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-RESEARCH ARTICLE-

Feeding Habits of the Mediterranean Horse Mackerel, *Trachurus mediterraneus* (Steindachner, 1868) in the Sea of Marmara (Bandırma Bay, Turkey)

Hatice Torcu Koç*, Zeliha Erdoğan

University of Balikesir, Faculty of Science and Arts, Department of Biology, Cagıs Campus, 10145, Balikesir, Turkey.

Abstract

Feeding habits of the horse mackarel, *Trachurus mediterraneus* in Bandırma Bay, the Sea of Marmara were investigated in the years of 2013-2015. Stomach contents of 90 specimens collected by commercial vessels were analysed. The food items were determined to consist of 2 major systematic groups: Crustacea (Copepoda, Cladocera, Mysidacea, Ampipoda, Decapoda), and Pisces. The predominant and preferred prey category was of crustaceans. Besides, crustaceans were identified as the most important food items considering the index of relative importance (IRI). However, fish eggs were occasional foods. Euphausiacea, was food category with especially abundant in spring while copepoda was the most in autumn. Feeding intensity varied throughout 3 seasons (winter, spring, and autumn). The lowest and highest feeding intensities were recorded in winter and autumn, respectively. Euphausiids were observed to be dominant prey during winter and spring. The lowest and highest feeding intensities were recorded in winter and autumn, respectively. The study shows that species is carnivorous and Euphausiacea is a food item with highest occurrence.

Keywords:
Trachurus mediterraneus, diet composition, Bandırma Bay, Turkey.

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Introduction

Carangidae is one of the most important families of tropical marine fishes found in the Atlantic, Indian and Pacific Oceans. Members of *Trachurus* genus (Perciformes, Carangidae) are common and widely distributed in the Mediterranean (Smith-Vaniz, 1986). In Turkish Seas, this genus is represented by three species: Atlantic horse mackerel, *T. trachurus* (Linnaeus, 1758),

* *Corresponding Author: Hatice Torcu Koç, e-mail: htorcukoc@hotmail.com*

Mediterranean horse mackerel, *T. mediterraneus* (Steindachner, 1868) and blue jack mackerel, *T. picturatus* (Bowdich, 1825) (Bilecenoglu et al. 2002, 2014). Mediterranean horse mackerel (*T. mediterraneus*) is the second important commercial species that has been caught in Turkish waters (TUIK, 2017).

As the connection between the Mediterranean via the Dardanelles and the Black Sea via the Bosporus, the Sea of Marmara is a small basin with a unique topography and attributes that determine its biological and ecological characteristics (Kocatas¸ et al. 1993). The Sea of Marmara is situated between Mediterranean and Black Sea which are different ecosystems and serves as a sheltering, feeding and nesting area for economically important pelagic species as *T. mediterraneus* from each other (Kocatas et al. 1993). Studies on the fish fauna and fisheries in the Sea of Marmara were carried out by Erazi (1942), Slastenenko (1956), Geldiay (1969), Unsal (1988), Unsal and Oral (1993), Zengin and Mutlu (2000), Bök et al. (2000), Torcu-Koc (2004). However, there is a lack of feeding habits of *T. mediterraneus* in the region. The feeding habits of marine predators within the food web is important to describe their ecological role within the ecosystem (Navarro et al. 2013). In addition, feeding habit studies are necessary for conservation strategies, and ecosystem-based management through the estimation of trophic levels (Pauly & Christensen, 2000). Karlo-Riga (2000) presented otolith morphology and age and growth of *T. mediterraneus* in the Eastern Mediterranean. Although Sever & Bayhan (1999) and Bayhan et al. (2005, 2013) reported feeding of horse mackerel in İzmir Bay, the information on the feeding habits of this species in Bandırma Bay is scarce. Feeding habits and food items for each fish species are very important to know the relation between all species live in the same fishery ecosystem. Fish migration, growth, reproduction and all other biological aspects were influenced by the food items and feeding habits (Shehata, 1994). Feeding-habit studies are necessary for the ecosystem-based management of aquatic resources (Pauly & Sala, 2000). The results of the food and feeding study would be useful in future for stocking and management of this species in along the coasts of Turkey.

