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Age, Growth, Reproduction and Fecundity of the Sharpsnout Seabream (*Diplodus puntazzo* Walbaum, 1792) in the Black Sea Region

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Abstract

In this study, the Sharpsnout Seabream (*Diplodus puntazzo*) population parameters (age, sex composition, length-weight relationship (LWR), age-length relationship, growth parameters, condition factor, gonadosomatic index, reproductive) of the sharpsnout seabream (*Diplodus puntazzo*) in the southern Black Sea Region have been investigated. In the study carried out between April 2018 and March 2019, 276 sharpsnout seabream were sampled and the average length and weight were calculated as 30.0 cm and 463.9 g, respectively. Male and female ratio was determined as 1:1.32 (P>0.05). Age of fish varied between 0-9 years. The von Bertalanffy growth parameters were L_∞=48.1 cm, k=0.2656 year^{-1} and t_0=-1.6587 year for all individuals. The LWR was found as W=0.0399 L$^{2.7212}$ for all individuals. Total mortality rate (Z=0.560), natural mortality rate (M=0.501) and fishing mortality rate (F=0.059), growth performance index (ϕ'=2.73) and condition factor value (K=1.55) were calculated. The maximum GSI value was 6.83 in September. Mean relative fecundity was calculated as 14695.4 eggs / 1g. The mean egg diameter was calculated as 486.83 µm. This study is very important in terms of being the first study on this species in the Black Sea and will provide a source for future studies.

Introduction

A member of the family Sparidae, the Sharpsnout Seabream (*Diplodus puntazzo*, Walbaum, 1792) is a valuable species that naturally disperses in the Eastern Atlantic Ocean, along the coast of South Africa, the Mediterranean, the Aegean Sea, and the Black Sea. Due to the warming of global water temperatures, it continues to spread along the European coasts of the Atlantic (Vinagre *et al*., 2010). It is among the common species of the Mediterranean, Aegean and Sea of Marmara (Russell et al., 2014). Although in the coastal areas with rocky habitats, it lives at depths of 0-150 m, it is commonly found at depths of 0-20 m (Jardas, 1996). Juveniles are commonly found in river mouths, estuaries or lagoons.

Though they can grow up to a maximum length of 60 cm, they are mostly around 30 cm (Fischer *et al*., 1987). Like other Sparidae species, they are hermaphrodite. Young individuals are male, and after maturity, they transform into females. The reproduction occurs at the end of summer, early autumn (Pajuelo *et al*., 2008). Sharpsnout seabream is a high-value demersal species. It is sold for 8-10 USD per kg at the

Black Sea markets (observations of Dr. Mehmet AYDIN). The average production in Turkey for the last ten years was 10.2 tons (TUIK, 2018)

There is little study on the species natural populations. The studies that were conducted in the Mediterranean Sea in recent years mainly focus on the species aquaculture (Boglione *et al*., 2003). In addition, Ventura *et al*. (2015) on requitment, Mouine *et al*. (2012) on the reproduction biology, Favaloro and Mazzola (2003; 2006) and Yıldırım *et al*. (2014) on the species skeletal anomalies, and Çoban *et al*. (2012) and Altın *et al*. (2015) studied feeding and growth performance under aquaculture. Its European populations were studied by Palma and Andrade (2002), and its genetic structure was studied by Bargelloni *et al*. (2005). Although there are some studies on the natural populations of this species in the Mediterranean Sea, the only study done in the Black Sea is by Aydın and Sağlam (2019). In this study, it was reported that the species feeds on rapana eggs. There is no study on the population structure of the species in the Black Sea.

In this study, it was aimed to examine the population parameters (age, length-weight relationship, sex composition, age-length relationship, growth parameters, condition factor, GSI and reproduction biology) of sharpsnout seabream that inhabits Sinop-Hopa, the Black Sea. The study is very important from the point of its contribution to literature and science in terms of being the first study conducted in the Black Sea and containing the data necessary for sustainable management of the species.

Materials and Methods

In the study carried out between April 2018 and March 2019, 276 sharpsnout seabream were sampled with trammel nets with different mesh sizes (inner mesh 50, 60, 70 and 80 mm) at different depths (0–20 m) from the southern Black Sea Region (between Sinop and Hopa) (Figure1).

Captured fish were preserved in iceboxes for examination in the laboratory. Total length (TL, in nearest 0.1 cm), total wet weight (W) and gonad wet weight (GW) (at 0.01g precision) of all specimens were recorded. The sex of each specimen was determined by examining the gonads macroscopically.

The total length-weight relationship (LWRs) of the fish was calculated by applying the exponential regression equation $W=aTL^b$, where *a* and *b* are constants (Ricker, 1975). The total length-weight relationships were examined separately as female, male, and all. Pauly's *t*-test (1984) was used to compare the "*b*" values of male and female groups (Pauly, 1984). Age was estimated by scales removed from the left anterodorsal of fish. Scale preparation for aging was done according to the method by Chugunova (1963).

