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 Alexandra 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.
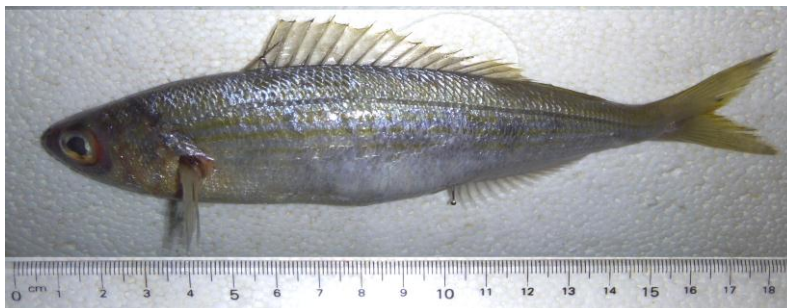

Fig. 1: Bogue, *Boops boops* (Linnaeus, 1758), From Mediterranean water front the coastal area off Alexandria, Egypt.

For last 10 years, *B. boops* catch decreased from 3677 MT in 2007 to be 2150 MT in 2016. *B. boops* (Lenneous,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-Anfoushi and Abu Qir) in the Mediterranean Sea front Alexandria; 31°14.1' N & 29°56.6'E (Fig. 2).
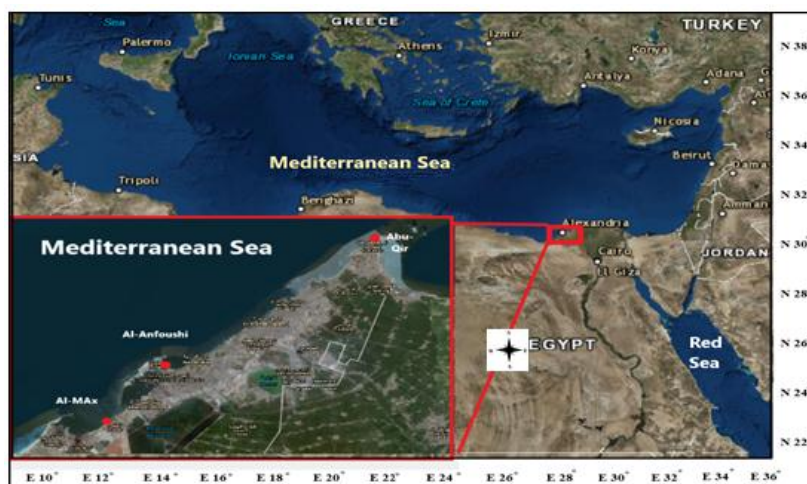

Fig. 2: Map of Egypt showing the Mediterranean coastal area off Alexandria with different landing sites during the present study.

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) $K = 100W/L^3$; where W is the total weight (g), and L is the total length (cm). Fish age was determined using scales and von Bertelanffy growth parameters were estimated. Gonado-somatic Index (GSI) was calculated using the equation, $GSI = 100W_g/W$, 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_∞ 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 1: Fish number, length, weight and samples statics of *B. boops* collected from the Mediterranean waters front Alexandria during 2018.

	Sex	Fish No.	Minimum	Maximum	Average	SD	SE
Total	**M**	683	9.3	21.6	13.40	±1.819	0.0696
length	**F**	684	10.0	23.1	13.81	±1.779	0.0680
(cm)	**C**	1367	9.3	23.1	13.60	±1.810	0.0490
Total	**M**	683	7.7	116.9	24.40	±10.913	0.4176
Weight	**F**	684	7.4	133.1	27.12	±12.152	0.4646
(g)	**C**	1367	7.4	133.1	25.77	±11.624	0.3144

*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,
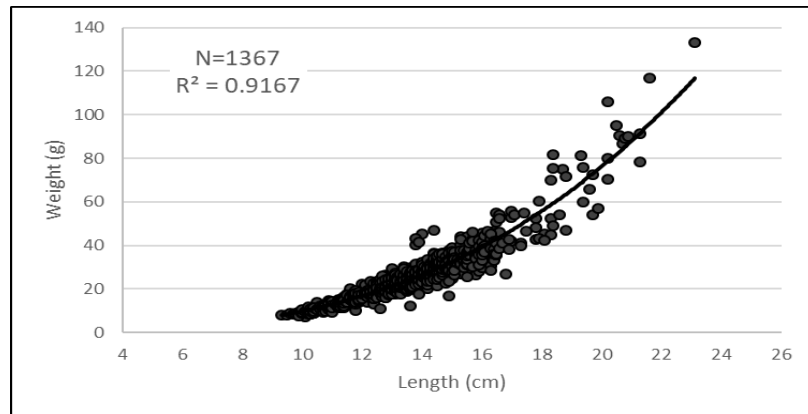$W = 0.011L^{2.960}$ ($R^2 = 0.9167$) for combined sexes.

