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**BIOLOGY OF THE WHITING (*Merlangius merlangus euxinus*,
Nordmann 1840) IN THE MARMARA SEA (TURKEY)**

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Abstract

*In this study; age, length, weight distributions; the relations between the age-length, the age-weight, the length-weight, condition index and the reproduction characteristics of the whiting (*Merlangius merlangus euxinus* Nordmann, 1840) caught on the Marmara Sea were investigated.*

The condition index of the whiting was found 0.746 in 920 investigated males and females.

The growth of the whiting was found to be allometric and its relationships between age-length, age-weight, length-weight positive and strong.

The stock in the investigated area consisted mainly of fish in age groups I-V and the abundance of fish was found in age groups I and II. The length-weight relationship was $W=0.005L^{3.14}$ and total mortality rate was found %66.9.

The spawning time of whiting extended from January to December, with a maximum in November-January and March-April.

According to our researchs it has been concluded that the whiting's fishing length must be minimum 17 cm.

Keywords: Whiting, Biology, Marmara Sea, Turkey

1. INTRODUCTION

Turkey's fish production changes by years and 60-80% of it is comprised of pelagic fishes. The main fish types hunted in Turkey's seas can be stated as anchovy, horse mackerel and grey mullet in the Black Sea that has the highest share; sardine and grey mullet in the Mediterranean Sea; sardine in the Aegean Sea and anchovy, horse mackerel and grey mullet in the Marmara Sea. The prominent deep fishes are turbot, whiting and red mullet in the Black Sea; striped red mullet, hake and barracuda in the Aegean Sea and the Mediterranean Sea and whiting in the Marmara Sea [1].

The types hunted in the greatest numbers in our seas are anchovy, sardine, horse mackerel and whiting [2].

The whiting located in the Marmara Sea, which is some sort of bridge, comes from the Black Sea in which stock amount is high and hunting is performed intensively. It cannot be said that the amount of pelagic and demersal fish stocks in the Marmara Sea, which constitutes 15% of the Turkey's fishing [1], is determined properly. However the whiting (*Merlangius merlangus euxinus*, Nordmann, 1840), which comes just after some pelagic fish types, also lives in deep waters of the Marmara Sea and is hunted in high numbers, is of great importance [1].

In this study, the growing up, sexual distribution, reproduction and maturing characteristics and death rate of the whiting population in the Marmara Sea are examined. The findings of this study will be a basis for the future population dynamics studies about the distribution, growing up, amount and stock composition of this type in the Marmara Sea.

2. MATERIAL DEFINITION AND METHODS

The whiting (*Merlangius merlangus euxinus*, Nordmann, 1840), which belongs to the Gadidae family, is a bento-pelagic or demersal sea fish [3]. It has three dorsal fins and two anal fins. Its first dorsal fin is located just behind its head. Pelvic fins come before the pectoral fins. Its eggs are spherical and they do not include more than one fat drop. Its head length is more than its head height. Its lower jaw is more rear than its upper jaw. Its eyes are big. There is no thorny ray in its fins. Its tail fin is either curdled or a little hollowed. The fact that there is a black spot on its pectoral fin base is one of its traits of characteristics [4].

2.1 HOW THE SAMPLES WERE ATTAINED

In the process of sampling of the whiting, which is hunted by means of deep trolls in the Marmara Sea, whiting fishes had been sampled from the products, which are turned into fishes within the commercial fisher boats, in the periods between 1st January 2003 and 1st March 2003, and between 1st August 2003 and 1st December 2003 for 8 months once a month according to the random sampling method and the sampled fishes were taken to the laboratory of the Biology Department of the Natural Sciences and Literature Faculty taken part in the Marmara University at the same day of collecting samples. These were examined and divided according to their sexes. In this period, 920 whiting fish subjects were accumulated in total in terms of monthly sampling method. It was paid attention to the fact that the subjects could represent the population in quality and in quantity.

