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RESEARCH ARTICLE

Length-weight relationship of horse mackerel *Trachurus mediterraneus* Aleev, 1956 from Bulgarian Black Sea coast

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Abstract

This study was conducted to determine length-weight relationship of horse mackerel *Trachurus mediterraneus* (Aleev, 1956) from Bulgarian Black Sea coast. Length and weight of fish were measured during May-December 2009, then converted into logarithmic values. The coefficient of determination (r^2) of different samples showed high degree of correlation between legth and weight, 0.8571, 0.9716, and 0.9994 for female, male and both sexes, respectively.

Keywords: Horse mackerel, *Trachurus mediterraneus*, length-weight relationship, Black Sea, Bulgaria

Introduction

Growth of fish is quite variable. The size of individual fish is strongly influenced by environmental conditions, such as temperature and food supply (Yankova *et al*. 2013). The relationship between length and its weight in fish also vary over time and between locations, depending on the abundance of food, competitors and reproductive activity. Length-weight relationships have various uses in fisheries research and management. The knowledge of the biology of commercially important fish in economic terms (size values, i.e. minimum, maximum, and mean; and size relationships, i.e. length-weight) helps the sustainable exploitation of the Black Sea's natural resources. Length and weight measurements in conjunction with age data can give information on the stock composition, age at maturity, life span, mortality, growth, and production (Bolger and Connolly 1989; Diaz *et al*. 2000). Length-weight relationship is essential to provide basic information in fisheries biology (Paswan *et al*. 2012).

Length-weight relationships data for the fish species of the Turkish Black Sea coast are limited (Şahin *et al.* 1997; Genç *et al.* 1999). Very little work concerning length-weight relationships of horse mackerel *Trachurus mediterraneus* was published by Prodanov *et al.* (1997), Yankova *et al.* (2010a, 2010b, 2011). Therefore, the present studuy aimed at compensating for this and examines the LWR of horse mackerel *T. mediterraneus* in the Bulgarian Black Sea waters.

Materials and Methods

The investigated area included the Bulgarian Black Sea waters off Cape Kaliakra, Varna, Cape Emine, Bourgas, and Sozopol (Figure 1).

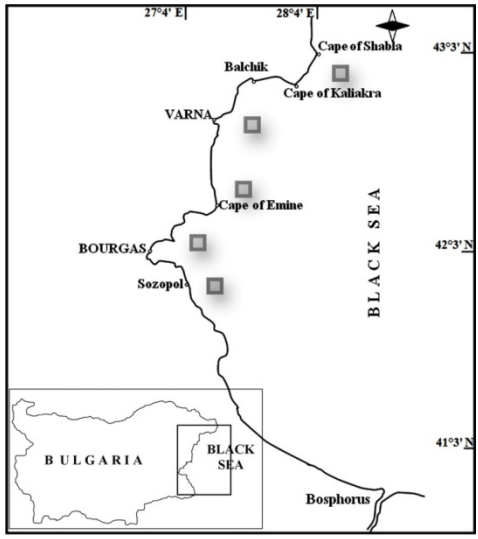

Figure 1. Study area.

A total of 2900 fish samples (1650 female and 1250 male) were collected during May-December 2009. The samples were transported to the research laboratory in plastic bags for measurement of length and weight. The total and standard lengths were measured to the nearest 0.1 cm. Body weight was measured to the nearest 0.01 g using a balance. The sex of fish was determined by an internal examination of gonads.

The mathematical function suggested by Le Cren (1951) was used in estimating LWRs:

$$W = aL^n \text{ or } (\log W = \log a + n \log L)$$

where W is the total body weight (g), L the total length (cm), and a and n are the coefficients of the functional regression between W and L. The values of

constant 'a' and 'n' are determined empirically from data, as the coefficient of condition. Logarithmic transformed data of body weight, total and standard lengths for different groups (females and males) are presented in Tables 1 and 2, respectively.

Table 1. Log weight, log total length and log standard length of female horse mackerel.

Age	Average log W_t (g)	Average log total length (cm)	Average log standard length (cm)
1	0.914	1.033	1.019
2	1.059	1.064	1.012
3	1.239	1.118	1.109
4	1.360	1.151	1.088
5	1.493	1.188	1.095
6	1.552	1.208	1.103
7	1.663	1.238	1.114

Table 2. Log weight, log total length and log standard length of male horse mackerel.

Age	Average log W_t (g)	Average log total length (cm)	Average log standard length (cm)
1	0.857	1.158	1.044
2	1.217	1.173	1.102
3	1.326	1.137	1.079
4	1.472	1.173	1.145
5	1.599	1.208	1.159
6	1.728	1.253	1.145

Tables 3 and 4 showed regression equation of weight on total length and standard length with coefficient of determination (r^2) and exponent value (n). An allometric coefficient n value larger or smaller than 3.0 shows an allometric growth, or isometric growth when it is equal to 3.0 (Bagenal and Tesch 1978).

Results and Discussion

In the present investigation, the total length as well as standard length has been taken as parameters. The minimum and maximum total length recorded was 9.5 cm and 18.0 cm, respectively. The weight of fish taken was 6.47 g as minimum and 53.6 g as maximum.

