Age, growth and population structure of bogue, *Boops boops*, in the Mediterranean waters front Alexandria, Egypt

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ABSTRACT

The annual catch of bogue, *Boops boops*, in Egypt decreased from about 4000 MT to be 2000 MT in last 10 years. The present study provided information on the fisheries biology of *B. boops*, from Egyptian Mediterranean waters for management purpose. Monthly random samples of total 1367 specimens were collected from three landing sites front Alexandria during 2018. Results showed that, the total length of *B. boops* varied from 9.3 to 23 cm, while the total weight ranged between 7.4 and 133.1 g. The length-weight relationship revealed that “b” value (2.96) is indicating a tendency towards isometric growth with statistically highly significant coefficient. The longevity of *B. boops* was estimated to be 4 years and age groups I\(^+\) and II\(^+\) were the most abundant in the catch constituting more than 85%. The length at first capture and first maturity was 12.5 and 13.2 cm respectively. The mortalities rates were 0.671, 1.589 and 2.26 y\(^{-1}\) for natural, fishing and total mortalities, respectively. The bogue stocks in the Mediterranean waters front Alexandria was exposed to over exploitation (E= 0.70). For fisheries management, some measures were proposed for stock maintenance, fisheries development and catch sustainability.

INTRODUCTION

Fish products have traditionally been among the most important commodities traded in the Mediterranean Sea basin, and fish consumption has always been an integral part of people’s diet. However, with the rapidly increasing demand for seafood in recent decades, marine living resources have become more vulnerable because of human fishing activities (FAO, 2018). In Egypt, fish production is rapidly increasing because of growing the aquaculture production (1008 thousand MT) which recently contributed by more than 80% of total fish production (1706 thousand MT). On the other hand, capture fisheries from natural resources undergoes gradually decreasing in last 20 years (GAFRD, 2018). The Mediterranean Sea constitutes a very important sector in the Egyptian fisheries, both for significant total catch and a large number of economically important species (UNEP, 1989). The fish production from the Alexandria coastal area (13500 MT) contributed with about 25% of 54000 MT fish landed from Mediterranean water in Egypt (GAFRD, 2018).
Bogue, *Boops boops*, (Fig. 1) was the dominant fish species recorded from the Mediterranean Sea where it contributed with about 16% of fish landed in Alexandria area.

![Fig. 1: Bogue, Boops boops (Linnaeus, 1758), From Mediterranean water front the coastal area off Alexandria, Egypt.](image)

For last 10 years, *B. boops* catch decreased from 3677 MT in 2007 to be 2150 MT in 2016. *B. boops* (Lennaeus,1785), is a teleost belonging to family Sparidae, inhabits the eastern Atlantic, from Norway to Angola (Bauchot & Hureau, 1986) and the Mediterranean Sea, including the Black Sea (FishBase, 2018). Some studies had been conducted on Bogue biology in the Mediterranean waters; in Turkey (Kara & Bayhan, 2008 & 2015; Soykan et al, 2015), in Greece (Stergio & Moutopoulos, 2001), in Adriatic (Hernandez, 1989), in Tunisia (Anato & Ktari, 1986) and in Algeria (Boutiba, 1992; Ramdane et al., 2013; Rachid et al., 2014; Kherraz et al., 2016). Little biological studies were published in the Egyptian waters (Hassan, 1990; Allam, 2003; El-Okda, 2008; Mehanna, 2014).

The present study aimed to provide the required biological data of Bogue in the coastal area off Alexandria for its fisheries management purposes, development and sustainability.

**MATERIALS AND METHODS**

**Area of study:**
Fish samples were collected from three land sites (Al-Max, Al-Anfousy and Abu Qir) in the Mediterranean Sea front Alexandria; 31°14.1’ N & 29°56.6’E (Fig. 2).

![Fig. 2: Map of Egypt showing the Mediterranean coastal area off Alexandria with different landing sites during the present study.](image)
Age, growth and population structure of *B. boops* in the Mediterranean sea

**Samples and data collection:**
Monthly samples of bogue, *B. boops*, were collected from different landing sites in Alexandria area during the period from January, 2018 to December, 2018. Fish samples were freshly transferred to the laboratory in ice-box for latter measuring and examination. All specimens were measured for total and standard length (0.1 cm) and for total and gutted weight (0.1 g). Scales and otolith were preserved and the samples were dissected for determination of the sex and gonad maturation.