The goal of the present paper is to investigate the diet composition and seasonal fluctuations in prey items of the species.

Material and Methods

The sampling was obtained using commercial vessels in Bandırma Bay (the Sea of Marmara) (40°25'3"N 28°2'22"E) between the years of 2013 and 2015 in Figure 1. Because of technical insufficiencies, sampling could not be carried out during summer.

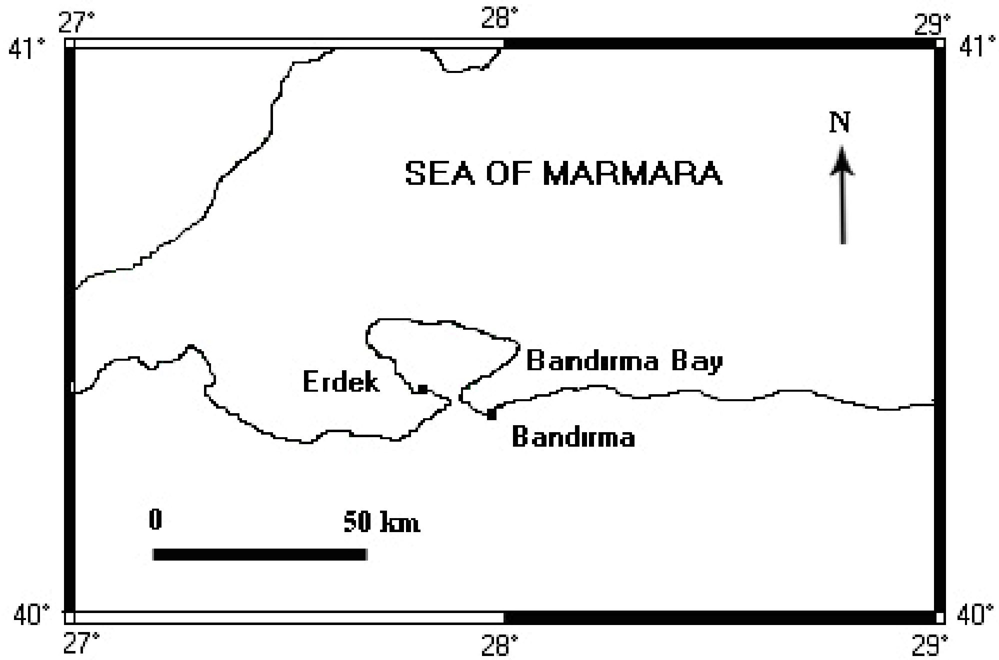

Figure 1. Sampling map in the Sea of Marmara.

After capture, fish were dissected and gut removed and preserved in 4% formalin solution to stop digestion. The digestive tube full and empty of food, was weight and the composition of food has been determined by analysing at microscop and binocular lamp. Filling index or Gastrosomatic index (GSI) is a useful and an efficient way for comparing the scale of feeding (food consumption) during various months and for determining the environmental and physiological effects on feeding habits. The GSI was obtained according to the following equation (Desai, 1970): GSI= (Weight of gut/ Body weight) ×100.

After removal of surface water by blotting on tissue paper, wet weight to the nearest 0.001 g were recorded in the laboratory. Numerous indices have been described for quantitatively expressing the different prey in diet of fish (Hyslop, 1980). Those used in the present study were: Percentage frequency of occurrence (F%), based on the number of stomachs in which a food item was found, expressed as the percentage of total number of non-empty stomachs; Percentage of numerical abundance (Cn%) i.e. the number of each prey item in all non-empty stomachs, expressed as the percentage of total number of food items in all stomachs in a sample; The main food items were identified using the index of relative importance (IRI) of Pinkas et al. (1971), as modified by Hacunda (1981):

$IRI = \%F x (\%Cn+\%Cw)$ This index has been expressed as: $\%IRI = (IRI/ \sum IRI) \times 100$

Results

Feeding Intensity

Of the 90 stomachs of Atlantic horse mackerels examined in Bandırma Bay, the Sea of Marmara between 2013 and 2015, 4.5% contained food items as 1.82 % in autumn, 1.48% in spring, 1.20 in winter, respectively as seen in Figure 2.