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).
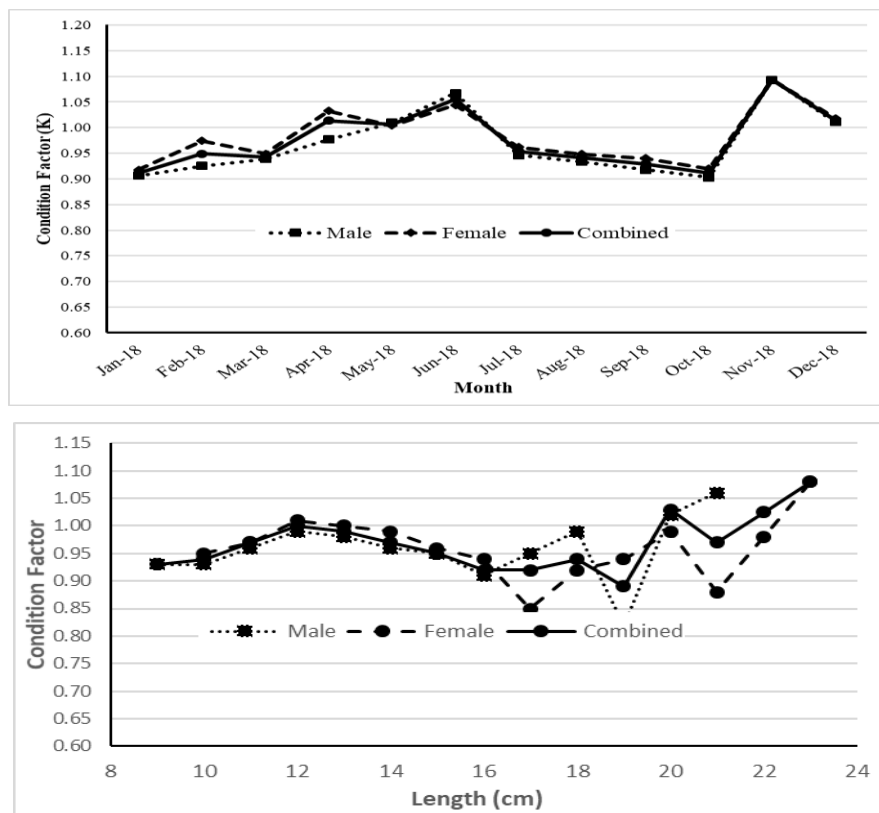

Fig. 4: Condition Factor variation of *B. boops* from the Mediterranean water front Alexandria during 2018 according to month (above) and according to size (lower).

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).
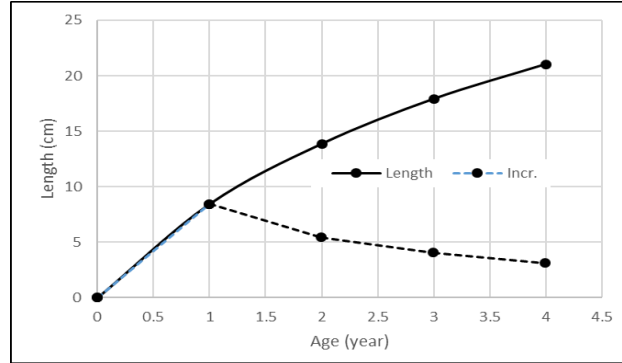

Fig. 5: Length at the end of each age group of *B. boop* from the Mediterranean waters fron Alexanderia during 2018.

