Some biological aspects of bogue *Boops boops* (Linnaeus, 1758) from Saros Bay (Northern Aegean Sea, Turkey)

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ABSTRACT

This study was conducted to determine the growth parameters, mortality and length at first maturity of bogue *Boops boops* (Linneaus, 1758) in Saros Bay (Northern Aegean Sea). A total of 363 specimens were obtained, monthly, from commercial fishermen between February 2016 and January 2017. The total length and weight of sampled fish ranged from 11.3 to 24.1 cm and from 16.61 to 165.32 g, with a mean of 16.9 cm and 60.40 g, respectively. The length-weight relationship was calculated as $W = 0.0080TL^{3.13}$. The von Bertalanffy growth equations were computed to be $L_\infty = 27.9$ cm, $k = 0.21$ year^{-1}, $t_0 = -1.57$ year. The growth performance index (Φ') was found as 2.21. The length at first maturity was estimated as 16.6 cm. Total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F) and exploitation rate (E) of the bouge were 0.44 year^{-1}, 0.38 year^{-1}, 0.06 year^{-1} and 0.13 year^{-1}, respectively. The present study provides preliminary information on the growth parameters, mortality and length at first maturity of *B. boops* for the Saros Bay (Northern Aegean Sea, Turkey).

Keywords: fisheries management, growth parameters, Perciformes, Sparidae, stock assesment.

INTRODUCTION

The information on the age and growth of fish species is important for a comprehensive understanding of their population dynamics. This knowledge forms the basis for the calculations of growth, productivity estimates, and mortality rates (Campana 2001). In this connection, the growth parameters, the core of fisheries biology and ecology, are used for tasks such as: (a) development of stock assessment models (Hilborn and Walters 1992); (b) building of ecosystem models (Pauly et al. 2000); (c) testing life history patterns and tradeoffs, both within and between species (Rochet 2000; Stergiou 2000); (d) calculating maximum sustainable yield (Beddington and Kirkwood 2005); (e) estimating vulnerability of fish to overfishing (Cheung et al. 2005); and (f) predicting empirical equations for predicting other biological parameters, such as natural mortality (Pauly 1980) and length at first maturity (Froese and Binohlan 2000). The existence of accurate growth parameters estimates is essential for all of the above to be realized (Apostolidis and Stergiou 2014).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer's Catalog of Fishes 2020). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al. 2014) while they previously were listed as distinct and separate (Golani et al. 2006; Nelson 2006; Mater et al. 2011). As far as it is known, 24 Sparidae species within 13 genera (*Boops* Cuvier, 1814; *Centracanthus* Rafinesque, 1810; *Dentex* Cuvier, 1814; *Diplodus* Rafinesque, 1810; *Evynnis* Jordan and Thompson, 1912; *Lithognathus* Swainson, 1839; *Oblada* Cuvier, 1829; *Pagellus* Valenciennes, 1830; *Pagrus* Cuvier, 1816; *Sarpa* Bonaparte, 1831; *Sparus* Linnaeus, 1758; *Spicara* Rafinesque, 1810; *Spondyliosoma* Cantor, 1849) from Turkish territorial waters were reported (Mater et al. 2011) and there are two more species (*Crenidens crenidens* Forsskål, 1775 and *Rhabdosargus haffara* Forsskål, 1775) in the Eastern Mediterranean (Golani et al. 2006) which are lessepsian (Paruğ and Cengiz 2020a).

The genus *Boops* is represented by two species, worldwide: *Boops boops* (Linnaeus, 1758) and *Boops lineatus* (Boulenger, 1892) (Froese and Pauly 2021). *Boops boops* is a demersal or semipelagic species inhabiting inshore waters above various bottoms (sand, mud, rocks or posidonia beds) in the whole Mediterranean, eastern and western Atlantic (Bauchot and Hureau 1986) and moves in aggregations, ascending to the surface mainly at night (Bauchot 1987). It is known to be distributed in all Turkish seas (Fricke et al. 2007). *Boops boops* is exported to European countries such as Greece and Italy, especially during the winter months in their fishing season which is found to be the most abundant. It is of economic importance, and fishing, widely used in the Northern Aegean Sea (Turkey), is commonly made with handline fishing, gill net, and purse seine (Cengiz et al. 2013). According to the Turkish Statistical Institute, *B. boops* yield from fisheries was 2598.8 tonnes (t) in 2020. In the whole General

Fisheries Commission for the Mediterranean (GFCM) areas, its landings varied from catch of 20.586 t in 2016 to 19.711 t in 2018 (FAO 2020).

