647}$

$r = 0.991987$

Table (2)
Average back-calculated lengths at the end of different years of life of *Siganus rivulatus* (males) from the Red Sea.

Age group	Frequency	Mean length	Avarage calculated length at the end of each year (cm).			
			1	2	3	4
I	31	16.43	13.32			
II	16	23.78	12.89	20.60		
III	12	26.58	12.59	20.16	24.61	
IV	2	29.19	12.97	20.16	23.97	27.53

Table (3)
Average back-calculated lengths at the end of different years of life of *Siganus rivulatus* (females) from the Red Sea.

Age group	Frequency	Mean length	Average calculated length at the end of each year (cm).				
			1	2	3	4	5
I	13	16.68	13.15				
II	17	24.51	13.27	20.86			
III	21	27.23	13.14	20.27	25.00		
Iv	2	29.05	13.37	20.37	25.03	28.15	
V	2	31.90	13.82	21.01	24.93	28.18	30.65

Growth in Weight:

The weights at the end of each year of life were estimated by applying the corresponding length-weight equation to the back-calculated length and the results are given in tables (4)and (5). The growth in weight was found to be much slower in the first year of life for both sexes. Males and females attained their highest annual increment in the second year of life after which a gradual decrease in the annual increment was observed.

Table (4)
Calculated weights at the end of different years of life of *Siganus rivulatus* (males) from the Red Sea.

Age group	Frequency	Mean weight at capture (gm.)	Calculated weights at the end of each year (gm.)			
			1	2	3	4
I	31	43.47	23.71			
II	16	134.63	61.60	81.75		
III	12	170.19	20.20	76.89	135.44	
IV	2	221.80	21.98	76.89	125.68	166.19

Table (5)
Calculated weights at the end of different years of *Siganus rivulatus* (females) from the Red Sea.

Age group	Frequency	Mean weight at capture (gm.)	Calculated weights at the end of year (gm.)				
			1	2	3	4	5
I	13	45.52	22.86				
II	17	143.56	23.46	84.81			
III	21	171.28	22.81	78.71	141.85		
IV	2	219.80	23.96	79.27	142.34	198.73	
V	2	294.02	26.33	86.55	140.73	199.34	233.08

Theoretical Growth:

The mathematical growth models permit the description and comparison of growth of different species or the same species at different times and localities. The constants obtained from the fitting of the observed growth data in mathematical models are used in yield equations and fishery management. The classical growth models in fishery biology are those of Gompertz (1825), Logistic (Verhulst, 1845, Winsor, 1932). and Von Bertalanffy(1934), of which the last one is the most widely used.

The Von Bertalanffy equations for the theoretical growth in length and in weight can be written in the from:

$$l_t = L_\infty [1 - e^{-k(t-t_0)}] \text{ for growth in length,}$$

and

$$W_t = W_\infty [1 - e^{-k(t-t_0)}]^b \text{ for growth in weight,}$$

where,
l_t = length at age,
L_∞ = assymptotic length,
k = growth coefficient,
t_0 = age at which the length is theoretically nil,
W_t = weight at age t, and
W_∞ = theoretical maximum weight calculated by the conversion of theoretical maximum length by the length - weight equation.

The parameters of the von Bertalanffy theoretical growth in length and in weight for males and females of *S. rivulatus* are given in table (6), from which it is obvious that females have higher maximum theoretical L and W than males (31.54 cm and 273.91 grams for males and 34.22 cm and 346.11 grams for females). It is also evident that males have a higher value of K than females (0.50056 for males and 0.43395 for females) which indicates a faster decrease in growth acceleration of males than females.

Mortality:

The mortality estimates for *S. rivulatus* are based on the analysis of the catch curve by using different methods. The estimates obtained are the first for this species in the Egyptian Coast of the Red Sea. As shown from table (7), a slight difference in the mean annual mortality rates between males and females was noticed (A = 0.5581 for males and 0.5092 for femlaes). Also a slight difference in the instantaneous mortality coefficient between males (Z = 0.8166) and females (Z = 0.7117) were observed. These differences between the mortality of males and females may be a result of differnces in fish behaviour or that males are more vulnerable to the fishery than females of the same size.

Table (6)
Von Bertalanffy growth parameters of
Siganus rivulatus.

	k	L_{∞}	t_0	W_{∞}
Males	0.50056	31.54	-0.09373	273.91
Females	0.43395	34.22	-0.10020	436.11

Table (7)
Estimated annual mortality rate (A), survival rate (S)
and instantaneous mortality coefficient (Z) of
Siganus rivulatus from the Red Sea.

Method	Males			Females		
	A	S	Z	A	S	Z
Chapman & Robson	0.5578	0.4422	0.8160	0.5056	0.4944	0.7044
Semilogarithmic	0.5564	0.4436	0.8129	0.5144	0.4856	0.7224
Codded mean age	0.5601	0.4399	0.8209	0.5075	0.4925	0.7082
Mean Value	0.5581	0.4419	0.8166	0.5092	0.4908	0.7117

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