J. Egypt. Acad. Soc. Environ. Develop., 17 (1): 25-36 (2016) (D-Environmental Studies)
E.mail: easedjournal_egypt@yahoo.com ISSN 1110-8770
www.jades.journals.ekb.eg eISSN 2314-5471 (online)

Age, growth and maturity of the thin-lipped grey mullet, *liza ramada* in Bardawil lagoon, North Sinai, Egypt

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ABSTRACT

Age and growth of 599 thin-lipped grey mullet, *Liza ramada* from the Bardawil lagoon were estimated by ring counts on scalesduring April to December, 2013. Lengths (Lt) ranged between 11.6 to 45.8 cm and the corresponding weight (Wt)was 28 to 668 g. All fishes aged from 0 to 6 years, with age 1st, 2nd, 3th year being the most dominant age groups. The length-weight relationship indicated negative allometric growth (b=2.764). Back–calculated lengths were16.9, 23.1, 28.3, 32, 35.5 and 38.3 cm to ages 1st, 2nd, 3th, 4th, 5th and 6th, respectively. Von-Bertalanffy growth parameters (VBGP) were $L\infty$=50.95cm, K=0.1977yr^{-1}, t_0= -1.04yr^{-1}. The growth performance index (φ) was 2.71.The sex ratio of *L. ramada* in the present study was ≈ 1:2 male to female, respectively. The reproductive activity starts in September, while the highest values of GSI were at November and December. The length at first sexual maturity (L_{m50}) was estimated at 28.6 cm (≈ 3.1 years) and 29.6 cm (≈ 3.4 years) for males and females, respectively.

Key words: Thin-lipped grey mullet, *Liza ramada*, age, growth, maturity, Bardawil lagoon

INTRODUCTION

In Bardawil lagoon, the fishing operations are seasonally, starting from April to December, sometimes it extends to January. Mullet fishes (Mugilidae) play an increasingly important role in local markets.The thin-lipped grey mullet,*L. ramada*is one of the most common mullet landed and consumed by Egyptian families, where prices of this fishes are lower than any other seafood. Mullets (Mugilidae) are among the most common species from tropical and temperate marine coastal waters in the world and constitute a fundamental protein resource for a number of human populations living in coastal areas (Nelson, 1994). The life history information is the most important study to our understanding of the species biology to enable the control of fishing.

The aim of this work is to study age, growth and maturity of the thin-lipped grey mullet *L. ramada.* This will provide the required information for the sustainable use of the resource and fishery management in Bardawil lagoon.

MATERIALS AND METHODS

The study was carried out in Bardawil lagoon (Fig. 1). The lagoon is located in the Sinai Peninsula, Egypt and it covers an area of 693 km^2.

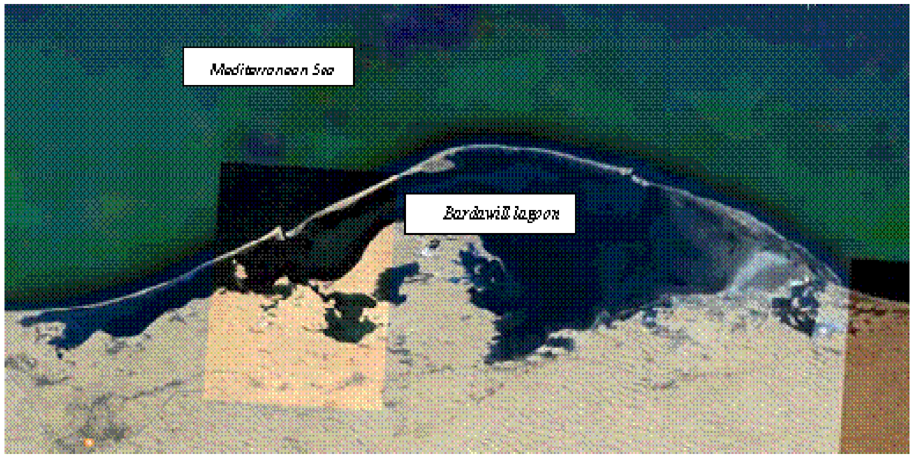


Fig. (1). The Bardawil lagoon

599 specimens of thin-lipped mullet *Liza ramada* were monthly collected from the landing sites at Bardawil lagoon during April to December 2013. The total length (to the nearest mm) and the total weight (to the nearest 0.1 g) of all individuals were recorded. The age was determined by scale reading (Paul, 1968). Annual rings on scales were examined under a binocular stereomicroscope at 10 magnifications using reflected light.

