SOME BIOLOGICAL ASPECTS OF GOLDEN GREY MULLET, *Liza aurata* (Risso, 1810) FROM BARDAWIL LAGOON, EGYPT

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**ARTICLE INFO**

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<td>Received: 07/05/2021</td>
<td>The present study presents biological aspects of golden grey mullet, <em>Liza aurata</em> (Risso, 1810) from Bardawil lagoon, Egypt. A total of 1329 specimen's individuals of <em>Liza aurata</em> were collected from different landing sites of Bardawil Lagoon in the period from May 2017 to February 2018. Length-weight relationship, condition factor, age composition, and fish growth were studied. The length and weight ranged from 12.2 to 33.6 (cm) and 13.8 to 340 (g) respectively. The Length-Weight relationship (LWR) was determined according to the power regression model. The length-weight relation of <em>Liza aurata</em> in Bardawil Lagoon was found as W = 0.0071 L^{3.053} (r² = 0.9756). The highest value of condition factor of the studied species was recorded in May and declined to lowest level in November. Growth and mortality were evaluated based on age estimation from scale readings of total 605 individuals. The Von Bertalanffy growth function to be Lt = 38.51 [1-e-0.2421(t+1.4222)] and Wt = 491.96 [1-e -0.2421(t+1.4222)] ³⁸⁶³. The total (Z) and natural (M) mortality rates were found to be 0.8865 and 0.3543 years⁻¹ respectively. The estimated exploitation rate was found to be E = 0.60 indicating that the current fishing pressure on <em>L. aurata</em> suffers from overfishing in the area of study.</td>
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**INTRODUCTION**

Bardawil Lagoon (North Sinai, Egypt) plays an essential role in the fish production in Egypt, where it produces very economically important species of fishes such as sea bass, sea bream, common sole, grey mullet, eel, meager and white grouper (Abdel-Hakim *et al.*, 2010). The total production of golden grey mullet, *Liza aurata* (Risso, 1810) in Bardawil Lagoon retched to about 170 tons during the fishing season 2017 (Administration Bardawil lagoon). Golden grey mullet, *Liza aurata* (Risso, 1810), is one of the species of the family Mugilidae that constitutes the target of fishery exploitation of Bardawil Lagoon. The golden grey mullet, *Liza aurata*, is a pelagic coastal species which usually lives in inshore waters, entering Lagoons and estuaries. It rarely enters freshwater and prefers a muddy bottom (Jardas, 1996). Mullet's catch is composed mainly from *Mugil cephalus*, *L. ramada* and *L. aurata*, while both *Chelon labrosus* and *L. saliens* are found in very small amounts and recorded under the “others” group (Mehanna *et al.*, 2019). Although the mullets in Bardawil Lagoon contribute greatly to the economy of Egypt, very limited studies concerning their dynamics and management are available (Ismail, 1973; Mehanna, 2006). The study of length-weight relationship (LWR) of fish is important in fisheries biology and population dynamics where many stock assessment models require the use of LWR parameters (Jamabo *et al.*, 2009).
length and weight of fish is among the important morphometric characters, they can be used for the purpose of taxonomy and ultimately in fish stock assessment (Goel et al., 2011). The actual relationship between length and weight may depart from the cubic value 3 and this may be due environmental condition in which the animal lives and also due to the physiological condition of the animal (Ighwela et al., 2011). Weight-length relationships (WLR) are used for estimating the weight corresponding to a given length of fish (Tesch, 1971). The aim of the present study is to describe the data on some biological parameters of golden grey mullet from Bardawil Lagoon, located North Sinai Egypt, that could be useful for managing of this important species.

MATERIALS AND METHODS

Sampling Site

Bardawil Lagoon (Fig.1) lies in the north of Sinai, southern east the Mediterranean Sea. It located between 31°03′N to 31°14′N and between 32°40′E to 33°30′E. The Lagoon is shallow with a maximum depth of 6.5 m in its western arm, a minimum depth of 0.3 m, and an average depth of 1.21 m (Zaghloul et al., 2018).

