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Growth Parameters of Blotched Picarel (*Spicara maena* Linnaeus, 1758) From Saros Bay (Northern Aegean Sea, Turkey)

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ABSTRACT

In this study, growth parameters of 648 specimens of *Spicara maena* captured by small-scale commercial fishermen around Saros Bay between January 2016 and December 2016 were studied. Of the 648 specimens analyzed, 509 were female and 139 were male. The length-weight relationship was calculated as W=0.0024$TL^{3.34}$ for females and W=0.0032$TL^{3.29}$ for males. The von Bertalanffy growth equations were computed as L_∞=22.1 cm, k=0.27 year^{-1}, t_0=-1.42 year for the females; L_∞=20.6 cm, k=0.39 year^{-1}, t_0= –1.11 year for the males. The growth performance index (Φ′) was found as 2.12 and 2.22 for the females and males, respectively. This study includes preliminary information on the growth of the blotched picarel in Saros Bay (Northern Aegean Sea, Turkey).

INTRODUCTION

The determination of the age and information on the growth of fish species is important for a comprehensive understanding of their population dynamics. Thus, this knowledge forms the basis of the calculations of growth, productivity estimates, and mortality rates (Campana, 2001) and help in describing the present status and history of fish populations along with the future program of the fishery management (Khan & Khan, 2014; Ayyıldız et al., 2020). However, the knowledge from LWR is essential to assess fish stocks, fisheries, and environmental monitoring programs (Froese et al., 2011; Giarrizzo et al., 2015) and studies on LWR are relevant due to the need to comprehend the fish lifecycle, principally in the regions where fisheries represent one of the most important economic activities (Frietas et al., 2014).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer's Catalog of Fishes, 2020; Fishbase, 2020a). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al., 2014; Fishbase, 2020b) while they were previously listed separately (Golani et al., 2006; Nelson, 2006). Genus *Spicara* is represented in the Mediterranean by two species, *Spicara maena* and *Spicara smaris* (Karachle & Stergiou, 2014). According to Froese & Pauly (2020), *Spicara flexuosa* is considered as a synonym of *Spicara maena*. However, the genetic distances and phylogenetic tree topologies revealed that three *Spicara* species were distinctly separated from each other and *S. flexuosa* and *S. maena* are more closely related than *S. smaris* (Bektas et al., 2018). Blotched picarel (*Spicara maena* Linnaeus, 1758), belonging to the family Sparidae, is a commercial species inhabiting the Eastern Atlantic: Portugal, Morocco, and the Canary Islands including the Mediterranean and even the Black Sea. It mostly occurs over *Posidonia* beds and sandy or muddy bottoms and distributes up to 100 m of depth. This species mainly feeds on zooplankton and is a protogynous hermaphrodite (Froese & Pauly, 2020).

Numerous studies are available on *Spicara maena*. The growth parameters of this fish from Greek waters were studied by Mytilinieou & Papaconstantinou (1991) while the same aspects were investigated in Tunisian waters by Hattour et al. (1985), in Egypt by Rizkalla (1997), and in the Adriatic Sea by Dulčić et al. (2000). However, Arculeo et al. (1996) researched the protein differences among the Mediterranean species of the genus *Spicara* while some authors gave the information on its fecundity from Eastern Adriatic Sea (Matić-Skoko et al., 2004) and from Algeria (Harchouche, 2006; Dalouch et al., 2019). In addition, the feeding habits of the blotched picarel were studied in Algeria by Harchouche et al. (2009) and in the North Aegean (Greece) by Karachle & Stergiou (2014). As for Turkish waters, the information on growth and reproduction of the species was obtained from Babadillimani Bight (Çiçek et al., 2007), İzmir Bay (Mater et al., 2001; Soykan et al., 2010), Gallipoli Peninsula (Cengiz et al., 2014a), Edremit Bay and Sea of Marmara (Saygılı et al., 2016a), and Saros Bay (Cengiz, 2019, 2020). However, Saygılı et al. (2016b) examined the otolith morphometry of blotched picarel in the same regions. Yet, there is no information concerning the growth of *Spicara maena* which was so far available on Saros Bay (Northern Aegean Sea, Turkey). For this reason, the aim of the present study was to determine the preliminary information on the growth of the blotched picarel from Saros Bay and to compare these results with the previous studies in other areas.

