J. Black Sea/Mediterranean Environment
Vol. 24, No. 2: 115-127 (2018)

RESEARCH ARTICLE

Length–weight relationships of 13 fish species from the western Black Sea (Zonguldak-Amasra), Turkey

Dilek Türker[1], Habib Bal[2*]

[1]Faculty of Science and Arts, Department of Biology, University of Balıkesir, Balıkesir, TURKEY
[2]Department of Fisheries, Livestock Research Institute, Bandırma, Balıkesir, TURKEY

[*]**Corresponding author:** habipbal@hotmail.com

Abstract

In this study, length-weight relationship (LWR) parameters are reported for 13 fish species collected from the western Black Sea and a total of 3132 fish individuals were sampled. The *b* values varied from 2.84 for *Scorpaena maderensis* to 3.49 for *Trachurus mediterraneus*, with a mean of 3.13 (±0.074). The LWRs and regressions for all species were highly significant ($P<0.05$), whereas they were isometric for six species (*Merlangius merlangus*, *Sprattus sprattus*, *Trachinus draco, Pomatomus saltatrix, Trachurus trachurus* and *Chelidonichthys lucernus*). Two species (*Scorpaena porcus*, *Scorpaena maderensis*) showed negative allometry and five species (*Mullus barbatus, Merluccius merluccius, Engraulis encrasicolus, Trachurus mediterraneus, Uranoscopus scaber*) indicated positive allometry. In this study, LWR for *S. maderensis* in the Black Sea was investigated for the first time.

Keywords: Length-weight relationship, fish, growth, bottom trawl

Received: 05.02.2018, **Accepted:** 04.05.2018

Introduction

The length-weight relationship (LWR) has great importance in fish biology, physiology, ecology and fishery assessment (Gonçalves *et al*. 1997). The conversion of growth in length equations to growth in weight is also useful for between-region comparisons of life histories of species (Binohlan and Pauly 1998; Radkhah and Eagderi 2015). Several studies were conducted on the LWRs of fish species along the coasts of Turkey, such as in the Marmara Sea (Keskin and Gaygusuz 2010; Bök *et al*. 2011), the Black Sea (İşmen 2002; Kalaycı *et al*. 2007; Genç *et al*. 1999; Ak *et al*. 2009; Yankova *et al*. 2011; Kasapoğlu and Düzgüneş 2013; Yıldız *et al*. 2018), the Aegean Sea (Moutopoulos and Stergiou 2002; Koutrakis and Tsikliras 2003; Karakulak *et*

al. 2006; Özaydın and Taskavak 2006), the Mediterranean Sea (Taskavak and Bilecenoğlu 2001; Sangun *et al*. 2007).

In the present study, the LWR_S of 13 fish species from the western Black Sea were determined. The result of the study can be a baseline data for fisheries biologists and also contributes scientifically to the sustainability of regional fisheries.

Materials and Methods

The study was conducted in April and December 2013 in the coasts of Zonguldak and Amasra, the western Black Sea (Figure 1). The one 12 m long fishing boat was used for the study. Fishing gear used was bottom trawl nets of 16 mm cod-end mesh size. Average haul duration was 30 minutes and towing speed varied from 2.5 to 3.0 knots at 25–75 m depths. The catch was sorted into species and the number of each species was recorded. Samples were preserved in iceboxes for further examination in the laboratory. Specimens were measured to the nearest 0.1 cm for total length (TL) and weighed to the nearest 0.01 g for total weight (TW). Parameters of the LWR_S were calculated by method using the equation $W= aL^b$, were W is the total weight (g), L is the total length (cm), *a* coefficient related to the body form and *b* is an exponent indication growth. The parameters *a* and *b* were calculated by the least squares method using the logarithmic form of the equation. Descriptive statistics were derived using Excel (Microsoft Excel® 2010). The hypotheses of growth type were tested by *t*-test.