Sampling and Measurements

Monthly random samples of golden grey mullet, Liza aurata (Risso, 1810) (Fig. 2) were collected from the commercial catch in different landing sites of Bardawil Lagoon from May 2017 to February 2018. In the laboratory, total fish length and total weight of 1329 specimens were measured to the nearest 0.1 cm and 0.1 g, respectively.

The relationship between length and weight was described according to the power regression model: \( W = a L^b \) (Ricker, 1975), where: \( W \) is the total weight (g), and \( L \) is the total length (cm), \( a \) and \( b \) are constants. The condition factor (K) was calculated monthly by formula \( K = ((100W)/L^3) \) (Hile, 1936), where: \( W \) is the body weight (g) and \( L \) is total length (cm).

Foe aging, scales were detached from 605 individuals of Liza aurata, cleaned and investigated under microscope. The growth rings on the scales were counted to determine age group. The equation that describes the length at all ages is as follows equation (Lee, 1920), \( [L_n = ((L-a)(S_n/S) + a)] \) where: \( L_n \) is the length of fish at age "n", \( S_n \) is a magnified scales radius to "n" annulus. \( S \) is a magnified total Scales radius, \( L \) is a fish length at capture and \( a \) constant derived from the relationship between total Scales radius and fish length at capture.

The von Bertalanffy models, 1934 and 1938, \( (L_t = L_\infty (1 - e^{-kt}) \) was used to describe growth in size, where \( L_t \) is the length at age \( t \), \( L_\infty \) the asymptotic length, \( K \) the body growth coefficient and defines the growth rate towards \( L_\infty \) and \( t_0 \) the hypothetical age at which a fish would have zero length. The values of \( L_\infty \), \( K \) and \( t_0 \) were estimated by plotting \( L_t \) vs L t+1 (Ford, 1933 and Walford, 1946). The growth performance index (\( \hat{O} \)) described by Pauly and Munro (1984) was calculated using the relationship \( \hat{O} = \log K + 2 \log \frac{L_\infty}{t} + 3 \log W_0. \)

Total mortality (\( z \)) can be computed using six methods 1- (Beverton and Holt, 1957) based on age data , where \( Z = 1/(t - t) \) where \( t \) is the age that corresponds to the average length of the fish in the samples, from the age of two years to the largest fish in the sample, \( t \) is the age of the most frequent fish catches; 2- (Beverton and Holt, 1957) based on length data since \( Z = K((L_{\infty} - L_{\infty}^-)/(L_{\infty}^- - L_c)) \) Where \( L_c \) is the length of the first capture , \( L_{\infty}^- \) is the average fish length ranges from 50% to the longest fish in the sample; 3-(Beverton and Holt's, 1957) based on length data where \( Z = K^*(L_{\infty} - L)/(L' - L_c) \) where \( L' \) is the average
Fig. 1. Bardawil Lagoon

Fig. 2. Golden grey mullet, *Liza aurata*, from Bardawil Lagoon

Fish length of samples and \( L_r \) is the smallest length in samples. 4-(Chapman and Robson, 1960) where \( Z = L_n S \) where \( S = (A/(B+A-1)) \), \( A = N_1 + 2N_2 + 3N_3 \) and \( B = N_0 + N_1 + N_2 + N_3 \), where \( N_0 \) is the number of fish in age 1, \( N_1 \) is the number of fish is age II, \( N_2 \) is the number of fish is age III and \( N_3 \) is the number of fish is age IV; 5- Estimation of \( Z \) from a linearized catch curve based on age composition data as \( Z = b \) and 6- The Powell- Wetherall method (Powell, 1979) discussed in- (Wetherall et al., 1987) as \( Z = 1-k \).