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).
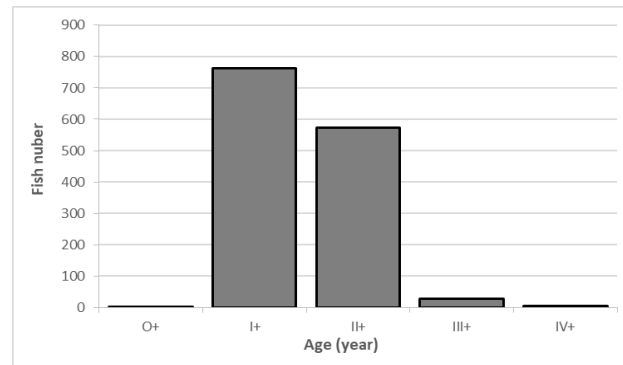

Fig. 6: Fish number corresponding to each age group of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.

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_∞, K and t_o respectively. Length-weight relationship equation was applied to calculate W_∞ (276.20 g). Growth performance was calculated to be 2.418. Growth in length and in weight is represented by equations:

$L_t = 30.65 [1-e^{-0.279(t+0.156)}]$ growth in length,

$W_t = 276.2 [1-e^{-0.279 (t+0.156)}]^3$ 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).
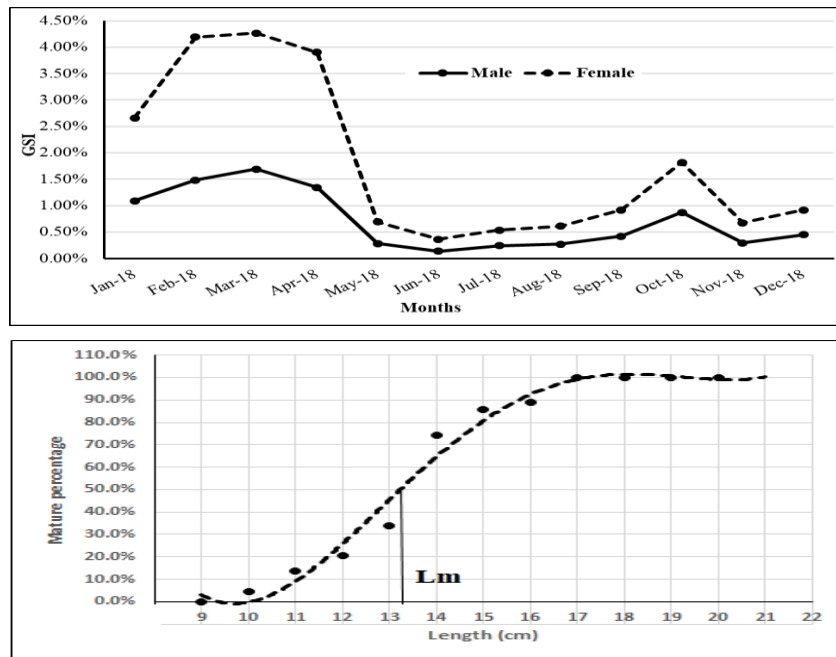
Fig. 7: Gonadosomatic index (above) and length at fist sexual maturity (lower) of *B. boops* from the Mediterranean water front Alexandria, Egypt during 2018.

Population structure:

Length at first capture (L_c), 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 Paulys' 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).
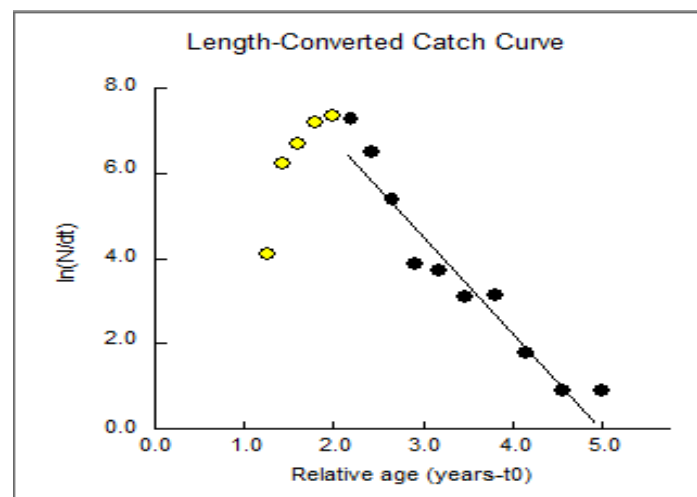

Fig. 8: Length –converted catch curve for estimation total mortality of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.