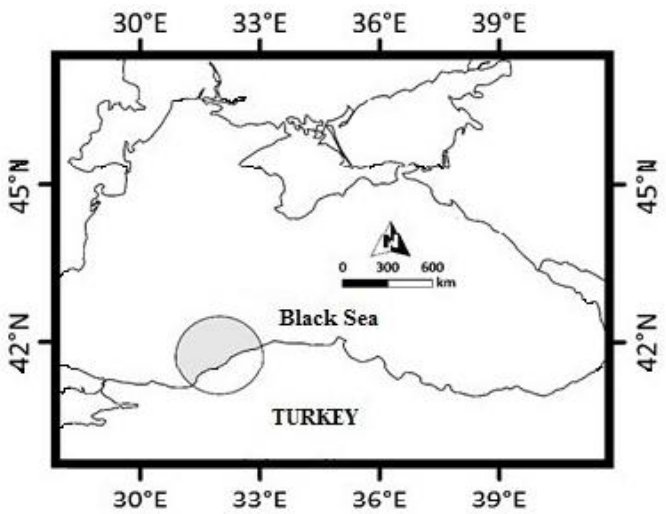

Figure 1. Study area

Results

In this study, a total of 3132 individuals of 13 fish species belonging to 11 families were sampled. There has been no available information on LWR for *Scorpaena maderensis* and *Merluccius merluccius* from the Black Sea. Thus, present study provided LWR record for these two sepcies in the Black Sea for the first time.

The samples size, minimum, maximum lengths and weights, LWR_S of fish species and growth type (isometric or allometric) are given in Table 1. The percentage distributions of the families belonging to the samples are as follows, Mullidae 21.16%, Carangidae 19.69%, Clupeidae 20.91%, Gadidae 10.15%, Engraulidae 9.96%, Uranoscopidae 6.03%, Merlucciidae 3.86% and 7.53% for the other four families (Trachinidae, Scorpaenidae, Pomatomidae, and Triglidae).

According to Tesch (1971), all *b* values range from 2 to 4. For this study, box-whiskers plot of the exponent *b* is shown in Figure 2. The *b* values varied from 2.84 for *Scorpaena maderensis* to 3.49 for *Trachurus mediterraneus*, with a mean of 3.13±0.074. Growth types were determined as positive allometric for five species (*Merluccius merluccius*, *Uranoscopus scaber*, *Mullus barbatus*, *Engraulis encrasicolus, Trachurus mediterraneus*) ($b>3$, $P<0.05$), for six species (*Merlangius merlangus, Trachinus draco, Pomatomus saltatrix, Sprattus sprattus Trachurus trachurus, Chelidonichthys lucernus*) isometric ($b=3$, $P>0.05$) and for two species (*Scorpaena porcus, Scorpaena maderensis*,) negative allometric ($b<3$, $P<0.05$) respectively.

This research is new contribution on LWR for the 13 fish species from the western Black Sea. The results of this research could be used as a reference for fisheries and stock management in the area. It also allows the comparison with the results of the research made in other regions.

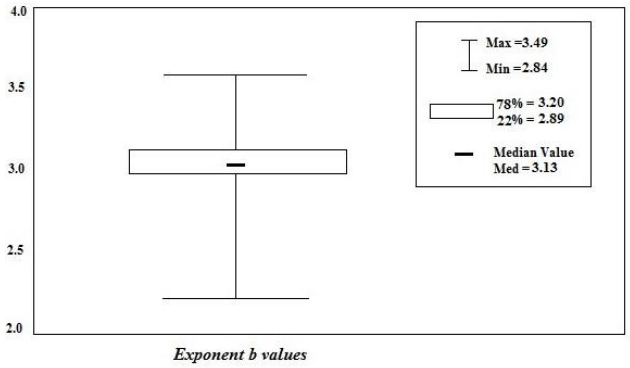

Figure 2. Box-Whisker plot of *b* of the length weight relationships for the 13 species from the western Black Sea, Turkey

