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Food Composition of the Whiting, *Merlangius merlangus* in the South-eastern Coast of the Black Sea

Necati DEMİR[1], İsmet BALIK[2*]

[1]Ministry of National Education, Ordu Anatolian High School, Ordu, Turkey
[2]*Akdeniz University, Kemer Maritime Faculty, Dumlupınar Bulvarı, 07058 Kampüs, Antalya

Corresponding author: E-mail: ibalik@akdeniz.edu.tr

Research Article

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Abstract

In this study, the food composition of whiting, *Merlangius merlangus*, from the South-eastern coasts of the Black Sea was seasonally investigated. With this aim, stomach contents of 762 specimens, the total length of 12.7-18.6 cm, and the body weight of 17-56.5 g, collected between September 2016 and August 2017 were analyzed. It was determined that 75.7% (577 stomachs) of the stomachs examined were empty. The percentage of empty stomachs didn't show seasonal variation with maximal occurrence in autumn (76.9%) and minimal in winter (74.5%). The prey items identified macroscopically in the stomachs were horse mackerel, *Trachurus mediterraneus*, anchovy, *Engraulis encrasicolus*, whiting, *Merlangius merlangus*, sprat, *Sprattus sprattus*, goby, *Gobius* sp. from fish species and Gastrapod from Mollusca. Horse mackerel was the most important ingested prey (IRI%=43.2), followed by anchovy (IRI%=32.0) and whiting (IRI%=19.3). In the diet of the whiting, the sprat and the goby were less important than other fish species. The most important food was horse mackerel in the spring and summer seasons, while it was anchovy in the autumn and winter seasons. Cannibalism was the highest (F%=25) in the spring period and followed by summer (F%=23.8), autumn (F%=21.6) and winter (F%=16.2), respectively. It was determined that whiting consumed individuals of their species as food, up to 37.6% of their length and 11.2% of their weight.

Keywords: South-eastern Black Sea, Whiting, *Merlangius merlangus*, Food composition, Cannibalism.

Karadeniz'in Güney-doğu Kıyılarında Mezgit Balığının, *Merlangius merlangus* Besin Kompozisyonu

Özet

Bu çalışmada, Karadeniz'in güney-doğu kıyılarındaki mezgit, *Merlangius merlangus* balıklarının besinleri ve besleme alışkanlıkları mevsimsel olarak araştırılmıştır. Bu amaçla, Eylül 2016-Ağustos 2017 arasında avlanan ve boyları 12,7-18,6 cm, ağırlıkları 17-56,5 g arasında değişen 762 bireyin mide içeriği analiz edilmiştir. İncelenen midelerin %75,7'sinin (577 mide) boş olduğu belirlenmiştir. En fazla boş mideye sonbaharda (%76,9), en az boş mideye ise kış (%74,5) mevsiminde rastlanmıştır. Mezgit balığı midelerinde makroskopik olarak yapılan incelemelerde besin olarak balık türlerinden istavrit, *Trachurus mediterraneus*, hamsi, *Engraulis encrasicolus*, mezgit, *Merlangius merlangus*, çaça, *Sprattus sprattus* ve kaya balığı, *Gobius* sp. ile mollusklardan Gastrapoda tespit edilmiştir. En önemli besinin istavrit (%IRI=43,2) olduğu, onu hamsi (%IRI=32,0) ve kendi türünün (mezgit) (%IRI=19,3) izlediği saptanmıştır. Mezgit balığı diyetinde çaça ve kaya balığının önemi diğer balık türlerine göre daha düşük bulunmuştur. İlkbahar ve yaz mevsimlerinde en önemli besin istavrit iken, sonbahar ve kış mevsimlerinde hamsidir. Kanibalizm ilkbaharda en yüksek (%F=25) iken, bunu sırasıyla yaz (%F=23,8), sonbahar (%F=21,6) ve kış (%F=16,2) mevsimleri izlemiştir. Mezgit balıklarının kendi türüne ait boylarının %37,6'sına, ağırlıklarının %11,2'sine kadar olan bireyleri besin olarak tükettikleri belirlenmiştir.