**Data analysis:**
Length-weight relationship of *B. boops* was estimated by using the power equation of logarithmic modification equation: \[ W = a L^b \] (Ricker, 1975). The condition factor (K) was monthly calculated according to Hile (1936) \[ K = 100 W/L^3 \]; where \( W \) is the total weight (g), and \( L \) is the total length (cm). Fish age was determined using scales and von Bertalanffy growth parameters were estimated. Gonado-somatic Index (GSI) was calculated using the equation, \[ GSI = \frac{100 W_g}{W} \], where \( W_g \) is gonad weight and \( W \) is body weight. Length-converted catch curve used to determine the total mortality (Pauly, 1984). Nature mortality (M) was estimated based on Pauly's empirical equations using the growth parameters (\( L_\infty \) and K) and water temperature (T): \[ \ln(M) = -0.0152 - 0.279 \ln(L_\infty) + 0.6543 \ln(K) + 0.463 \ln(T) \]. Fishing mortality (F) was calculated by simple subtraction \[ F = Z - M \]. Rate of exploitation (E) was calculated according to Cushing (1968): \[ E = F/Z \]. Virtual Population Analysis (VPA) modified from Jones & van Zalinge (1981) was adapted to accommodate length frequencies. For prediction of the yield, relative yield, biomass and relative biomass-per-recruit based on the knife-edge selection model (Beverton & Holt, 1966) was used. Figures, calculations and statistical operations were processed using MS office (ver. 2016), SPSS (ver. 20), GraphPad, and FISAT II softwares.

**RESULTS**

**Length-weight relationship:**
Total samples of 1367 of *B. boops* were collected from the Mediterranean Sea during the period from January 2018 to December 2018. Fish total length ranged from 9.3 to 23.1 cm with an average of 13.6±1.81 cm. While, the total weight varied between 7.4 and 133.1 g with an average of 25.8±11.624 g (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Fish No.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>SD</th>
<th>SE</th>
</tr>
</thead>
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<td>683</td>
<td>9.3</td>
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<td>13.40</td>
<td>±1.819</td>
<td>0.0696</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>684</td>
<td>10.0</td>
<td>23.1</td>
<td>13.81</td>
<td>±1.779</td>
<td>0.0680</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1367</td>
<td>9.3</td>
<td>23.1</td>
<td>13.60</td>
<td>±1.810</td>
<td>0.0490</td>
</tr>
<tr>
<td>Total Weight</td>
<td>M</td>
<td>683</td>
<td>7.7</td>
<td>116.9</td>
<td>24.40</td>
<td>±10.913</td>
<td>0.4176</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>684</td>
<td>7.4</td>
<td>133.1</td>
<td>27.12</td>
<td>±12.152</td>
<td>0.4646</td>
</tr>
<tr>
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<td>C</td>
<td>1367</td>
<td>7.4</td>
<td>133.1</td>
<td>25.77</td>
<td>±11.624</td>
<td>0.3144</td>
</tr>
</tbody>
</table>

*M: males; F: females; C: combines sexes, SD: standard deviation and SE: standard error.

The results revealed that the fish weight increased with the increasing in fish length increasing (Fig. 3). The length-weight relationship is expressed by the power equations:
\[ W = 0.010L^{2.978} \] (\( R^2 = 0.9185 \)) for males,  
\[ W = 0.012L^{2.912} \] (\( R^2 = 0.9128 \)) for females,  
\[ W = 0.011L^{2.960} \] (\( R^2 = 0.9167 \)) for combined sexes.
Fig. 3: Length-weight relationship of *B. boops* from the Mediterranean water front Alexandria during 2018.

**Condition factors:**

The monthly variation of condition factor (K) mean values exhibited specific fluctuation in both sexes during different months of the years. It ranged from 0.90 to 1.09, showing the same trend in both males and females. K mean values increased gradually from January (0.90) to June (1.06), then it gradually decreased to be 0.91 in October and rapidly increased to be 1.09 and 1.01 in November and December, respectively. In general, K values increased with fish size increasing. Average values of K increased from 0.93 in length group 9.0 cm to be 1.06 in length group 23.0 cm except groups 17.0, 18.0 and 19.0 cm had lower values (Figure 4).

