Mar. Sci. Tech. Bull. (2021) 10(2): 142-153
e–ISSN: 2147–9666
info@masteb.com

dergipark.org.tr/en/pub/masteb
www.masteb.com
DOI: 10.33714/masteb.814299

Marine Science and Technology Bulletin

RESEARCH ARTICLE

Determination of some biological characteristics and population parameters of the blotched picarel (*Spicara flexuosa* Rafinesque, 1810) distributed in the Eastern Black Sea (Rize - Hopa)

Göktuğ Dalgıç[1*] • İbrahim Oğuz Ergün[1] • Hatice Onay[1] • Yusuf Ceylan[1]

[1] *Recep Tayyip Erdogan University, Faculty of Fisheries, Department of Fishing Technology, 53100, Rize, Turkey*

ARTICLE INFO

Article History:
Received: 22.10.2020
Received in revised form: 23.12.2020
Accepted: 29.12.2020
Available online: 21.01.2021

Keywords:
Spicara flexuosa
Eastern Black Sea
Growth
Age

ABSTRACT

This study was carried out in order to determine some biological characteristics of the fish species of *Spicara flexuosa*, which is distributed on the Eastern Black Sea coast, and to contribute to the management of the picarel in all the seas of our country. Between October 2015 and September 2016, 599 fish samples were obtained and examined in the laboratory. It was determined that the examined individuals were distributed between the ages of I-VII which 31.22% of the population was male and 68.78% was female. The minimum-maximum total length values of the samples were between 8.7 and 21.8 cm; and the weight values ranged from 7.1 to 129.94 g. It has been determined that the mean total length of males is statistically different from that of females ($P<0.05$). Von Bertalanffy growth equilibrium was calculated as "L_∞=22.71 cm TL, K=0.243 year^{-1}, t_0=-2.306 year^{-1}; W_∞=118.27 g" for females, "L_∞=38.34 cm TL, K=0.063 year^{-1}, t_0 = -6.381 year^{-1}; W_∞=755.37 g" for males, and "L_∞=33.42 cm TL, K=0.080 year^{-1}, t_0=-5.381 year^{-1}; W_∞=401.24 g" for all individuals. The length-weight relation of all individuals was found as $W= 0.0118*L^{2.9727}$ (R^2=0.9487). When the ratio of gonadosomatic index (GSI) data and gonadal maturity stages were examined over the year, it was determined that the reproduction of the picarel in the Black Sea occurred between June and September.

Please cite this paper as follows:

Dalgıç, G., Ergün, İ.O., Onay, H., Ceylan, Y. (2021). Determination of some biological characteristics and population parameters of the blotched picarel (*Spicara flexuosa* Rafinesque, 1810) distributed in the Eastern Black Sea (Rize – Hopa). *Marine Science and Technology Bulletin*, 10(2): 142-153.

* Corresponding author
E-mail address: goktug.dalgic@erdogan.edu.tr (G. Dalgıç)

Introduction

Species that belong to the genus *Spicara* occur in shallow rocky and muddy bottoms (in the coastal shelf up to 130 m depth) throughout the Mediterranean and the Black Sea, in the Atlantic from Portugal to Morocco and around the Canary Islands (Fischer et al., 1987; Froese & Pauly, 2013). The genus *Spicara* has posed numerous identification problems and consequently many different species have been described, leading to a variety of synonyms. For many years *Spicara flexuosa* Rafinesque, 1810 considered as the synonym of *Spicara maena* (Linnaeus, 1758) but cariological and genetic studies conducted in the recent years prove that those both are two different species (Vasiliev, 1980; Chiba et al., 2009; Imsiridou et al., 2011; Turan, 2011). It is possible to distinguish *S. maena* and *S. flexuosa* using meristic and morphometric features (Tortonese, 1986; Fischer et al., 1987; Rizkalla, 1996). *Spicara flexuosa* is distributed widely along the Turkish coastline (Bilecenoğlu et al., 2014) and various studies (Vasiliev, 1980; Vasilieva & Salekhova, 1983; Ilkyaz et al., 2007, Imsiridou et al., 2011, Turan, 2011; Minos et al., 2013, Bektaş et al., 2018) on the genetics and morphology of the species are available. There are studies conducted by Sever (2019) and Lipskaya & Salekhova (1980) on the nutrition of the species in the Mediterranean. However, studies on the biology of the species are very limited (Hattour et al., 1985; Mytilineou, 1987; Mytilineou & Papaconstantinou, 1991; Şahin & Genç, 1999; Mater, 2001; Malkav, 2002; Özvarol, 2014). The aim of this study is to reveal the age, growth, reproduction, mortality and population structure of *S. flexuosa* distributed in the South East Black Sea.

MATERIALS AND METHODS

Study Area and Sampling

The samples of *S. flexuosa* were obtained monthly between October 2015 and September 2016 (except August 2016) from the fishermen engaged in commercial fishing by using gillnets with mesh sizes from 16 mm to 20 mm from the Southeast Black Sea coast (Rize-Hopa). A total of 599 (412 females, 187 male) fish sample were taken to the laboratory and total length (TL) and weight measurements were made according to gender. The TL of each picarel was measured with 1 mm interval and the specimens were weighed (wet weight) on a balance with a sensitivity of 0.001 g. Each pair of sagittal otoliths was also removed and stored in plastic eppendorf tubes for further process (aging).

Age Determination

The otoliths were kept in 4% NaOH solution for 15-20 minutes and after the skin residues were cleaned, they were made transparent by passing through 40% and 70% alcohol series. Afterward, ages were determined by reflecting light from the top with a magnification of 0.8-8.0 under the Nikon SMZ1000 brand stereomicroscope. The photographs of each otolith were taken using a Nikon DSFI1 digital camera and two readers were recorded the ages independently. The age of 494 fish were successfully recorded from a total of 599 sagittal otoliths, while 105 of them could not be measured.

Growth

Size Frequency

Monthly size–frequency distributions for both sexes were calculated as 2 cm total length-class intervals. Size–frequency distribution analysis for females and males was conducted using the Kolmogorov–Smirnov two-sample test. Comparison of the mean total length between female and male was performed using t-test. Statistical analyses were considered significantly different at the level of $\alpha = 0.05$. Statistical analysis carried out using a computer program PAST v2.14 (Hammer et al., 2001).

