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RESEARCH ARTICLE

Trophic interactions of uncommon batoid species in the Sea of Marmara

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Abstract

The feeding habits and trophic levels of three uncommon batoid species (*Dasyatis pastinaca*, *Myliobatis aquila*, *Torpedo marmorata*) were investigated in the Sea of Marmara, with two different methodical approaches: stomach content analysis and stable isotope analysis. The stomach contents indicated that the teleost species is the most important prey group for *D. pastinaca* and *T. marmorata*, while Mollusca is the main prey group for *M. aquila*. Niche breadths were calculated 0.54 for *D. pastinaca* while 0.29 for *M. aquila*. No significant diet overlap was detected between *D. pastinaca* and *M. aquila* (0.21) based on Pianka index. $\delta^{15}N$ muscle and $\delta^{15}N$ liver values statistically differed between *D. pastinaca* and *M. aquila* (F_{pseudo}muscle=33.736, p=0.03; F_{pseudo}liver= 26.173, p= 0.01). The trophic levels were 4.20±0.73 for *D. pastinaca*, 4.04±0.63 for *M. aquila* and for *T. marmorata* 4.46±0.79 by stomach content analysis. The trophic levels of species from stable isotope analysis by $\delta^{15}N$ were calculated as 3.67 for *T. marmorata*, 3.32 for *D. pastinaca* and 2.56 for *M. aquila*. The difference in trophic levels may be explained by long-term and short-term feeding strategy of these species. *Torpedo marmorata* and *M. aquila* have higher $\delta^{15}N$ values compared to samples from other regions of the Mediterranean.

Keywords: Elasmobranchii, stomach content analysis, stable isotope analysis, trophic levels, diet overlap, niche breadth.

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Introduction

Predation is an essential element for the community structure (Hairston *et al.* 1960). Determining the trophic ecology of predator fish species is crucial in understanding their role in marine food webs. Based on their feeding strategy, some predator fish species prefer to feed on a wide variety of prey sources, which is defined as "general feeding characteristics". Those general feeders have great predation pressure on controlling prey populations and impact on spatially linked different food webs. The divergence of these species may cause changes in community dynamics and possibly affect each trophic level (Baum *et al.* 2003; Ferretti *et al.* 2010).

The Sea of Marmara, which is located northeastern part of the Mediterranean Sea, is a small semi-closed sea connecting to the Mediterranean through the Çanakkale Strait (Dardanelles) and the Black Sea through the Istanbul Strait. Hydrography of the Sea of Marmara comprises both the Mediterranean and the Black Sea characteristic and the system is under the influence of both currents as a transition zone (Beşiktepe *et al.* 1994). The Sea of Marmara has 13 shark species and 10 batoid species. The number of total elasmobranchs represent approximately 10% of the total number of fish species of the Sea of Marmara (Keskin 2007; Kabasakal 2016). While the total annual landings of all batoid species reported as 81 tons in 2000, it decreased to 5.3 tons in 2019, and this collapse corresponds to a decrease of approximately 93% (TUIK 2019). The fishing pressure on fish stocks since the 1950s, which is increasing day by day with technological developments, has led to overexploitation of top predators and even the extinction of those species around word seas (Baum *et al.* 2009). Therefore, overexploitation of top predators might trigger differences on the food web and ecosystem functionality (Hindell *et al.* 2000). The Sea of Marmara has unfortunately lost most of its large predator species due to various reasons such as the uncontrolled fisheries operations, being home to a large metropolis like Istanbul which affected directly anthropogenic inputs of the Sea of Marmara (Ulman *et al*. 2020).

Species belong to order Batoidea are defined as long-lived with low growth rate and low fecundity (Jeschke and Kokko 2009). Batoid have a significant role in the marine food web as a meso-predator (Rosenblatt *et al.* 2013; Heupel *et al.* 2014), feeding on different trophic levels from zooplankton to divers marine species (Hussey *et al.* 2014). These species have a low population growth rate, and they are sensitive to antropogenetic impacts such as fishing activities, pollution, and habitat deterioration; thereby, their stocks have a very low recovery rate (Dulvy *et al.* 2014; Stevens 2000). *Dasyatis pastinaca* is a coastal species, distributed from 5 to 200 meters, and inhabits sandy and muddy bottoms and generally feeds on bottom fishes, crustaceans, and mollusks while, *Myliobatis aquila* may found shallow waters, in accordance with literature information, it feeds on benthic crustaceans, mollusks, and fish (Froese and Pauly 2020). *Torpedo marmorata*, in generally, is distributed seagrass areas and adjacent soft bottoms, mainly feeds on small fishes and crustaceans (Froese and Pauly 2020).