Fig. 4: Condition Factor variation of *B. boops* from the Mediterranean water front Alexandria during 2018 according to month (above) and according to size (lower).
Age determination:

The longevity of *B. boops* was estimated to be 4 years by counting the annual growth rings and back calculation of 586 individual scales. Length at the end of 1st year (I) was estimated as 8.44 cm, at 2nd year (II) 13.86 cm, at 3rd year (III) 17.91 cm and at 4th year (IV) 21.03 cm with increment of 8.44, 5.42, 4.03 and 3.12 cm, respectively (Fig. 5).

![Fig. 5: Length at the end of each age group of *B. boops* from the Mediterranean waters from Alexandria during 2018.](image)

The data of the abundance percentage revealed that, fishes belonging to age groups I+ and II+ were the most dominant that constituted 55.8% and 41.8% respectively followed by age group III+ (2.0%) while age group IV+ contributed only about 0.3% (Fig. 6).

![Fig. 6: Fish number corresponding to each age group of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.](image)

The results revealed that the values of von Bertalanffy growth parameters were estimated as 30.65 cm, 0.279 year\(^{-1}\) and -0.156 year, for \(L_\infty\), \(K\) and \(t_0\) respectively. Length-weight relationship equation was applied to calculate \(W_\infty\) (276.20 g). Growth performance was calculated to be 2.418. Growth in length and in weight is represented by equations:

\[
L_t = 30.65 \left[1-e^{-0.279(t+0.156)}\right] \quad \text{growth in length,}
\]

\[
W_t = 276.2 \left[1-e^{-0.279 (t+0.156)}\right]^3 \quad \text{growth in weight.}
\]

For all samples, the sex ratio was recorded to be 1: 1.03 (males to females). Monthly variation of gonado-somatic index (GSI) in both males (from 1.09% to 1.69%) and females (from 1.57% to 2.57%) revealed that *B. boops* is spawn during the period from January to April, the peak in March. Length at first maturity estimated to be 13.2 cm (1.86 year) for bogue females. There is no female larger than 17 cm total length are immature (Fig. 7).
Fig. 7: Gonadosomatic index (above) and length at first sexual maturity (lower) of *B. boops* from the Mediterranean water front Alexandria, Egypt during 2018.

**Population structure:**

Length at first capture (*Lc*), length at recruit was estimated at 12.5 and 11.03 cm respectively. The age at first capture and at recruit were calculated to be 1.72 and 1.45 year respectively. Total mortality rate (*Z*) was estimated using length converted catch curve (Fig. 8) and it was 2.26 y\(^{-1}\) while the natural mortality (*M*) was calculated from Pauly’s equation with water mean temperature of 20.83 °C and it was 0.671 y\(^{-1}\). The fishing mortality (*F*) simply calculated as *Z*-M (1.589 y\(^{-1}\)). The exploitation ratio was 0.703. Yield per recruit (*Y/R*), biomass per recruit (*B/R*), relative Yield (*Y/R’*) and relative biomass per recruit were estimated to be 17.90 g, 11.26 g, 0.022 and 0.014, respectively (Table 2).

Fig. 8: Length –converted catch curve for estimation total mortality of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.
Virtual Population Analysis was figured the numbers of survival, natural loss, fishing mortalities and catches corresponding to each length groups. VPA showed that fish of small sized groups were most naturally lost and the length groups from 12 to 14 were the most abundant in catch and exposed to more fishing mortalities by the fishing gears (Fig. 9).

![Virtual Population Analysis](image)

**Fig. 8**: Relative yield and biomass per recruit (above) and virtual population analysis (lower) of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.