There are many studies on biology of bogue (Girardin 1981; Anato and Ktari 1986; Girardin and Quignard 1986; Alegría-Hernández 1989; Djabali et al. 1990; Hassan 1990; Abdel-Rahman 2003; Allam 2003; El-Haweet et al. 2005; Khemiri et al. 2005; El-Okda 2008; Amira et al. 2019; Azab et al. 2019), as a summary. As for Turkish sea, the information on biology of *B. boops* come from Saros Bay (Cengiz et al. 2019), Edremit Bay (Bilge 2008), Izmir Bay (Öztürk 1998; Bilge 2008; Kara and Bayhan 2015; Soykan et al. 2015) and Babadıllimanı Bight (Manaşırlı et al. 2006). However, Ceyhan et al. (2018) and Cengiz (2021a) made studies on the maximum length records of the species, while Cengiz et al. (2013) and İlkyaz et al. (2017) extrapolated the selectivity parameters of bogue. This study provides preliminary information on the growth parameters, mortality and length at first maturity of *B. boops* for the Saros Bay (Northern Aegean Sea, Turkey) and compares these results with the previous studies in different areas of Mediterranean Basin.

METHODS

The northern Aegean coasts of Turkey are divided to sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökceada and Bozcaada Islands and the Edremit Bay (Cengiz and Paruğ 2020; Cengiz 2021b). The length of Saros Bay is about 61 km and the width at the opening to the Aegean Sea is about 36 km (Eronat and Sayın 2014). As the bay had been closed to bottom trawl fishing since 2000 (Cengiz et al. 2014) and no industrial activity was prevalent in the area (Sarı and Çağatay 2001), it can be considered as a pristine environment (Cengiz et al. 2015; Cengiz 2021c). For these reasons, Saros Bay and its coastal area were declared as a Special Environmental Protection Area (SEPA) due to its landscape, geomorphological, ecological, floristic biogenetic and touristic properties (Güçlüsoy 2015) (Figure 1).

Samples were obtained monthly between February 2016 and January 2017 in random stratified sampling from commercial fishermen catching fish species by drive-in fishing method around Saros Bay. The individuals were measured to the nearest centimeter (total length), weighed to the nearest 0.01 g (total weight). The length-weight relationship was estimated by fitting an exponential curve, $W = aL^b$ (Le Cren 1951). Parameters a and b of the exponential curve were estimated by linear regression analysis over log-transformed data $\log W = \log a + b \log L$, where W is the total weight (g), L is the total length (cm), a is the intercept, and b is the slope or allometric coefficient, using the least-squares method. Value $b > 3$ shows positive allometric growth, while value $b < 3$ indicates negative allometric growth. It is isometric growth when value b is equal to 3 (Bagenal and Tesch 1978). The growth type was identified by Student's *t*-test.

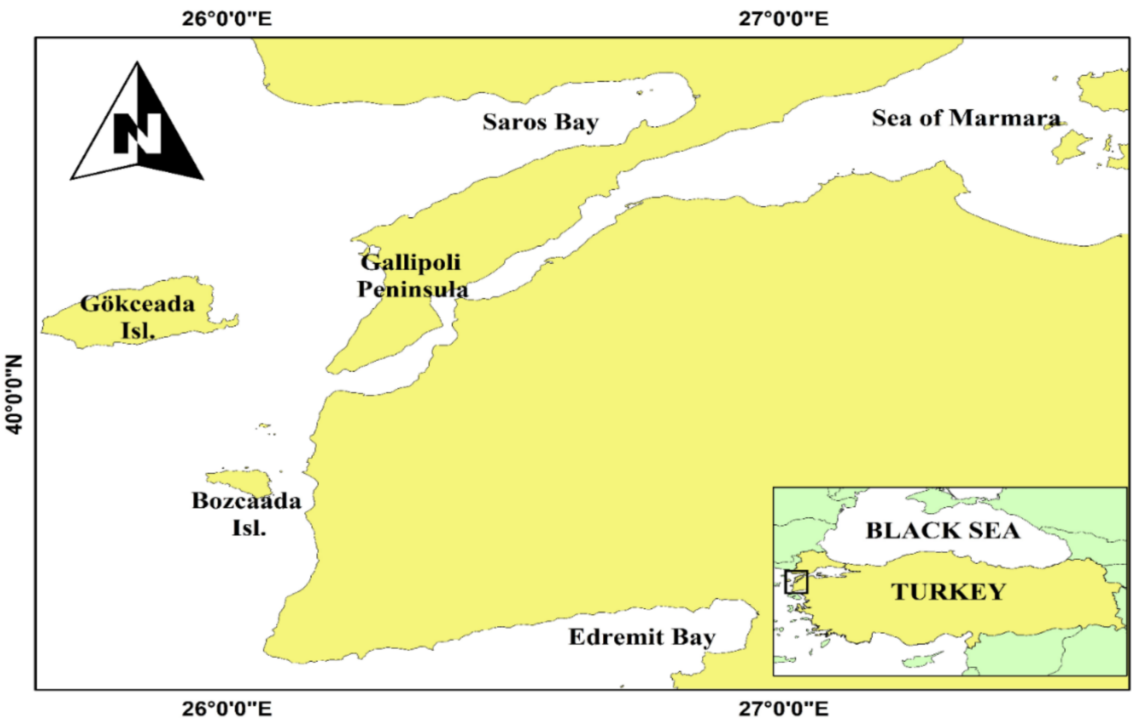

Figure 1. Saros Bay and the northern Aegean coasts of Turkey.

