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Length-Weight and Length-Length Relationships of the *Scorpaena* Species (Actinopteri: Scorpaenidae) in Izmir Bay (Aegean Sea of Turkey)

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ABSTRACT

In this study, 173 specimens of *Scorpaena porcus* (n=50), *Scorpaena elongata* (n=20), *Scorpaena scrofa* (n=101), *Scorpaena notata* (n=2) were obtained from commercial fishermen in the Aegean Sea between 2017 and 2019. The length-weight relationships were determined for *S. porcus*, *S. scrofa* and *S. elongata* as $W=0.0119TL^{3.182}$, $W=0.0176TL^{3.004}$ and $W=0.0656TL^{2.579}$, respectively. Negative allometry was found for *S. scrofa* and *S. elongate*, whereas positive allometry was present for *S. porcus.* However, with less than 5 individuals *S. notata* showed maximum, minimum, and mean total length and weight values. *S. notata* (2 individuals) had a mean total length and weight of 15.7-16.6 cm and 72.31-93.26 g. The results also demonstrated that the length-length relationships were strongly correlated for all *Scorpaena* species ($r^2>0.980$, $P<0.05$).

INTRODUCTION

Aquatic biologists and fisheries managers have frequently used length-weight relationships (LWRs) to evaluate fish stocks, the ecology of fisheries and the population dynamics in aquatic ecosystems, as well as in aquatic environments that are semi-controlled (Ricker, 1968). Length-weight relationships help appraise the general health, reproduction history, life cycle and condition of fish species (Pauly, 1993). They can be helpful in comparing local and interregional morphologies in both populations and species. In addition, length-weight models can be used to assess the ecological health and productivity levels of aquatic ecosystems (Deekae & Abowei, 2010). Models such as these serve to assess the health and growth patterns of fish (Muchlisin et al., 2010; Ndiaye et al., 2015). There are 231 species of Scorpaenidae worldwide (Fricke et al., 2022), while there are eight species found off the Turkish coasts (Karataş et al., 2021).

It is often possible in fisheries studies to measure fish length more easily and quickly than to measure mass. Having a knowledge of the length-weight relationship facilitates the determination of the mass if only the length is known. When working in the field, tail flukes are often cut; this can make it difficult to obtain accurate measurements of total length.

Knowing the length enables the researcher to work out total length.

The length-weight relationships of the different *Scorpaena* fish populations have been indicated in previous studies in the seas around Turkey (Koca, 2002; Karakulak et al., 2006; Özaydın & Taşkavak, 2006; Ismen et al., 2007; Demirhan & Can, 2007; Alpaslan et al., 2007; Ak et al., 2009; Keskin & Gaygusuz, 2010; Akalın et al., 2011; Bok et al., 2011; Kasapoğlu & Düzgünleş, 2013; Bilge et al., 2014; Deval et al., 2014; Altın et al., 2015) and other regions (Jardas & Pallaoro, 1992; Petrakis & Stergiou, 1995; Dulčić & Kraljevic, 1996; Stergiou & Moutopoulos, 2001; Moutopoulos & Stergiou, 2002; Mendes et al., 2004; Ferreira et al., 2008; Crećhriou et al., 2013; Moutopoulos et al., 2013; Dimitriadis & Konstantinidou, 2018; Meiners-Mandujano et al., 2018; Miled-Fathali et al., 2019).

Nevertheless, the length-weight parameters of the same species can differ in the population as a result of fishing, reproductive activities and feeding etc. It is thus necessary to be aware of the length-weight relationships of fish caught in a specific place during a specific period of time.

The aim of the current study was to determine the length-weight and length-length relationships of *Scorpaena* species caught in Izmir Bay in 2017 and 2019.