## DISCUSSION

The relation between length and weight is one of the most biological characters of fishes where weight of the fish increases as a function of its length. In present study, “b” values of length-weight relationship of *B. boops* were of usual, ranged from 2.92 to 2.98 (Hile, 1936; Martin, 1949). These values were around the ideal,
indicating a tendency towards isometric growth (Allen, 1938). From length-weight relationship equations, it was observed that the exponent “b” in the case of males (2.98) is higher than that of females (2.91), indicating the better condition of males than females of this fish. Value of ‘b’ in pooled data (2.96) was nearly similar that obtained by Magnusson (1987) in Cape Verde and Anato & Ktari (1986) in Tunisian coast. Ideal value “b= 3” was reported by many authors (Mosaad, 1990; Djabali et al., 1993 and Merella et al., 1997). Positive allometry growth (b> 3) for B. boops was recorded in the Egyptian waters (Abdallah, 2002), in Turkish waters (Hernandez. 1989; Kara & Bayhan, 2008 & 2015; Soykan et al., 2015) and in Tunisian water (Hajjej et al., 2010). While negative allometry growth (b< 3) was recorded in the Algerian waters (Zouhir et al., 2013; Rachid et al., 2014; kherraz et al., 2016) and in Egyptian waters (El-Okda, 2008) and in Spain (Valle et al., 2003). According to Pauly & Gayanilo (1997), b values may be ranged from 2.50 to 3.50. Variations in exponent “b” values of fish at various localities may be attributed to the variations in environmental conditions and localities (Andreu-Soler et al., 2006; Olim & Borges, 2006). The parameters are affected by a series of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health and preservation techniques (Tesch, 1971; Bagena & Tesch, 1978; Hossain et al., 2006).

The mean value conditions factor (K) was about 1, indicating to the ecological conditions at the Mediterranean Sea are nearly suitable for the growth of these fishes. These observations were differed with that obtained by Soykan et al. (2015) who recorded 0.266 at Aegean Sea, Turkey and attributed the low value of condition factor to the pollution problems in this sea. In the present study, K-factor exhibited specific fluctuation in both sexes during the different months of the years. In males and females, the highest value of K-factors (1.09) was recorded during November and the lowest value (0.90) occurred during January and October. The variation in condition factor (k) reflects the physiological state of the fish in relation to its welfare, nutritional aspect, gonad development (Laleye, 2000), environmental conditions, stress and pollution (Angelescu et al., 1958).

Age determination is essential for fishery assessment and for the management of Bogue fisheries (Gordo 1995; Panfili et al. 2002; Sana et al. 2005). A number of 586 scales of fishes ranging from 9.0 to 23.1 cm total length were observed and used for estimation of the growth parameters. The results revealed that the maximum life span of B. boops was 4 years, and age group I+ and II+ were the most frequent in the catch, constituting together more than 90%. On the other hand, the age group III+, IV+ and 0+ were represented by very small percentages in the catch. Growth parameters of B. boops were reported in different locations. L∞ ranged from 24.0 to 36.0 cm; k ranged from 0.17 to 0.54; t0 ranged from 1.94 to -0.33 year and performance ranged from 2.15 to 2.60. In the present study, the growth parameters were laying in the ranges that recorded in previous studies in the Mediterranean waters except value of t0 (Table 3). The difference in growth parameters between different locations could be attributed to the difference in fish size, fishing pressure and/or due to the difference in ecological parameters.

In the present study, the monthly distribution of gonado-somatic index values indicated that its values were peaked from January to April (i.e. during the spawning season). These results agreed mostly with other studies (Mouneimne, 1978 in Libanon waters; Anato & Ktari, 1983 in Tunisian coasts; Hassan, 1990 in Egyptian waters and Massaro, 2012 in Canary Island). Minor differences in the spawning season may reflect different temperature regimes and/or feeding dominance among the areas (Kashiwagi et al., 1987).
Table 3: Growth parameters (L∞, K and t₀) and the growth performance of Boops boops from different location

<table>
<thead>
<tr>
<th>Location</th>
<th>Sex</th>
<th>L∞ (cm)</th>
<th>K</th>
<th>t₀ (year)</th>
<th>Ø</th>
<th>Reference</th>
</tr>
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<tr>
<td>Adriatic Sea</td>
<td>C</td>
<td>33.89</td>
<td>0.17</td>
<td>-1.3</td>
<td>2.28</td>
<td>Hernandez, 1989</td>
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<td>Algeria</td>
<td>F</td>
<td>27.30</td>
<td>0.22</td>
<td>-1.94</td>
<td>2.21</td>
<td>Djabali et al., 1990</td>
</tr>
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<td>Algeria</td>
<td>M</td>
<td>26.60</td>
<td>0.21</td>
<td>-2.6</td>
<td>2.17</td>
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<tr>
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<td>F</td>
<td>34.13</td>
<td>0.26</td>
<td>-1.50</td>
<td>2.48</td>
<td>Kherraz et al., 2016</td>
</tr>
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<td>0.38</td>
<td>-0.75</td>
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<td>0.30</td>
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<td>Bouaziz et al., 2010</td>
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<tr>
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<tr>
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<td>Livadas, 1989</td>
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<td>Tunisia</td>
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<td>32.27</td>
<td>0.11</td>
<td>-1.69</td>
<td>2.07</td>
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</tr>
<tr>
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<tr>
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<td>29.87</td>
<td>0.24</td>
<td>-0.98</td>
<td>2.33</td>
<td></td>
</tr>
</tbody>
</table>