Table1. Length–weight relationship parameters for 13 fish species from the western Black Sea

Family/Species	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	± 95% CI of b	r^2	Growth type
Mullidae/ *Mullus barbatus*	663	9.0-18.4	7.97-71.29	0.004	3.36	3.28-3.39	0.92	A^+
Gadidae/ *Merlangius merlangus*	318	7.8-22.7	2.67-76.28	0.006	3.01	2.93-3.06	0.96	I
Clupeidae/ *Sprattus sprattus*	655	5.1-11.8	0.95-9.96	0.007	3.11	3.05-3.16	0.98	I
Merlucciidae/ *Merluccius merluccius*	121	12.5-37.8	13.53-494.95	0.005	3.16	3.02-3.21	0.98	A^+
Uranoscopidae/ *Uranoscopus scaber*	189	6.6-25.5	4.28-312.65	0.009	3.21	3.10-3.35	0.98	A^+
Trachinidae/ *Trachinus draco*	88	8.1-31.6	3.69-289.39	0.007	3.01	2.89-3.06	0.97	I
Scorpaenidae/ *Scorpaena porcus*	32	5.4-25.5	3.4-305.56	0.026	2.87	2.78-2.95	0.98	A^-
Scorpaenidae/ *Scorpaena maderensis*	78	6.0-10.0	4.32-20.44	0.032	2.84	2.77-2.90	0.96	A^-
Engraulidae/ *Engraulis encrasicolus*	312	7.4-14.1	1.84-22.11	0.002	3.38	3.32-3.43	0.97	A^+
Pomatomidae/ *Pomatomus saltatrix*	38	15.9-22.2	33.11-101.03	0.005	3.15	3.03-3.26	0.97	I
Carangidae/ *Trachurus mediterraneus*	128	6.5-11.6	1.21-32.0	0.002	3.49	3.35-3.62	0.97	A^+
Carangidae/ *Trachurus trachurus*	489	8.0-16.6	3.03-38.3	0.0056	3.12	3.07-3.18	0.98	I
Triglidae/ *Chelidonichthys lucernus*	21	14.3-26.8	27.96-.169.4	0.01	2.98	2.93-3.02	0.96	I

Discussion

The parameter *b* may vary seasonally between habitats and even daily for the same species from different areas. Thus, the LWR in fish is affected by a number of factors including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat (Bagenal and Tesch 1978; Gonçalves *et al*. 1997; Taskavak and Bilecenoglu 2001). Also, the regional differences of obtained *b* values may present spatial variations resulting from the influence of water quality or food availability on fish growth (Sparre *et al*. 1989; Mommsen 1998). When *b* is equal to 3 or close to 3, growth in the fish is said to be isometric, fish becomes more robust with increasing length (Bagenal and Tesch 1978). Similarly when *b* is far less or greater than 3, growth in the fish is allometric the fish becomes thinner with increase in length (King 1996).

The coefficient of determination (r^2) range from 0.92-0.98 The LWR_S for all species were highly significant ($P<0.05$) statistically. Parameter *b* values and growth type for *M. barbatus, P. saltatrix, S. porcus* were similar obtained from the Black Sea ($P>0.05$) (Kasapoğlu and Düzgüneş 2013). However, *b* values 2.527 for *P. saltatrix* in the Marmara Sea (Bök *et al*. 2011) growth type was found negative allometric. The coefficient of determination value for *M. merluccius* was found very highly ($r^2=0.98$) in the Aegean Sea (Özaydın and Taskavak 2006). In our study it was also high ($r^2=0.95$). Growth type for *T. trachurus* was found isometric ($P>0.05$, $b=3$) by Demirel and Dalkara (2012) in the Marmara Sea. However, its growth type was reported negative allometric in the Aegean Sea (Karakulak *et al*. 2006). The exponent *b* for *Engraulis encrasicolus* in this study was higher than those in the middle and eastern Black Sea (Kasapoğlu and Düzgüneş 2013; Kalaycı *et al*. 2007), Mediterranean Sea (Sangun *et al*. 2007). But there are also studies showing similar *b* value (Çiçek *et al*. 2006).