2.2 HOW THE SAMPLES WERE EVALUATED

First of all, total length measurements of the samples transported to the laboratory were taken. The length measure unit was cm. The subjects whose lengths were measured had been stayed on a blotting paper for about five minutes and then, their total weights were measured by using a 0.0001 g. sensitive balance. Later on, the oto-liths for age settling were inferred and they were taken into the envelopes on which the data about date, length and weight are written.

2.2.1. MORPHOLOGICAL EVALUATION

2.2.1.1. AGE SETTling

The oto-liths were utilized in settling ages of the fishes. Various techniques can be used when an age settling procedure is performed on the basis of oto-liths. The common methods in this area are direct observation, dyeing, splitting-burning, acidification and taking section under a stereoscopic microscope [5]. Among these, the most suitable method for whiting fish is the splitting and burning method [6, 7]. This method is particularly useful for evaluation of the mature subjects and the oto-liths that cannot be seen properly under microscope.

2.2.1.2. SEX SETTling

The abdominal sites of all subjects were opened by using a laboratory scissors in order to determine their sexes. Afterwards the gonads were extracted, and structural differences of the genitals were examined with naked eye for sex setting. The fishes whose gonads have a granular structure were taken as females and the other fishes were evaluated as male subjects.

2.2.1.3. REPRODUCTION PERIOD

The Monthly Gonad-somatic Index (GSI) values were accounted by benefiting from the connection between the gonad weights and total weights of the subjects.

When GSI values were accounted, the following equalization was utilized [8]:

$$GSI = \left(\frac{GW}{BW} \right) \times 100$$

In this equalization 'GW' is gonad weight (g) and 'BW' is body weight (g).

2.2.1.4. CONDITION FACTOR SETTling

Fulton's Condition Factor informs about the change in the nutrients stocked in the muscle tissues of fishes. The following equalization was utilized in settling of the Condition Factor [9, 10].

$$K = \left(\frac{W}{L^3} \right) \times 100$$

In this equalization 'W' represents the weight (g) of fish and 'L' represents total length (cm).

2.2.1.5. EGG FERTILITY (FECUNDITY)

In order to calculate egg fertility of the whiting fish, firstly the ovaries of the female subjects whose weights had already been measured were removed with the help of forceps and later on, the weights of these ovaries were determined. One sub-sample was taken from front, midst and back of the ovary (i.e. 3 sub-samples in total). Some fountain water was dropped on the eggs in the sub-sample located on counting micro-slide in order to enable them to spread easily and homogeneously. Afterwards the sampled eggs were examined under a binocular microscope (10×10) by using a 1/10 scale micrometric ocular. Thus, the egg quantity in the sub-sample was estimated. The diameters of 10 eggs were measured and an average egg diameter was attained by calculating average of these diameters. By using the egg quantity value in the sub-sample, total Egg Fertility (F) of the respected subject's ovary was calculated on the basis of the equalization below [8].

$$F = \left(\frac{G \times N}{g} \right)$$

In this equalization 'G' is the gonad weight (g), 'N' is the quantity of the eggs in sub-sample and 'g' represents the sub-sample weight (g).

By using the calculated Fecundity value, the connection of fertility with age, length and weight was determined.

2.2.1.6. DEATH RATE

The annual rate of the deaths occurred due to the hunting and natural reasons among the subjects, which constitute the whiting population in the Marmara Sea, was calculated according to the Graham (1956) method which was mentioned by [11]. By means of this method, the rate of the deaths happened among fishes and the average "whole death" rate in the population at age intervals in one year were settled.

2.2.2. GROWING UP

Age groups were formed by using the subjects whose ages were determined and average length and weight values for every age group were calculated.

The scale of growing was examined on the basis of the length and weight for each sex and for both two sexes. In the mathematical examination of the growing in length, von Bertalanffy's growing parameters and equations that indicate age-length relation and age-weight relation were used. Thus maximum and minimum length (L_{∞}) and weight (W_{∞}) values which can be attained by the whiting fish in the Marmara Sea were accounted. The differences among the length and weight values of the subjects were set through measurements and calculations [12 ,13].

