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Age, Growth and Mortality of *Liza carinata* Valenciennes, 1836 (Pisces: Mugilidae) in Bitter Lakes, Suez Canal, Egypt

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ABSTRACT

The longevity, growth and mortality parameters of keeled mullet *Liza carinata* population in the Bitter Lakes, Suez Canal, Egypt were estimated during the period from December 2016 to November 2017. The estimated length-weight relationship for combined sexes (♂♀) was $W= 0.0177\ L^{2.8115}$. The longevity of this species was estimated to be 4 years. The highest growth rate in length was recorded in the first year of life (66.35 %). Growth for both sexes was described by the von Bertalanffy equation as: $L_t = 23.5\ (1\text{-}e^{-0.42\ (t+1.07)})$ for growth in length; $W_t = 128\ (1\text{-}e^{-0.42\ (t+1.07)})^{2.8}$ for growth in weight. Based on these growth parameters, the total mortality (Z) was estimated to be 2.56 y^{-1}. The estimated values for natural mortality (M) and fishing mortality (F) were 0.51 y^{-1} and 2.05 y^{-1} respectively. The estimated value of the exploitation rate (E) was 0.8 y^{-1}. All the results refers to that the *L. carinata* stock in the Bitter Lakes, Suez Canal suffer from high rates of fishing effort exceeding that gives maximum sustainable yield and consequently a depleted stock.

INTRODUCTION

Estimating age and growth of fish population is a prerequisite to generate the information on recruitment, longevity, mortality and fluctuations in fishery caused by various year classes; all of which can contribute towards planning for a rational exploitation of these fish stocks. Such studies with proper statistical refinements are helpful in describing the present status and past history of a fish population. Mortality is an essential parameter in understanding the dynamics of any fish population. Without knowledge of how fast individuals are removed from a population it is impossible to model the population dynamics or estimate sustainable rates of exploitation or other useful management parameters. Knowledge of all these parameters is essential in the development of fisheries (Gulland, 1969; Sparre *et al*., 1989; Khan and Khan, 2014; Quist and Isermann, 2017).

Mullets are a group of fishes under family: Mugilidae and order: Mugiliformes. Members of family Mugilidae are medium to large-sized fishes; elongate with subcylindrical body. They are widely distributed in both tropical and temperate seas. Mullets are distributed along the sea coast, lagoons, lakes, and in the estuaries. They are chiefly marine (coastal) and brackish water; some in freshwater. They are landed

throughout the year where they are a valuable source of food-fishes (Nelson 2006; Rajan, 2018).

Mullets are one of the most important fish groups in the Suez Canal; contributing by 12 % of the total catch. The species composition of Mullet fish group in the Suez Canal as well as Bitter and Timsah Lakes were represented by four species; *Mugil cephalus*, *Liza carinata*, *L. ramada*, and *L. aurata*. The Mullet, *Liza carinata is* commonly known as keeled mullet and locally known as Sehlia is colonized the Mediterranean Sea by Lessepsian migration from the Red Sea through the Suez Canal. The keeled mullet is the target of the commercial fishery along the Bitter Lakes, Suez Canal, forming a significant component of the catch. There is a high market demand and so premium prices on keeled mullet in Bitter Lakes, Suez Canal, Egypt (Mehanna, 2004; Crosetti *et al.*, 2015; GAFRD, 2016 and Shakman, *et al.*, 2016).

The aim of the present study was to estimate the fundamental parameters for evaluating fish population demographics and dynamics; growth and mortality parameters of one of the main target species; *L. carinata* in one of the most important fishing areas as well as the largest water body along Suez Canal; Bitter Lakes.

MATERIALS AND METHODS

Collection and investigation of fish samples

Bitter Lakes (30° 20` N, 32° 23` E) is the largest water body along Suez Canal. It is divided into Great and Little Lakes, together having a surface area of about 250 km^2. Both Great and Little Bitter Lakes have a main landing site; Fanara (Fig. 1.) upon which the small artisanal fishing boats are landed and selling their yield.

