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Biometric Features of marbled spinefoot *Siganus rivulatus* (Forsskål & Niebuhr, 1775) from Mersin Bay (Northeastern Mediterranean), Turkey

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ABSTRACT

In the study, it was aimed to determine the morphometric measurements of *Siganus rivulatus* (Forsskål & Niebuhr, 1775) sampled from Mersin Bay in February 2021. The average value of some morphometric measurements of fish from Mersin Bay (n=196) were found that the total length 17.87 ± 3.11 cm, standard length 13.88 ± 1.96 cm, fork length 17.06 ± 1.35 cm, head length 3.60 ± 0.76 cm, eye diameter 1.08 ± 0.23 cm, interorbital distance 1.60 ± 0.34 cm, body width 2.32 ± 0.48 cm, dorsal fin base length 10.45 ± 2.19 cm, anal fin base length 6.26 ± 1.31 cm, pectoral fin length 2.56 ± 0.53 cm and caudal peduncle height 0.78 ± 0.16 cm. The total length-weight relationship of the species was determined as $W = 0.008xTL^{3.16}$ (r^2=0.973) and it was found that the fish showed positive allometric growth.

KEYWORDS: *Siganus rivulatus*, Mersin Bay, Morphometric measurements, Length-weight relationships.

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1. Introduction

The marbled spinefoot *Siganus rivulatus* (Forsskål and Niebuhr, 1775) is an Indo-Pacific species belonging to the Siganidae family of the order Perciformes that migrated from the Red Sea to the Mediterranean Sea. It has been reported that they are distributed in sea and brackish waters up to a depth of 30 m (Bariche et al., 2004), and that they are not found in deeper than 60 m (Bilecenoğlu and Kaya, 2002; Gurbet and Kara, 2013). They prefer to live in rocky and sheltered habitats surrounded by algae in the school of approximately 50-100 individuals. *S. rivulatus* is an herbivore species that are fed by grazing (Bariche, 2006). Bony rays in the fins are poisonous (Robins et al., 1991) and pose a threat to humans. It has been reported that it is not officially included in commercial fisheries statistics in our country (Bilecenoğlu and Kaya, 2002).

The first record of *S. rivulatus* from the Eastern Mediterranean was notified by Steinitz (1927) (Gurbet and Kara, 2013). The species has been reported to migrate to Eastern Mediterranean coasts along the north and west. On the migration route, the species was the first recorded in İskenderun Bay on the northeastern coast of Turkey in 1942 was reported by Kosswig (Kosswig, 1950). Other records of the species from the Turkish coast between Iskenderun Bay and Anamur were presented by Haas and Steinitz (1947), Ben-Tuvia (1953-1966), Akyüz (1957), Whitehead (1984, 1986), and Gücü et al., (1994). The records of the species from the Southeast and South Aegean in 1987-1990 were reported (Papaconstantinou 1987, 1990). The researchers noticed that the species has high success in establishing a population in the Eastern Mediterranean from Fethiye Bay (Torcu et al., 2001) and Izmir Bay (Gurbet and Kara, 2013) among the other lessepsian species.

Morphometric characters allow taxonomic distinction of the species, determination of growth characteristics, and prediction of population dynamics at a certain location. The length-weight relationship is important in determining the distinction between individuals that make up the population (King, 2007), while the condition factor reflects the productivity of the habitat, determining the suitability of abiotic factors, and revealing the intra and interspecific relationship of the population (Alam et al., 2014; Ujjania et al., 2012; Dan-Kishiya, 2013). Determination of all these parameters is necessary for fisheries management in a region (Abdelhak et al., 2020).

Although studies have been reported on the morphometric measurements of different populations of *S. rivulatus* (Yeldan and Avşar, 2000; Bilecenoğlu and Kaya, 2002; Dulcic and Pallaoro, 2004; Shakman et al., 2008; El-Drawany, 2015; Gabr et al., 2018; Abdelhak et al., 2020; Karakulak et al., 2020; Soykan et al., 2020; Soykan et al., 2021), this study is being presented the morphological features of this species from Mersin Bay.

In this study, some morphometric characteristics, and length-weight relationships of *S. rivulatus* were determined.