Anahtar kelimeler: Güney-doğu Karadeniz, Mezgit, *Merlangius merlangus*, Besin kompozisyonu, Kanibalizm

INTRODUCTION

Studies on feeding habits of marine fish, such as predator-prey relationships are useful to assess the role of marine fish in the ecosystem (Bachok et al., 2004). However, data on food composition are useful for developing trophic models as a tool for understanding the complexity of coastal ecosystems (Lopez-Peralta and Arcila, 2002; Stergiou and Karpouzi, 2002). Diet analysis is also necessary for

exploring the trophic overlap within and between species and determining the intensity of the inter-and intraspecific interactions in marine fish communities (Morte et al., 2001)

The whiting is distributed from Norway and Iceland to the Mediterranean and into the Adriatic, the Aegean, the Azov, and the Black Seas (Milić and Kraljević, 2011). This species, which is found intensely on the shores of the Atlantic Ocean, is very rare in the northern coasts of the Mediterranean and more intensely in the northern coasts of the Black Sea. Whiting, *Merlangius merlangus* is the most important fish species for small-scale fisheries on the Turkish coast of the Black Sea.

There are few studies on the diet of whiting in the Black Sea (İşmen, 1995; Banaru and Harmelin-Vivien, 2009; Samsun et al., 2011; Mazlum and Bilgin, 2014; Şensurat-Genç et al., 2019), although it is one of the most important target species. Spatial and temporal monitoring of changes in the trophic levels of the fishes are closely related to their vitality or sustainability. Trophic relationships can be disrupted by pollution, anthropogenic effects, and interspecific competition (Şensurat-Genç et al., 2019). Şensurat-Genç et al. (2019) stated that whiting mainly consumes small fish and crustaceans in the Black Sea. However, in recent years fishing pressure on small-bodied fish species such as red mullet, *Mullus barbatus*, horse mackerel, *Trachurus mediterraneus* and sprat, *Sprattus sprattus* has increased. For this reason, the populations of these fish species, which are the important foods of whiting, have decreased. Cannibalism increases in the population of whiting which feeds almost only on small fish, if there is not enough food in the environment (Bromley et al., 1997). It is inevitable to be affect the whiting diet from this decrease. Therefore, it is beneficial to investigate the biological and ecological characteristics of fish species that may occur due to environmental factors. This study aimed to investigate the food variety and cannibalistic behavior characteristics of the whiting living in the South-eastern Black Sea.

MATERIALS AND METHODS

Sampling

Whiting samples were collected monthly from gillnet fisheries in Ordu coasts and from gillnet fisheries and bottom trawl fisheries in Samsun coasts, between September 2016 and August 2017 (Figure 1).