Fig. 1: A map of Suez Canal Lakes with a larger view to Bitter Lakes and Fanara Fishing Harbor.

Samples were collected monthly from Fanara landing site during the period from December 2016 to November 2017. Samples were taken to the laboratory, investigated accurately for removing any other mullet species in the samples and after classification, *L. carinata* sample were classified into length groups and a subsample was taken from each length group. Finally the following measurements were taken for each specimen; the total length "TL" (cm) and total weight "W" (g). The sex and maturity stage for each fish specimen were determined. Fish scales were taken and preserved for using in age determination.

Length – Weight Relationship (LWR)

Length - Weight relationship was calculated using the equation $W = a L^b$ (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.

Age Determination:

The age was determined directly by the examination and counting of annual growth rings on scales of fish specimens. The total radius of the scale "S" and the distance between the focus of the scale and the successive annuli were measured. The relationship between scales radius (S) and total fish length (TL) was determined according to the formula TL = a + b (S). The back-calculated lengths at the end of each year of life were estimated by Lee (1920) equation as follows:

$\mathbf{L_n = (L - a) S_n / S + a}$ where "L_n" is the calculated length at the end of n^{th} year, "L" is the length at capture, "S_n" is the scale radius to n^{th} annulus, "S" is the total scale radius and "a" is the intercept of the regression line with the Y-axis.

Growth Parameters and Growth Performance Index:

L. carinata growth was described by the equation: $\mathbf{L_t = L\infty\ (1 - e^{-k(t-to)})}$ (von Bertalanffy, 1938) where L_t = predicted length at time t; $\mathbf{L\infty}$= asymptotic length or maximum attainable length; e = Base of the natural log t; t = Time; t_o = The age at zero length; K = growth coefficient.

Von Bertalanffy growth parameters "L∞ and K" were estimated by applying Chapman (1961) method. "t_o" was estimated from the following rearranged formula of the von Bertalanffy equation: $\mathbf{- ln [1 - (L_t/L_\infty)] = - k*t_o + k*t}$.

Pauly and Munro (1984) formula was applied to estimate the growth performance index 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 and Exploitation Ratio:

The three types of mortality coefficients; Total (Z), natural (M) and fishing (F) mortality were estimated. "**Z**" was computed using the methods of Jones and Van Zalinge (1981), Pauly (1983) as well as Hoenig and Lawing (1982). "**M**" was computed using Taylor (1960), Ursin (1967), Rikhter and Efanov's Empirical Model (1976) as well as Pauly (1980) methods. "**F**" was calculated from the equation:
F = Z - M. The exploitation ratio "**E**" was estimated using the equation **E = F / Z** (Gulland, 1971).

RESULTS AND DISCUSSION

Length – Weight Relationship (LWR):

Estimated length weight relationship (Fig. 2) was applied for 1263 specimens of *L. carinata* combined sexes from Bitter lakes. *L. carinata* specimens varied in total lengths (TL) from 9.1 to 21 cm and in total weights (W) from 9 to 96 g. The obtained LWR for *L. carinata* in Bitter Lakes was $W = 0.0177L^{2.8115}$ **(**$R^2 = 0.9325$).

The results of LWR of the previous studies are summarized in Table (1). The values of coefficient "b" obtained in this study are similar to that of Taskavak and Bilecenoglu (2001) in the Mediterranean Sea and Hakimelahi *et al.* (2010) in Bersian Gulf and Hussain *et al*. (2010) in Northern Arabian Sea as well as Hefny *et al*. (2016) in Suez Bay and lastly lower than the values recorded by Mehanna (2004) in Bitter Lakes. The parameters of length-weight relationships may be affected by various factors, such as time of sampling, food availability, environmental conditions, differences in age, stage of maturity as well as sex (Mehanna *et al.*, 2019).