MATERIAL AND METHODS

The northern Aegean coasts of Turkey are divided into sub-regions as Saros Bay, Gallipoli Peninsula, Gökçeada Island, Bozcaada Island, and Edremit Bay (Cengiz & Paruğ, 2020). The length of Saros Bay is about 61 km and the largest width of the bay is about 36 km (Eronat & Sayın, 2014). As bottom trawling is forbidden in the bay since 2000 (Cengiz et al., 2014b) and no industrial activity was prevalent in the area (Sarı & Çağatay, 2001), it can be considered as a pristine environment (Cengiz et al., 2015). Samples were monthly obtained between January 2016 and December 2016 in random stratified sampling from the catches of the small-scale commercial fisherman around Saros Bay (Figure 1).

Specimens were measured to the nearest centimeter (total length), weighed to the nearest gram (total weight). Sexes were determined by examining the gonads both macroscopically and microscopically. Chi-square (χ2) test was performed to find out the differences in the sex ratio.

Figure 1. Saros Bay (Northern Aegean Sea, Turkey)

Student's *t*-test was used to analyze the differences in the mean length and weight of the sexes. The length-weight relationship was estimated with fitting an exponential curve (Equation 1) (Le Cren, 1951)

$$W = aL^b \qquad (1)$$

where a and b parameters of the exponential curve were estimated with linear regression analysis over log-transformed data (Equation 2):

$$\log W = \log a + b \log L \qquad (2)$$

where W is the total weight (g), L is the total length (cm), a is the intercept, and b is the slope or with allometric coefficient using the least-squares method. If the value $b > 3$, it shows positive allometric growth while value $b < 3$ indicates negative allometric growth. It is isometric growth when value b is equal to 3 (Bagenal & Tesch, 1978). The growth type was identified by Student's *t*-test.

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 with 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 1 year (Cengiz, 2019). Growth parameters were estimated with using the von Bertalanffy growth equation (Equation 3):

$$L_t = L_\infty\left[1 - e^{-k(t-t_0)}\right] \qquad (3)$$

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 Stock Assessment Tools (FISAT II) were used to estimate growth parameters which were calculated with 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 & Munro, 1984). It was estimated with using the formula (Equation 4):

$$\Phi' = \log(k) + 2\log(L_\infty) \quad (4)$$

RESULTS

Length Distribution and Length-Weight Relationship

Of 648 specimens examined in this study, 509 (78.5%) were females and 139 (21.5%) were males. The sex ratio (F:M) was 1:0.27, which is significantly different from the equal representation of sexes (χ2 test: P<0.05). The mean ± standard error (and range) of total length were 12.7 ± 0.07 (8.6 – 15.9) cm TL for the females and 15.1 ± 0.12 (11.6 – 18.3) cm TL for the males (Figure 2). The respective values for the total weight were 27.70 ± 0.56 (5.20 – 65.90) g for the females and 43.02 ± 1.02 (16.48 – 85.12) g for the males. The student's t-test showed significant differences between the mean lengths and weights of both sexes (all P<0.05). The length-weight relationship was estimated as W=0.0024$TL^{3.34}$ (r^2=0.93) for the females and W=0.0032$TL^{3.29}$ (r^2=0.94) for the males (Figure 3). The b-values and t-test results indicated positive allometric growth for both sexes. However, the length-weight relationships reveal that the males are heavier than the females (Figure 3). The individuals longer than 16.0 cm were all males (Figure 2, Table 1).

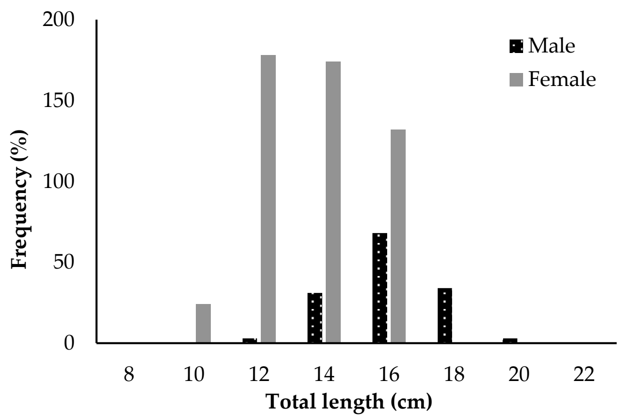

Figure 2. The length-frequency distribution for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

Age Composition and Growth Parameters

Results obtained from the otolith study showed that the ages of the fishes were found to be within the range of 1 to 5 years. Most of the females were 2 years old while most of the males were 3 (Table 1). The von Bertalanffy growth equations were computed as L_∞ =22.1 cm, k=0.27 year⁻¹, t_0 = –1.42 year for females; L_∞=20.6 cm, k=0.39 year⁻¹, t_0= –1.11 year for the males (Figure 4). The growth performance index (Φ') was found as 2.12 and 2.22 for females and males, respectively. The t-test showed no significant differences from the growth performance indexes in the other localities.