C, combined sexes; F, females; M, males and * the value of Ø was calculated

Length at first maturity in the present study for females (13.2 cm) was agreed with that observed in Gulf of Lion (Girardin & Quignard, 1986), in Libanon waters (Mouneimne, 1978), in Adriatic Sea (Hernández, 1989) and in Egyptian waters (El-Agmy et al., 2004). It was smaller than that observed by Monteiro et al. (2006) in Portugal and Massaro (2012) in Canary Island.

The obtained value of L for B. boops was 11.05 cm, while the value of L∞ was 12.2 cm, whereas the value of females Lm was 13.2 cm. Results revealed that the estimated value of L∞ was lower than estimated Lm, which was an evidence of over-fishing that prevent them from spawning at least once before being caught. Estimated exploitation ratio (E) was 0.703/year, which seemed to be higher than 0.5; optimum level of exploitation (Gulland, 1971), indicating that the stock of B. boops is overexploited. Yield per Recruit (Y/R) analysis shows a clear status of growth overexploitation, due both to a high fishing mortality and an exploitation of the fishery based on juveniles under the minimum legal size. Also, the stock is in danger of recruitment overexploitation due to the decreasing trend in recruitment.

For management purpose, length of first capture should be larger than 13.2 cm, decrease fishing effort of trawls during winter season (bogue spawning period) and the current exploitation rate should be reduced from 0.70 to be < 0.50 i.e. the fishing mortality should be reduced by 58.0 % of current fishing mortality to maintain a sufficient spawning biomass for sustainability.

REFERENCES


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ARABIC SUMMARY

العمر، النمو والتركيب العشائري لأسماء الموزة (Boops boops) في مياه البحر المتوسط أمام الأسكندريت، مصر

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انخفضت كمية الإنتاج السنوي لمسايد أسماك الموزة في مصر من حوالي 2000 طن إلى حوالي 1000 طن سنوياً وذلك في السنوات العشر الأخيرة. وتتوفر هذه الدراسة معلومات بيئية عن مساید هذا النوع لأغراض إدارة مصايدها في مياه البحر المتوسط بمصر. وقد تم تجمع عينات عشوائية شهرية بإجماعية 1377 عينة من ثلاثة مناطق أبرزها أهالي واسع تم إعدادها خلال عام 2018. وأظهر النتائج أن الطول الكلي لسمكة الموزة يتراوح بين 9.3 إلى 23 سم، كما تراوح الوزن الكلي بين 0.4 و 133.1 جم. كما كانت دراسة العلاقة بين الطول والوزن أن قيمة "b" (2.92) تشير إلى ميل للنمو المثالي بالعمل الذي ي دمشق حسابية عالية. وتم تحديد أربع سنوات عمرية لمسايد الأسماك في منطقة الدراسة وكانت الفئات ذات عمر سنة وجيدة والإكتشاف في المصمود بنسبة 89%، كما وجد أن الطول عند أول صيانة للسمكة وطول عند أول نضج جنسي للسمكة هو 15.2 و 13 سم على التوالي. وكانت معدلات النمو خلال فترة الدراسة 2.71 و 1.58 و 2.22 للنوع الطبيعي، النمو الفعلي تساوي حسابات الصيد والنمو الكلي، على التوالي. ويتعذر المخزون السمكي لهذا النوع في مياه البحر المتوسط أمام الإسكندرية للاستغلال المغرف (معدل الاستغلال = 0.7). وقد تم اقتراح بعض الاتجاهات الخاصة بإدارة مصايد هذا النوع لضمانها مخزونها وتنمية واستدامة مصايدها.