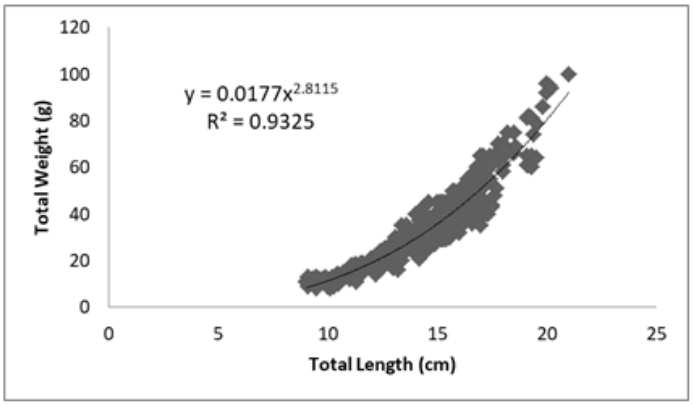

Fig. 2: Length – Weight Relationship of *L. carinata* from Bitter Lakes.

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

Locality	Sex	a	b	Reference
Mediterranean Sea	♂♀	0.0022	2.864	**Taskavak and Bilecenoglu, 2001**
Bitter lakes	♂♀	0.0094	3.0479	**Mehanna, 2004**
Bersian Gulf	♂♀	0.0214	2.823	**Hakimelahi *et al.*, 2010**
Northern Arabian Sea	♂♀	0.0887	2.205	**Hussain *et al.*, 2010**
Suez bay	♂	0.034	2.56	**Hefny *et al.*, 2016**
	♀	0.012	2.94	
Bitter lakes	♂♀	**0.0177**	**2.8115**	**Present study**

Age and Growth

Investigation of *L. carinata* scales revealed that *L. carinata* fish population in Bitter lakes have a maximum life span of 4 years. The previous available studies recorded a maximum life span of *L. carinata* of 3 years (Mehanna, 2004 in Bitter Lakes). This variation may be due to variations in the maximum length of fish specimens obtained during the investigation period between different studies.

Growth in lengths and weights at the end of each year of life were represented in Fig. (3). The mean back-calculated total lengths corresponding to various age groups for *L. carinata* at Bitter Lakes were 13.8, 17.1, 19.5 and 20.8 cm for 1st, 2nd, 3rd and 4th year of life. Additionally the annual increment in length were 13.8 (66.4 %), 3.3 (15.9), 2.4 (11.6 %) and 1.3 cm (6.2 %) for 1st, 2nd, 3rd, and 4th year of life.

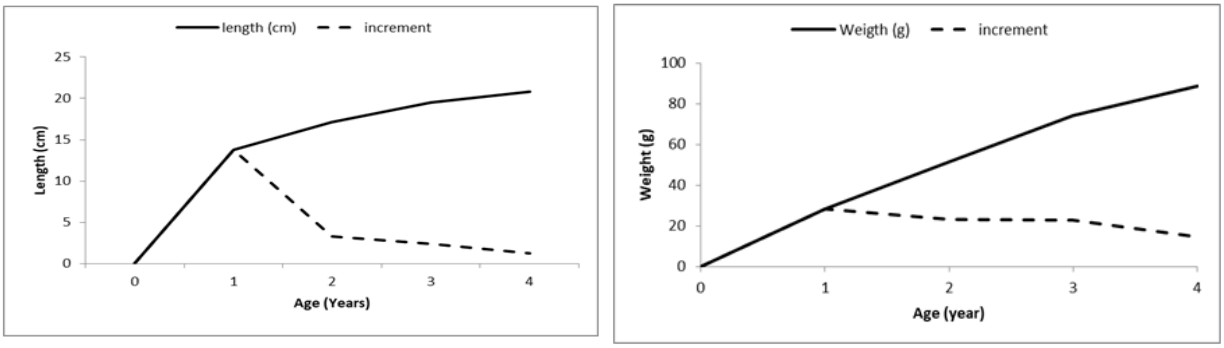

Fig. 3: Growth in length and weight as well as annual growth increment of *L. carinata* from Bitter lakes.