According to the results of the study performed with 229 beam trawl operations in the Sea of Marmara between 2011 to 2013; while the CPUE value of *T. marmorata* species was 0.03 kg /h, the CPUE value of *D. pastinaca* was determined as 0.09 kg/h. *Myliobatis aquila* was not observed in that study. In addition, the CPUE value of *Raja clavata,* which is another batoid species in the same region, was calculated as 0.48 kg/h (İsmen *et al.* 2013). Moreover, within the scope of this study carried out between 2017-2018, when considering the abundance of these three species is very low compared to other batoid and shark species, therefore, these species are defined as uncommon batoid species in the Sea of Marmara. Several researchers studied the feeding ecology and trophic levels of the batoid species in the adjacent seas of the Sea of Marmara. Saglam *et al.* (2010) in the Black Sea, İşmen (2003) and Yeldan *et al.* (2009) in the northeastern Mediterranean and Stergiou and Karpouzi (2002), Valls *et al.* (2011), Barría *et al.* (2015), Saadaoui *et al.* (2015), Karachle and Stergiou (2017), and Mulas *et al.* (2019) in the Mediterranean Sea evaluated feeding ecology of the batoid species. However, there is no study on the feeding ecology of the batoid species in the Sea of Marmara.

The present study was carried out to understand the feeding strategies, diet overlap, and niche breadth of three batoid species, using different two methodological approaches (stomach content analysis and stable isotope analysis) in the Sea of Marmara.

Materials and Methods

Samplings were performed seasonally at 34 stations in the Sea of Marmara (Figure 1) between December 2017 and 2018. Sampling followed the International Bottom Trawl Survey in Mediterranean (MEDITS) (MEDITS 2013) protocol, and 151 hauls were made by bottom trawl between the depths of 25 and 215 m. Bottom trawling was carried out for 30 minutes at a constant speed of 2.5 knot^{-1}, using MEDITS net with a commercial fishing vessel at 24-meter length with special permission given by Turkish Ministry of the Agriculture and Forestry.

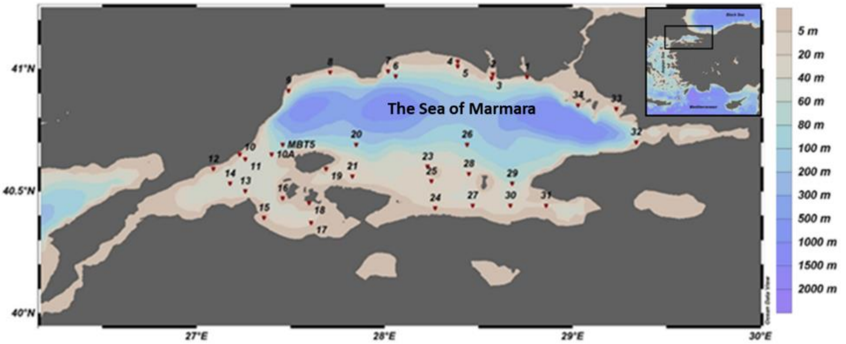

Figure 1. Sampling stations and the location of the Sea of Marmara, northeastern Mediterranean

The disc width (DW) of specimens were measured to the nearest 0.1 cm on board. The stomach was dissected from the body and fixed at the 4% formalin solution on board and brought to the laboratory for the analysis. At the laboratory, the prey composition of the stomach contents was identified at the lowest taxonomic level possible and weighed, and abundance of the prey items were recorded. In order to define the feeding habits of the species; frequency of occurrence (F%), numerical (N%) and volumetric (W%) measures of each taxonomic level in the prey composition were calculated and the index of relative abundance and as standardized equation were estimated (Cortés 1997) using the following formulas:

$$IRI = (N\%+W\%)* F \%)$$

$$IRI\% = (IRI/\sum IRI) *100$$

The empty stomach percentage, i.e. vacuity index (*v*), was estimated according to Hyslop (1980). As for the determination of the feeding strategy and the niche breadth, Levins index (1968) which was revised after Simpson (1949) diversity index, was used as:

$$B = 1/\Sigma_{\mathrm{p_j}}^2$$

where pj represents the ratio of the abundance of the j prey item to total prey abundance. Niche breadth values were considered following levels: high (> 0.6), intermediate (0.4 - 0.6) or low (<0.4) (Novakowski *et al.* 2008).