In this study, maximum length of some species (*M. barbatus, M. merlangus, U. scaber, T. draco, P. saltatrix*) was smaller than in other studies along the Black Sea (Genç *et al*. 1999; Özpiçak *et al*. 2017; Ak *et al*. 2009; İşmen 2002). This can be explained by the choice of fishing gear, nets and intense fishing in the coast of western Black Sea. The LWR_S results of previous studies are given in Table 2.

Table 2. The LWR results of previous studies

Species	n	LT	Length (cm) Min-Max	a	B	GT	Location	References
Mullus barbatus	-	TL	17.3-24.7		3.12		Adriatic Sea	Dulčić and Kraljević 1996
	-	TL	4-23.5	0.0063	3.18		East Black Sea	Genç *et al*. 1999
	-	TL	16.9-25.0	0.0142	2.93		Portugal	Mendes *et al*. 2004
	76	TL	12.5-22.3	0.0049	3.27	A^+	North Aegean Sea	Karakulak *et al*. 2006
	2693	TL	5.3-19.0	0.0074	3.12		Aegean Sea	Çiçek *et al*. 2006
	99	TL	10-15.7	0.0049	3.32	A^+	Marmara Sea	Bök *et al*. 2011
	2021	TL	3.8-21.5	0.0076	3.13		Black Sea	Kasapoğlu and Düzgüneş 2013
	1565	TL	8.7-21.5	0.0071	3.16	A^+	Antalya Bay	Özvarol 2014
	479	FL	7.5-20.0	0.0102	3.17		İzmir Bay	Özaydın and Taskavak, 2006
	102	TL	8.7-20.1	0.0062	3.22	A^+	Gallipoli Peninsula	Cengiz 2013
Merlangius merlangus	-	TL	9-24.0	0.0039	3.24		Middle Black Sea	Samsun and Erkoyuncu 1998
	-		5.6-43.2	0.0052	3.14		Eastern Black Sea	Genç *et al*. 1999
	-		5.5-32.5	0.0042	3.24		Black Sea	İşmen 2002
	904	TL	7.7-22.7	0.0067	3.02		Middle Black Sea	Kalaycı *et al*. 2007
	943	TL	6.7-29.5	0.004	3.16		Eastern Black Sea	Ak *et al*. 2009
Sprattus sprattus	-		3.3-13	0.0026	3.33		Black Sea	Avşar 1995
	-		7.2-13.2	0.0021	3.46		Eastern Black Sea	Şahin 1999
	-		8.6-11.9	0.0226	2.51		Adriatic	Sinovčić *et al*. 2004
	5087	TL	5.6-12.6	0.0079	2.86		Middle Black Sea	Kalaycı *et al*. 2007
	423	TL	5.6-10.7	0.0064	2.92		Black Sea	Kasapoğlu and Düzgüneş 2013
	52		3.8-5.5	0.023	3.52	A^+	Marmara Sea	Keskin and Gaygusuz 2010
Merluccius merluccius	501	TL	12.3-47.0	0.0050	3.15		Aegean Sea	Özaydın and Taskavak 2006
	222	TL	26.8-83.1	0.0127	2.86	A^-	Gallipoli peninsula	Öztekin *et al*. 2016
	55	TL	12.7-28.3	0.0005	2.91	I	Argolikos Gulf	Kapiris and Klaoudatos 2011
	319	TL	8.9-44.8	0.0026	3.36	A^+	Marmara Sea	Bök *et al*. 2011
	31	TL	16-28.7	0.0096	2.89	A^-	Antalya Bay	Özvarol 2014
	29	TL	13.2-31	0.033	2.35	A^-	North Mediterranean Sea	Sangun *et al*. 2007
	21	TL	21.5-40.5	0.0061	3.03	I	Aegean Sea	Ceyhan *et al*. 2009
	715	TL	9.3-52.0	0.010	2.88	A^-	Marmara Sea	Demirel and Dalkara 2012