Growth Parameters

The von Bertalanffy growth equation (VBGE) was used to describe the growth of sharpsnout seabream for the whole sampled population (King, 1995; Sparre & Venema, 1992). The Von Bertalanffy growth parameters

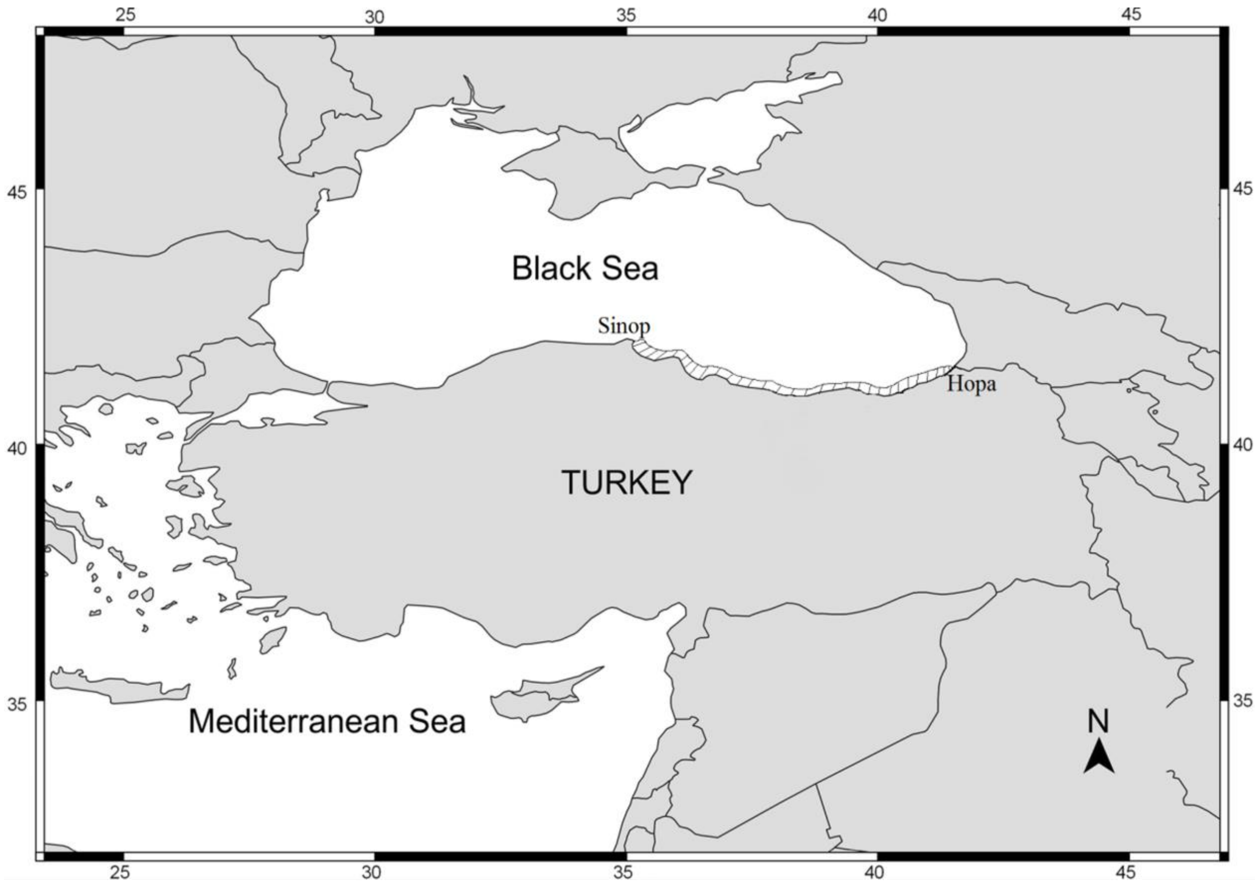

Figure 1. Study area

[L_∞=a/(1-b); k=-Ln b and t_0=t+(1/k) *Ln(1-(L_t/L_∞))] were determined using at age-length data and the growth were estimated by using the Von Bertalanffy function: $L_{(t)}=L_\infty(1-e^{-k\,(t-to)})$, where L_t is the total length at age t, L_∞ is the asymptotic length, k is the growth coefficient, and t_0 is the theoretical age when the fish would have been at zero total length (King, 1995; Sparre & Venema, 1992).

The growth performance was determined using the growth index (ϕ'=Log(k)+2*Log(L_∞)) (Sparre & Venema, 1987; King, 1995).

Condition Factor

In this research, the condition factor of Sharpsnout seabream was calculated monthly with no female and male grouping. Fulton's coefficient of condition factor (C) was calculated by C=(W/TL^3)×100 (Ricker, 1975).

Gonadosomatic Index

Monthly values of the gonadosomatic index were calculated for each sex. GSI=(GW/W)*100 (De Vlaming et al., 1982).

Fecundity

The total fecundity was calculated by enumeration of the eggs obtained from the female samples in September when the GSI reached its highest value. Individuals used for egg counting were processed on the day they were caught, and the egg counts and measurements were performed on the same day after their gonads were removed. In order to determine total fecundity, 28 mature ovaries were examined. The number of eggs obtained from the ovaries and the subsamples taken from the front, middle, and rear parts of the hydrated oocytes were counted using the gravimetric method and calculated according to the following formula (Holden & Raitt, 1974): $F=\frac{G}{g}*n$, where F is the total number of eggs in the ovary, G is ovary weight (g), g is the weight of the subsample taken from the ovary (g), and n is the total number of eggs (including previtellogenic oocytes) in the ovary taken from the subsample but only mature oocytes are taken into account while measuring egg diameters.

