



-RESEARCH ARTICLE-

The length-weight and length-length relationships of bluefish, *Pomatomus saltatrix* (Linnaeus, 1766) from Samsun, middle Black Sea region

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Abstract

In this study, length-weight relationship (LWR) and length-length relationship (LLR) of bluefish, *Pomatomus saltatrix* were determined. A total of 125 specimens were sampled from Samsun, the middle Black Sea in 2014 fishing season. Bluefish specimens were monthly collected from commercial fishing boats from October to December 2014. All captured individuals (N=125) were measured to the nearest 0.1 cm for total, fork and standard lengths. The weight of each fish (W) was recorded to the nearest 0.01 g. According to results of analyses, there were no statistically significant differences between sexes in term of length and weight ($P>0.05$). The minimum and maximum total, fork and standard lengths of bluefish ranged between 13.5-23.6 cm, 12.50-21.80 cm and 10.60-20.10 cm, respectively. The equation of length-weight relationship were calculated as $W=0.008TL^{3.12}$ ($r^2>0.962$). Positive allometric growth was observed for bluefish ($b>3$). Length-length relationship was also highly significant ($P<0.001$) with coefficient of determination (r^2) ranging from 0.916 to 0.988.

Keywords:

Pomatomus saltatrix, length-weight parameters, Samsun, middle Black Sea, Turkey

Article history:

Received 6 September 2017, Accepted 21 September 2017, Available online 30 October 2017

Introduction

The bluefish *Pomatomus saltatrix* (Linnaeus, 1766) is a highly important commercial fish that is under serious fishing pressures in Turkey. *P. saltatrix* is a pelagic and migratory fish species that widely abundant all over the world except North and Central Pacific Ocean (Briggs, 1960). Bluefish can be caught by fishing rod, dragnet and trawl net etc. in Turkey. *P. saltatrix* is not a

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target species in Black Sea fishing but hunted together with horse mackerel, whiting and other species as by-catch (Özdemir et al., 2006). The bluefish are overfished especially at the western Black Sea and Marmara Sea during their seasonal migration of nutrition-reproduction between Black and Aegean Sea (Ceyhan & Akyol, 2006).

Although there are lots of studies about otolith characteristics, age, growth, reproduction, diet and stock characteristics of the bluefish (Barger, 1990; Hare & Cowen 1994; Buckel et al., 2004; Ceyhan & Akyol 2006; Turan et al., 2006; Ceyhan et al., 2007; Robillard et al., 2008; Robillard et al., 2009; Cengiz et al., 2012; Villegas-Hernández et al., 2015; Zengin et al., 2017), studies concerning the length-weight and length-length relationships are limited (Frota et al., 2004; Kalaycı et al., 2007; Ak et al., 2009; Özdemir et al., 2009; Bal et al., 2015).

The study of length-weight (LWR) and length-length (LLR) relationships is considered to be important to get different kinds of information of fish in fish biology such as growth rate, age structure, age at first maturity, discrimination of stocks and population dynamic studies (Kohler et al., 1995; Stergiou & Politou, 1995; Morey et al., 2003; Sinovcic et al., 2004; Vaslet et al., 2008; Borah et al., 2017; Ergüden et al., 2017; da Silva et al., 2017). In addition, the length-weight relationships can also be used to calculate relative condition factor, setting yield equations for estimating the number of fish landed and in comparing the population in space and time (Le Cren, 1951) and length-length associations are important in comparing growth studies using different length types (Moutopoulos & Stergiou, 2002; Yilmaz et al., 2010; Kashyap et al., 2014; Tsagarakis et al., 2015).

The aim of this study is to determinate the length-weight and length-length relationships of this highly important commercial bluefish species in Samsun Coast of the Black Sea, Turkey. In this study, total length-fork length, fork length-standard length and standard length-total length relationships were calculated and length-weight relationships were investigated to reveal the length transformations of *P. saltatrix* obtained from commercial fishing boats on Samsun offshore.

