International Journal of Fisheries and Aquatic Research
ISSN: 2456-7248
Impact Factor: RJIF 5.44
www.fishjournals.com
Volume 2; Issue 6; November 2017; Page No. 29-33

On the biology of *Terapon puta* (Cuvier, 1829) in the bitter lakes, Egypt

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Abstract
The present work was carried out to study the age, growth, length-weigh relationships, spawning season, length at first sexual maturity and mortality of the commercial small scaled fish *Terapon puta* in the bitter lakes, Egypt. Fish samples which were collected during the period from January to December 2014 were selected to represent all fish size categories in the catch. Each fish specimen was measured, weighted and then dissected to detect the maturity stage of the gonads.
The length-weight relationships were estimated for males and females as: $W = 0.021606 \times L^{2.90}$, $W = 0.020092 \times L^{2.92}$ respectively. The age data derived from the scale readings were used to estimate the growth parameters of the von Bertalanffy growth equation. The estimated parameters were: $L\infty = 20.4$ cm, $K = 0.26128$ and $t_o = -1.325577$ for males and $L\infty = 20.7$ cm, $K = 0.26189$ and $t_o = -1.316511$ for females.
It was found that, the small scaled fish matured at a total length of about 11.5 cm. The natural spawning period of this fish species is in the summer, from May to July.
The annual rates of total, natural and fishing mortality were calculated as 0.8840, 0.2214 and 0.6626 yr–1 respectively. Current exploitation rate 'E' was estimated at 0.75.

Keywords: *terapon puta*, bitter lakes, growth, length weight, mortality

Introduction
The great Bitter Lake is one of several lakes located along the Suez Canal, which connects the eastern Mediterranean and Red Sea via the Suez Canal. This lake is a saltwater lake in Egypt; it is connected to the Small Bitter Lake, through which the canal also runs. The bitter lakes are one of the most important fishing area on which the cities of the Suez Canal in obtaining fish from them.
Terapon puta belong to the family Teraponidae is a medium size food fish which inhabits the sea in Egyptian coasts. *Terapon puta* are lived Indo-West Pacific: northern Indian Ocean and the Indo- Australian Archipelago (Quratulan and Semra, 2015) [1]. A lessepsian migrant, now prevalent in the Mediterranean (Golani *et al*., 2002) [2] and adults inhabit coastal waters, entering brackish estuaries (Allen and Swainston, 1988) [3]. *Terapon puta* could be in also in fresh waters (Sommer *et al*., 1996) [4]. They are feed on fishes and invertebrates. *T. puta* are mainly found in shallow water and can be considered as one of the most successful Lessepsian fish.
Although the broad distribution of this species along the indo-pacific waters, modest information on its biological character has been reported by Ben-Tuvia (1986) [5] in Bardawil lagoon, Egypt; Paxton *et al*. (1989) [6] in Australia studied the general biology of *T. puta*; Alwany and Hassan (2008) [7] studied the relationship between otoliths size and the fish body size of *T. puta* from the Gulf of Suez, Egypt; Nandikeswari *et al*. (2013) [8] studied sex ratio and the population characteristics of *T. puta* in India; Karna and Panda (2012) [9] studied Length-Weight Relationship of *Terapon puta* in Chilika Lagoon, Odisha (India) and Quratulan and Semra (2015) [1] studied Length-Weight Relationship of *Terapon puta* in Karachi Fish Harbour. The main aim of the present study was to shed light on some biological and dynamic features of the *Terapon puta*. Using such information is essential for the management and the good accuracy of the fishing in the Bitter lakes.

Materials and Methods
As regards to 460 specimens of small scaled fish, *Terapon puta*, were collected monthly around 2014, from the landing site at Bitter lakes. Fishes were put immediately in crushed ice and transported to the laboratory, where they were subjected investigation.

Fig 1: Showing Great Bitter Lake (study area)

The body length–scale radius relationship was determined using the least square method. The back calculated lengths at

the end of each year of life were obtained by using Lee's equation (Lee, 1920)

$$Ln = S_n (L - a) / S + a$$

Where (Ln) is the calculated lengths at the end of (n) year, (L) is the fish length, (Sn) is the distance from the scale focus to the successive annuli, (S) is the total scale radius and (a) is the intercept of the regression line on the (Y) axis.