2. Material and Methods

In the study, 196 individuals of *S. rivulatus* were caught with a commercial trawl net from Mersin Bay in February 2021. The coordinates of the sampling area are 36 ° 11'26.0 "N 33 ° 48'11.3" E and the sampling station is presented in Figure 1. The sampling depth of the species is 40 m.

The morphometric measurements of each individual were measured with the Insize electronic caliper with a sensitivity of 0.01 mm and a scale with a precision of 0.1 g. The total length, fork length, standard length, head length, body width, eye diameter, interorbital distance, dorsal fin base length, anal fin base length, pectoral fin length, and caudal peduncle height of each individual were measured.

Figure 1. Study area

The number of dorsal fin rays, anal fin rays, ventral fin rays, and pectoral fin rays was determined as meristic measurements. A linear (y = ax + b) regression model was used to determine the equations defining the relationships between morphometric characters and total length or head length. In the equations, 'y' is the dependent variable (morphometric character), 'x' is the independent variable (total length/head length), and '*a*' and '*b*' are constants. To define these relationships, the model with the highest determination coefficient (r^2) was chosen.

The allometric growth equation ($W = aL^b$) was used to determine the length-weight relationship of the species (Ricker, 1975). Where W is the weight (g), L is the total length (cm), *a* and *b* are the growth constants.

Principal Component Analysis (PCA), Inter-cluster Correlation Analysis (ICC), and Univariate Analysis of Variance (ANOVA) were used to measure the multivariate analysis of the individuals. The SPSS, Statistica for Windows Version 20.0, and Excel Windows 2010 package programs were used for analysis.

3. Results

In this study, some morphometric characteristics, and length-weight relationships of *S. rivulatus* were determined. Table 1 shows the mean and standard deviations of some morphometric measurements, the percentages of minimum and maximum values of the eye diameter and interorbital length of the head length and the other parameters of the total length, and some meristic measurements of *S. rivulatus* (n=196).

Total length 17.87±3.11 cm, standard length 13.88±1.96 cm, fork length 17.06±1.35 cm, head length 3.60±0.76 cm,

eye diameter 1.08±0.23 cm, interorbital distance 1.60±0.34 cm, body width 2.32±0.48 cm, dorsal fin base length 10.45±2.19 cm, anal fin base length 6.26±1.31 cm, pectoral fin length 2.56±0.53 cm and caudal peduncle height 0.78±0.16 cm of fish were measured.

The number of dorsal fin rays (D: I- XII / 10), anal fin rays (A: VII / 9), pectoral fin rays (P: I / 15), and ventral fin rays (V: III / 2) has been determined as the meristic characters of samples.

Table 1. Some morphometric and meristic measurements of *S. rivulatus* sampled from Mersin Bay

Morphometric Measurements (cm)	**Mean ± SD**	**TL% &* HL% (min-max)**
Total length (TL)	17.87 ± 3.11	100
Standart length (SL)	13.88 ± 1.96	77.63
Fork length (FL)	17.06 ± 1.35	95.45
Head length (HL)	3.60 ± 0.76	20.15
Eye diameter (ED)	1.08 ± 0.23	30.21*
Interorbital distance (IOD)	1.60 ± 0.34	44.50*
Body width (BW)	2.32 ± 0.48	12.96
Dorsal fin base length (DFB)	10.45 ± 2.19	58.43
Anal fin base length (AFB)	6.26 ± 1.31	35.04
Pectoral fin length (PF)	2.56 ± 0.53	14.32
Caudal peduncul height (CP)	0.78 ± 0.16	4.33
Meristic Measurements		
Dorsal fin (D) rays	D: I - XII / 10	
Anal fin (A) rays	A: VII / 9	
Pectoral fin (P) rays	P: I / 15	
Ventral fin (V) rays	V: III / 2	

*; indicates HL% min-max ratio; SD indicates the standard deviation

An index was created by determining the percentage of eye diameter and interorbital length to head length and the other morphometric features to the total length ratio of examined in order to prevent the error that may be caused by sexual and age-related changes in the individuals. Table 1 shows the percentage of some morphometric measurements of *S. rivulatus* to the total length/head length.

The correlation coefficients of some morphometric measurements of *S. rivulatus* were presented in Table 2. It was determined that the morphometric measurements of fish showed a positive linear relationship at the level of $p < 0.01$.