Material and Methods

Bluefish specimens were monthly collected from commercial fishing boats operating in offshore area of Samsun between October and December 2014 (36°35'30.64''E, 41°51'57.96''N. The coordinates were recorded using GARMIN GPS. All captured individuals (N=125) were measured to the nearest 0.1 cm for total length (TL), fork length (FL) and standard length (SL). The weight of each fish (W) was recorded to the nearest 0.01 g. Sex was determined by macroscopic examination of the gonads (71♀, 54♂).

Length-weight relations were calculated using the equation $W = aL^b$, where W is the total weight of the fish (g), L is the fork length (cm), a and b are the parameters of the equation (Bagenal & Tesch, 1978). The parameters a and b of LWR were estimated by linear regression on the transformed equation: $\log W = \log a + b \log TL$. The t-test employed to test whether the slopes (b) were significantly different from 3, indicating the growth type: isometric (b=3), positive allometric (b>3) or negative allometric (b<3). Analysis of covariance (ANCOVA) was used to test differences of the b values of length-weight relationship between sexes (Zar, 1999).

All length-length relationships of female, male and entire samples were computed using linear regression analysis (Zar, 1999). Relationships between TL & FL, FL & SL, and SL & TL were estimated separately according to all samples. All statistical analyses were tested by at the 0.05 significance level. SPSS 20, Minitab 15.0 and the Excel software were utilized in the evaluation of data.

Results

Overall, 125 bluefish samples were collected and analyzed. Within collected samples females (N=71) slightly prevailed over the males (N=54). According to results there were no statistically significant differences between sexes in term of length and weight ($P>0.05$). The minimum and maximum total length (TL) of bluefish in fishing season ranged between 13.5 cm and 23.6 cm, respectively. The minimum legal catch size for bluefish is determined as 14.0 cm according to fisheries rules in all of the Turkish seas. Descriptive statistics of the bluefish samples are displayed in Table 1.

Table 1. Descriptive statistics length and weight values of *P.saltatrix*

Variables	N	Minimum	Maximum	Mean	SE
TL	125	13.50	23.60	18.64	0.184
FL	125	12.50	21.80	17.19	0.165
SL	125	10.60	20.10	15.06	0.164
W	125	22.01	161.19	67.17	1.96

LWR showed that high compatibility between length and weight of the bluefish ($P<0.001$, $r^2 >0.962$) (Figure 1). The equations of length-weight relationship were calculated as $W=0.008TL^{3.12}$. The value of 'b' of length-weight relationships was found to be significantly different from 3.0 in *P. saltatrix* in the present study. According to results, the type of growth for bluefish was positive allometric growth in Samsun offshore of middle Black Sea region ($b >3$).

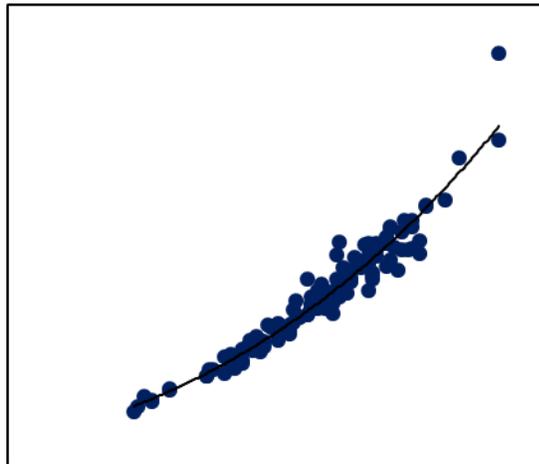


Figure 1. Length-weight relationship of *P.saltatrix* for all individuals

LLR were calculated by the simple linear regression. The length-length relationship was also highly significant ($P<0.001$) with coefficient of determination (r^2) ranging from 0.916 to 0.988 (Table 2).

Table 2. LLR relationships between total, fork and standard length of Bluefish from Samsun offshore, Black Sea.

