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Comparative study on *Liza ramada* (Risso, 1827) fishery status and management between Suez Canal Lakes, Egypt

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ABSTRACT

The population parameters of the thin lipped grey mullet *Liza ramada* in the Suez Canal lakes; Bitter and Timsah Lakes were investigated based on samples collected from landing sites of the Timsah and Bitter lakes during the period from December 2016 to November 2017. Based on the reading of scale's growth rings, the life span for *L. ramada* was 6 years at Bitter lakes and 7 years at Timsah Lake. The growth parameters (L∞ and K) of von Bertalanffy growth equation for combined sexes of *L. ramada* in Bitter Lakes were L∞ = 49.48 cm and K= 0.48/yr. while *L. ramada* population in Timsah Lake have L∞ = 52.2 cm and K= 0.46/yr. Mortality parameters (Z, M, F) were 2.54, 0.57 and 1.96 year^{-1} respectively at Bitter Lakes and the same parameters were 2.05, 0.53 and 1.52 year^{-1} respectively at Lake Timsah. The estimated exploitation ratios were 0.77 and 0.74 year^{-1} for *L. ramada* population at Bitter and Timsah Lakes respectively. Relative yield per recruit (Y/R)' model was used for evaluating *L. ramada* fishery status and the results obtained revealed that stock of *L. ramada* in both investigated areas; Bitter and Timsah Lakes were being overexploited and a suitable management measures should be applied for protecting these valuable fishery resources.

INTRODUCTION

The Suez Canal is an artificial waterway in Egypt extending from Port Said in the North and continues southward for 193.3 km to Suez, connecting the Mediterranean Sea with the Red Sea (SCA, 2012).

Suez Canal has three lakes; Great and Little Bitter Lakes as well as Timsah Lake. The Suez Canal lakes considered as an important source for fishery resources in Egypt. They produce high economic fish species like mullets, tilapia, shrimp, molluscs, crab, striped piggy, seabass, seabream, cuttlefish and rabbitfish. There are about 777 fishing boats operated in Suez Canal lakes using several fishing methods; long line, gillnet, trammel net, crab net, traps, bivalves dredges and beach seine (Mehanna and El-Gammal, 2007; Ahmed and El-Karamany, 2013; GAFRD, 2017).

Mullets (Family: Mugilidae) are among the most common species from tropical and temperate marine coastal waters in the world and constitute a fundamental source of animal protein for numerous human populations living in coastal areas.

In total, family Mugilidae includes 30 genera and 78 species with a worldwide distribution (Nelson, 2006).

The thin lipped grey mullet, *Liza ramada* (Risso, 1827) is a pelagic species inhabiting various habitats, from shallow brackish and marine waters close to lagoons, estuaries and river deltas, and surviving in extreme salinity conditions as well as abrupt changes of water quality (Thomson, 1990).

The main purpose of this study was to compare population parameters that characterize *L. ramada* fishery in both Timsah and Bitter Lakes along the Suez Canal in order to give detailed information about their fishery status for maintaining this valuable fish resource, and achieving the sustainable management.

MATERIALS AND METHODS

Study area and Sampling:

The two investigated lakes through which the Suez Canal passes were Timsah (30° 13`, 30° 35`N and 32° 16`, 32° 18`E) and Bitter Lakes (30° 20` N, 32° 23` E). Timsah Lake has a surface area of 15 km^2 while the little and great Bitter lakes together have a surface area of about 250 km^2. There are two main landing sites along the investigated lakes; "Ismailia" landing site for Timsah Lake and "Fanara" landing site for Bitter Lakes (Fig. 1). Landing site, Fanara is relatively larger than that of Ismailia, and both are having fishing boats that are small, simple in design, ranged in length from 6-8 m and width from 2-3 m, using multiple fishing methods; long line, gillnet, trammel net, crab net, traps, bivalves dredges and beach seine.

Monthly random samples of *L. ramada* were collected from landing sites; Ismailia on the Timsah Lake and Fanara on Bitter Lakes from December 2016 to November 2017.

