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Age, growth and reproductive biology of the keeled mullet *Liza carinata* from the Suez Bay, Red Sea, Egypt.

Azza A. El-Ganainy[1]; Fawzia A. A. Abd El-Rahman[2]; William Rizkalla[2]; Hamza A. El-Shabaka[2] and Mazaya E. Abo-Mesalem[2]

1- National Institute of Oceanography and fisheries, Suez branch, 183, Suez, Egypt.
2- Department of Zoology, Faculty of Science, Ain Shams University, Abbassia Sq, 11566, Cairo, Egypt.

ABSTRACT

The age, growth and reproductive biology of the *Liza carinata* from the Suez Bay were studied. Age determination was based on otolith readings and validated by the decomposition of the seasonal length frequency distributions collected during the period from January 2009 to January 2011. The estimated von Bertalanffy growth equation was $L_t = 21.279\ (1 - e^{-0.463\ (t + 0.325)})$. The fish grows allometrically (b = 2.8692; 95% CI: 3.1687-3.370) and relatively rapid, achieved more than 50% of the growth during the first year of life. Seasonal distribution of gonado-somatic index (GSI) values showed that the main peak of GSI was in autumn. The seasonal development of maturity stages indicated that the spawning activity occurs during autumn. The size at which 50% of fishes are mature was 13.3 cm for males and 13.5 cm for females, which indicates that all individuals over two years of age were sexually mature**.** The absolute fecundity of the present species ranged from 60732.3 to 98549.3 eggs for fishes in the size ranging from 13.6 to 18.4 cm in total length. This study recommends altering the closer season in Suez Bay to be during autumn in order to protect the spawning biomass of *Liza carinata* resources in the Bay.

Keywords: Age, Growth, Spawning season, Fecundity, Suez Bay**,** *Liza carinata*

INTRODUCTION

The mullets are worldwide distributed species in tropical and temperate coastal waters. The keeled mullet *Liza carinata* locally named "Sehlia" is a mugilid of commercial value for fisheries and aquaculture in Suez Bay and Suez Canal sector (El Ganainy and El Boray, 1999). In spite of the importance of mullets to fishery resources in the Suez Bay, no management policies have been established to protect this valuable resource in the Bay. *L. carinata* represented about 18% of the total catch of the Suez Bay during the last ten years (2002- 2012) (GAFRD, 2012). In spite of its abundance, this species has been poorly studied, and a few information is available on its life cycle in capture fisheries. Thus, Salem and Mohammed, 1982; El-Boray, 1993; El Ganainy and El Boray, 1999; El-Halafawy, 2004; Mehanna, 2004 studied some biological aspects of the species in Suez Bay and Bitter Lakes.

The aim of this study is to determine the age, growth and reproductive biology of *Liza carinata* in Suez Bay in order to establish some management regulations to protect the spawning biomass of this valuable resource in the Bay.

MATERIAL AND METHODS

Samples used in this study were collected from the commercial fishermen operating in the Suez Bay using trammel nets. Each *Liza carinata* specimens was dissected to determine the sex, where the sex determination was based on a visual examination of the gonad, and sometimes it involved the use of a microscope. A total of 474 specimen were measured to study the length frequency distribution, being arranged into size groups of I cm intervals. Age was determined by counting the annual rings on the otolith of *L. carinata* as the otoliths contain concentric growth band pairs, including translucent and opaque bands. The growth band pairs on the otoliths were examined under a binuclear stereomicroscope. The assigned ages at each length group were used for the estimation of the growth parameters (L_∞, K and t_o) according to von Bertalanffy (1938) growth formula:

$$L_t = L_\infty (1 - e^{-K(t - t_0)})$$

Where L_t is the length at age, L_∞ is the asymptotic length in cm, K is the growth coefficient and t_0 is the age at which length equal to zero.

More insight in the identification of cohorts and age determination was gained by splitting the pooled length distributions into normal components using Bhattacharya (1967) method as incorporated in FiSAT software (Gayanilo *et al.,* 1998).