MATERIAL AND METHODS

In this study, 173 specimens of *S. porcus* (n=50), *S. elongata* (n=20), *S. scrofa* (n=101), *S. notata* (n=2) were obtained from commercial fishermen in the Aegean Sea between 2017 and 2019. Total length (TL) and standard length (SL) of each specimen was measured using a 0.1 cm class interval. The total weight (W) of each individual was measured to the nearest 0.01 g. The total length of all specimens was employed to work out the length-weight relationship (LWR). This was calculated by log transformed data log (Eq. 1):

$$W = \log a + b \log L \quad (1)$$

where, W is the total weight (g), L is the total length (cm), a is the intercept and b is the slope or allometric coefficient (Ricker, 1979). The statistical significance level of r^2 was predicted using linear regressions on the transformed equation. An allometric coefficient (b) larger or smaller than 3.0 shows an allometric growth (Bagenal & Tesch, 1978). Value b is > 3, which can be said to show a positive allometric growth. However, b<3 demonstrated a negative allometric growth or isometric growth when it was equal to 3.0. Moreover, the SL vs TL relationships were calculated using linear regressions. Length-length relationship (LLR) was measured as Eq. (2) to standardize the length values used in other studies.

$$TL = a + bSL \quad (2)$$

Covariance analysis was conducted to test for probable significant differences in both slope and intercept. Statistical analyses were evaluated at a significance level of P<0.05

RESULTS

The study examined 173 scorpaenid species of fish with 101 *Scorpaena scrofa*, 50 *Scorpaena porcus*, 20 *Scorpaena elongata* and 2 *Scorpaena notata*.

Table 1. Descriptive statistics and estimated parameters of length-weight relationships for four *Scorpaena* species in Izmir Bay (Aegean Sea) from 2017 to 2019 (N: number of individuals, *a*: intercept, *b*: slope, r^2: coefficient of determination)

Species	N	TL range (cm)	W range (g)	*a*	*B*	95% C.I. of *b*	r^2	Growth type
S. scrofa	101	17.3-33.1	95.37-708.91	0.0176	3.004	2.892-3.116	0.963	-allometry
S. porcus	50	12.6-28.4	33.76-516.03	0.0119	3.182	3.042-3.322	0.972	+allometry
S. elongata	20	19.7-28.3	134.57-358.68	0.0656	2.579	2.347-2.811	0.958	-allometry
S. notata	2	15.7-16.6	72.31-93.26	-	-	-	-	-