Mortality Rates

Decreases in stocks take place through two different kinds of deaths. These deaths are natural mortality rate (M) and fishing mortality rate (F). The sum of the two gives the instantaneous total mortality rate (Z). Z was calculated by using the survival rate (S). Survival rate is defined as the ratio of the number of fish surviving at the end of a certain period to the number of fish at the beginning of the period (Ricker, 1975), and it is calculated according to the following equation:

$S_{(t)}=\frac{N_{(t+1)}}{N_{(t)}}$ where $N_{(t)}$ is the number of fish in the related age group and $N_{(t+1)}$ is the number of fish in the related age group at the end of one year. In this equation, the relation between the survival rate and the total mortality rate is as follows:

$$S_{(t)}=e^{-Z(t)}$$

Total mortality rate (Z) is calculated as follows:

$$Z=-ln(S)$$

Natural mortality (M) is calculated according to Pauly (1980).

$$LogM=-0.0066-0.279logL_\infty+0.6543logk+0.463logT$$

Here, T is the CTD derived average annual water temperature of the environment in which the Sharpsnout seabream lives (ºC).

Results

Length-frequency Distribution

The sampled 276 individual's length-frequency distribution was done with 2 cm intervals (Figure 2).

When the length-frequency distribution was examined the highest number of individuals was observed in 31-32 cm length group, with 19.64 % (Figure 2). The 58.91 % of the whole sampling belongs to the 29-36 cm length group. During the monthly samplings, the highest number of individuals were obtained in October (Table 1).

The smallest measured individual was measured 15.3 cm and the largest 45.4 cm. In terms of weight, the smallest was 50.59 g and the heaviest was 1186.48 g. Samples' monthly length-frequency distribution is given in Figure 3.

Sex Composition

During the study, 55.80% (154) of the sampled individuals were identified as female, 42.39% (117) as male, and 1.18% (5) as hermaphrodite (Table 2). The sex ratio was estimated at 1:1.2 (Table 2). The difference between sex ratios were found statistically significant (χ^2=5.052, df=1, P>0.05).

Length-weight Relationship

Statistically, no difference was observed between the male individual's average length (30.3 cm±5.64) and female average length (30.5 cm±5.54) (P<0.05) (Table 3).

The smallest hermaphrodite individual's length was measured to be 22.7 cm, the largest 25.6 cm, the

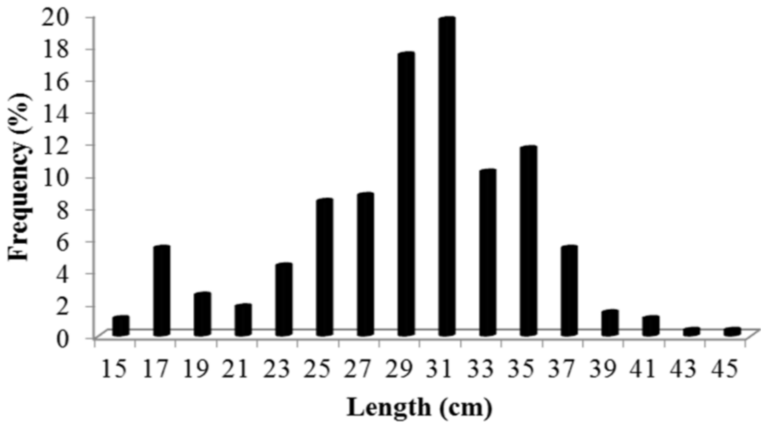

Figure 2. Total length-frequency distribution

Table 1. Number of sampled individuals per months

Months	Jan.	Feb.	Mar.	Apr.	May.	jun.	Jul.	Agu.	Sep.	Oct.	Nov.	Dec.
Number	2	8	34	8	12	24	8	25	22	106	18	9

