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Research Article

Study of some biological traits and population dynamics of the European sea bass from Bardawil Lagoon, Sinai, Egypt

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Abstract

Random samples of European sea bass, *Dicentrarchus labrax* (Linnaeus, 1758), were collected from different landing sites of Bardawil Lagoon, Egypt in order to investigate some of its biological aspects and population dynamics. This was done during the fishing seasons of 2011 and 2012, since the total length of samples was ranged from 18 to 62 cm. and total weight was fluctuated between 37.8 and 2250 g. Length-weight relationship was $Tw = 0.007*TL^{3.075}$. The estimated total length at first capture (Lc) was 19.06 cm, while the total length at first maturity (Lm) was 25.9cm. The parameters of the von Bertalanffy growth function (VBGF) in length were K = 0.32 $year^{-1}$, L∞ = 69.11cm and t_0 = - 0.28 year. The mean of total mortality (Z), fishing mortality (F) and natural mortality (M) were 0.918, 0.471 and0.447 respectively. While the exploitation rate (E) was 0.513, which means that the stock of *S. aurata* in Bardawil Lake was worryingly exploited. Sea water enters the lagoon at present.

Keywords: European Sea Bass; *Dicentrarchus Labrax*; Bardawil Lagoon; Population Dynamics; Biological Traits; Length-Weight Relationship

Introduction

Bardawil Lagoon is one of the important fish producing lake occupying about 8000 km^2 or 13% of the Sinai Peninsula along the northern coast of Egypt [30]. It is mainly a flat low lying plain, with depth ranging from 0.5 m to a rather rare 3 m. Sea water enters the lagoon at present through three inlets: two artificial tidal inlets (270 and 300 m wide and 4-7 m deep), they are maintained open by a periodic dredging and natural eastern inlet of Zaranik. The latter has a little effect on the overflowing or salinity of the lagoon water. This is because Zaranik is extremely shallow and separated from the rest of the lagoon by a series of insignificant islets and sand bars. Nonetheless, the two artificial openings are essential in order to ensure satisfactory exchange of water between the lagoon and the open sea [30]. The same authors declared that, the fish production of this Lagoon depends on the water exchange between it and the sea, which regulates lagoon salinity. Moreover, it is the least polluted because no drainage canals discharge its water in it.

European sea bass, *Dicentrarchus labrax* (Linnaeus, 1758), is a demersal fish species found throughout the Mediterranean French coast [18,16] and Portuguese coast [53,54]. In Bardawil Lagoon *D. labrax* is one of the most important fishes, but since 1990's, the catch of this species has dramatically declined due to the irrational management strategy and uncontrolled fish export policy from the lagoon [31]. Many authors have studied the biology of fish *D. labrax* and its management in Bardawil lagoon, such as [1,2,4,5,9,20,26,29,37,47-49] in addition to [51] in Lake Edku, [25] in Port Said and [7] in Lake Edku during sea bass migration to the Mediterranean through Boughaz El-Maadiya.

Other have also studied the biology and management of D. labrax further fish at other places of world [12,13,39,40,44].

The present study aims to investigate some biological aspects of European sea bass, *D. labrax* to assess and develop its fisheries status in Lake Bardawil. The obtained results would lead to evaluate the effect of ongoing fishing operations on the stock of this fish species and consequently to manage and develop their fisheries in Lake Bardawil, which may be helpful for solving the animal protein lack problem in Egypt.

Material and Methods

As regards to/521 specimens of *D. labrax* (18-62 cm TL) were collected monthly from three landing sites (El-Nasr, Eghzewan and EL-Telol) in Bardawil Lagoon during fishing seasons of 2011 and 2012.

Figure 1: European sea bass, *Dicentrarchus labrax* collected from Bardawil Lagoon.

Fishes were put immediately in crushed ice and transported to the laboratory and were subjected for investigation. Date of capture, total fish length and total fish weight were recorded for each specimen. The samples were grouped into 1 cm length classes, each fish was measured to the nearest mm for total length and weighed to the nearest 0.1gram total weight, and then the sex and maturity were determined macroscopically. The weight of the gonads was recorded to the nearest 0.01 gram. LFDA program was used to evaluate growth as recommended by [32] and this was fitted to the von Bertalanffy growth model to estimate the von Bertalanffy growth parameters L∞ and K [46].

