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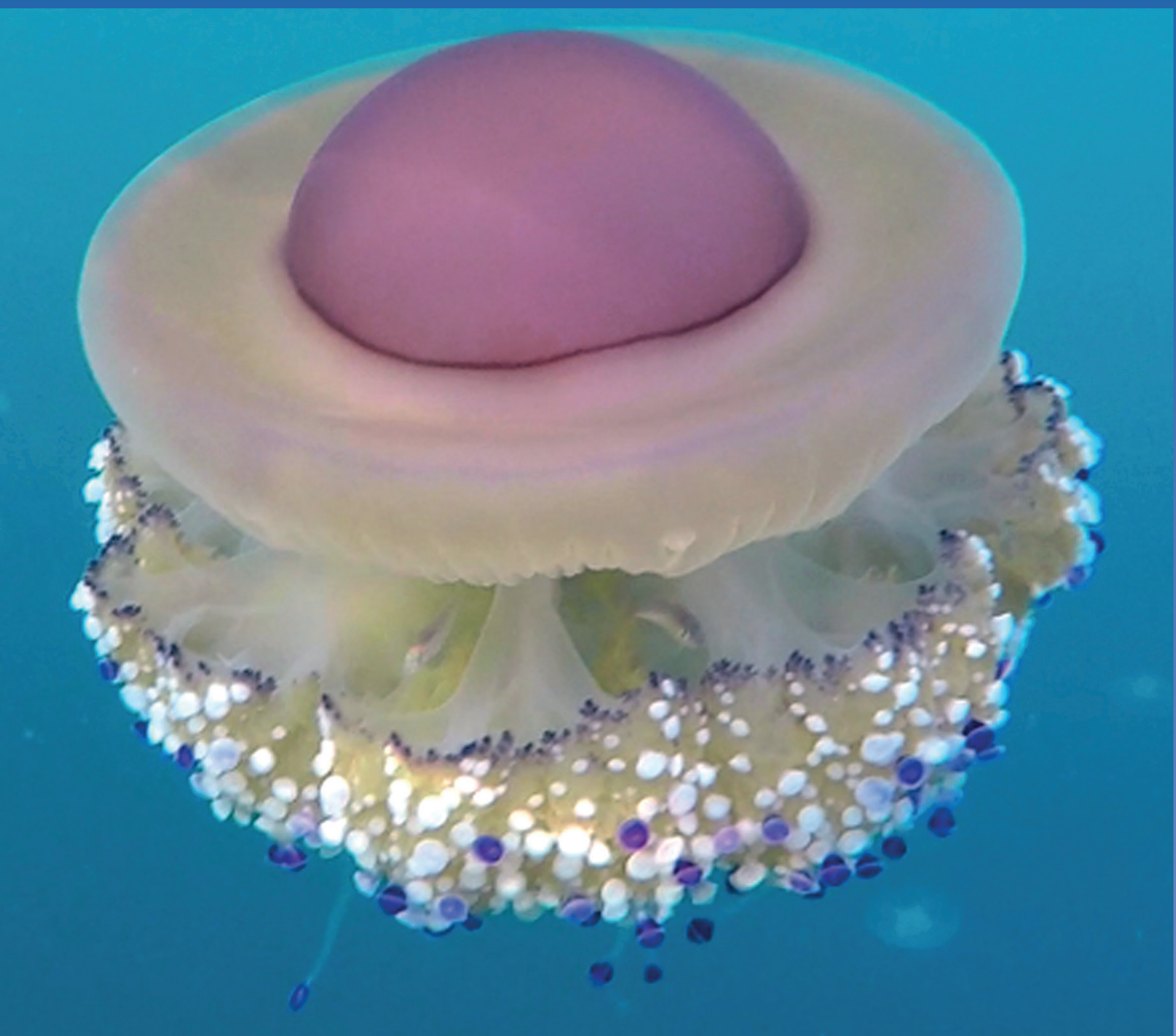

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Original Article

Determination of Benthic Macroinvertebrate Fauna and Some Physicochemical Properties of Kanak Dam Lake (Şarkışla–Sivas)

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ABSTRACT

This paper aims to identify the benthic macroinvertebrate fauna and some physicochemical characteristics of Kanak Dam Lake located in Şarkışla, Sivas. For this, water and sediment samples were taken from 4 stations of the lake between August 2016 to July 2017 at monthly intervals, and a detailed physicochemical analysis was carried out on these samples. While the identification of benthic macroinvertebrates was made to the lowest possible taxa (species, genus or families), some physicochemical characteristics of the lake water such as temperature, pH, electrical conductivity, dissolved oxygen, SO_4, PO_4, NO_3-N, NO_2-N, Mg, Ca, total hardness, salinity and Cl levels were determined using various titrimetric and spectrophotometric methods. As a result, a total of 30 taxa were identified and were classified as Oligochaeta, Chironomidae, Gastropoda and other Insecta (Ephemeroptera, Trichoptera, Hemiptera (adult), Odonata, Plecoptera and larval Coleoptera). All the identified taxa were determined as the first records for the lake. While the temperature, pH, electrical conductivity, dissolved oxygen, chloride and sulfate levels were found to have the first class quality according to Turkey's water control regulations the NO_3-N and NO_2-N levels in the lake were found to have the second and third class water quality, respectively. The total hardness of the lake water was found to be at lighthard water quality The Shannon Weiner diversity index for macrobenthic fauna of the dam lake was found to be 0.64 on average. The sampling stations and months were evaluated also statistically by using the Bray-Curtis Cluster Index in terms of the distribution of the benthic macroinvertebrates and physicochemical parameters.