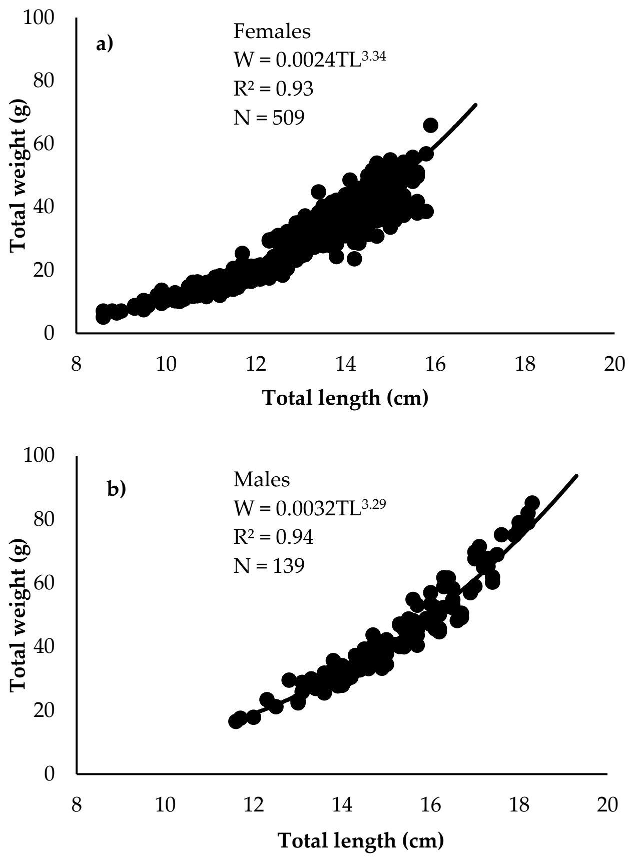

Figure 3. The length-weight relationships for the females (a) and males (b) of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

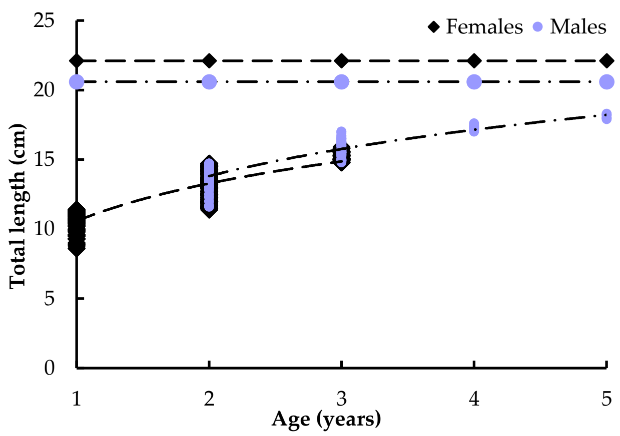

Figure 4. The growth curves for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

Table 1. The age-length key for the females and males of *Spicara maena* from Saros Bay (Northern Aegean Sea, Turkey)

Length class (cm)	Age (years) 1	2	3	4	5	Females	Males
8.0 – 9.0	5	-	-	-	-	5	-
9.1 – 10.0	19	-	-	-	-	19	-
10.1 – 11.0	70	-	-	-	-	70	-
11.1 – 12.0	47	64	-	-	-	108	3
12.1 – 13.0	-	72	-	-	-	67	5
13.1 – 14.0	-	133	-	-	-	107	26
14.1 – 15.0	-	107	33	-	-	103	37
15.1 – 16.0	-	-	61	-	-	30	31
16.1 – 17.0	-	-	21	1	-	-	22
17.1 – 18.0	-	-	-	9	3	-	12
18.1 – 19.0	-	-	-	-	3	-	3
Females							
N	141	317	51	-	-	509	-
Min	8.6	11.4	14.8	-	-	8.6	-
Max	11.4	14.7	15.9	-	-	15.9	-
Mean	10.6	13.2	15.2	-	-	12.7	-
S.E	0.05	0.06	0.04	-	-	0.07	-
Males							
N	-	59	64	10	6	-	139
Min	-	11.6	14.8	17.0	17.9	-	11.6
Max	-	14.7	17.0	17.6	18.3	-	18.3
Mean	-	13.8	15.7	17.3	18.1	-	15.1
S.E	-	0.10	0.07	0.06	0.06	-	0.12