On the other hand, calculated weights at the different years of life were 28.4, 51.5, 74.3 and 88.6 g for 1st, 2nd, 3rd and 4th year of life. These findings revealed that *L. carinata* from Bitter Lakes attainted its highest growth rate in the first year of life,

whereas in the following years, the rate of growth slows down and that is agreed with Mehanna (2004) for *L. carinata* in Bitter lakes.

The estimated growth parameters (L∞ & K) using Chapman (1961) method (Fig. 4) for combined data of *L. carinata* in Bitter Lakes as well as the value of t_0 estimated from von Bertalanffy plot (Fig. 5) were embedded in von Bertalanffy's growth model and the obtained equations were as follow:-

For growth in length: $Lt = 23.5\ (1\text{-}e^{-0.42\ (t+1.07)})$; L_t is the length at age t.

For growth in weight: $Wt = 128\ (1\text{-}e^{-0.42\ (t+1.07)})^{2.8}$; W_t is the weight at age t.

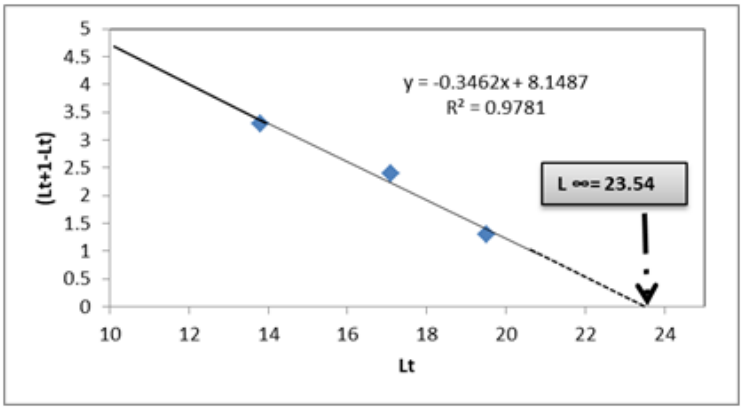

Fig. 4: Estimation of "L∞ & K" from Chapman method for *L. carinata* of Bitter Lakes.

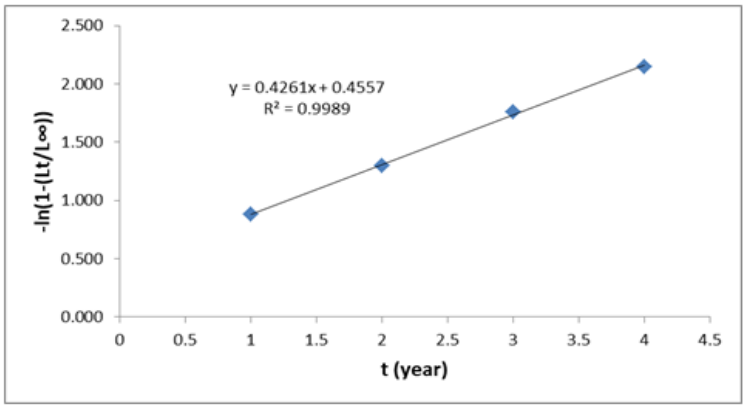

Fig. 5: Von Bertalanffy plot of *L. carinata* from Bitter lakes for estimating "to" of *L. carinata* from Bitter Lakes.

The only previous study dealing with the estimating of growth parameters in the same area was that of Mehanna (2004) and gave nearly similar results:
for growth in length: $Lt = 23.59\ (1 - e^{-0.6\ (t\ +0.3)})$, and for growth in weight: $Wt = 143.57\ (1 - e^{-0.6\ (t\ +0.3)})^{3.04}$].

The estimated growth parameters of the present study were easy compared to those of previous studies of the same species in different regions by using the growth performance index (Ø'). This index is used to measure the overall growth performance. The present study reported Ø' of *L. carinata* in Bitter lakes equals 2.37. The Ø' value of the present study were similar to the calculated values in the previous studies; Mehanna (2004) (Ø' = 2.52 for *L. carinata* in Bitter Lakes).

