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RESEARCH ARTICLE

Length-Weight Relationships of *Fistularia commersonii* Rüppell 1835 from the Northeastern Mediterranean Sea, Türkiye

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Abstract: In this study, the length-weight data for bluespotted cornetfish, *Fistularia commersonii* in the Iskenderun Bay (NE Mediterranean Sea, Türkiye) was reported. *F. commersonii* specimens were caught from Iskenderun Bay between September 2018 and March 2019. The total length and total weight of both sexes varied from 23.0-108.1 cm and 4.0-599.58 g. The length-weight relationship was determined as $W= 0.0005xL^{2.963}$ ($R^2= 0.969$) with negative allometric growth for both sexes. The values of the exponent b of the length-weight relationships (LWRs) were 2.993 for females and 2.925 for males. This present study provides the first comprehensive gender-based description of the length-weight relationships of *F. commersonii* from the northeastern Mediterranean Sea, Türkiye

Anahtar kelimeler:

Fistularidae
Boy
Ağırlık
Regresyon parameterleri
Iskenderun Körfezi
Akdeniz

Kuzeydoğu Akdeniz'den (Türkiye) *Fistularia commersonii* Rüppell 1835'nin Boy-Ağırlık İlişkileri

Öz: Bu çalışmada, İskenderun Körfezi'ndeki (KD Akdeniz, Türkiye) külah balığı, *Fistularia commersonii* Rüppell 1835 için uzunluk-ağırlık verileri rapor edilmektedir. İskenderun Körfezi'nden yakalanan *F. commersonii* örnekleri üzerinde Eylül 2018 ve Mart 2019 tarihleri arasında bir çalışma yapılmıştır. Her iki cinsiyetin toplam uzunluğu ve toplam ağırlığı 23.0-108.1 cm ve 4.0-599.58 g arasında değişmiştir. Boy-ağırlık ilişkisi, her iki cinsiyet için negatif allometrik büyüme $W= 0.0005xL^{2.963}$ ($R^2= 0.969$) olarak belirlenmiştir. Boy-ağırlık ilişkilerinin (LWR'ler) b üssünün değerleri, dişiler için 2.993 ve erkekler için 2.925'tir. Bu çalışma, Türkiye'nin Kuzeydoğu Akdeniz bölgesinden *F. commersonii*'nin boy-ağırlık ilişkilerinin cinsiyetlerine göre ilk kapsamlı tanımını sunmaktadır.

Introduction

Members of the family Fistularidae are represented by the genus *Fistularia* Linnaeus, 1758 with four valid species described in the literature so far; *Fistularia commersonii* (Rüppell, 1838), *Fistularia corneta* (Gilbert and Starks, 1904), *Fistularia petimba* (Lacepède, 1803), and *Fistularia tabacaria* (Linnaeus, 1758) (Fritzsche, 1976). *F. commersonii* and *F. petimba* species have been reported in the Mediterranean waters (CIESM, 2022) and the Red Sea (Fischer & Bianchi, 1984).

The blue-spotted cornetfish *F. commersonii* is a reef-associated fish species and occurs between depth ranges of 0 - 132 m (Mundy, 2005) and is commonly found in sandy bottoms and near seagrass meadows (Fritzsche, 1976; Watson & Sandknop, 1996; Bilecenoglu et al., 2002; Pais et al., 2007). It mainly feeds on many small fishes, various squids, and shrimps (Hiatt & Strasburg, 1960; Khalaf & Disi, 1997; Saad & Sabour, 2010).

Living organisms that migrate to the Mediterranean via the Red Sea are called "Lesepsian species". *F. commersonii* is known as a lessepsian sprinter species (Stern et al., 2017) with a fast-spreading and wide geographical distribution (Karachle et al., 2004). This lessepsian splinter species was first recorded from the coasts of Israel (Eastern Mediterranean) (Golani, 2000, Golani et al., 2007, Golani, 2010).

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The length-weight relationship is a critical parameter in fish biology (Erguden et al., 2017; Erguden et al., 2018; Erguden et al., 2020) and is used to recognize the ecology and life cycle of fish species when morphological comparison of populations from different geographical areas are made (Petrakis & Stergiou, 1995). The length-weight relationship parameters can also provide information on the stock condition and growth studies. In addition, the length-weight relationship is commonly used to convert growth-in-length equations for the prediction of weight-at-age and apply in stock assessment models (Pauly, 1993), to calculate condition indices (Anderson & Neumann, 1996).