The otoliths were evaluated for age determination. Following removal, the sagittal otoliths were put in a mixture of first 5% HCL and then 3% NaOH solutions, washed in distilled water and subsequently dried. The sagittal otoliths placed in watch glass filled with water were read using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be one year (Cengiz 2019). Growth parameters were estimated by using the von Bertalanffy growth equation: $L_t = L_\infty [1 - e^{-k(t-t_0)}]$, where L_t is fish length (cm) at age t, L_∞ is the asymptotic fish length (cm), t is the fish age (years), t_0 (years) is the hypothetical time at which the fish length is zero, and k is the growth coefficient (year^{-1}). FAO-ICLARM Stok Assessment Tools FISAT II) were used to estimate growth parameters, which were calculated with the non-linear least-squares method. The growth parameters obtained in this study were compared with the parameters obtained in other studies from various geographical areas using the growth performance index (Φ') (Pauly and Munro 1984). It was estimated using the formula, $\Phi' = \log(k) + 2*\log(L_\infty)$. The length at first maturity was determined from asymptotic length by using the empirical relationship of Froese and Binohlan (2000): $\log L_m = 0{\cdot}8979*\log L_\infty - 0.0782$ (for all samples). Total mortality rate (Z) was estimated from linearized catch curve based on age composition data (Sparre and Venema 1992). Natural mortality rate (M) was computed from Pauly (1980)'s multiple regression formula: $M = 0.8*\exp(-0.0152-0.279*\ln L\infty + 0.6543*\ln K + 0.463*\ln T)$, where L_∞ and K are the parameters obtained from the von Bertalanffy growth equation and T (°C) is the annual mean water temperature at the study locality. Fishing mortality rate (F) was estimated from F=Z–M, and the exploitation rate (E) from E=F/Z.

RESULTS

A total of 363 individuals were, monthly, collected from commercial fishmongers around Saros Bay. The mean ± standard error (and range) of total length and total weight for all samples were 16.9 ± 0.16 (11.3 – 24.1) cm (Figure 2) and 60.40 ± 1.79 (14.61 – 165.32) g, respectively. The length-weight relationship was estimated as $W = 0.0080TL^{3.13}$ ($R^2 = 0.98$) (Figure 3). The *b*-values and *t*-test results indicated positive allometric growth.

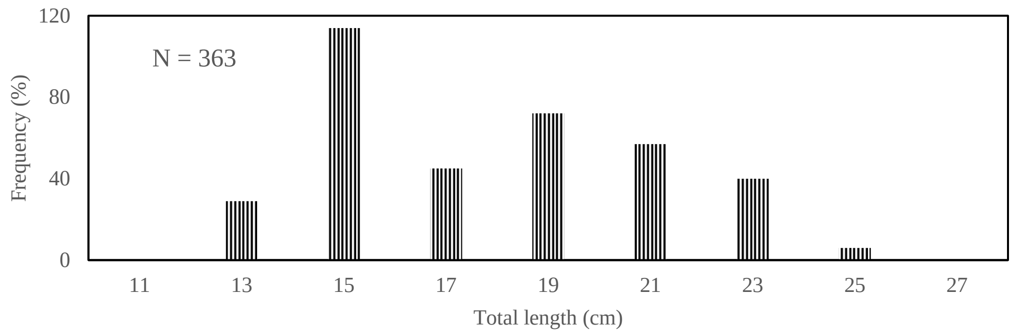

Figure 2. The length-frequency distribution for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

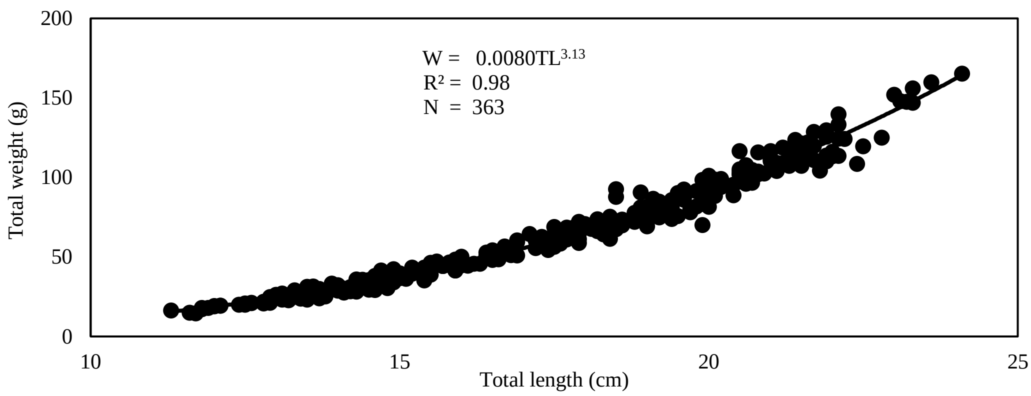

Figure 3. The length-weight relationships for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

