Marine Science and Technology Bulletin

RESEARCH ARTICLE

Length-weight relationships and relative condition factor of *Spicara flexuosum* (Rafinesque, 1810) inhabiting the Black Sea and the Turkish Straits System

Aslı Şükriye Şalcıoğlu[1][*] (iD) • Adem Yavuz Sönmez[2] (iD)

[1] *Boğaziçi University, Institute of Environmental Sciences, Department of Environmental Sciences, 34347, Istanbul, Türkiye*

[2] *Kastamonu University, Fisheries Faculty, Department of Basic Sciences, 37100, Kastamonu, Türkiye*

ABSTRACT

Length-weight relationships and condition factor of *Spicara flexuosum* collected from İstanbul, Rize, Çanakkale and Sinop-Kastamonu by using commercial gill nets and hand-line fishing methods were evaluated between 2013 and 2014 in this study. The overall length-weight equation ($W=0.0236 L^{2.7334}$) indicated negative allometric growth from all sampling periods. Samples collected from Istanbul and Çanakkale exhibited positive allometric growth while *S. flexuosum* showed negative allometric growth in Rize and Sinop-Kastamonu in December 2013 and January 2014 respectively. The relative condition factor among regions varied from 0.99 to 1.08, indicating a state of wellbeing among all locations. This study provides the baseline data of length-weight relationships and condition factor analyses for *S. flexuosum* species from Turkish coastal waters for future management purposes for this species.

Introduction

Spicara spp. (Picarels) are members of the Centracanthidae or Sparidae family groups and are small-to medium-sized fish (Froese & Pauly, 2022). Morphologic misidentification which

was previously observed for the *Spicara* genus, especially *Spicara flexuosa* (Rafinesque, 1810) and *Spicara maena* (Linnaeus, 1758) (Salekhova, 1979; Vidalis & Tsimenides, 1996) has been eliminated based on previous studies in the literature (Chiba et al., 2009; Imsiridou et al., 2011; Minos et al., 2013;

---

* Corresponding author
E-mail address: asli.salcioglu@gmail.com (A. Ş. Şalcıoğlu)

Şalcıoğlu et al., 2021). *Spicara flexuosa* is now genetically identified and gained valid species status (Şalcıoğlu et al., 2021; Şalcıoğlu, 2022), recalled as *S. flexuosum* (Rafinesque, 1810) in the FishBase (Froese & Pauly, 2022).

Different meristic and morphometric studies were previously available (Vasilieva & Salekhova, 1983; Rizkalla, 1996; İlkyaz et al., 2007) in the literature about *Spicara* species. Some studies were based on biology, growth, nutrition (Soykan et al., 2010; Dalgıç et al., 2021), length-weight relationship (İşmen et al., 2007; Soykan et al., 2010; Özvarol, 2014) and condition factor (Mytilineou & Papaconstantinou, 1991; Dulčić et al., 2000; Mater et al., 2001) of this fish species.

Length–weight relationship (LWR) studies of fish species determine important resources for the management of fish stocks. (Martin-Smith, 1996; Froese et al., 2011). Fisheries biologists need length–weight relationship (LWR) data to understand the rational management of fishing resources and the most widely used tools for fisheries data (Yedier et al., 2019). Previous studies have shown that LWRs are generally different not only between species but also among different stocks of the same species in relation to region, season and age group (Gerritsen & McGrath, 2007; Froese et al., 2011; Demirel & Murat-Dalkara, 2012).

The relationship between the length and weight of fish provides information on the weight variation of individuals in relation to their length (Condition factor, K). The condition factor of the fishes is generally used for comparison of two or more populations living in similar or different ecological conditions based on the food or climate (Weatherley & Gill, 1987). Furthermore, these data are valuable resources for fisheries management and conservation of fish stocks (Jisr et al., 2018).

Length-weight relationships of *Spicara flexuosum* populations were previously evaluated in FishBase for Greece coasts (Petrakis & Stergiou, 1995; Moutopoulos et al., 2013) for Italian coast (Giacalone et al., 2010) for Portugal coast (Borges et al., 2003). However, none of the studies have been found in FishBase for *S. flexuosum* species in Turkish coastal waters with different locations and periods, although some studies have been found in the literature (Mater et al., 2001; Özvarol, 2014; Dalgıç et al., 2021; Samsun & Erdoğan Sağlam, 2021). The aim of this study is to provide seasonal determination of length-weight relationship and condition factor data of *S. flexuosum* sampling from Turkish Straits System and Black Sea coastal waters for future fisheries management purposes.