Pianka (1974) index was the method to estimate diet overlap between species shown below:

$$O_{jk} = \frac{\sum_i^n p_{ij}\ p_{ik}}{\sqrt{\sum_i^n p_{ij}^2 \sum_i^n p_{ik}^2}}$$

where p_{ij} abundance of prey i in predator j, p_{ik} abundance of prey i in predator k and n total abundance of prey items. Pianka index values range between 0 and 1 and highest value represents a high overlap of the species' diet.

The index results were interpreted according to Grossman (1986) and the categories of low, medium and high overlap were defined (range category of 0-0.39, 0.40-0.60 and 0.61-1, respectively).

The trophic level (T_L) for species was calculated by using the W% with the TrophLab software manual (Pauly *et al.* 2000). TrophLab estimates T_L of species with standard error (±SE) using the diet composition and the trophic level (T_L) of the different prey (Pauly *et al.* 2000).

For the stable isotope analysis (SIA), the available white muscle and liver samples were taken of fish and frozen at the vessels. Both tissues were addressed to lipid extraction according to Bligh and Dyer (1959) and Hussey *et al.* (2012), prior to SIA. Pre-treatment analysis is considered essential in terms of the potential of lipids to deplete $\delta^{13}C$ in tissues (Post *et al.* 2007; Kim and Koch 2012; Carlisle *et al.* 2017). The SIA analysis (^{13}C:^{12}C and ^{15}N:^{14}N) was conducted using a PDZ Europa ANCA-GSL elemental analyser interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer at the University of California, Davis (UCD) Stable Isotope Facility. Stable isotope ratios of carbon and nitrogen were expressed in delta notation with the equation:

$$\delta X = [(Rsample/Rstandard) - 1] \text{ x } 1000$$

where X is the heavy isotope, R_{sample} is the ratio of heavy to light isotope in the sample (e.g., ^{13}C:^{12}C), and $R_{standard}$ is the ratio of heavy to light isotope in the reference standard. As a reference, Pee Dee Belemnite was used for carbon, and atmospheric N_2 was used for nitrogen. Trophic positions of each species were estimated based on isotopic values by Vander Zanden and Rasmussen (2001):

$$TPconsumer = TP\ basal + (\delta 15Nconsumer - \delta 15Nbasal)/\ \Delta\delta 15N$$

where $\delta^{15}Nconsumer$ is the value for each Batoid species, $\delta 15Nbasal$ is deep-water pink shrimp (*Parapenaeus longirostris*) for *D. pastinaca* and *T. marmorata* (n=4 $\delta^{15}N$ mean = 9.82±0.33), and is Bivalvia species (n=2, $\delta^{15}N$ mean = 8.42) for *M. aquila*, Δ is the trophic enrichment factor between prey and predator. Following Hussey *et al.* (2010), 1.95 for $\Delta^{15}N$ values and TP basal =2 were used.

Permutation multivariate analysis of variance (PERMANOVA) was used in order to compare the difference in prey species composition between predators based on the Bray-Curtis dissimilarity matrices with 999 permutations. SIMPER analysis was used to define the average dissimilarity, following the application of Bray-Curtis matrix on the stomach content data. Abundance data were subjected to log transformation (logx+1) prior to analysis. In order to determine the differences between the ^{15}N and ^{13}C values of the species, permutation multivariate analysis of variance (PERMANOVA) based Euclidean distance matrix with 999 permutations was used. All analyses were performed using Primer-7 (v.7.0.17) software.

Results

Stomach content analysis (SCA)

A total of 51 stomachs belonging to three batoid species was analyzed. *Myliobatis aquila* has the highest vacuity index value of 40% while *D. pastinaca* has a lower index value (12.5%) (Table 1).