The length weight relationship was estimated from the allometric equation

$W=a L^b$ Ricker (1975)

Where W is total body weight (g), L the total body length (cm), a and b are the coefficients of the functional regression between (W) and (L).

The mortality coefficients were estimated by using VIT software for each length class and age group. The vector of natural mortality by age was calculated from Caddy's formula, using the PROBIOM Excel spreadsheet [3].

The total mortality coefficient Z was estimated by using the method of [41]. The natural mortality coefficient M was assessed using [52] equation as

$M = 3/t_{max}$

Where t_{max} is the maximum age attainable by individual specimens in the given population, while the fishing mortality coefficient

$F = Z– M$

Meanwhile, the exploitation rate E was obtained as

$E = F/Z$ [24].

The length at first maturity L_{50} (the length at which 50% of fish reach their sexual maturity) was estimated by fitting the logistic curve for the sexually mature individuals.

The spawning season was detected by following the monthly variation in both gonado-somatic index (GSI) and maturity stages where GSI was determined as

GSI = WgX100/Wt.

Wg is the gonad weight and Wt. is the total body weight in grams.

Results

Length frequency distribution

It is evident that the length frequency distribution of *Dicentrarchus labrax* (Figure 2) ranged between 18-62 cm and the length group 25 (24-26 cm) represented the majority of the samples about 160 specimen (30.71%).

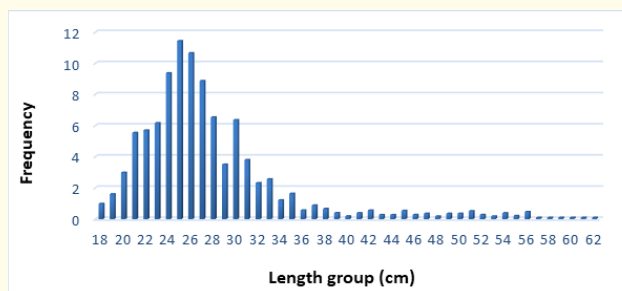

Figure 2: Length-frequency distribution for *D. labrax* from Bardawil lagoon during the fishing period of 2011 and 2012.

Age composition and Growth

The catch of *D. labrax* is composed of six age groups plus age group zero. As shown in figure 3, the smaller age groups (0 and I) represent the majority of the examined sample. Age group (I) was the most dominant; representing 72.69% of the total catch, followed by age group (0) which was represented by 95 specimen (18.23%) The other age groups represented by 4.48%, 2.33%, 1.44%, 0.56% and 0.29% of the total catch for Age groups (II), (III), (IV), (V) and (VI) respectively.

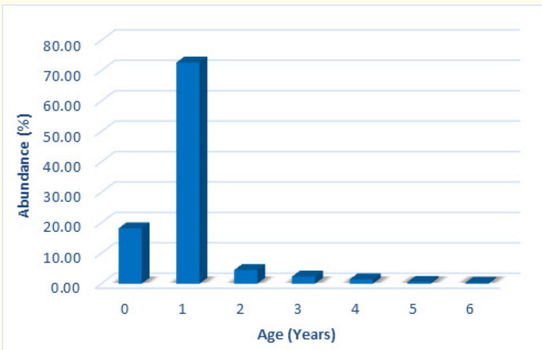

Figure 3: Age composition of *D. labrax* from Bardawil lagoon.

Growth in length

The table 1 and figure 4 showed that, the average length at the end of each year of *D. labrax* was 23.23, 35.79, 44.92, 51.54, 56.35 and 59.85 cm for the six age groups of this fish. The maximum growth in length was recorded at the end of the first year of life where the fish gain 38.8% of its final growth at fourth year of age, then after, the fish gain 21%, 15.3%, 11.1%, 8% and 5.8% of its final growth by the second, third, fourth, fifth and sixth year of life, respectively.

Age	I	II	III	IV	V	VI
Length	23.23	35.79	44.92	51.54	56.35	59.85
Increment	23.23	12.56	9.13	6.62	4.81	3.5
Increment%	38.8	21	15.3	11.1	8	5.8

Table 1: The lengths (cm) at the end of each year of life for *D. labrax* from Bardawil lagoon during the fishing period of 2011 and 2012.