The relationship between length and weight was computed using the formula $W = a\,L^b$ where W is the total weight in grams, L is the total length in centimeters and a & b are constants whose values were estimated by the least square method. The back–calculated lengths to age classes were recorded using Lee's (1910) equation as: L_n (S_n/S) L (Where: L_n is the total length in centimeters, S_n is magnified scale radius to "n"annulus, S is the scales radius in millimeters and L is the total length in centimeters). The back–calculated weights at the end of each year were estimated by applying the equations of length–weight relationship.

Theoretical growth in length was obtained by fitting the von Bertalanffy growth model, using the Gulland and Holt (1959) method. Von Bertalanffy (1949) for theoretical growth in length can be written in the form: $L_t = L_\infty\,(1 - e^{-k\,(t - t_0)})$ (Where: L_t = the length at age t , L_∞ = the asymptotic length at t_∞, K = growth coefficient and t_0 = age at which the length is theoretically nil).

The condition factor (Kc) was calculated by using Hile (1936) formula as: $Kc = (W * 100)/L^3$ (Where: K is the composite coefficient of condition, W is the total weight in gram and L is thetotal length in cm).

The growth performance index (φ) was estimated as:$\varphi = \log K + 2 \log L_\infty$ (Where: K and L_∞ are parameters of von Bertalanffy) (Pauly and Munro, 1984).

All Fishes were dissected for sex determination and maturity investigation. When sexual differentiation is not possible, individuals were removed. The gonads after being removed were weighed to the nearest 0.01 g; the monthly gonado-somatic indices (GSI) were calculated by the equation of Bariche *et al.* (2003) as follows:

GSI= (Gonad Weight / (Body Weight - Gonad Weight))*100

During the spawning period, by the naked eyes and by microscopic examination in young specimens, mature individuals were determined.The length at first sexual maturity (L_{m50}) was determined by 50% of fish which reach their sexual maturity. Then L_{m50} was estimated as the point on the X-axis corresponding to 50% point on the Y-axis.

RESULTS AND DISCUSSION

Age determination

Age was determined in 599 specimens of thin-lipped grey mullet *L. ramada* ranged from 11.6 to 45.8cm (L_t) and the corresponding weight was 28 to 668 g (W_t). The length frequencies for all individuals are presented in Figure (2).

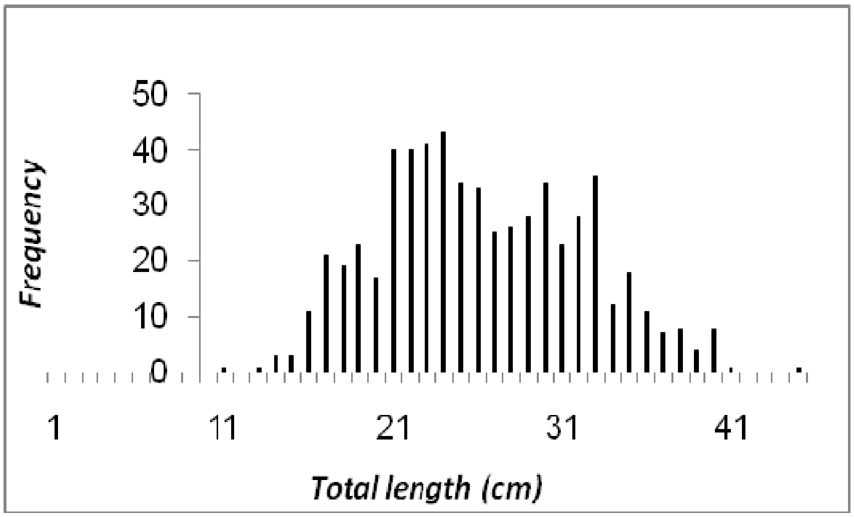


Fig. (2). Length-frequency distribution of *L. ramada* collected from Bardawil lagoon, during 2013.