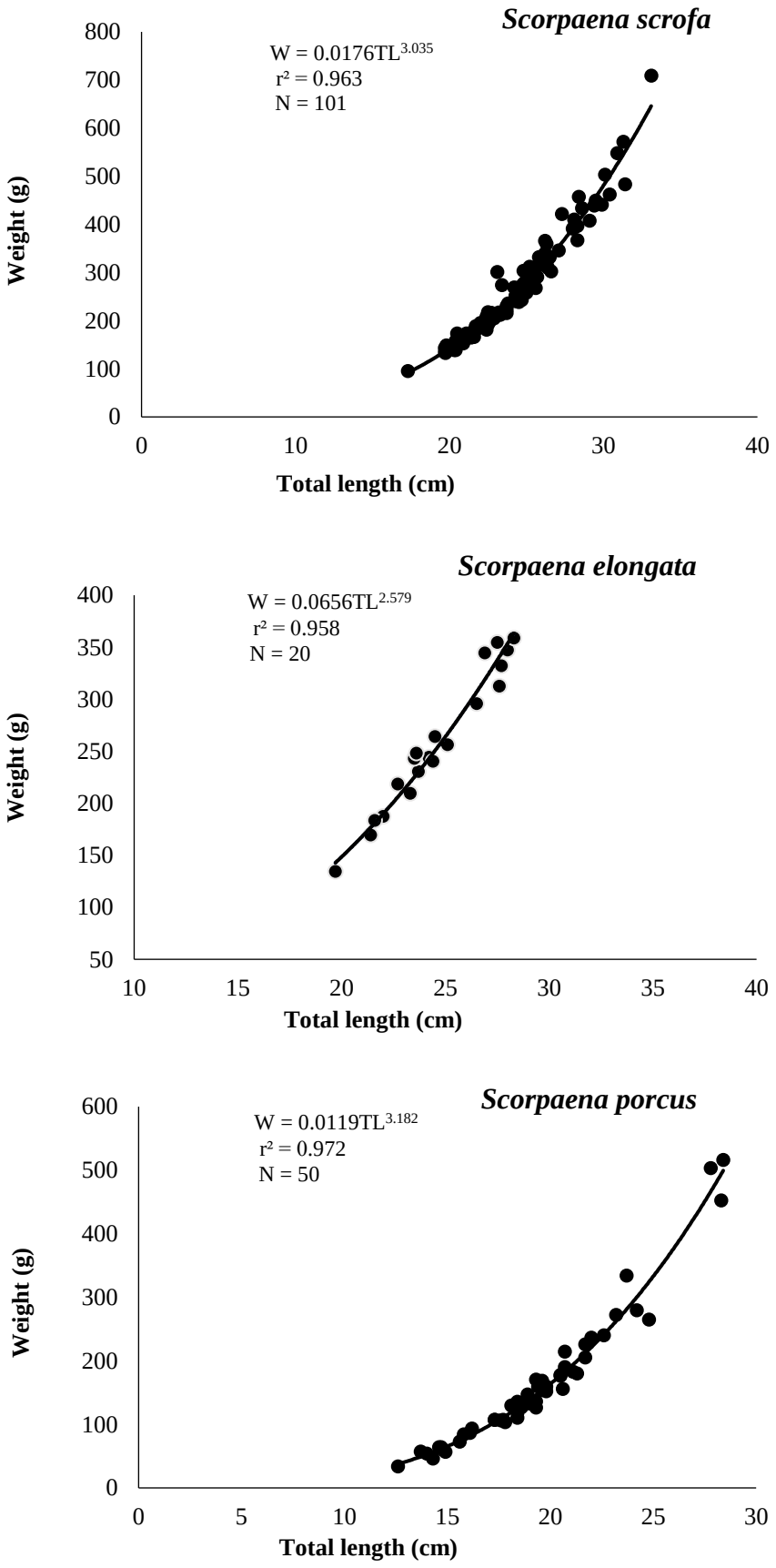

Figure 1. Length-weight relationships for three Scorpaena species from Izmir Bay (Central Aegean Sea, Turkey).

Table 2: Length-length relationships between total length (TL), and standard length (SL) of *Scorpaena* species in Izmir Bay (Aegean Sea) from 2017 to 2019 (N: number of individuals, *a*: intercept, *b*: slope, r^2: coefficient of determination)

Species	Equation	N	*a*	*b*	r^2
S. scrofa	TL=a+bSL	101	0.3354	0.7744	0.986
S. porcus	TL=a+bSL	50	0.6342	0.8171	0.989
S. elongata	TL=a+bSL	20	0.3588	0.7827	0.990

Table 3. LWRs of three Scorpaena species from different areas (N: number of individuals, a: intercept, b: slope, r^2: coefficient of determination)