The condition and development of the gonads were studied by applying the gonado-somatic index method, in which the gonad weight can be related to fish weight: [Gonad weight (G Wt) / Total fish weight (Wt)] × 100.

About 35 females of *Liza carinata* in the ripe maturity stage, collected during this study period, were used for analyzing their ovaries during the spawning season. From each female, the two ripe ovaries were removed. Each ovary was weighed to the nearest 0.1gm. The paired ovaries were then preserved in 5% neutral formalin or in aqueous Bouin's fluid. The ovaries were then weighed and the central region of each ovary was used as a representative sample for fecundity. A subsample of about 0.1 to 0.2 gm. from each ovary was weighed by using a digital balance to the nearest 0.001 gm. and then crumbled in a large petri-dish containing glycerol. The numbers of mature ova that are likely to be spawned in each subsample were counted.

The absolute fecundity was calculated using the following equation:

$$F = \frac{\text{Weight of the ovary (W)}}{\text{Weight of the ovary subsample (W')}} \times \text{Number of eggs of the subsample.}$$

RESULTS AND DISCUSSION

Length-Weight Relationship

The total length measurements of *Liza carinata* ranged from 8.5 to 18.1 cm with an average of 14.01 ± 1.373 cm, while the total weight measurements varied from 5.8 to 72.0 gm, with an average of 31.64 ± 10.34 gm. A high degree of correlation was found between the logarithms of weight and length which indicate that an equation of the type $W = a L^b$ fits the data well (Fig. 1). The length-weight equation computed was:-

$$W = 0.0055 L^{2.8692}$$

(ANOVA, $F = 4096.9$, $P < 0.01$) by: ($r^2 = 0.919$, No = 452, $SE_a = 0.135$, $SE_b = 0.051$).

The growth of weight relative to length was negative allometric ($b = 2.8692$; 95% CI: 3.1687-3.370) as the obtained isometric index value (b) was significantly different from 3 (Student's t-test; $P < 0.01$). This value is in close agreement with that recorded by some authors in different localities (Table 1).

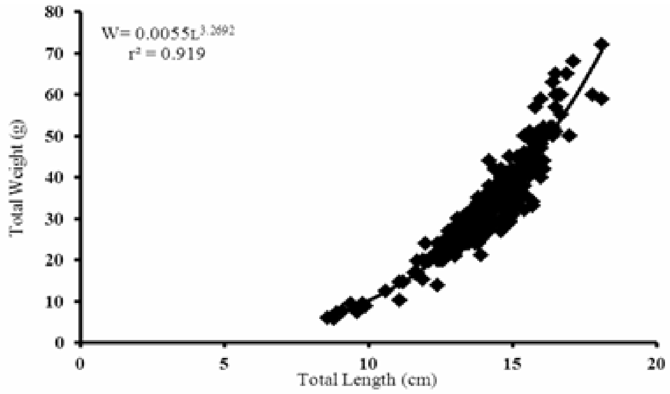

Fig. 1 Total length total weight relationship of ***L. carinata*** from the Suez Bay

Table 1: Summary of the recorded length-weight constants of *L. carinata* in the different localities.

Source	b	a	Locality
Salem and Mohammed (1982)	2.8017	0.02136	Lake Timsah
El-Ganainy and El- Boray (1999)	2.5897	0.03405	Suez Bay
Taskavak and Bilecenoglu (2001)	2.864	0.0022	Mediterranean Sea
Hakimelahi *et al.* (2010)	2.8233	0.0214	Bersian Gulf
Hussain *et al.* (2010)	2.205	0.0887	Northern Arabian Sea
The present study	2.869	0.0055	Suez Bay

Age and growth

Otoliths of about 474 fish were used for age determination. Readings showed 4 age classes from 0 to III years. The mean observed lengths at different age classes were 8.95, 10.22, 14.32 and 16.9 cm, respectively, (Table 2) which indicated rapid growth in the first year of life as the fish attaining more than 50 % of its maximum size, whereas in the following years the rate of growth slows down. The aged specimens were used for estimating the von Bertalanffy growth parameters by the non linear least squares method (Prager *et al* 1990). The resulting VBGF parameters are L_∞= 21.279 cm, K= 0.463 year^{-1} and t_o= -0.325.

