AGE, GROWTH, LENGTH-WEIGHT RELATIONSHIP AND REPRODUCTION OF THE ATLANTIC HORSE MACKEREL (*Trachurus trachurus* Linnaeus, 1758) IN ORDU (BLACK SEA)

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ABSTRACT

In this study, it was aimed to estimate some biological parameters of horse mackerel (*Trachurus trachurus*). Totally, 1307 sampled individuals were studied and mean length and weight of sampled individuals were calculated as 12.4 cm and 16.2 g. Sex rate (female : male) is determined as 1:1.02. It was also found that length-weight relationship of all individuals $W=0.0049\ L^{3.17}$ with an age interval of 0-7 von Bertalanffy growth equation was found as $L_t= 20.5\ (1-e^{-0.2313(t+2.996)})$. The highest value of gonadosomatic index was found in June.

Keywords: *Trachurus,* age, growth, length-weight relationship, reproduction, Black sea

ORDU BÖLGESİ'NDEKİ (KARADENİZ) İSTAVRİT BALIĞININ (*Trachurus trachurus* Linnaeus, 1758) BÜYÜME, YAŞ, BOY, AĞIRLIK İLİŞKİSİ VE ÜREMESİ

ÖZET

Karadeniz'de yapılan bu araştırmada istavrit (*Trachurus trachurus*) balığının bazı biyolojik temel parametrelerin tahmin edilmesi amaçlanmıştır. Toplam 1307 adet örnek incelenmiş ve ortalama boyları 12.4 cm ve ortalama ağırlıkları 16.2 g olarak hesaplanmıştır. Dişi erkek oranı ise 1:1.02 olarak belirlenmiştir. Tüm bireyler için boy ağırlık ilişkisi $W=0.0049L^{3.17}$ olarak ve 0-7 yaş arasında dağılım gösterdiği tespit edilmiştir. von Bertalanffy büyüme denklemi $L_t= 20.5\ (1-e^{-0.2313(t+2.996)})$ olarak bulunmuştur. En yüksek gonadsomatic indeks değeri haziran ayında belirlenmiştir.

Anahtar Kelimeler: *Trachurus,* yaş, büyüme, boy-ağırlık ilişkisi, üreme, Karadeniz

1. INTRODUCTION

Anchovy (*Engraulis encrasicolus*) and horse mackerel (*Trachurus mediterraneus*) are the main species that have commercial importance and are caught in Turkish waters [1]. Horse mackerel is an economically important species which is also the fourth highly caught species. Horse mackerel fishing is conducted with different fishing gears including pelagic trawl, set nets, purse seine, and hand line [2,3]. 80% of the total horse mackerel is produced in the Black Sea region [1]. Trachurus

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genus is the members of Carangidae family and it also includes 3 worldwide economically important species, *T. mediterraneus* (Mediterranean horse mackerel), *T. trachurus* (Atlantic horse mackerel) and *T. picturatus* (Blue jack mackerel) [4,5].

There are a plenty of studies considering *T.trachurus* which is intensively caught in the Black Sea. First information regarding the biological dimensions, morphology and geographic distributions of *Trachurus* species is belonging to Slastenenko [6]. Karlou-Riga [7] studied otolith morphology, age and growth parameters of the Mediterranean horse mackerel in the Eastern Mediterranean between the years 1989 and 1992. Bostancı [5] studied otolith dimensions and some populations parameters of the Mediterranean horse mackerel, and Santic et al [8] also studied the feeding nutrition habits of the Mediterranean horse mackerel in the Adriatic Sea in 1996. In another study, while Waldron et al. [9] studied the age distribution of the Atlantic horse mackerel, Jardas et al. [10] investigated the biometric characteristics of the Atlantic horse mackerel in the Adriatic Sea. In addition, length-weight relationships of the Atlantic horse mackerel were determined by many researchers. Stock composition and population parameters of the *Trachurus mediterraneus* was determined by Kasapoğlu [16] and, the otolith dimensions and some biological parameters of the *T.mediterraneus* were researched by Atılgan et al. [3]. It is necessary to constantly monitor reproduction, growth, migration, stock size, life span and death rates of the *T. trachurus* population in the Black Sea ecosystem which is also vitally importance for sustainable fisheries. It is thought that there is not sufficient studies considering the Atlantic horse mackerel which is in the forth sequence in terms of total capture production in the Turkish waters. Therefore, it is also supposed that this study shall fill this gap at least.

2. MATERIALS AND METHODS

A total of 1307 horse mackerel individuals were collected from gillnets, purse seine, line fishing taken from Ordu (41° 37′18′′ N-37° 22′ 26′′ E and 40° 58′ 35′′ N-38° 02′ 58′′ E) from May 2011 through April 2012. The samples were collected at monthly intervals.