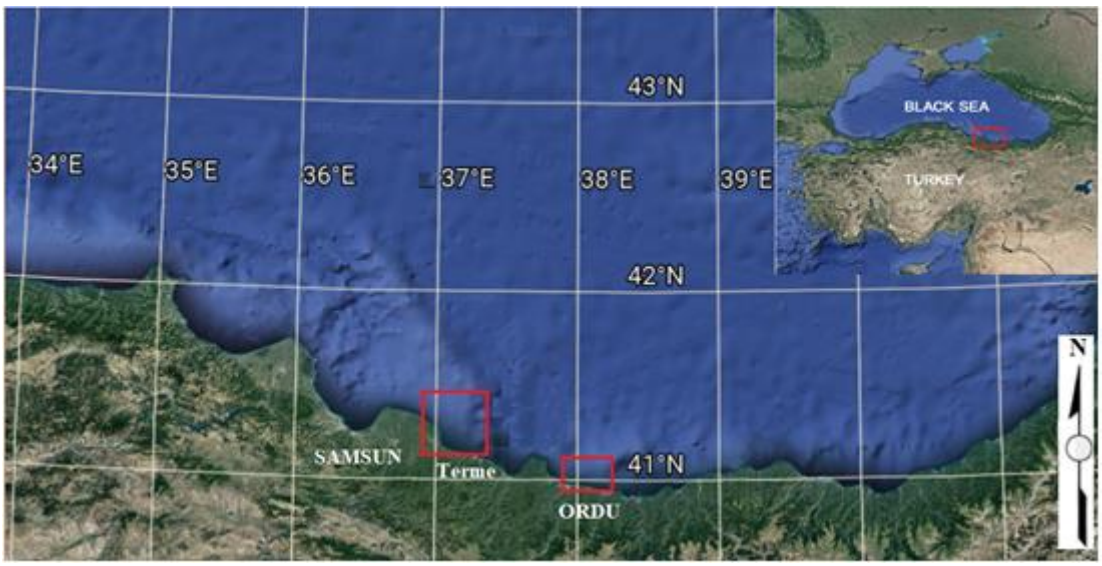

Figure 1. Study areas

After the fishing operation, the whiting samples were randomly taken immediately after the gillnet boats and bottom trawl vessels entered fishing ports. Total length to the nearest cm and body weight to the nearest gram were recorded from fresh fish. Then the stomachs were removed immediately from all fish and preserved in 4% formaldehyde solution for later analysis. In the laboratory, only macroscopic food items in the stomachs were identified to the lowest possible taxonomic level after

which they were counted and weighed after removal of surface water using blotting paper (Hyslop, 1980).

Stomach data analysis

Macro-food-containing stomachs were categorized as "full" and not containing "empty". The importance of the different prey types was evaluated calculating the percentage frequency of occurrence (F%) = (Number of stomachs containing prey *i*/total number of non-empty stomachs)* 100, Percentage numerical abundance (N%)=(Number of prey *i*/Total number of prey items in all stomachs)*100 and Percentage gravimetric composition (W%)=(Wet weight of prey *i*/Total weight of all preys)*100 (Hyslop, 1980). The index of relative importance (IRI) of prey type *i* as given by Cortés (1997) is derived as follows: IRI=F%*(W%+N%). Also, the percentage of relative importance index: IRI%=(IRI/ΣIRI) *100 was determined.

Cannibalism

Proportionally relationships between predator and prey whiting in length and weight were determined.

Statistical analysis

Proportional food overlap among between seasons was calculated using Schoener's dietary overlap index (C) (Schoener, 1979): $C_{xy}=1-0.5*\sum|P_{xi}-P_{yi}|$, where P_{xi} and P_{yi} are the proportion of prey *i* (based on IRI%) found in the diet of groups *x* and *y*. This index ranges from 0 (no prey overlap) to 1 (all food items in equal proportions). Schoener's index values above 0.6 are usually considered to indicate significant overlap (Wallace, 1981).

Percentage of relative importance index (IRI%) by weight of each prey category was computed for each individual. IRI% for all prey types was then square root transformed to reduce the importance of the most abundant prey. Bray-Curtis similarity was used to compare the differences among seasons. To test the relationship between lengths of the predator and prey whiting, Pearson correlation analysis was used for parametric data and Spearman correlation analysis was used non-parametric. Statistical analyses were carried out using the PRIMER 6.1.18 statistical package and SPSS programs.

RESULTS

A total of 762 stomach samples (380 samples from Ordu and 382 samples from Samsun) were collected during the study. Of the total number of stomachs examined (n=762), 577 were empty (75.7%). As seen in Table 1, seasonal index of the empty stomachs varied slightly over the yea**r.**

Table 1. Seasonal distributions of full and empty stomachs collected from the south-eastern coast of the Black Sea.

	Full		**Empty**	
Season	N	N%	N	N%
Spring	46	24.2	144	75.8
Summer	36	24.3	112	75.7
Autumn	49	23.1	163	76.9
Winter	54	25.5	158	74.5
Total	185	24.3	577	75.7

A total of 6 prey types (macro-organisms) were found in the stomachs of whiting collected from the south-eastern coast of the Black Sea. The percentage frequency of occurrence (F%), percentage abundance (N%), the percentage by weight (W%), and index of relative importance (IRI%) for prey types of whiting are given in Table 2. According to IRI% values, horse mackerel (43.2%), anchovy (32.0%), and whiting (19.3%) were the main prey groups of whiting in the south-eastern coast of the Black Sea.