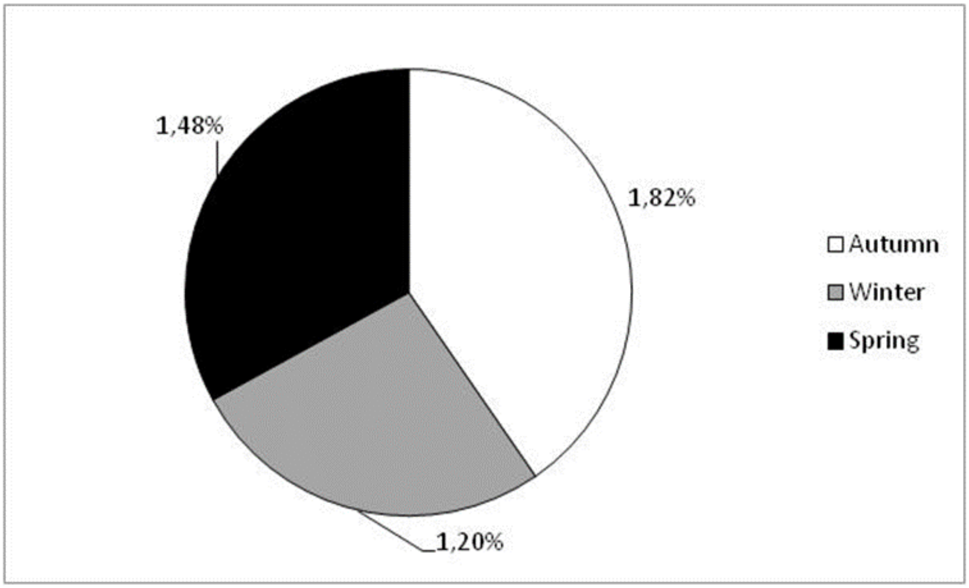

Figure.2. Stomach fullness of *Trachurus mediterraneus* according to seasons.

Trophic Spectrum

Our observations showed that the trophic spectrum consisted of almost exclusively in euphasids, copepods, and amphipods. Stomach contents of *T. mediterraneus* included preys from two major taxonomical groups (Crustacea and Osteichthyes) in Figure 3.

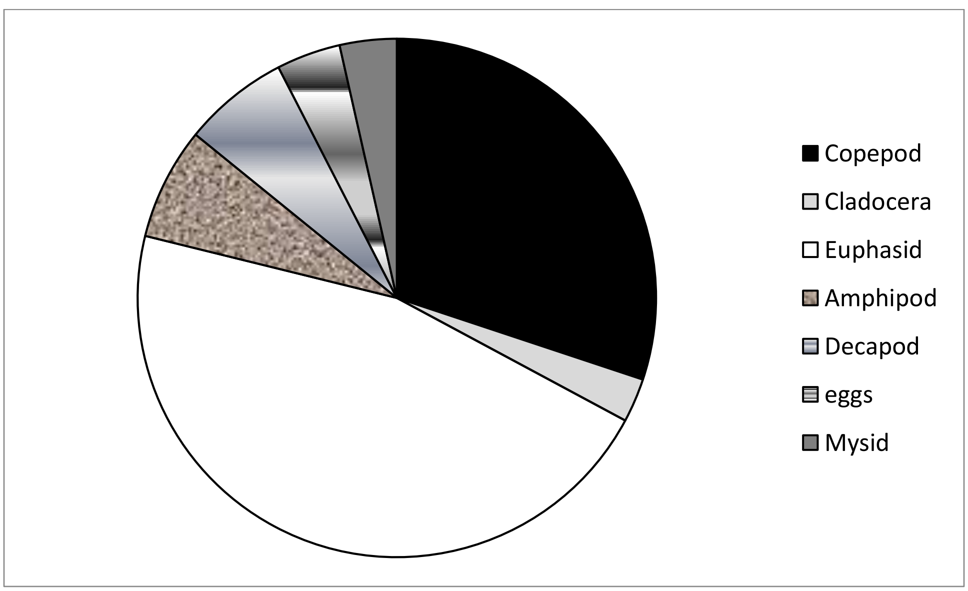

Figure 3. Food composition of *Trachurus mediterraneus*.