Table 2: Population structure of combined sexes of *B. boops* from the Mediterranean waters front Alexandria during 2018.

Parameter	Symbol	Value	Parameter	Symbol	Value
Age at zero length	t_o	-0.156 y	**Stock estimation**	**P**	**3057 MT**
Asymptotic body length	L_∞	30.65 cm	**Length at first maturity**	**L_m(50%)**	**13.2 cm**
Asymptotic body weight	W_∞	276.20 g	**Life span**	**t_{max}**	**11.952 y**
Coefficient of growth	**K**	0.279 y^{-1}	**Length at first capture at 50%**	**L_c**	**12.50 cm**
Total mortality	**Z**	2.260 y^{-1}	**Age at first capture**	**t_c**	**1.73 y**
Natural mortality	**M**	0.671 y^{-1}	**Length at recruitment**	**L_r**	**11.05 cm**
Fishing mortality	**F**	1.589 y^{-1}	**Age at recruitment**	**t_r**	**1.45 y**
Exploitation rate	**E**	0.703	**Yield per recruit**	**Y/R**	**17.90 g**
Annual survival rate	**S**	0.1044 y^{-1}	**Biomass per recruit**	**B/R**	**11.26 g**
Annual mortality rate	**A**	0.8957 y^{-1}	**Relative yield per recruit**	**Y/R'**	**0.022**
Catch	**C**	2150 MT	**Relative biomass per recruit**	**B/R'**	**0.014**

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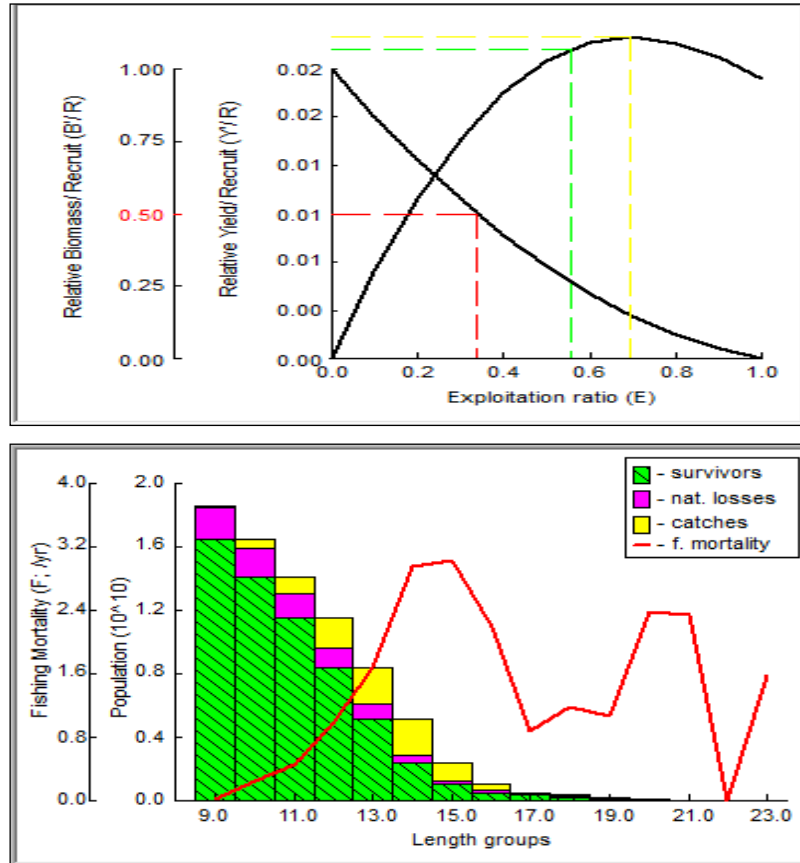
Fig. 8: Relative yield and biomass per recruit (above) and virtual population analysis (lower) of *B. boops* from Mediterranean water front Alexandria, Egypt during 2018.