Results obtained from the otolith reading of 363 individuals displayed that the ages of the fishes were found to be within the range of 1 to 9 years. Table 1 revealed fishes belonging to age groups 2 and 3 were the most dominant. The von Bertalanffy growth equations were computed as L_∞ = 27.9 cm, k = 0.21 year^{-1}, t_0 = –1.57 year for all samples (Figure 4). The growth performance index (Φ') was found as 2.21. The length at first maturity was estimated as 16.6 cm.

Total mortality rate (Z) for all samples was 0.44 year^{-1} (Figure 5). The annual water temperature mean in the study locality was 14.3°C. Thus, natural mortality rate (M) was estimated as 0.38 year^{-1}. Fishing mortality rate (F) was found to be 0.06 year^{-1}. The exploitation rate (E) was calculated as 0.13 year^{-1}.

Table 1. The age-length key for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

Length class (cm)	**Age (years)**									**All samples**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
11.0 – 13.0	26	3	-	-	-	-	-	-	-	29
13.1 – 15.0	28	84	2	-	-	-	-	-	-	114
15.1 – 17.0	-	18	27	-	-	-	-	-	-	45
17.1 – 19.0	-	1	38	33	-	-	-	-	-	72
19.1 – 21.0	-	-	-	8	42	7	-	-	-	57
21.1 – 23.0	-	-	-	-	1	20	12	5	2	40
23.1 – 25.0	-	-	-	-	-	-	-	4	2	6
All samples										
N	54	106	67	41	43	27	12	9	4	363
%	14.88	29.20	18.46	11.29	11.85	7.44	3.31	2.48	1.10	100
Min	11.3	13.0	14.7	17.5	19.2	20.4	21.3	21.5	22.5	11.3
Max	13.9	17.4	19.0	20.2	21.5	21.9	22.2	23.3	24.1	24.1
Mean	13.0	14.4	17.0	18.6	20.0	21.3	21.9	22.6	23.3	16.9
S.E.	0.09	0.09	0.11	0.10	0.09	0.08	0.08	0.22	0.35	0.16

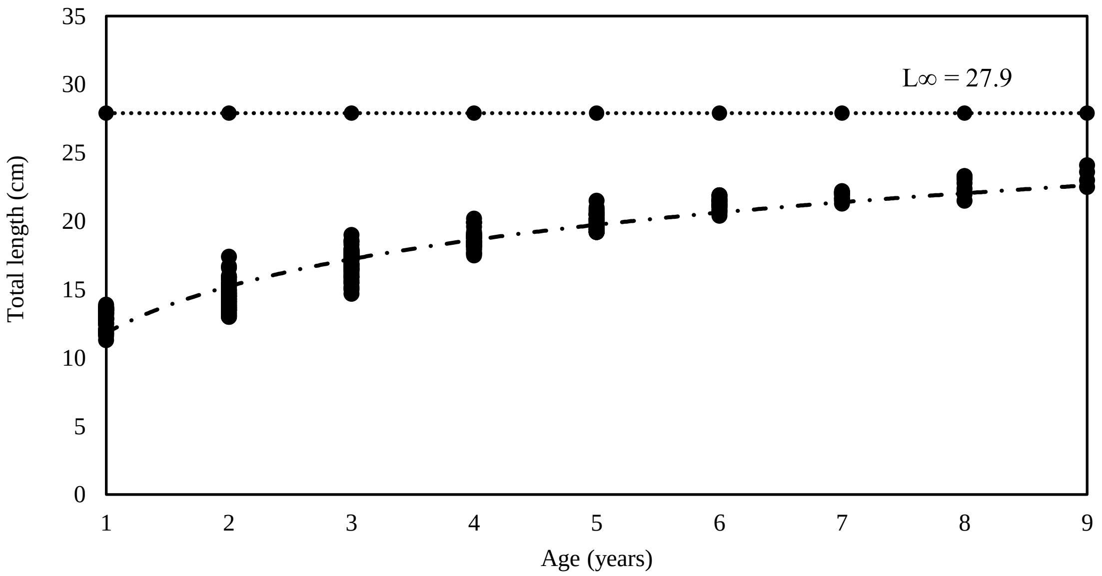

Figure 4. The growth curves for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