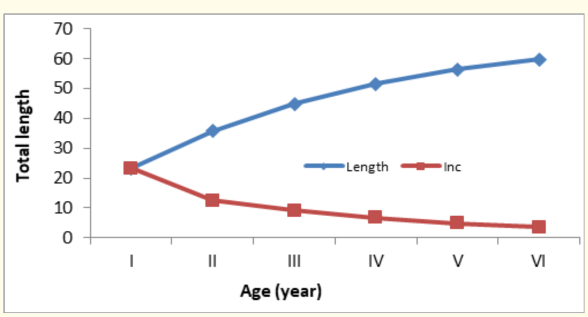

Figure 4: Growth in length and increment curves at the end of each year of life for *D. labrax* from the Bardawil lagoon in fishing period of 2011 and 2012.

Von bertalanffy growth formula

The estimation of Von Bertalanffy growth parameters was obtained by fitting the VBGE to back calculated lengths. The parameters of VBGE obtained in the present study for *D. labrax* K was 0.32 year^{-1}, L_∞ was 69.11cm, t_o was -0.28 year. The maximum age (t_{max}) of this fish species was 9.38 years for *D. labrax*. By applying the length-weight relationship W_∞ was equal 3414 gm and the value of growth performance (Ø) in length and growth performance in weight were 3.18 and 1.86 respectively.

Length-weight relationship

Length-weight relationship is an essential biological parameter needed to appreciate the suitability of the environment for any fish, which reflect its importance in most fishery biological studies. It plays an important role in the practical application of fisheries management [35] and [33]. The length-weight relationships of *D. labrax* inhabiting Bardawil Lagoon were found to be

Whole sample $W = 0.007L^{3.075}$ $R^2 = 0.968$

Length-weight relationship of *D. labrax* is represented graphically in figure 5 and it is clear that, the value of (b) is not deviated from the cube (b = 3.075) which indicates isometric growth. The correlation coefficient "r" is statistically highly significant (0.968).

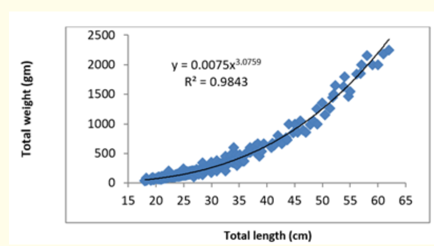

Figure 5: Length-weight relationship of *D. labrax* from Bardawil Lagoon during the fishing period of 2011 and 2012.

Length and age at first maturity

The length at 50% maturity of *D. labrax* from the curve in figure 6 was estimated at 25.53 cm. Derivative of the von Bertalanffy equation was applied to calculate the age at first sexual maturity (t_m) from its corresponding length (L_m). And found that, the age at first sexual maturity (t_m) = 1.2 year.

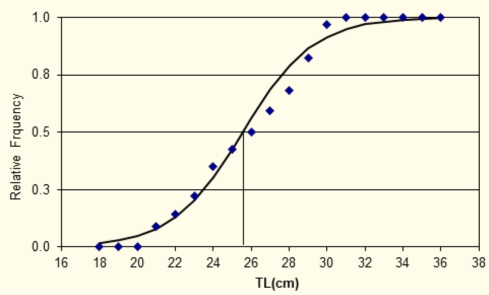

Figure 6: Length at first sexual maturity (L_m) of D. labrax from Bardawil Lagoon during the fishing period of 2011 and 2012.

Gonadosomatic index (GSI)

The Gonadosomatic index (GSI) is widely used to determine the spawning period of a fish species. As the GSI reaches its maximum value gives a perfect indication of the time of breeding. A monthly variation of gonad index of *D. labrax* is represented in figure 7. The evolution of the present data showed that, generally GSI is higher in female specimens than in males. The minimum value of G.S.I. of the females of *D. labrax* was (0.56) during April and increases gradually to reaches the higher values in October (0.98), November (2.18) with the peak in December (3.15).