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; Bagenal & 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; t_o 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 t_o (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

Location	Sex	L_∞ (cm)	K	t_o (year)	Ø	Reference
Adriatic Sea	C	33.89	0.17	-1.3	2.28	Hernandez, 1989
Algeria	F	27.30	0.22	-1.94	2.21	Djabali *et al.*, 1990
Algeria	M	26.60	0.21	-2.6	2.17	
Algeria	F	34.13	0.26	- 1.50	2.48	Kherraz *et al.*, 2016
Algeria	M	26.78	0.38	- 0.75	2.43	
Algeria	F	30.66	0.30	0.00	2.45[*]	Bouaziz *et al.*, 2010
Algeria	M	26.66	0.30	0.00	2.33[*]	
Cyprus	C	24.00	0.53	-0.45	2.49[*]	Livadas, 1989
Egypt	C	29.80	0.18	-1.33	2.20	Hassan, 1990
Egypt	C	31.68	0.153	-1.78	2.19	Allam, 2003
Egypt	F	29.70	0.25	-0.70	2.34	El-Haweet *et al.*, 2005
Egypt	M	28.10	0.18	-1.13	2.15	
Egypt	C	30.11	0.15	-1.51	2.14	El-Okda, 2008
Egypt	C	27.24	0.54	-0.33	2.60	Mehanna, 2014
Greece	C	36.00	0.40	---	2.71	Tsangridis & Filippousis, 1991
Morocco	C	31.50	0.28	-0.96	2.44[*]	Zoubi, 2001
Portugal	C	28.06	0.22	-1.42	2.24[*]	Monteiro *et al.*, 2006
Tunisia	C	32.27	0.111	-1.69	2.07	Anato & Ktari, 1986
Turkey	F	30.79	0.239	- 0.90	2.36	Kara & bayhan, 2015
Turkey	M	29.87	0.243	- 0.98	2.33	
Turkey	C	29.58	0.266	-1.14	2.37	Soykan *et al.*, 2015
Egypt	C	30.65	0.279	-0.16	2.42	Present study

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_r for *B. boops* was 11.05 cm, while the value of L_c was 12.2 cm, whereas the value of females L_m was 13.2 cm. Results revealed that the estimated value of L_c was lower than estimated L_m, 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.

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ARABIC SUMMARY

العمر، النمو والتركيب العشائري لأسماك الموزة (*Boops boops*) في مياه البحر المتوسط أمام الأسكندرية، مصر

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انخفضت كمية الإنتاج السنوي لمصايد أسماك الموزه في مصر من حوالي ٤٠٠٠ طن إلى حوالي ٢٠٠٠ طن سنوياً وذلك في السنوات العشر الأخيرة. وتوفر هذه الدراسة معلومات بيولوجية عن مصايد هذا النوع لأغراض إدارة مصايدها في مياه البحر المتوسط بمصر. وقد تم تجميع عينات عشوائية شهرية بإجمالي ١٣٦٧ عينة من ثلاثة مناطق إنزال أمام الاسكندرية خلال عام ٢٠١٨. وأظهرت النتائج أن الطول الكلى لسمكة الموزة يتراوح بين ٩.٣ إلى ٢٣.٠ سم ، كما تراوح الوزن الكلي بين ٧.٤ و ١٣٣.١ جم. كما كشفت دراسة العلاقة بين الطول والوزن أن قيمة "b" (٢.٩٦) تشير إلى ميل للنمو المتماثل بمعامل ذي دلالة إحصائية عالية. وتم تحديد أربع سنوات عمرية لأسماك الموزه في منطقة الدراسة وكانت الفئات ذات عمر سنة وسنتان هما الأكثروفرة في المصيد بنسبة ٨٥%. كما وجد أن الطول عند أول مصيد للسمكة والطول عند أول نضج جنسي للسمكة هي ١٢.٥ و ١٣.٢ سم على التوالي. وكانت معدلات النفوق خلال فترة الدراسة ٠.٦٧١ و ١.٥٨٩ و ٢.٢٦ للنفوق الطبيعي، النفوق الناتج عن عمليات الصيد والنفوق الكلي، على التوالي. ويتعرض المخزون السمكي لهذا النوع في مياه البحر المتوسط أمام الإسكندرية للاستغلال المفرط (معدل الأستغلال = ٠.٧). وقد تم اقتراح بعض التدابير الخاصة بإدارة مصايد هذا النوع لصيانة مخزونتها وتنمية واستدامة مصايدها.