Length-Weight Relationship

Length-weight relationships were estimated by fitting an exponential curve to the data (Equation 1) (Ricker, 1973, 1975). Parameters *a* and *b* of the exponential curve were estimated by linear regression analysis over log-transformed data (Equation 2).

$$W = aL^b \tag{1}$$

$$\log W = \log a + b \log L \tag{2}$$

where *W* is the total weight (g), *L* is the total length (cm), *a* is the intercept and *b* is the slope, using the least-squares method. The association-degree between variables of *W* and *L* was calculated by the determination coefficient (r^2). Additionally, 95% confidence limits of the parameter b were estimated. The Student's t test was used for comparison of the slopes (Zar, 1996).

The growth parameters were measured by using von Bertalanffy Growth Model (Equation 3) (Ricker, 1975).

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

In this formula, L_t: The average length of the fish at age t (cm), L_∞: Maximum length that a fish can reach theoretically at infinity (cm), k: Growth coefficient (year^{-1}), t: Age (year), t_0: Theoretical age of the fish before they are hatched (year). The growth constants calculated in this study and the constants calculated in other studies were compared by using the Munro's Phi index and the t test. When this test was being applied, the growth constants (k) and (L_∞) values, which were obtained from the previous studies on the same species, were used. For each of these values, φ' values were calculated using Equation 4. The hypothesis assuming that there were no differences between the growth constants calculated and the other constants in previous studies was accepted (ts<tt) (Pauly & Munro, 1984; Avşar, 1998).

$$\varphi' = \log(k) + 2 \times \log(L_\infty) \tag{4}$$

Sex Ratio

The sex ratio of the *S. flexuosa* used in the study was examined by months and lengths. Whether the sex ratio (female / male ratio) is different from 1/1 or not was tested by the two-square test (χ^2).

Mortality

The total mortality rate (Z) was calculated by taking advantage of using average length according to Beverton & Holt (1957) and the Equation 5.

$$Z = \frac{K \times (L_\infty - \bar{L})}{\bar{L} - L'} \tag{5}$$

In this equation, K is the growth constant, $\bar{L}$ is the average length of fish used in the calculation of growth constants and L', for the fish used in the data set, shows the size corresponding to the class range in which the smallest fish are found. In order to calculate the natural mortality rate, the following formula (Equation 6) suggested by Pauly (1980) was used.

$$M = 0.8 \times exp(-0.0152 - 0.279 \times \ln(TL_\infty) + 0.6543 \times \ln(K) + 0.4634 \times \ln(TC^\circ)) \tag{6}$$

In the formula, TC° refers the average of annual surface water temperature and is considered as TC°=15.2°C, which is the long-term average of the Black Sea region (Bat et al., 2007). L_∞ is the asymptotic total length (cm) and K is the growth coefficient (Gayanilo et al., 2005). Fishing mortality rate is calculated with the following formula using the Z value and the mortality rates are calculated according to Pauly (1980) method (Equation 7).

$$F = Z - M \tag{7}$$

So where F *is* fishing mortality rate (year^{-1}), M refers natural mortality rate (year^{-1}) and Z is the instant total mortality rate (year^{-1}). The exploitation rate (E) is calculated by the ratio of the fishing mortality factor (F) to the total mortality factor (Z) (Equation 8).

$$E = \frac{F}{Z} \tag{8}$$

where, Z is the total mortality rate (year^{-1}), M is the natural mortality rate (year^{-1}), F is the fishing mortality rate (year^{-1}) E is the exploitation rate.

Reproduction Biology

Gonad Maturity and Spawning Time

Morphological characters were primarily used in sex determination of *S. flexuosa* fish. In males, the upper part of the lateral line is dark brown and there are distinct blue-purple bands on the side of the body, with distinct blue-purple bands and spots on the dorsal and caudal fins. During the breeding period, this coloration becomes brighter. In females, the body is bright yellowish and the abdomen area is white, only in the breeding period, faint blue-purple stripes are visible on the side of the body. In the breeding period, the same coloration in female individuals is seen only on the dorsal fin, unlike male individuals (Matic-Skoko et al., 2004). In individuals whose gender could not be determined morphologically, the fish was dissected and the sex determination of the individuals who reached sexual maturity was done macroscopically. In individuals who did not reached sexual maturity yet, gonads were examined under a microscope and their genders were determined. The individuals with a granular structure, yellowish orange color, swollen and abundant blood vessels gonads were evaluated as female, others as male. The development of gonads is morphologically divided into 5 categories as follows (Matic-Skoko et al., 2004):

Stage 1: Not mature; gonads are cylindrical, soft translucent, pink and white in females, while in males, they are very small and seem like only translucent filamentous strings.

Stage 2: Precocity; gonad development of females can be easily observed with the naked eye. Pink gonads are located on both sides of the body cavity like soft tulle. In males, the gonads are thicker and longer. Pink or white male gonads can be noticed with the naked eye.

Stage 3: Development; gonads in females are granular, colored, dark yellow-slightly orange. The development of blood vessels can be observed easily. Gonads in males are well developed, thickened and white in color. In males and females, the ovaries occupy half the body cavity.

Stage 4: Mature; gonads cover the entire body cavity in orange-red color in females. There are prominent blood vessels scattered over the surface. The membrane covering the eggs is very thin and bursts with light pressure. In males, the gonads are creamy white and cover the entire body cavity.

Stage 5: Spent-Relaxation; in females, ovaries are elongated, honey-colored, saggy and loose, while the gonads in males are in skin color, bloody and wrinkled.

Gonadosomatic Index

Gonads were weighed in 0.01 g precision balance to determine the reproductive period and gonadosomatic index value. In determining the breeding season, the gonadosomatic index (GSI) value for both sexes was calculated according to the formula given in the Equation 9 (Erkoyuncu, 1995).

$$GSI = \left(\frac{W_g}{W}\right) \times 100 \qquad (9)$$

Here, W_g is the gonad weight, and W is the total fish weight.

Size at Sexual Maturity

In the breeding season, individuals with gonad development stages 1 and 2 were considered immature, and individuals with gonad development stages 3, 4 and 5 were considered as mature (Matic-Skoko et al., 2004). Using the ratio of mature and immature individuals with 2 cm length intervals of female and male *S. flexuosa* obtained during breeding time, 50% maturity length of the gender was calculated according to the formula given in the Equation 10 for both genders (Campbell, 1985; King 1995).

$$P = {}^{1}\!/_{1 + e^{(a+bTL)}} \qquad (10)$$

In this formula, P is the ratio of mature female and male fish, a and b refer equation constants, TL is the total fish length (cm). The 50% maturity length is calculated by using the equation constants (a and b) for female and male individuals by (a/b) formula.