The natural mortality (\( M \)) were obtained by using six methods: 1-(Alverson and Carney, 1975) where \( M = 3 * K / [\exp (t_{\text{max}} * 0.38 * K) - 1] \) 2- Hewitt and Hoenig (2005) where \( M = 4.22/t_{\text{max}} \), where \( t_{\text{max}} \) is the maximum age of the fish in the sample 3-Jensen (1996) since \( M = 1.5k \). 4- Ursin, (1967) where \( M = W (-1/3) \) where \( W \) is the average weight of the samples; 5- Estimation of \( M \) by (Jennings et al. 2001) where \( M = 3/t_{\text{max}} \) and 6- Pauly (1980) where \( \log M = [-0.0066 - 0.279 \log L + 0.6543 \log K + 0.4634 \log T] \) where “\( T \)” is the annual average water temperature. Maximum age of the fish \( (t_{\text{max}}) = 3/K \), while fishing mortality \( (F) = Z - M \). The exploitation rate \( (E) \) was calculated as follows: \( E = F / Z \) (Gulland, 1971). Length at first capture \( (L_c) \) was calculated from the plot of the probability of capture against size.  

**RESULTS AND DISCUSSION**

**Length Frequency Distribution**

The length frequency distribution of 1329 specimens of *L. aurata*, which caught from Bardawil Lagoon during period from May 2017 to February 2018 were ranged from 12.2 to 33.6 cm (Fig. 3). This figure shows that, the most frequent length group was 19-19.9 cm and the lowest number was recorded in the length group 31-31.9 cm.
Length–Weight Relationship

Length–weight relationship for fish used to provide information on the condition of fish, their isometric or allometric growth, in the analysis of ontogenic changes, to compare life histories of fish species between regions as well as other aspects of fish population dynamics. Also, length-weight relationship is useful for the conversion of growth-in-length equations to growth-in-weight, for use in stock assessment models and to estimate stock biomass from limited sample sizes (Binohlan and Pauly, 1998 and Ecoutin et al., 2005).

The length-weight relationship of *L. aurata* from Bardawil Lagoon (Fig. 4) was estimated from specimens ranging in their total length from 12.2 to 33.6 (cm) and in their total weight from 13.8 to 340 (g). The relationship from the sexes combined was calculated from the following formula: \( W = 0.0071L^{3.053} \) \((r^2 = 0.9756)\).

Hile (1936) have demonstrated that, the value of (b) remains constant at (3) for ideal fish. In the present study the value of (b) was 3.053, which not significantly different from (3) indicating isometric growth. It may be said that the weight of *L. aurata* from Bardawil Lagoon increases in proportion slightly higher than the cube of length. Table 1 shows different results from the previous studies, moreover, these differences in results may be due to feeding intensity, environmental conditions, gonad maturation and other factors. The value of (b) agree with (Kraljević et al., 2011; Hotos and Katselis, 2011; Hotos, 2019) but disagree with (Ilkyaz et al., 2006; Fazli et al., 2008; Khayyami et al., 2014; Mehanna, 2006). Our results are not consistent with Mehanna (2006) in the same era. This may be due to the fact that the total production of Lake Bardawil in 2006 was higher than in the year of study, since total production amounted to 4704 tons in 2006 (GAFRD, 2013), while total production was 3718.5 tons year of study (Administration Bardawil lagoon).

Condition Factor (Kc)

In the present study the monthly average condition factor of golden grey mullet was highest in May and declined to the lowest level in November (Fig. 5). This may be concerned with the spawning period of the studied species. Ghadirnejad (1996) reported that, the spawning season of golden grey mullet starts in November and continues until January. The previous author mentioned that a substantial increase in condition factor to a maximum around September, due to the developing eggs for the spawning season. The spawning of golden grey mullet starts in September and continues until (November and December) in Iranian waters of the Caspian Sea (Ghadirnejad, 1996; Fazli, et al., 2008).
Table 1. Relationship between Length and weight of *L. aurata* from different regions