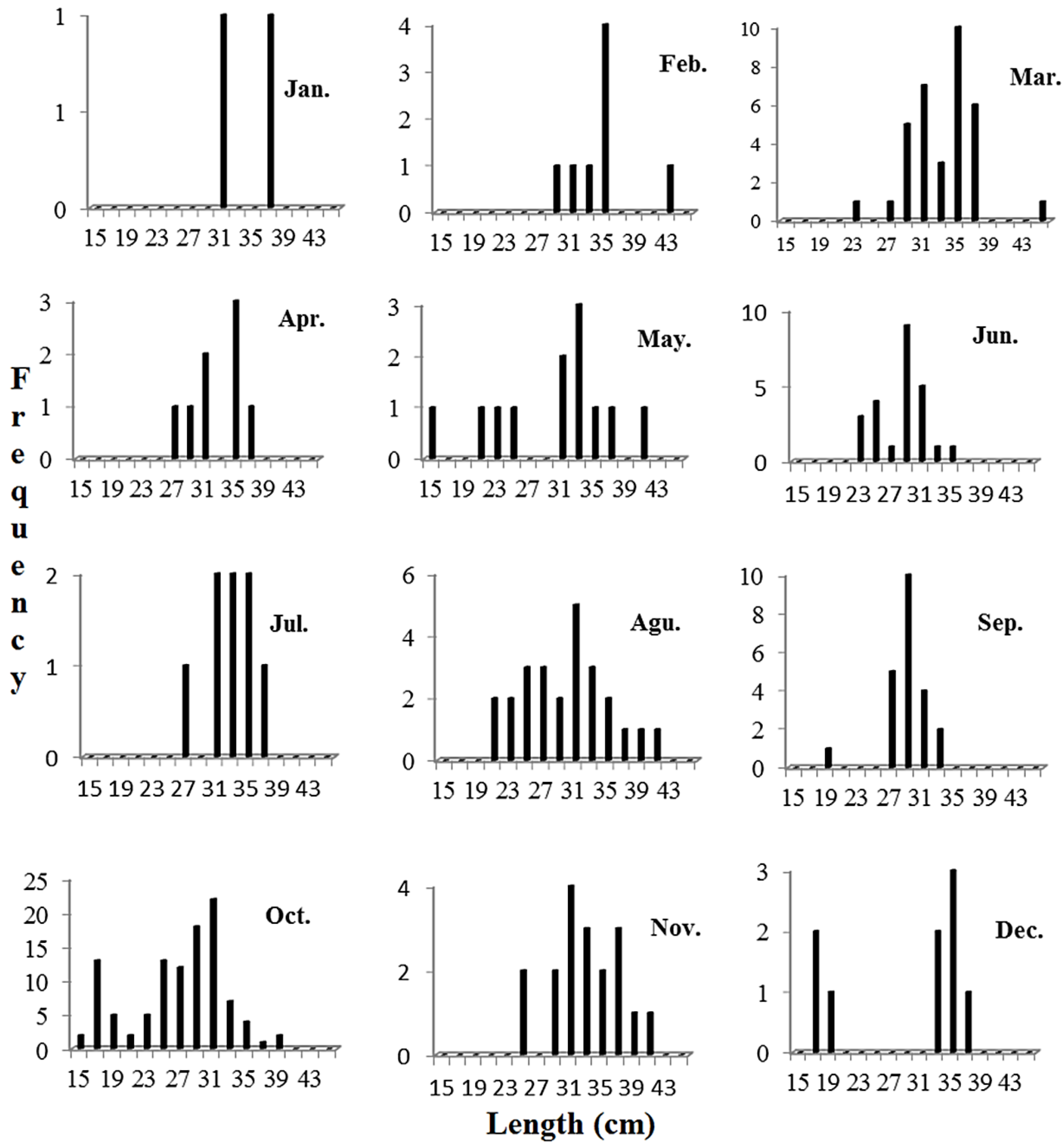

Figure 3. Monthly total length-frequency distributions

average length as 24.12 cm±1.28, and all were estimated as age 1.

Male, female and overall sharpsnout seabreams were estimated to show negative allometry (b<3) (Figure 4).

Age Composition

Age composition of the samples were estimated to be between age 0 and 9. A large portion of the population (39.13%) was in age 2 group (Table 4). In the study, 18 individuals were estimated to be age 0, and the smallest individual was 15.3 cm (Figure 5). No individual smaller than this was obtained. Probably the mesh size of the net that was used during the study was not able to catch individuals smaller than this size, as a result, smaller than this size were not sampled.

Growth and Mortality

The von Bertalaffy growth parameters and growth equations of overall samples are given in Table 5.

Table 2. Monthly sex ratio data

Months	N			Chi-square	P
	Female	Male	(M:F)	(χ^2)	
Jan.	1	1	1:1	0	P<0.05
Feb.	4	4	1:1	0	P<0.05
Mar.	22	12	1:1.83	2.94	P<0.05
Apr.	4	4	1:1	0	P<0.05
May.	6	6	1:1	0	P<0.05
Jun.	17	7	1:2.43	4.167	P>0.05
Jul.	5	3	1:1.66	0.5	P<0.05
Agu.	9	16	1.77:1	1.96	P<0.05
Sep.	15	7	1:2.14	2.909	P<0.05
Oct.	49	52	1.06:1	0.089	P<0.05
Nov.	16	2	1:8	10.889	P>0.05
Dec.	6	3	1:2	1	P<0.05
	154	117	1:1.32	5.052	P>0.05
Total	271 (+ 5 Hermaphrodite)				

(1df, 5%)

Table 3. Length and weight relationship parameters

	L (cm)			W (g)		
	Avg. ± SE	Min.	Max.	Avg. ± SE	Min.	Max.
All	30.3 ± 5.59	15.3	45.4	463.9 ± 214.4	50.6	1186.5
Female	30.5 ± 5.54	16.9	45.4	475.5 ± 212.3	88.4	1095.8
Male	30.3 ± 5.64	15.3	44.5	458.3 ± 217.1	50.6	1186.5

