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**RESEARCH ARTICLE** **ARAŞTIRMA MAKALESİ**

# Comparison of length-weight relationships for whiting, *Merlangius merlangus* (Linnaeus, 1758) caught from three different areas of the south-eastern Black Sea

# Güney-doğu Karadeniz'in üç farklı kıyısından yakalanan mezgit balıklarının, *Merlangius merlangus* (Linnaeus, 1758) boy-ağırlık ilişkilerinin karşılaştırılması

**İsmet Balık[1*] • Meryem Öztaş[2]**

[1] Akdeniz University, Kemer Maritime Faculty, Dumlupınar Bulvarı 07058 Kampüs, Antalya, Turkey https://orcid.org/0000-0003-2168-8572
[2] İstanbul University, Institute of Science, Department of Marine Biology, 34134, İstanbul, Turkey https://orcid.org/0000-0002-5604-6003
*Corresponding author: ibalik@hotmail.com

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**Abstract :** The purpose of this study was to compare Length-Weight Relationships (*LWRs*) of whiting, *Merlangius merlangus* (Linnaeus, 1758) caught from three different areas (Medreseonu and Persembe coastal waters of Ordu province and Piraziz coastal waters of Giresun province, Turkey) of the south-eastern Black Sea. During a year in 2010, whiting specimens were collected monthly by similar mesh-sized experimental gillnets from each sampling areas. Total length (*TL*) and weight (*W*) of each fish specimens were measured. LWRs were calculated using length and weight values for males, females and combined sexes. Then, the calculated b values of the whiting caught from the sampling areas were compared. The parameter *b* values of the LWRs were calculated as 2.7429, 2.9097 and 2.8600 for Medreseonu, Persembe and Piraziz coastal waters, respectively. These *b* values of the LWRs showed that whiting grows negative allometric in all of the sampling areas. According to the sex groups, only the female individuals captured from of Persembe coast showed isometric growth, while both the male and female individuals captured from the Medreseonu and Piraziz coastal waters and the male individuals caught from Persembe coast showed negative allometric growth.

***Keywords:*** *Black Sea, whiting, Merlangius merlangus, length-weight relationship*

**Öz:** Bu çalışmanın amacı, güney-doğu Karadeniz'deki üç farklı alandan (Ordu ilinin Medreseönu ve Persembe kıyıları ile Giresun ilinin Piraziz kıyısı) yakalanan *Merlangius merlangus* (Linnaeus, 1758)'un Boy-Ağırlık İlişkilerini (*BAİ*) karşılaştırmaktır. Bir yıl boyunca 2010 yılında aylık olarak benzer özellikteki uzatma ağları ile üç örnekleme sahasından mezgit örnekleri toplanmıştır. Her bir örneğin total boyu (*TL*) ve ağırlığı (*W*) ölçülmüştür. Boy ve ağırlık değerleri kullanılarak erkek, dişi ve örneklerin tamamı için boy-ağırlık ilişkileri hesaplanmıştır. Daha sonra, araştırma sahalarından avlanan mezgit balıkları için hesaplanan *b* değerleri karşılaştırılmıştır. Medreseonu, Persembe ve Piraziz kıyılarından yakalanan örnekler için *b* değeri sırasıyla 2.7429, 2.9097 ve 2.8600 hesaplanmıştır. BAİ'lerinin *b* değerleri, mezgit balıklarının örneklemem sahalarının tamamında negatif allometrik büyüdüklerini göstermiştir. Eşeylere göre ise, sadece Persembe kıyılarından yakalanan dişi mezgitlerin izometrik büyüme gösterdikleri, Medreseonu ve Piraziz kıyılarından yakalanan hem erkek hem de dişi bireyler ile Persembe kıyılarından yakalanan erkek bireylerin negatif allometrik büyüme gösterdikleri saptanmıştır.

***Anahtar Kelimeler:*** *Karadeniz, mezgit, Merlangius merlangus, boy-ağırlık ilişkisi*

## INTRODUCTION

Organisms generally increase in size (length, weight) during development. The key factors that influence the growth of fish are the quantity of food available, the number of fish utilizing same food source, temperature, oxygen, and other water quality factors besides the size, age and sexual maturity of the fish. Every animal in its life exhibit growth both in length and in weight and the relationship between these two has both applied and basic importance (Kuriakose, 2017).