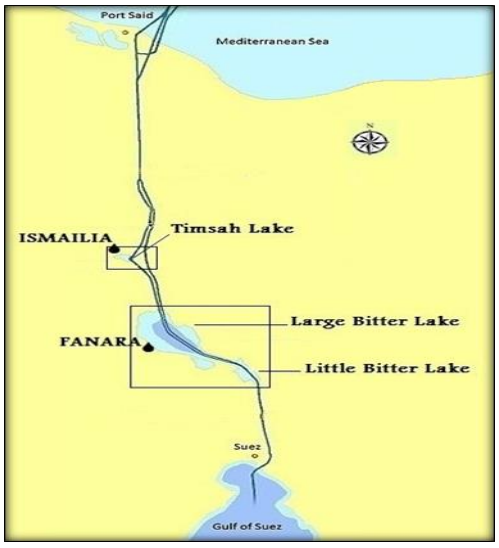

Fig. 1: A map of study area; Timsah and Bitter Lakes as well as landing sites; Ismailia and Fanara.

Investigation of *L. ramada* samples:

The total length "TL" (cm) and total weight "W" (g) as well as sex and maturity stage for each fish specimen were determined. Fish scales were taken for age determination.

Length – Weight Relationship (LWR):

Length - Weight relationship was calculated using the equation $\mathbf{W= a\ L^b}$ (Beckman, 1948), where 'W' is the total body weight of the fish; 'L' is the total length; 'a' is the intercept of the regression curve and 'b' is the regression coefficient. a and b values were estimated by the least square method.

Growth Parameters:

The von Bertalanffy (1938) growth equation was applied to investigate growth in length and weight for both sexes of *L. ramada* in both investigated areas according to the equation: $\mathbf{L_t = L\infty\ (1 - e^{-k(t-to)})}$.

Von Bertalanffy growth parameters "L∞ and K" were estimated by applying the method of Ford (1933) - Walford (1946). "t_o" was estimated from the following rearranged formula of the von Bertalanffy equation: $\mathbf{- \ln [1 - (L_t/L_\infty)] = - k*t_o + k*t}$.

Growth Performance Index (Ø'):

The growth performance index was computed according to the formula of Pauly and Munro (1984) as follows: $\mathbf{Ø' = Log_{10}\ K + 2\ Log_{10}\ L_\infty}$ where: Ø' = Phi-prime, i.e. a length-based index of growth performance.

Mortality Parameters (Z, M, F):

Total mortality coefficient (**Z**) was estimated using the methods of Jones and Van Zalinge (1981), Pauly (1983) as well as Hoenig and Lawing (1982). Natural mortality coefficient (**M**) was estimated according to Taylor (1960), Ursin (1967), Rikhter and Efanov's Empirical Model (1976) as well as Pauly (1980). The geometric means for the methods used in estimating **Z** and **M** are then used for estimating fishing mortality coefficient (**F**) according to the equation: **F = Z - M**.

Exploitation Ratio (E):

The exploitation ratio (i.e. the fraction of deaths caused by fishing) was estimated by the formula suggested by Gulland (1971) through the following relation: **E = F / Z**.

Length at first capture (L_c) and at first sexual maturity (L_{50}):

The length, at which 50% of the fish retained in the gear "**Lc**" was estimated using catch curve analysis (Pauly, 1984). The length, at which 50% of fish species reach their sexual maturity "$\mathbf{L_{50}}$", was estimated by fitting the percentage maturity against fish lengths. $\mathbf{L_{50}}$ value is the point on x-axis corresponding to 50% point on y-axis.

Relative Yield per Recruit (Y/R)':

Relative yield per recruit (Y/R)' was estimated using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in the FiSAT software package, as follows:

$$\mathbf{(Y/R)' = E\ U^{M/K}\ [1 - (3U/1+m) + (3U^2/1+2m) - (U^3/1+3m)]}$$

Where: **m** = (1-E)/(M/K) = (K/Z); **U** = 1 - (L_c/L_∞).