Material and Methods

Fish Sampling

S. flexuosum specimens were obtained by a random sampling method between 2013 and 2014 from commercial fishing by using gill nets (mesh sizes from 16 mm to 20 mm) from the Southeast Black Sea coast (Rize-Fener) (December 2013), (41.0387900 N, 40.4949340 E), Sinop-Kastamonu Central Black Sea coast (January 2014) (41.969994 N, 34.532061 E); and using handline fishing methods for Istanbul (February 2014) (40.5382480 N, 29.4102180 E) and Çanakkale (Dardanos) (June 2014) (40.101300 N, 26.375620 E). Fish samples were identified according to main morphological characteristics (Whitehead et al., 1986). A total of one hundred ten individuals were sampled, total length (TL) measurements were conducted by a Vernier caliper at 1 mm intervals, and the body weight (BW) of the specimens were weighed on a balance with a sensitivity of 0.001 g.

Length-Weight Relationship and Condition Factor

Body length (TL) and body weight (BW) were calculated by the

$$W = a \times L^b \tag{1}$$

where, W is the total weight (g). The parameters a and b were estimated by linear regression;

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

L is the total length (cm), a is the intercept (Coefficient related to the body) and b is the slope of log-transformed linear regression (Le Cren, 1951).

The model fit to the data was measured by the coefficient of the Pearson r-squared (r^2) test (Froese, 2006).

Fish growth is expressed by the values of the exponent b; when b=3, weight is isometric. When the value of b is greater than 3, the weight increase is allometric (Positive allometric if b>3, when the b value is smaller than 3, negative allometric if b<3). (Morey et al., 2003). The t test was used, if b was statistically significantly different from 3 (Pauly, 1984). 95% confidence interval (C.I.) of b values were also evaluated.

The relative condition factor (K_n) was calculated according to the following equation by Le Cren (1951):

$$K_n = \frac{W}{a \times L^b}, \tag{3}$$

where, W is the observed weight, and $a \times L^b$ is the calculated weight from the length-weight relationship.

This equation is used to reduce and eliminate the allometry of fish (Bagenal & Tesch, 1978) and is preferred to the Fulton's condition factor, which assumes isometric growth (Fulton, 1911). Student's t-test was used to evaluate test differences between the mean condition factor values of all individuals (Zar, 1999). All statistical analyses were conducted using Microsoft Excel 2013 and IBM SPSS Statistics version 22.0 for Windows package software (IBM Corp., Armonk, NY, USA).

Results

Descriptive statistics of the length-weight relationships and condition factor results are given in Table 1. Parameters were calculated according to locations.

All values of a ranged from 0.00834 to 0.0694. The b values ranged from 2.2979 to 3.2124. The estimated b values felt within the range reported in FishBase (2.627–3.696) for *S. flexuosum* (Froese & Pauly, 2012) except from Sinop-Kastamonu samples. Among all locations, the determination coefficients ranged from 0.85 to 0.96 (Table 1). p values were found to be significantly different ($p<0.05$) according to Pauly' test; therefore, growth is "positive allometric" for Istanbul and Çanakkale and "negative allometric" for Rize and Sinop-Kastamonu locations. Considering all individuals, growth is considered negative allometric ($b=2.7334$), ($p<0.05$), (Figure 1a-e).

Length values ranged from 11.04 to 18.84 cm, 14 to 18.6 cm, 11.4 to 16.2 cm and 12.31 to 19.50 cm; weight values ranged from 15 to 102, 27.15 to 73.78, 16.35 to 48.06 g and 24.42 to 68.48 g for the Istanbul, Rize, Çanakkale and Sinop-Kastamonu samples, respectively. Of all the regions examined, the minimum total length was found in Istanbul (11.04 cm), and the maximum total length (19.50 cm) was found in Sinop-Kastamonu and the minimum (15 g) and maximum weight (102 g) were collected from İstanbul (Bosporus Strait) in February.

The relative condition factor values ranged from 0.9990 (±0.06) (Canakkale) to 1.0800 (±0.01) (Sinop-Kastamonu).