Studies of the Length-Weight Relationship (*LWR*) of fishes were performed since the late 19th century, and are an important tool to describe several biological aspects (Le Cren, 1951; Froese, 2006). The LWR allows to 1) estimate fish weight based on length and vice versa, 2) analyze the growth pattern by the allometric coefficient of the analyzed species, and 3) obtain the body conditions of the sampled fish specimens (i.e. fat storage or gonadal development etc.) (Froese, 2006). Additionally, the knowledge from LWR is essential to assess fish stocks, fisheries, and environmental monitoring programs (Froese et al., 2011; Giarrizzo et al., 2015). According to Freitas et al. (2014), the LWR studies become relevant due to the need to comprehend the fish lifecycle, principally regions where fisheries represent one of the most important economic activities and fish stocks are the main food source for many traditional communities (Freitas et al., 2017).

Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes more slender as it increases in weight while positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Riedel et al., 2007).

The growth pattern (*b*) within the same species can be changeable, depending on the season, food availability, population, sex, environmental conditions or physiology (Freitas et al., 2017). Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indices (Ecoutin and Albaret, 2003). LWR of fishes is important in fisheries and fish biology because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them (Sarkar et al., 2008; Mir et al., 2012). Like any other morphometric characters, the LWR can be used as a character for the differentiation of taxonomic units and the relationship changes with the various developmental events in life such as metamorphosis, growth, and onset of maturity (Thomas *et* al., 2003). Besides this, LWR can also be used in setting yield equations for estimating the number of fish landed and comparing the population in space and time (Singh et al., 2011). LWR parameters (*a* and *b*) are useful in fisheries science in many ways, to estimate weight of individual fish from its length, to calculate condition indices, to compare life history and morphology of populations belonging to different regions (Sani et al., 2010) and to study ontogenetic allometric changes (Teixeira de Mello et al., 2006). LWRs can be used to predict weight from length measurements made in the yield assessment (Pauly, 1993).

The whiting is distributed from Norway and Iceland to the Mediterranean and into the Adriatic, the Aegean, the Azov and the Black Seas (Svetnovidov, 1986). In Turkey, annual catch amount of the whiting from 2010 to 2016 ranged between 7 and 13.5 thousand tons (TUIK, 2018). Most of this catch (between 6.3 and 12.6 thousand tons) was obtained from the Black Sea. In this study, the LWRs of the whiting caught from the Medreseonu, Persembe coasts of Ordu Province and the Piraziz coast of Giresun were compared. In the Persembe coast, there are a large number of the net cage for aquaculture. According to some fishermen, around of the net cages is very rich for the feeding of whiting. Because, this region constitutes important feeding grounds for whiting. Hence, the LWR may differ from other regions. The LWR equations of male, female and combined sexes for the whiting obtained from three different areas of the south-eastern Black Sea were separately determined and compared each other.

## MATERIAL AND METHODS

This study was carried out in Persembe and Medreseonu coastal waters of Ordu province and Piraziz coastal waters of Giresun province of the southern-eastern Black Sea from January to December 2010 (Figure 1). Samples were collected from commercial fishermen who have used 32-36 mm mesh-sized gillnets throughout sampling period in three sampling areas. The nets were made of monofilament twine, and they had been rigged with a hanging coefficient of 0.5. The length of each gill net was 100 m. Twine diameter size of all nets was 0.18 mm. All nets were set and hauled at the sampling areas 2 hours before the sunset and 2 hours before the sunrise. The catches of whiting were removed from the nets and then the total length (*TL*) and the total body weight (*W*) of whiting samples were measured.

The length and weight-frequency distributions of the sexes were compared with the Kolmogorov-

Smirnov test. Differences among sampling areas in terms of the mean length and weight were tested by Kruskal-Wallis test. Mann-Whitney U test was used for pairwise comparisons. All the statistical analyses were considered at significance level of 5%. The Statistical Package SPSS was used to analysis data.

The length-weight relationships were estimated from the formula (Le Cren, 1951), $W=a*TL^b$ Where: *W* is total body weight (g), *TL* is the total length (cm), *a* and *b* are coefficients of the functional regression between *W* and *TL*. Student's t-test was used to confirm whether *b* values obtained in the linear regressions were significantly different from the isometric value ($b = 1$ in case of length-length relationships or $b = 3$ in case of length weight relationships) (Sokal and Rohlf, 1987).