<table>
<thead>
<tr>
<th>Sex</th>
<th>L-W relationship</th>
<th>Author</th>
<th>Area</th>
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<tr>
<td>Combined sexes</td>
<td>( W = 0.0071L^{3.053} )</td>
<td>present study</td>
<td>Bardawil Lagoon</td>
</tr>
<tr>
<td>Females</td>
<td>( W = 0.006L^{3.114} )</td>
<td>Kraljević <em>et al.</em>, 2011</td>
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</tr>
<tr>
<td>Males</td>
<td>( W = 0.0058L^{3.130} )</td>
<td>Hotos and Katselis, 2011</td>
<td>Gulf of Patraikos</td>
</tr>
<tr>
<td>Combined sexes</td>
<td>( W = 0.0062L^{3.069} )</td>
<td>Hotos, 2019</td>
<td>Lagoon of Klisova-Messolonghi</td>
</tr>
<tr>
<td>Combined sexes</td>
<td>( W = 0.0054TL^{3.15} )</td>
<td>Fazli <em>et al.</em>, 2008</td>
<td>Caspian Sea</td>
</tr>
<tr>
<td>Females</td>
<td>( W = 0.1152L^{2.9426} )</td>
<td>Mehanna, 2006</td>
<td>Bardawil Lagoon</td>
</tr>
<tr>
<td>Males</td>
<td>( W = 0.1278L^{2.7856} )</td>
<td>Ilkyaz <em>et al.</em>, 2006</td>
<td>Homa Lagoon</td>
</tr>
<tr>
<td>Combined sexes</td>
<td>( W = 0.0086L^{2.9356} )</td>
<td>Khayyami <em>et al.</em>, 2014</td>
<td>Guilan</td>
</tr>
<tr>
<td>Combined sexes</td>
<td>( W = 0.0111L^{2.9299} )</td>
<td></td>
<td>Golestan</td>
</tr>
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</table>

Fig. 4. Length-weight relationship of *L. aurata* in Bardawil Lagoon, 2017

Fig. 5. Monthly variation in \( (K_c) \) for males, females and combined sexes of *L. aurata* in Bardawil Lagoon, 2017
Age and Growth

Age distribution of 605 L. aurata samples from Bardawil Lagoon ranged from 0 to 4 years based on results of the fish scales reading (Fig. 6). The age group 1 was a dominant group and composed 41.7% of the whole age distribution. The group 1 was followed by the age group 0 (25.3%), group 2 (17.7%), group 3 (11.4%). The age group 4 was representing with low percentage in the population (4.0%) (Fig. 6). Also, minimum, maximum and mean lengths of different age groups of L. aurata in Bardawil Lagoon during 2017 (Table 2) showed overlapping in lengths between all recorded age groups.

Back-Calculations in Length and Weight

The back-calculated lengths recorded in this study were 17.8, 21.81, 25.1 and 28.16 (cm) for age groups 1, 2, 3, and 4 years, respectively (Fig. 7). The results showed that the highest increment in length occurred at the first year of life 17.08 (cm) and then declined rapidly thereafter till reached 3.06 (cm) at age of group 4. The increments in weight were 41.14, 45.63, 46.36, and 56.08 (g) for age groups 1, 2, 3 and 4 years respectively (Fig. 8). The back calculated weight was 41.14, 86.78, 133.14, and 189.22 (g) for age groups 1, 2, 3 and 4 years, respectively.

Table 3 shows a lot of variation in the values of the growth parameters of L. aurata different areas. These differences may be attributed to the difference in biological characters of the studied species in those areas or to the possible false age estimation. In some studies, the younger age groups were not collected (Kraljević and Dulčić, 1996) and others the fish older than two or three years were not recorded (Drake et al., 1984).

Hotos (2019) reported that the lower annual average temperature in the northern latitudes as compared to the southern ones, affect the characteristics of growth of this fish, promoting the creation of the first annulus at a comparatively smaller size.