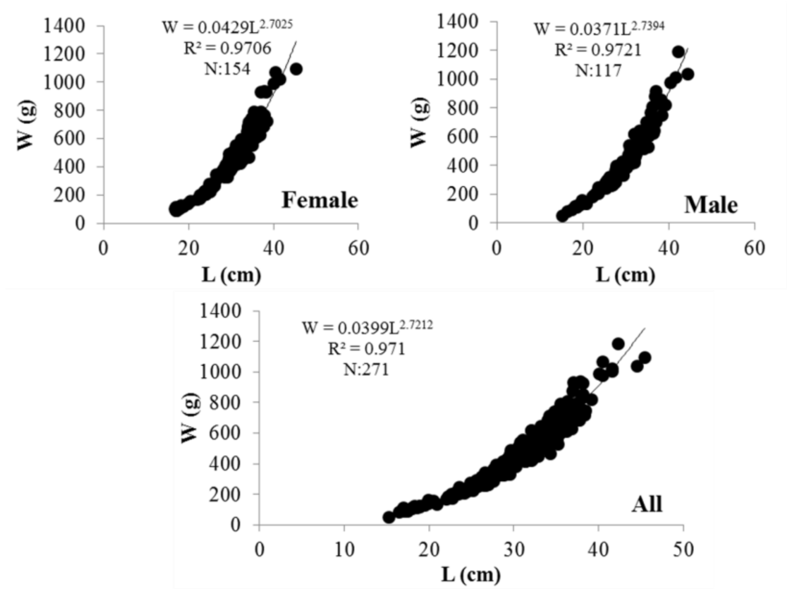

Figure 4. Total length-weight relationship in *Diplodus puntazzo*

We calculated the total mortality rate (Z) as 0.560 by using the survival rate (S) with a value of 0.571. The natural mortality rate (M) was calculated from the growth parameters of *D. puntazzo* and the temperature at the sampling depth. The average (±SD) depth of sampling area was 15±10 m, where the average annual temperature was 15±6°C for these depths. Based on available data, the natural mortality rate was calculated as M=0.501 and the fishing mortality rate (F=Z-M) was computed as 0.059.

Reproduction

GSI values of female and male samples were estimated monthly. When the monthly GSI values of the females were examined, it was observed that the values started to rise from August and reached its highest in September. The highest GSI value for the females was estimated at 6.83, in September, and the lowest was estimated at 0.31, in December. The highest GSI value for the males was 7.635 and development showed parallelism with females (Figure 6).

Fecundity

The smallest individual that was examined for the fecundity was 25.2 cm in length and 259.93 g in weight. The largest individual was 33.9 in length and 650.37 g in weight. Length and fecundity, weight – fecundity, length and egg diameter, gonad weight and egg diameter relationship were given Figure 7. The lowest egg count was estimated 82650.0 and the highest as 887259.5 eggs. The average fecundity of the examined individuals for fecundity was estimated as 428331.6±208442.2 eggs. The average relative fecundity was estimated as 14695.4 egg/1g (8305.0–22727.2) (Table 6).

Though no significant relationship was found between egg diameter with length (r=0.169) and weight (r=0.321), there was a significant relationship between egg count with length (r=0.502) and weight (r=656).

Table 4. *Diplodus puntazzo* species length-weight relationship by age

Age	N	Avg.L (cm)	Avg.W (g)
0	18	17.87	106.11
1	45	24.85	252.83
2	108	29.73	418.09
3	45	33.14	546.29
4	28	35.19	653.21
5	12	36.76	747.04
6	9	37.81	793.27
7	3	38.43	750.28
8	5	41	1045.29
9	3	43.83	1050.69
Total	276		

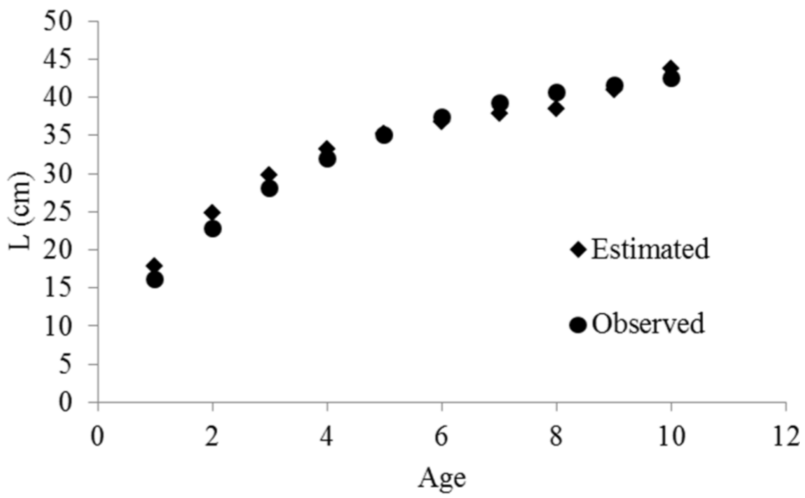

Figure 5. Age-total length relationship in *Diplodus puntazzo* the southern Black Sea.