In the Mediterranean Sea, previous compherensive studies of the bluespotted cornetfish which were carried out were focused on the population structure of the species (Bariche, & Kajajian, 2012), maximum length and biological data (Edelist, 2014; Castriota et al., 2014; Mouine-Oueslatia et al., 2017), diet (Bariche, 2007; Bariche et al., 2009; Kalogirou et al., 2007), reproduction (Bariche et al., 2013, morphometry (Raghep, In press), new record (Golani, 2000, Bilecenoglu et al., 2002; Corsini et al., 2002; Azzurro et al., 2004; Ben Souissi et al., 2004; Fiorentino et al., 2004; Pipitone et al., 2004; Azzurro, 2006; Micarelli et al., 2006; Sanchez-Tocino, 2007; Dulcic et al., 2008; Kara & Oudjane, 2008; Psodomakis et al., 2009; Rafrafi-Nouira et al., 2011; Meloni & Piras, 2013) and distribution (Gokoglu et al., 2002; Corsini et al., 2002; Ligas et al., 2007; Pais et al., 2007; Joksimović et al., 2008; Occhipinti-Ambrogi & Galil, 2008; Garibaldi & Orsi Relini, 2008; Hemida & Capapé C. 2009; Elbaraasi & Elsalini, 2009; Bodilis et al., 2011; Deidun & Germanà, 2011; Azzurro et al., 2013; Türker Çakır et al., 2014; Bănaru & Harmelin-Vivien, 2018).

Although only a few studies have been conducted on *F. commersonii* length-weight relationships (Taskavak & Bilecenoglu, 2001; Erguden et al., 2009) and maximum length (Torcu Koc et al., 2019) in the Mediterranean coasts of Turkey, none of the results of the reported length-weight data were evaluated with respect to gender. The present study, comprehensively reports the length-weight relationships (LWRs) of male and female *F. commersonii* foe rhe first time in the eastern Mediterranean, Türkiye.

Material and Methods

A total of 146 fish specimens were collected from a commercial trawler at 10-30 m depths between September 2018 and March 2019 from 4 different fishing localities (Samandag, Arsuz, Pirinclik, Dörtyol) in the Iskenderun Bay, Turkey (Figure 1). The collected specimens were identified onboard and then preserved in an ice box. In the laboratory, each fish was measured for total length (TL) to the nearest 0.1 cm and weighed to the nearest 0.01 g. Fish specimens were identified based on Fritzche (1976) and Golani (2000) and also validated following FishBase (Froese & Pauly, 2022).

Figure 1. Sampling areas in the Iskenderun Bay

The length-weight relationships were established using linear regression analysis with the equation $W= axL^b$ (*W*: fish weight, *TL*: fish total length, *a*: intercept parameter, and *b*: slope parameter). Logarithmic expression was used for the data. TW and TL were converted: lnTW =ln(a) + bln(TL) (Bagenal & Tesch, 1978; Avşar, 2016).

The determination coefficient (r^2) was used as an indicator of the quality of the linear regression. A significant difference of b values from 3, which represent isometric growth, was tested using a t-test (Pauly 1993). Analysis of variance (ANOVA) was used to test the difference of the b values of the length-weight relationship between sexes (Zar, 1999). All data were statistically analyzed by using Microsoft Excel 2018 and IBM SPSS statistics (Version 23.0, Armonk NY: IBM Corp.) package programs.

Results

In this study, a total of 146 (86 females and 60 males) *F. commersonii* specimens which were caught from Iskenderun Bay were examined. The population of *F. commersonii* of comprised of 58.9% of females and 41.1% of males. The sex ratio for female and male individuals (M:F) was 1.00:1.43. The difference between male to female ratio was not statistically significant at 0.05, ($p>0.05$).

The total length of all individuals ranged from 23.00 to 108.10 cm TL and weighed between 4.00 g. and 599.58 g. Males and females ranged from 23.00 to 98.50 cm TL and 29.00 to 108.10 cm TL. The maximum TL and weight recorded as 108.10 cm and 599.58 g, respectively belonged to a female individual of *F. commersonii*. The descriptive statistics and estimated parameters of the length-weight relationship are given in Table 1. The ANOVA test indicated the differences length-weight relationships between females and males were not statistically significant ($P > 0.001$). Length-weight relationships are given in Table 2 for females, males and both sexes, including sample size (n), equation parameters a and b, the 95% confidence limits for both parameters and the coefficient of determination (r^2)**.**

Table 1. Mean and standard deviation, maximum, minimum for length (L) and weight (W) parameters of each sex of *Fistularia commersonii*