RESULTS AND DISCUSSION

Length – Weight Relationship:

The length and weight measurements of 566 specimens of *L. ramada* "sexes combined"; (TL: 16 – 48 cm & weights: 48 – 924 g) in the Bitter Lakes as well as the length and weight measurements of 745 specimens of *L. ramada* "sexes combined"; (TL: 15 – 50.4 cm & weights: 28 – 972 g) in the Timsah Lake were used for the estimation of length-weight relationship.

The length-weight relationships of *L. ramada* population in Bitter Lakes and Timsah Lake were shown in Fig. (2), and were described by the power function

equations as follows: $W = 0.0151\ L^{2.8262}$ with $R^2 = 0.9614$ for *L. ramada* in Bitter lakes and $W = 0.0104\ L^{2.9366}$ with $R^2 = 0.9821$ for *L. ramada* of Timsah lake. The values of regression coefficient "b" are relatively similar to that of other previous studies worldwide (Table 1).

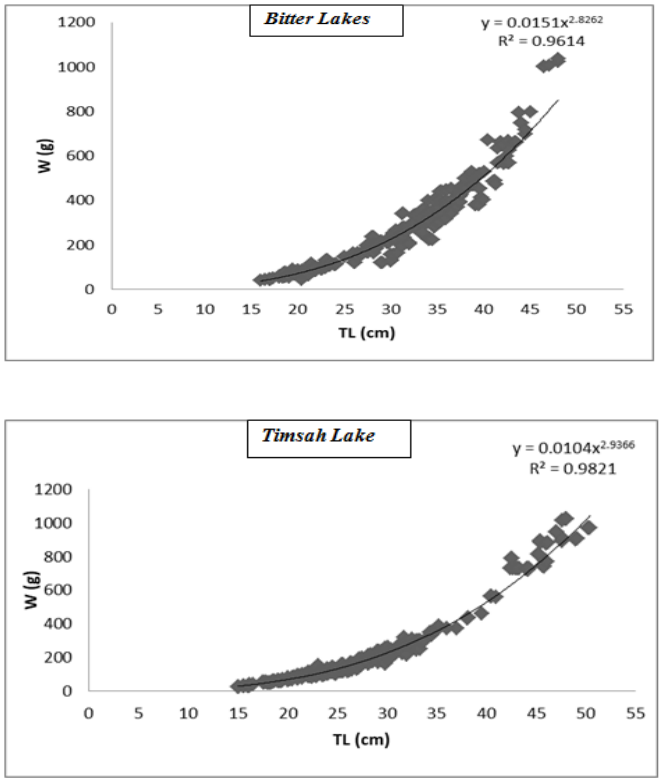

Fig. 2: Length – Weight Relationship of *L. ramada* from Bitter and Timsah Lakes.

Table 1: Estimated value of a, b of LWR for *L. ramada* from previous studies around the world.

Locality	Sex	Length range	a	b	Author
France	♂		0.0176	2.940	**Campillo, 1992**
	♀		0.0257	2.840	
France	♂♀		0.0120	3.000	**Djabali *et al*., 1993**
Croatia	♂♀	23.5-59.8 cm TL	0.0214	2.934	**Dulcic and Kraljevi, 1996**
Greece	♂♀	1.5-39.5 cm TL	0.0177	3.013	**Koutrakis and Sinis, 1994**
Morocco	♂♀	12.1-36.7 cm TL	0.0184	2.821	**Kraiem *et al*., 2001**
Tunsia	♂♀	12.3-39.0 cm TL	0.0057	3.141	
Egypt	♂♀	12.2-40.8cm TL	0.0060	3.130	
Wadi ElRaiyan lakes	♂♀	19.0-49.5 cm TL	0.0064	3.072	**El-Gammal& Mehanna, 2004**
Bitter lakes	♂♀	18.0-41.6 cm TL	0.0068	3.058	**Mehanna and El-Gammal 2007**
Timsah lake	♂♀	14.0-42.4 cm TL	0.0077	3.0299	
Croatia	♂	25.6-48.0 cm TL	0.014	2.852	**Glamuzina *et al*., 2007**
	♀	27.5-58.0 cm TL	0.003	3.278	
Bardawil lake	♂♀	16.9- 42 cm TL	0.0052	3.134	**Mehanna, 2006**
Turkey	♂♀		0.0005	2.2531	**Kasimoglu *et al*., 2011**
Libya	♂♀		0.016	2.847	**Mohammed *et al*., 2016**
Bardawil lagoon	♂	12 – 42 cm TL	0.017	2.7695	**Mehanna *et al*., 2019**
	♀	11 – 47 cm TL	0.017	2.7687	
Bitter lakes	♂♀	**16.0-48.0 cm TL**	**0.0151**	**2.8262**	**Present study**
Timsah lake	♂♀	**15.0-50.4 cm TL**	**0.0104**	**2.9366**	