Results

Size Composition

Total 599 *S. flexuosa* (412 females, 187 males) were obtained between October 2015 and September 2016. Total length of females ranged between 10.0 and 20.6 cm (mean 14.10±2.0709 cm) and weights ranged between 11.21 and 109.1 g, (mean 32.96±0.952 g) whereas total length of males varied between 8.7 and 21.8 cm (mean 16.4±2.0638 cm) and their weights varied between 7.1 and 129.94 g (mean 52.13±1.45 g) (Figure 1). The average total length of males is greater than that of females, and the difference was statistically significant (P=7.99-32). In addition, the length-frequency distribution was found to be statistically different between male and female individuals (Kolmogorov-Smirnov test: d=0.47455, P=3.66E-26). The dominant length group was calculated to be between 12 and 16 cm (32.3%) in females and 14 and 18 cm (35%) in males.

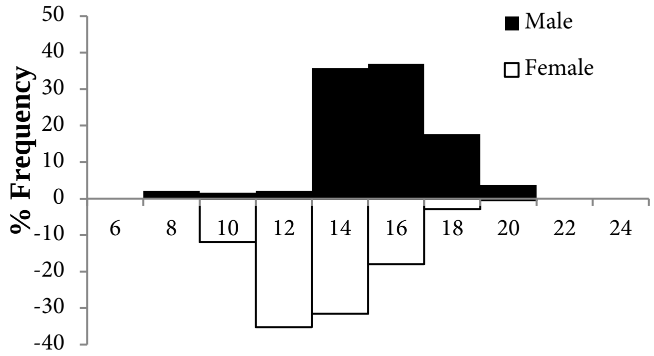

Figure 1. Length frequency composition of *S. flexuosa* individuals

Throughout the year, the smallest individual was sampled in April and the largest individual was sampled in November. The small individuals were very common in the stock in April, and a single 14.1 cm of male individual was sampled in May (Figure 2).

Length - Weight Relationship

The relationship between the length-weight values obtained from *S. flexuosa* individuals was calculated from the $W= aL^b$ growth equation. The length-weight relationship for females and males was calculated as follows: Female; $W=0.0172L^{2.8292}$ (R^2=0.9670), male; $W=0.0059*L^{3.2249}$ (R^2=0.9487), all individuals; $W=0.0118L^{2.9727}$ (R^2 =0.9487). The length-weight equation slope coefficient (b) was found to be different from isometric growth (b=3) in female (Pauly's t test=4.2744) and male (Pauly's t test=4.2613) individuals. While female individuals showed negative allometric growth, positive allometric growth was detected in male individuals. This difference is thought to be related to the nutritional conditions.

Age Composition

Age readings were made on a total of 494 individuals (318 females and 176 males). It was determined that the oldest individual was 7 years old for both males and females. It was determined that the dominant age group was 1 year (39.6%) for females and 3 years age group for males (31.8%). Approximately 81.8% of the population were found to be between 1 and 3 years old (Figure 3).

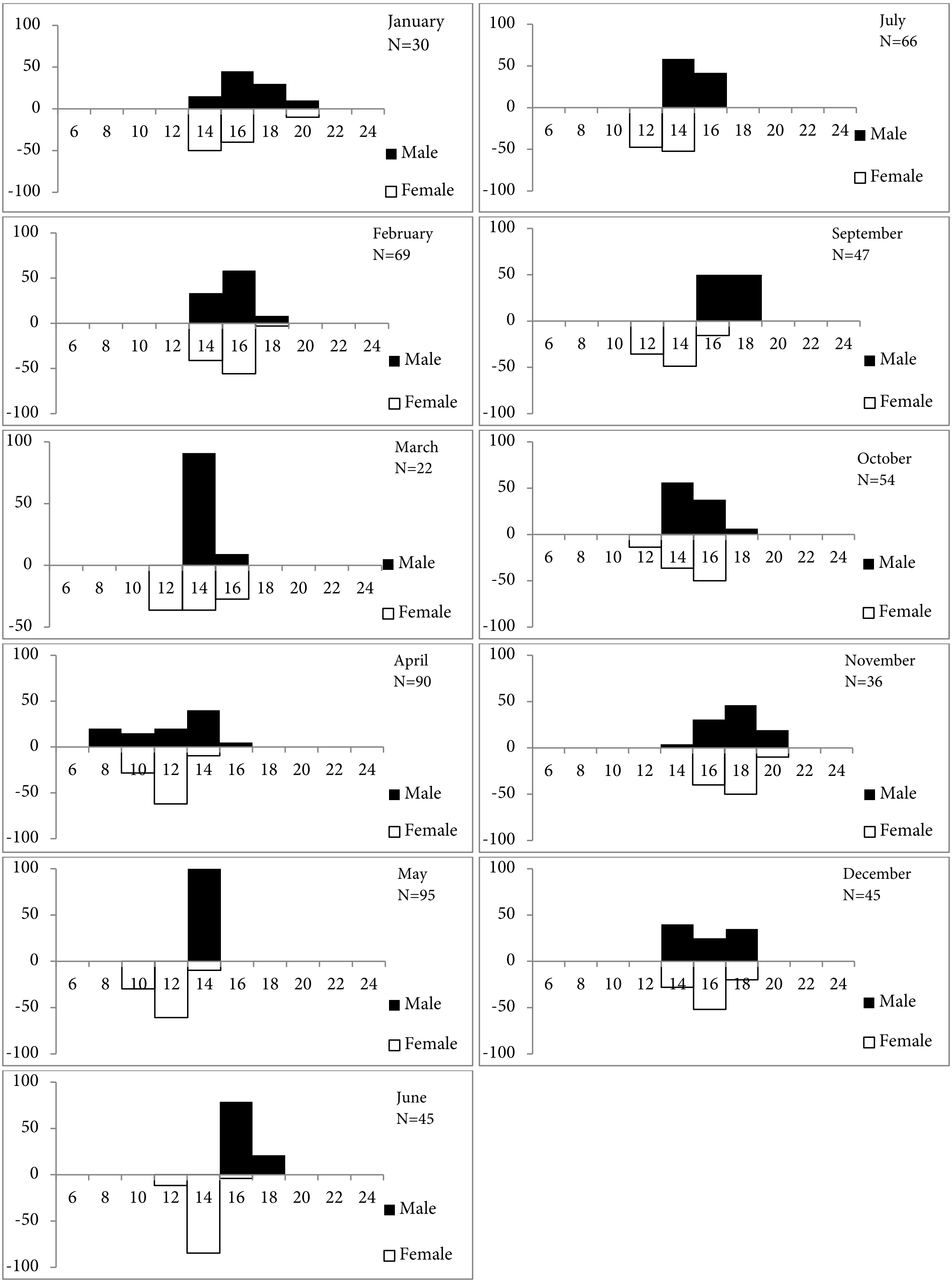

Figure 2. Monthly frequency distribution of *S. flexuosa* individuals

Table 1. Growth model parameters of *S. flexuosa* individuals, L_∞=asymptotic length, K=growth factor, t_o=age when fish length is theoretically zero, W_∞=asymptotic weight, parameter, *Φ'*=growth performance index