Sex	n	Total Length (Min-Max)	Total Length Mean±SE	Total Weight (Min-Max)	Total Weight Mean±SE
Female	86	29.00-108.10	64.00±2.11	7.00-599.58	140.56±15.27
Male	60	23.00-98.50	63.67±2.11	4.00-39 6.30	131.21±14.40
Both sexes	146	23.00-108.10	63.86±1.62	4.00-599.58	136.72±10.68

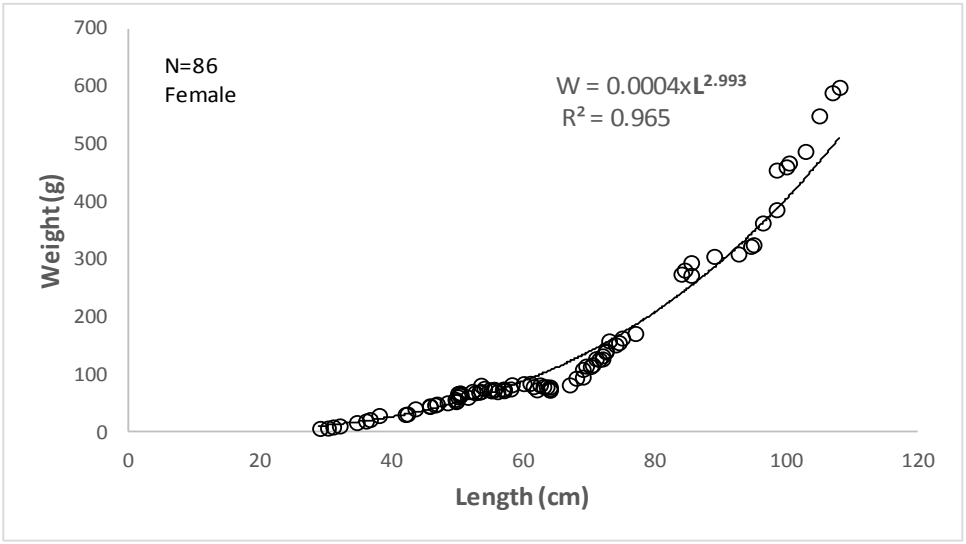
n: Sample size; Min: minimum; Max: maximum

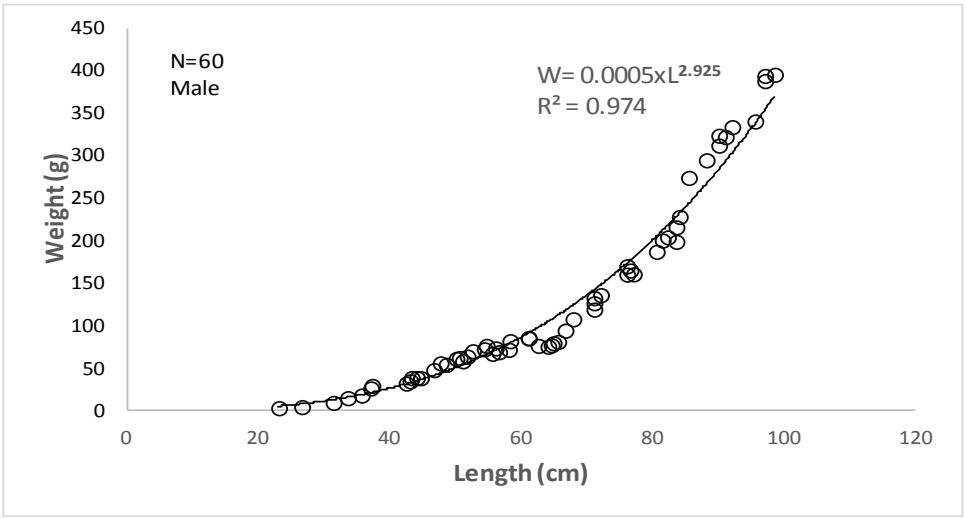
Table 2. Length-weight relationships of *Fistularia commersonii* from Iskenderun Bay, Turkey

n	Sex	a	b	r^2	SE of b	95% CI of b	P	Growth Type
86	Female	0.00040	2.993	0.965	0.062	2.870-3.117	<0.05	Allometric (-)
60	Male	0.00050	2.925	0.974	0.063	2.799-3.050	<0.05	Allometric (-)
146	Both sexes	0.00050	2.963	0.969	0.044	2.875-3.050	<0.05	Allometric (-)

n: Sample size; a: Intercept of the relationship; b: Slope of the relationship; S.E: Standart error, r^2: Coefficient of determination