Length–weight relationship was obtained since the total weight of each fish specimen was given with a digital balance to an accuracy of 0.01 g and total length was measured with a precision of 0.01 cm. This relationship is usually expressed by the equation:

$$W = a L^b$$

Where (W) is the total body weight in g, (L) is total length in cm; (a) is coefficient related to body form and (b) is an exponent indicating isometric growth when it is equal to three. Growth was expressed in terms of the von Bertalanffy equation

$$L_t = L\infty (1 - e^{- k (t - to)})$$

Whereas (L) is the asymptotic total length, (Lt) is the total length at age (t), (k) is the growth curvature parameter and (t_0) is the theoretical age when fish is at zero total length. These growth parameters were estimated by means of von Bertalanffy plot (Sparre and Venema, 1992) [12].

To determine the length at first maturity, males and females were grouped into 10 mm size groups and the percentage occurrence of fish at the different maturity stages in each size group was calculated.

The sex and maturity stage of each specimen were determined by visual and microscopic examination of the gonads. The gonado-somatic index (GSI) was calculated monthly by the equation:

$$GSI = \text{Gonad weight/Gutted weight x100}$$

Total mortality rate (Z) was estimated based on the length at first capture methods evaluated by Beverton and Holt (1957).

$$Z = K * (L\infty - Lm / Lm - L c)$$

Where:

Lm = The average total length of the entire catch.

Lc = The length at which 50% of the fish entering the gear are retained (Sparre *et al*, 1989) [14].

Instantaneous natural mortality rates (M) were estimated using the equation derived by Ursin (1967) based on the mean total length where :

$$M = W^{-(1/b)}$$

W = mean total length.

b = constant of length weight relationship.

Fishing mortality rates (F) were calculated as the difference between Z and M (Z = F + M). The value of the average annual exploitation rate (E) was obtained by E = F/Z (Sparre *et al*, 1989) [14].

Results

Off the 460 of *Terapon puta* specimens obtained From the Bitter lakes, 235 were females (51.09%) and 225 males (48.91%). Total length of the specimens was ranged from8.0 to 16.7 cm whereas total weight of the specimens was varied between10.17 and 69.90 g.

Growth in Length

The relationship between the scale radii and the total fish lengths of both sexes of *Terapon puta* showed direct proportional one with high correlation presented in the following equations.

L = 4.36968 + 1.45184 S $r^2 = 0.987$ for female
and L = 4.35185 + 1.48148 S $r^2 = 0.986$ for male.

From these equations the calculated lengths at the end of every year of life were computed by back calculations according to Lee's formula:

Ln = Sn (L – 4.36968) /S + 4.36968 for female and
Ln = Sn (L – 4.35185) /S + 4.35185 for male.

The results indicated that the natural life of the studied fish species is only four years. The observed lengths and growth increments of both sexes were presented in (Tables, 1&2).

Table 1: Back calculated lengths at the end of each year of life of female *T. puta* from the Bitter lakes.

Age group	Mean number	Observed Length cm.	Back calculated lengths in cm			
			1	2	3	4
0^+	46	8.2	8.5			
I^+	69	11.4	8.7	11.2		
II^+	80	15.2	8.9	12.3	14.5	
III^+	40	16.4	9.2	12.1	15.2	16.4
Average total	235		8.8	11.9	14.9	16.4
Increment			8.8	3.1	2.0	1.5
Increment %			53.6	18.9	12.2	9.14

Table 2: Back calculated lengths at the end of each year of life of male *T. puta* from the Bitter lakes.

Age group	Mean number	Observed Length cm.	Back calculated lengths in mm			
			1	2	3	4
0^+	55	8.0	8.4			
I^+	61	11.7	8.0	11.0		
II^+	66	14.5	8.7	11.7	13.7	
III^+	43	16.2	8.5	11.8	14.8	16.5
Average total	225		8.4	11.5	14.3	16.5
Increment			8.4	3.1	2.8	2.2
Increment %			50.9	18.8	16.9	13.3

The growth parameters calculated on the basis of von Bertalanffy growth equation was:

$L\infty$= 20.7 cm, K = 0.26189 and t_o = -1.316511 for females and
$L\infty$ = 20.4 cm, K = 0.26128 and t_o = -1.325577 for males.

The calculated and observed total lengths at age data are presented in table (3). The observed lengths and growth increments of both sexes are similar at different year of life. *Terapon puta* attained more than 50 % of its maximum size during the first year of life (i.e. rapid growth occurs at the first year of life). After the completion of the first year, the annual growth rate ranged between3.1 and 1.5 cm.