Parameters	L_∞	k	t_o	W_∞	(*Φ'*)
Total	33.42	0.080	-5.381	401.24	1.95
Female	22.71	0.243	-2.306	118.27	2.09
Male	38.34	0.063	-6.381	755.37	1.96

Growth

Among the extreme values that affect the calculations in female and male individuals are represented as a single individual in age groups, individuals of 20.6 cm for females and 21.8 cm for males were excluded from the evaluation. L_∞ value was higher in males than females. This value was calculated as 22.71 cm for females and 38.34 for males. The K value was higher in females than males, 0.243 in females and 0.063 in males. The growth performance index (Φ') value calculated using the parameters calculated by growth models (L_∞ and K) was determined to be 2.09 for females and 1.96 for males (Table 1).

Mortality

Fishery mortality rate (F) and exploitation rate (E) were calculated from the data obtained as Z year^{-1} 0.800; F year^{-1} 0.3239; M year^{-1} 0.4761; E year^{-1} 0.404. It has been determined that the stock exploitation ratio of *S. flexuosa* is operated at a value lower than the optimum value (E=0.5), that means, there is no fishing pressure. In the study, it was seen that the fishery mortality rate was caused only by discard.

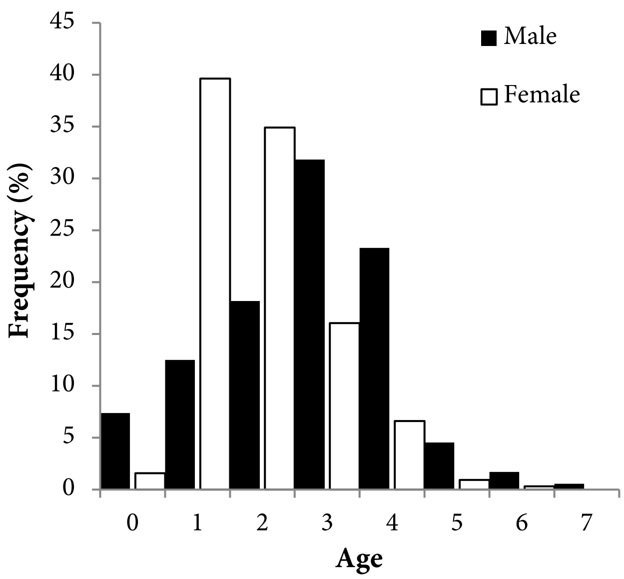

Figure 3. Age composition of male and female fish of *S. flexuosa* individuals

Reproductive Biology

Sex Ratio

In all the *S. flexuosa* samples examined, the female/male ratio (2.20) was in favor of the females, and the difference was statistically significant (χ^2 = 83.488, P < 0.001).

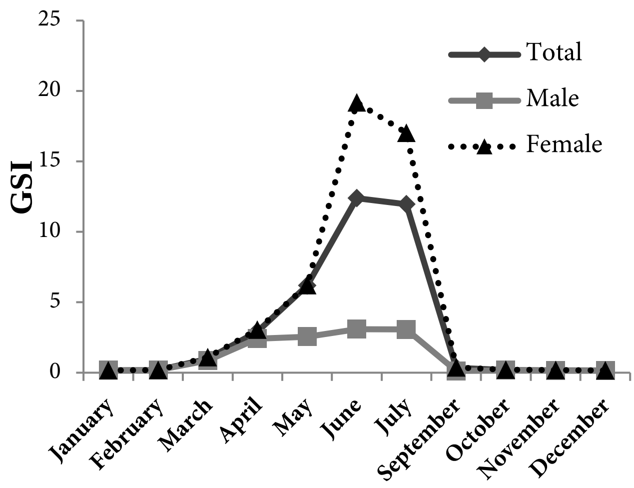

Figure 4. Monthly gonadosomatic index (GSI) values of females, males and all *S. flexuosa*

Spawning Season

According to the monthly gonadosomatic index (GSI) values, a peak occurred in June and the GSI value reached its lowest level in September by decreasing regularly after June. According to the monthly fluctuations of GSI values and the monthly development of gonad maturity stages, it was determined that the spawning time of the *S. flexuosa* in the study area is between June and September (Figure 4). Due to scarce of sample in August the value was left as blank in Figure 4. Male and female individuals in first and second gonad development stages were determined between September and April. Females in the 3rd and 4th stages were generally determined between March and July, while the males in the 3rd and 4th stages were mostly determined between April and July. Individuals in the emptied rest stage (5th stage) were identified in September. (Figure 5 and Figure 6).

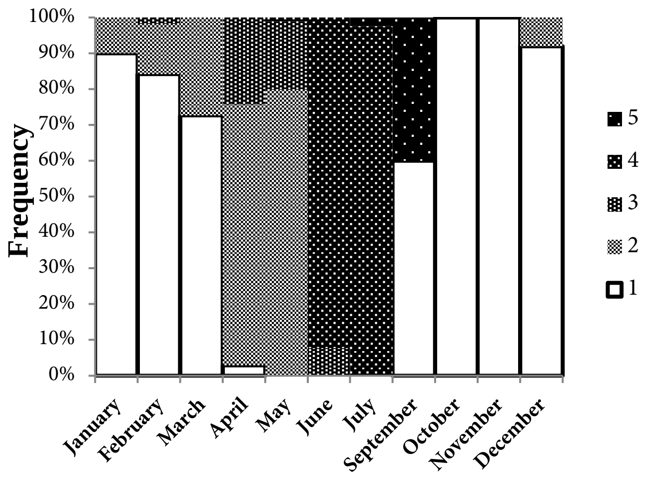

Figure 5. Percentage rates of monthly gonad stage (1; immature, 2; developing, 3; mature, 4; spawing, 5; spent) of female *S. flexuosa*