Table 5. The von Bertalanffy Growth parameters and growth performance

L_∞	k	t_0	b	ϕ'	$L_t = L_\infty [1 - e^{(-k(t-t_0))}]$
45.1	0.2656	-1.6587	2.7212	2.73	$L(t)=45.1[1-e^{-0.2656\,(t+1.6587)}]$

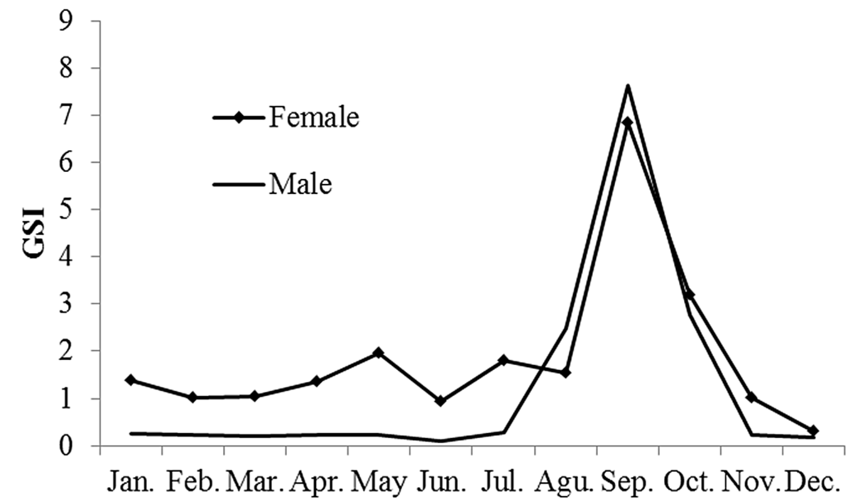

Figure 6. Monthly distribution of gonadosomatic index (GSI) values of the *Diplodus puntazzo* by sex.

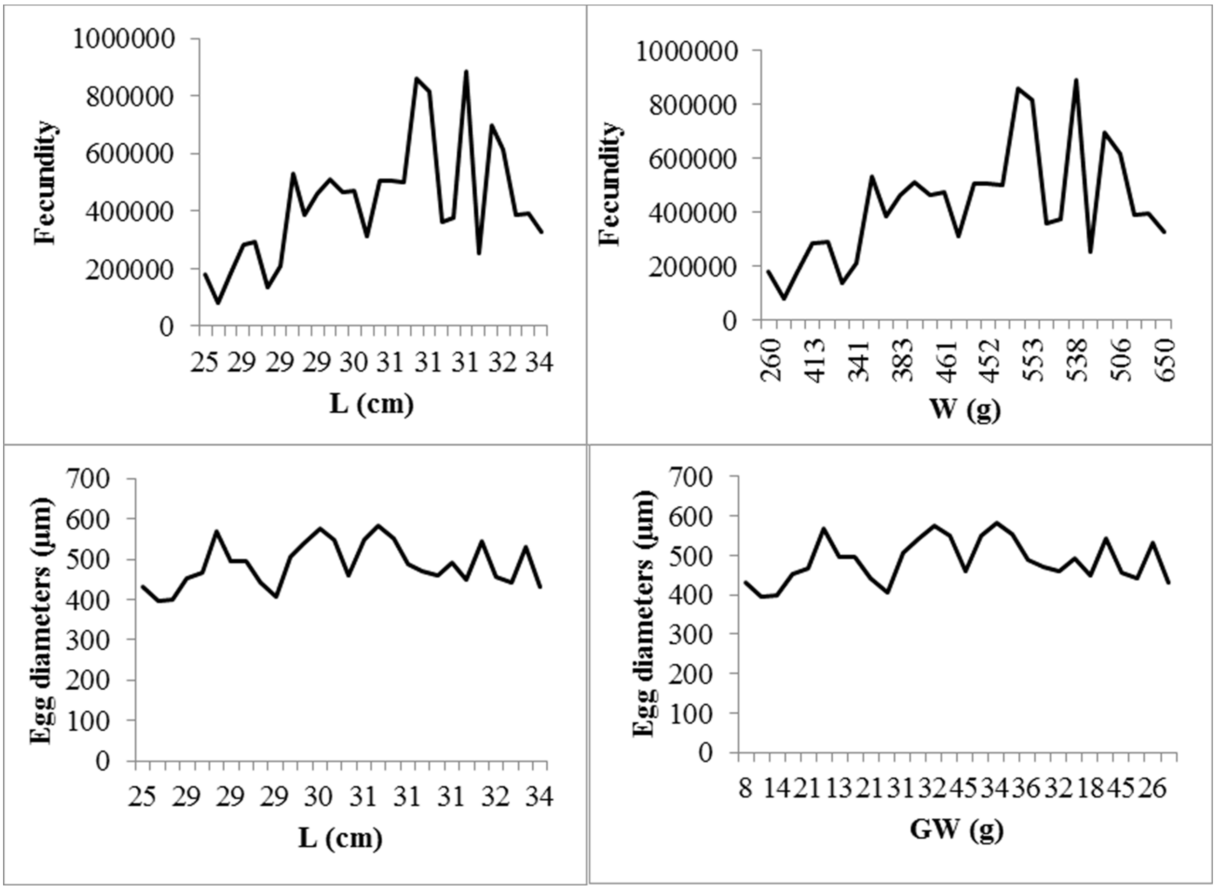

Figure 7. L – fecundity, W – fecundity, L – egg diameter and GW – egg diameter relationship

Table 6. Egg diameters and counts of September

		Egg diameter (µm)		
	Avg.	SE	Min.	Max.
September	486.83	55.45	243.30	802.6
		Avg. egg number (number/1gr)		
	Avg.	SE	Min.	Max.
September	14695.44	3385.41	8305.08	22727.27

Condition Factor

The condition factor determines the changes in a living organism due to seasonal or monthly diet. In this study, sharpsnout seabream' monthly condition factors of female, male and overall individuals were estimated (Figure 8). The average condition factor was estimated at 1.55, and the lowest was in February (1.378) and the highest was in July (1.712).