Discussion

LWR parameters could be influenced by different factors, such as age, feeding condition, gonad maturity, sex, and size (Froese, 2006; Freitas et al., 2022). Moreover, spatial variation in fish growth is influenced by water quality, food resources, and physiological conditions of the sea, such as salinity and temperature (Moutopoulos & Stergiou, 2002; Gerritsen & McGrath, 2007).

Table 1. The mean total length and weight values, parameters of the length-weight equations and relative condition factors of *Spicara flexuosum* (SD. Standard deviation)

Region	Time	N	L, mean S.D.	W, mean S.D.	WL equation	a	b	95% C.I. of b (S.D)	R^2	Growth type	K_n. S.D.
Rize	December, 2013	27	16.16 (±1.12)	44.59 (±9.88)	$W=0.0125 L^{2.9336}$	0.0125	2.9336	2.735-3.433 (±0.19)	0.88	A (-)	1.0030 (±0.07)
Sinop-Kastamonu	January, 2014	34	16.76 (±5.08)	46.03 (±31.15)	$W=0.0694 L^{2.2979}$	0.0694	2.2979	1.729-3.435 (±0.07)	0.96	A (-)	1.0800 (±0.01)
İstanbul	February, 2014	23	16.54 (±1.86)	71.39 (±60.81)	$W=0.00834 L^{3.2124}$	0.00834	3.2124	2.958-3.880 (±0.32)	0.85	A (+)	1.0139 (±0.17)
Çanakkale	June, 2014	26	13.92 (±1.31)	32.95 (±9.30)	$W=0.009 L^{3.1061}$	0.009	3.1061	3.022-3.523 (±0.12)	0.95	A (+)	0.9990 (±0.06)
Total		110	15.27 (±5.98)	41.74 (±37.81)	$W=0.0236 L^{2.7334}$	0.0236	2.7334	2.469-3.297 (±0.25)	0.76	A (-)	0.8799 (±0.02)

Note: * A (+): Positive allometric growth, A (-): Negative allometric growth.
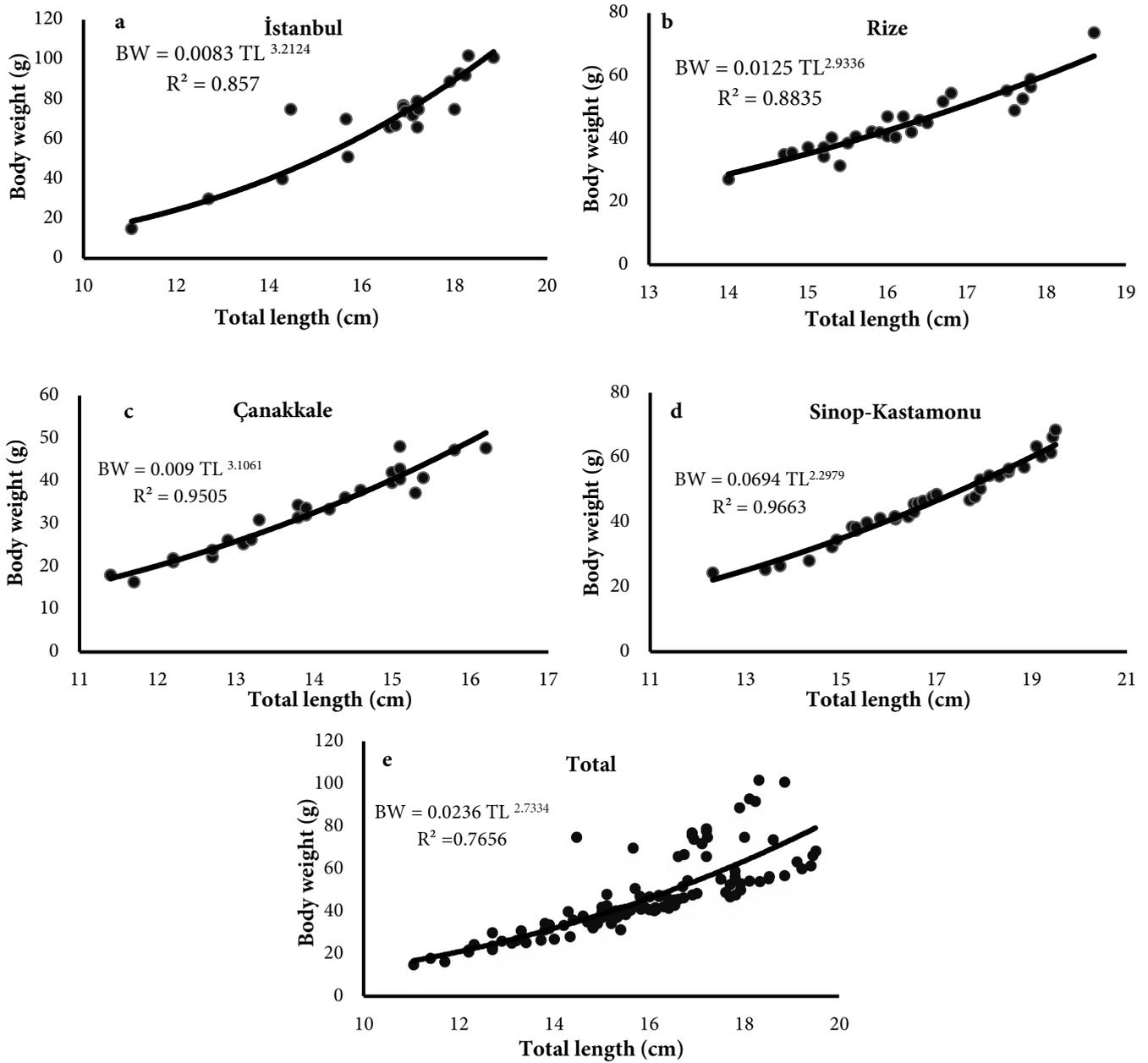
Figure 1. Length-weight relationship for *Spicara flexuosum* populations a) İstanbul, b) Rize, c) Çanakkale, d) Sinop-Kastamonu, e) Total samples