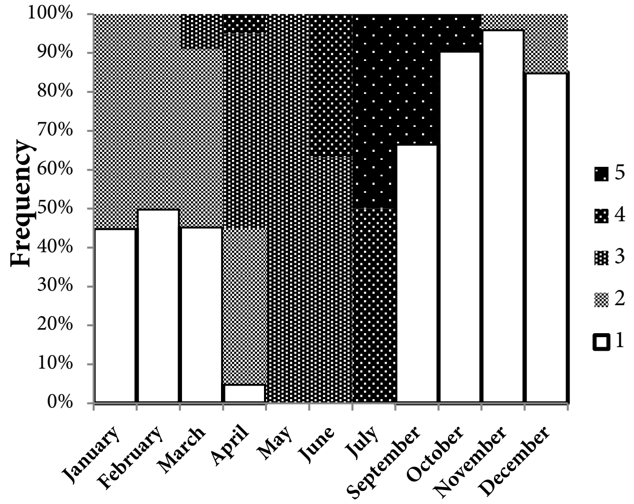

Figure 6. Percentage rates of monthly gonad stage (1; immature, 2; developing, 3; mature, 4; spawing, 5; spent) of male *S. flexuosa*

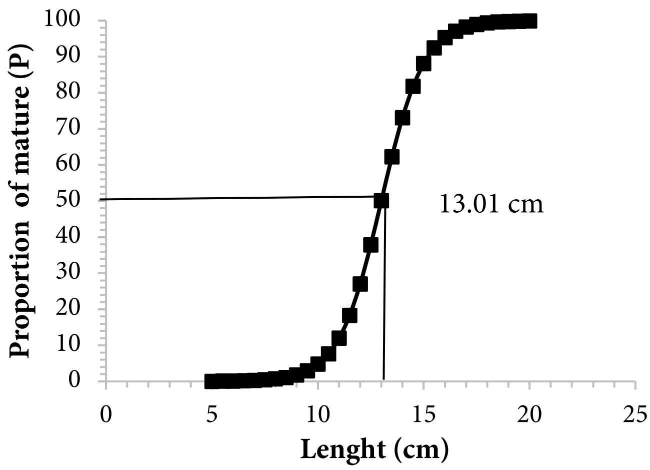

Figure 7. 50% sexual maturity length of male *S. flexuosa*

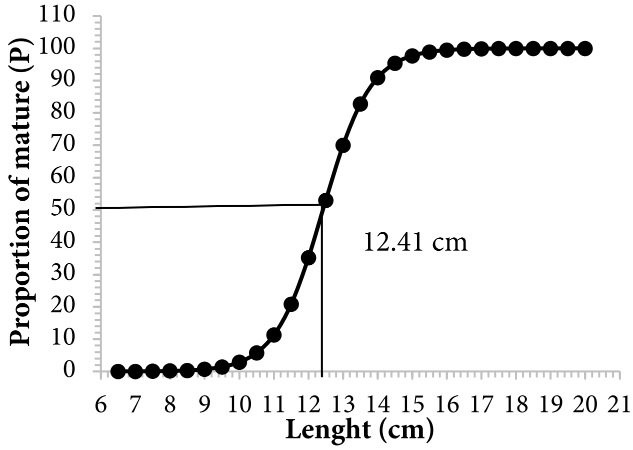

Figure 8. 50% sexual maturity length of female *S. flexuosa*

Size at Maturity

The sexual maturity was calculated using data of 176 female (131 mature) and 41 male (25 mature) individuals sampled in the breeding season in 2 cm length class interval. The maturity length of the breed was calculated as 12.41 cm for females and 13.01 for males. (Figure 7 and Figure 8).

Discussion

Population Structure

Many morphological and genetic studies have been conducted on the *Spicara* genus. From these studies, it has been discussed that *Spicara smaris* species sampled in the waters of our country can be distinguished from *S. flexuosa* and *S. maena* species morphologically and that *S. flexuosa* and *S. maena* species can be the same species. (İlkyaz et al., 2007; Froese & Pauly, 2018). However, in another study conducted recently and in which up-to-date genetic analysis of the species has been carried out, it was stated that all of the picarel living on the Black Sea coast were *S. flexuosa*, and the other two species probably did not enter the Black Sea due to their salinity tolerance (Bektaş et al., 2018). In the light of the mentioned study, it is thought that the fish studied in the research conducted by Şahin & Genç (1999) and İşmen (1995) previously in the Black Sea were *S. flexuosa* instead of *S. smaris*. In the study, the smallest individual was sampled in April, and an intense recruitment to the stock was observed in the same month. The finding of a single male individual in the specimens in May is thought to be due to the species' nesting behavior for spawning. The maturation of the gonads in May supports our interpretation (Figure 4). In another study 440 *S. flexuosa* specimens were examined in Antalya Bay (Mediterranean Sea) and the length range was reported as 9.0-17.3 cm (Özvarol, 2014). Two studies were done in 1989, 1991 and 1992 years in a region (Trabzon coast) very close to the region where our sampling took place.

Among them, Şahin & Genç (1999) reported the length range from 11.1 cm to 22.5 cm for females and 11.3 to 22 cm for males. In another study, it was reported that all individuals varied between 10.0 and 18.5 cm in 1991 and 1992, and no female individuals larger than 17.0 cm were encountered (İşmen, 1995). In the north of the Black Sea, male pickarels can reach 19.4 cm in length and 82 g in weight, and females can reach up to 15.7 cm in length and 45 g in weight (Slastenenko, 1956). The weights of male individuals obtained in the study varied between 7.1 and 129.94 g, while females varied between 11.21 and 109.1 g. Şahin & Genç (1999) reported that male *S. flexuosa* individuals varied between 12.94 and 90.54 g and females varied between 11.88 and 120.03 g. İşmen (1995) reported that *S. flexuosa* fish can be found in the Black Sea between 17.81 and 64.53 g, regardless of gender. Our findings are in agreement with Şahin & Genç (1999) when compared with other studies conducted in the Black Sea. The differences with our study and those two studies would be due to the different sampling methods used.

Length-Weight Relationship

When the relationship between length and weight values obtained in the study was examined, the "b" value was found to be 3.2249 for males, 2.8292 for females and 2.9727 for all individuals. In previous studies in the Black Sea, İşmen (1995) found the "b" value to be 3.26; Şahin & Genç (1999) reported 3.12604 for males and 3.22926 for females, so, they calculated a positive allometric growth in *S. flexuosa*. With the results we have obtained, it is thought that the difference in growth observed in females in previous studies would be due to the nutritional conditions. Erkoyuncu (1995) reported that different populations of the same species or possibly the same population may differ in various years according to feeding conditions.