Table 3: Total length at age values (mm) of small scaled *T. puta* from the Bitter lakes.

Age Mean observed length Calculated (Von Bert.) Back calculated					
Groups Female	**Male**	**Female**	**Female**	**Male**	**Male**
0^+ 8.2	8.0	9.42	9.29	8.8	8.4
I^+ 11.4	11.7	12.01	11.84	11.9	11.5
II^+ 15.2	14.5	14.02	13.81	14.9	14.3
III^+ 16.4	16.2	15.60	15.32	16.4	16.5

Length-Weight Relationship

The length-weight relationships were evaluated separately for males and females of *Terapon puta* and presented in figures (2, 3). The exponent b demonstrated negative allometric growth. The equations for the relationships were:

$W = 0.020092 \times L^{2.92}$ for females ($r^2 = 0.98$) and

$W = 0.021606 \times L^{2.90}$ for males ($r^2 = 0.98$)

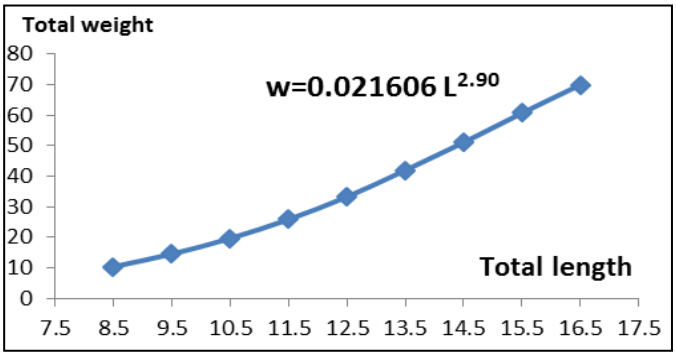

Fig 2: Length- weight relationship of male *Terapon puta* off Bitter Lakes in Egypt

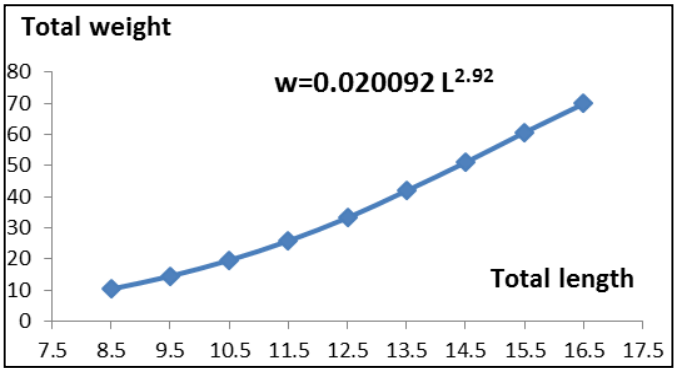

Fig 3: Length- weight relationship of female *Terapon puta* off Bitter Lakes in Egypt

Sex Ratio and Maturation

The mean sex ratio around all the studied period of female to male was 1.095:1.00. During the period of January to May, the data of sex ratio for each month showed that the number of female exceeded the number of male. The proportion of male is highest during the months of June to August. Almost all the monthly samples were contained more females than males as shown in table (4).

Table 4: Showing sex ratio of *T. puta* month wise. off Bitter Lakes in Egypt.

Months	No.of fish	Male		Female		Ratio	
		No.	%	No.	%	Male	Female
January	33	15	45.45	18	54.54	1	1.20
February	37	17	45.95	20	54.05	1	1.18
March	38	16	42.10	22	57.89	1	1.38
April	39	18	46.15	21	53.84	1	1.67
May	44	20	45.45	24	54.54	1	1.20
June	43	22	51.15	21	48.84	1	0.95
July	40	20	50.00	20	50.00	1	1.00
August	36	18	50.00	18	50.00	1	1 .00
September	35	18	54.29	17	48.57	1	0.89
October	38	21	55.26	17	44.73	1	0.81
November	43	23	53.49	20	46.51	1	0.87
December	34	17	50.00	17	50.00	1	1.00
Total	460	225	48.91	235	51.08	1	1.095

The GSI results revealed that fish spawning occurred at July in the Bitter Lakes, when the GSI for both sexes reached its highest level (Fig.4).