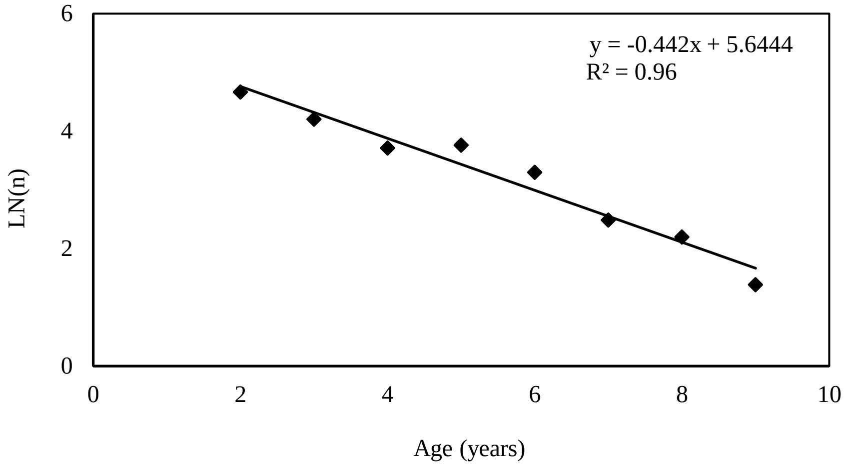

Figure 5. Age structured catch curve for estimation of total mortality (Z) of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

DISCUSSION

Table 2 summarizes the results about the length-weight relationships (LWRs) between the present study to previous ones.

The *b* values in LWRs falls between 2.5 and 3.5 (Froese 2006) or 2 to 4 (Tesch 1971). In this study, the *b* value of *B. boops* was within these expected ranges. Generally, the *b* value obtained from LWR estimation within the same species can change depending on the degree of gonad maturity, sex, diet, sample preservation techniques, stomach fullness (Wootton 1990), number of specimens analyzed, area/season effects, sampling duration (Moutopoulos and Stergiou 2002), fishing gear used (Kapiris and Klaoudaos 2011), and size selectivity of the sampling gear (İşmen et al. 2007). For these reasons, Torres et al. (2012) underlined that LWRs may change temporarily and/or spatially, so these studies should be regularly updated for each separate population.

The mean lengths at different ages for *B. boops* given by various authors are listed in Table 3. However, Table 4 indicates the maximum ages, growth parameters and growth performance indices of *B. boops* reported in Mediterranean Basin.

The maximum age of the bogue was reported as 11 years by Girardin and Quignard (1986) in the Gulf of Lion and 13 years by Khemiri et al. (2005) in eastern Tunisian coasts. The maximum ages can vary widely among the populations within species especially those that have wide distributions (Gibson 2005). In this case, the reasons for differences in longevity could be attributed to the effects of temperature, intensities of competition for food, food availability, life history strategies, and fishing efforts (Nash and Geffen 2005). Within the Mediterranean Sea, there exists a west-east gradient (Krom et al. 1991). The Eastern Mediterranean has been identified as one of the most oligotrophic areas of the world (Azov 1986; Paruğ and Cengiz 2020b). These values from the western Mediterranean areas are the highest one compared to all other eastern Mediterranean values. This may be because the eastern Mediterranean is one of the most oligotrophic areas of the world. The differences in growth parameters among the study areas could probably be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences and aging methodology used (Monterio et al. 2006), incorrect age interpretation (Matić-Skoko et al. 2007; Bayhan et al. 2008), size, quantity and quality of food and water temperature (Santic et al. 2002), and differences in length at first maturity (Champagnat 1983). Besides, the selectivity of the fishing tool used can also affect the estimates of growth parameters (Ricker 1969; Potts et al. 1998). Therefore, the possible reasons for the differences in the results between the other studies and this study may be related to one or more factors given above. Table 5 documents the previous studies on length at first maturity of *B. boops* from different areas.

The length at first maturity from asymptotic length by using the empirical relationship has been calculated by many authors (Ateş et al. 2008; Cengiz 2013; Hossain et al. 2013; Kindong et al. 2019, etc.). The differences in lengths at first maturity between different areas could be attributed to food availability and temperature (Nikolsky 1963; Hempel 1965), overfishing pressure and selectivity (Trippel 1995; Helser and Almeida 1997; Jennings et al. 2001), genetic factors (Wootton 1998), and the use of different methods (Trippel and Harvey 1991; Froese and Binohlan 2000). Table 6 reports the results of earlier studies concerning mortality rates of *B. boops* from different areas.