Age Composition

In the study the dominant age group in females was 1 year (39.6%), while it was 3 years (31.8%) in males. Among the samples examined, the oldest male individual is 7 years old. On the Mediterranean coast of Greece, the dominant age group was 1 year for females and 3 years for males, and the oldest individual was 5 years old (Mytilineou & Papaconstantinou, 1991). Mater et al. (2001) reported that the dominant age group of *S. flexuosa* was 2 years for females and 3 years for males, and the oldest individual was 4 years old in Izmir Bay. In the Black Sea, Şahin & Genç (1999) found the dominant age group to be 2 years for females, 3 years for males, and the oldest individual to be 6 years old, while İşmen (1995) reported that the oldest individual was 5 years old. The data obtained from the study and other studies are in harmony and it has seen that the dominant age group for males in all seas is 3 years. The 7-year-old individual identified in this study is the oldest fish reported from all seas and one can say that the current population is less exploited compared to the other seas. It is also thought that this situation may be related to the physical and chemical parameters of the environment and nutrient abundance.

Growth

Considering to the data obtained in the study, it was calculated as L_∞=33.42 cm, K=0.080 years^{-1}, t_0=-5.381 years for all individuals. The results of studies on stocks of the same species living in different seas are given in table 2. accordingly, the lowest L_∞ value was given as 19.05 cm for female *S. flexuosa* fish in Aegean Sea (Malkav, 2002), while the highest value was reported as 33.52 cm for female *S. flexuosa* fish in Eastern Black Sea (Şahin and Genç, 1999). L_∞ is theoretically defined as the maximum (asymptotic) length of the fish and inversely proportional to the growth coefficient, K. These parameters can vary considerably even within the same species. Generally, the "K" value is higher in warm seas, the "L_∞" value is lower, and in cold seas the "K" value is lower and the "L_∞" value is higher (Erkoyuncu, 1995). As seen in table 2, Şahin and Genç (1995) found the "L_∞" value to be high for females and lower for males, contrary to our study. This result is thought to originate from a single 22.40 cm female individual obtained in the study. Similarly, in our study, the female individual of 20.6 cm obtained from the samples increased the "L_∞" value, therefore single individuals in the age groups for female, male and all individuals were excluded from the calculations. The t_0 value, which corresponds to the age, when the fish length is theoretically zero, is the value that is considered the beginning of the growth curve, which has no biological meaning (Erkoyuncu, 1995). The t_0 value calculated for all individuals in the study is mostly similar when compared to other studies. However, İşmen (1995) gave the t_0 value as -0.01 years. This value differs from many other studies. İşmen (1995) stated in his study that he could not sample the 1-year old group due to the selectivity of the sampling gear. The reason for the change of K value according to years and regions may be due to the different size composition of the studied fish, age composition, biotic (such as prey predator relationship, genetic variation) and abiotic (such as temperature, salinity) environmental factors. The growth performance index (Φ') which was calculated according to Von Bertalanffy growth constants was calculated using the "L_∞" and "K" values and it was found to be Φ'=1.9514 for all individuals, to be Φ'=2.0986 for female individuals and to be Φ'=1.9692 for male individuals.

Table 2. Growth and mortality rates in studies *S. flexuosa*

Reference	L_∞	K	T_0	W_∞	Z	M	F	*Φ*	Region
İsmen (1995)	20.05	0.44	-0.01	87.20	1.58	0.87	0.71	2.2476	East Black Sea
Şahin (1995)									
Female	33.52	0.125	-2.848	-	-	-	-	2.1602	East Black Sea
Male	27.37	0.192	-2.404					2.1475	
Mater (2001)	19.45	0.205	-0.399	78.31	-	-	-	1.8895	Aegean Sea
Malkav (2002)									
Total	21.86	0.25	-2.36	-	-	-	-	2.077	
Female	19.05	0.23	-2.23	-	-	-	-	1.9215	Aegean Sea
Male	23.97	0.28	-2.28	-	-	-	-	2.2064	
Yeldan et al. (2015)	21.72	0.385	0.135	118.87	-	0.62	-	2.2591	Mediterranean
This study									
Total	33.42	0.080	-5.381	401.24	0.80	0.48	0.32	2.1096	
Female	22.71	0.243	-2.306	118.27	-	-	-	2.0752	East Black Sea
Male	38.34	0.063	-6.381	755.37	-	-	-	1.9675	

In other studies, conducted in the Eastern Black Sea region, İşmen (1995) reported Φ'=2.2476 for all individuals, while Şahin and Genç (1999) reported Φ'=2.1602 (Table 2). The results obtained in the study gave similar results with the previous studies in the Black Sea, and the difference between the values reported in previous studies was not found to be statistically significant ($P > 0.05$, $t_{0,05} = -1.239 \times 10^{-4}$). In population dynamics studies, the growth performance index was proposed to determine the average growth of the species by evaluating the L_∞ and K value together, and it was reported that it could be used to compare the growth under the effect of different environmental factors (Pauly, 1991).

Mortality

In the study, natural and fisheries-related mortality rates of *S. flexuosa* in the Black Sea were found to be 0.4761 year^{-1} and 0.3239 year^{-1}, respectively. And the total mortality rate was determined as Z=0.800 year^{-1}. When the results were examined it was determined that the stock belonging to the *S. flexuosa* species was operated at a value lower than the optimum value (E=0.5). that means there was no fishing pressure. In the study, it was seen that the fishing mortality rate was caused only because bycatch of small fish. In an other study conducted in the eastern Black sea "Z" value as 1.58 years^{-1} (İsmen. 1995). As given in table 2 when comparing our study with the previous study it is thought that the difference in the mortality rate may have been caused by the fishing pressure by years, the type of fishing gear used and the biotic and abiotic factors that keep growth characteristics under control with the participation of new individuals. In the study area National Statistical Institue is not announce *S. flexuosa* fishing and according to our findings only 12.1 tons fish was captured as discard species from other fishing operations such as purse seining, gill nets.