Overall, the b value for both of female (b = 2.993) and male (b = 2.925) population were calculated as negative allometric growth (b < 3.00) (Figure 2). The length-weight relationships of *F. commersonii* for female, male and both sexes, were described as $W= 0.0041xL^{2.993}$ ($R^2= 0.965$), $W= 0.0005xL^{2.925}$ ($R^2= 0.974$) and $W= 0.0005xL^{2.963}$ ($R^2= 0.969$) respectively (Figure 2). The length-weight regressions were significant ($P < 0.001$) for all sexes, with all r^2 values greater than 0.96.





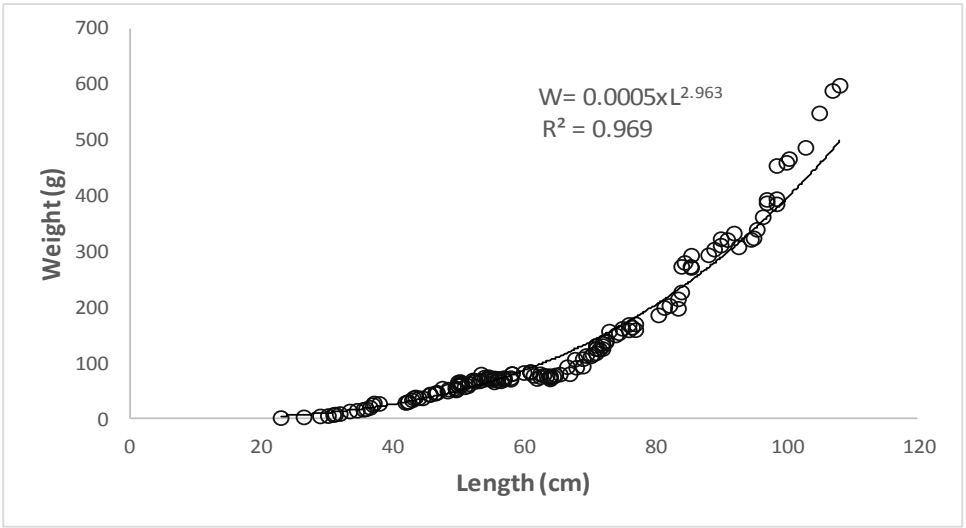


Figure 2. Length-weight relationship of female, male and both sexes for *Fistularia commersonii* from the Iskenderun Bay (Eastern Mediterraenan Sea)

Discussion

Overall, sex ratio (male: female = 1.00:1.43) was slight different from the accepted ratio of 1:1 ($\chi 2 = 5.21$, $p > 0.05$) with the dominance of females in the population which is similar to Bariche & Kajajian (2012) who found the sex ratio as 1:1.51 from the eastern Mediterranean waters. The sex ratio may vary from species to species, even differing from one population to another within the same species, and may also show temporal variations within the same population (Nikolsky, 1980). Small differences in the sex ratio may also be due to the sample size.

The total lengths for both sexes ranged between 23.0-108.0 cm (63.86 ± 1.42) and the total weight ranged between 4.0-599.58 g (136.72±10.68). Females were found to grow slightly larger than the males. Larger samples with higher length and weight values were reported in other studies. For example, Torcu Koc et al. (2019) reported max length (116.5 cm TL) and weight data (1291.88 g) for *F. commersonii* collected from Iskenderun Bay (Mediterranean Sea, Turkey) (Table 3). Similarly, Dulcic et al. (2008) declared a maximum length of 115.0 cm TL and a maximum weight of 1210.0 g for *F. commersonii* from the Adriatic Sea, Croatia. In the previous studies in Table 3; Golani (2000) reported the standard length as 26.8-51.6 cm for *F. commersonii* from the Mediterranean Sea (Israel). While Corsini et al. (2002) stated that the minimum and maximum values of standard lengths of the samples collected from Rhodes Island (Adana, Turkey) ranged between 14.1-73.4 cm, Kalogirou et al. (2007) reported the standard length as 5.0-108.0 cm for *F. commersonii* collected from SE Aegean Sea (Greece). However, Saad & Sabour (2010) reported the total length as 29.0-108.0 cm for *F. commersonii* collected from the Syrian coast (Syria). Deidun and Germana (2011) stated that the minimum and the maximum values of total length for *F. commersonii* collected from Maltese Islands (Malta), ranged between 30.0-110.0 cm. Bariche & Kajajian (2012) reported the total length as 19.2-113.1 cm from the Tunisian coast (Tunisia). Bilge et al. (2014) reported the total length as 31.4-63.2 cm for *F. commersonii* collected from the Southern Aegean Sea (Turkey). In addition, investigation on the populations of the *F. commersonii* living in the Central Mediterranean Sea and South of Sicily showed that the minimum and the maximum values of total length ranged between 66.0-115.0 cm and 66.0-115.0 respectively (Castriota et al., 2014; Vitale et al., 2016). The nearest one to the length values presented in our study stated that the minimum and the maximum values of the total length as 24.1-107.5 for *F. commersonii* collected from West of Alexandria, (Egypt) Raghep (2002). Comparison of previously published maximum length-weight data for *F. commersonii* from different Mediterranean areas is given in Table 3.Size differences are related to sex, fishing gear, season and habitat and are also considerably affected by factors such as reproductive activity, nutrition and environmental factors (Le Cren, 1951; Froese, 2006).