Table 2. Continued

	92	TL	5.2-24.7	0.0103	3.15		North Mediterranean Sea	Sangun *et al*. 2007
	620	TL	1.8-56.4	0.008	3.22	A^+	Eastern Black Sea	Ak *et al*. 2009
	2	TL	19.6-28.7				Gallipoli peninsula	Öztekin *et al*. 2016
Uranoscopus scaber	155	TL	5.2-23.4	0.0252	2.85		Black Sea	Kasapoğlu and Düzgüneş 2013
	69	TL		0.0150	3.05		Southern Black Sea	Demirhan and Can 2007
	82	TL	10.7-24.6	0.0109	3.15	A^+	Marmara Sea	Bök *et al*. 2011
	49	TL	8.0-25.1	0.015	3.06	I	Marmara Sea	Demirel and Dalkara 2012
	33	TL	14-22.2	0.000009	3.56	A^+	Argolikos Gulf	Kapiris and Klaoudatos 2011
	62	TL	13.0-36.4	0.0080	2.97	I	Gallipoli peninsula	Öztekin *et al*. 2016
	106	TL	2.4-29.3	0.009	2.84	A^-	Gökçeada Island	Altın *et al*. 2015
Trachinus draco	54	TL	9-20	0.0052	3.09	I	North Mediterranean Sea	Sangun *et al*. 2007
	338	TL	5-35.0	0.004	3.43	A^+	Eastern Black Sea	Ak *et al*. 2009
	14	TL	9.6-24.2	0.0074	2.93	I	Western Mediterranean	Merella *et al*. 1997
	103	TL	7.8-28.2	0.0264	2.88	A^-	Gallipoli peninsula	Öztekin *et al*. 2016
	78	TL	3.0-23.2	0.014	3.08	I	Gökçeada Island	Altın *et al*. 2015
Scorpaena porcus	50	TL	14.1-25.6	0.0201	3.00	I	Aegean Sea	Özaydın and Taskavak 2006
	351	TL	5.0-34.2	0.009	3.27	A^+	Eastern Black Sea	Ak *et al*. 2009
	42	TL		0.0210	2.98		Black Sea	Kasapoğlu and Düzgüneş 2013
Scorpaena maderensis	47	TL	3.1-17.8	0.017	2.98	I	Gökçeada Island	Altın *et al*. 2015
	525	TL	5.4-17.8	0.0140	3.06	I	North-eastern Atlantic	Morato et al. 2001
	46	TL	10.5-13.5	0.000005	3.02	I	Aegean Sea	Kapiris and Klaoudatos 2011
	18	TL	2.1-3.6	0.002	3.22	A^+	Gökçeada Island	Altın *et al*. 2015
Engraulis encrasicolus	392	TL	7-17	0.0156	2.66	A^-	North Mediterranean Sea	Sangun *et al*. 2007
	575	TL	8.0-14.7	0.0174	2.60	A^-	Middle Black Sea	Kalaycı *et al*. 2007
	1588	TL	5.9-14.6	0.0124	2.71		Black Sea	Kasapoğlu and Düzgüneş 2013
	630	TL		0.0037	3.18		Aegean Sea	Çiçek *et al*. 2006