Species	References	Country, Locality	N	Length range (TL, cm)	*a*	*b*	r^2
S. porcus	Jardas & Pallaoro (1992)	Croatia, Adriatic	-	5.8-30.0	0.0171	3.034	0.995
	Petrakis & Stergiou (1995)	Greece, Euboikos Gulf	100	7.0-23.5	0.0291	2.840	0.970
	Stergiou & Moutopoulos (2001)	Greece, Aegean Sea	231	11.5-40.5	0.0236	2.887	0.950
	Stergiou & Moutopoulos (2001)	Greece, Evvoikos	100	7.0-23.5	0.0290	2.840	0.970
	Stergiou & Moutopoulos (2001)	Greece, Cyclades	231	11.5-40.5	0.0236	2.887	0.951
	Koca (2002)	Turkey, Sinop Peninsula	633	12.0-25.0	0.0540	2.590	0.931
	Morey et al. (2003)	Spain, Coast of Iber	-	6.1-35.5	0.0183	3.020	0.969
	Karakulak et al. (2006)	Turkey, Gökçeada Island	255	8.0-27.3	0.0250	2.915	0.931
	Özaydin & Taskavak (2006)	Turkey, İzmir Bay	50	14.1-25.6	0.0210	3.004	0.960
	Ismen et al. (2007)	Turkey, Saroz Bay	-	10.0-22.0	0.0256	2.878	0.993
	Demirhan & Can (2007)	Turkey, Black Sea	470	4.6-17.5	0.0124	3.190	0.940
	Alpaslan et al. (2007)	Turkey, Dardanelles	-	10.5-32.0	0.0230	2.960	0.700
	Ak et al. (2009)	Turkey, Coast of Trabzon	351	5.0-34.2	0.0090	3.272	0.880
	La Mesa et al. (2010)	İtaly, Adriatic artificial reef	210	8.0-27.0	0.0202	3.030	0.950
	La Mesa et al. (2010)	İtaly, Adriatic nature reef	134	11.0-22.1	0.0257	2.940	0.950
	La Mesa et al. (2010)	İtaly, Adriatic offshore	71	13.5-28.0	0.0136	3.120	0.970
	Keskin & Gaygusuz (2010)	Turkey, Erdek Bay	45	4.9-19.0	0.0158	3.088	0.983
	Akalın et al. (2011)	Turkey, İzmir Bay	221	7.0-27.0	0.0209	2.987	0.993
	Bok et al. (2011)	Turkey, Sea of Marmara	15	17.3-21.4	0.0067	3.343	0.944
	Crec'hriou et al. (2013)	France, Coast of Catalan	111	9.5-32.0	0.0260	2.920	0.968
	Moutopoulos et al. (2013)	Greece, Korinthiakos Bay	103	10.5-31.8	0.0192	2.965	0.969
	Kasapoglu & Duzgunes (2013)	Turkey, Black Sea	136	8.5-29.2	0.0173	3.034	0.980
	Bilge et al. (2014)	Turkey, South Aegean Sea	63	7.7-26.8	0.0170	3.045	0.986
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	70	8.6-23.6	0.0295	2.830	0.980
	This study	Turkey, İzmir Bay	50	12.6-28.4	0.0119	3.182	0.972
S. scrofa	Dulčić & Kraljevic (1996)	Croatia, Eastern Adriatic	125	19.7-53.6	0.0156	3.298	0.960
	Stergiou & Moutopoulos (2001)	Greece, Cyclades	37	10.7-32.2	0.0169	2.999	0.980
	Moutopoulos & Stergiou (2002)	Greece, Aegean Sea	37	10.7-32.2	0.0169	2.999	0.980
	Mendes et al. (2004)	Portugal, from Nazaré to St André	22	14.3-42.8	0.0121	3.124	0.933
	Karakulak et al. (2006)	Turkey, Gökçeada Island	15	12.3-39.1	0.0180	3.005	0.985
	Özaydin & Taskavak (2006)	Turkey, İzmir Bay	129	8.2-30.1	0.0291	2.796	0.990
	Ferreira et al. (2008)	Madeira islands, Atlantic	12	20.0-46.0	0.0153	3.039	0.974
	Crec'hriou et al. (2013)	France, Coast of Catalan	32	14.0-49.0	0.0260	2.890	0.993
	Moutopoulos et al. (2013)	Greece, Korinthiakos Bay	53	11.7-36.8	0.0169	3.002	0.981
	Bilge et al. (2014)	Turkey, Southern Aegean Sea	74	9.6-42.9	0.0217	2.964	0.996
	Altın et al. (2015)	Turkey, Gökçeada Island	16	6.3-13.2	0.0120	3.135	0.983
	Dimitriadis & Konstantinidou (2018)	Greece, Zakintos Island	335	10.5-39.7	0.0260	2.867	0.980
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	61	11.3-38.3	0.0205	2.947	0.950
	This study	Turkey, İzmir Bay	50	17.3-33.1	0.0176	3.004	0.963
S. elongata	Deval et al. (2014)	Turkey, Antalya Bay	114	5.6-42.1	0.0230	2.880	0.996
	Meiners-Mandujano et al. (2018)	Morocco	45	18.6-41.2	0.0148	3.017	0.971
	Miled-Fathali et al. (2019)	Tunisian, Tunisian Bay	22	14.2-50.0	0.0127	3.077	0.990
	This study	Turkey, İzmir Bay	20	19.7-28.3	0.0656	2.579	0.958