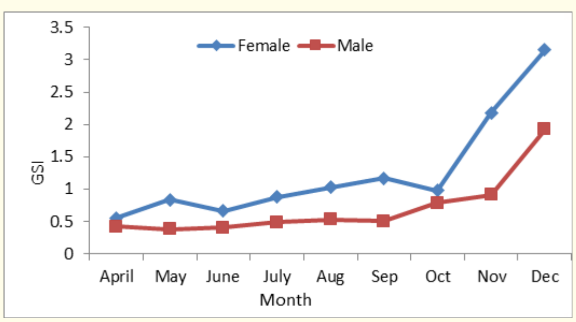

Figure 7: Monthly variations of the gonado somatic index (GSI) for *D. labrax*, from Bardawil lagoon during the fishing period of 2011 and 2012.

On the other hand, the values of Gonadosomatic index of male for *D. labrax*, were increase in October (0.79) and November (0.91) with the maximum value of (1.92) during December and the minimum value was in May (0.38).

Length and age at recruitment

Length at recruitment (L_r) is defined as the smallest length at which the fish enters the fishing ground and may become vulnerable to fishing. The obtained value of (L_r) of *D. labrax* was 14.18 cm and (t_r) was 0.44 year (Table, 2).

Length and age at first capture

The length at the first capture (L_c) is the length at which the fish may be become vulnerable to fishing gears. In the present study (L_c) for *D. labrax* was computed by using the equation of [10]. The (L_c) value was 19.06 cm, and the corresponding age at first capture (t_c) which marks the beginning of the exploited phase was 0.729 years (Table, 2).

Exploitation ratio

According to GFCM [21] (The General Fisheries Commission for the Mediterranean) which recommended that (E) should be equal to 0.4 and when the exploitation ratio is more than 0.5means that the fish is overexploited, but if it is less than 0.4this means that the fish is under exploitation. In the present study the value of exploitation ratio (E) for *D. labrax* was 0.513 suggesting that its population in the Bardawil Lagoon suffers from overfishing (Table 2).

Parameter	*D. labrax*
L_c (Length at capture)	19.06 cm
L_r (Length at recruitment)	14.18 cm
T_c (Age at capture)	0.729 year
T_r (Age at recruitment)	0.44yaer
S (Survival rate)	0. 40
E (Exploitation ratio)	0.513
M/K	1.397

Table 2: The Values of some fishery indices of *D. labrax* from Bardawil Lagoon during the fishing period of 2011 and 2012.

Discussion

In the present investigation, the length of *D. labrax*, was ranged between 18-62 cm since the length groups 22-26 cm represented the majority of the fish samples (31.47%). The catch of *D. labrax* was composed of six age groups plus age group zero where the smaller age groups (0 and I) signify the majority of the examined sample. Age group (I) was the most dominant; representing 72.69% of the total catch, followed by age group (0) which was represented by 18.20%. These results are confirmed by [48] in Bardawil Lagoon and in other localities by many authors as; [4,15,29,37,51].

The average length *D. labrax* of the present study by the end of each year was 23.23, 35.79, 44.92, 51.54, 56.35 and 59.85 cm for its six recorded age groups. These results are in harmony with [4] since he found that, by length frequency, the *D. labrax* was 6 years and the first length group was of the highest percentage in the catch. Similarly, [49] postulated that, six age groups were also identified for *D. labrax* and the growth in length and increment from the back calculated length was 23.36, 37.4, 47.6, 53.94, 59.06 and 62.88cm at the end of the six year, respectively. The last author showed that the first age group was the dominated one (65.35%) but the least one was the six-age grope (0.8%) in the catch.

However, [26] recorded seven age groups for *D. labrax* at Bardawil and gave lengths of 16.1, 30.8, 42.5, 51.7, 59.1, 64.9 and 69.6 cm for these age groups respectively. Nonetheless, [1] found that the back-calculated lengths during 2000 were 22.5, 30.5, 36.4 and 41.8 cm for ages I to IV, respectively but during 2001 as 22.3, 31.1, 37.2, 42.9 and 47.5 cm for five age groups, respectively. On the other hand, [29] mentioned that, the total length of *D. labrax* during 2004 varied from 22.8 to 63.6cm and the maximum life span of the studied fish in the Bardawil Lagoon was about four years. Meanwhile, [37] found that, the maximum life span of the same fish in Bardawil Lagoon was eight years for length range of 20-71 cm. These variations can be explained by the early investigation of [6] and [14]. They showed that, growth rate is extremely variable, even when fish were taken from the same location if growth estimation based on the length frequency. This variability may be linked to variations in the ecological conditions [55].