**Figure 1.** Black Sea and sampling areas

## RESULTS

During the study, a total of 480 specimens of the whiting collected from each area and their LWRs were estimated. The total length of fish specimens ranged from 11.8 to 21.9 cm for Medreseonu, from 11.8 to 21.4 cm for Persembe and from 11.2 to 22.1 cm for Piraziz (Figure 2). The length distribution of male and female individuals sampled from Medreseonu and Piraziz coastal waters were statistically different (Kolmogorov-Simirnov test, $P<0.05$), but not different (Kolmogorov-Simirnov test, $P>0.05$) for individuals sampled from Persembe coastal waters. Differences of the mean lengths of male individuals caught from sampling areas were not statistically significant (Kruskal-Wallis test, $P>0.05$), while the mean length of female individuals sampled from Medreseonu coast was statistically different from Persembe coast (Mann-Whitney U test, $P<0.05$).

The weight of fish specimens ranged from 11.1 to

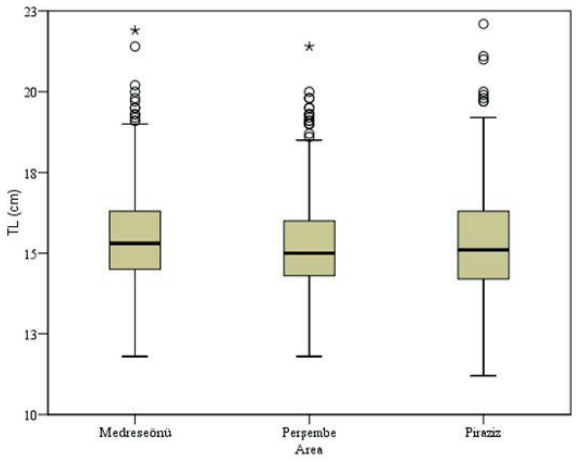


**Figure 2.** Median, quadrature, minimum and maximum values of total length for the whiting from Medreseonu, Persembe and Piraziz

78 g for Medreseonu, from 11.1 to 69.1 g for Persembe and from 9.7 to 76.5 g for Piraziz (Figure 3). The weight distributions of male and female individuals were also different in three sampling areas (Kolmogorov-Smirnov test, $P<0.05$). In terms of the mean weight, no difference was found among sampling areas (Kruskal-Wallis test, $P>0.05$). On the other hand, the mean weight of female individuals sampled from Medreseonu were statistically different (Mann-Whitney U test, $P<0.05$) from Perşembe and Praziz.

Mean lengths for combined sexes were 15.5 ± 1.507, 13.3 ± 1.436 and 15.3 ± 1.657 cm, while the mean weights were 28.3 ± 8.687, 27.0 ± 8.594 and 27.2 ± 9.223 g for the Medreseonu, Persembe and Piraziz coasts, respectively. In general, average length

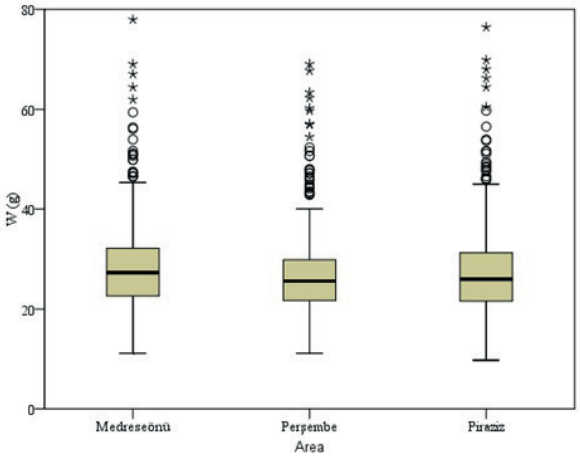


**Figure 3.** Median, quadrature, minimum and maximum values of weight for the whiting from Medreseonu, Persembe and Piraziz

and weight of female individuals were found to be higher than those of male individuals in all sampling areas. The mean values of the total length and weight, the regression coefficients obtained from LWRs and growth type of the whiting were presented in Table 1 for three different areas. According to the 95% confidence intervals of *b*, female individuals caught from Persembe show isometric growth (*b* = *3*). The type of growth for males and combined sexes caught from Persembe and for males, females and combined sexes caught from the Medreseonu and Piraziz coasts were negative allometric (P<0.05).