Keywords: Water quality, Oligochaeta, Benthic macroinvertebrates, Dam lake

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INTRODUCTION

Dams are structures that have been built for water irrigation of agricultural land to meet the water needs of mankind. Today's modern dams have strategic importance since they play major roles in energy production in developing countries. They also have significant influence in agricultural activities. The Kanak Dam located on the Kanak stream in the town of Şarkışla of Sivas province was built with the intention to solve the drinking and potable water problem of the towns of Şarkışla, Gürçayır and Cemel as well as for flood prevention and irrigation of the agricultural land in the area. Standing at 37.5 meters high, the Kanak Dam has a surface level of 1.84 square kilometers and an irrigation area of 2270 ha; the core of the dam was made of a mixture of clay, gravel and core sand (DSİ, 2016). There have been many studies on the dam lakes in Turkey; Kırgız (1988), Ahıska, (1999), Çamur-Elipek (2003); Balık et al., (2004); Taşdemir & Ustaoğlu (2005); Yıldız & Balık (2006); Arslan et al., (2007); Yıldız et al., (2008); Ersan et al., 2009; Taşdemir et al., (2010); Fındık & Göksu (2012); Özbek et al., (2016). There are a few studies on the dam lakes in the region; Dirican (2008); Mutlu et al., (2014); Dirican (2015); Yıldız & Karakuş (2018).

There has been no study on the macrobenthic invertebrate fauna and physicochemical parameters of the Kanak Dam Lake thus far. The aim of this study is to identify the benthic macroinvertebrate fauna and physicochemical characteristics of the Kanak Dam Lake. This study further aimed to contribute to the taxonomical and environmental studies performed in Turkish dam lakes.

MATERIALS AND METHODS

The study area is located 10 km southeast of the city center of Şarkışla, within the area surrounded by Cemel, Döllük, Konakyazı and Samankaya villages. The water and sediment sample-taking took place at four different stations between August 2016 and July 2017 at monthly intervals. The location of the Kanak Dam Lake and the sampling stations are presented in *Figure 1*.

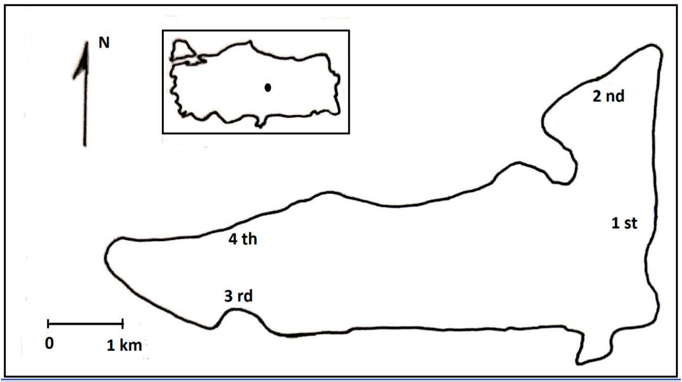

Figure 1. The location of Kanak Dam Lake and the sampling stations.

Station 1 is located just behind the dam. **Station 2** is located in a narrow channel area of the lake and has rich vegetation. **Station 3** is part of the lake before joining the Kanak stream. **Station 4** is located where the stream meets the lake and has rich vegetation, being the shallowest part of the lake. Water temperature (using a basic thermometer), electrical conductivity (using a conductivity meter) and pH level (using a pH meter) were measured in the field. In order to measure and analyze the other parameters, water samples were taken using the Ruttner sampler. The samples were then transported to the laboratory in 2 liter dark colored bottles.The analyses were carried out using classical titrimetric and spectrophotometric methods proposed by Egemen & Sunlu (1999). The water quality of the samples were determined according to the Surface Water Control Regulation for inland waters in Turkey (Anonymous, 2016). Benthic macroinvertebrate samples were taken from each station twice by using an Ekman Birge grab (15 x 15 cm) and washed with mesh sieves of 1.19 mm, 0.595 mm, and 0.297 mm. All obtained organisms were immediately fixed in 4% formaldehyde in the field and then transferred to 70% ethanol. The benthic macroinvertebrate samples were identified to the lowest possible taxon (species, genus or families) under a stereomicroscope in the laboratory. Brinkhurst (1971,1978), Brinkhurst & Jamieson (1971), Brinkhurst & Wetzel (1984), Kathman & Brinkhurst (1998), Milligan & Michael (1997), Sperber (1948, 1950), Timm (1999) and Wetzel et al., (2000) were used as a guideline for identifying Oligochaeta specimens. Oliver et al., (1978), Saether (1980), Cranston (1982), Pinder & Reiss (1983), Fittakau & Roback (1983) were used for identification of larval Chironomids. McDonald et al., (1991) and Merritt & Kenneth, (1984) were used for identifying the other insecta specimens. The number of individuals per m^2 and their densities as (%) of the taxa were also evaluated. All the physicochemical data obtained were transformed by using statistical techniques on LogBase10 in Microsoft Office Excel 2003 and SPSS 9.0 for Windows (Krebs, 1999). The Bray Curtis Cluster analysis in the programme BioDiversity Pro 2.0 was used to determine the similarities of the sampling stations and months to evaluate the distribution of the benthic macroinvertebrate species and the physicochemical features (McAleece et al., 1997). The Shannon-Wiener Index was used to evaluate the species diversity of the dam lake (Krebs, 1999).