Table 2. Food composition of *M. merlangus* in the south-eastern coast of the Black Sea expressed as F% - frequency of occurrence; N% - Numerical abundance; W% - weight percentage; IRI% - index of the relative importance

Prey	N%	F%	W%	IRI	IRI%
Fish species					
T. mediterraneus	32.3	32.3	34.8	2164.4	43.2
E. encrasicolus	29.1	29.1	25.9	1603.4	32.0
M. merlangus	21.3	21.3	24.2	965.9	19.3
S. sprattus	11.0	11.0	10.4	236.2	4.7
Gobius spp.	3.9	3.9	4.4	32.8	0.7
Mollusc					
Gastropod	2.4	2.4	0.4	6.4	0.1

It is understood that whiting consumed mostly horse mackerel in the spring season in the south-eastern coast of the Black Sea (Table 3). The second most important prey type was whiting in this season. The importance of other food types was slight. In the summer season, a food composition similar to the spring season was determined (Figure 2). However, the importance of anchovy and sprat increased in this season. Contrary, the importance of horse mackerel decreased in the summer season. Anchovy was the most important prey type in autumn and winter. This food type was followed by whiting, horse mackerel, and sprat in the autumn season and by horse mackerel, whiting, and sprat in the winter season, respectively. Other types of food had little importance in autumn and winter.

Table 3. Seasonal food composition of *M. merlangus* in the south-eastern coast of the Black Sea expressed as F% - frequency of occurrence; N% - Numerical abundance; W% - weight percentage; IRI% - index of the relative importance.

	Spring					**Summer**				
Prey	N%	F%	W%	IRI	IRI%	N%	F%	W%	IRI	IRI%
Fish species										
T. mediterraneus	53.1	53.1	57.1	5854.2	78.7	38.1	38.1	41.7	3041.4	57.5
E. encrasicolus	6.3	6.3	3.3	59.9	0.8	19.0	19.0	18.1	707.4	13.4
M. merlangus	25.0	25.0	30.1	1376.7	18.5	23.8	23.8	21.4	1077.2	20.4
S. sprattus	6.3	6.3	5.3	72.0	1.0	14.3	14.3	15.7	429.0	8.1
Gobius spp.	6.3	6.3	3.9	63.5	0.9	4.8	4.8	3.0	36.9	0.7
Mollusc										
Gastropod	3.1	3.1	0.3	10.9	0.1	0.0	0.0	0.0	0.0	0.0
	Autumn					**Winter**				
Prey	N%	F%	W%	IRI	IRI%	N%	F%	W%	IRI	IRI%
Fish species										
T. mediterraneus	18.9	18.9	20.4	743.8	13.3	24.3	24.3	21.2	1108.5	20.6
E. encrasicolus	43.2	43.2	35.4	3402.2	60.7	40.5	40.5	43.8	3420.4	63.7
M. merlangus	21.6	21.6	25.9	1028.0	18.3	16.2	16.2	18.2	557.9	10.4
S. sprattus	13.5	13.5	17.6	420.9	7.5	10.8	10.8	7.5	197.6	3.7
Gobius spp.	0.0	0.0	0.0	0.0	0.0	5.4	5.4	8.9	77.5	1.4
Mollusc										
Gastropod	2.7	2.7	0.6	9.0	0.2	2.7	2.7	0.3	8.2	0.2

However, it can be said from Schoener Overlap Index values (C>0.8) that there is a significant similarity between seasons in terms of the food sources of whiting the south-eastern coast of the Black Sea.