In the present study the maximum growth in length of *D. labrax* was recorded at the end of the first year of life where the fish gain 38.8% of its final growth at sixth year of age, then after, the fish gain 21%, 15.3%, 11.1%, 8% and 5.8% of its final growth by the second, third, fourth, fifth and sixth year of life, respectively. Same finding was also recorded in the previous studies of [1,4,13,25,26,29,51,56].

The growth parameters of von Bertalanffy, in the present investigations were K= 0.32 year^{-1}, L_∞= 69.11 cm and t_{o}= -0.28 years. From the length-weight relationship, W_∞ was about 3414 gm. [49] reported that, in the Bardawil Lagoon the growth parameters of von Bertalanffy were recorded as L_∞= 70.82 cm, K = 0.35 year^{-1} and t_o = -0.217 year. The decrease in L_∞ values can be attributed to disappearance of the largest fish sizes from the catch. [29] Estimated the constants of the von Bertalanffy growth model as L_∞ = 72.5 cm TL, K = 0.260 year^{-1}, t_o = -0.396 yr.

The European Sea bass in Bardawil Lagoon, [37] noticed that L_∞= 76.36 cm, K = 0.29 year^{-1} and t_o = -0.19 year. But [26] estimated these growth parameters as $L\infty$ =87.6 cm, K = 0.33 year^{-1} and t_o = 0.115, as well [29] estimated these von Bertalanffy growth parameter as L_∞ = 72.5 cm TL, K = 0.260 year^{-1}, t_o = -0.396 yr. [36] mentioned that the differences in growth parameters is due to age, sex, maturity and sampling period for the same species.

As for the length-weight relationship of the European sea bass, *Dicentrarchus labrax,* the exponent "b" was found to be (3.075) indicating isometric growth. Similarly [29] and [48] mentioned that the exponent "b" was 3.055 and 3.0067 respectively, while [26] found that this value was 2.8241, [1] gave (b) value at 2.7977 and 2.7316 during 2000 and 2001, respectively, and [20] found that it was 3.2379. This exponent by [49] in 2000 and 2001 was 2.8 and 2.73, respectively, and by [5] was equal to 2.83. Later on, [37] recorded that, the exponent "b" value was 2.891 and [2] recorded that, it was 2.824.

This can be explained by the supposition that, the physiological changes, hydrological environmental conditions and different food availability during life span can all affect the growth exponent "b" of a fish [19]. It was also established that the growth exponent changes with respect to the locality in which fish inhabits, and also to its sex, length, age and gonad maturity [46]. Another cause for the observed differences in length weight relationships for the same species, among different authors might be the sampling procedure, namely sampling size and length range [38]. Table (3)

Location	Author	sex	a	b
Bardawil Lagoon	Bebars, 1986	M	0.011	2. 88
		F	0.008	2.96
	Hegazy and Sabry, 2001	M+F	0.018	2.82
	Abd-Alla, 2004	M+F (2000)		2.798
		M+F (2001)		2.732
	Salem, 2004	M+F (2000)	0.019	2.8
		M+F (2001)	0.023	2.73
	Khalifa, 2005	M+F	0.0078	3.055
	Gaber, 2007	M+F		3.238
	Ameran., *et al.* 2008	M+F	0.018	2.83
	Abdel-Hakim., *et al.* 2010	M+F	0.0187	2.824
	Mehanna *et al.*, 2010	M+F	0.014	2.89
	Shalloof *et al.,* 2019	M+F	0.0093	3.0067
Alexandria	Wassef and El-Emary, 1989	M+F	0.00875	3.05
Port Said	Haggag, 2005	M+F (2002)		2.69
Lake Edku	Talaat., *et al.* 1992	M+F	0.0096	3.013
El-Maadiya	Bakhoum., *et al.* 2015	M+F	0.029	2.6786
Walesh water	Cambie., *et al.* 2013	M+F (South)	0.01135	2.969
	Carroll, 2014	M+F (South)	0.023	2.788
Spain	Morey., *et al.* (2003)	M+F	0.0051	3.159
Croatia	Dulcic and Kraljevic (1996)	M+F	0.0000067	3.146
Greek	Moutopoulos., *et al.* (2011)	Klisova	0.0081	3.074

Table 3: Estimated Length- Weight parameters of *D. labrax* in different regions by different authors.

show the estimated length- weight parameters of *D. labrax* in different regions by different authors.