Age-length relation equation:

$$W_t = W_{\infty} [1 - e^{-k(t-t_0)}]^n$$

Age-weight relation equation:

$$L_t = L_{\infty} [1 - e^{-k(t-t_0)}]$$

In these equations, the meanings of the symbols can be stated as;

L_t : Average length (cm) of a fish at (t) age,

t : Age of the fish (year),

t_0 : The age in which the length of the fish is accepted as zero conceptually,

L_{∞} : The conceptual maximum length (cm) that the fish could access in eternity,

W_t : Average weight (g) of a fish at (t) age,

W_{∞} : The conceptual maximum weight (g) that the fish could access in eternity,
 n : The statistical parameter that indicates body shape of the fish and that can change according to the nutrient condition of the environment where the fish lives,
 k : Coefficient of growing (year⁻¹),
 e : Logarithm base,

2.2.2.1. THE SETTLING OF THE RATE OF GROWING

The growing of the subjects in length and in weight was reviewed as absolute growing and proportioned growing. Annual growing rates were found by measuring lengths and weights of the fishes directly. In the calculation of the proportioned growing, the following equations were used [11].

$$\text{The proportioned length increase} = \frac{L_t - L_{t-1}}{L_{t-1}} \times 100,$$

$$\text{The proportioned weight increase} = \frac{W_t - W_{t-1}}{W_{t-1}} \times 100$$

In these equations “ L_{t-1} ” indicates the average length (cm) of the fish 1 year before its t age and “ W_{t-1} ” represents the average weight (g) of the fish one year before its t age.

2.2.2.2. AGE-WEIGHT RELATION

In order to determine the relation between the age and weight in the studied subjects, the equation of growing which was developed by Huxley was used [12]. This equation is stated as $W = a \times L^b$. In this equation “ W ” represents average weight (g), “ a ” indicates condition coefficient, “ L ” is average length (cm) and “ b ” is the mathematical value that gives body shape of the fish. For the statistical significance controls of the acquired results, t-test was used [14].

3. RESEARCH FINDINGS

3.1. AGE DISTRIBUTION

In the study made on 920 female and male whiting samples which were attained from the Marmara Sea, the subjects belonged to I-V age groups were determined. The age settling of all fish samples were carried out and the distribution of the samples according to the age groups and sexes was given in Table 1.

Age Groups	Female		Male		Female+Male	
	N	%	N	%	N	%
I	103	28.6	274	49.91	377	38.78
II	173	48.1	265	47.32	438	45.06
III	51	14.1	12	2.14	63	6.48
IV	24	6.7	6	1.07	30	3.08
V	9	2.5	3	0.53	12	1.23
Total	360	39.13	560	60.90	920	100.00

Table 1 The Distribution of the Whiting According to the Age Groups and Sexes

3.2. THE SETTLING OF THE REPRODUCTION PERIOD (GSI)

The age settling of 360 female subjects used in this study was made, and on the basis of the GSI data acquired, it is observed that their giving egg periods have continued in the whole year but maximum reproduction occurs in the November - January period and March – April period.

Year	Months	GSI (%)
2003	January	5.291 ± 0.312
	February	2.824 ± 0.176
	March	4.389 ± 0.278
	April	3.503 ± 0.438
	September	1.218 ± 0.108
	October	1.451 ± 0.165
	November	5.017 ± 0.250
	December	4.633 ± 0.136

Table 2 The GSI Values of the Whiting

3.3. EGG FERTILITY (FECUNDITY)

In determining egg fertility, it is found that the subject's length measurement values were between 11 cm and 17 cm and the ages of these subjects were between I. and II. scales. The average egg fertility value that was calculated by utilizing these samples was found as 14.582 ± 1220 .

In respect of $F=aL^n$ equation that is between Egg Fertility (F) and Length (L) expressed exponentially, when logarithms of two sides are taken, the relation turns into a linear equation as $\log F = \log a + n \log L$, namely into $\log F = 1.504 + 2.269 \log L$.

The $F=aA^n$ relation between the egg fertility (F) and age (A) turns into an equation as $\log F = 4.331 + 1.101 \log A$.