RESULTS AND DISCUSSION

In the study period, a total of 30 taxa consisting of 1,295 individuals per m^2 on average were determined. The identified specimens were grouped as "Oligochaeta", "Chironomidae", "Gastropoda" and "Other Insecta". A total of 5 species were identified, belonging to Oligochaeta (composed of 408 ind./m^2), 15 taxa belonging to Chironomidae, (composed of 127 ind./m^2), belonging to Gastropoda (composed of 3 ind./m^2) and 9 taxa belonging to Other Insecta (composed of 757 ind./m^2) (*Table 1*). It was concluded that Other Insecta make up the largest proportion of the lake's benthic macroinvertebrate fauna, accounting for 58.47% of the fauna. Other Insecta was followed by Oligocheta, Chironomidae, Gastropoda accounting for 31.50%, 9.80%, and 0.23% abundance, respectively (*Table 1*). The most taxa were identified at station 4 with 23 taxa. This was followed by station 2, station 3 and station 1 with 12, 9 and 8 taxa, respectively (*Table 2*). All the identified taxa were the first recorded for the Kanak Dam Lake. Oligochaeta and Chironomidae species are one of the most important freshwater species and are important food resources for some benthic macroinvertebrates and fishes (Brinkhurst & Jamieson, 1971). Numerous studies have shown a correlation between the population of Chironomidae and the number of diverse species of Oligochaeta, and this correlation was observed to be negative (Darby, 1962; Ponyı, 1983). In these studies, Oligochaeta was found to be the dominant group when larval Chironomids were found at a low density. This result is consistent with the findings of the studies that have been conducted at various dam lakes in Turkey so far. In a study conducted by Kırgız (1988), it was reported that Oligochaeta had an abundance level of 18.16% while Chironomidae had 77.27% in Seyhan Dam Lake of the Adana Province of Turkey. In another study conducted at Lake Terkos in the Istanbul province, a contrasting result was reported, that Oligochaeta was the dominant group in the lake (82% Oligochaeta, 10% Chironomidae and 8% other groups) Çamur-Elipek (2003). Further, in a study by Balık et al. (2004), Chironomidae was found as the dominant group with a 86.50% abundance, while Oligochaeta was found to have a 8.72% abundance in Buldan Reservoir of the Denizli province. In the Kemer Dam Lake of the Aydın Province, Oligochaeta was found to be the dominant group with 10 taxa while Chironomidae was found

Table 1. Monthly distribution of benthic macroinvertebrates (ind/m^2)in Kanak Dam Lake.

	Aug.	Sep.	Octo.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Ave.	%
Oligochaeta														
Dero digidata	1569	817	1273	534	0	11	0	0	0	22	6	17	354	27.3
Limnodrilus hoffmeisteri	0	0	0	289	0	0	0	0	6	0	17	17	27	2.09
Chaetogaster diaphanus	0	0	37	14	0	0	0	0	0	0	50	36	11	0.85
Tubifex tubifex	0	0	0	95	0	6	0	0	0	0	34	22	13	1.0
Stylaria lacustris	0	0	15	0	0	0	0	0	0	0	0	15	3	0.23
Total Oligochaeta	1569	817	1325	932	0	11	0	0	0	22	107	107	408	**31.50**
Number of taxa	**1**	**1**	**3**	**4**	**0**	**2**	**0**	**0**	**1**	**2**	**4**	**7**		
Chironomidae														
Tanytarsus gregarilus	0	6	112	0	0	0	0	0	0	0	28	28	15	1.16
Tanytarsus brundini	6	0	0	22	0	67	0	100	72	0	11	17	25	1.93
Tanypus punctupennis	11	0	6	0	0	0	0	0	0	0	50	17	7	0.54
Micropsectra praecox	0	0	0	0	0	11	0	0	0	0	17	6	3	0.23
Micropsectra radialis	0	0	0	0	0	0	0	0	6	0	39	0	4	0.30
Orthocladius thienemanni	0	0	0	0	0	195	0	0	33	0	0	0	19	1.46
Stictochiro nomus sp.	0	0	0	0	0	0	0	0	92	0	0	0	8	0.62
Stictochirono-mus sticticus	0	0	0	0	0	0	0	0	45	0	11	0	5	0.39
Chironomus rparius	0	0	0	0	0	0	0	0	6	0	17	0	2	0.15
Chironomus plumosus	0	0	0	0	0	0	0	0	17	0	17	0	3	0.23
Procladius sp.	6	6	28	0	0	0	0	0	6	6	133	33	18	1.39
Pottashia gaedii	0	0	0	0	0	39	0	0	0	0	0	0	3	0.23
Cricotopus bicinctus	0	0	0	0	0	17	0	39	0	0	0	0	5	0.39
Cricotopus intersectus	0	0	0	0	0	0	0	0	6	0	39	11	5	0.39
Halocladius varians	0	0	0	0	0	0	0	0	6	0	45	11	5	0.39
Total Chironomidae	23	12	146	22	0	329	0	139	289	0	407	123	127	**9.80**
Number of taxa	**3**	**2**	**3**	**1**	**0**	**5**	**0**	**2**	**10**	**1**	**11**	**7**		
Gastropoda	0	0	11	0	0	0	0	0	0	0	17	11	3	**0.23**
Total Gastropoda	0	0	0	0	0	0	0	0	0	0	17	11	3	
Number of taxa	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**		

Table 1. (continued).