Table 2. Comparision of length-weight relationships of *B. boops* in Mediterranean Basin. ♀ = Female, ♂ = Male, Σ = All samples, N = Sample size; *a* and *b* = the parameters of the relationships

References	Location	Sex	N	Length range (cm)	*a*	*b*
Petrakis and Stergiou (1995)	south Euboikos Gulf (Greece)	Σ	256	9.6 – 24.3	0.000012	3.09
Çiçek et al. (2006)	Babadıllimanı Bight (Turkey)	Σ	391	7.5 – 21.4	0.0080	3.04
Karakulak et al. (2006)	Gökçeada Island (Turkey)	♂	213	15.3 – 27.8	0.0074	3.11
		♀	232	15.4 – 32.1	0.0032	3.39
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Σ	314	7.5 – 21.4	0.0084	3.03
İşmen et al. (2007)	Saros Bay (Turkey)	Σ	189	10.5 – 22.0	0.0045	3.24
Bilge et al. (2008)	İzmir Bay (Turkey)	Σ	1245	9.5 – 27.1	0.0065	3.10
	Edremit Bay (Turkey)	Σ	1150	9.3 – 28.1	0.0041	3.32
Cherif et al. (2008)	Gulf of Tunis (Tunisia)	Σ	243	12.0 – 26.0	0.0070	3.06
El-Okda (2008)	Alexandria (Egypt)	Σ	920	-	0.0254	2.66
Hajjej et al. (2010)	Gulf of Gabes (Tunisia)	Σ	346	12.6 – 22.6	0.0102	3.03
Ramdene et al. (2013)	Bejaia (Algeria)	♂	-	-	0.0130	2.81
		♀	-	-	0.0150	2.77
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Σ	1372	9.0 – 29.0	0.0160	2.79
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Σ	2068	9.7 – 27.4	0.0039	3.26
Kara and Bayhan (2015)	İzmir Bay (Turkey)	♂	429	12.2 – 27.0	0.0028	3.42
		♀	503	11.3 – 27.9	0.0069	3.12
Soykan et al. (2015)	İzmir Bay (Turkey)	Σ	421	11.0 – 23.8	0.0050	3.25
Kherraz et al. (2016)	Oran (Algeria)	♂	496	9.0 – 26.0	0.0130	2.86
		♀	578	11.2 – 32.3	0.0120	2.88
Kara et al. (2018)	Gediz Estuary (Turkey)	Σ	51	8.5 – 13.8	0.0092	2.02
Azab et al. (2019)	Alexandria (Egypt)	♂	683	9.3 – 21.6	0.0100	2.97
		♀	684	10.0 – 23.1	0.0120	2.91
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Σ	1734	10.1 – 30.9	0.0016	2.81
Cengiz et al. (2019)	Saros Bay (Turkey)	♂	564	13.7 – 25.6	0.0095	3.07
		♀	374	13.4 – 27.6	0.0085	3.11
Milled-Fathalli et al. (2019)	Gulf of Tunis (Tunisia)	Σ	45	12.5 – 21.0	0.0119	2.88
Babaoğlu et al. (2021)	Çandarlı Bay (Turkey)	Σ	65	6.8 – 13.8	0.0094	3.01
This study	Saros Bay (Turkey)	Σ	363	11.3 – 24.1	0.0080	3.13

The discrepancies between the mortality rates from different areas could probably be attributed to various factors such as different ecological conditions and intensive fishing activities between the localities, and employed various methods (Joksimović et al. 2009). In this study, the low exploitation rate (E) indicated that bogue is not subjected to the fishing pressure. There are two reasons for this case: (1) As the bay had been closed to bottom trawl fishing since 2000, there is no overfishing on bogue; (2) Kumova et al. (2015) stressed that the nets used with drive-in fishery method did not give rise to the fishing pressure on bogue population.

Table 3. The mean lengths at different ages for of *Boops boops* estimated by different ageing methods from some localities in Mediterranean Basin. *from Bilge (2008), **from El - Okda (2008), ♀ = Female, ♂ = Male, Σ = All samples.