The diet of *T. mediterraneus* consisted of at least 7 prey taxa belonging to 2 major systematic groups (Crustacea and teleost eggs). The index of relative importance of different prey species found in the stomachs according to seasons in Figure 4. According to the frequence of preferred food, Euphasiacea was the most frequent prey group. The relative importance of different prey groups and taxa as given in the Table 1. As to index of relative importance, crustaceans dominated (%IRI= 99.67, 99.76, 100.0) in autumn, winter and spring, respectively in Figure 4-7. So it can be regarded as the preferred food. Fish eggs (%IRI= 0.33, 0.24) was found except for spring and can be considered as a secondary food. Frequency of occurence, numerical abundance, and the index of relative importance of different prey taxa found in the stomachs according to seasons were calculated in Table 1.

Table 1. Diet composition of *Trachurus mediterraneus* (%F: frequency of occurrence, %Cn: percentage numerical composition, IRI: index of relative importance).

Prey Groups	Autumn (2013-2015)			Winter (2013-2015)			Spring (2013-2015)		
	%F	%Cn	IRI	%F	%Cn	IRI	%F	%Cn	IRI
Crustacea									
Copepoda	45	47.7	2146.5	30	7.96	238.8	45	15.54	699.3
Cladocera	-	-	-	5	14.93	373.25	-	-	-
Euphasiacea	60	25.54	1532.4	5	44.44	1111	100	75.48	7548
Amphipoda	25	13.8	345	30	22.22	666.6	55	5.28	290.4
Decapoda	35	12.84	449.4	5	6	3	-	-	-
Mysidacea	30	0.80	24	15	9.02	135.3	30	3.68	110.4
Fish eggs	25	0.60	15	10	0.6	6	-	-	-

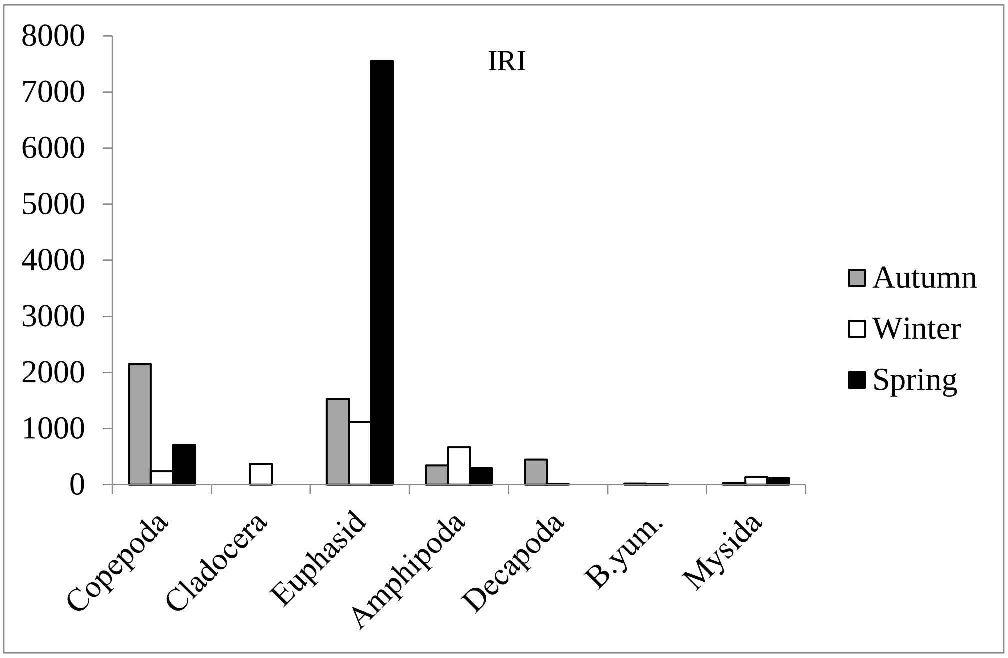

Figure 4. Seasonal variations of *Trachurus mediterraneus* diet based on the %IRI values of the prey groups.

