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AGE DETERMINATION AND GROWTH STUDIES OF SOLEA VULGARIS IN ABU-KIR BAY.

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ABSTRACT

The otoliths are used for age determination and growth studies of **Solea vulgaris** obtained from Abu-Kir Bay during 1973/1974. The length-weight relationship and the condition factor of the different sexes are also analysed.

INTRODUCTION

Solea vulgaris are among the flat fish which contribute to the fishery of various countries. They only contribute a small percentage (1.5 %) of the Egyptian Mediterranean waters. However, soles are among the marine species, which are highly esteemed as food by the Egyptians.

The biology of **S. vulgaris** in the Egyptian waters is not well known. Few scientific work has been done in this concern (El-Zarka, 1963). So, the aim of the present work is to study the age of that fish and to assess its growth rate in our Mediterranean waters.

MATERIAL AND METHODS

Monthly samples of **Solea vulgaris** were obtained from Abu Kir Bay during the period from August 1973 to July 1974. For every fish the total length and gutted weights were measured, the sex was determined, and the otoliths were collected for age determination and growth studies.

The otoliths of 713 fish, varying in total length from 12 to 32 cm, were collected, cleaned and examined under a dissecting microscope, after being immersed in xylol.

The use of xylol for clearing up the otoliths was recommended (Kutaygil, 1965). Reading of otoliths was done using reflected light on a dark background. In case of old fish, the otolith was burned. Burning of otolith proved to be a useful way to render the growth rings clear (Christensen, 1964; Soliman, 1973). The distance from the focus of otolith to the successive annuli, as well as the total radius of the otolith on a diagonal line between the focus and the margin was obtained for each otolith.

Age Determination

Determination of fish age, is one of the most important tools in studying fish growth. various bony structures are used to determine fish ages. Of these, the scales are the most commonly used. However, the scales of **Solea vulgaris** are of the ctenoid type. They are very small and the circuli are difficult to interprete. For that reason, age determination was done by reading of otoliths. The otolith of **Solea vulgaris** is elliptical in outline. When viewed in xylol against background in reflected ligh, it shows dark (transparent) and light is the focus.

Growth in Length

The relationship between the total fish length and the otolith radius of **Solea vulgaris** was based on the measurements of fish with lengths ranging from 120 to 320 mm. The available data (Table 1) were applied to have the value of the ratio of the total body length and the average otolith radius (L/S ratio).

TABLE 1
Fish length-otolith radius relationship of **Solea vulgaris** in Abu Kir Bay (1973-74).

Total length (cm)	Number of fish	Otolith radius (x 10)	L/S ratio
12	4	1.00	12.00
13	12	0.93	13.93
14	17	1.05	13.33
15	28	1.15	13.04
16	53	1.27	12.60
17	106	1.35	12.59
18	121	1.46	12.33
19	155	1.53	12.42
20	97	1.63	12.27
21	57	1.65	12.73
22	40	1.75	12.57
23	21	1.72	13.37
24	14	1.81	13.26
25	9	1.73	14.45
26	4	2.15	12.09
27	5	2.16	12.50
28	4	2.03	13.79
29	2	2.35	12.34
30	2	2.05	14.63
31	2	2.10	14.76
32	1	2.80	11.43
Average L/S ratio			12.98

The relationship between fish length and otolith radius when represented graphically shows a linear relationship. The mathematical relationship between these two parameters, can be represented by the equation

$$L = a + b\,s$$

where L = total length of fish in cm, S = length of otolith radius in micrometer devision (x 10), a and b are constants.

Applying this equation for **Solea vulgaris**, the following equation was obtained

$$L = 1.116 + 12.295 \quad S$$

The intercept of the regression line, which is equal to 1.116 mm is used accordingly as a correction factor in the back calculation of lengths at the different years of life.

Calculated Growth in Length

For studying the growth rate of **Solea vulgaris** in Abu Kir Bay, the mean values of lengths at capture are used in back calculation to find out the length of the different age groups. The data on average length at capture and average caculated lengths at the end of each year of life for the females and males are given in Table (2a) and (2b), respectively.

TABLE (2-a)
The average calculated lengths for females S. vulgaris at the end of different years of life in Abu Kir Bay (1973-1974)

Age group	No. of fish	Average length at capture (mm)	Average calculated length at the end of the year (mm)			
			l_1	l_2	l_3	l_4
0	96	160				
I	266	195	170			
II	35	233	166	220 (54)		
III	3	293	168	219 (51)	266 (47)	
Grand average length			170	220	266	
Grand average increment			170	54	47	
Sum of increment			170	224	271	

TABLE (2-b)
The average calculated length for males
Solea vulgaris at the end of different years of
life in Abu Kir bay (1973-1974).