The variation in "b" values within the same species may be due to biotic and abiotic factors such as seasonal fluctuations in environmental parameters, physiological condition of the animal at the time of collection, sex, gonad development and food availability in the environment (Froese, 2006).

Longevity:

The maximum life span of *L. ramada* by investigating the fish scales' growth rings is 6 years and 7 years in Bitter Lakes and Timsah Lake respectively (Fig. 3). From results, it is clear that there is a variations between *L. ramada* fish population inhabiting the Bitter lakes and Timsah Lake along the Suez Canal during the investigation period. Previous studies recorded the longevity of *L. ramada* in Egypt and in different countries around the world were given in Table (2).

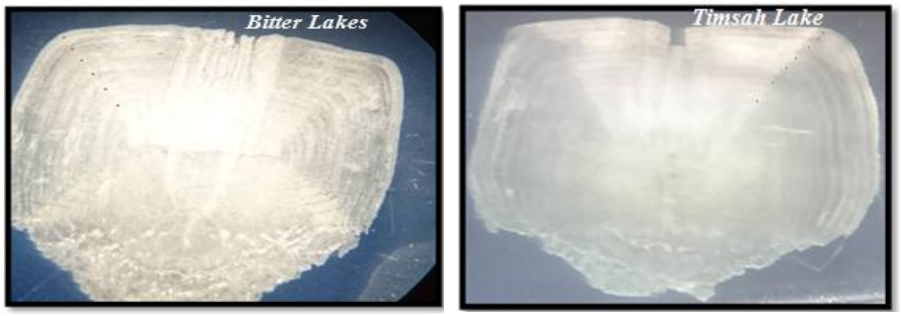

Fig. 3: Microscopic examination of a scale of *L. ramada* fish specimen from Bitter lakes Timsah Lake.

Table (2): Longevity of *L. ramada* from previous studies around the world.

Location	**Age (yr)**	**Author**
Mediterranean, Egypt	6	Rafail, 1968
Egypt (Burullus lake)	6	Hosny and Hashem, 1995
Morocco Tunsia Egypt	6 6 6	Kraiem *et al*., 2001
Wadi ElRaiyan, Egypt	8	EL-Gammal & Mehanna, 2004
Turkey	8	Gocer and Ekingen, 2005
Egypt (Bardawil lake)	5	Mehanna, 2006
Croatia	8	Glamuzina *et al.*, 2007
Egypt, (Timsah Lake) (Bitter Lakes)	5 5	Mehanna and EL-Gammal, 2007
Turkey	6	Kalay *et al*., 2008
Turkey	6	Kasimoglu *et al*., 2011
Libya	4	Khalifa *et al*., 2016
Bardawil lagoon	5 (males) 7 (females)	Mehanna *et al.*, 2019
Timsah lake **Bitter lakes**	**7** **6**	**Present study**

The estimated longevity values were found to be in the range given in the previous studies (Table 2). The reported longevity from these studies ranged from 4 years (in Libya), 5-8 years (in Egypt), 6 years (in Moroco, Tunsia, Egypt, Turkey) to 8 years (in Turkey) and these variations may be due to variations in environment and also variations in water quality parameters that may affect fish behavior.