Mathematical Models of Growth

The parameters of Von Bertalanffy growth were calculated as L∞ = 38.51 (cm), K = 0.2421 year⁻¹ and t₀ = 1.4222. The data obtained equations were L₄ = 38.51 [1 – e⁻⁽0.2421(t+1.4222)⁾] for length, and W₁ = 491.96 [1 – e⁻⁽0.2421(t+4.222)⁾]³.053 for weight. The value of L₉₀ = 38.51 (cm) are good agreement with (Kraljević and Dulčić, 1996) from Mirna Bay (North Adriatic) as L∞ = 39.8 (cm). Fehri-Bedoui and Gharbi (2005) reported that L∞ = 39.7 (cm) in Tunisian coasts and (Kraljević et al., 2011) mention that L∞ = 40.0 (cm) in Mirna estuary (northern Adriatic Sea. In contrast recorded L₉₀ in the present study less than that reported by (Albertini-Berhaut, 1978), since L₉₀ = 45 (cm) in Gulf of Marseilles, Modrusan et al. (1988) estimated L₉₀ = 51 (cm) in Krka estuary-middle Adriatic, Arruda et al. (1991) estimated L₉₀ = 68.5 (cm) in Ria de Aveiro – Atlantic. Also, the value of L∞ in this study was higher than that recorded by Andaloro, (1983) since L₉₀ = 24.3 (cm) in Marsala Lagoon and that reported by Mehanna (2006) since L₉₀ = 33.8 (cm) in Bardawil Lagoon.

Growth Performance Index (Ǿ)

Growth performance index (Ǿ) had been used since it is the best index for expressing the fish growth (Pauly and Munro (1984)). It is computed according to the latter authors depending on the Von-Bertalanffy growth parameters (L∞ & K) as follows: Ǿ = Log K + 2Log L∞. It was found that the growth performance of L. aurata in the present study = 2.55. These results agree with the results in N. Adriatic since Ǿ = 2.52 (Kraljević and Dulčić, 1996), but lower than the results from Italy, Ǿ = 2.99 (Konides et al., 1992) value In the Lagoon of Klisova-Messolonghi in 2.82 (Hotos, 2019). Mehanna (2006) reported that the values of growth performance
Fig. 6. Age distribution of *Laurata* in Bardawil Lagoon, 2017

Table 2. Minimum, maximum and mean lengths from different age groups of *L. aurata* in Bardawil Lagoon, 2017

<table>
<thead>
<tr>
<th>AGE</th>
<th>Number of Samples</th>
<th>Minimum Length (cm)</th>
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<th>Mean Length (cm)</th>
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<td>1</td>
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<td>3</td>
<td>69</td>
<td>20.8</td>
<td>29.9</td>
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</tr>
<tr>
<td>4</td>
<td>24</td>
<td>22</td>
<td>33.6</td>
<td>28.8</td>
</tr>
<tr>
<td>Total</td>
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Fig. 7. Increment in length of *Laurata* in Bardawil Lagoon, 2017

Fig. 8. Increment in weight of *Laurata* in Bardawil Lagoon, 2017
Table 3. Lengths (cm) at different ages of L. aurata from different areas

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<td>18.2</td>
<td>25.2</td>
<td>30.7</td>
<td>34.66</td>
<td>40.1</td>
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<td>18.8</td>
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<td>21.9</td>
<td>26.8</td>
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<td>21.81</td>
<td>25.1</td>
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index $\Phi$ of L aurata were 2.84 in Bardawel Lagoon and the $\Phi$ values obtained were consistent with other estimates. It was found that $\Phi = 2.66$ for L. ramada at Burullus lake, 2.91 at Wadi El-Raiyan lakes and 2.98 at Lake Timsah and was 2.82 at Bitter Lakes).

**Mortality**

In the present study, the annual rates of total, natural, fishing mortality and exploitation rate of L. aurata were 0.8865, 0.3543, 0.5322 and 0.6 respectively. These results are not consistent with that obtained by various authors and in different locations.