References	Location	Ageing Method	Sex	Age (years)										
				0	1	2	3	4	5	6	7	8	9	10
Alegría-Hernández (1989)**	Central Adriatic Sea (Croatia)	Otolith	Σ	-	-	14.7	17.7	20.0	22.0	23.8	-	-	-	-
		Length-frequency	Σ	-	-	14.1	17.0	19.4	21.5	23.2	-	-	-	-
Girardin and Quignard (1986)*	Gulf of Lyon	Scale	Σ	-	9.1	14.2	17.4	20.4	22.5	24.3	25.7	27.4	28.6	29.6
Hassan (1990)**	Egypt	Scale	Σ	-	10.2	13.3	15.9	18.3	20.2	21.7	-	-	-	-
Öztürk (1998)*	İzmir Bay (Turkey)	-	Σ	-	12.8	14.8	17.2	19.1	-	-	-	-	-	-
Abdel-Rahman (2003)**	Alexandria (Egypt)	Scale	Σ	-	9.3	11.3	13.3	14.9	16.4	17.9	-	-	-	-
Allam (2003)**	Alexandria (Egypt)	Scale	Σ	-	11.0	14.0	16.3	18.6	20.5	-	-	-	-	-
El-Haweet et al. (2005)**	from Matrouh city to Saloum Bay (Egypt)	Scale	Σ	-	9.7	12.9	15.5	17.6	19.5	21.4	-	-	-	-
		Length-frequency	Σ	-	9.5	13.4	16.2	18.4	20.5	22.5	-	-	-	-
Khemiri et al. (2005)*	eastern Tunisian coasts	Otolith	Σ	-	11.5	14.4	17.0	19.0	20.5	22.0	-	-	-	-
	northern Tunisian coasts	Otolith	Σ	-	12.0	15.0	17.8	19.9	21.6	23.1	-	-	-	-
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Otolith	Σ	-	8.5	11.7	13.4	14.8	17.1	19.2	-	-	-	-
Bilge (2008)	İzmir Bay (Turkey)	Otolith	Σ	10.1	12.9	15.2	16.1	18.4	19.9	21.3	22.1	22.9	24.9	-
	Edremit Bay (Turkey)	Otolith	Σ	10.2	13.0	15.7	16.9	18.5	20.0	21.5	22.3	23.0	25.1	-
El - Okda (2008)	Alexandria (Egypt)	Otolith	Σ	-	9.5	12.6	15.0	17.0	-	-	-	-	-	-
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Length-frequency	Σ	-	13.8	17.1	21.4	24.7	27.4	-	-	-	-	-
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Otolith	Σ	-	10.7	13.7	15.2	16.3	17.7	19.3	21.0	22.1	22.4	-
Kara and Bayhan (2015)	İzmir Bay (Turkey)	Otolith	♂	-	11.3	15.2	18.4	21.1	22.8	-	-	-	-	-
			♀	-	11.2	15.1	18.7	21.4	23.1	-	-	-	-	-
Azab et al. (2019)	Alexandria (Egypt)	Scale	Σ	-	8.4	13.8	17.9	21.0	-	-	-	-	-	-
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Length-frequency	Σ	-	14.4	17.4	20.5	24.5	29.3	-	-	-	-	-
This study	Saros Bay (Turkey)	Otolith	Σ	-	13.0	14.4	17.0	18.6	20.0	21.3	21.9	22.6	23.3	-

Table 4. The results of maximum ages, growth parameters and growth performance indices obtained from previous studies for *Boops boops* in Mediterranean Basin. * from Monterio et al. (2006), **from Bilge (2008), ***from El-Haweet et al. (2005), +*Φ'* was calculated, ♀ = Female, ♂ = Male, Σ = All samples, L_∞ = theoretical asymptotic length, K = growth rate coefficient, t_0 = theoretical age when fish length is zero, *Φ'* =growth performance index.

References	Location	Ageing Method	Sex	L_∞	K	t_0	Age range (year)	Φ'
Girardin (1981)*	Gulf of Lyon	Otolith	Σ	46.5	0.08	-3.54	0 - 7	2.54
Anato and Ktari (1983)*	Tunisia	Otolith	Σ	39.6	0.11	-1.69	1 - 8	2.24
Alegría-Hernández (1989)***	Central Adriatic Sea (Croatia)	Otolith	Σ	33.2	0.17	-1.48	2 - 6	2.28
		Length-frequency	Σ	33.9	0.16	-1.46	2 - 6	2.20
Girardin and Quignard (1986)*	Gulf of Lyon	Scale	Σ	33.5	0.19	-0.75	1 - 11	2.34
Djabali et al. (1990)	Beni-Saf (Algeria)	Length-frequency	♀	27.3	0.22	-1.94	-	2.21
			♂	26.6	0.21	-2.60	-	2.17
Hassan (1990)***	Egypt	Scale	Σ	29.8	0.18	-1.33	1 - 6	2.20
Tsangridis and Filippousis (1991)	Grecee	Length-frequency	Σ	36.0	0.40	-	-	2.71
+Öztürk (1998)**	İzmir Bay (Turkey)	-	Σ	34.6	0.15	1.71	1 - 4	2.25
Abdel-Rahman (2003)***	Alexandria (Egypt)	Scale	Σ	33.5	0.09	-2.64	1 - 6	2.00
Allam (2003)***	Alexandria (Egypt)	Scale	Σ	37.1	0.15	-1.78	1 - 5	2.19
El-Haweet et al. (2005)	from Matrouh city to Saloum Bay (Egypt)	Scale	Σ	31.9	0.15	-1.53	1 - 6	2.18
		Length-frequency	Σ	29.7	0.25	-0.70	1 - 6	2.34
+Khemiri et al. (2005)	eastern Tunisian coasts	Otolith	Σ	26.7	0.22	-1.43	1 - 13	2.20
	northern Tunisian coasts	Otolith	Σ	28.7	0.20	-1.41	1 - 9	2.22
+Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Otolith	Σ	33.6	0.10	-1.90	1 - 6	2.05
+Bilge (2008)	İzmir Bay (Turkey)	Otolith	Σ	32.1	0.12	-3.20	0 - 9	2.09
	Edremit Bay (Turkey)	Otolith	Σ	31.5	0.13	-3.11	0 - 9	2.11
El - Okda (2008)	Alexandria (Egypt)	Otolith	Σ	30.1	0.15	-1.50	1 - 6	2.14
Ramdene et al. (2013)	Bejaia (Algeria)	Otolith	♂	27.0	0.24	-1.53	-	2.24
			♀	27.5	0.28	-1.20	-	2.32
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Length-frequency	Σ	29.6	0.33	-	1 - 5	2.46
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Otolith	Σ	30.0	0.11	-2.91	1 - 9	2.00
Kara and Bayhan (2015)	İzmir Bay (Turkey)	Otolith	♂	29.8	0.24	-0.98	1 - 5	2.34
			♀	30.7	0.23	-0.90	1 - 5	2.37
Layachi et al. (2015)	coastal area of Nador-Saïdia (Morocco)	Length-frequency	Σ	30.0	0.41	-0.30	-	2.54
Soykan et al. (2015)	İzmir Bay (Turkey)	Otolith	Σ	29.5	0.26	-1.14	1 - 5	2.37
Kherraz et al. (2016)	Oran (Algeria)	Length-frequency	♂	26.7	0.38	-0.75	-	2.43
			♀	34.1	0.26	-1.50		2.48