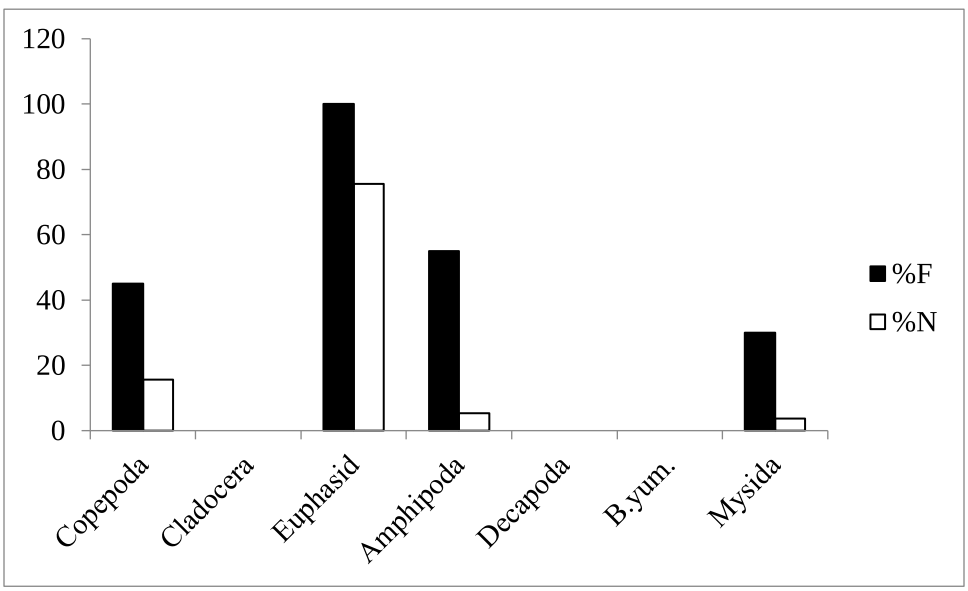

Figure 5. Food groups which were consumed in spring (2013-2015).

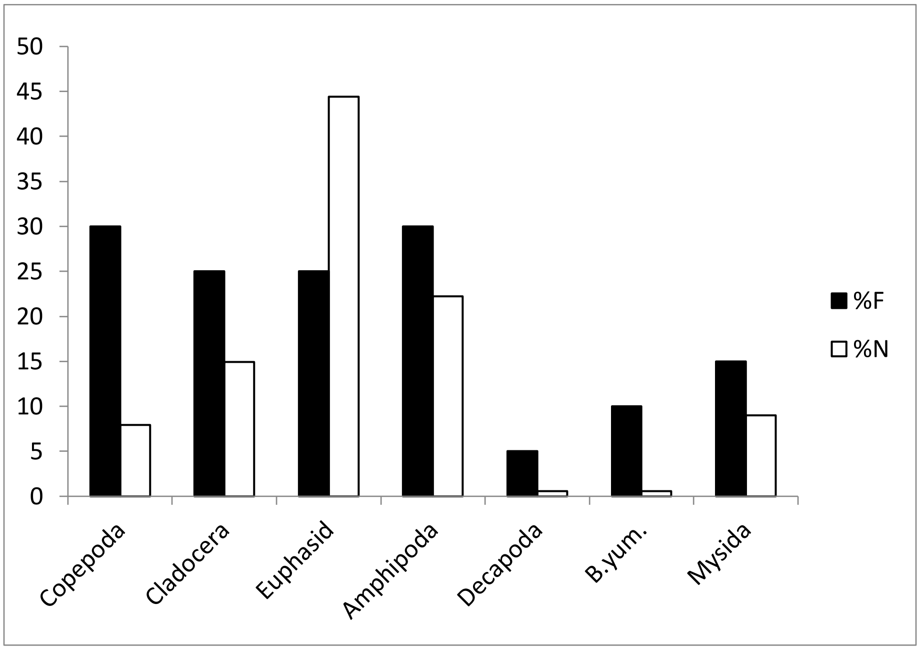

Figure 6. Food groups which were consumed in winter (2013-2015).