Growth:

The back-calculated lengths at the end of each year of life were 21.63, 31.81, 39.50, 42.70, 44.91 and 47.0 cm at Bitter Lakes for 1st, 2nd, 3rd, 4th, 5th, and 6th year of life respectively and 21.31, 32.42, 40.13, 44.70, 47.01, 48.90 and 50.21 cm at Lake Timsah for 1st, 2nd, 3rd, 4th, 5th, 6th and 7th year of life respectively. The results indicated that *L. ramada* in both areas attains its highest growth rate in length during the first year then the annual increment gradually decreases during the following years.

The mean back calculated lengths were used for estimation of growth parameters of von Bertalanffy (1938) growth model using Ford (1933) – Walford (1946) method. The values of L∞, k, t_o for *L. ramada* were (49.48 cm, 0.48/ yr and -0.24 y) & (52.2 cm, 0.46/ yr and -0.18 y) in Bitter and Timsah Lakes respectively. It is clear from results that *L. ramada* population in Timsah Lake has a higher asymptotic length than that of *L. ramada* population in Bitter Lakes. The estimated values of L_∞ & K for *L. ramada* from previous studies around the world were given in Table (3). Mehanna and El-Gammal (2007) on *L. ramada* in Suez Canal Lakes have recorded relatively similar results of L∞ and K. On the other hand the results of the present study concerning L∞ were relatively near to the values recorded in previous studies worldwide while the values of K obtained in the present study were higher than that recorded in previous studies in different localities around the world (Hosny and Hashem, 1995; Stergiou *et al.,* 1997; Djabali *et al.,* 1993; Moura and Gordo, 2000; Kraiem *et al.,* 2001; Glamuzina *et al.,* 2007; Elawad *et al.,* 2016; Khalifa *et al.,* 2016; Mehanna *et al.,* 2019). These differences between values may be attributed to sampling method that affect sampled fish sizes and hence maximum length obtained during the investigation period.

Table 3: Estimated value of L_∞ & K for *L. ramada* from previous studies around the world.

Locality	L_∞ (cm)	Length used	K (/yr)	Author
Egypt (Burullus Lake)	56.0	TL	0.15	**Hosny and Hashem, 1995**
Greece	33.5	SL	0.35	**Stergiou *et al.*, 1997**
France	47.0	SL	0.15	**Djabali *et al.*, 1993**
Tunisia	47.8	TL	0.32	**Djabali *et al.*, 1993**
Portugal	51.3	TL	0.10	**Moura and Gordo, 2000**
Moroco	50.7	TL	0.20	**Kraiem *et al.*, 2001**
Tunisia	53.0	TL	0.21	**Kraiem *et al.*, 2001**
Egypt (Edku Lake)	54.6	TL	0.22	**Kraiem *et al.*, 2001**
Croatia	59.3	TL	0.14	**Glamuzina *et al.*, 2007**
Egypt (Bardawil lake)	44.1	TL	0.5	**Mehanna, 2006**
Egypt				**Mehanna and El-Gammal, 2007**
(Timsah Lake)	45.4	TL	0.45	
(Bitter Lakes)	44.9	TL	0.44	
Turkey	48.9	TL	0.21	**Kasimoglu *et al*., 2011**
Libya	35.4	TL	0.19	**Elawad *et al.*, 2016**
Libya	35.4	TL	0.19	**Khalifa *et al.*, 2016**
Bardawil lagoon				**Mehanna *et al.*, 2019**
Male	45.79	TL	0.40	
Female	49.92	TL	0.35	
Bitter lakes	**49.5**	**TL**	**0.48**	**Present study**
Timsah lake	**52.2**	**TL**	**0.46**	

Growth performance index:

The growth performance index was estimated to compare growth parameters obtained for the same species in different areas. The computed growth performance index for *L. ramada* was 3.06 and 3.09 at Bitter and Timsah lakes respectively. The $Ø'$ value obtained was consistent with that of Mehanna and El-Gammal, 2007 ($Ø'$ of *L. ramada* in Lake Timsah and Bitter Lakes were 2.97 and 2.95 respectively). On the other hand the results of the present study are inconsistent with that calculated by Elawad *et al.* (2016) as well as Khalifa *et al.* (2016) for *L. ramada* in Libya, where they found that $Ø' = 2.4$.