Table 2: Mean lengths at age and standard deviation of the different age groups of *L. carinata* from the Suez Bay.

Age group	Number of fish	Length range (cm)	Mean calculated length (cm)	Mean observed length (cm)	S.D.
0	12	8.6 - 10.1	9.35	8.95	0.748
I	127	9.6 - 12.3	10.59	10.22	0.653
II	263	12.0 - 15.9	13.82	14.32	0.213
III	72	15.1 - 18.1	16.67	16.9	0.198

Salem and Mohammed (1982) studied age and growth of *Mugil seheli* in Lake Timsah and they gave lengths of 11.93, 14.79 and 15.91 cm for age groups I, II and III, respectively. El-Ganainy and El-Boray (1999) assigned two cohorts for *L. carinata* from Suez Bay by splitting the length distributions into normal components using Bhattacharya (1967) method. Mehanna (2004) in the Bitter Lakes recorded a maximum life span of three years with lengths of 13.10, 17.97 and 20.58 cm for the 1st, 2nd and 3rd years of life, respectively.

Length frequency distribution

The seasonal length frequency distributions (Fig 2) show that the smallest fishes (< 10 cm) younger than one year old represented by about 23% of the total catch.

Most of these individuals were caught during autumn, referring that recruitment to the fishery occurs during this season.