Age group	No. of fish	Average length at capture (mm)	Average calculated length at the end of the year (mm)			
			l_1	l_2	l_3	l_4
0	61	159				
I	205	183	161			
II	22	218	158	208 (50)		
III	4	266	162	212 (50)	254 (42)	
IV	1	310	168	255 (57)	267 (42)	305 (38)
Grand average length			161	209	257	305
Grand average increment			161	50	42	38
Sum of increment			161	211	253	291

From these tables, it is clear that there is a considerable agreement in the average calculated lengths at the end of each year of life for all age groups. It is also evident that the lengths 170, 220 and 266 mm are the calculated lengths for females at the end of the first, second and third years of life respectively. While for males, the values 161, 209, 257 and 305 mm are calculated to be the lengths of the first four years of life respectively. This shows that the females have a higher growth rate than the males.

It has to be noted also that the growth rate of **Solea vulgaris** is rapid in its first year of life, then it decreases with the increase of age. This is more evident when computing the percentage increase in length of **Solea vulgaris** in different years of life with respect to the maximum length reached, table 3. It is evident that the percentage increase of length for both sexes is rapid in the first year of life and then decrease with the increase of age.

Length-Weight Relationship

During growth, the weight of fish increases as a function of its length. The length-weight relationship of most fish can be expreased in the general equation : $W = C L^n$ where W = weight in grames, L = length in mm., c and n are constants derived from the available data using the statistical

TABLE 3

Calculated total length and length increment for females and males **Solea vulgaris** in Abu Kir bay (1973-1974).

Age	Female: Calculated length (mm)	Female: Increment (mm)	Female: % increase	Male: Calculated length (mm)	Male: Increment (mm)	Male: % increase
I	170	170	63.91	161	161	52.79
II	220	54	20.30	209	50	16.39
III	266	47	17.67	257	42	13.77
IV	-	-	-	305	38	12.46

least square method (Hile, 1941; Le Cren, 1951; ... etc.). Hile (1936) demonstrated that the exponent (n) can vary widely from one species to another and between different populations of the same species.

In the analysis of length-weight relationship of **Solea vulgaris**, 1316 fish were used with total lengths ranging between 90 and 320 mm for females and between 120 and 340 mm for males. The length-weight relationship was computed for each sex respectively. To avoid the bias caused by the weight of stomach contents and gonads and variations occuring in them, the gutted weight of the fish was used in these computations.

The formulae representing the length-weight relationship for the females and males of **Solea vulgaris** are as follows:

$$\text{for females}: \text{Log } W = -1.5919 + 2.8255 \log L$$
$$\text{for males}: \text{Log } W = -2.0690 + 2.9031 \log L$$

It is clear that the value of the exponent "n", is nearly equal in males and females. Very small differences are observed between the calculated weights of females and males of the same length group. The formula representing this relation, for the combined sexes is the following:

$$\text{Log } W = -4.8571 + 2.8608 \text{ Log } L$$

Using these equations for the different length groups of each sex separately and for the conbined sexes show a good agreement between the observed and the calculated gutted weights (Table 4).

Growth in Weight

Using the previously obtained length-weight equations, the calculated weights of **S. vulgaris** are computed for the different sexes, at different ages.

TABLE 4
Mean observed and calculated gutted weights of females, males and combined sexes of *Solea vulgaris* from Abu Kir Bay during 1973-1974.

T.L. (mm)	Females			Males			Sexes combined		
	No.	obs.wt. (gm)	calc.wt. (gm)	No.	obs.wt. (gm)	calc.wt. (gm)	No.	obs.wt. (gm)	calc.wt. (gm)
90	1	6.00	5.55	-	-	-	1	6.00	5.41
110	1	10.00	9.78	-	-	-	1	10.00	9.61
120	4	12.75	12.51	4	12.25	11.59	8	12.50	12.33
130	9	17.78	15.68	11	17.05	14.62	20	17.38	15.50
140	20	19.58	19.34	20	19.03	18.12	40	19.31	19.16
150	24	23.94	23.51	21	23.88	22.14	45	23.91	23.34
160	38	26.50	28.20	51	26.18	26.71	89	26.32	28.08
170	82	31.35	33.47	84	28.95	31.84	166	30.14	33.39
180	93	35.96	39.36	122	34.0	37.61	215	34.85	39.34
190	104	41.77	45.84	113	38.17	44.00	217	39.90	45.93
200	105	48.66	52.98	70	44.96	51.04	175	47.18	53.16
210	88	58.00	60.81	25	53.96	58.82	113	57.11	61.12
220	56	64.13	69.36	15	66.83	67.32	71	64.70	69.82
230	38	75.38	78.63	6	76.92	76.60	44	75.59	79.30
240	27	88.04	88.69	9	82.94	86.68	36	86.77	89.58
250	17	105.88	99.51	5	101.80	97.54	22	104.95	100.70
260	16	108.81	111.30	5	111.00	109.30	21	109.33	112.70
270	6	118.92	123.70	2	126.00	122.00	8	120.69	125.50
280	5	129.20	137.20	2	143.00	135.60	7	133.14	139.30
290	8	163.56	151.40	2	177.00	150.20	10	166.25	153.90
300	1	186.00	166.50	1	148.00	165.70	2	167.00	169.60
310	2	186.00	182.80	1	192.00	182.30	3	188.00	186.30
320	1	232.00	199.90	-	-	-	1	232.00	203.90
340	-	-	-	1	249.00	237.40	1	249.00	241.80

It is clear that the percentage increase in weight for both sexes is low in the first years of life, after which its increase in weight is higher for the females than for the males in all age groups, table 5. This means that the females seem to put on weight at a higher rate than the males.