DISCUSSION

Table 2 summarizes the studies on the length-weight relationship (LWR). Soykan et al. (2010) reported that the individuals longer than 18 cm were all males. Whereas, Dulčić et al. (2000) determined that the samples longer than 19.8 cm were all males. This case may be explained by protogynous hermaphroditism because females are predominated in smaller size classes and males larger ones (Çiçek et al., 2007; Soykan et al., 2010). The allometric coefficient *b* varied from 2.66 to 3.67 for species in different regions. 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 & Stergiou, 2002), fishing gear used (Kapiris & Klaoudaos, 2011), and size selectivity of the sampling gear (İşmen et al., 2007).

The mean lengths at different ages for the females and males of *S. maena* given by various authors are listed in Table 3. However, to compare the growth of *S. maena* population with others, all available literature data of the maximum ages and von Bertalanffy growth parameters and Φ' values including the results from the present study are presented in Table 4. In this sense, the maximum ages can vary widely among the populations within species especially those that

Table 2. Comparison of the length-weight relationship of *S. maena* with previous studies

Reference	Location	N	Sex	Length range (cm)	a	b
Petrakis & Stergiou (1995)	South Euboikos Gulf (Greece)	33	Σ	11.7 – 18.4	0.00083	2.66
Dulčić & Kraljević (1996)	Eastern Adriatic Sea (Croatian)	220	Σ	14.5 – 27.5	0.0000396	3.03
Moutopoulos & Stergiou (2002)	Cyclades (Greece)	808	Σ	14.3 – 26.0	0.010	3.09
Çiçek et al. (2006)	Babadillimani Bight (northeastern Mediterranean Turkey)	1381	Σ	4.2-17.8	0.008	3.11
Karakulak et al. (2006)	Gökçeada Island (northern Aegean Sea, Turkey)	133 142	♀ ♂	11.5 – 18.1 13.5- 22.0	0.004 0.001	3.35 3.67
İşmen et al. (2007)	Saros Bay (northern Aegean Sea, Turkey)	353	Σ	8.8 – 17.8	0.00984	3.01
Gökçe et al. (2010)	Iskenderun Bay (Eastern Mediterranean, Turkey)	17	Σ	13.0 – 17.9	0.021	2.80
Soykan et al. (2010)	Central Aegean Sea (Turkey)	2547	Σ	7.5 – 20.0	0.011	3.02
Demirel & Dalkara (2012)	Sea of Marmara (Turkey)	175	Σ	10.4 – 18.0	0.010	3.25
Bolognini et al. (2013)	Adriatic Sea (Italy)	1810	Σ	8.5 – 25.5	0.007	3.15
Cengiz et al. (2014a)	Gallipoli Peninsula (northern Aegean Sea, Turkey)	- -	♀ ♂	- -	0.011 0.044	3.26 3.16
Saygılı et al. (2016a)	Sea of Marmara (Turkey) Edremit Bay (northern Aegean Sea, Turkey)	155 168	Σ Σ	8.4 – 18.1 12.8 – 18.8	0.003 0.010	3.53 3.06
This study	Saros Bay (northern Aegean Sea, Turkey)	509 139	♀ ♂	8.6 – 15.9 11.6 – 18.3	0.002 0.003	3.34 3.29

Note: N: Sample size; ♀ = Female, ♂ = Male, Σ = All samples; *a* and *b*: intercept and slope of length- weight relationships.