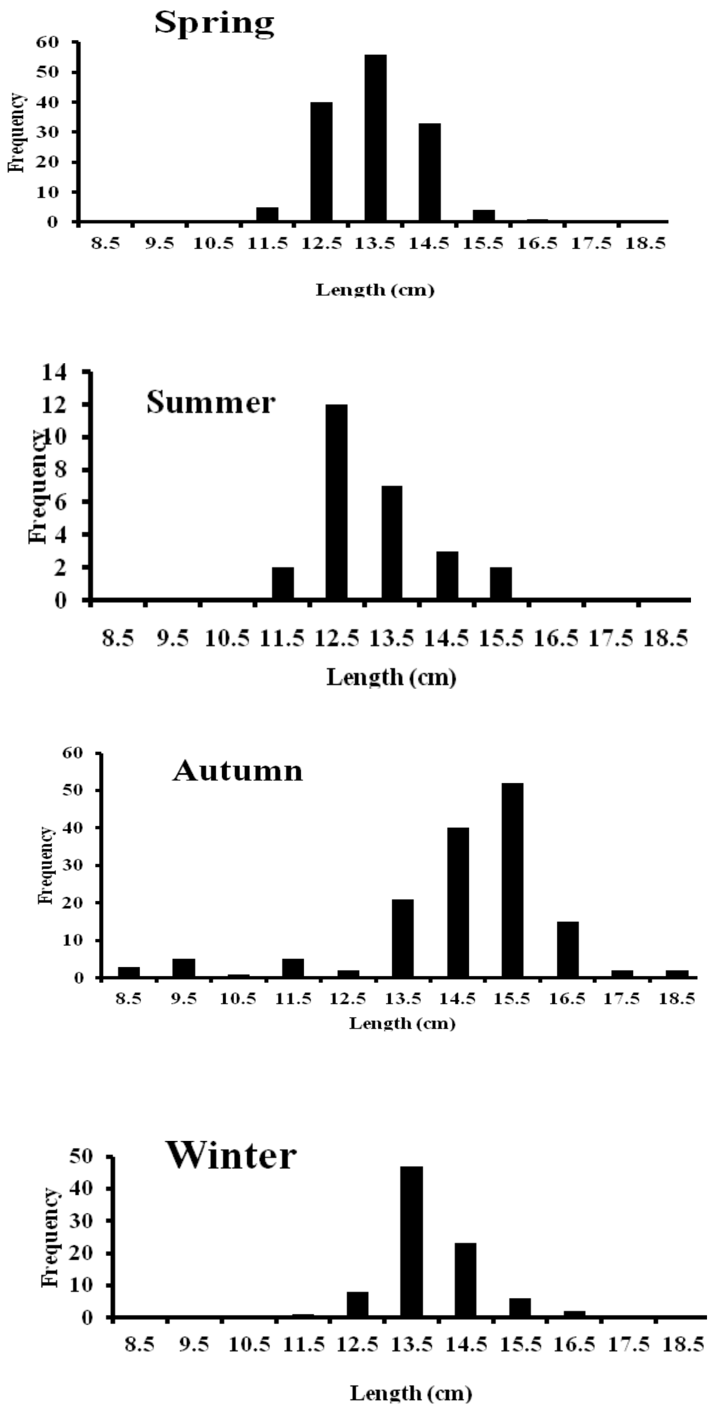

Fig. 2: Seasonal length frequency distributions of *L. carinata* collected from the Suez Bay during 2009-2011.

The pooled length frequency distributions were analyzed by Bhattacharya (1967) method as incorporated in FiSAT software (Fig. 3). Three components could be identified which were considered as distinct age groups. These groups are almost well discriminated according to the values of the separation index which must be over

2 to allow an objective separation of the adjacent groups (Rosenberg and Beddington, 1988) (Table 3).

Table (3) Mean lengths at age, population number, standard deviation (S.D.) and the separation index for each age group as estimated from Bhattacharya method.

Age group	Mean calculated Length	Population number	S.D	Separation index
I	**10.59**	**127**	**0.69**	**-**
II	**13.82**	**263**	**0.47**	**3.52**
III	**16.67**	**72**	**1.04**	**2.76**

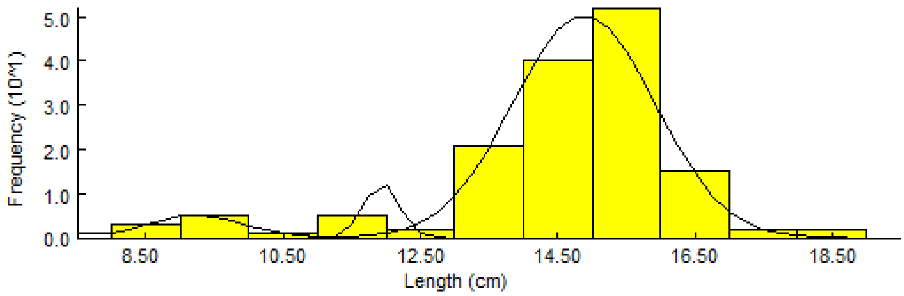

Fig. 3: Decomposition of the pooled length frequency distributions of *L. carinata* collected from the Suez Bay.

The sex ratio

The variations of sex ratio in *L. carinata* were studied seasonally. The results showed that females dominant during all the year, particularly in autumn which show the highest number and percentage of females 81.3 % (Fig 4). The overall sex ratio of males to females during this study period was 1: 2.24.

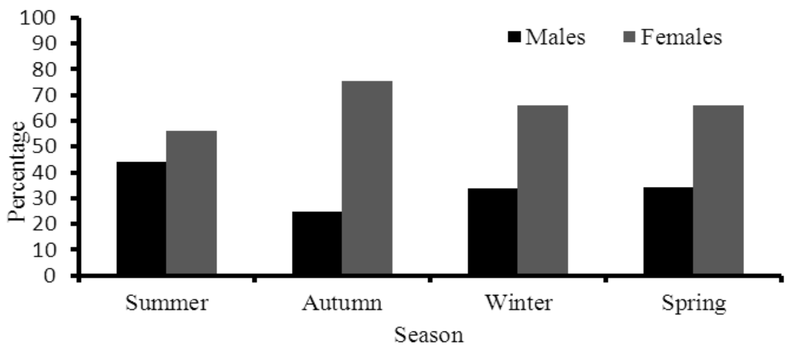

Fig. 4: Seasonal sex ratio of *L. carinata* from the Suez Bay

Gonado- somatic index (GSI)

Analysis of the seasonal variations of the GSI (Fig 5) showed that the average values of gonad weight percentages increased substantially from spring until autumn. The maximum values were recorded in autumn; this indicates that *L. carinata* spawns during autumn.