Mortality and exploitation Rates:

The estimated values of total mortality (Z) and natural mortality (M) coefficients from different methods as well as the values of fishing mortality (F) coefficient calculated from mean value of Z and M as well as the estimated values of exploitation ratio (E) was given in Table (4). The values of Z, M, and F of *L. ramada* were (2.54, 0.57 and 1.96 / yr.) and (2.05, 0.53 and 1.52 / yr) for Bitter and Timsah Lakes respectively. It is clear that the values of all the mortality coefficients "Z, M, F" of *L. ramada* population in the Bitter lakes are slightly higher than that of *L. ramada* population in Timsah Lake. Additionally both populations have higher fishing mortality than natural mortality that is an indication to overfishing. Also for the estimated values of exploitation ratios, it is noticed that the fishery of *L. ramada* in Bitter Lakes (0.77) is higher exploited than that of Timsah Lake (0.74 / yr) and both population are exceeded the optimum value suggested by Gulland (1971) where E=0.5; that is refers to an overexploited fish stocks.

Table 4: Estimated values of "Z, M, F and E" from different methods for *L. ramada* from Bitter and Timsah Lakes.

Method		***L. ramada***	
		Bitter lakes	**Timsah lake**
Total Mortality Coefficient (/ y)	Hoeing and Lawing (1982)	1.5	2.64
	Jones & van Zalinge (1981)	2.9	2.21
	Pauly (1983)	3.2	1.30
	Mean	**2.54**	**2.05**
Natural Mortality Coefficient (/ y)	Taylor (1960)	0.5	0.68
	Ursin (1967)	0.15	0.83
	Rikhter – Efanov (1976)	0.82	0.43
	Pauly (1980)	0.86	0.17
	Mean	**0.57**	**0.53**
Fishing Mortality Coefficient (/ y)		**1.96**	**1.52**
Exploitation Ratio (/ y)		**0.77**	**0.74**

These results are conflict with that estimated by Hosny and Hashem (1995) in Burullus Lake, Egypt who have estimated the values of Z, M, F and E as follow 0.67, 0.57, 0.10 and 0.15 respectively. Mehanna (2006) studied Z, M, F and E for *L. ramada* in Bardawil Lake and the estimated values were 1.22, 0.16, 1.06 and 0.87 / yr. respectively. Mehanna and El-Gammal (2007) have recorded Z, M, F and E for *L. ramada* in Suez Canal Lakes; Timsah and Bitter Lakes and the obtained results were relatively lower than that of the present study (1.52, 0.43 and 1.09 $year^{-1}$ respectively at Lake Timsah and the same parameters were 1.62, 0.43 and 1.19 $year^{-1}$ respectively at Bitter Lakes. Exploitation ratio was estimated as 0.72 and 0.74 $year^{-1}$ at Timsah and Bitter Lakes respectively. Also the results of the present study far from that of Elawad *et al.* (2016), whose found that Z, M, F and E equals 0.4, 0.2, 0.2 and 0.5 per year respectively for *L. ramada* in Benghazi Coast, Libya. Differences between values may

be due to different fishing activities exerted as well as changes in water quality parameters between different regions.

Length at first capture (L_c) and at first sexual maturity (L_{50}):

The resultant curve derived from the catch curve provided an estimate of L_c at 22.59 and 22.41 cm for *L. ramada* from Bitter and Timsah lakes respectively (Fig. 4). These values were corresponding to an age of 1.06 and 1.05 year for *L. ramada* from Bitter and Timsah lakes respectively. These results are similar to the findings of Mehanna and EL-Gammal, 2007; they estimated L_c equals 20.15 cm (0.97 yr) at Lake Timsah and 19.22 cm (0.98 yr) at Bitter Lakes.