Table 3. The mean lengths at different ages for the females, males and all samples of *S. maena* given by various authors

Reference	Location	Age (Years)								
		Sex	1	2	3	4	5	6	7	8
Mytilineous & Papaconstantinous (1991)[a,b]	Patraikos Gulf (Greece)	♀	9.2	11.2	12.6	13.5	14.4	-	-	-
		♂	9.3	11.4	13.0	14.0	14.4	-	-	-
Dulčić et al. (2000)	Adriatic Sea (Croatia)	Σ	9.5	15.9	19.4	21.5	23.4	24.6	-	27.5
Mater et al. (2001)[a,b]	Izmir Bay (Aegean Sea, Turkey)	♀	11.3	12.9	13.7	14.9	-	-	-	-
		♂	-	12.8	13.9	14.9	-	-	-	-
Çiçek et al. (2007)	Babadillimani Bight (northeastern Mediterranean, Turkey)	♀	7.6	11.8	14.9	-	-	-	-	-
		♂	-	12.9	15.2	17.3	-	-	-	-
Saygılı et al. (2016a)	Sea of Marmara (Turkey)	Σ	11.2	13.5	15.1	15.8	-	-	-	-
	Edremit Bay, (northern Aegean Sea, Turkey)	Σ	-	14.1	15.4	16.2	17.3	17.8	-	-
This study	Saros Bay (northern Aegean Sea, Turkey)	♀	10.6	13.2	15.2	-	-	-	-	-
		♂	-	13.8	15.7	17.3	18.1	-	-	-

Note: [a]FL: Fork length, [b]syn. *S. flexuosa*, ♀ = Female, ♂ = Male, Σ = All samples

Table 4. The results of maximum ages, growth parameters and growth performance indices obtained from previous studies for *S. maena*

Reference	Location	Method	Sex	Age (Year)	L_∞	K	t_0	Φ'
Mytilineous & Papaconstantinous (1991)[a,b]	Patraikos Gulf (Greece)	Otolith	♀	1 - 5	16.3	0.31	-1.89	1.92
			♂	1 - 5	17.5	0.34	-1.90	2.02
Dulčić et al. (2000)	Adriatic Sea (Croatia)	Scale	Σ	1 - 8	24.8	0.53	-0.08	2.51
Mater et al. (2001)[a,b]	Izmir Bay (Aegean Sea, Turkey)	Otolith	♀	1 - 4	17.1	0.31	-0.63	1.96
			♂	2 - 4	18.2	0.24	-2.62	1.90
Çiçek et al. (2007)	Babadillimani Bight (northeastern Mediterranean Turkey)	Otolith	♀	1 - 3	25.3	0.26	-0.35	2.22
			♂	2 - 4	37.3	0.09	-3.38	2.10
Soykan et al. (2010)	Izmir Bay (central Aegean Sea, Turkey)	Otolith	Σ	1 - 7	21.9	0.25	-1.16	2.08
Cengiz et al. (2014a)	Gallipoli Peninsula (northern Aegean Sea, Turkey)	-	♀	-	21.8	0.26	-1.52	2.09
			♂	-	20.3	0.36	-1.08	2.17
Saygılı et al. (2016b)	Sea of Marmara (Turkey)	Otolith	Σ	1 - 4	17.2	0.52	-1.04	2.18
	Edremit Bay (northern Aegean Sea, Turkey)	Otolith	Σ	2 - 6	18.7	0.20	-1.98	2.09
This study	Saros Bay (northern Aegean Sea, Turkey)	Otolith	♀	1 - 3	22.1	0.27	-1.47	2.12
			♂	2 - 5	20.6	0.39	-1.11	2.22

Note: [a]FL: Fork length, [b]syn. *S. flexuosa*, ♀ = 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

have wide distributions (Gibson, 2005). In this case, the reasons of 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 & Geffen, 2005). Within the Mediterranean Sea, there exists a west-east gradient (Krom et al., 1991; Turley et al., 2000). The Eastern Mediterranean has been identified as one of the most oligotrophic areas of the world (Azov, 1986; Krom et al., 1993; Paruğ & Cengiz, 2020). The maximum age of the blotched picarel was reported as VIII in the Adriatic Sea (Croatia) by Dulčić et al. (2000). This value from the western Mediterranean area is 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.

Besides, the differences in mean lengths at ages and growth parameters among the study areas could probably be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences, ageing 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.

CONCLUSION

The present study provides preliminary information on the growth of *Spicara maena* for Saros Bay. There are no technical regulations imposed on *Spicara maena* fisheries in Turkey. If some legal regulations are not implemented (e.g., determination of minimum landing size, fishing gear selectivity, catching quota, fishing effort control, efficacious monitoring and surveillance systems, etc.), the sustainability of stock can be at risk as time goes by. This information will help fisheries scientists in future studies about *S. maena* populations worldwide.

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Compliance with Ethical Standards

Authors' Contributions

Both authors have contributed equally to the paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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