The LWR relationships of three *Spicara* species were previously examined by several researchers along the Mediterranean regions. İşmen (1995) reported the total length of all *S. smaris* specimens varied between 10.0 and 18.5 cm in the Black Sea. For *S. maena* species, minimum and maximum total lengths have been reported ranging from 7.5 (Soykan et al., 2010; Central Aegean Sea) to 22 cm (Karakulak et al., 2006; North Aegean Sea) along the Turkish coastal waters. Considering minimum and maximum length values for *S. flexuosum* along the Mediterranean coasts, total lengths ranging from 6.5 (Mytilineou & Papaconstantinou, 1991; Greece) to 20 cm (Giacalone et al., 2010; Italian coasts) (Table 2). On the other hand, minimum and maximum length and weight of *S. flexuosum* were found ranging from 8.7 (Dalgıç et al., 2021; Rize, Eastern Black Sea) to 22.5 cm (Samsun & Erdoğan-Sağlam, 2021; Ordu, Southeastern Black Sea) (Table 2) and 7.1 to 129.94 g (Dalgıç et al., 2021), respectively, along the Turkish coasts. The minimum-maximum total length (11.04 cm-19.50 cm) and weight (15-102 g) values of *S. flexuosum* in this study were nearly identical to those of other studies from the Turkish coast.

Parameters of the b values were within the range from 2.2979-3.2124 in this study. b values varied between 2.594 (Mater et al., 2001; Aegean Sea) to 3.389 (Petrakis & Stergiou, 1995; Greece coast) for *S. flexuosum* (Table 2). The b values have been found nearly identical for our results along the

Turkish coasts (Özvarol, 2014; Dalgıç et al., 2021; Samsun & Erdoğan-Sağlam, 2021) Greece (Mytilineou & Papaconstantinou, 1991), Portugal (Borges et al., 2003) and Italian coast (Giacalone et al., 2010) in recent years (Table 2). Moreover, the (LWR) results of this study Rize (b=2.9336) and Sinop-Kastamonu (b=2.2979) are in agreement with that of Dalgıç et al. (2021), who found negative allometric growth (b=2.9727) of *S. flexuosum* in the eastern Black Sea.

Determination coefficient values for each region were found to be greater than 0.85, which are in agreement with previous studies of *S. flexuosum* along the Turkish coasts, (Mater et al., 2001; Özvarol, 2014; Dalgıç et al. 2021; Samsun & Erdoğan-Sağlam 2021), Greece (Mytileniou & Papaconstantinou, 1991; Petrakis & Stergiou, 1995) Portugal (Borges et al., 2003) and Italy (Giacalone et al., 2010) (Table 2).