The b value of the length-weight relationships varies between 2.5 to 3.5 (Froese 2006). A value of *b* indicates that fish grows symmetrically or isometrically and allometrically in which *b* is different from 3. In this study, b values were calculated as 2.993, 2.925, and 2.963 for females, males and both sexes which indicated negative allometric (-) growths, respectively. Comparison of the b values from different regions showed that these values vary from negative to positive allometric growths (Table 4).

The b values found in the present study were generally in agreement with similar results for the Mediterranean waters of Turkey (Table 4). Erguden et al. (2009) reported the b value as 2.540 for *F. commersonii* from Southeastern Mediterranean. Bilge et al. (2014) reported the b value as 2.727 from Southern Aegean Sea, Turkey. On the contrary, the previous studies of positive (+) allometric growth of *F. commersonii* have been reported by Kalogirou et al. (2007) and Castriota et al. (2014). In their studies, b values for both sexes of *F. commersonii* were calculated as b= 3.377 in the SE Aegean Sea and 3.372 from the Mediterranean Sea. Similar findings from the Mediterranean waters were reported; Bariche and Kajajian (2012) and Vitale et al. (2016) reported b values as 3.406 and 3.619 respectively, for *F. commersonii*. These differences of b value may stem from differences in ecological factors (Wootton, 1998). According to Le Cren (1951), b value may fluctuate in a particular species due to gender, food availability, preservation method, gonadal maturation, and physiological condition.

Length-weight relationships in fishes are affected by several factors including habitat, area, seasonal effect, general fish condition, gonad maturity, sex, diet and stomach fullness, health and preservation techniques (Tesch, 1971; Bagenal & Tesch, 1978). Consequently, the present length and weight relationships reported in this study may be usefult for fishery biologists to compare general health status, morphological characteristics and the growth pattern of *Fistularia commersonii* populations from different locations and habitats and can be used as a guideline for this species in the future.

Table 3. Comparison of maximum length-weight data for *F. commersonii* from different localities in the Mediterranean Sea

References	Max Length (cm)	Length Type	Weight (g)	Locality/Country
Golani (2000)	51.6	SL	82.5	Mediterranean Sea, Israel
Bilecenoglu et al. (2002)	72.8	TL	-	Antalya Bay, Turkey
Gökoglu et al. (2002)	77.5	TL	350.0	Antalya Bay, Turkey
Gökoglu et al. (2002)	64.0	TL	180.0	Gökova Bay, Turkey
Corsini et al. (2002)	73.4	TL	-	Rhodes Island, Greece
Karachle et al. (2004)	92.0	TL	448.1	North Western Aegean Sea, Greece
Ben Soussi et al. (2004)	98.7	TL	-	Gabes Gulf, Tunisia
Fiorentino et al. (2004)	90.4	TL	345.0	Strait of Sicily, Italy
Azurro et al. (2004)	104.5	TL	-	Strait of Sicily, Italy
Pipitone et al. (2004)	84.5	SL	-	NW Sicily, Italy
Micarelli et al. (2006)	78.9	TL	-	North Tyrrhenian Sea, Italy
Sanchez-Tocino (2007)	104	TL		Iberian Peninsula
Garibaldi & Orsi Relini (2008)	92.6	TL	450.0	Ligurian Sea
Dulcic et al. (2008)	115.0	TL	1210.0	Adriatic Sea, Croatia
Psomadakis et al. (2008)	84.7	-	-	Latium coasts, Italy
Joksimovic et al. (2009)	71.5	TL	-	Montenegrin Coast
Bariche et al. (2009)	112.0	TL	-	Lebanon
Hemida & Capape (2009)	83.5	TL	-	Algerian coast
Kara & Oudjane (2009)	86.3	TL	405.0	Algerian Coast, Algeria
Psomadakis et al. (2009)	101.3	TL	-	Aegean Sea, Greece
Ergüden et al. (2009)	65.0	TL	98.20	Eastern Mediterranean, Iskenderun Bay, Turkey
Deidun & Germanà (2011)	102	TL	450.0	Maltese Waters, Maltese
Bodilis et al. (2011)	100	TL	-	French Coast, France
Bariche et al. (2013)	113.0	TL	-	Mediterranean Sea
Meloni & Piras (2013)	92.0	TL	170.0	South Western Mediterranean Sea, Sardinia, Italy
Edelist (2014)	99.5	TL	926.0	Israel
Türker-Çakır et al. (2014)	53.9	TL	68.8	Edremit Bay, Turkey
Mouine-Oueslatia et al. (2017)	80.0	TL	930.2	Gulf of Tunis, Tunisia
Bănaru & Harmelin-Vivien (2018)	99.0	TL	347.2	Bay of Marseille, France
Elbaraasi & Elsalini (2009)	95.0	TL	395.0	Benghazi, Libya Coast
Torcu Koc et al. (2019)	116.5	TL	1291.88	Iskenderun Bay, Turkey
This study	108.1	TL	599.58	N.E Mediterranean, Turkey