The maximum length in the present study was close to that of Salem *et al*. (2010) who recorded 46.6 cm, but more than that given by Mehanna (2006) who recorded 42 cm for the same species in Bardawil lagoon. Age-length key of *L. ramada* for all age classes are presented in Table (1). All fishes aged from 0 to 6 years. Most of the investigated fish were belonging to 1-3 age classes (≈ 80%).

Stock assessment is based on estimates of numbers of fish per age classes. All age-at-length data of the investigated stock are often combined without weighing, under the assumption that differences between gear types and regions can be disregarded (ICES, 2005). Young fish of *L. ramada* were high in Bardawil catch than other age classes, which may be caused by variation in length-at-age distributions or in the relative abundance in young fish or may be related to using non selective harmful fishing gear. The exploitation history of fish populations affects their demography and sustained heavy exploitation and results in truncated age structures by removing the largest (and presumably older) individuals (Ricker, 1969 ; Goni, 1998).

Table (1). Age - length key of *L. ramada* collected from Bardawil lagoon during 2013.

Length Interval	Age class (years) 0	I	II	III	IV	V	VI	Total
11.5	1							1
12.5								0
13.5	1							1
14.5	3							3
15.5	3							3
16.5	6	5						11
17.5	4	17						21
18.5	2	17						19
19.5		23						23
20.5		17						17
21.5		38	1	1				40
22.5		31	8	1				40
23.5		33	8					41
24.5		14	28	1				43
25.5			32	2				34
26.5			30	3				33
27.5			23	2				25
28.5			12	14				26
29.5			8	18	2			28
30.5			2	29	3			34
31.5				17	6			23
32.5				16	12			28
33.5				19	16			35
34.5				2	10			12
35.5				3	14	1		18
36.5				2	8	1		11
37.5				1	2	3	1	7
38.5					2	4	2	8
39.5						3	1	4
40.5						4	4	8
41.5						1		1
42.5								0
43.5								0
44.5								0
45.5							1	1
Length	**16.1**	**21.2**	**26.0**	**30.9**	**34.0**	**38.9**	**40.2**	**599**
N	**20**	**195**	**152**	**131**	**75**	**17**	**9**	

The length - weight relationship

The length - weight relationship of a fish can be described by a cube law $W = aL^3$ (where W = weight of fish in g, L = length of fish in cm and a = constant). The cube law represents a condition in an ideal fish, where in the fish maintains constant shape (Allen, 1938). Generally, the length-weight relationship is affected by various factors as the availability of food, rate of feeding, development of gonads, spawning…etc. Therefore, length-weight equation should include fishes of both sexes which sampled at various times of the year to be most useful. Figure (3) showed the length-weight relationship of 599 individual of *L. ramada* in the Bardawil lagoon. In the present study, the value of (b) for *L. ramada* was about 2.764 during the fishing season 2013 which represented by the equation:

$W = 0.017L^{2.764}$.

This indicated that the growth in weight is negative allometric (the weight did not follows the cube of length). Moreover, the b value of the length-weight relationship in this study differs from those found by Mehanna (2006) (b = 3.13) for *L. ramada* in Bardawil lagoon. The length-weight relationship for *L. ramada* in the present study is higher than that obtained by Kasimoglu *et al.* (2011) (b= 2.253) for *L. ramada* in Turkey (the Southern Aegean Sea). Enin (1994) mentioned that the parameter b is equal to 3 at isometric growth, when it is less or greater than 3 it is allometric. Bagenal and Tech (1978) mentioned that, length-weight relationship is a practical index of the condition of fish and varies over the year according to factors such as food availability, feeding rate, gonad development and spawning period.