The b values, which vary according to species, age, and sex, reflect the shape of the fish. Furthermore, the reproductive period of the fish, such as gonad development and the availability of food in their surrounding area, can influence the b value (Jobling, 2002). The spawning period of *S. flexuosum* is generally observed in spring and summer seasons (March to June) along the Mediterranean and Turkish coastal waters (Çiçek et al., 2007, Soykan et al., 2010). The length at first maturity of *S. flexuosum* was reported by Mytilineou (1987) to be 9.1 mm. Considering b values, samples from Rize and Sinop-Kastamonu samples exhibited negative allometric growth. There are some factors such as season, density dependent factors (Giacalone et al., 2010) (food resources) and reproductive seasons of fish that can be directly affect growth performance. Rize and Sinop-Kastamonu samples were collected in December and January (winter) out of the spawning period, and available food might not be good enough for consumption in winter. Furthermore, overfishing pressure of the fish (Turkish coastal waters) might be negatively influenced growth characteristics (Oğuz et al., 2012). The b values can also be affected by environmental conditions, sampling season and locations and size composition of the samples (Froese, 2006). Sampling from fish with different geographical locations could also be directly affected b values as previously observed *Raja clavata* (Thornback ray) from Mediterranean (b=3.262) (Başusta et al., 2012) and Aegean Sea (b=2.82) (İlkyaz et al., 2008) as stated in the review by Gündogdu et al. (2016).

Table 2. The LWR parameters of *Spicara flexuosum* in the literature and this study.

Authors	Region	n	Length range (cm)	a	b	R²	Growth Type*	Condition factor
Mytilineou & Papaconstantinou (1991)	Greece	692	6.5-15.6	0.00037 F* 0.00006 M*	2.79 F* 3.17 M*	0.95 0.96	A (-) F* A (+) M*	1.39±0.02 F* 1.46±0.02 M*
Petrakis & Stergiou (1995)	Greece	441	11.9-17.7	0.00490	3.389	0.97	A (+)	-
Mater et al. (2001)	Türkiye (Aegean Sea)	412	9.20-15.50	0.0411	2.594	0.92	A (-)	1.255
Borges et al. (2003)	Portugal	45	10.2-19	0.00972	3.076	0.98	I	-
Giacalone et al. (2010)	Italy	6043	6.5-20	0.0141	2.89	0.94	A (-)	-
Özvarol (2014)	Türkiye (NE Mediterranean)	440	9-17.3	0.0260	2.655	0.81	A (-)	-
Dalgıç et al. (2021)	Türkiye (Black Sea)	599	8.7-21.8	0.0118	2.972	0.94	A (-)	-
Samsun & Erdoğan Sağlam (2021)	Türkiye (Black Sea)	318	11-22.5	0.0079	3.0915	0.94	A (+)	1.01
This study	Rize (Black Sea)	27	14-18.6	0.0125	2.9336	0.88	A (-)	1.0030 (±0.07)
This study	Sinop-Kastamonu (Black Sea)	34	12.31-19.50	0.0694	2.2979	0.96	A (-)	1.0800 (±0.01)
This study	İstanbul (TSS)	23	11.04-18.84	0.00834	3.2124	0.85	A (+)	1.0139 (±0.17)
This study	Çanakkale (TSS)	26	11.4- 16.2	0.009	3.1061	0.95	A (+)	0.9990 (±0.06)

Note: *I: Isometric growth, A (+): Positive allometric growth, A (-): Negative allometric growth, F: Female, M: Male. TSS: Turkish Straits System.

Considering the *a* values, it can be seen that all a values (Table 1) fall within the range of 0.00834 to 0.0694. Froese (2006) pointed out that a value is directly related to the growth rate of the fish. According to this statement, *a* increases as the *b* value decreases, and *b* increases as the *a* value decreases thus having an inverse relationship (Froese, 2006). This statement has also confirmed in our study,   for Istanbul (a=0.00834; b=3.2124, Istanbul); and (a=0.0694; b=2.2979) Sinop-Kastamonu locations.