All the specimens of *Scorpaena scrofa* examined showed length group values of 28-94 cm with 17.3-33.1 cm length. The mean total length and weight values of the species were 22.32±0.32 cm and 269.93±11.21 g, respectively. The total length-weight relationship was found to be $W=0.0176TL^{3.004}$ (r^2=0.963) with a negative allometric growth. 50 individuals of *S. porcus* species exhibited minimum maximum length range of 12.6-28.4 cm Its mean total length and weight values were 19.29±0.52 cm and 164.88±15.10 g, respectively. The total length and weight relationship was $W=0.0119TL^{3.182}$ (r^2=0.972) with a positive growth. 20 individuals of *S. elongata* had a minimum maximum length range of 19.7-28.3 cm. Its mean total length and weight values were 24.61±0.56 cm and 258.73±14.87 g, respectively. Total length weight relationship was $W=0.0656TL^{2.579}$ (r^2=0.958) with a positive allometric growth. Nevertheless, with fewer than five individuals *S. notata* showed minimum, maximum and mean total length and weight values. *S. notata* (two individuals) had mean total length and weight of 15.7-16.6 cm and 72.31-93.26 g, respectively (Table 1, Figure 1). Of the LLRs shown in Table 2, all were highly significant ($P<0.05$), and all coefficient of determination values were larger than 0.980.

DISCUSSION

The current study examined 173 individuals from three *Scorpaena* species. Previous studies on the length-weight relationship for the three species examined in the current study are presented in Table 3.

The *b* values in LWRs lie between 2.5 and 3.5 (Froese, 2006) or from 2 to 4 (Tesch, 1971). In the current study, the *b* values of the fish species studied fell within these ranges, as expected. The *b* value for *S. porcus* ranged from 2.590 to 3.190 in other areas, while the value ranged from 2.796 to 3.135 for *S. scrofa*. The *b* value for *S.elongata* was determined to be 2.579. Although this value is different from those in the studies of Meiners-Mandujano et al. (2018) and Miled-Fathali et al. (2019), it is similar to Deval et al. (2014) (Table 3).

Length-weight relationships may vary in different seasons, and they are influenced by factors such as temperature, size, maturity, food availability and salinity. Differences in *b* values can be put down to one or a mixture of these factors, including the number of specimens studied, the effects of the region and/or season, and differences in the ranges of lengths of the specimens; the length of time in which the sample was collected can also be added to these (Moutopoulos & Stergiou, 2002). Furthermore, the extent of sexual maturity, fullness or emptiness of the gut, diet, sampling techniques, and the number of specimens and period of sampling can also have an effect on its value (Wootton, 2003; Eagderi et al., 2020).

CONCLUSION

To conclude, this study has given new information regarding LWRs and LLRs for three *Scorpaena* species from Izmir Bay (the Central Aegean Sea of Turkey). It has provided additional data concerning these previously reported species, and will thus be of use in future biological studies.

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Compliance with Ethical Standards

Authors' Contributions

Conceptualization: BB, BT. Data collection and analysis: BT. Conducting the laboratory experiments: BT, OH. Writing: BB, BT.

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.

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