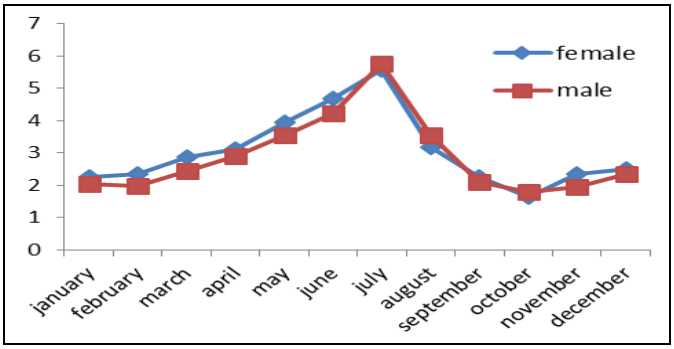

Fig 4: Monthly changes in the Gonadosomatic Index of both sexes of *Terapon puta* off Bitter Lakes in Egypt

Length at first maturity

Examination of the male and female maturity stages indicated that females and males of *Terapon puta* matured at 11.5 cm total length (at the age group 1^+) (Fig. 5).

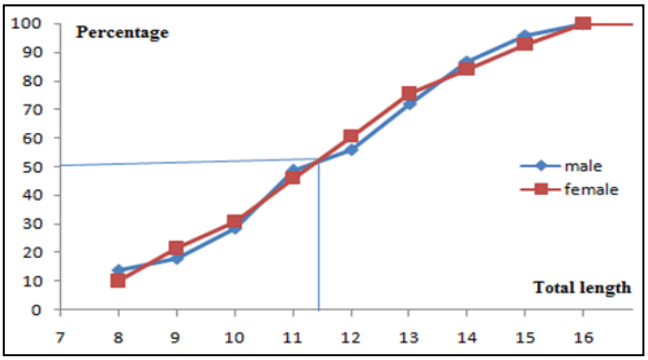

Fig 5: Length at first sexual maturity of both sexes of *Terapon puta* off Bitter Lakes in Egypt

Mortality Rates

The total mortality coefficient (Z) was found to be 1.7039 $^{year-1}$. But the Natural mortality coefficient "M" which obtained from the mean total length was 0.42453 $^{year\ -1}$. Using the estimated (M) and (Z) the fishing mortality (F) was obtained (1.40754 $^{year-1}$), where Z=M + F.

Exploitation Rate (E)

The current exploitation rate "E" was estimated at 0.75. Accordingly, the high value of the current exploitation rate indicates that the stock of *T. puta* in the Bitter Lakes is subjected to overfishing.

Length at First Capture (Lc)

The length at first capture L50% (the length at which 50% of the fish are first exposed to capture) was estimated as a component of the length converted catch curve analysis (FiSAT), was found to be 10.8 cm which corresponds to an age group I^+.

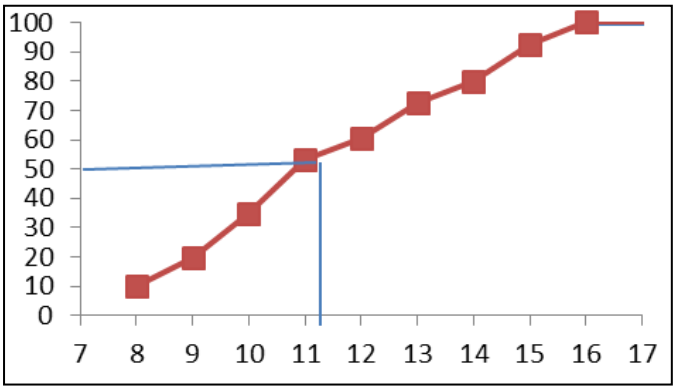

Fig 6: Cumulative curve from which length at first capture was determined

Discussion

Terapon puta is one of the most important and desirable commercial fish spread throughout the Suez Canal. It is also considered one of the most successful Lessepsian fish now prevalent in the Mediterranean Sea (Golani *et al*., 2002) [2]. The age is essential to assess population dynamics and the state of exploited resources (Shakman *et al*, 2008) [16]. *Terapon puta* is a short life span fish, so it is exhibited a relatively high growth rate in the first year of life. The maximum ages for males and females of *Terapon puta* were observed at four years in the present study. However, Sabrah *et al* (2016) [17] stated that, the maximal age of *Terapon puta* were three years in the Bitter lakes, Egypt. These differences between the age groups may be returned to the way of samples collection and its length range or the method used in age determination (Bariche, 2005) [18]. The largest individuals caught in the Bitter Lakes were 16.7 cm, Similar observation was made by Sabrah *et al* (2016) [17] also Allen and Swainston (1988) [3] reported 16.0 cm as a maximum total length of *Terapon. puta* in Australia.