The fact that there is a full logarithmic relation between egg fertility and length indicates that average egg fertility of a mature female fish whose length is known can be calculated. In this respect, when the length raises the egg fertility increases.

3.4. EGG DIAMETER

When the eggs of the fishes used in the study were examined, it was seen that the diameters of them are between 1.11 mm and 1.32 mm and the average egg diameter is 1.22 ± 0.01 .

3.5. GROWING

The growing of the whiting population in the Marmara Sea was evaluated under the headings of the growing in length and the growing in weight of the samples and both of these headings were investigated as annual growing and proportioned growing.

3.5.1. THE GROWING IN LENGTH

The growing in length was taken as absolute growing and proportioned growing.

3.5.1.1. THE ABSOLUTE LENGTH GROWING

Von Bertalanffy's parameters of growing in length that indicates the relationship between the age and length were calculated by using the average length values of the samples, which were taken from the Marmara Sea, on the basis of the age and these parameters were given in the Table 3.

Sexes	L_{∞} (cm)	k	to (year)	Relations
Female	39.8	0.13	-0.87	$L_t = 39.8 [1 - e^{-(t+0.87) \cdot 0.13}]$
Male	32.2	0.15	-1.01	$L_t = 32.2 [1 - e^{-(t+1.01) \cdot 0.15}]$
Total	38.5	0.15	-1.47	$L_t = 38.5 [1 - e^{-(t+1.47) \cdot 0.15}]$

Table 3 von Bertalanffy's Parameters and Relations of Growing with Regard to the Samples Acquired from the Marmara Sea

The whiting fishes' average total length values which were measured directly and calculated for the same age groups with the help of von Bertalanffy's equation of length growing are indicated in the Table 4. It was found that there is no significant difference between the length values found by measuring and the ones found through calculation ($P > 0.05$).

Sexes	Age Groups				
	I	II	III	IV	V
Females					
The Measured Length	8.89	13.18	17.14	20.46	22.59
The Calculated Length	8.67	13.21	17.01	19.65	22.09
Males					
The Measured Length	9.11	14.09	18.00	21.27	23.65
The Calculated Length	9.04	14.00	18.22	21.02	23.76
Total					
The Measured Length	9.62	14.76	18.85	22.24	24.72
The Calculated Length	11.83	15.16	19.16	23.21	24.10

Table 4 The Whiting Fishes' Average Total Length Values (cm) Measured According to the Age and Sex and Calculated on the Basis of von Bertalanffy's Parameters

3.5.1.2. THE PROPORTIONED LENGTH GROWING

The rates of growing which were calculated by using the average length values of the Marmara Sea's whiting fishes at various ages were found as 20.45%, 18.37%,

10.67%, 8.74% and 4.08% for ages of I, II, III, IV and V, respectively. In this regard, it is seen that the average length rates between the ages of I and II are significantly high.

3.5.2. THE ABSOLUTE WEIGHT GROWING

The hypothesized maximum weight value (W_{∞}) and t_0 , k and n values of the whiting fishes caught in the Marmara Sea and the relations respecting these values are given in the Table 5.

Sexes	W_{∞}	k	t_0 (year)	Relations
Female	428.47	0.13	-0.87	$W_t = 428.47 [1 - e^{-0.106(t+2.17)}]^{3.04}$
Male	439.70	0.15	-1.01	$W_t = 439.70 [1 - e^{-0.055(t+1.682)}]^{3.17}$
Total	431.00	0.15	-1.47	$W_t = 431.0 [1 - e^{-0.122(t+1.785)}]^{3.14}$

Table 5 von Bertalanffy's Parameters and Relations of Growing with Regard to the Samples Acquired in the Marmara Sea

The average weight values of the whiting subjects in the Marmara Sea according to the age groups and the calculated weight values of them are given in the Table 6. It was seen that there is no significant difference between the weight values found by measuring and the ones found through calculation ($P > 0.05$).