Sex Ratio

The ratio of male *S. flexuosa* fish to females in this study was 2.19 in favor of females. This rate has been reported as 1.25 in *S. flexuosa* species which have been studied in the Mediterranean for long years (1994-2002) (Ragonese et al., 2004). Mater et al. (2001) reported the ratio of males to females for the species in Izmir Bay as 0.71. In the Black Sea Şahin and Genç (1999) reported the female-to-male ratio as 1.59. The differences between our study and other studies are thought to be due to the variation in sampling gears used and according to the number of individuals sampled by months. Changes in sex ratio may be due to differences in mortality by sex and migration.

Spawning Season

When the monthly GSI values and gonad development stages are examined, *S. flexuosa* shows reproductive activity between May and September during the study period. Şahin & Genç (1999) stated that the GSI value of *S. flexuosa* in the Black Sea reached the highest in May. Fisher et al. (1987) reported that the breeding activities of the *S. flexuosa* fish in the Black Sea were carried out between May and September. Our results are in agreement with other studies. Determining the breeding season and the first breeding length of the fish species living in the ecosystem, accordingly, determining the minimum fishing length in the product to be landed and the season in which the fishing will take place is extremely important for a sustainable fishing model (İlkyaz et al., 2018). In the Communique Regulating Fisheries for Commercial Purposes published in 2016 by the Ministry of Food Agriculture and Livestock (Republic of Turkey) there is no regulation for *S. flexuosa* fishing in our country. There is a lack of information regarding the first breeding length and minimum landing size in the studies of the *S. flexuosa* species. Soykan et al. (2010) reported the first breeding length for *S. maena* as 11.51 cm for females and 13.12 cm for males in their study in the Aegean Sea and İlkyaz et al. (2018) recommended the minimum fishing length for the species as 13 cm according to the results obtained.

Conclusion

Regular studies and monitoring of natural stocks are essential for both fisheries management and fisheries biology to ensure the sustainability of the ecosystem. Especially in the Black Sea, conducting researches on the biology and population characteristics of fish that are not subject to fishing prohibition and monitoring the effects of these species on the ecosystem are important in terms of the balance of fish stocks. The results would be useful for optimum management and future positive fisheries management strategies.

Acknowledgements

Authors would thank to MSc. Erhan Ozturk and MSc. Orhan Kobya for their help in laboratories. This work was supported by Research Fund of Recep Tayyip Erdogan University Project Number: 2015.53001.103.03.02.

Compliance with Ethical Standards

Authors' Contributions

Author GD designed the study, IOE and HO wrote the first draft of the manuscript, YC performed and managed statistical analyses. All authors read and approved the final manuscript.

Conflict of Interest

The authors confirm that no conflicts of interest exist and the funders had no role in study design data collection, analysis, and decisions.

Ethical Approval

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

References

Avşar, D. (1998). Fishery biology and population dynamics. Baki Kitap ve Yayınevi. Adana Turkey. 303p.

Bat, L., Şahin, F., Satılmış, H. H., Üstün, F., Birinci Özdemir, Z., Kıdeys, A. E. & Shulman, G. E. (2007). The changed ecosystem of the Black Sea and its impact on anchovy fisheries. *Journal of FisheriesSciences.com*, ***1***(4): 191-227. https://doi.org/10.3153/jfscom.2007024

Bektas, Y., Aksu, I., Kalayci, G., Irmak, E., Engin, S. & Turan, D. (2018). Genetic differentiation of three *Spicara* (Pisces: Centracanthidae) species. *S. maena*. S. *flexuosa* and *S. smaris*: And intraspecific substructure of *S. flexuosa* in Turkish coastal waters. *Turkish Journal of Fisheries and Aquatic Sciences,* ***18***(2): 301-311. https://doi.org/10.4194/1303-2712-v18_2_09

Beverton, R. J. H. & Holt, S. J. (1957). On the Dynamics of Exploited Fish Populations. Chapman and Hall, London. Facsimile reprint, 1993.

Bilecenoğlu, M., Kaya, M., Cihangir, B. & Çiçek, E. (2014). An updated checklist of the marine fishes of Turkey. *Turkish Journal of Zoology,* ***38***: 901-929. https://doi.org/10.3906/zoo-1405-60

Campbell, A. (1985). Aplication of a yield and egg-per-recruit model to the lobster fishery in the Bay of Fundy. *North American Journal of Fish Management*, 91-104. https://doi.org/10.1577/1548-8659

Chiba, S. N., Iwatsuki, Y., Yoshino, T. & Hanzawa, N. (2009). Comprehensive phylogeny of the family Sparidae (Perciformes: Teleostei) inferred from mitochondrial gene analyses. *Genes, Genetics and Systematics,* ***84***: 153-170. https://doi.org/10.1266/ggs.84.153

Erkoyuncu, İ. (1995). *Fishery biology and population dynamics.* Ondokuz Mayıs Üniversitesi Yayınları. Samsun Turkey. 265 p.

Fischer, W., Bauchet, M. L. & Schneider, M. (1987). FAO d' identification des especes pour les besoins de la peche (Revision) Mediterrance et mer Noire. Zone de peche 37 vol II. FAO. Rome. 1529 p.

Froese, R. & Pauly, D. (2018). FishBase. World wide web electronic publication. www.fishbase.org. version (02/2018).

Froese, R. & Pauly, D. (2013). FishBase. World wide web electronic publication. http://www.fishbase.org (version 02/2013).

Gayanilo, F. C. J., Sparre, P. & Pauly, D. (2005). FAO-ICLARM Stock Assessment Tools II (FISAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8. Revised version. Rome. FAO.168p.

Hammer, Ø., Harper, D. A. T. & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, ***4***(1): 9.

Hattour, A., Turki, B. & Zammouri, N. (1985). Quelques aspects de la biologie de l'espéce *Spicara flexuosa* (Rafinesque. 1810) des eaux Tunisiennes. *Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche de Salammbô*, ***12***: 143-162.

Imsiridou, A., Minos, G., Gakopoulou, A., Katsares, V., Karidas, T. & Katselis, G. (2011). Discrimination of two picarel species *Spicara flexuosa* and *Spicara maena* (Pisces: Centracanthidae) based on mitochondrial DNA sequences. *Journal of Fish Biology*, ***78***: 373–377. https://doi.org/10.1111/j.1095-8649.2010.02858.x

Ismen, A. (1995). Growth, mortality and yield per recruit model of picarel (*Spicara smaris* L.) on the eastern Turkish Black Sea coast. *Fisheries Research*, ***22***: 299-308. https://doi.org/10.1016/0165-7836(95)94955-P

İlkyaz, A. T., Metin, G. & Kınacıgil, H. T. (2007). Ege denizi izmarit türlerinin (*Spicara smaris. S. flexuosa* ve *S. maena*) morfolojik farklılıklarının tür belirlemede kullanımı. *Proceedings of the XIV. National Fisheries Symposium*, pp. 481.