Taxa	Aug.	Sep.	Octo.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Ave.	%
Other Insecta														
Hemiptera (adult)	0	34	11	0	0	0	0	161	1797	6	23	50	174	13.44
Total Hemiptera	0	34	11	0	0	0	0	161	1797	6	23	50		
Number of taxa	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**		
Trichoptera	11	6	45	6	0	100	0	80	45	34	51	51	36	2.78
Total Trichoptera	11	6	45	6	0	100	0	80	45	34	51	51		
Number of taxa	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**		
Ephemeroptera														
Heptogenia	0	0	0	0	0	0	0	0	0	17	11	0	2	0.16
Caenidae	322	1445	1305	3144	0	22	0	28	11	28	39	28	531	41.0
Baetis sp.	0	0	0	0	0	6	0	0	0	0	17	11	3	0.23
Total Ephemeroptera	322	1445	1305	3144	0	28	0	28	11	45	67	39	536	
Number of taxa	1	1	1	1	0	2	0	1	1	2	3	2		
Odonata														
Anizoptera	0	0	0	0	0	6	0	0	0	6	11	17	3	0.23
Zygoptera	0	6	0	0	0	0	0	0	0	0	17	6	2	0.16
Total Odonata	0	6	0	0	0	6	0	0	0	6	28	23		
Number of taxa	0	1	0	0	0	1	0	0	0	1	2	2		
Plecoptera	0	0	0	0	0	50	0	0	0	0	0	0	4	0.31
Total Plecoptera	0	0	0	0	0	1	0	0	0	0	0	0		
Coleoptera (larvae)	0	0	0	0	0	6	0	0	0	0	17	0	2	0.15
Total Coleoptera	0	0	0	0	0	6	0	0	0	0	17	0		
Total Insecta	356	1485	1361	3150	0	190	0	269	1853	85	186	163	757	**58.47**
Number of taxa	6	7	10	7	0	13	0	5	14	7	26	19	1295	

to have only 2 taxa (Yıldız et al., 2008). In this study, *Dero digidata,* belonging to Oligochaeta, was found to have the highest abundance level at all the sample-taking stations (86.76%) while *Stylaria lacustris* was found to have the lowest abundance level (0.74%). *Dero digitata* is known to be a cosmopolitan species and prefers a sandy-muddy substrate. In a study conducted in the Lakes Region, Yıldız & Balık (2006) reported that *Dero digitata* were the most dominant organisms in the region and the second most dominant organism in the Topçam Dam Lake. It is possible to state that *Dero digitata* mostly prefers to live in human-made environments (Taşdemir et al., 2009). Our findings support the scientific literature surrounding these claims.

In this study, it was observed that *Procladius* (*Holotanypus*) sp., belonging to Chironomidae, had the highest abundance out of all the sampling stations with an abundance level of 14.18%, while *Stictochironomus stictus* was found to have the lowest abundance with an abundance level of 1.57%. *Procladius* (*Holotanypus*) sp. prefers muddy substrates in stagnant or slow flowing water bodies, especially in pools and small lakes (Rosenberg & Resh, 1993; Armitage et al., 1995). The species has been identified in previous studies conducted at various dam lakes (Çamur Elipek 2003; Balık et al., 2004; Arslan et al., 2007; Yıldız et al., 2008; Taşdemir et al., 2010; Özbek et al., 2016). Chironomidae (e.g. *Chironomus plumosus*) is a common freshwater species, often regarded as an indicator of organic pollution (Brinkhurst & Jamieson, 1971) In this study, it was found that *C. plumosus* have a low abundance level (2.36%).

In this study Gastropoda was found to be present at only station 2 (*Table 2*). It has been reported that the species of Gastropoda

Table 2. The distribution of benthic macroinvertebrates (ind./m²) in Kanak Dam Lake in terms of the sampling stations.

	1st	2nd	3rd	4th	%
Oligochaeta					
Dero digidata	146	418	493	357	86.76
Limnodrilus hoffmeisteri	35	0	0	9	6.61
Chaetogaster diaphanus	0	17	17	9	2.70
Tubifex tubifex	17	0	0	0	3.19
Stylaria lacustris	0	13	13	0	0.74
Total Oligochaeta		0		0	**100**
Chironomidae					
Tanytarsus gregarilus	15	43	0	0	11.82
Tanytarsus brundini	0	0	0	98	19.69
Tanypus punctupennis	0	11	11	0	5.51
Micropsectra praecox	0	0	0	11	2.36
Micropsectra radialis	0	0	0	17	3.14
Orthocladius thienemanni	0	0	0	76	14.96
Stictochironomus sp.	0	0	0	30	6.30
Stictochironomus sticticus	0	0	0	19	3.93
Chironomus rparius	0	0	0	7	1.57
Chironomus plumosus	0	0	0	11	2.36
Procladius sp.	13	28	26	19	14.18
Pottashia gaedii	0	0	0	13	2.36
Cricotopus bicinctus	0	0	0	18	3.94
Cricotopus intersectus	0	18	0	0	3.94
Halocladius varians	0	0	0	20	3.94
Total Chironomidae		0		0	**100**
Gastropoda	0	13	0	0	1
Total Gastropoda	0	13	0	0	100
Other Insecta					
Hemiptera (adult)	11	74	599	11	22.98
Trichoptera	13	28	14	85	4.75
Number of taxa	**8**	**12**	**9**	**23**	
Ephemeroptera					
Heptogenia	0	0	0	9	0.27
Caenidae	139	620	96	1269	70.14
Baetis sp.	0	0	0	11	0.40
Anizoptera	0	0	0	13	0.40
Zygoptera	0	11	0	0	0.27
Plecoptera	0	0	0	17	0.52
Coleoptera (larvae)	0	0	0	9	0.27
Total Insecta					**100**
Total Number	**389**	**1294**	**1360**	**2138**	