Table 1. Diet composition of the three batoid species in the Sea of Marmara
(N%, percentage in number; W%, percentage in weight; FO%, frequency of occurrence; IRI%, index of relative importance of each prey item)
DP= *Dasyatis pastinaca*, MAQ= *Myliobatis aquila*, TM: *Torpedo marmorata*.
n: number of sample, DW: Disc Width VI: vacuity index

	DP (n:4)VI: 12.5%				**MAQ (n:15) VI: 40%**				**TM (n:4) VI:25%**			
	DW:19.4 – 67 cm				DW: 17-5. 75 cm				DW:17.5 -21.5 cm			
	Mean Depth=58m				Mean Depth=78m				Mean Depth=43m			
Taxonomic groups	**N%**	**W%**	**FO%**	**IRI%**	**N%**	**W%**	**FO%**	**IRI%**	**N%**	**W%**	**FO%**	**IRI%**
Anthozoa					0.51	0.99	11.11	0.14				
Nematoda												
Undefined Nematoda	7.39	0.03	35.7	5.03								
Sipuncula												
Undefined Sipuncula									50.00	3.72	66.67	28.23
Polychaeta												
Undefined Sedentaria	14.79	6.64	17.86	7.26								
Sternaspis scutata	0.70	0.15	7.14	0.12								
Pectinariidae	5.99	0.36	3.57	0.43								
Lagis koreni	0.70	0.28	3.57	0.07								
Glyceridae	0.35	0.03	3.57	0.03								
Undefined Polychaetes	19.01	3.51	25.00	10.69	14.95	2.59	44.44	9.47				
Mollusca												
Undefined Mollusca					13.88	2.51	33.33	6.65				
Scaphopoda					46.28	14.50	44.44	32.84				
Undefined Bivalvia					14.43	5.70	33.33	8.15				
Crustacea												
Dendrobranchiata	3.87	0.51	10.71	0.89	2.06	5.67	22.22	2.09				
Parapenaeus longirostris	3.17	6.42	25.00	4.55								
Undefined Crustacea	14.44	2.37	39.29	12.53	1.54	4.67	33.33	2.52				
Undefined Decapoda	3.52	5.92	17.86	3.20	0.51	0.26	11.11	0.10				
Teleostei												
Trachurus sp.	6.69	28.78	10.71	7.21	1.03	15.14	11.11	4.00				
Lesueurigobius friesii									8.33	11.09	33.33	5.10
Undefined Teleostei	19.37	45.01	39.29	48.00	4.63	48.50	55.56	35.86	41.67	85.19	66.67	66.67

SCA results showed that *D. pastinaca* mainly fed on teleost species (55 % IRI), while *M. aquila* preferred mollusks and teleost (48% and 38% IRI, respectively). Stomach content composition between *D. pastinaca* and *M. aquila* were found significantly different based on the N% (F_{psuedo}= 3.2355 p=0.002). According to the SCA results, which was performed on four stomach samples, teleost was found as main prey of *T. marmorata* (71% IRI), but *T. marmorata* was not assessed statistically due to the lack of sufficient samples (Table 1). The trophic levels were calculated as 4.20±0.73 for *D. pastinaca* and 4.04±0.68 for *M. aquila* and for *T. marmorata* 4.46±0.79 by SCA results (Table 2). The results of SIMPER analysis based on abundance data of prey items indicated a high percentage (87.41%) of dissimilarity between *D. pastinaca* and *M. aquila* (Table 3). Six prey groups constituted 70% of the total dissimilarity and the highest contribution was originated from the Scaphopoda (Mollusca) in the diet of *M. aquila*.