Sexes	Age Groups				
	I	II	III	IV	V
Females					
The Measured Weight	13.49	20.23	35.31	77.74	103.10
The Calculated Weight	11.02	21.58	38.54	78.02	112.04
Males					
The Measured Weight	12.58	18.28	32.96	63.80	89.51
The Calculated Weight	10.34	16.22	28.05	56.33	89.05
Total					
The Measured Weight	14.92	21.98	39.08	75.64	125.38
The Calculated Weight	13.90	23.65	41.61	76.05	110.21

Table 6 The Whiting Fishes' Average Total Weight Values (g) Measured According to the Age and Sex and Calculated by means of von Bertalanffy's Parameters

3.5.2.1. THE PROPORTIONED WEIGHT GROWING

The rates of growing which were accounted by utilizing the average weight values of the Marmara Sea's whiting fishes at various ages were found as 92.15%, 77.08%, 41.22%, 33.42% and 20.04 for the ages of I, II, III, IV and V, respectively. In this manner, the growing rate between the ages of I and II is significantly higher in comparison to the related value in other ages.

3.6 THE LENGTH-WEIGHT RELATION

The relations accounted by using the above-mentioned length-weight equation regarding the whiting population in the Marmara Sea are given in the Table 7.

Sexes	N	a	b	Relations
Female	360	0.006	3.04	$W=0.006L^{3.04}$
Male	560	0.004	3.17	$W=0.004L^{3.17}$
Total	920	0.005	3.14	$W=0.005L^{3.14}$

Table 7 von Bertalanffy's Growing Parameters and Relations of the Whiting Fishes in the Marmara Sea

3.7 CONDITION

920 whiting fishes' average condition factors calculated by using individual length and weight measurements were found as 0.736 ± 0.0026 in males, 0.758 ± 0.0020 in females and 0.746 ± 0.0019 in total.

3.8. DEATH RATE

Total death rate of the 920 subjects acquired from the Marmara Sea was found as 66.9% (Table 8).

Age Groups	I	II	III	IV	V	Total (N)
The Number of Subject (N)	377	438	63	30	12	920
The Subject Rate (0%)	409.7	476	68.4	32.6	13	1000
The Age Groups Remainder (0%)		407.6	35.6	19.6		
The Death Rate between Ages (%)		85.61	52.38	60.0		
Total Average Death Rate (%)			66.9			

Table 8 The Average Death Rate of the Whiting Fishes in the Marmara Sea (%)

4. DISCUSSION

In this study, the biological traits and some population parameters like age-length relation, age-weight relation, length-weight relation, reproduction period and condition factor of the whiting fish which of great importance for Turkey's fishing domain were examined. 920 subjects were investigated in total and it was observed that the age groups

of these subjects are between I and V. It is seen that this age composition is in accordance with the data established by [15]. [16] mentions with regard to the sampled subjects in his study made in the Central Black Sea that the highest amount of subjects is of II age group and this is followed by age groups of I, III, IV, V and VI in rank. In the studies made on whiting populations in different sides of Turkey, [17] found the subjects belonged to 0-VIII age groups in the Eastern Black Sea; [18] found the subjects of the I-VII age groups at the Central Black Sea between 1988 and 1989; [16] found the subjects of the I-VI age groups at the Central Black Sea between 1991 and 1994; [15] found the subjects belonged to the I-VI age groups in the Samsun Bay; [19] found the subjects of I-IX age groups in the Black Sea and those of the I-VI age groups in the Sinop region and finally [20] found subjects of the I-IX age groups at the eastern coasts of Trabzon. As it is the case in our study, the mentioned researchers generally indicate that the amount of the subjects belonged to the II age group is higher. Only [19] and [20] declared the subjects of the age group I are dominant in the Black Sea and at the eastern coasts of Trabzon, respectively. This can be caused by the fact that the research areas are different.

According to the GSI data obtained, it is seen that the giving egg of the whiting fish continues irregularly in whole year but it reaches maximum amount between November and January and between March and April (Table 2). However this period is between September and March according to the results of the research made in the Eastern Black Sea (Sinop-Hopa) by [17]. Samsun (1996) said in his study carried out in the Sinop area that the giving egg period of the whiting fish is between November and May. [20] found that the giving egg period of the whiting fish starts on October and continues until June and the reproduction in this period is more intensive between November and December and between March and June in the study performed in the eastern coasts of Trabzon. Regarding this matter, [19] mentions that the giving egg period spreads from October till July and it scores its maximum point between January and February in his study made on whiting fishes in the Black Sea. The different reproduction period found in our study can be stemmed from the fact that climatic characteristics and physical features like temperature of the Marmara Sea are dissimilar in comparison to the Black Sea.