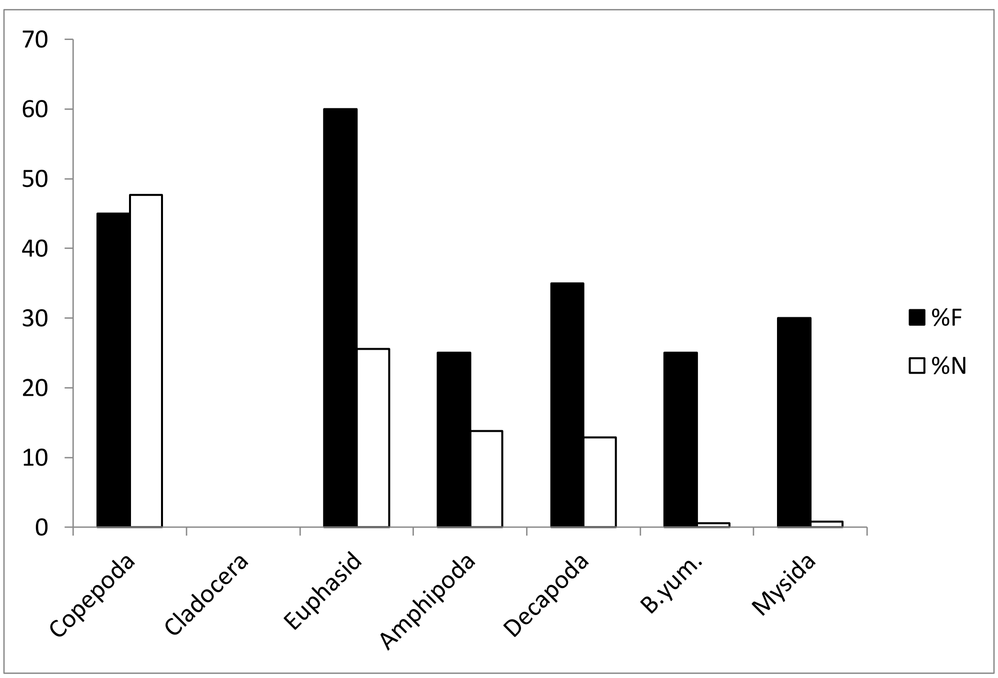

Figure 7. Food groups which were consumed in autumn (2013-2015).

Discussion

The Marmara Sea is the passageway between the Black Sea and Aegean Sea, and currents or water masses play an important role in its environmental conditions (e.g. temperature, salinity, food). It is thought that environmental conditions play the largest part in biological traits and diversity of fish species as *T. mediterraneus*. The Sea of Marmara comprises two different water masses from two different seas. Black Sea-sourced upper water masses vary between 50 and 75 m in thickness depending on the amount of incoming water from the Black Sea; water temperatures, especially seasonally, are between 6^{o}Cand 27^{o}C. Living organisms in the Sea of Marmara are not easily influenced by salinity variations, which can be in accordance with hypersaline waters of the Mediterranean Sea (35–39%o) and hyposaline waters of the Black Sea (16–18%o).But, as thermoklin stagnation arising from variations in temperature and salinity changes the chemical structure of the Sea of Marmara, ecological conditions of the sea vary at the same time (Karakulak et al. 2000, Torcu et al. 2012). As the southern Marmara in which Bandırma Bay placed is relatively larger and deeper, with open sea, and thefore, its structure possibly supplies a greater diversity of fish communities as *T. Mediterraneus.*

The data we obtained in this study show that the main preys of the Marmara Sea horse mackerel are crustaceans. While determinations of *T.mediterraneus* diet in Izmir Bay state that the main food items are mysidaceans, brachyural larvae and copepods (Sever & Bayhan, 1999; Bayhan et al. 2013), in European waters, the main food items are found as copepods, decapods, fish eggs and larvae, small fish and cephalopods (Dahl & Kirkegaard, 1987; Ben Salem, 1988; Olaso et al. 1999; Yankova et al. 2008).