n: Sample size; TL: Total length; SL; Standard length

Table 4. Comparison of length-weight relationships parameters for *F. commersonii* from different regions

Author(s)	Area	n	Length Type (cm)	Sex	Length Min-Max (cm)	a	b	r^2
Fritzsche (1976)	Pacific Ocean	29	SL	-	17.8-86.5	-	-	-
Pauly et al. (1998)	Manila, Philippines	2	TL	-	78.0-104	0.00056	3.000	-
Golani (2000)	Mediterranean Sea, Israel	3	SL	-	26.8-51.6	-	-	-
Corsini et al. (2002)	Rhodes Island, Greece	37	SL	F+M	14.1-73.4	-	-	-
Kalogirou et al. (2007)	SE Aegean Sea, Greeece	245	SL	F+M	5.0-108.0	0.000147	3.377	0.994
Ergüden et al. (2009)	Southeastern Mediterranean, Turkey	12	TL	F+M	58.0-65.0	0.01120	2.540	0.981
Saad & Sabour (2010)	Syrian Coast	40	TL	F+M	29.0-108	-	-	-
Deidun and Germana (2011)	Maltese Island	21	TL	F+M	30.0-110.0	-	-	-
Rafrafi-Nouira et al. (2011)	Tunisian coast	14	TL	F+M	94.3-107.4	-	-	-
Bariche & Kajajian (2012)	Mediterranean Sea	1073	TL	F+M	19.2-113.1	0.01066	3.406	0.989
Bilge et al. (2014)	Southern Aegean Sea, Turkey	48	TL	F+M	31.4 - 63.2	0.01180	2.727	0.992
Castriota et al. (2014)	Central Mediterranean Sea	60	TL	F+M	66.0-115.0	0.00010	3.372	0.857
Vitale et al. (2016)	South of Sicily	23	TL	F+M	69.0-104.0	0.0000009	3.619	-
Raghep (2022)	West of Alexandria, Egypt	338	TL	F+M	24.1-107.5	-	-	-
This study	N.E Mediterranean, Turkey	146	TL	F+M	23.0-108.1	0.0005	2.963	0.969

n: Sample size; TL: Total length; SL; Standard length; F: Female; M: Male; a: Intercept of the relationship; b: Slope of the relationship; r^2: Coefficient of determination

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Conflict of Interest

Authors declare no conflict of interest pertaining to the publication of this manuscript.

Author Contributions

Deniz Ergüden (DE): Designed the study, Data curation, Validation, Investigation, Formal analysis, Writing - original draft, final editing. Mevlut Gürlek (MG): Validation, Supervision, Investigation, review & editing. Cemal Turan (CT): Data curation, Validation, Supervision, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. All authors discussed the results and contributed to the final version of the paper.

Ethics Approval

The materials used in the article were collected from the commercial trawler. Ethics committee approval is not required for this study. The study was carried out with the research permit (date: 29.09.2017 and number: E.2412565) of the Ministry of Agriculture and Forestry, General Directorate of Fisheries and Aquaculture.

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