Mehanna (2006) reported that the total mortality coefficient $Z$, the natural mortality coefficient $M$, the fishing mortality coefficient $F$ and Exploitation rate $E$ were estimated as 1.36, 0.22, 1.14 and 0.84 year respectively for L. aurata in Bardawill Lagoon. (Konides et al., 1992) estimated all the above measurements in the Ionian Sea are $Z$= 0.85, $M$ = 0.21, $F$=0. 64 and $E$= 0.75, while (Kraljević and Dulčić 1996) in the N. Adriatic Sea found $Z$= 1.12, $M$= 0.44, $F$= 0.68 and $E$= 0.61 in the N. Adriatic Sea. Also our results were greater than obtained from the Lagoon of Klisova-Messolonghi (W. Greece), since the total ($Z$) and natural ($M$) mortality rate was found to be 0.54 and 0.33 years$^{-1}$ respectively (Hotos 2019).

Gulland (1971) suggested that the optimum exploitation rate for any fish stock is about 0.5 at F=M and more recently, Pauly (1987) proposed a lower optimum F that equal to 0.4 M. Patterson (1992) reported that an exploitation rate of about 0.4 is safe for the stock. The Lc value in the present study was estimated as 19.5 cm (Fig. 9) corresponding to an age of 1.49 year. The results showed that the stocks of L. aurata at Bardawil Lagoon were overexploited. For the management purpose, the current exploitation rate must be reduced from 0.60 to 0.4 (54%). (Abdallah et al., 2013) mentioned that to maintain a sufficient spawning biomass, the length at first capture should be raised from 19.5 to about 23.73 cm for L. aurata.

Based on the result, it can be concluded that the studied species suffers from overfishing due to some illegal practices such as matching the size of the mesh gears and also there is a miss of information on the extent of the state of the catch.

Also, the destructive fishing gears should be banned meanwhile; the technological development and biological effect of several fishing methods operating inside the Lagoon should also be taken into account when analyzing the impact of the fishery on the different fish stocks.
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الملخص العربي

بعض الجوانب البيولوجية لأسماك الدهبان (Liza aurata) من بحيرة البردويل، مصر

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تمت دراسة بعض الجوانب البيولوجية لأسماك الدهبان من بحيرة البردويل وذلك خلال الفترة من مايو 2017 إلى فبراير 2018 حيث تم جمع عدد 1329 عينة من مواقع الالانزاغ المختلفة ودراسة العلاقة بين الطول والوزن، معدل الحالة، معدلات النمو ومعدلات النفوذ. تراوحت أطوال العينات بين (12.2 إلى 33.6 سم)، الوزن بين (13.8 إلى 340 جم). كانت العلاقة بين الطول والوزن ثابتة ومتقاربة بالمعادلة 3.053 * W = 0.0071 * L (W = 0.0071 * L). تم تحديد العمر عن طريق قراءة القشور حيث كانت الفئات العمرية من 0 إلى 4 سنوات. تم حساب النمو في الطول والوزن في نهاية كل عام على أنها عادة 17.08 و21.81 و25.1 و28.16 سم للسنة الأولى والثانية والثالثة والرابعة على التوالي. تم حساب معادلات النمو لعائدة فون براتالوفي (K = 38.51) سم، W = 2022 و(0.2421 - L∞/L0 = 1.4222). وتم حساب معدل أداء النمو (Lc = 19.5) سم عند عمر (1.49 سنة) و(0.3523 و0.5322) للفئات الكلية الطبيعية ونفوذ الصيد على التوالي. سجل معدل الاستغلال الحالي (E) = 0.6. وتم استخدام تمثيل طبق على العمود من الصيادين لمعرفة تفاعل الصيد غير القانوني. النقص الشديد في المعلومات عن حالة المصيد من الناحية البيولوجية والاقتصادية. لذا يجب وضع خطة تنمية شاملة لتطوير بحيرة البردويل للحفاظ على المخزونات السمكية وأيضاً الحث على استخدام حرف الصيد المطلوبة للصيادين وتقليل مساعدي حرف الصيد غير القانوني.

الكلمات الاسترشادية: علاقة الطول بالوزن، النمو، بحيرة البردويل.

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