The condition factor of the fish varies with sex, size, season and degree of gonad development (Heincke, 1908) and also influenced by different ecological conditions, age and feeding behaviors of the fish and are generally decreased after spawning seasons (Froese, 2006). As opposed to negative allometries, positive allometric growth and high condition factors of Istanbul (1.0139±0.17) and Çanakkale (0.9990± 0.06), as observed in this study, could be influenced by gonadal maturity and available food resources. However, considering all stations, (İstanbul, Çanakkale, Rize, Sinop-Kastamonu) mean calculated condition factor value is smaller than one (≤0.879). Condition factor values (1.275±0.122) have been previously evaluated for *S. maena* species in the Central Adriatic (Dulčić et al., 2000) and *S. flexuosum* in the Greece coasts (1.39±0.02) (Mytilineou & Papaconstantinou, 1991) and Türkiye (Central Aegean Sea) (Mater et al., 2001) (1.255), which were found to be greater than those in this study. On the other hand, condition factor value has been found as 1.01±0.005 which was found to be nearly identical value from our study in recent years in Black Sea (Samsun & Erdoğan-Sağlam, 2021). Little seasonal variation in the condition factor was observed among all regions in this study, as stated by Mytilineou & Papaconstantinou (1991) in Greece. Variation in condition factor might also be affected by increasing age (Mytilineou & Papaconstantinou, 1991), which was not considered in this study.

Conclusion

This study provided LWRs and the condition factor data for *Spicara flexuosum* species collected from Turkish coastal waters. *S. flexuosum* showed negative allometric growth in Rize and Sinop-Kastamonu locations in winter months. On the other hand, species exhibited positive allometric growth in İstanbul and Çanakkale in early spring and summer months. Condition factor values for each location were found to be equal to or greater than one, showing the wellbeing of fish. Overall condition factor value was found to be smaller than one in this study. On the other hand, samples from Istanbul were better in

February (early spring) than in other periods and regions based on both LWRs and condition factor results.

Currently, no regulation is implemented for *S. flexuosum* fisheries in Turkish coastal waters (e.g., minimum landing size); therefore, this study can help authorities and researchers establish future regulations of *S. flexuosum* in the Turkish coastal waters as well as other regions around the world.

Acknowledgements

Compliance With Ethical Standards

Authors' Contributions

AŞŞ: Designed, prepared and wrote the draft, performed and managed all statistical analyses.
AYS: Provided Sinop-Kastamonu data.
Both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

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

References

Bagenal, J. B., & Tesch, F. W. (1978). *Methods for Assessment of Fish Production in Freshwaters* (3rd ed.). Blackwell Science Publications, Oxford.

Başusta, A., Başusta, N., Sulikowski, J., Driggers, W., Demirhan, S., & Cicek, E. (2012). Length–weight relationships for nine species of batoids from the Iskenderun Bay, Turkey. *Journal of Applied Ichthyology*, *28*(5), 850-851. https://doi.org/10.1111/j.1439-0426.2012.02013.x

Borges, T. C., Olim, S., & Erzini, K. (2003). Weight–length relationships for fish species discarded in commercial fisheries of the Algarve (southern Portugal). *Journal of Applied Ichthyology, 19,* 394–396. https://doi.org/10.1111/j.1439-0426.2003.00480.x

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

Çiçek, E., Avşar, D., Yeldan, H., & Manaşırlı, M. (2007). Population characteristics and growth of *Spicara maena* (Linnaeus, 1758) inhabiting in Babadillimani Bight (northeastern Mediterranean-Turkey). *International Journal of Natural and Engineering Sciences, 1*, 15-18.

Dalgıç, G., Ergün, I. 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*, 142-153. https://doi.org/10.33714/masteb.814299

Demirel, N., & Murat-Dalkara, E. (2012). Weight–length Relationships of 28 Fish Species in the Sea of Marmara. *Turkish Journal of Zoology, 36*, 785-791. https://doi:10.3906/zoo-1111-29

Dulčić, J., Kraljević, M., Grbec, B., & Cetinić, P. (2000). Age, growth and mortality of blotched picarel *Spicara maena* L. (Pisces: Centracanthidae) in the eastern central Adriatic. *Fisheries Research, 48*, 69-78. https://doi.org/10.1016/S0165-7836(00)00112-0

Freitas, M., Ideia, P., Biscoito, M., Kaufmann, M., & Sousa, R. (2022). Length-weight relationships for eight Chondrichthyes from the north-eastern Atlantic Ocean. *The Egyptian Journal of Aquatic Research, In press*. https://doi.org/10.1016/j.ejar.2022.01.002

Froese, R. (2006). Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *Journal of Applied Ichthyology, 22(4),* 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x3