Relationships	a	b	Equation	r ²
TL-FL	-0.457	1.11	TL=a+bFL	0.988
FL-SL	2.68	0.964	FL=a+bSL	0.918
TL-SL	-0.823	0.852	SL=a+bTL	0.916

Discussion

Pomatomus saltatrix is one of the most exploited commercial and recreational fisheries worldwide (Robillard et al., 2008; Özdemir et al. 2009). Consequently, all population parameters of bluefish could be pursued. The length-weight relationship parameters are extremely important for fish biology and fisheries management (Garcia et al., 1989). Also, length-length associations have a great importance in the comparison of studies using different lengths types (Moutopoulos & Stergiou, 2002).

In this study, the minimum and maximum TL of bluefish are 13.50 and 23.60, respectively. There are some studies proving knowledge about minimum, maximum total lengths and b values of *P. saltatrix* for some areas over the world (Table 3).

Table 3. Length-weight relationships of *P.saltatrix* from different areas

Location	TL (cm) (Min-Max)	a	b	Growth Type	References
South Atlantic	-	0.010	2.77	Negative Allometry (-)	Barger (1990)
Brazil	8.6-25.0	0.076	3.05	-	Haimovici & Velasco (2000)
Middle Coast of Brazil	48.0-75.5	0.059	2.50	Negative Allometry (-)	Frota et al. (2004)
Aegean & Marmara Sea	8.4-45.3	0.006	3.22	-	Ceyhan (2005)
Middle Black Sea	13.2-21.7	0.013	2.79	Negative Allometry (-)	Kalaycı et al. (2007)
Middle Black Sea	9.2-23.4	0.003	3.32	-	Özdemir et al. (2009)
Eastern Black Sea	11.6-22.2	0.003	3.33	Positive Allometry (+)	Ak et al. (2009)
Black Sea	12.5-20.2	0.009	3.00	-	Kasapoğlu & Düzgüneş (2013)
South Marmara Sea	12.3-43.7	0.011	2.96	Isometric	Bal et al. (2015)
Middle Black Sea	13.50-23.60	0.008	3.12	Positive Allometry (+)	This Study

Le Cren's concept hypothetically stated that the value of 'b' in ideal fish to be 3, indicating an isometric growth, which is widely used as a scale in length–weight relationship study (Singh & Serajuddin, 2017). The greater value of 'b' mainly depends on shape and fatness of individuals of fish. The values of 'b' in the present study indicated positive allometric growth. Kalaycı et al. (2007), Özdemir et al. (2009), Ak et al. (2009) and Kasapoğlu & Düzgüneş (2013) were investigated length-weight relationships of *P.saltatrix* in Black Sea Region, too. b values of these studies were 2.79, 3.32, 3.33 and 3.00, respectively. Our results are similar with Ak et al. (2009). Kalaycı et al. (2007) have found negative allometry in the Middle Black Sea. Their results are different from this study. This differences related to the fishing period, ecological factors such as temperature, food supply, spawning conditions. Growth type of same species can change between localities (Table 3). Le Cren (1951) pointed out that intraspecific variations in length–weight relationship may be because of variations in ecological conditions of habitats and physiology or either of them. Also, these differences depend on sample size, fishing equipments, season, fishing pressure and reproduction season, etc. When analyzed, the regression coefficients of the relationship between TL and W found to be the high ($r^2 > 0.962$) (Figure 1) and statistically significant ($P < 0.001$).

Total length (TL), fork length (FL) and standard length (SL) is usually utilized in different types of studies such as describing fish growth parameters and systematic studies (Arslan et al., 2004; Ma et al., 2010; Jia & Chen, 2011; Yılmaz & Polat, 2011; Yılmaz et al., 2012; Mohaddasi et al., 2013; Motamedi et al., 2014; Saylar & Benzer, 2014; Van Beveren et al., 2014; Hedayati et al., 2016; Turan et al., 2017). Therefore, length-length transformations in fish are useful for comparative studies using different length measures (Yılmaz et al., 2010; Tsagarakis et al., 2015). In this study LLR of bluefish were estimated. Bal et al. (2015) estimated LLR for bluefish from South Marmara Sea but there is no study for LLR of bluefish from middle Black Sea Region. In this study, LLR and LWR data of *P.saltatrix* from Samsun coast is examined. It is thought that the obtained data will contribute to the work to be carried out in relation to the further studies concerning this commercially important fish species.

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