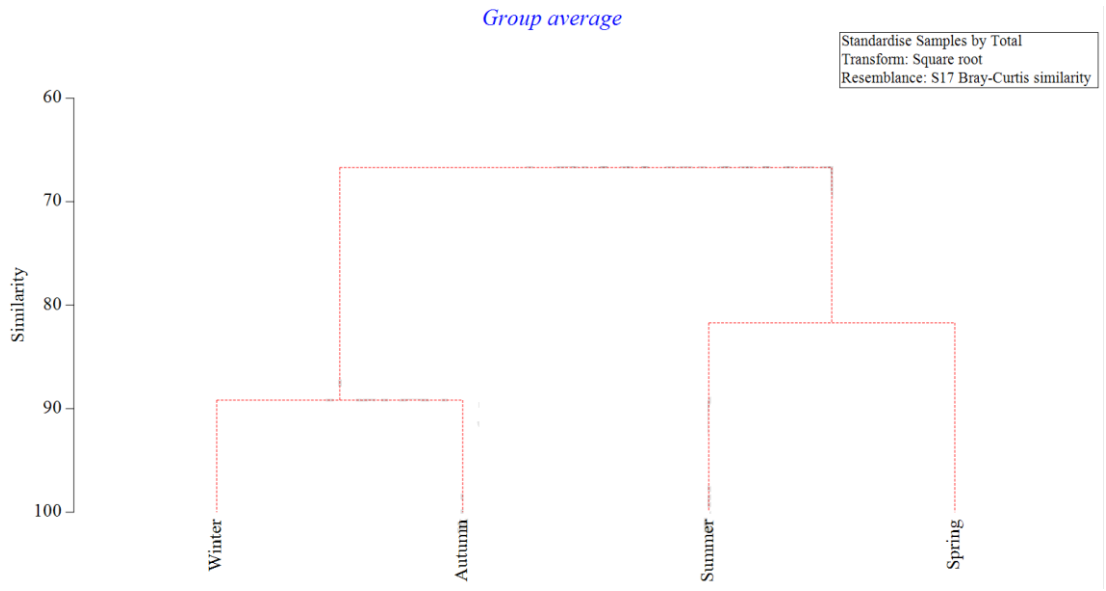

Figure 2. Similarity dendogram based on cluster analysis plot ordination of seasonal food composition collected from the south-eastern coast of the Black Sea.

Cannibalism

During the study, a total of 27 whiting foods were identified in the stomachs of whiting samples collected from Ordu and Samsun coasts. Only one whiting was observed in each stomach. Spearman correlation analysis results showed that there was no significant relationship between the lengths (r=0.072; P=0.720) and the weights (r=0.244; P=0.229) of predator and prey whiting. Cannibalism was the highest (F%=25) in the spring period. Mean length and weight values of predator and prey whiting were given in Table 4 and Figure 3. It was determined that whiting consumed up to 37.6% of their maximum length and up to 11.2% of their maximum weight.

Table 4. The mean, minimum and maximum lengths and weights of predator and prey whiting collected from the south-eastern coast of the Black Sea.

		Predator	**Prey**
	N	27	27
Total length (cm)	Mean	14.9	3.9
	Std. Error of Mean	0.3	0.3
	Minimum	12.7	1.7
	Maximum	18.6	7.0
Weight (g)	Mean	27.5	3.0
	Std. Error of Mean	2.1	0.2
	Minimum	17.0	1.33
	Maximum	56.5	6.32