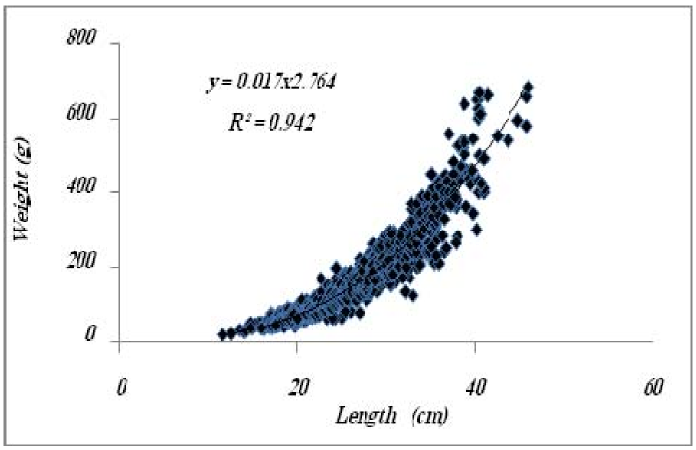


Fig. (3). Length-weight relationship of *L. ramada* collected from Bardawil lagoon during 2013.

Back –calculation

To estimate previous growth history of *L. ramada*, the relationship between scale radius and the total length was studied by back – calculation (Table 2).

Table (2). Back – calculated lengths at the end of different years of life of *L. ramada* collected from Bardawil lagoon during 2013.

Age	no. of fish	Obs. length	Average back calculated lengths at the end of age years (cm)					
			I	II	III	IV	V	VI
0	20	16.1						
I	195	21.1	16.9					
II	152	25.9	16.7	23.1				
III	131	30.8	16.7	23.6	28.3			
IV	75	34	15.2	22.2	27.5	32		
V	17	38.8	13.3	20.8	26.4	31.1	35.3	
VI	9	40.2	14.5	21.5	26.9	31.4	35.1	38.3
	599	Increment	16.9	6.2	5.2	3.7	3.3	3

The back–calculated lengths were 16.9, 23.1, 28.3, 32, 35.5 and 38.3 cm corresponding to ages 1st, 2nd, 3th, 4th, 5th and 6th , respectively. The lengths at the end of years of *L. ramada* in Bardawil lagoon, 2013 were smaller, especially for older fish comparing with similar studies by Mehanna (2006) (back-calculated lengths were 21.09, 30.05, 36.33, 39.26 and 41.08 cm at ages I, II, III, IV and V years, respectively) and Salem *et al.* (2010) who found that, the back – calculated lengths were 19.3,27, 32.3, 36.1, 39.3 and 42.2cm at ages 1st, 2nd, 3rd, 4th, 5th and 6th , respectively. The highest annual increment in the present study occurred at first year of life16.9 cm, while, beyond this age, the growth rate slows down to ≈ 3: 6 cm per year.This change in value was identifying by similar studies. The lowest of growth was related to slower growing individuals with highly exploited and disturbances by fishing boats. Environmental conditions and availability and type of food resources could affect fish growth rates and thus lengths at age (Wootton, 1990)

The back–calculated weights at the end of years for *Liza ramada* in Bardwil lagoon were estimated by applying the equation of length–weight relationship as illustrated in Table (3).

Table (3). Average and increment of weight at the end of different years of *L. ramada* collected from Bardawil lagoon during 2013.

Age	no. of fish	Obs. weight	Average and increment of weight at the end of each year (gm)					
			I	II	III	IV	V	VI
0	20	42.4						
I	195	80.4	**43.8**					
II	152	142.9	42.2	**102.5**				
III	131	220.3	42.1	109.7	**179.7**			
IV	75	285.3	32.4	92.4	166.9	**254.4**		
V	17	444.8	22.5	76.7	148.3	234.4	**331.3**	
VI	9	548.6	28.2	84.6	156.4	241.2	328.1	**417.6**
	599	**Increment**	**43.8**	**58.8**	**77.2**	**74.7**	**76.9**	**86.3**

The increasing of weight is very important than increasing of length for fishermen, where the landings are recorded as a weights. The back-growth was calculated as 43.8, 102.5, 179.7, 254.4, 331.3, and 417.6g at the end of 1st, 2nd, 3rd, 4th, 5th and 6th years of life, respectively. Mehanna (2006) recorded that, the back calculated weights were 73.39, 222.6, 403.5, 514.57and 593 gm. for ages 1st, 2nd, 3rd, 4th and 5th years respectively. Salem *et al.* (2010) found that the back calculated weights were 63.63, 160.2, 262.9, 357.5, 452.1 and 550.4 at ages 1st, 2nd, 3rd, 4th, 5th and 6th , respectively. In the present study, the growth was lower than that previous study indicating that, the environmental factors unsuitable during the study period.