Reproduction of sea bass, *D. labrax,* takes place in the Mediterranean Sea at late October and November and the fish return to the Lagoon after spawning during the second half of February i. e., they are winter spawners [31]. The results of this study confirm this where the minimum value of G.S.I. of the *D. labrax* females was (0.56) during April, and it increased gradually to reaches its higher values in October (0.98), November (2.18) with a peak in December (3.15). Otherwise, values of Gonadosomatic index of male were increase in October (0.79) and November (0.91) with the maximum value of (1.92) during December but its minimum value was observed in May (0.38). Meanwhile, [7] Illustrated that the spawning season of *D. labrax* takes place at summer in Egyptian Mediterranean water. This can be explained by the fact that, the time of bass breeding somewhat differs from one place to another, in the Mediterranean it is happened from December to March in Tunisian waters [11]; from January to March in Sete, France [8] and in Spain [6]; from December to March and April in Egypt [45]. Whereas, it is delayed to March-April in the Atlantic coast of France [50] and April to June or early July in Irish waters [28], at the end of winter to the beginning of spring in Aveiro lagoon, Portugal [23] and in the British waters tack place from March to May [42].

The length at first sexual maturity of *D. labrax*, was estimated at 25.53 cm. corresponding to age (t_m) = 1.2 year. These results are in close to that of [26] since they suggested that, in Bardawil Lagoon females of *D. labrax* attained their first sexual maturity at 25.8 cm. However, [1] stated that it was 23.4 and 23.0 cm for males as well 30.4 and 31.0 cm for females in 2000 and 2001, respectively. Similarly, [5] reported that, the length at first maturation of the same fish was about 31.6 cm. Otherwise, [13] stated that the population of North Wales is dominated by females, so there is an evident that female of sea bass do not reach maturity until 42 cm in length [43]. [27] Suggested that sea bass female maturation may occur at around 41 cm in length. Furthermore, in south-west coast of Portugal [22] said that this fish attained maturation at 48.23 cm. A change over time in the age or size at which maturation occurs can be interpreted as a sign of evolutionary change within a species [34].

Otherwise, the present results clearly indicated that the fishery of sea bass in the Bardawil Lagoon suffers from a higher fishing mortality (F) coefficient (0.471) than natural mortality (M) coefficient (0.447) so; the mean total mortality coefficient (Z) was 0.918. [7] Found that, the coefficient of natural mortality for wild sea bass was (0.172 ± 0.017) very lower than that of the present fish. He mentioned also that the lowest value of natural mortality for sea bass inhabiting Lake Edku, in spite of the poisoning effect of pesticides and trace metal, as well as low quality of water body, indicated that this species have high tolerance to the unsuitable environmental living conditions.

The value of exploitation ratio (E) of *D. labrax* was 0.513. According to [21] the population of this species in the Bardawil Lagoon suffers from overfishing. This result is in accordance with [49] who illustrated that the current exploitation rate (E =0. 623) as well as [37] appeared that the (E) = 0.766. [1] Explain that the exploitation rates were 0.748 and 0.644 for years 2000 and 2001 respectively and [29] mentioned that the exploitation rate "E" as 0.838. The values of both fishing mortality and exploitation rates were relatively high indicating a high level of exploitation.

Conclusion

The aim of this research is to develop sea bass *Dicentrarchus labrax* fisheries in Lake Bardawil. The results obtained can assess the impact of fishing operations on stocks of this species and work on the development of their fishery in Lake Bardawil. This study confirmed that the fishing effort and exploitation rate of sea bass was higher than the optimal level in Lake Bardawil. Consequently, this study recommended that it is necessary to widening the mesh size used to catch sea bass to protect this species from exploitation.

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