İlkyaz. A. T., Metin. G., Soykan. O. & Kınacıgil. H. T. (2018). Spawning season. first maturity length and age of 21 fish species from the central aegean sea. turkey. Turkish Journal of Fisheries and Aquatic Sciences. ***18***(1):211-216. https://doi.org/10.4194/1303-2712-v18_1_24

King, M. (1995). *Fisheries biology. assessment and management*. Fishing News Books. Blackwell Scientific Publications Ltd., Oxford. UK. 341 p.

Lipskaya, N. Y. & Salekhova, L. P. (1980). Studies in nutrition and morphophysiological indicators of the genus Spicara fishes. *Ekologiya Morya*, ***2***: 66-81.

Malkav, S. (2002). Investigation of the biological features of the picarel (*Spicara flexuosa*, Rafinesque. 1810) distributing in İzmir Bay. MSc Thesis. Ege University, İzmir, Turkey. 41 p.

Mater, S., Malkav, S. & Bayhan, B. (2001). Investigation of the biological features of the picarel (*Spicara flexuosa*. Rafinesque. 1810) distributing in Izmir Bay. *Journal of Fisheries & Aquatic Sciences*, ***8***(1-2): 25-32.

Matic-Skoko, S., Kraljevic, M. & Dulcic, J. (2004). Fecundity of blotched picarel. *Spicara maena* L. (Teleostei: Centracanthidae) in the eastern central Adriatic Sea. *Acta Adriatica*, ***45***(2): 155-162.

Minos, G., Imsiridou, A. & Katselis, G. (2013). Use of morphological differences for the identification of two picarel species *Spicara flexuosa* and *Spicara maena* (Pisces: Centracanthidae). *Mediterranean Marine Science*, ***14***: 26-31. http://dx.doi.org/10.12681/mms.423

Mitilineou, C. (1987). Contribution to the study of the biology of *Spicara flexuosa*. Raf. 1810 in the Patraikos Gulf. MSc. Thesis. University of Athens, Athens, Greece. 152p.

Mytilineou, C. & Papaconstantinou, C. (1991). Age and growth of *Spicara flexuosa* (Rafinesque. 1810) (Pisces. Centracanthidae) in the Patraikos Gulf (Greece). *Scientia Marina*, ***55***(3): 483-490.

Özvarol, Y. (2014). Length–weight relationships of 14 fish species from the Gulf of Antalya (northeastern Mediterranean Sea. Turkey). *Turkish Journal of Zoology*, ***38***: 342-346. http://dx.doi.org/10.3906/zoo-1308-44

Pauly. D. & Munro. J. L. (1984). Once more on the comparison of growth in fish and invertebrates. Fishbyte. *The World Fish Center*. ***2***(1): 1-21.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *Journal du Conseil / Conseil Permanent International pour l'Exploration de la Mer.*, ***39***: 175-192. http://dx.doi.org/10.1093/icesjms/39.2.175.

Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Pap. (234):52 p.

Ragonese, S., Fiorentino, F., Garofalo, G., Gristina, M., Levi, D., Gancitano, S., Giusto, G. B., Rizzo, P. & Sinacori, G. (2004). Distribution, abundance and biological features of picarel (*Spicara flexuosa*), Mediterranean (*Trachurus mediterraneus*) and Atlantic (*T. trachurus*) horse mackerel based on experimental bottom-trawl data (MEDITS. 1994-2002) in the Strait of Sicily. p. 100-114. In: Report of the MedSudMed expert consultation on small pelagic fishes: stock identification and oceanographic processes influencing their abundance and distribution. MedSudMed (Eds). GCP/RER/010/ITA/MSM-TD-05. *MedSudMed Technical Documents*, ***5***: 100-114.

Ricker, W. E. (1975). Computation and interpretation of Biological statistics of fish populations. *Bulletin Fishery Research Board Canada*, ***191***: 382 pp.

Ricker, W. E. (1973). Linear regression in fisheries research. *Journal of the Fisheries Research Board of Canada*, ***30***: 409-434.

Rizkalla, S. I. (1996). A comparative study on the morphometric characters of fishes belonging to family: Centracanthidae in the Egyptian Mediterranean waters. *Journal of King Abdul Aziz University Marine Sciences*, ***7***(1): 255-261.

Sever, T. M. (2019). Diet composition of the blotched picarel *Spicara flexuosa* Rafinesque. 1810 (Actinopterygii: Sparidae) from the Aegean Sea. Turkey. *Acta Zoologica Bulgarica*, ***71***(4): 581-588.

Slastenenko, E. (1956). *The fishes of Black Sea*. Karadeniz Havzası Balıkları, Et ve Balık Kurumu Müdürlüğü Yayınları. 711 p.

Soykan, O., İlkyaz, A. T., Metin, G. & Kınacıgil, H. T. (2010). Growth and reproduction of blotched picarel (*Spicara maena* Linneaus. 1758) in the central Aegean Sea. Turkey. *Turkish Journal of Zoology*, ***34***: 453–459.

Şahin, T. & Genç, Y. (1999). Türkiye'nin doğu Karadeniz kıyılarındaki izmarit balığı (*Spicara smaris*. Linnaeus. 1758)'nın bazı biyolojik özellikleri. *Turkish Journal of Zoology*, ***23***(1): 149-155.

Tortonese, E. (1986). Centracanthidae (pp. 908-911). In: Whitehead, P. J. P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E. (Eds.), *Fishes of the north-eastern Atlantic and the Mediterranean*. Paris. France: UNESCO.

Turan, C. (2011). The systematic status of the Mediterranean Spicara species (Centracanthidae) inferred from mitochondrial 16s rDNA sequence and morphological data. *Journal of Black Sea/Mediterranean Environment,* ***17***(1): 14-31.

Vasiliev, V. P. (1980). The selective mortality of different chromosome morphs in *Spicara flexuosa* Raf. *Genetica*. ***52***(53): 327-331.

Vasilieva, E. D. & Salekhova, L. P. (1983). The precision of diagnoses of the *Spicara* (Perciformes. Centracanthidae) species. Based on osteological features. *Zoological Journal,* ***62***(7): 1044-1056.

Zar, J. H. (1996). *Biostatistical analysis*. 3rd ed. London. Prentice-Hall.