are more intense in spring and summer and have a strong tolerance of hardness and salt (Robert & Dillion, 1999). In our study, the specimens belonging to this group were found in June, July and October. It was identified in this study that while the other insecta group comprised 58.47% of the macrobenthicfauna, Caenidae represented 70.14% of the fauna during the sampling period. The other insecta group collected from the lake was found to consist of 9 taxa (*Table 1*). Caenidae, Hemiptera and Trichoptera were observed at all stations. Caenidae had the highest number of individuals at station 4 with 1,269 ind./m², it had the lowest number of individuals at station 3 with 96 ind./m². Heptogenia, Anizoptera and Coleoptera larvae were found to have the lowest abundance (0.27%) within this group (*Table 2*). Ephemeroptera require a moderate amount of dissolved oxygen in the water and prefer clean water, but they can occasionally survive in a low amount of dissolved oxygen. Ephemeroptera belong to the feeding group of grazers and feed on algae or detritus (Haldar et al., 2016). Hemiptera was found to have the highest number at station 3 with 599 ind./m² and having the lowest number of individuals with 11 ind./m² at station 1 and station 4 (*Table 1 and Table 2*). Trichoptera was found to have an abundance of 4.75% within this group. It was found that station 4 had the highest number of individuals per meter square with 85 and station 1 had the lowest with 13 (*Table 2*). Trichoptera are a good indicator of pollution-free water as they dwell in clean water and are very sensitive to polluted water. They can be found anywhere from warm streams to cool streams including lakes, ponds and marshes (Haldar et al., 2016). In this study the dissolved oxygen value of the dam lake was found to have first class water quality (*Table 3*). Zygoptera, belonging to Odonata, was found to have the lowest abundance (0.27%) within this group (*Table 2*). Odonata can survive in waters with a very low amount of dissolved oxygen and therefore are found in areas where there is a moderate amount of pollution. They belong to the feeding group of predators (Haldar et al., 2016). Coleoptera larvae were found to have the lowest abundance (0.27%) within this group (*Table 2*). Coleopterans larvae are pollution-sensitive and can be found in moderately polluted water (Haldar et al., 2016).

It is observed that Oligochaeta and Chironomidae are found at a lot of dam lakes.(Balık et al., 2004; Taşdemir et al., 2010; Ersan et

Table 3. The values of measuredphysicochemical parameters in Kanak Dam Lake.

Parameters Months/ Stations	W.T.(°C)	pH	E.C.(µs/ cm)	D.O. (mg/L)	Salinity (‰)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	T.H. (°F)	NO_2-N (mg/L)	NO_3-N (mg/L)	PO4 (mg/L)	SO4 (mg/L)
August	16.5	8.41	377.5	8.41	0.03	1.49	32.06	6.32	16.5	0.017	19.76	0.177	0.750
September	13	8.50	376.7	8.94	0.03	3.99	37.27	0.97	17.35	0	15.69	0.152	0.611
October	3.25	8.33	409.7	5.18	0.04	3.74	44.08	0.89	18.4	0	16.93	0.105	0.560
November	4.5	8.25	445.2	10.80	0.02	3.49	45.28	1.03	20.7	0	13.97	0.067	0.458
December	-2.25	8.24	441	8.36	0.03	2.99	40.56	1.00	18	0	14.12	0.237	0.472
January	-5.25	8.3	406.7	7.08	0.03	3.74	52.7	0.96	21.1	0	13.41	0.165	0.508
February	-4	8.3	416.2	7.34	0.03	3.24	44.58	0.96	18.15	0	13.19	0.215	0.463
March	4.5	7.63	469	12.84	0.03	2.74	51.10	1.00	21	1.589	29.4	0.348	0.821
April	6.25	7.13	411.7	11.32	0.04	4.24	53.90	1.08	22.31	0.034	12.17	0.010	0.378
May	15	8.06	491.2	4.56	0.03	2.99	46.28	1.01	19.9	0.019	11.23	0.131	0.370
June	18.75	8.12	488.2	8.35	0.03	2.49	41.48	0.97	18.4	0.030	12.89	0.252	0.629
July	18.75	8.31	487.2	8.45	0.03	3.24	44.4	1.04	17.85	0.034	12.15	0.227	0.471
Average	7.41	8.13	435.0	8.46	0.03	3.19	44.47	1.43	19.13	0.14	15.40	0.17	0.540
1st Station	7.25	8.05	429.6	8.32	0.03	3.16	43.70	1.05	19.06	0.14	14.33	0.14	0.51
min-max	(-5)-20	6.51-8.62	353-517	4.95-13.1	0.02-0.05	0.99-4.99	32.8-52.1	0.80-18.8	16-20.6	0-1.54	9.41-27.8	0.008-0.36	0.27-0.72
2nd Station	7.08	8.09	410.2	8.42	0.03	2.66	44.44	2.33	18.67	0.16	15.48	0.16	0.51
min-max	(-6)-20	6.44-8.62	257-483	6.85-13.5	0.01-0.05	1.99-3.99	36.4-48	0.72-17.9	16.2-23	0-1.784	12.3-26.1	0.01-0.18	0.35-0.96
3rd Station	7.83	8.20	434.1	8.78	0.03	2.91	42.16	1.15	18.30	0.14	16.03	0.18	0.54
min-max	(-5)-19	7.74-8.52	378-500	7.23-13.3	0.02-0.05	0.99-4.99	31.2-48.8	0.80-20.8	16.4-21.8	0-1.52	9.52-29.9	0.01-0.25	0.28-1.06
4th Station	7.5	8.21	466.2	8.38	0.05	4.07	47.60	1.23	20.53	0.14	15.80	0.22	0.60
min-max	(-5)-20	7.2-8.5	380-568	4.18-11.4	0.02-0.08	1.99-7.99	27.2-67.3	0.87-24.6	17-24	0-1.50	8.90-33.6	0.08-0.41	0.22-0.89

(W.T: Water Temperature; E.C.:Electrical conductivity; T.H.:Total Hardness) al., 2009; Yıldız et al., 2008; Arslan et al., 2007). Chironomidae was found as the dominant group in Buldan Reservoir (Denizli) (86.50%, Chironomidae, 8.72% Oligochaeta and 4.77% Gastropoda) by Balık et al., (2004). In Tahtalı Dam Lake (İzmir), 82%, Chironomidae, 17% Oligochaeta, 1% Amphipoda was reported by Taşdemir et al., (2010). In a study conducted at the Mamasin Dam Lake by Ersan et al., (2009), 86.23% Chironomidae, 7.3% Oligochaeta and 6.47% Mollusca was reported. While Oligochaeta was found to be the dominant group in Kemer Dam Lake (Aydın) (92.72%), Chironomidae was found to have an abundance level of 7.28% (Yıldız et al., 2008). In a study conducted at the Musaözü Dam Lake (Eskişehir) by Arslan et al. (2007), Oligochaeta was found to have 42,5% abundance while Chironomidae larvae and the Varia were observed to have abundance levels of 30.5% and 27%, respectively. In the Kanak Dam Lake the other Insecta group was found as the dominant group. This may be due to either the high water quality observed in the dam that can maintain the life cycle of insects, or it may be related to the age of the dam. In a study conducted at the Sarıkum Lake (Sinop) by Akbulut et al. (2002) the other insecta group was found to be the dominant group.