Theoretical growth

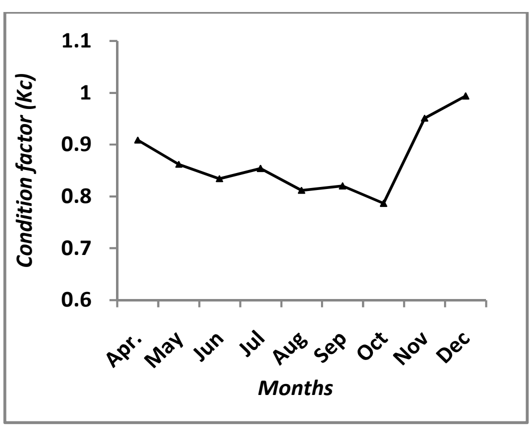
In the present study, the Von-Bertalanffy growth parameters of *L. ramada* were $L\infty$=50.95 cm, K=0.1977yr^{-1}, t_0= -1.04yr^{-1}. The growth parameters and lifespan in the present results were lower than that obtained by Sinovcic *et al.* (1986) in Adriatic Sea for the same species (L_∞=52.5cm, K=0.25yr^{-1} and t_0=-0.1 yr^{-1}) of about 8yr.The low L∞ may be due to the over fishing in the lagoon at the last period, and the rarity of larger and older individuals within the landings. Parsons (1982) stated that, in general, the older the year class, the higher the L∞ value.

The growth coefficient (K) is related to the longevity of fish. In the present study, the growth coefficient (K) is lower comparing with the similar previous studies. Mehanna (2006) in Bardawil lagoon of the same species recorded that K=0.51yr^{-1}. The K value (determines how fast the fish approaches its L∞) contributed with the lifespan of fish and fast growth. Therefore, this parameter affected by growth factors such as food availability and environmental factors.

The growth performance (φ) in the present study for *L.ramada* was (φ =2.71) slightly higher than that estimated for the same species in lake Borollus (φ =2.66) (Hosny and Hashem, 1995). On the other hand, it was lower than (φ=2.91) for the same species at Wadi El- Raiyan lakes (EL Gammal and Mehanna, 2004), (φ =2.98) at Lake Timsah (Mehanna and Amin, 2005) and (φ =3.0) in Bardawil lagoon (Mehanna, 2006). This result is close to that of Salem *et al*. (2010) in Bardawil lagoon for the same species (φ=2.84).The differences in growth performance (φ) is related to temperature (Ricker, 1975), salinity (Popper and Gundermann, 1975) and possibly to differences in food items (Golani,1993).

Condition factor

The condition indices portrayed by morphometric measurements represent a basis for developing an explanatory hypothesis about biological responses or different ecological scenarios for populations (Liao *et al.,* 1995). The condition factor (Kc) is used for comparing the condition, fatness, or well-being of fishes (Mir *et al.,* 2012).In the present study, the condition factor of *L. ramada* was recorded according to seasonality and different lengths (Fig. 4).



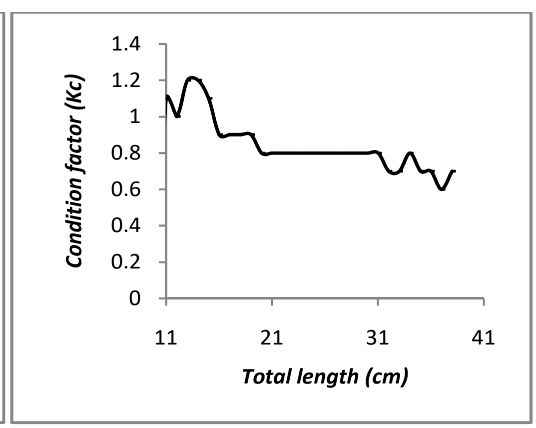


Fig. (4). Relationship between Kc values and months and the total length intervals of life of *L. ramada* collected of Bardawil lagoon during 2013.