Table 2. Continued

Pomatomus saltatrix	17	TL	14.5-18.5	0.387	2.77	I	Marmara Sea	Demirel and Dalkara, 2012
	290	TL	10.6-24.0	0.0325	2.52	A^-	Marmara Sea	Bök *et al*. 2011
	14	TL	11.6-22.2	0.003	3.33	A^+	Eastern Black Sea	Ak *et al*. 2009
	25	TL	12.5-20.2	0.0092	3.01	I	Black Sea	Kasapoğlu and Düzgüneş 2013
	143	TL	13.2-21.7	0.0130	2.86	A^-	Middle Black Sea	Kalaycı *et al*. 2007
	1230	TL	12.3-43.7	0.011	2.96	I	South Marmara Sea	Bal *et al*. 2015
	125	TL	13.5-23.6	0.008	3.12	A^+	Middle Black Sea	Özpiçak *et al*. 2017
	67		48.0-75.5	0.059	2.50	A^-	Middle coast of Brazil	Frota *et al*. 2004
Trachurus mediterraneus	624	TL	6.2-19.5	0.0050	3.13		Black Sea	Kasapoğlu and Düzgüneş 2013
	549	FL	9.3-22.6	0.0051	3.27		Aegean Sea	Özaydın and Taskavak 2006
	31	TL	14.2-26.6	0.0047	3.17	A^+	North Aegean Sea	Karakulak *et al*. 2006
	496	TL	7.5-18.5	0.018	2.72	A^-	Marmara Sea	Demirel and Dalkara 2012
	489	TL	11.6-27.1	0.0060	3.13	A^+	Gallipoli Peninsula	Cengiz 2013
Trachurus trachurus	264	TL	10.5-24.3	0.0113	2.89	A^-	North Aegean Sea	Karakulak *et al*. 2006
	156	TL	11.2-21.0	0.027	2.95	I	Marmara Sea	Demirel and Dalkara 2012
	307	TL	8.0-16.4	0.0056	3.12	A^+	Marmara Sea	Bök *et al*. 2011
	151	TL	10.2-19.0	0.0086	3.01	I	Gallipoli Peninsula	Cengiz 2013
Chelidonichthys lucernus	90	TL	8.0-64	0.01	2.98	I	Marmara Sea	Bök *et al*. 2011
	474	TL	6.7-24.5	0.0166	2.74	A^-	North Mediterranean Sea	Sangun *et al*. 2007
	352	TL	10.5-56.0	0.009	3.00	I	Marmara Sea	Demirel and Dalkara 2012
	17	TL	6.3-15.1	0.0113	2.89	I	Marmara Sea	Keskin and Gaygusuz 2010

n: sample size, LT: length type, TL: total length, FL: fork length, min: minimum, max: maximum, a: intercept, b: slope, GT: growth type, A^-: negative allometric, I: isometric, A^+: Positive allometric.

Acknowledgements

Thanks due to Kadriye ZENGİN and Büşra ÇOKTUĞ for the field sampling.

Türkiye, Batı Karadeniz'den (Zonguldak-Amasra) 13 balık türünün boy-ağırlık ilişkileri

Öz

Bu çalışmada, Batı Karadeniz'den örneklenmiş 13 balık türü için boy-ağırlık ilişkisi parametreleri rapor edilmiş ve toplam 3132 örnek incelenmiştir. *b* değerleri *Scorpaena maderensis* için 2.84, *Trachurus mediterraneus* için 3.49 ortalama 3.13 (± 0.074) olarak hesaplanmıştır. Bütün türler için boy-ağırlık ilişkileri ve regresyon katsayılarının yüksek olduğu tespit edilmiştir ($P<0.05$). Bununla birlikte 6 türün izometrik (*Merlangius merlangus, Sprattus sprattus, Trachinus draco, Pomatomus saltatrix, Trachurus trachurus* ve *Chelidonichthys lucernus*), 2 türün (*Scorpaena porcus, Scorpaena maderensis*) negatif allometrik ve 5 türünde (*Mullus barbatus, Merluccius melluccius, Engraulis encrasicolus, Trachurus mediterraneus, Uranoscopus scaber*) pozitif allometrik büyüme gösterdiği belirlenmiştir. Bu çalışma ile Karadeniz'de ilk kez *S. maderensis* için boy-ağırlık ilişkisi incelenmiştir.

Anahtar kelimeler: Boy-ağırlık ilişkisi, balık türleri, büyüme, dip trolü

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