The monthly physicochemical characteristics of the lake water are presented in *Table 3*. According to the water quality class levels in Anonymous (2016), the temperature, pH, electrical conductivity, dissolved oxygen, chloride and SO_4 levels of water were found at first class water quality (*Table 3*). However, the NO_3-N, NO_2-N and PO_4 levels of the water were found at second and third class water quality level. The total hardness of water was found to be light hard (°F) water quality level in Kanak Dam Lake.

Water temperature is the most important factor affecting the biologic activities of benthic macroinvertebrates in the lakes. The water temperature level of the Kanak Dam Lake fluctuated between -6°C and 20 °C during the study period. This fluctuation was caused by seasonal temperature changes in the weather. Similar physicochemical results were found in various studies conducted at the dam lakes in the region so far Dirican (2008); Mutlu et al., (2014); Dirican (2015); Yıldız & Karakuş (2018).

pH is a measure of how acidic or basic water is. The pH value of the lake water was found to be between 6.44 and 8.62. The pH value did not vary much among the stations (*Table 3*). In the study performed in Kılıçkaya Dam Lake (Sivas) and in the Çamlıgöze Dam Lake (Sivas), it were reported that both lakes have first class quality (Dirican 2008; Dirican 2015). In another other study which was performed by Mutlu et al. (2014) in Karacalar Dam Lake (Ulaş-Sivas), it was reported that the lake water had a pH level of 8.33 on average. Further, in the 4 Eylül Dam Lake (Sivas) by Yıldız & Karakuş (2018) the pH level of the surface water was reported to be 7.73 on average.

Electrical conductivity (EC) is a measure of water's capability to transmit electric current. The electrical conductivity of water depends on the presence, total concentration, mobility, valence and relative change of ions in water as well as water temperature. The electrical conductivity of water is positively correlated with water temperature (Hem, 1985). The electrical conductivity level of the Kanak Dam Lake water was observed to have values ranging from 257 µs/cm to 568 µs/cm. The highest value of EC was recorded at station 4 (*Table 3*). This station is the point where the Kanak stream meets the dam lake. The pollution from the stream may have increased when combined with the dam. EC value may be high due to pollution. In a study conducted by Dirican (2008) at the Kılıçkaya Dam Lake, the EC level of the water was observed to be between 344 µmhos/cm and 364 µmhos/cm. In another study conducted at 4 Eylül Dam Lake, the researchers reported that the surface water had an EC level of 181.5 µs/cm Yıldız & Karakuş (2018).

The dissolved oxygen level of water is an important factor for aquatic life and the chemical characteristics of the aquatic environment. In inland ecosystems, the minimum dissolved oxygen should not be less than 5 mg/L for aquatic life (Egemen, 2011). In the Kanak Dam Lake, the dissolved oxygen level was observed to fluctuate between 4.18 mg/L to 13.51 mg/L during the study period. The dissolved oxygen levels did not vary much among the stations (*Table 3*). In a study which was performed at Kılıçkaya Dam Lake, the dissolved oxygen level was reported to range from 8.64 mg/L to 8.94 mg/L Dirican (2008). In another research conducted at the Çamlıgöze Dam Lake, the water was observed to have first class quality level (Dirican, 2015). Further, in the Karacalar Dam Lake, it was reported that dissolved oxygen was 11.12 mg/L on average (Mutlu et al., 2014). In a study conducted by Yıldız & Karakuş (2018), it was reported that the dissolved oxygen amount in surface waters was found to be 7.88 on average.

Salinity refers to the total concentration of dissolved inorganic ions in water or soil and is therefore a component of all waters (Williams & Sherwood, 1994). The average salinity level at the Kanak Dam Lake was found to be 0.01‰ during the study period. The salinity levels did not vary much among the stations (*Table 3*). In the Karacalar Dam Lake, the salinity level was reported to be 0.011 ppt on average (Mutlu et al., 2014).

Chloride is an important chemical found in all natural waters, generally at a low concentration (Taş, 2011). The chloride level at the Kanak Dam Lake was observed to vary between 0.99 mg/L to 7.99 mg/L in the study period. These findings are consistent with the findings of various studies conducted at the freshwater environments in the region. At the Kılıçkaya Dam Lake (Sivas), the chloride level of the lake water was reported to have first class quality level Dirican (2008); and the Karacalar Dam Lake (Sivas) was reported to have a chloride level ranging from 9.20 mg/L to 20.08 mg/L (Mutlu et al. 2014). Our results were similar to the other studies which have been performed in the freshwater environments of the region.