Mean length and weight of the male individuals caught from Medreseonu were greater than those of Persembe and Piraziz. The LWRs were calculated as $W=0.0188*TL^{2.6572}$ for male specimens caught from Medreseonu, $W=0.0122*TL^{2.8093}$ for male specimens caught from Persembe and $W=0.0107*TL^{2.8576}$ for male specimens caught from Piraziz. The b value for male individuals collected from Piraziz was the greatest. This was followed by Persembe and Medreseonu areas, respectively. However, it was determined that male individuals grow negative allometric in all three areas.

Female individuals caught from Medreseonu had greater mean total length and body weight than those caught of other areas. The LWR of females were as $W=0.0128*TL^{2.7988}$ in the Medreseonu, $W=0.0084*TL^{2.9568}$ in the Persembe and $W=0.0112*TL^{2.8474}$ in the Piraziz. The b value of females caught from Persembe was the greatest. While female individuals show isometric growth in the Persembe area, negative allometric growth in the other areas.

Mean length and weight of the whiting specimens for combined sexes were greatest in the Medreseonu. This area was followed by the Piraziz and Persembe areas, respectively. The LWR of combined sexes caught from the Medreseonu, Persembe and Piraziz areas were found as $W=0.0149*TL^{2.7429}$, $W=0.0094*TL^{2.9097}$ and $W=0.0107*TL^{2.86}$, respectively. The b value of combined sexes in Persembe was greater than those of the other areas. However, combined sexes have negative allometric growth in all of the fishing areas.

## DISCUSSION

The LWR in fishes can be affected by a number of factors including season, habitat, gonad maturity, sex, diet, and stomach fullness, health and preservation techniques, and differences in the length ranges of the specimens caught (Pauly, 1984). The exact relationship between length and weight differs among species of fish according to their inherited body shape, and within a species according to the condition (robustness) of individual fish. LWR provides information on growth patterns and growth of animals. During their development, fish are known to pass through stages in their life history which are defined by different LWRs (Yousuf and Khurshid, 2008).

In terms of the mean weight of the male individuals caught from sampling areas, while there was no difference among sampling areas, the mean weight of the female individuals caught from Medreseonu was different those of Persembe and Piraziz. There may be many reasons for this. However, probably the most important reason is that the rate of the individual in reproductive size is higher in the Medreseonu than in the other sampling areas.

Parameter *b* value which varies according to species, age, and sex, shows the shape of the fish. A comparison between the b values determined for

**Table 1.** Mean total lengths and weights of male, female and combined sexes collected by three different areas of the south-eastern Black Sea, *a* and *b* values of LWRs, confidence intervals of *b* and growth types

| | Sex | N | TL(cm) | W (g) | a | b | 95% CI of b | Growth type | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Med. | M | 224 | 15.3±1.414 | 26.8±8.053 | 0.0188 | 2.6572 | 2.555-2.760 | -A | 0.8106 |
| | F | 256 | 15.8±1.549 | 29.6±9.026 | 0.0128 | 2.7988 | 2.704-2.894 | -A | 0.8785 |
| | All | 480 | 15.5±1.507 | 28.3±8.687 | 0.0149 | 2.7429 | 2.675-2.811 | -A | 0.8529 |
| Pers. | M | 203 | 15.2±1.457 | 26.3±8.429 | 0.0122 | 2.8093 | 2.71-2.910 | -A | 0.7913 |
| | F | 273 | 15.3±1.411 | 27.6±8.662 | 0.0084 | 2.9568 | 2.871-3.043 | I | 0.8648 |
| | All | 480 | 13.3±1.436 | 27.0±8.594 | 0.0094 | 2.9097 | 2.848-2.972 | -A | 0.8383 |
| Piraziz | M | 210 | 15.0±1.691 | 25.7±8.968 | 0.0107 | 2.8576 | 2.753-2.961 | -A | 0.9167 |
| | F | 270 | 15.5±1.601 | 28.3±9.279 | 0.0112 | 2.8474 | 2.756-2.941 | -A | 0.9273 |
| | All | 480 | 15.3±1.657 | 27.2±9.223 | 0.0107 | 2.8600 | 2.794-2.926 | -A | 0.9239 |