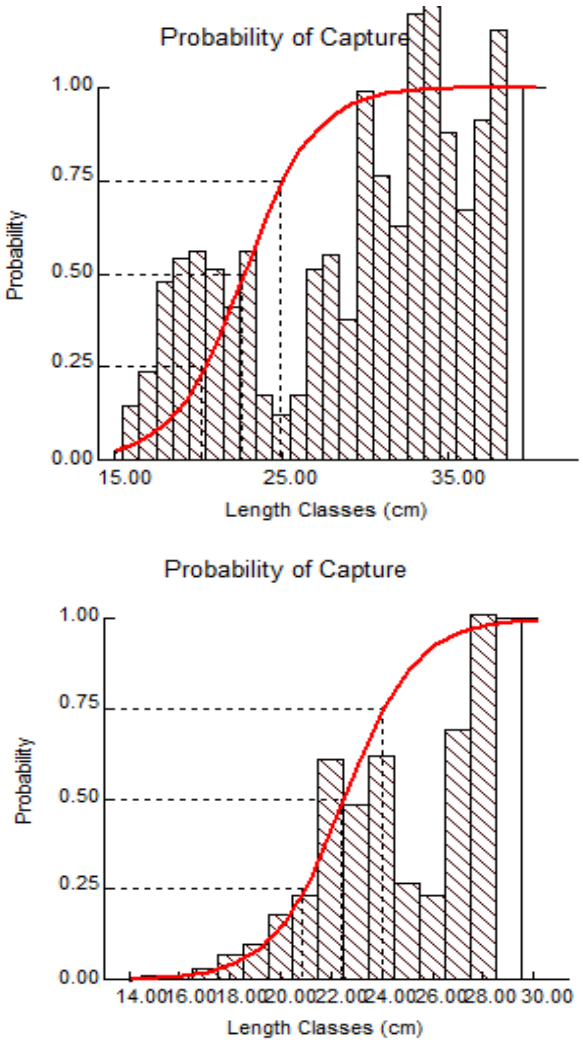

Fig. 4: Length at first capture of *L. ramada* from Bitter and Timsah lakes.

From the maturation curve (Fig. 5), the length at first sexual maturity was 30.1 and 34 cm for *L. ramada* in Bitter and Timsah Lakes respectively. This length corresponds to 1.75 and 2.14 years for *L. ramada* from Bitter and Timsah lakes respectively. Mehanna and EL-Gammal, 2007 have estimated L_{50} equals 26.34 cm (1.60 year) at Lake Timsah and 25.22 cm (1.58 year) at Bitter Lakes, both values are lower than that recorded in the present study.