Our investigation shows that the Mediterranean horse mackerel fed mostly with plankton and fish, as other *Trachurus* species (Olasa et al. 1999; Santic et al. 2003; Yankova et al. 2008). The data we obtained in this study show that the main preys of Mediterranean horse mackerel are fish and zooplankton in the Sea of Marmara. Our data indicates that, its food consisted of copepod, cladocer, euphasid, amphipod, decapod, mysid, and fish eggs, according to 3 seasons (winter, spring, and autumn). The digestive filling index (FI) depends on seasons. The rate of fully stomachs varied significantly with season, the maximum number was observed during autumn (1.82%) and a minimum number observed during winter (1.2%) in Figure 2. Our observations are more closely of Santic et al. (2003, 2004) data, the trophic spectrum consisting almost exclusively in euphasid, copepod, and amphipods (Fig. 3). Euphausiacea, was especially abundant in food category during spring while Crustacea was the most in autumn. Euphausiacea was determined to be dominant food group according to frequency of occurrence (F%), percentage numerical composition (N%), index of relative importance (%IRI) (Table 1, Fig. 4-7).

Our findings are in line with the studies of food composition of *T. mediterraneus* which were in Aegean Sea, Middle Adriatic, Middle Black Sea, northern Aegean Sea (Santic et al. 2003; Bayhan & Mater, 2000; Bayhan et al. 2005; Ulunehir Aydın, 2017). On the other hand, descriptions of *T. mediterraneus* diet in Izmir Bay and Edremit Bay state that the main food items are mysid, brachyural larvae and copepoda (Sever & Bayhan, 1999; Bayhan & Mater, 2000; Ulunehir Aydın, 2017). In the Portuguese coast, horse mackerel fed on fish; however, the main prey was crustacean (Cabral & Murta, 2000). Namely, Stoyanov et al. (1963) and Yankova et al. (2008) reported that *Trachurus mediterraneus ponticus* living in the Bulgarian territorial waters feeds in summer with different development stages of small fish (anchovy, sprat) and crustaceans such as mysids. Besides, copepods are known to be abundant all year round in the Aegean Sea (Stergiou et al. 1997) and crustaceans and copepods are also of great importance in the diet of several pelagic and semi-pelagic fishes such as *Merlangius merlangus euxinus (*Ismen, 1995; Seyhan & Grove, 1998), *Sardina pilchardus* (Sever et al. 2005), and *Scomber japonicus* (Sever et al. 2006).

According to data in spring, values of 100%F and 48% N% represent euphasids and copepods, respectively (Fig. 5). While value of 30%F present amphipod and copepod, euphasids were determined as dominant with the value of 44.44% N, according to data in winter (Fig. 6). Besides, the values of 60% F and 47.69% N represent euphasid and copepod, respectively in autumn (Fig. 7). Our results are observed to be harmony with one study in Aegean Sea (Sever & Bayhan, 1999).

According to IRI%, the reason why that euphasids form the most important food group comfirm the relevant literature (Fig. 4, Table 1). Euphausids also consisted of more than 50 % of the total IRI in Adriatic Sea specimens of *T. mediterraneus* (Šantić et al. 2004) with a harmony in our study, except for copepods. However, our results showing a little seasonal variations in distributions of food categories confirm those by Santic et al. (2003) and Yankova et al. (2008). Besides, fish eggs were determined to the most abundant in autumn (Fig. 7). Sever and Bayhan (1999) reported to find teleost eggs throughout the year, especially the most in summer.

Consequently, the euphausiid crustaceans dominated in the diet throughout the year, whereas fish constituted a significant part in autumn in the years of 2013-2015. This is probably due to the fact that euphausiid crustaceans are present in the Sea of Marmara all year round.

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