The highest value of condition factor (Kc) in the present study was recorded in April, declined from May until October and started to increase during November and December.The higher Kc values in April may be due to closing period in the Bardawil lagoon, where the fishing season starting in mid April. After opening of fishing season, growth in fish may be affected by stress of vessels noise, which decreases fish feeding activity. Davidson *et al.* (2009) noted that, a growth rate of rainbow trout was slower during the first month of noise exposure; however fish acclimated to the noise thereafter. Noise in the environment can lead to reduce food consumption (Voellmy *et al.,* 2014). Increasing of condition factor (Kc) values at November and December and with older fish (more than 30 cm) may be due to increasing in somatic growth and gonad maturation and onset maturity. In Bardawil lagoon, the size at maturity of *L. ramada* was ≈ 29cm (L_t). The condition factors can be attributed to the richness of nutrients, population density, age and spawning season (kasimoglu *et al.*, 2011).

Sex ratio

A total of 215 males (35.9%) and 384 females (64.1%) of thin-lipped grey mullet *L. ramada* were sexed by opening the abdomens and examining the gonads.The percent of males to females with age classes are illustrated in Table (4).

Table (4). Sex ratio of *L. ramada* collected from Bardawil lagoon during 2013.

Age	Males		Females	
	N	%	N	%
0	9	45.0	11	55.0
I	67	34.4	128	65.6
II	55	36.2	97	63.8
III	52	39.7	79	60.3
IV	26	34.7	49	65.3
V	4	23.5	13	76.5
VI	2	22.2	7	77.8
Average		33.7		66.3

Gonads of 599 specimens of *L. ramada* were examined for sex ratio determination. It was ≈ 1:2 male to female, respectively. El-Halfway *et al*. (2007) reported sex ratio of *L. ramada* in Lake Timsah as 1:1.7 males to females, respectively. Also, they observed that, the sex ratio is not constant throughout the different months.

Gonado-somatic index

The reproductive activity of *L. ramada* started in September with a peak in December as it has the highest GSI values for males and females of *L. ramada* (Fig. 5).

The age and size at sexual maturity may be important in assessing the optimum age of first capture of a species and the time and place of spawning and can be used to plan fishing tactics. Most of samples, which collected in November and December, were matured. These result was close to that given by El-Halfway *et al*. (2007), as the spawning season of *Liza ramada* in Timsah Lake extended from November to January. The spawning season of *L. ramada* in Turkey occurred between October and December, showing a peak in November (Ergene, 2000 and Kasimoglu *et al.,* 2011).

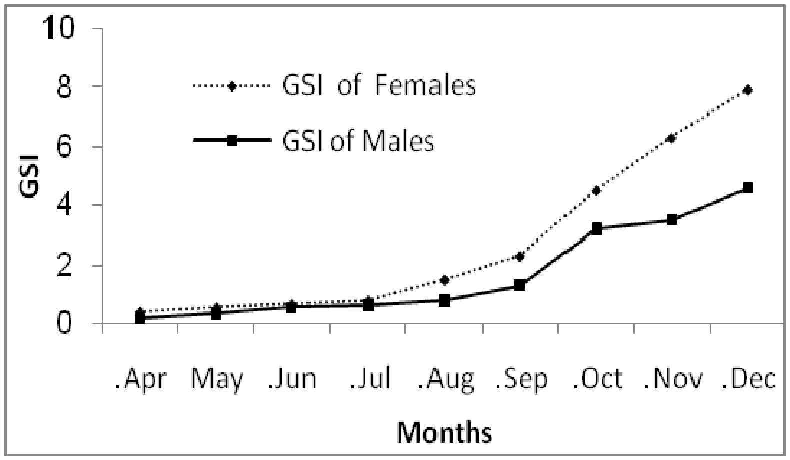


Fig. (5). Monthly variation of GSI values for males and females of life of *L. ramada* collected from Bardawil lagoon during 2013.

Length at first sexual maturity

The length at which 50% (L_{m50}) of individuals attained sexual maturity was 28.6cm (≈ 3.1 years) and 29.6 cm (≈ 3.4 years) for males and females, respectively (Fig. 6).