References	Location	Ageing Method	Sex	L_∞	K	t_0	Age range (year)	Φ'
Azab et al. (2019)	Alexandria (Egypt)	Scale	Σ	30.6	0.27	-0.16	1 - 4	2.42
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Length-frequency	Σ	32.3	0.28	-0.58	1 - 5	2.46
This study	Saros Bay (Turkey)	Otolith	Σ	27.9	0.21	-1.57	1 - 9	2.21

Table 5. Previous studies on lengths at first maturity of *Boops boops* from different areas in Mediteranean Basin. *from Layachi et al. (2015), ♀ = Female, ♂ = Male

References	Location	Length at first maturity (cm)
Matta (1958)*	Tuscan Archipelago (Italia)	13.0 (♀) - 11.6 (♂)
Mouneime (1981)*	Lebanon	13.0
Ktari and Anato (1983)*	Tunusia	14.0 to 18.0
Chali Chabane (1988)*	Bou Ismail (Algeria)	13.5
Meguedad and Mahious (1989)*	Oran (Algeria)	13.2
Hassan (1990)*	Egypt	10.0 to 13.0
El Agamy et al. (2004)*	Egypt	12.0 (♀) - 13.0 (♂)
Kherraz (2011)*	Oran (Algeria)	17.1
Bottari et al. (2014)	southern Tyrrhenian Sea (Italia)	13.1 (♀) - 14.2 (♂)
Layachi et al. (2015)	coastal area of Nador-Saïdia (Morocco)	14.3 (♀) - 13.3 (♂)
Soykan et al. (2015)	İzmir Bay (Turkey)	12.9 (♀) - 9.3 (♂)
Amira et al. (2019)	central Algerian coast	14.7
This study	Saros Bay (Turkey)	16.6

Table 6. Results of earlier studies concerning mortality rates of *Boops boops* from different areas in Mediterranean Basin.

References	Location	Z	M	F	E
Allam (2003)	Alexandria (Egypt)	1.28	0.45	0.82	0.46
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	1.25	0.35	0.90	0.72
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	0.41	0.24	0.18	0.43
Soykan et al. (2015)	İzmir Bay (Turkey)	1.17	1.15	1.02	0.87
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	1.03	0.37	0.66	0.64
This study	Saros Bay (Turkey)	0.44	0.38	0.06	0.13

In conclusion, efficient fisheries management and enforcement regulations are known to be necessary to protect natural resources and provide their sustainability. Regular monitoring of the stock status is vital for optimal fishing and stock management, both related to sustainable fisheries (Kara and Bayhan 2015). For these reasons, the molecular characterisation and stable isotope analysis (using otoliths) of bogue must be made to determine if there is a single stock or more in Turkish waters. This may ensure knowledge on whether there may be two or more genetically distinct stocks that may have overlapping distributions. And what's more, it should be carried out into the early life history of the fish to determine otolith microstructure, spawning periodicity, dietary habits of larvae and map out nursery grounds as well as migratory routes. The results of the present study deal with the age and growth of *B. boops* to obtain growth parameters estimation, which are significant input parameters to stock assessment techniques and shall provide an insight into the life history of bogue. Further investigations and longer-term sampling studies should be required to certify this first evaluation. Nonetheless, the available information must be taken into account to make a contribution to fishery managers and international scientific literature.

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