Discussion

Many fish populations sex ratio is expected to be very close to 1:1 even though factors such as differences between each sex' mortality rate due to fisheries or natural causes, migratory behavior for reproductive purposes, differences between each sex in terms of maturity age or size, and different sex and size group individuals inhabiting different habitats (Nikolskii, 1980). During the study a total of 276 sharpsnout seabream individuals were obtained, 55.80% (154) identified as female, 42.39% (117) as male, and 1.18% (5) as hermaphrodite. The sex ratio was estimated to be 1:1.32. The study conducted by Chaouch et al. (2013) estimated the sex ratio as 1:2.8, Mouine et al. (2006) as 1:4 and Pajuelo et al. (2008) as 1:2.03. Studies have shown that there are more females in the population. As a result of hermaphroditism, it is known that individuals turn in to females after reaching the first maturity length. Therefore, the majority of female individuals in the population should be considered as expected. Pajuelo et al. (2008) reported twice more (3.59 %) hermaphrodite individuals, and Chaouch et al. (2013) reported that in the Mediterranean Sea hermaphrodite individuals are between 14-21 cm in length. In this study hermaphrodite, individuals were measured larger (22.7-25.6 cm). In a study conducted by Pajuelo et al. (2008) reported even larger sizes from Canary Islands (26-46 cm). Statistically, no difference was found between male average length (30.3 cm) and female' average length (30.5 cm) ($P<0.05$). Pajuelo et al. (2008) has also did not report any relation between average lengths of each sex.

The maximum length and weight data are given in Table 7. Though Fischer et al. (1987) reported that the species maximum length can reach up to 60 cm, in an experimental study from the Adriatic Sea by Kraljević et al. (2007) the maximum length only reached to 46.7 cm. The maximum length in this study was measured as 45.4 cm. A study conducted from the Black Sea by Aydın and Sağlam (2019) reported another large individual as 41.6 cm in length and 1007.2 g in weight.

Domínguez - Seoane et al. (2006) reported oldest age as 10 from Canary Islands, and Kraljević et al. (2007) from the Adriatic Sea reported age 18 and identified the species as a long-living species. Kraljević et al. (2007)

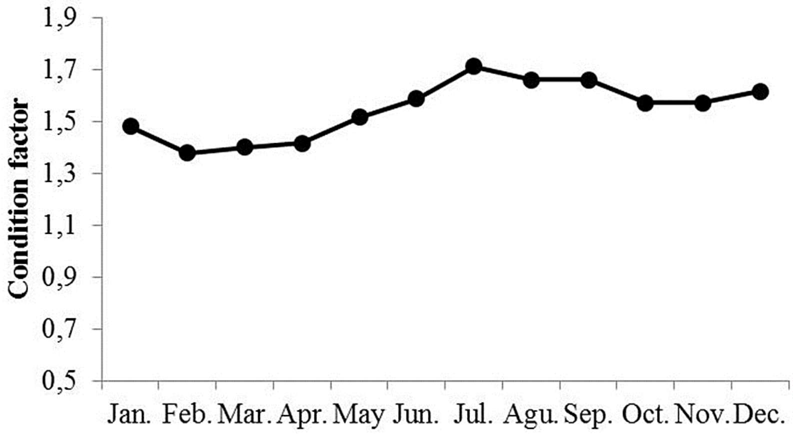

Figure 8. Monthly distribution of the Condition factor for *Diplodus puntazzo*.

Table 7. The maximum length and weight reported by other studies from the Black Sea, Aegean Sea, Sea of Marmara, Mediterranean Sea and the Adriatic Sea

References	Regions	N	L_{max} (cm)	W_{max} (g)
Karakulak *et al*. (2006)	Aegean Sea	7	25.2	-
Özaydin *et al*. (2007)	Aegean Sea	27	21.4	-
Kraljević *et al*. (2007)	Adriatic	630	46.7	1545.00
Kapiris & Klaoudatos (2011)	Aegean Sea	29	23.9	209.00
Chaouch *et al*. (2013)	Mediterranean	490	26.1	230.83
Altin *et al*. (2015)	Aegean Sea	87	24.5	209.80
Öztekin *et al*. (2016)	Marmara	2	32.3	535.00
Kara *et al*. (2018)	Aegean Sea	61	13.5	41.30
Aydın & Sağlam (2019)	Black Sea	11	41.6	1007.2
This study	**Black Sea**	**276**	**45.4**	**1186.48**

reported the largest individual from the eastern Adriatic Sea as 46.7 cm and 1545 g in weight. As mentioned before the largest individual in this study was 45.5 cm 1186.48 g and is the largest reported individual from the Black Sea, Sea of Marmara, Aegean Sea and the eastern Mediterranean Sea, which is also the second-largest reported individual for the whole Mediterranean Sea. The other studies conducted from the Black Sea, Aegean Sea, Sea of Marmara, Mediterranean Sea and the Adriatic Sea is given in Table 7.