The highest correlation coefficients ($r = 0.985$, $p<0.01$) was found between TL and FL while the lowest ($r = 0.235$, $p<0.01$) was between PFB and ED ($p<0.01$). ED showed a weak positive correlation with BW, CP, PFB, and BW with PFB, while other characters showed a stronger positive linear correlation with each other.

The length-weight relationship of *S. rivulatus* was calculated and found as $W=0.008xTL^{3.16}$ ($r^2=0.973$). It was determined fish showed positive allometric growth. It was determined fish showed positive allometric growth. The %95 Confidence Intervalce value of b was found 3.1838 – 3.1362.

Table 2. Correlation coefficients of the morphometric characters of *S. rivulatus*

	TL	SL	FL	W	HL	ED	IOD	BW	DFB	AFB	PFB	CP
TL	1											
SL	0.959**	1										
FL	**0.985****	0.958**	1									
W	0.902**	0.908**	0.904**	1								
HL	0.877**	0.870**	0.883**	0.839**	1							
ED	0.490**	0.495**	0.460**	0.468**	0.512**	1						
IOD	0.685**	0.692**	0.686**	0.692**	0.625**	0.509**	1					
BW	**0.481****	0.532**	0.513**	0.692**	0.468**	0.245**	0.401**	1				
DFB	0.973**	0.933**	0.970**	0.899**	0.876**	0.464**	0.645**	0.498**	1			
AFB	0.919**	0.887**	0.919**	0.856**	0.796**	0.397**	0.627**	0.523**	0.907**	1		
PFB	0.649**	0.634**	0.662**	0.634**	0.602**	0.235**	0.448**	0.279**	0.620**	0.570**	1	
CP	0.692**	0.679**	0.694**	0.724**	0.704**	0.281**	0.587**	0.438**	0.698**	0.680**	0.527**	1

**Correlation is significant at the level 0.01 (2-tailed), *Correlation is significant at the level 0.05 (2-tailed)

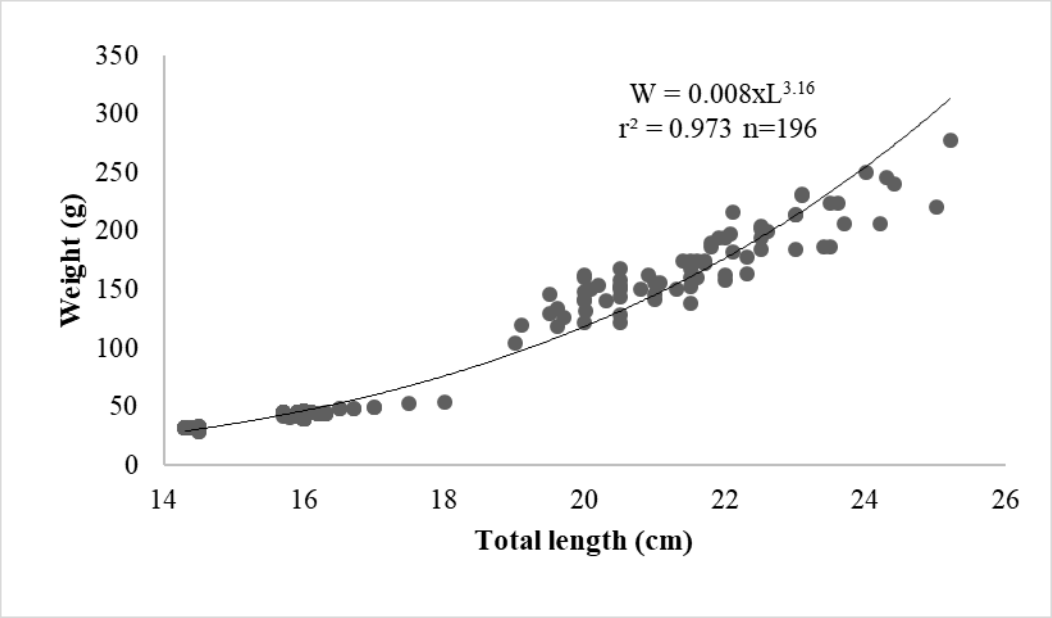

Figure 2. The length-weight relationships of *S. rivulatus* sampled from Mersin Bay

4. Discussion

Lessepsian species are highly influential on Northeast Mediterranean biodiversity and fisheries (Ergüden et al., 2009). Determining the morphometric characteristics of these invasive species may be important in reflecting the status of any more established populations. The morphometric changes that can be determined for the species can give an idea about genetic variations. In this research, some morphometric and meristic characteristics of individuals of *S. rivulatus* were determined and compared with previous research findings (Table 3).