Condition Factor

Calculations of the condition factor (K), are based on the cube law

$$K = W / L^3,$$

where W = weight in grams and L = length in mms.

The value of (K) gives an indication of the degree of the well being of the fish. Low values indicate poor condition while the high values indicate good condition.

The condition factor has also been used to indicate the suitability of an environment for a certain fish species by comparison of the values for a specific locality with that of others (Ricker, 1971).

TABLE 5

Calculated weights, without increments, and percentage increase is weight for females and males of *Solea vulgaris* in Abu Kir Bay (1973-1974).

Age	Female			Male		
	Calculated length (mm)	Increment (mm)	% increase	Calculated length (mm)	Incre- ment (mm)	% increase
I	33.20	33.20	27.97	27.08	27.00	15.58
II	69.29	37.99	38.01	58.20	31.90	18.40
III	118.70	50.25	42.33	105.30	42.60	24.51
IV	-	-	-	173.80	55.70	35.05

D'Ancona (1936), pointed out that the condition factor varies with month, season, state of gonadal maturity and possibly age.

In these computations, gutted weight was used instead of the total weights. The effect of fish length, sex and season on the condition factor of the fish are studied.

1 - The effect of length:

When fish lengths were grouped in 50 mm length intervals, and the condition factor for each length group was calculated for each sex separately, we obtained the data given in table 6.

This data show that for the females, (K) is generally higher in small size than in big size groups. For the males, the value of K tends to increase with length, after a drop in the second length group (180 - 220 mm).

TABLE 6

Mean condition factor per length group for the females and males *Solea vulgaris* in Abu Kir Bay (1973-1974).

Total length (mm)	Mean 'K' for femals	Mean 'K' for male
130-170	0.7032	0.6627
180-220	0.6176	0.5744
230-270	0.6519	0.6383
280-320	0.6337	0.6772

2- The effect of sex:

From table 6, it is clear that for the same length group, the mean condition factor for the males is lower than that of females.

3- Seasonal effect:

Table 7 shows the monthly mean values of the condition factor throughout the period of investigation (August 1973 - July 1974). It is clear that (K) for both sexes are higher in the period from August to December. The males show a sudden drop in (K) in February.

The least value of (K) reached by both sexes is in the month of May for the females and June for the males.

Thes variations in (K) become more clear when the seasonal instead of the monthly variations were considered (Table 8). The condition factor for the females decreases in winter and reaches its lowest value in spring. It reaches its highest value in summer and autumn. This drop coincides with the spawning season of this fish, which takes place in January and February. In spring the fish body is exhausted by spawning and hence, (K) reaches its lowest value.

For the males, it appears that the fish did not follow the same trend as that of females. The condition factor is lower in winter than in spring. It reaches its lowest value in summer time. In autumn, the (K) reaches its highest value.

TABLE 7

Monthly variation of the condition factor for **Solea vulgaris** in Abu Kir Bay for females and males in the period (1973-1974).

Month	Female		Male	
	No.of Fish	K	No.of Fish	K
August 1973	56	0.7043	46	0.6402
September	85	0.6702	120	0.6280
October	61	0.6436	50	0.6244
November	45	0.6742	33	0.6600
December	65	0.6643	59	0.6270
January 1974	96	0.6480	12	0.6278
February	68	0.6451	48	0.5849
March	41	0.6414	37	0.6337
April	84	0.6275	84	0.6002
May	68	0.6038	45	0.6400
June	32	0.6391	37	0.5593
July	40	0.6235	43	0.5755

TABLE 8
Seasonal variation in the condition factor for the females and males of **Solea vulgaris** in Abu Kir Bay (1973-1974).

Sex	Autumn	Winter	Spring	Summer
Female	0.6711	0.6540	0.6294	0.6843
Male	0.6418	0.6185	0.6274	0.6085

SUMMARY

Age determination of **Solea vulgaris** was done by means of otolith. This was rendered clear by immersing it in xylol and examining on a dark. The relationship between otolith radius and fish length is proved to be linear. Back calculation of length at various ages was made for the males and females separately. In general, the growth rate of thin fish is high in its first year of life, after that it decreases as the fish gets older. Also, the females were found to have higher growth rates than the males.

The length-weight relationship was studied and the growth in weight was computed. Also, the condition factor was analysed. It was found to be higher for the females than for the males. Also, seasonal variation in the condition factor was noted between the two sexes.

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