Mortality Parameters and Exploitation Rate:

The loss to *L. carinata* population in Bitter Lakes was expressed from the estimation of mortality coefficients (M, F and Z). The estimated Z, M and F from different methods are given in Table (2). The mean value of the total mortality

coefficient estimated from three different methods for *L. carinata* combined sexes was 2.56 y^{-1}. The mean values of natural mortality coefficient from different methods was 0.51 y^{-1}. The fishing mortality coefficient was 2.05 y^{-1}.

Table 2: Estimated values of "Z, M, F and E" from different methods for *L. carinata* from Bitter Lakes.

Method		***L. carinata* in Bitter Lakes**
Total Mortality Coefficient (/ y)	Hoeing and Lawing (1982)	2.67
	Jones & van Zalinge (1981)	2.54
	Pauly (1983)	2.47
	Mean	**2.56**
Natural Mortality Coefficient (/ y)	Taylor (1960)	0.42
	Ursin (1967)	0.31
	Rikhter – Efanov (1976)	0.56
	Pauly (1980)	0.77
	Mean	**0.51**
Fishing Mortality Coefficient (/ y)		**2.05**
Exploitation Ratio (/ y)		**0.8**

Accordingly, the exploitation rate (E) was computed as 0.8 y^{-1}. Gulland (1971) reported that the optimum exploitation rate of any exploited fish stock is 0.5 y^{-1}, so the high values of the present exploitation rate and fishing mortality revealed an excessive fishing effort exerted into the *L. carinata* in Bitter Lakes. The estimated mortality coefficients "Z, M and F" of the present study were relatively lower than that reported in the previous studies; Mehanna (2004) was gave Z, M, F and E equals 4.2, 0.96, 3.24 and 0.67 y^{-1} for *L. carinata* in Bitter Lakes.

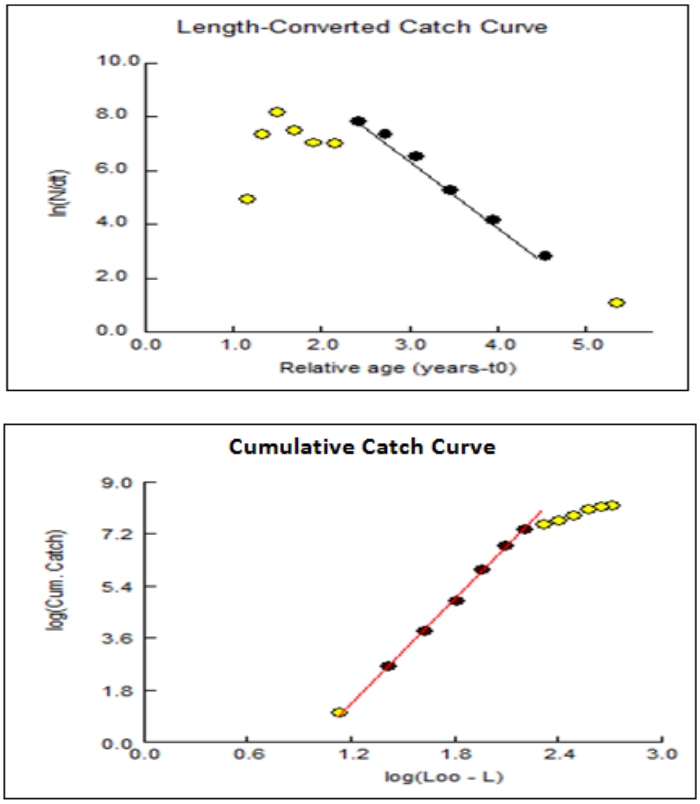

Fig. 6: Length converted catch curve and cumulative catch curve for estimating "Z" of *L. carinata* from Bitter Lakes.

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