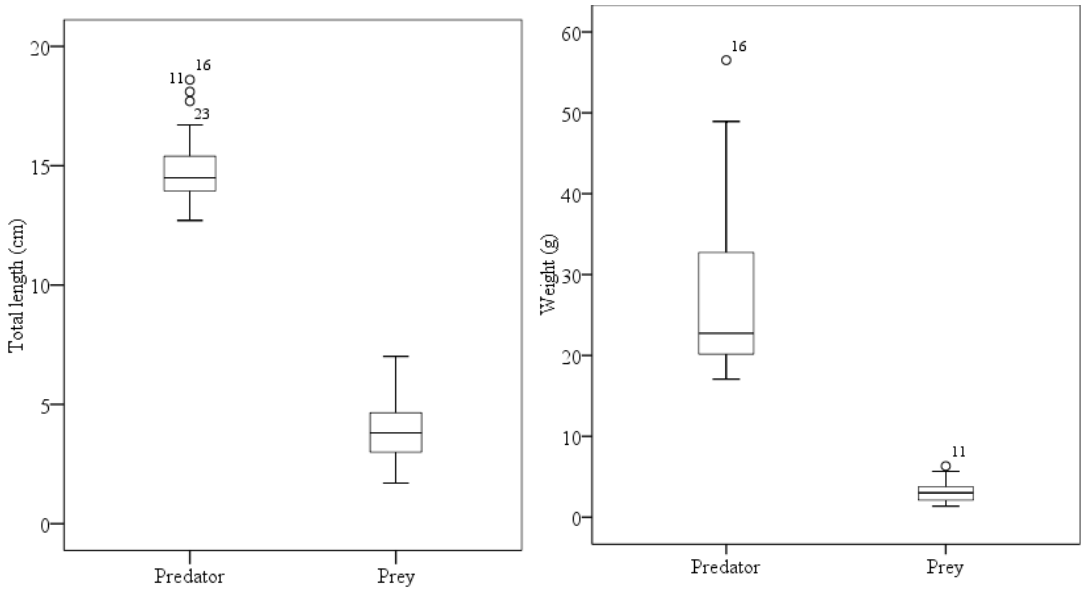

Figure 3. Boxplot graphs for lengths and weights of predator and prey whiting which consumed their own species or consumed by own species the south-eastern coasts of the Black Sea.

DISCUSSION

In terms of macro-organism content, 75.7% of stomachs examined were empty. The proportion of empty stomachs was found as 57% in the middle Black Sea between 2001 and 2003 (Samsun et al., 2011), 23.9% in an area of the south-eastern Black Sea near our sampling sites (Şensurat-Genç et al., 2019), approximately 50% in the North Sea (Hislop et al., 1991), 37.2% in 1991, 40.3% in 1992 and 1993 in the eastern Irish marine ecosystem (Seyhan, 1994). Another study reported that 50% of the stomachs examined were empty in all seasons and approximately 20% were completely full in all seasons in Rize offshore of the South-eastern Black Sea in 2004-2005 (Mazlum ve Bilgin, 2014). In the western Baltic Sea, the rate of empty stomachs was determined as 34% by Ross et al. (2018). According to that study, the rate of empty stomachs was high, possibly because whiting followed a different feeding strategy or it was fed less but larger foods. McDermott and Fives (1995) stated that only 2 of the 40-whiting had empty stomachs in the western Irish Sea. In general, it is understood that the rate of the empty stomach in our study is higher than the rates reported in previous studies conducted in the Black Sea and some other seas. There could be many reasons for this. Probably the most important factor is to consider only macro-organisms in our study. Secondly, there may be a decrease in the small, bodied fish populations that the whiting consumes as food. Our research has revealed that the whiting in the south-eastern coasts of the Black Sea is fed almost exclusively with small individuals of its own species (whiting) and other small-bodied fish species (horse mackerel, anchovy, sprat, and rockfish). Especially the decrease of anchovy in the last 25 years and sprat in the last 10 years (Balık, 2019) has negatively affected the feeding of whiting in the south-eastern Black Sea.

According to İşmen (1995), the whiting in the Black Sea mostly feeds on fish, crustaceans, and polychaetes. However, Samsun et al. (2011) reported in the central Black Sea coast of Turkey that anchovy was the dominant fish species in the diet of this species in the early 2000s. In the study carried out by Mazlum and Bilgin (2014) in the Rize offshore of the South-eastern Black Sea between 2004 and 2005, was reported that this fish species is generally fed with three fish species (anchovy, whiting, and sprat). It is reported by Bradova and Prodanov (2003) that the whiting feeds mainly on sprat but during the winter months, it consumes also anchovy especially along the Anatolian coast of Turkey and the Caucasian coast in front of Georgia. In the north-western Black Sea, the whiting diet was mainly composed of S. sprattus, polychaetes (Melinna palmata and Nereis spp.), shrimps (C. crangon), and amphipods (Ampelisca diadema). Off the Danube Delta of Romania, whiting preyed mainly on polychaetes in spring and autumn seasons, while in the south of the delta, it consumed a high quantity of S. sprattus in spring. Rare prey of whiting included bivalves, cumaceans, and mysids

in both seasons (Banaru and Harmelin-Vivien, 2009). In terms of foods of whiting, it is understood that the results of our study were similar with the results of studies conducted previously in Turkey's Black Sea coast.