Froese, R., & Pauly, D. (Eds.) (2022). FishBase. World Wide Web electronic publication. Retrieved on February 17, 2022, from http://www.fishbase.org

Froese, R., Tsikliras, A. C., & Stergiou, K. I. (2011). Editorial note on weight-length relations of fishes. *Acta Ichthyologica et Piscatoria, 41,* 261-263. https://doi.org/10.3750/AIP2011.41.4.01

Froese R., & Pauly, D. (Eds.) (2012). FishBase. World Wide Web electronic publication. Retrieved on August 02, 2022, from http://www.fishbase.org

Fulton, T. W. (1911). *The sovereignty of the sea: an historical account of the claims of England to the dominion of the British seas and of the evolution of the territorial waters, with special reference to the rights of fishing and the naval salute*. William Blackwood and Sons, Edinburgh.

Gerritsen, H. D., & McGrath, D. (2007). Significant differences in the length–weight relationships of neighbouring stocks can result in biased biomass estimates: examples of haddock (*Melanogrammus aeglefinus*, L.) and whiting (*Merlangius merlangus*, L.). *Fisheries Research, 85*, 106−111. https://doi.org/10.1016/j.fishres.2007.01.004

Giacalone, V. M., Anna, G. D., Badalamenti, F., & Pipitone, C. (2010). Weight-length relationships and condition factor trends for thirty-eight fish species in trawled and untrawled areas off the coast of northern Sicily (central Mediterranean Sea). *Journal of Applied Ichthyology, 26*, 954-957. https://doi.org/10.1111/j.1439-0426.2010.01491.x

Gündoğdu, S., Baylan, M., & Çevik, C. (2016). Comparative study of the length-weight relationships of some fish species along the Turkish coasts. *Mediterranean Marine Science 17*(1), 80-108. http://dx.doi.org/10.1268/mms.1280

Heincke, F. (1908). *Bericht über die Untersuchungen der Biologischen Anstalt auf Helgoland zur Naturgeschichte der Nutzfische. (1. April 1905 bis 1. Oktober 1907).* [Report on the investigations of the Biological Institute on Helgoland on the natural history of commercial fish (April 1, 1905 to October 1, 1907). In: Die Beteiligung Deutschlands an der Internationalen Meeresforschung, 4. & 5. Jahresbericht. Verlag von Otto Salle, Berlin.

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.* [Morphological differentiation of (*Spicara smaris. S. flexuosa and S. maena*) from Aegean Sea for determination of species]. *Proceedings of the XIV. National Fisheries Symposium,* pp. 481.

İlkyaz, A., Metin, G., Soykan, O., & Kinacigil, H. (2008). Length– weight relationship of 62 fish species from the Central Aegean Sea, Turkey. *Journal of Applied Ichthyology, 24*(6), 699-702. https://doi.org/10.1111/j.1439-0426.2008.01167.x

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

İşmen, 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

İşmen, A., Özen, Ö., Altınağaç, U., Özekinci, U., & Ayaz, A. (2007). Weight-length relationships of 63 fish species in Saros Bay, Turkey. *Journal of Applied Ichthyology, 23*, 707-708. https://doi.org/10.1111/j.1439-0426.2007.00872.x

Jisr, N., Younes, G., Sukhn, C., & El-Dakdouki, M. H. (2018). Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. *The Egyptian Journal of Aquatic Research, 44*, 299–305. https://doi.org/10.1016/j.ejar.2018.11.004

Jobling, M. (2002). Environmental factors and rates of development and growth. In Hart, P. J. B., & Reynolds, J. D. (Eds.), *Handbook of fish biology and fisheries* (pp. 107-119). Blackwell.

Karakulak, F. S., Erk, H., & Bilgin, B. (2006). Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *Journal of Applied Ichthyology, 22,* 274-278. https://doi.org/10.1111/j.1439-0426.2006.00736.x

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis*). *Journal of Animal Ecology*, *20*, 201–219.

Martin-Smith, K. M. (1996). Length/weight relationships of fishes in a diverse tropical freshwater community, Sabah, Malaysia. *Journal of Fish Biology, 49*, 731–734. https://doi.org/10.1111/j.1095-8649.1996.tb00069.x

Mater, S., Malkav, S., & Şahinoğlu-Bayhan, B. (2001). *İzmir Körfezi (Ege Denizi)'nde dağılım gösteren izmarit balığı (Spicara flexuosa Rafinesque,1810)'nın bazı biyolojik özelliklerinin belirlenmesi* [A study on some biological peculiarities of the picarel *Spicara flexuosa* Rafinesque, 1810 distributed in the bay of Izmir Aegean Sea]. *Ege Journal of Fisheries & Aquatic Sciences, 18*(1-2), 25-32.