The total length and weight values reported from different locations of *S. rivulatus* are different. Abdelhak et al., (2020) reported that the average total length of

individuals sampled from the Red Sea, Suez Channel, and the Mediterranean were 20.09 cm, 13.64 cm, and 13.31 cm respectively. They also reported that the average weight determined from the Red Sea, Suez Canal, and Mediterranean samples were determined as 106.7, 41.44, and 32.51 g, respectively. Abdelhak et al., (2020) reported that although there are some morphometric differences between the Mediterranean and the Red Sea / Suez Channel populations of *S. rivulatus*, these populations are morphometrically and genetically similar. In previous studies conducted in different locations of the Mediterranean, the total length and weight values of *S. rivulatus* were reported as follows, 21.5 cm and 128.7 g in Antalya Bay (Bilecenoğlu and Kaya, 2002), 27.1 cm (no weight data) in Gökova Bay (Soykan et al., 2021), 15.2 cm and 43.45 g in Izmit Bay (Karakulak et al., 2020) and 11.1 cm (no weight data) in the Adriatic Sea (Dulcic and Pallaoro, 2004). In this study, the average total length and weight of *S. rivulatus* sampled from Mersin Bay were found as 17.87 cm and 90.73 g, respectively. The highest TL value were noticed from Gökova (Soykan et al., 2021), Antalya Bay (Bilecenoğlu and Kaya, 2002) and Red Sea (Abdelhak et al., 2020). Although our findings were lower than these data, they were higher than the Izmit Bay (Karakulak et al., 2020), Suez Canal/Mediterranean (Abdelhak et al., 2020), and Adriatic Sea (Dulcic and Pallaoro, 2004) findings. This may indicate that *S. rivulatus* can establish anymore population in the Mediterranean Sea.

The comparison of examined morphometric characters with previous studies is presented in Table 3. Although there are differences in morphometric measurements such as total length, body width, dorsal fin base length, and anal fin base length between fish sampled from different locations, there is no distinction between meristic features that were compared to previous findings.

The head length of *S. rivulatus* in our study (3.60 cm) was similar to the Red Sea population (3.80 cm) of *S. rivulaus* (Abdelhak et al., 2020). Head length was reported as the smallest value in fish from the Adriatic Sea (Dulcic and Pallaoro, 2004) and the highest value in fish from Gökova Bay (Soykan et al., 2021). The highest eye diameter was found in fish from the Gökova Bay (Soykan et al., 2021) and this was followed by our finding. The lowest eye diameter value was reported in Suez Canal/Mediterranean fish (Abdelhak et al., 2020). Although all morphometric measurements of fish in Gökova Bay were higher than fish in other locations compared in this study, the highest IOD value was found in this study. However, the IOD value of fish in Gökova Bay (Soykan et al., 2021) and the Red Sea (Abdelhak et al., 2020) was close to our findings.

The body width of the fish in the present study was the lowest among the other fish compared (Table 3). Dorsal fin ray base length and anal fin ray base length determined in this study have the second highest values after Gökova Bay fish (Soykan et al., 2021).

The distinction between morphometric measurements may be related to sampling time as well as sex, age, habitat efficiency, and abiotic characteristics of the environment in different populations.

In this study, it was determined that correlation coefficients of the morphometric measurements of *S. rivulatus* showed a positive linear relationship at $p < 0.01$ level ($r^2 = 0.98$ n =196).

Table 4 shows the comparison of the length-weight relationship of *S. rivulatus* determined in this study with previous studies.