For each fish, the total length (L) and the total weight (W) were measured. The sex of all specimens was recorded by macroscopic examination of the gonads as male, female. Thereafter, each gonad was removed from fish and weighed (WG) to 0.01 g.

The relationship between length and weight was established as $W = aL^b$, where W is total body weight (g), L is total length (cm), and a and b are coefficients [17,18]. The parameters a and b of length-weight relationships were estimated by linear regression analysis on log-transformed lengths and weights. The degree of association between the variables was estimated by the determination coefficient (R^2). The growth type was identified by Student's t-test, which was applied to

determine the significance of differences between the isometric growth (b = 3) and allometric growth ($b \neq 3$) [19].

For the age determination, a total of 532 individuals were selected from each 0.5 cm size interval to represent all length groups. The sagittal otolith pairs were removed and cleaned, and stored in dry conditions inside the microplate. Age determination was performed using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent rings were counted : 1 opaque zone, together with 1 transparent zone, was considered the annual macrostructure. Age estimations were made by 2 independent readers [20].

The von Bertalanffy growth equation was used in order to determine the relationship between age-length : $L_t = L_\infty (1\text{-}e^{-k (t\text{-}t_0)})$ where L_t is the length at age t; L_∞ is the asymptotic length (cm), k is a growth constant, determining the rate of change in the length increment; and t_0 is the hypothetical age when the length is zero [21].

To compare the growth parameters obtained in this study with those reported by other authors for the same species, the growth performance index (Φ) was used Munro and Pauly [22] :

$\Phi = \text{Ln}(k) + 2 \times \text{Ln}(L_\infty)$; where k is the growth coefficient, and L_∞ is the asymptotic length.

The reproductive period was determined by analyzing the monthly variation in the gonadosomatic index (GSI = (WG / W) × 100) [17].

The chi-square analysis was used to determine whether the sex composition differs between female and male and to compare overall sex ratios in studied specimens [23].

3. RESULTS

During the study period, a total of 1307 individuals were sampled; 660 were females (50.49%), 647 were males (49.51%). The sex ratio (female/male) was calculated as 1:1.02 and it was not significantly different from unity ($\chi^2 = 0.12$, $P > 0.05$).

Length-weight relationship

Mean length was determined as 12.42±2.23 cm. Length frequency distribution of the Atlantic horse mackerel is given in Figure 1.

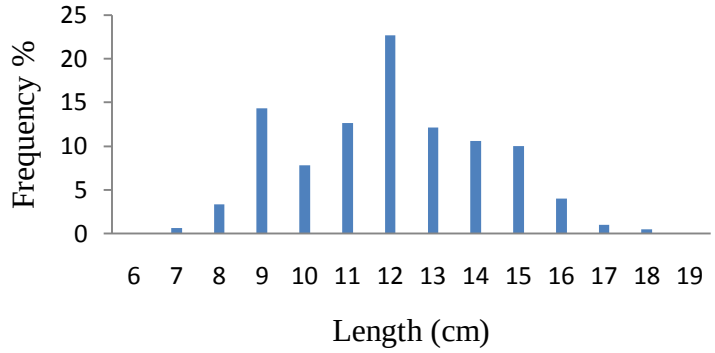

Figure 1. Length frequency distribution of the Atlantic horse mackerel.

Maximum, minimum length and weight data were given in Table 1. Difference in lengths of the female and male individuals were not statistically important (P>0.05).

Table 1. Length and weight values of the female and male individuals

	Length(cm)			**Weight (g)**		
	Mean±STD	**Minimum**	**Maximum**	**Mean±STD**	**Minimum**	**Maximum**
All	12.42±2.2	6.9	19.02	16.48±9.1	2.32	59.89
Female	12.46±2.3	6.9	18.9	16.73±9.5	2.32	59.89
Male	12.47±2.2	7.9	19.02	16.2±8.7	2.85	59.77

Length-weight relationships of the Atlantic horse mackerel population was given in Figure 2. b values from the results of length-weight relationships was found as b>3 for female, male and all individuals and positive allometric growth was determined (Table 2).