*M: Male, F: Female, All: Total of male, female and juvenile, I: Isometric, -A: Negative allometry, +A: Positive allometry, GT: Growth type, a and b: Regression constants.*

different populations of the same fish species can be used to determine whether there is a change in the general shape of the individual. In this study, except for the female individuals sampled from the Persembe area, the value of *b* was smaller than 3. The value of $b<3$ shows negative allometric growth, $b = 0$ shows isometric growth and $b>3$ shows positive allometric growth (Morey et al. 2003). According to Pervin and Mortuza (2008), *b* values may range from 2.5 to 4.0 suggesting. Consistent with this range, the results of our study indicated that the whiting in the south-eastern Black Sea had negative allometric growth. While the female individuals caught from Persembe area showed isometric growth, the male individuals caught from Persembe, and the male and female individuals caught from Medreseonu and Piraziz areas showed negative allometric growth. Except for Duzgunes and Karacam (1990), Demirel and Dalkara (2012), Saglam and Saglam (2012), Ozdemir and Duyar (2013), Samsun and Akyol (2017), and Ozdemir et al. (2018), the value of b was found to be greater than 3 in all of the studies given in Table 2. In terms of growth type, the results obtained in this study are similar to those reported by Duzgunes and Karacam (1990), Ozdemir and Duyar (2013), Demirel and Dalkara (2012) and Samsun and Akyol (2017). However, the results of our research are different from the other results given in Table 2.

Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes more slender as it increases in weight while positive allometric growth implies the fish becomes relatively stouter or deeper bodied as it increases in length (Riedel et al., 2007). The value of *b* greater than three indicates that the fish become plump as they increase in length and *b* value smaller than 3 shows that the fish gets slimmer with increasing length (Jobling, 2002). There are many factors affecting the value of *b* throughout the fish life. Several important factors such as gonad development and the availability of food in their natural habitats can greatly affect the *b* value (Rosli and Isa, 2012). In recent years, the population of whiting in the south-eastern Black Sea is mostly composed of small individuals, due to overfishing pressure. Therefore, growth was found to be negative allometric.

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**Table 2.** Total length-weight relationship values for the whiting from different locations

| Researchers | Region | a | b | Growth type |
|---|---|---|---|---|
| Duzgunes and Karacam, 1990 | Middle Black Sea | 0.2721 | 2.5730 | - Allometric |
| Samsun, 1995 | Middle Black Sea | 0.0045 | 3.1870 | + Allometric |
| Ciloglu, 1997 | East Black Sea | | 3.2440 | + Allometric |
| Samsun and Erkoyuncu, 1998 | Middle Black Sea | 0.0039 | 3.2384 | + Allometric |
| Genc et al, 1998 | East Black Sea | 0.0052 | 3.1420 | + Allometric |
| Ciloglu et al., 2001 | East Black Sea | 0.0037 | 3.2590 | + Allometric |
| Genc et al., 2002 | East Black Sea | 0.0058 | 3.0767 | + Allometric |
| İsmen, 2002 | East Black Sea | 0.0042 | 3.2400 | + Allometric |
| Atasoy et al., 2006 | Marmara Sea | 0.0050 | 3.1400 | + Allometric |
| Kalaycı et al., 2007 | Middle Black Sea | 0.0067 | 3.0248 | + Allometric |
| Ak et al., 2009a | East Black Sea | 0.0040 | 3.1690 | + Allometric |
| Ak et al., 2009b | East Black Sea | 0.0037 | 3.2663 | + Allometric |
| Samsun, 2010 | Middle Black Sea | 0.0043 | 3.2016 | + Allometric |
| Demirel and Dalkara, 2012 | Marmara Sea | 0.0120 | 2.8360 | - Allometric |
| Saglam and Saglam, 2012 | East Black Sea | 0.0064 | 3.0441 | İzometric |
| Ozdemir and Duyar, 2013 | Middle Black Sea | 0.0104 | 2.8555 | - Allometric |
| Yesilcicek et al., 2015 | East Black Sea | 0.0046 | 3.1950 | + Allometric |
| Yıldız and Karakulak, 2017 | West Black Sea | 0.0040 | 3.2533 | + Allometric |
| Samsun and Akyol, 2017 | Middle Black Sea | 0.0113 | 2.8660 | - Allometric |
| Ozdemir et al., 2018 | Middle Black Sea | 0.0068 | 3.0202 | İzometric |
| | Medreseonu | 0.0149 | 2.7429 | - Allometric |
| This study | Persembe | 0.0094 | 2.9097 | - Allometric |
| | Piraziz | 0.0107 | 2.8600 | - Allometric |

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