At the end of the calculations achieved by utilizing 920 whiting fishes taken from the Marmara Sea, the average egg fertility was found as 14.582 ± 1.220 in amount. Yet the concerned value was found as 12.000 by [17] in his study made in the Eastern Black Sea (Sinop-Hopa) while [19] mentioned that it was 263.000 in the whole Black Sea. This situation can be caused by the fact that the fishes grow in different zoo-geographical areas or they feed with dissimilar nutrients.

In the light of our findings, the average egg diameter of the whiting fish is 1.22 ± 0.01 . [21] stated in the study made in the Black Sea that the egg diameter is between 1.10 mm and 1.33 mm. This is between 0.97 mm and 1.32 mm according to the study carried out in the Black Sea by [19]. Thus the egg diameter values reached in our study are in conformity with the values given by both [21] and [19].

It is obtained that the whiting fishes in the Marmara Sea achieve the highest proportioned length raise between the ages of I and II and that this rate decreases in the following ages regularly. The proportioned length growing values found in our study are in accord with the values indicated in the study made by [22] in the Sinop area.

The average weights of the whiting fishes in the Marmara Sea on the basis of the age groups, and the parameters of growing used in calculating the relation between the age and the weight are all in accordance with the values acquired in the studies by [17] in the Eastern Black Sea (Sinop-Hopa), by [18] in the Central Black Sea in the period between 1988 and 1989, by [15] at the Samsun Bay, by [22] in the Sinop area and by [20] at the eastern coasts of Trabzon. Our values of proportioned weight growing are in conformity with the data attained by [22] in the research performed the Sinop area.

The exponent value acquired the length-weight relation of the whiting fishes in the Marmara Sea was found as 3.14 (Table 7). This shows that whiting is a fat (plump) fish. The researchers found different “b” exponential values in their studies on whiting fishes. For instance the concerned value was found as 3.24, 3.238 and 3.244 by [19] in the Black Sea research, by [22] in the Sinop research and by [20] in the Trabzon study, respectively.

At the end of the research, it becomes clear that the whiting population reaches sexual maturity at the age of II and the average length of this age group is 13-14 cm (Table 4). The age of reaching sexual maturity was given as II by [17] at the end of the study made in the Eastern Black Sea (Sinop-Hopa), by [18] in the conclusion of their study performed in the Central Black Sea and by [15] at the end of the research carried out at the Samsun Bay.

The average condition value of the whiting fishes in the Marmara Sea is calculated as 0.746. The condition value was accounted as 0.74 by [22] for the Sinop area while it was found as 0.79 by [20] for the eastern coasts of Trabzon.

The total death rate of the whiting population of the Marmara Sea was determined as 66.9% in this study. The concerned value was given as 1.17 for Giresun-Hopa area and as 1.28 for Sinop-Giresun area by [17] in the Eastern Black Sea research, as 1.20 for the Central Black Sea by [18], as 1.32 for the Samsun Bay by [15], as 2.01 for the Central Black Sea by [16] and as 1.63 for the Black Sea by [19].

5. CONCLUSION

This study performed with the purpose of determining bio-ecological characteristics of the whiting (*Merlangius merlangus euxinus*, Nordmann, 1840) population in the Marmara Sea was carried out between January 2003 and December 2003. It was found that the 920 whiting samples are at the ages between I and V, the highest number of subjects is of age groups of I and II and the reproduction period of the population is between November and January and between March and April. It is also observed that the average length and weight values of these samples on the basis of the age groups are lower than the related values of the samples taken part in our other seas.

According to the study result, the smallest hunt size of the whiting fish that reaches sexual maturity at the age of II must be 17 cm.

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