Table 3. The comparison of some morphometric and meristic features of *S. rivulatus* with previous studies

	Present study (Mersin Bay)		Abdelhak et al., (2020) (Red Sea[a], Suez Channels[b], Mediterranean Sea[c])		Dulcic and Pallaoro, (2004) (Adriatic Sea)	Karakulak et al., (2020) (İzmit Bay, Marmara Sea)		Soykan et al., (2021) (Gökova Bay, Aegean Sea)
MM (cm)	**Mean±SD**	**TL%**	**Mean±SD**	**TL%**	**Mean**	**Mean**	**TL% *HL%**	**Mean**
TL	17.87±3.11	100	20.09±2.75[a] 13.64±3.13[b] 13.31±2.72[c]	100	11.1	15.1	100	27.1
SL	13.88±1.96	77.63	15.83±2.15[a] 10.77±2.46[b] 10.47±2.09[c]	78.79[a] 78.94[b] 78.68[c]	9.2	12.8	84.8	21.9
FL	17.06±1.35	95.45	-	-				25.2
HL	3.60±0.76	20.15	3.80±0.49[a] 2.68±0.51[b] 2.65±0.49[c]	18.92[a] 19.68[b] 19.87[c]	2.3	3.0	19.9	4.7
ED	1.08±0.23	30.21*	0.97±0.11[a] 0.76±0.12[b] 0.73±0.14[c]	-	0.8	1.0	33.3*	1.4
IOD	1.60±0.34	44.50*	1.41±0.23[a] 0.96±0.22[b] 0.86±0.18[c]	-	0.7	1.1	36.7*	1.5
BW	2.32±0.48	12.96	6.03±0.89[a] 4.12±0.97[b] 3.80±0.77[c]	-	3.1	4.7	31.1	9.5
DFB	10.45±2.19	58.43	-	-	6.1	8.8	58.3	13.2
AFB	6.26±1.31	35.04	-	-	3.6	5.3	35.1	9.6
PF	2.56±0.53	14.32	-	-	1.8	2.3	15.2	-
CPH	0.78±0.16	4.33	-	-	-	0.8	5.3	1.2
Meristic measurements								
DF	D: I- XII / 10		D: XIV+10		D: XIII-XIV / 10	XIII + 10		-
AF	A: VII / 9		A: VII+9		A: VII / 9	VII + 9		-
PF	P: I / 15		P: 15-16		P: 16-17	-		-
VF	V: III / 2		V: I+3+I		V: I+3+I	V: I+3+1		-

The findings were reported by Shakman et al., (2008) on the Libyan coast (*b=2.82*) and by Abdelhak et al., (2020) in the Mediterranean Sea (*b=2.90*) were not similar and the species showed negative allometric growth and also some studies reported isometry Gabr et al., 2018 (Coast of Jeddah); El-Drawany, 2015 (Bitter Lakes, Egypt); Abdelhak et al., 2020 (Suez Channel), while the other studies (Bilecenoğlu and Kaya 2002; Abdelhak et al., 2020; Soykan et al., 2020) and present study showed positive allometric growth (Table 4).

Table 4. The comparison of *S. rivulatus* length-weight relationship with previous studies

Locality	LW Equations	References
Red Sea Coast of Jeddah, Saudi Arabia	$W = 0.011\ L^{3.06}$	Gabr et al., 2018
Bitter Lakes in Egypt	$W=0.00952L^{3.042}$	El-Drawany, 2015
Gulf of Antalya	$W=0.00642L^{3.221}$ (female) $W=0.00792L^{3.135}$ (male)	Bilecenoğlu and Kaya, 2002
Red Sea Suez Channel Mediterranean Sea	$W=0.0112L^{3.034}$ $W=0.0085L^{3.182}$ $W=0.0154L^{2.909}$	Abdelhak et al., 2020
Libyan Coast	$W= 0.233L^{2.820}$	Shakman et al., 2008
Gökova Bay, Aegean Sea	$W= 0.00941L^{3.082}$	Soykan et al., 2020
Mersin Bay	$W= 0.008L^{3.16}$	Present Study

5. Conclusion

S. rivulatus is one of the economically important lesepsian species and it is known that this species has established successful populations on the migration route it follows in the Mediterranean. Siganids are found in the Mediterranean, where there are few herbivorous fish species; It has contributed positively to the normalization of the food web by recycling the algae and providing food for the groupers.

The morphometric characteristics of the species have been tried to be revealed within the previous research in different regions from the Red Sea, to the middle Mediterranean. In this research, morphometric characters of this species were presented for the first time from Mersin Bay. The findings obtained will contribute to the next research and fisheries management.

Conflict of Interest

The authors declare that there is no conflict of interest.

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