Salem and Mohammed (1982) showed that the maximum value of the gonado-somatic index of *Mugil seheli* in Lake Timsah occurs in December; but El-Boray (1993) pointed out that the gonado-somatic index peak of *Mugil seheli* in Suez Bay extends from November to March. Moreover, Mahmoud (1997) indicated that the gonado-somatic index peak of *Mugil seheli*, reared in farms, is sharp in November and December.

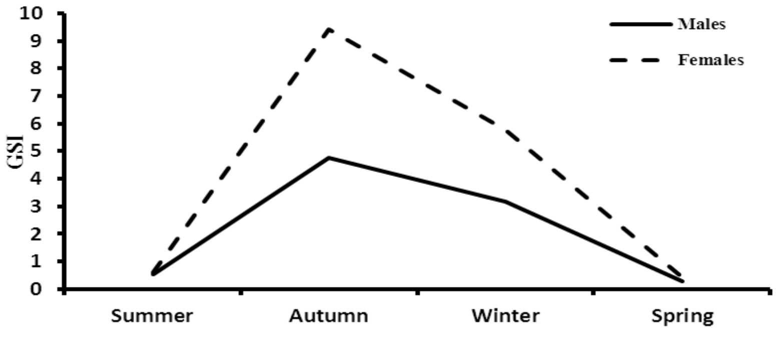

Fig. 5: Seasonal variation in gonado-somatic index (CSI) of *L. carinata* from the Suez Bay

Length at first maturity

Analysis of the percentage of mature and immature fish in each length class (Fig 6) showed that the minimum size of maturity is 12.5 and 13.0 cm for males and females respectively. However, the size at which 50% of fishes are mature is 13.3 cm for males and 13.5 cm for females. Considering the age groups of these fishes, males of 13.3 cm and females of 13.5 cm belong to age group II. These results show that for both sexes of *L. carinata*, all fishes over two years of age are sexually mature.

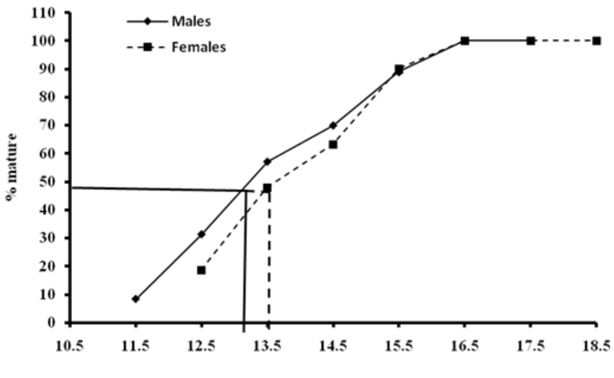

Fig. 6: Length at 50% maturity of *L. carinata* from the Suez Bay

Fecundity

To determine the egg productivity, the absolute and relative fecundity of 35 ovaries of *L. carinata* in the ripe maturity stage were counted during the spawning season. The relation between fecundity (F) and total length (L) of *L. carinata* from the Suez Bay was best fitted by a logarithmic plot (Table 4). The formula representing this relationship is as follows:-

$$F = 55879.2 + 28977.6 \log L \qquad r^2 = 0.98679$$

The weights (Wt) of the 35 fishes selected for fecundity studies were grouped in classes of 10 gm interval. The fecundity data obtained were plotted against the mean total weight of *L. carinata.* Table (5) shows that the best fit as measured by the coefficient of correlation, was realized by logarithmic regression between the logarithm of the total weight and the absolute fecundity. This relationship can be represented by the following equation:

$$F = 58018.9 + 108383.7 \log Wt. \qquad r^2 = 0.94563$$

These results are in accordance with those recorded by Salem and Mohammed (1982); El-Boray (1993) and Mahmoud (1997).