Magnesium ions cause water hardness. As magnesium is one of the atoms in the molecular structure of chlorophyll, it is significantly important for plants with chlorophyll. It also regulates the phosphorus mechanism in algae and plants. In freshwaters, the magnesium limit is 50 mg/L (Taş, 2011). The magnesium level in the Kanak Dam Lake was observed to range from 0.72 mg/L to 24.6 mg/L. Calcium has the highest abundance out of all metals in freshwaters and it is biologically very important. Calcium forms the skeletal structure of aquatic organisms (Bulut et al., 2010). It also, just like magnesium, causes water hardness. In the Kanak Dam Lake, the calcium level was found to fluctuate between 27.2

mg/L to 67.33 mg/L during the study period. These findings are consistent with the findings of similar studies performed in the region. Mutlu et al., (2014) reported that they found calcium levels of 26.26 mg/L and magnesium of levels 23.27 mg/L in their study at the Karacalar Dam Lake. In the study which was performed by Dirican (2015) in Çamlıgöze Dam Lake the water could be classified as moderately hard in terms of total hardness.

Nitrogen derivatives such as NO_2, NO_3 and NH_4^+ play an important role in the process of water pollution. The nitrite resources in waters are the organic compounds, fertilizers and minerals (Taş, 2011). NO_3 is the final product of nitrogenous organic minerals (Topal & Topal-Arslan, 2012). During the study period, the NO_2-N level in the Kanak Dam Lake was observed to fluctuate between 0 mg/L to 1.784 mg/L, while the NO_3-N level ranged from 8.90 mg/L to 33.6 mg/L. In a study performed by Dirican (2008) at the Kılıçkaya Dam Lake and in a study conducted by Mutlu et al., (2014) at the Karacalar Dam Lake, the NO_2-N and NO_3-N levels were reported to have first class quality.

Phosphorus is a necessary element for aquatic life. Phosphorus is the most basic element of eutrophication occurring in water (Harper, 1992). It is found in very small amounts in uncontaminated waters and determines the richness of lakes (Tepe & Boyd, 2003). In the Kanak Dam Lake, PO_4 level was reported to fluctuate between 0.0008 mg/L and 0.41 mg/L during the study period. In a study performed by Mutlu et al. (2014), the phosphorus level was reported to be between 0.001 mg/L and 0.017 mg/L in Karacalar Dam Lake.

The SO_4 level in Kanak Dam Lake was found to be significantly low during the study period, between 0.22 mg/L and 1.06 mg/L. In the studies performed by Dirican (2008 and 2015), the levels of sulphate were reported to be first class in Kılıçkaya Dam Lake and Çamlıgöze Dam Lake. Our findings are similar to the findings of the previous studies conducted in the region. The results obtained from the Shannon Weiner index suggest that the Kanak Dam Lake's macroinvertebrate diversity is not significantly high (Average H': 0.64). The Shannon Weiner values obtained from sampling stations were found to be close to each other. The diversity level was found to be H': 0.67 for station 1, H': 0.63 for station 2, H': 0.60 for station 3, and H': 0.68 for station 4. The results were obtained using the Bray-Curtis index and indicated that in the Kanak Dam Lake, July and June are the most similar months in terms of the physicochemical parameters of the lake water with 99.45%, similarity level followed by May and June with 98.37%, and January and February with 97.75%. August and May were observed to be the most different months (*Figure 2*). Further, results of the Bray-Curtis index indicated that in terms of the distribution of taxa at different sampling stations, September and October, August and October, September and November are very similar to each other with 83.32%, 67.86%, 61.79% similarity levels, respectively. August and February were found to be the most different months in terms of distribution of the taxa with 0% similarity level. (*Figure 3*). In terms of the composition taxa, station 2 and station 4 were found most similar to each other with 60.83% similarity level followed by station 2 and station 3 with a similarity level of 52.20% similarity, while station 1 and station 2 were found to be the most different with a 40.04% similarity level (*Figure 4*). This situation can be explained by the bottom structure (rich vegetation) of these stations. As a result of this study, macrobenthic invertebrate fauna of the reservoir, which has never been studied before, was determined. Similar studies should be repeated periodically so as to predict the future of dam lakes.

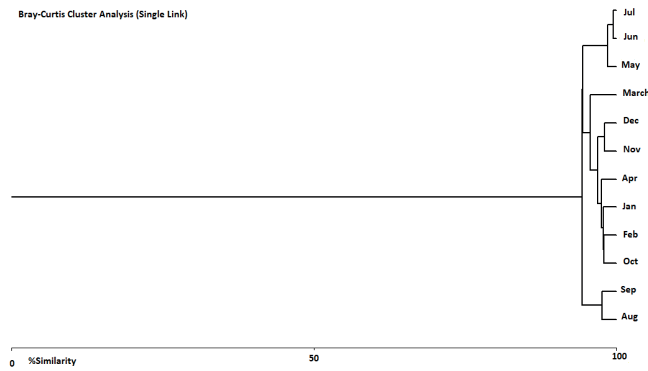

Figure 2. The dendrogram of similarity of months in Kanak Dam Lake in respect of physicochemical parameters.

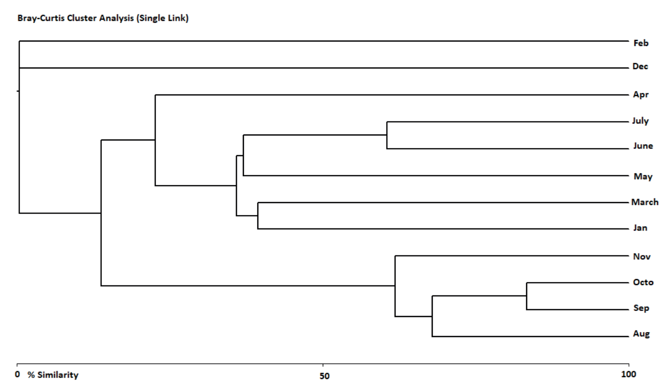

Figure 3. The dendrogramof similarity of months in Kanak Dam Lake in respect of macrobenthic invertebrates.