Table 2. Trophic levels values (SCA and SIA) of batoid species from different parts of the Mediterranean

Species	Area	Main preys	T_L(SCA)	T_L(SI)	References
Dasyatis pastinaca	Eastern Mediterranean	Natantia, Stomatopoda	3.7± 0.59*		İşmen 2003
Dasyatis pastinaca	North Aegean	Natantia, Polychaeta	3.46±0.53		Karachle and Stergiou 2010
Dasyatis pastinaca	NE Mediterranean	Natantia	3.6±0.59*		Yeldan 2009
Dasyatis pastinaca	NE Mediterranean	Teleost, Crustacea		4.94	Yemişken 2017
Dasyatis pastinaca	North Aegean	Crustacea, Teleost		5.2	Yemişken 2017
Myliobatis aquila	North Adriatic	Bivalvia	3.37±0.44*		Jardas *et al*. 2004
Myliobatis aquila	Baleric Islands	Reptantia	3.84±0.44*		Valls *et al.* 2003
Torpedo marmarota	North Aegean	Teleost	4.39±0.67		Karachle and Stergiou 2010
Torpedo marmarota	Mediterranean	Teleost	4.41±0.77*		Capepe *et al.* 2007
Dasyatis pastinaca	Sea of Marmara	Teleost	4.2±0.73	3.32	This study
Myliobatis aquila	Sea of Marmara	Mollusca	4.04±0.68	2.56	This study
Torpedo marmarota	Sea of Marmara	Teleost	4.46±0.79	3.67	This study

*obtained from Karachle and Stergiou (2017)

Table 3. The results of SIMPER analysis of three batoid species in the Sea of Marmara

Prey species	*D. pastinaca* Average Abundance	*M. aquila* Average Abundance	Average Dissimilarity	Contribution %
Scaphopoda	-	1.28	14.22	16.26
Undefined Teleostei	0.56	0.53	12.65	14.47
Undefined Polychaeta	0.47	0.67	11.16	12.77
Undefined Crustacea	0.48	0.23	8.64	9.88
Bivalvia	-	0.71	7.72	8.83
Mollusca	-	0.66	7.17	8.20

The Levins niche breadth index results were found as 0.54 for *D. pastinaca* and 0.28 for *M. aquila*. Based on the Levin index, *D. pastinaca* was defined as moderate generalist predator, while *M. aquila*, which had the low niche breadth, was defined as a specialist. The Pianka index was calculated as 0.21 which indicated very low diet overlap between those two species.

Stable isotope analysis (SIA)

According to SIA results, $\delta^{15}N$ muscle and $\delta^{15}N$ liver values statistically differed between *D. pastinaca* and *M. aquila* (for muscle F*pseudo*=33.736 *p*=0.03, for liver F*pseudo*= 26.173 *p*= 0.01) while there was no significant difference of $\delta^{13}C$ values for both muscle and liver (for muscle F*pseudo*=0.008 *p*=0.87; for liver F*pseudo*=2.068 *p*=0.22). SIA for *T. marmorata* were not statistically assessed due to the insufficient sample size. It was found that *T. marmorata* had the highest enrichment in $\delta^{15}N$, whereas *M. aquila* was found with the lowest in $\delta^{15}N$ (Table 4). The values of $\delta^{13}C$ and $\delta^{15}N$ distribution of each species are given in Figure 2. Muscle and liver isotope values of each species do present overlaps within species, however, according to ^{15}N and ^{13}C values an overlap does not exist between species (Figure 2). The trophic levels of species from $\delta^{15}N$ were estimated as 3.67 for *T. marmorata*, 3.32 for *D. pastinaca* and 2.56 for *M. aquila*.

Table 4. Mean isotopic values with standard deviation of three batoid species from the Sea of Marmara

	Muscle			Liver		
Species	**n**	**$\delta^{13}C$ ‰**	**$\delta^{15}N$‰**	**n**	**$\delta^{13}C$ ‰**	**$\delta^{15}N$ ‰**
M. aquila	4	18.88±0.39	9.53±0.69	4	19.06±0.14	8.36±0.60
D. pastinaca	4	19.00±0.70	12.41±0.57	4	18.36±0.93	12.50±1.27
T. marmorata	2	17.61±0.14	13.08±0.61	3	17.74±0.30	11.64±0.57