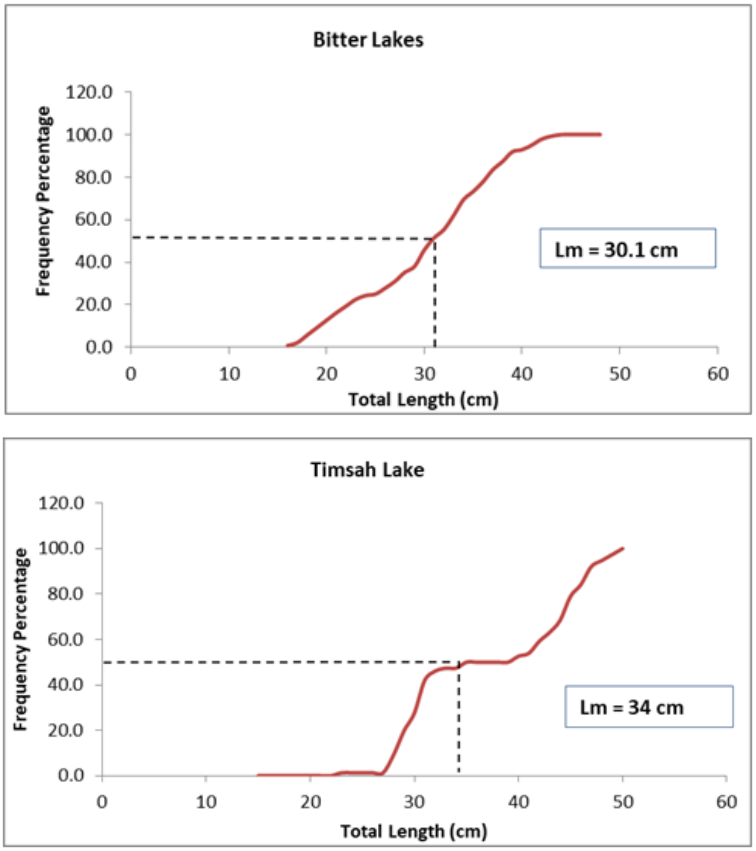

Fig. 5: Length at first sexual maturity of *L. ramada* from Bitter and Timsah lakes.

It is obvious that *L. ramada* from Bitter lakes become mature at lower age than *L. ramada* of Timsah Lake. On the other hand, it is found that Lc values (22.59 & 22.41 cm) are smaller than L_{50} values (30.1 & 34 cm) for *L. ramada* in both investigated areas; Bitter and Timsah Lakes respectively which means that the population of *L. ramada* in both investigated areas undergo severs fishing activities that prevent them from spawning before caught by fishermen and Lc values for both population should be increased to allow fish individuals escaping from fishing nets and give them a chance to spawn at least once during their life span.

Relative Yield per Recruit:

Relative yield per recruit model applied for *L. ramada* in Suez Canal lakes were shown in Fig. (6). The maximum (Y/R)' was obtained at E_{max} = 0.68 and 0.62 at Bitter and Timsah Lakes respectively. The obtained values of $E_{0.1}$ (the level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E) were 0.60 and 0.51 for *L. ramada* from Bitter and Timsah lakes respectively. $E_{0.5}$ (the exploitation level which will result in a reduction of the unexploited biomass by 50%) were estimated at 0.36 and 0.35 at Bitter and Timsah lakes respectively. The results showed that, the level of exploitation rate (E = 0.77) at Bitter lakes and (E = 0.74) at Timsah lake, length at first capture (L_c = 22.6 cm) at Bitter lakes and (L_c = 22.4 cm) at Timsah lake didn't achieve the maximum relative yield per recruit and the present levels of E and F are higher than that gives the maximum (Y/R)' for *L. ramada* in both region and greatly higher than those would conserve 50% of the spawning biomass for *L. ramada* in both region so the current exploitation rate must be reduced from 0.77 to 0.36 (53.2 %) at Bitter Lakes and from 0.74 to 0.35 (52.7 %) at Timsah Lake.

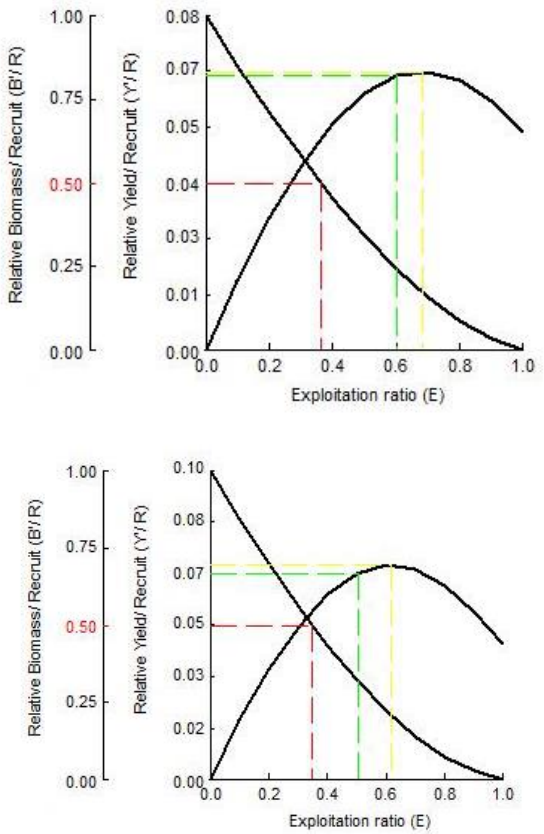

Fig. 6: Relative yield per recruit analysis for *L. ramada* from Bitter and Timsah lakes.

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