The exponent values (n) for female, male and combined were 3.2110, 3.3005 and 3.2773, respectively in case of total length as a parameter (Table 3). When the standard length was taken as parameter, the exponent values (n) for female, male and combined were 3.2762, 3.1602 and 2.7304, respectively (Table 4). It was observed that the values of 'n' were higher in females than those of males.

The coefficient of determination (r^2) for combined sex was 0.9833 and 0.9994 (Tables 3 and 4), respectively, in case of total length and standard length, as parameters. In both cases the correlation coefficient was found to be higher than 0.5, showing the length-weight relationship was in positive correlation. The values of 'a' and 'n' differ not only in different species but in same species also due sex, maturity stage, feeding intensity and so on.

Table 3. Regression equation of weight on total length of horse mackerel.

Source	Regression coefficient (n)	Intercept (a)	Coefficient of determination (r^2)	Length–weight relationship
Female	3.2110	-4.0043	0.9698	$W=0.01824*L^{3.2110}$
Male	3.3005	-3.8174	0.9717	$W=0.02198*L^{3.3005}$
Combined	3.2773	-4.9938	0.9833	$W=0.00678*L^{3.2773}$

Table 4. Regression equation of weight on standard length of horse mackerel.

Source	Regression coefficient (n)	Intercept (a)	Coefficient of determination (r^2)	Length–weight relationship
Female	3.2762	-5.0530	0.8571	$W=0.00639*L^{3.2762}$
Male	3.1602	-3.8174	0.9716	$W=0.02198*L^{3.1602}$
Combined	2.7304	-4.8638	0.9994	$W=0.00772*L^{2.7304}$

Tesch (1968) viewed the exponent (n) values of '3', which indicates the specific gravity of the tissue remains constant throughout its life for an ideal fish. Probably due to this reason, the 'n' value is found to be very close to 3 in many cases. Hence it is generally called the cube law. However, fish normally do not retain same shape of the body throughout their life span and the relationship may depart from the cube law. Seasonal fluctuation in environmental parameters, physiological condition of the fish at the time of collection, gonad development and nutritive condition of the fish are the causes for this variation (Sinha 1973). The exponent value (n) of total length and standard length taking as parameters indicated that the values of slope 'n' showed variation around '3'. The exponent value of total length combined was 3.2773, 3.2110 and 3.3005 for combined, females and males, respectively (Table 3). When the standard length was taken as a parameter, the values of (n) were 2.7304, 3.2762 and 3.1602, respectively, for combined,, females and males (Table 4). Thus it can be concluded that *T. mediterraneus* did not follow the cube law strictly.

Table 5 summarizes parameters and other relevant information for *T. mediterraneus* in the Black sea waters. Prodanov *et al*. (1997) observed that value of 'n' in the Bulgarian Black Sea coast was considerably lower than 3. Şahin *et al*. (1997) and Genç *et al*. (1999) observed that the value of 'n' in Turkish Black Sea Coast to be 3.2188 and 3.017, respectively. Yankova *et al*. (2010a) estimated a value of 3.3046. According to Ozaydin *et al*. (2000), such differences may be attributed to the sampling strategy used, such as the

sampling period, as well as to variations in temperature and probable differences between the trophic potential of various localities. Several authors have reported both isometric and allometric growth for the same fish species from various water bodies. As discussed by Prodanov *et al*. (1997), allometric growth patterns were reported for horse mackerel in the Bulgarian Black Sea waters. As discussed by Şahin *et al*. (1997), allometric growth patterns were reported for this species in the Turkish Black sea coast. An isometric growth patterns for horse mackerel from the Turkish coastal water of the Black Sea was shown by Genç *et al*. (1999). Comparison of the length-weight relationships observed in the present study with those of the other regions showed that the coefficient of the length-weight relationship differed from that reported by Prodanov *et al*. (1997) which was due to the season, the physiological state of the horse mackerel, and length range analyzed. These differences in growth, between the values of n, may be a result of several ecological factors, such as the characteristics of biotope, temperature, spawning conditions, and feeding, as reported by Ricker (1975). It is thought that this difference can also be result of the assessment methodologies in sampling.

Table 5. Parameters of the length-weight relationship (a, n) in horse mackerel reported in previous studies.

Study	Location	N	a	n	Length min-max
Şahin *et al*. (1997)	Turkish Black Sea	600	0.0048	3.2188	7.4-14.5
Prodanov *et al*. (1997)	Bulgarian Black Sea	N/A	0.3220	1.7170	N/A
Genç *et al*.(1999)	Eastern Black Sea	N/A	0.0075	3.017	6.5-19
Yankova *et al*. (2010a)	Bulgarian Black Sea	1995	0.0035	3.3046	10.5-17.00
Yankova *et al*. (2011)	Bulgarian Black Sea	1432	0.005	3.168	7-18.4

The coefficient of the length-weight relationship varies depending on season, physiological state of the fish, and length range analyzed (Şahin *et al*. 1997). The allometric coefficient depends on the feeding location of the populations, sex, length, age, and gonad maturity (Martin 1949; Ricker 1979).

Conclusion

The length-weight relationship of fish can be a useful tool for fishery management. Since *Trachurus mediterraneus* represents commercially important species in the Black Sea, it is advantageous to learn their length-weight relationships to enhance their management. The values obtained here would contribute to fishery or biomass assessment and trophic studies.

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