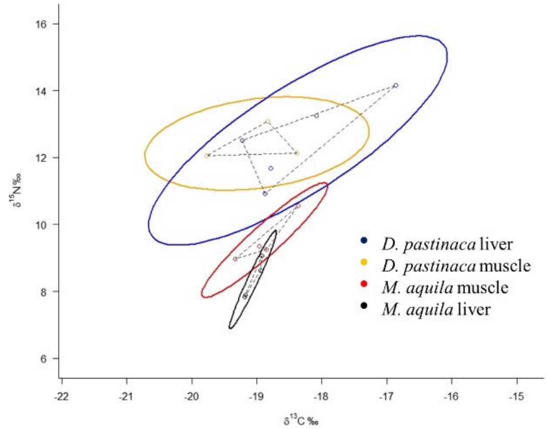

Figure 2. The distribution of isotopic values with 95% confidential interval of two batoid species from the Sea of Marmara

Discussion

Within this study, novel ecological information on the trophic ecology and diet were presented on three uncommon batoid species in the Sea of Marmara with by means of two different, widely used, methods, that is stomach content (SCA) and stable isotope (SIA) analyses.

According to SCA results, *D. pastinaca* fed on mainly teleost species; and crustaceans were the second preferred prey items. Our results were different from the studies conducted in other regions of the Mediterranean Sea and from the Black Sea where Crustacea were reported as main preys (Black Sea - Saglam *et al.* 2010; Eastern Mediterranean - Yeldan 2009, İşmen *et al.* 2003; Western Mediterranean - Yemişken 2017, Ponte *et al.* 2016; North Aegean Sea - Karachle and Stergiou 2008, 2010, Tiralongo *et al.* 2020). When considering *D. pastinaca* is as a benthic predator, benthopelagic species which is *Trachurus* sp. it may be an accidental prey item of *D. pastinaca*. In addition, the muscle tissue ^{15}N results of this species show similarity with other isotope studies in the Mediterranean (Barría *et al*. 2015; Yemişken *et al.* 2017) (Figure 3). This result is another indicator that increases the probability of *Trachurus* sp. becoming as accidental prey.

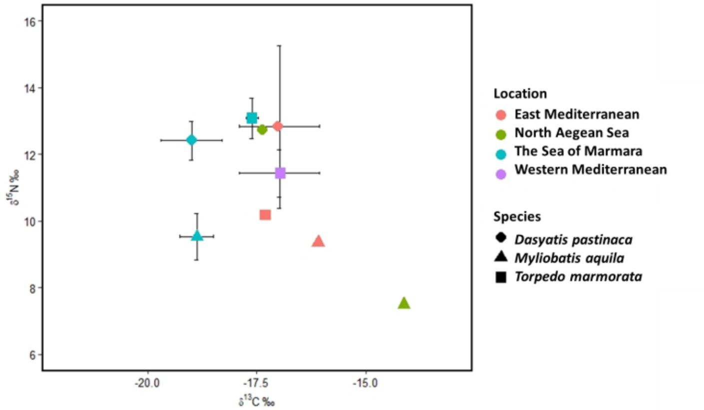

Figure 3. Comparison of isotopic values $\delta^{13}C$ and $\delta^{15}N$ of three batoid species from different parts of the Mediterranean

According to Levins niche breadth, *D. pastinaca* was determined as a moderate generalist predator in the Sea of Marmara. Likewise, Tiralongo *et al.* (2020) agreed that these results with 0.85 Levins index value in the central Mediterranean.

Myliobatis aquila was sampled at a mean depth of 78 meters in this study. According to our findings, mollusks were the main group due to the highest IRI % value. Teleost was the second prey items according to IRI% values. Our results were similar to other studies results from the Mediterranean and Atlantic coasts

(Jardas *et al.* 2004; Ponte *et al.* 2016). Valls *et al.* (2011) revealed that Crustacea were the most important prey group. This difference may be a result of regional food preferences or a low sample size. Therefore, according to the Bayesian mixing model performed in the western Mediterranean, Bivalvia and teleost contribute to a similar proportion of diet (Barría *et al*. 2015). Moreover, the Levins index of *M. aquila* was found low niche breadth which indicated "specialist predator", Valls *et al* (2011) revealed a similar niche breadth in the western Mediterranean (Levins index: 0.26).Overall, Pianka diet overlap value was found 0.21 that showed no diet overlap between *D. pastinaca* and *M. aquila*. This result was also supported by SIMPER analysis which explained by the high percentage of dissimilarity in prey abundance (N) between the two species.
Statistically significant differences in $\delta^{15}N$ values of muscle and liver tissue indicated that *D. pastinaca* and *M. aquila* likely fed on species of various trophic levels. Additionally, no significant differences in $\delta^{13}C$ values of muscle and liver tissue were evaluated that these two species might use similar carbon sources, considering the proportion of mollusks and crustaceans in their diet. Overall comparison of SIA results showed that $\delta^{13}C$ values were lower, but $\delta^{15}N$ values were similar among batoid species from the different part of the Mediterranean Sea as from the western Mediterranean by Barría *et al.* 2015 and by Yemişken (2017), as well from the northern Aegean by Yemişken (2017).