Table 4: Mean absolute and relative fecundity of *L. carinata* in relation to length.

Length Interval	Mid Length	No.	Observed absolute fecundity	Calculated absolute fecundity	Relative fecundity F/Lcm
13.0-13.9	13.6	2	60732.3	57678.9	4465.6
14.0-14.9	14.5	6	65279.8	66554.0	4502.1
15.0-15.9	15.7	8	71936.7	74836.9	4582.0
16.0-16.9	16.3	12	80830.8	82601.9	4958.9
17.0-17.9	17.8	6	91064.3	89909.8	5116.0
18.0-18.9	18.4	1	98549.3	96811.5	5663.8

Table 5: Mean absolute and relative fecundity of *L. carinata* in relation to weight.

Weight interval	Average weight	No.	Observed absolute fecundity	Calculated absolute fecundity	Relative fecundity F/W(gm)
20.1-30.7	25.4	2	58497.6	54242.1	2303.1
22.4-41.2	31.8	5	63568.2	64819.6	1999.0
30.3-50.3	40.3	9	70589.3	75969.9	1751.6
40.1-56.1	48.1	13	78365.9	84298.1	1629.2
40.2-65.6	52.9	5	90658.8	88775.5	1713.8
45.0-68.6	56.8	1	98549.3	92123.8	1735.0

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ARABIC SUMMARY

معدلات العمر و النمو و بيولوجية التكاثر لأسماك السهلية (ليزا كاريناتا) من خليج السويس، البحر الأحمر، مصر

عزه عبد الحميد الجناينى[١]، فوزيه عاشور عبد الغفارعبد الرحمن[٢]، وليم رزق الله[٢]، حمزه أحمد الشبكة[٢]، مزاية السيد أبو مسلم[٢]
١- معهد علوم البحار والمصائد المائية فرع السويس- السويس - مصر.
٢ - قسم علم الحيوان - كلية العلوم - جامعة عين شمس - القاهرة.

تمت دراسة العمر و معدلات النمو و بيولوجيا التناسل لسمكة السهلية (ليزا كاريناتا) من خليج السويس.
و لقد تم تحديد العمر عن طريق قراءة حلقات النمو المترسبة على الحصاة الأذنية (الأوتوليث) و تم تأكيد هذه النتائج عن طريق فصل التوزيع التكرارى الموسمى لأطوال الاسماك الى مجاميع عمرية خلال الفترة من يناير ٢٠٠٩ حتى يناير ٢٠١١. كما كانت نتائج معادلة فون برتالانس $L_t = 21.279\ (1 - e^{-0.463\ (t + 0.325)})$.
و اتضح ان نمو السمكة سريع حيث تحقق أكثر من ٥٠% من نموها خلال السنة الاولى من حياتها. كما أظهرت نتائج التوزيع الموسمى لمعامل المناسل- الجسدى ان تكاثر السمكة يتم خلال موسم الخريف و ان حوالى ٥٠ % من الاسماك تصبح ناضجة جنسيا عند طول ١٣.٣ سم للذكور و ١٣.٥ سم للإناث اى ان كل الافراد الاكثر من عامين فى العمر تكون ناضجة جنسيا.
تم حساب الخصوبة المطلقة للنوع محل الدراسة ووجد انها تتراوح بين ٦٠٧٣٢.٣ و ٩٨٥٤٩.٣ بيضة للأسماك التى تتراوح فى الاطوال بين ١٣.٦ و ١٨.٤ سم.
توصى هذه الدراسة بتغيير موسم حذر الصيد فى جونة السويس ليكون خلال موسم الخريف من اجل الحفاظ على الكتلة البيولوجية التناسلية لأسماك السهليه (ليزا كاريناتا) فى الجونه.