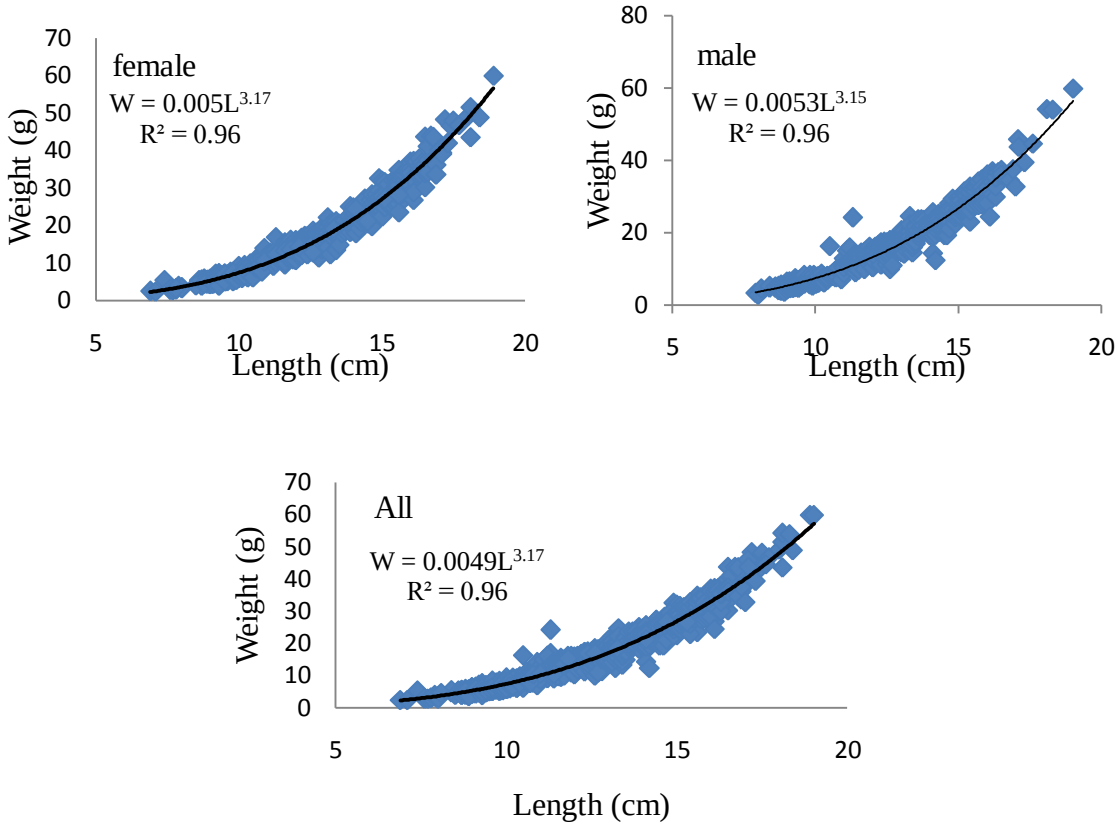

Figure 2. Length-weight relationship of the sampled individuals.

Table 2. Parameters of length-weight relationship for male, female and all individuals

Sex	N	a	b	R^2
All	1307	0.0049	3.17	0.96
Female	660	0.005	3.17	0.96
Male	647	0.0053	3.15	0.96

Age and growth

After age analysis of the 532 sampled *T. trachurus* individuals, it was determined that they are included in 0-7 age intervals. Age-length distribution of the male and female were given in Table 3 according to the different ages.

Table 3. Age-Length distribution of the male, female and all individuals in numbers (N).

Age	All (cm) (N)	Female (cm) (N)	Male (cm) (N)
0	10.01 (181)	9.9 (87)	10.11 (94)
1	12.29 (140)	12.27 (77)	12.31 (63)
2	13.77 (111)	13.76 (49)	13.78 (62)
3	15.35 (63)	15.37 (35)	15.32 (28)
4	16.29 (15)	16.32 (8)	16.26 (7)
5	16.89 (9)	16.85 (5)	16.97 (4)
6	17.6 (7)	17.6 (4)	17.4 (3)
7	18.47 (6)	18.46 (4)	18.47 (2)

Growth in length equation of all individuals according to the Von Bertalanffy equation is calculated as $L_t=20.5(1-e^{-0.2313(t+2.996)})$. Distribution according to the different age groups, it was found that the amount of sampled individuals 0-3 age group is determined as 93.1%. For mean lengths of individuals, observed and estimated via Von Bertalanffy growth equation for each age group was shown in Figure 3. In addition, no statistically difference was found between the observed and estimated values ($P > 0.05$).