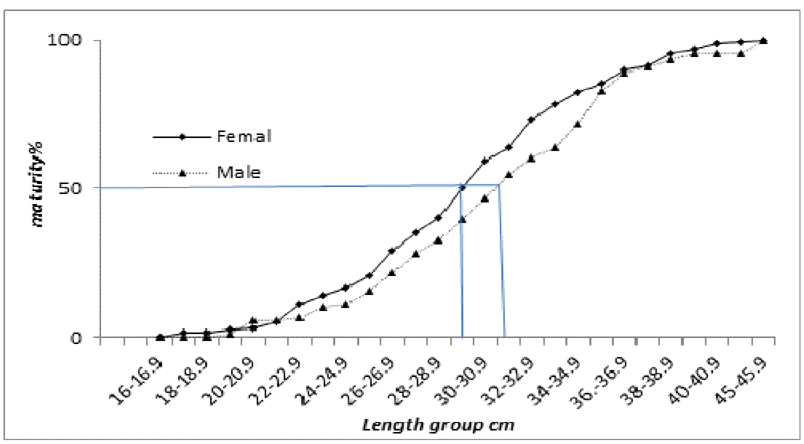


Fig. (6). L_{m50} of *L. ramada* (males and female) collected from Bardawil lagoon during 2013.

Ergene (2000) recorded the age of sexual maturity for *L. ramada* as three years in Akgöl-Paradeniz lagoons, Turkey. This age at first maturity value was the same as the present results. Immature individuals of this species are represent by 43% of the total catch, so it could be mentioned that the fishing gear in the lagoon is of medium harmful to this species according to Cetini *et al.*(2002) who mentioned that, if the percentage of immature specimens in total catch is above 50%, fishing gear would be considered as very harmful, if it is between

20 and 50%, it is considered as medium harmful, and if it is under 20% then the harmful influence of fishing gear is acceptable.

The present results recommended protecting this species during the spawning season in November – December period; at least near of inlets (Boughazis) between the lagoon and Mediterranean Sea, in order tosecure future spawning.

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العمر، النمو والتكاثرلاسماك الطوباره بمنخفض البردويل، شمال سيناء، مصر

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المستخلص

اجريت هذه الدراسه بمنخفض البردويل فى الفتره من ابريل الى ديسمبر خلال موسم صيد 2013. تم تحديد العمر ومعدلات النمو لعدد 599 سمكه عن طريق قراءه القشور. تدرجت اطوال العينات من 11.6 الى 45.8 سم متطابقه مع الاوزان 28 الى 668 جرام. حُددت المجموعات العمريه للعينات من المجموعه العمريه صفر الى ست سنوات عمريه وكانت السياده للمجموعات العمريه الاصغر واختفت الاسماك الاكبر من عمر ست سنوات. العلاقه بين الطول والوزن فى اسماك الطوباره اظهرت ان هناك زياده فى الطول على حساب الوزن وعن طريق الحساب الرجعى تم تحديد الاطوال عند نهايه كل سنه عمريه على النحو التالى16.9 ، 23.1، 28.3، 32، 35.5 و38.3 للمجموعات العمريه من 1 الى 6 سنوات على الترتيب. معدلات النمو لفون بيرتلانفى كانت على النحو التالى: الطول عند مالانهايه ($L\infty=50.95$) معامل النمو($K=0.1977yr^{-1}$) العمر الصفرى ($t_0= -1.04yr^{-1}$). كفاءه النمو 2.71.

أتضح من النتائج ان النسبه الجنسيه لاسماك الطوباره ذكر لكل 2 انثى تقريبا. بحسب دليل المناسل، وان موسم التكاثر يبدأ من سبتمبر ويصل الى القمه فى نوفمبر وديسمبر. الطول عند بدايه النضج الجنسى 28.6سم للذكور و29.6 سم للاناث. كما أظهرت الدراسه ان هناك نمو فى الطول على حساب الوزن وان معظم المصيد من الاسماك الغير ناضجه جنسيا مما يشكل خطر قريب على مخزون هذا النوع.