The growth parameters of a commercially important fish species, *Terapon puta* was studied in the great Bitter lakes, Egypt. The maximum theoretical length (L∞) is found to be 20.4 cm. for males and 20.7 cm. for females. While Sabrah *et al*., (2016) [17] concluded that the maximum theoretical length (L∞) of *Terapon puta* was 17.5 cm. in the Bitter Lakes, 15.5 cm. in Lake Timsah and13.1cm. in the Suez Bay. The differences between parameters of the von Bertalanffy growth equation in different locations may be resulted from different factors such as sampling, ageing method used or even geographical differences of habitats and fish condition.

In the present investigation the length-weight relationship of *Terapon puta* from the Bitter lakes coast has been studied. This relationship is an important fishery management tool and it is helpful for converting length measurements into weight estimates to provide some measure of biomass (Froese, 1998) [19] and are also important for comparative growth studies (Moutopoulos and Stergiou, 2002) [20].

The present study revealed that the calculated values of exponent 'b' for length and weight relationship of both males and females of *Terapon puta* were lesser than 3. It was 2.90 for males and 2.92 for females, these values of correlation coefficient indicated that the growth of *Terapon puta* in the Bitter lakes is negative allometric (b < 3). Similar results was made by Sabrah *et al*., (2016) [17] in the Lake Timsah and Bitter lakes and Nandikeswari & Sambasivam (2016) [21] from Puducherry Eastcoast of India. The previous information is in agreement with the present findings on the length-weight relationship of *Terapon puta*.

Gonado-somatic index has been considered as reliable estimate for gonad maturity and spawning of any species (Sabrah *et al*, 2016) [17]. The gonado-somatic index increased with the maturation of fish and reaches to its maximum at the peak period of maturity. Its abrupt decrease indicates the beginning of spawning (Mishra and Saksena, 2012) [22].

The present consequences revealed that the *Terapon puta* is a summer spawner. Ben-Tuvia (1986) [5] concluded that *T. puta* have one clear seasonal peak per year and the spawning season occurred in June, July and August in Bardawil lagoon, Egypt. Similar observation was made by Nandikeswari and Anandan (2013) [8], they reported that *T. puta* has spawning period beginning from March to October in India and Sabrah *et al*, (2016) [17] which concluded that the *T. puta* is a summer spawner.

The sex ratio of females to males for all individuals of *Terapon puta* was about 1.095: 1. While Nandikeswari, *et al*., (2013) [8] concluded that the overall sex ratio of male to female is 1.06: 1 with chi-square value. These changes in percentage of females to males were most probably due to spawning and feeding migration (Yeldan and Avşar, 2000) [24]. The increase in ratio of females in January to May and the decrease of such ratio in September until November may be due to feeding migrations. In the other hand, the relatively equal percentage in June, July, and August which is accepted as spawning period, all population members come together and form sex ratio of about 1 : 1 (spawning migrations).

The present study revealed that the examination of the male and female maturity stages indicated that females and males of *Terapon puta* matured at 11.5 cm total length (at the age group 1^+). Age and length at first maturity have extensive implications for studying population and ecology of community. Growth of a fish species is also density dependent i.e., increase in population size may have led to a decrease in per-capita food availability and, consequently a decrease in

the length at first maturity (Bigler *et al*., 1996) [25]. Determination of length at first maturity of the fish is required by most of models of stock assessment to estimate fishing mortality and population of spawning stock.

The exploitation rate of *Terapon puta* in the present study (E=0.75) is higher than 0.50. of Gulland which concluded that as a rule of thumb a fish stock is optimally exploited at a level of fishing mortality equal the natural mortality (F=M).Therefore, the stock of small scaled fish (*Terapon puta*) from the Great Bitter Lakes is being acutely over-exploited

Conclusion

This research provides information on the main biological aspects of commercially important fish species (*Terapon puta*) in the Great Bitter lakes, Egypt. Accordingly, the presence of a 0^+ age group in the samples of this study was probably due to the unselectively of the cod-end used in the trawl nets. However, the low levels of the older age groups after the age group 2^+ cannot be related to selectivity, and are more likely to be the result of very intensive fishing activities.

The investigation could powerfully ready to lend a hand to the researchers and policy makers for the preparation of very useful sustainable management plans of fishery resources of the Bitter Lakes.

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