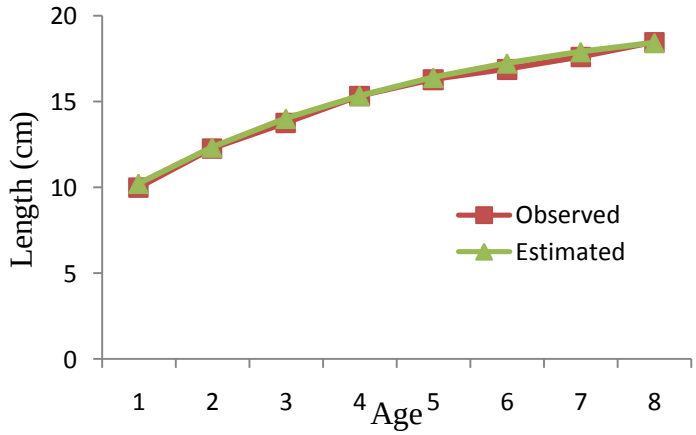

Figure 3. Observed and estimated lengths for different ages.

Calculated growth parameters by Von Bertalanffy growth equation is given in Table 4.

Table 4. Growth parameters of male, female and all individuals.

Sex	L_∞	k	t_0	Φ
All	20.5	0.2313	-2.9967	4.58
Female	20.2	0.2432	-2.8378	4.60
Male	20.6	0.2236	-3.1619	4.55

Reproduction

Spawning times of the *T. trachurus* was determined by considering the GSI data. GSI data of the female individuals showed variety between 0.86 and 6.18 (Figure 4).

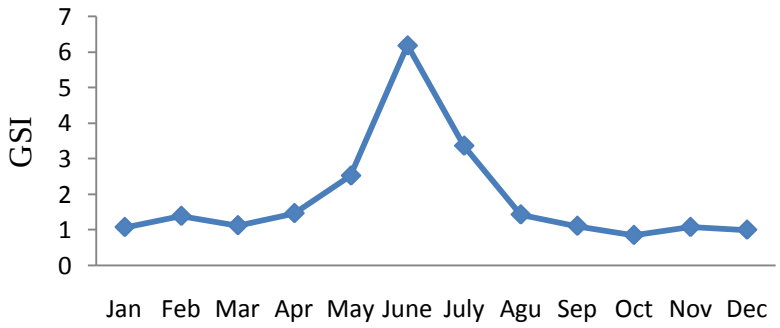

Figure 4. GSI graph of the Atlantic horse mackerels.

GSI values start to increase in March and reached the top in June and spawning period continued till October. The minimum GSI value was observed in October with the value of 0.856.

4. DISCUSSION

In the previous studies conducted in the Black Sea, mean length 14.1 cm, minimum 9.4 cm and maximum 16.8 cm [24], mean length 13.24 cm [25], mean 13.52 cm, minimum 9.2 cm and maximum length 19 cm [26], mean 12.7 cm, minimum 7.7 cm and maximum length 17.8 cm [3].

In this study, mean, minimum and maximum lengths were determined as 12.4 cm, 7.9 cm and 19.02 cm, respectively. Length results did not show any significant difference compared to the previous studies whereas, there is a considerable decrease in the mean lengths year after year. Besides, the decrease in the mean length of the fish population can be explained as a result of overfishing pressure. In

another study conducted in the Middle East region, totally 8 age groups determined, and individuals included in the 0-3 age group composed the majority with a rate of 90.41% [27]. Both studies shows great similarity.

In this study, length-weight relationship were determined as $W=0.0049L^{3.17}$. In other studies, it was found as $W=0.0076L^{3.05}$ [24], $W=0.0063L^{3.09}$ [25], $W=0.0089L^{2.95}$ [26] and $W=0.0093L^{2.95}$ [3]. In the results of previous studies, b values shows positive allometric growth except in the results from Şahin et al. [26] and Atılgan et al. [3]. In this study, L_{∞} value was determined as 20.05 cm. This parameter was found as 24.5 cm [28], 38.85 cm [29], 19.88 cm [30], 17.68 cm [24], 24.12 cm [31], 26.74 cm [25], 26.09 cm [16], 22.54 cm [32], 26.09 cm [26] in other studies. Therefore, there is a significant difference between this study and the previous studies. It is thought that this difference can be result of the assessment methodologies in sampling.

According to this study, the highest (6.18) and lowest (0.86) levels of GSI values for Atlantic horse mackerel was found in June and October, respectively. This result gives us the idea that the spawning period of this species in the region is June. In the other study conducted in the Aegean sea, a highest GSI value was determined [33]and conducted in the Black Sea, the maximum female GSI values were 4.90 in July, 3.29 in August and 1.04 in September [30] and another study, the female GSI was 2.37 in August and 0.987 in September [26]. Therefore, the early spawning period of the species in the Aegean Sea can be effected the sea temperature. In the previous studies conducted in the Black Sea, the spawning periods were very close to others and the different among them is because of the yearly changes in water temperature.

Atlantic horse mackerel is an economically forth most important species in Turkish waters, therefore, it is necessary to monitor and follow the changes in stock size in terms of sustainable fisheries.

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