Species von Bertalaffy growth parameters reported by other studies from different areas are presented in Table 8.

D. puntazzo is a native species for the Black Sea (Russell et al., 2014) and it is observed that its population increases day by day. But there are no studies on the species population in the Black Sea.

In recent years a large part of the coastal area of the Southern Black Sea has been filled up for road and airport construction as well as land acquisitions. Despite the negative impact these filled areas have on coastal marine habitats, it is thought that this development had a positive impact on some demersal species (shi drum, brown maegre, sharpsnout seabream, sea bream, seabass, striped sea bream, etc.) in terms of population increase. Lately, a noticeable increase has been observed on such species (Aydin & Sözer, 2016). Since the habitat structure of the Black Sea is limited in algae communities and rocky areas, unlike the Mediterranean and Aegean Sea, does not allow the shelter of such fish especially for small individuals. These species juveniles inhabit coastal algae communities and rocky habitats, and as they grow migrate to deeper waters (Fischer et al., 1987). It is thought that filled coastal areas provide suitable habitats for these species' juveniles. Petrakis & Stergiou (1997), within the scope of the European Union, identified this species legal length as 15 cm (age 3). In addition, in a study by Chaouch et al. (2013) reported that the species female reaches sexual maturity at 16.43 cm, and males reach 16.09 cm which corresponds to age 3. Mouine et al. (2006) identified this length as 21.55 cm, Pajuelo et al. (2008) identified this length for males as 28.1 cm and for females as 29.2 cm, Cetinić et al. (2002) estimated for males as 21.8 cm and for females as 22.6 cm. All the individuals that were obtained during this study are above the legal length identified by the European Union and most are larger than their first maturity length. There is no data on this species legal catch length in our country.

In this study, it was found that the species spawning starts in August and continues till November, but peaks in September. In other studies, conducted on species spawning has reported similar results (Table 9).

Again, Papadaki et al. (2008) reported sharpsnout seabreams spawning period accruing at 21-18.5 ºC from September till December, and peak in October.

In this study, the relative fecundity in September was estimated to be14695.4 egg/1g (8305.0 – 22727.2). Hernandez et al. (2003) estimated the fecundity to reach its peak in September with 2.4 million/kg eggs.

In this study, the condition factor was estimated at 1.55 (min:1.378 max:1.712). Hernandez et al. (2003), reported the condition factor minimum 1.83 and 2.51 maximum. The difference between both studies can be the result of study area difference.

Table 8. Similar studies von Bertalanffy growth parameters (L∞, k, t0) and growth performance index (ϕ')

L_∞	K	t_0	b	ϕ'	References
45.10	**0.2656**	**-1.6587**	**2.721**	**2.73**	**This study**
45.28	0.191	-0.306	3.001	---	Kraljević *et al*. (2007)
54.10	0.182	-2.531	2.590	---	Domínguez-Seoane *et al*. (2006)
28.39	0.183	-1.652	---	---	Chaouch *et al*. (2013)
23.19	0.472	-0.248	---	---	Bradai *et al*. (1998)

Table 9. Sharpsnout seabream spawning periods from different locations

Season	Regions	References
Oct.-Dec.	Cyprus	Georgiou and Stephano (1995)
Oct.-Nov.	Cyprus	Marangos (1995)
Sep.-Oct.	Italy	Micale et al. (1996)
Oct.-Nov.	Tunisian	Bradai (2000)
Agu.-Oct.	Spain	Hernandez *et al*. (2003)
Oct.-Dec.	Italy	Lahnsteiner and Paternello (2004)
Sep.	Tunisian	Mouine *et al*. (2006)
Sep.-Feb.	Canary Islands	Pajuelo *et al*. (2008)
Sep.-Dec.	Greece	Papadaki *et al.* (2008)
Oct.-Nov.	Tunisian	Chaouch *et al*. (2013)
Sep.	Black Sea	This study

Conclusions

Sharpsnout seabream, even though is a native species in the Mediterranean Sea, there is limited literature on its population. More studies should be conducted on such an economically valuable species population. Even though this study provides important information by being the most comprehensive work done for all our seas, and it is the first study for the Black Sea, more detailed studies should be carried out on this species. It is especially important for the studies to focus on matters such as nutritional characteristics and presence in ecosystem, breeding areas and first maturity length for the sustainability of the species. In this context, the necessary data needed by the ministry should be provided and the legal regulations should be completed as soon as possible.

Ethical Statement

This study was conducted in accordance with ethics committee procedures of animal experiments.

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Author Contribution

Author MA designed the study, ÇÖ wrote the first draft of the manuscript, and both authors conducted field work and lab work together. Both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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