The diet of *T. marmorata,* less sampled species, was found mainly constituted of teleosts. In spite of insufficient sample size, considering its limited distribution in the Sea of Marmara, the result of SCA and SIA might give basic ecological knowledge of this species in the Sea of Marmara Similar to our findings, Abdel-Aziz (1994) stated that adult *T. marmorata* fed solely on fish in the Mediterranean. Barría *et al.* (2015) established similar results using a stable isotope mixing model, and according to their outputs, teleost was the main prey item.

Jacobsen and Bennet (2013) revealed that 4.25 of T_L of Torpedinidae, Trophic levels with calculated SCA or SIA of these species are given in Table 3. Unsurprisingly, the trophic levels of the species were different with respect to $\delta^{15}N$ values, according to the SCA. This result is undoubtedly due to the difference in the short and long-term feeding strategies of the species. SCA gives only a snap-shot of the species' diet, while SIA analysis gives the long-term feeding strategy (Fry 2006).

With the results of this study, the first data set is presented for the trophic ecology of the batoid species, as an important meso-predators of the marine ecosystem of Sea of Marmara. Within the light of our contribution, future studies should be designed on protecting those species as they are also struggling with over-exploitation like many predators over the world.

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Marmara Denizi'nde yaygın olmayan batoid türlerinin trofik etkileşimi

Öz

Marmara Denizi'nde yaygın olmayan üç Batoidea türünün (*Dasyatis pastinaca*, *Myliobatis aquila*, *Torpedo marmorata*) beslenme alışkanlıkları ve trofik seviyeleri, mide içeriği ve kararlı izotop analizleri olmak üzere iki farklı metodoloji kullanılarak araştırılmıştır. Mide içeriği analiz sonuçlarına göre Teleost grubu *D. pastinaca* ve *T. marmorata* türleri için ana besin grubu olarak belirlenirken, Mollusca *M. aquila* türü için ana besin grubu olarak belirlenmiştir. *D. pastinca* türünün Levins niş genişliği indeksi 0,54 olarak bulunurken, *M. aquila* türü için 0,29 olarak hesaplanmıştır. *D. pastinaca* ve *M. aquila* türleri arasında düşük seviyede bir besin çakışması gözlenmiştir (Pianka = 0.21). Yine bu iki tür için $\delta^{15}N$ kas ve $\delta^{15}N$ karaciğer değerleri istatistiksel olarak anlamlı bir farklılık göstermiştir (F_{pseudo} kas=33.736, p=0.03; F_{pseudo} karaciğer= 26.173, p= 0.01). *D. pastinaca, M. aquila ve T. marmorata* türlerinin mide içeriği analizine göre hesaplanan trofik seviyeleri sırasıyla 4,20±0,73, 4,04±0,63 ve 4,46±0,79 hesaplanmıştır. Kararlı izotop analizlerinden elde edilen hesaplamalara göre ($\delta^{15}N$); trofik seviyelerin *D. pastinaca* için 3.32, *M. aquila* için 2.56 ve *T. marmorata* için 3.67 olarak belirlenmiştir. Mide içeriği ve $\delta^{15}N$ değeri ile hesaplanan trofik seviyelerdeki bu farklılık türlerin kısa ve uzun dönem beslenme stratejilerinden kaynaklanmaktadır. Ayrıca *M. aquila* ve *T. marmorata* türlerinin $\delta^{15}N$ değerleri Akdeniz'in diğer bölgelerinde örneklenenlere göre daha yüksek olduğu belirlenmiştir.

Anahtar kelimeler: Kıkırdaklı balıklar, mide içeriği analizi, kararlı izotop analizi, trofik seviye, besin çakışması, niş genişliği

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