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. https://doi.org/10.12681/mms.423

Morey, G., Morantaa, J., Massut, E., Graud, A., Linde, M., Rierad, F., & Morales, N. (2003). Weight–length relationships of littoral to lower slope fishes from the western Mediterranean. *Fisheries Research, 6,* 89–96. https://doi.org/10.1016/S0165-7836(02)00250-3

Moutopoulos, D. K., & Stergiou, K. I. (2002). Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology, 18*, 200–203. https://doi.org/10.1046/j.1439-0426.2002.00281.x

Moutopoulos, D. K., Ramfos, A., Mouka A., & Katselis, G. (2013). Length-weight relations of 34 fish species caught by small-scale fishery in Korinthiakos Gulf (Central Greece). *Acta Ichthyologica Piscatoria*, *43*(1), 57-64. https://doi.org/10.3750/AIP2013.43.1.08

Mytilineou, 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].

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

Oğuz, T., Akoğlu, E., & Salihoğlu, B. (2012). Current state of overfishing and its regional differences in the Black Sea. *Ocean & Coastal Management*, *58,* 47-56. https://doi.org/10.1016/j.ocecoaman.2011.12.013

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. https://doi.org/10.3906/zoo-1308-44

Pauly, D. (1984). *Fish population dynamics in tropical waters: a manual for use with programmable calculators ICLARM Studies and Reviews 8*, 325 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Petrakis, G., & Stergiou, K. I. (1995). Weight-length relationships for 33 fish species in Greek waters. *Fisheries Research*, *21*, 465-469.

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*, 255-261.

Samsun, S., & Erdoğan-Sağlam, N. (2021). Length-Weight Relationships and Condition Factors of Six Fish Species in the southern Black Sea (Ordu-Turkey). *Journal of Agricultural Faculty of Gaziosmanpasa University, 38*(2), 111-116. https://doi:10.13002/jafag4659

Salekhova, L. P. (1979). *Centracanthidae fishes of the genus Spicara from the Mediterranean and Black Sea.* Haykova-Dumka, Kiev Academy of the Science.

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. https://doi:10.3906/zoo-0903-29

Şalcıoğlu, A., Gubili, C., Krey, G., Sakinan, S., & Bilgin, R. (2021). Molecular characterization and phylogeography of Mediterranean picarels (*Spicara flexuosa*, *S. maena* and *S. smaris*) along the coasts of Turkey and the Eastern Mediterranean. *Regional Studies in Marine Sciences, 45*, 101836. https://doi.org/10.1016/j.rsma.2021.101836

Şalcıoğlu, A. (2022). Molecular identification of Mediterranean three *Spicara* species to improve 16S rRNA partial region sequences. *Veterinary Sciences: Research and Reviews*, *8*(1), 8-14. https://doi.org/10.17582/journal.vsrr/2022.8.1.8.14

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

Vidalis, K., & Tsimenidis, N. (1996). Age determination and growth of picarel (*Spicara smaris*) from the Cretan continental shelf (Greece). *Fisheries Research, 28*, 395-421. https://doi.org/10.1016/S0165-7836(96)00488-2

Weatherley, A. H., & Gill, H. S. (1987). *The biology of fish growth.* Academic Press.

Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielsen, J., & Tortonese, E. (1986). *Fish of the North-Eastern Atlantic and the Mediterranean*, Vol. I–III. UNESCO, Paris.

Yedier, S., Kontaş, S., & Bostancı, D. (2019). *Marmara Denizi'nde yaşayan Pagellus acarne (Risso, 1827)'nin kondisyon faktörü, boy-boy ve boy-ağırlık ilişkileri* [Condition factor, length-length and length-weight relationships for *Pagellus acarne* inhabiting the Sea of Marmara]. *Journal of Anatolian Environmental and Animal Sciences*, *4*(2), 82-88. https://doi.org/10.35229/jaes.542005

Zar, J. H. (1999). *Biostatistical Analysis.* (4th ed.). Prentice-Hall.