The most important difference understood from these comparisons is that the importance of anchovy in the diet of whiting has decreased in recent years. This is an expected result. Because, annual the catch of anchovy in Turkey was 280.000 tons in 2000 and 229.000 tons in 2010, while it decreased to 96.5 tons in 2018 (TOB, 2020). The decrease in the catch indicates that the anchovy population on Turkish coasts of the Black Sea has decreased significantly in recent years.

In studies conducted in habitats other than the Black Sea, slightly different results are reported. For example, Hislop et al. (1991) reported that at least 85% of whiting foods consisted of fish and Crustacea in the North Sea. All of the foods were commercially important fish species (Gadus morhua, Melanogram musaeglefinus, M. merlangus, Trisopterusesmarkii, S. sprattus, Clupea harengus and Ammodyte smarinus). McDermott and Fives (1995) reported that whiting in the western Irish Sea was composed of copepods, fish, decapod and mysids. In the study conducted by Staniland (1995) on the northeastern shores of the Shetland Islands in 1991, it was found that crustaceans were dominant in the diet of small whiting and fish were dominant in the diet of whiting larger than 15 cm. It was reported that the most consumed fish species was sand eels, but large individuals also feed on gadoids and clupeids. From these results, it is understood that the main food of whiting is related to the size of the fish and seasonal abundance of food. With the increase in the size of the whiting, the importance of prey fish increased, while the importance of crustaceans and polychaetes decreased.

Seasonally, the whiting in the south-eastern Black Sea was fed mostly with horse mackerel in spring and summer, and anchovy in autumn and winter. The second most important food was its own species in the spring, summer, and autumn seasons, and the horse mackerel in the winter. The rate of cannibalism was almost equal from spring to autumn. It was lower in winter than in other seasons Samsun et al. (2011) was found that the cannibalism rate was higher in the spring and summer seasons than in the autumn and winter seasons on Turkish middle Black Sea coast. In the study conducted by Mazlum and Bilgin (2014) in Rize coasts of the south-eastern Black Sea, it is reported that sprat fish constitute the most important food sources in spring, whiting in summer, and anchovy in the autumn and winter seasons. According to Bromley et al. (1997), they nearly feed only from fish, the whiting has a multistage ovulation period during the year, the fry that comes towards the ovulation, is the nutrition sources for older fry. Food requirements of whiting vary significantly depending on the water temperature. According to Özdemir (1983), whiting needs less food in winter. Larger et al. (1988) states that during the periods when the water temperature rises, fish receive more food due to the increase in digestive enzymes.

The results of this study showed that the feeding regime of whiting depends on the abundance of other foods in the same environment. With the decrease of other foods, the tendency towards cannibalism increases. According to Hislop et al. (1991), whiting is one of the most important carnivorous fish species in the North Sea. Ross et al. (2018) report that this species is the main piscivorous species in the western Baltic Sea. As stated by many authors above, the whiting is a carnivorous species. While cannibalism is frequently a response to food or density, other factors may also be important; in many species, several such factors are known to be involved (Fox, 1975). Starvation may increase cannibalistic tendencies, but it is not essential for initiating this behavior. Many animals will cannibalize as soon as all other food items are removed, but they may also respond simply to a reduction in the relative availability of alternatives (Fox, 1975). Our study results agree with this information.

Also, it was determined that whiting consumed individuals of their own species as food, up to 37.6% of their length and 11.2% of their weight. As a result, it is understood that cannibalism among whiting will increase if the small-bodied fish species decreases further.

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