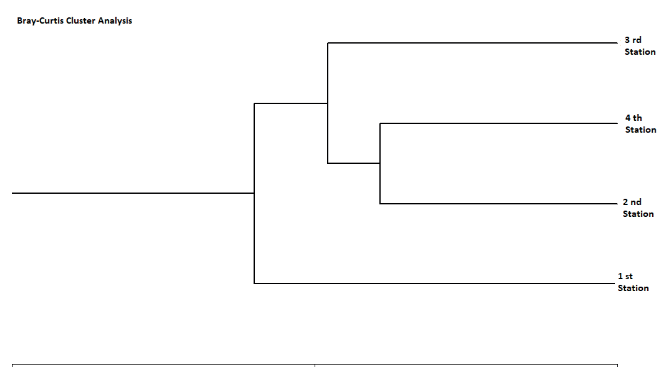

Figure 4. The dendrogramof similarity of stations in Kanak Dam Lake in respect to macrobenthic invertebrates.

CONCLUSION

With this study, we aimed to determine some physicochemical properties and benthic macroinvertebrate fauna of Kanak Dam

Lake. As a result of the research, 1,295 ind./m^2 and 30 taxa were identified. It was observed that the benthic macroinvertebrates were presented as Other Insecta group > Oligochaeta group > larval Chironomidae group > Gastropoda group. The identified taxa were the first recorded for the lake. In terms of the parameters examined, the lake was found to be between the first and second class water quality.

Conflict of interests: The authors declare that they have no conflict of interest.

Ethics committee approval: Ethics committee approval was not required.

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Disclosure: -

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Original Article

Confirmed Occurrence of *Mola mola* (Linnaeus, 1758) from Mersin Bay (Northeastern Mediterranean)

Deniz Ergüden[1], Deniz Ayas[2]

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ABSTRACT

In June 2018, a single female specimen of the Ocean sunfish, *Mola mola* (Linnaeus, 1758) (122 cm in total length and 80 kg in weight) was caught by a commercial trammel net at a depth of 393 m in Mersin Bay (Bozyazı coast), Turkey. This paper presents the first substantiated occurrence and hence, the confirmation of *M. mola* in the Northeastern Mediterranean, Turkey. Morphological and meristic measurements of the specimen were made and recorded with the catalog number MEUFC-18-11-101 in the Museum of the Systematic in, Mersin University's Faculty of Fisheries. Morphometric and meristic data matched other recordings of this species from parts of the Mediterranean, and the historical captured record of the species in the Mediterranean was documented.

Keywords: Ocean sunfish, rare occurrence, Mersin Bay, Mediterranean Sea, Turkey

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INTRODUCTION

The ocean sunfish, *Mola mola* (Linnaeus, 1758) is an oceanodromous, pelagic-oceanic species belonging to the Molidae family, and is the largest and most fecund Teleost fish in the world (Pope et al., 2010). Ocean sunfish are a generally solitary and highly migratory fish species, found in subtropical waters between depths of 30-480 m (Fricke, Kulbicki, & Wantiez, 2011). This species is distributed in the temperate and tropical regions of the Mediterranean, Atlantic, Indian, and Pacific Oceans (Sims & Southall, 2002; Froese & Pauly, 2019).

Ocean sunfish reach a maximum total length of 420 cm (Potter, Galuardi, & Howell, 2011) and a maximum published weight of 2,300 kg (Roach, 2003; Matsuura, 2015). They feed on fish, mollusks, zooplankton, jellyfish, crustaceans, and brittle stars (Clemens & Wilby, 1961; Scott & Scott, 1988; Kuiter & Tonozuka, 2001). Ocean sunfish are thought to migrate to higher latitudes in response to zooplankton migrations during the spring and summer months (Liu, Lee, Joung, & Chang, 2009).

The ocean sunfish is rarely found in the eastern Mediterranean Sea and the Adriatic Sea (Jardas, 1996; Dulcic et al., 2007). Recently, *M. mola* was recorded in Almazora, Castellon (Spain) in the western Mediterranean Sea (Ahuir-Baraja, Yamanou, & Kubicek, 2017). According to Silvani et al. (1999), this species was incidentally caught by regional fishermen in Mediterranean waters.

In Turkish waters, *M. mola* has previously been found in the Mediterranean Sea (Akyuz, 1957; Basusta & Erdem, 2000), and the Aegean Sea (Akşıray, 1958). Bilecenoglu et al. (2014) mentioned *M. mola* found in the northern Aegean Sea and the Marmara Sea in the marine checklist. *M. mola* was further documented off the Rize coast (Turkey) in the Black Sea (Öztürk & Özbulut, 2016). However, morphometric and meristic characteristics of the species among those that were caught were not recorded.

While *M. mola* has been found and documented in the Mediterranean Sea in Turkey in previous years (Bilecenoglu, Kaya, Cihangir, & Çiçek, 2014; Öztürk & Özbulut, 2016), this species is extremely rare in the northeastern part of the Mediterranean Sea. *M. mola* has not been previously documented in the Bay of Mersin.

This study aims to confirm its occurrence with some morphological properties from the Bozyazı coast (Mersin Bay, Northeastern Mediterranean). Additionally, historical records of ocean sunfishes in the Mediterranean coast will be discussed.

MATERIALS AND METHODS

Study area: The present study documents the findings of one ocean sunfish, *M. mola*, in the Bozyazı coast, Mersin Bay, Turkey (Figure 1) in June 2018. Bozyazı coast is an area on the Northeastern Mediterranean coast of Turkey with a highly productive coastal bottom, which promotes the development of plankton and is suitable for trawl fishing.

Sampling: One female specimen of *M. mola* (Linnaeus, 1758) was caught by a trammel net on 05 June 2018 in the Bozyazı Coast (Mersin Bay) (Coordinate: 36°05′15.2″N 32°58′28.7″E). This specimen was preserved in 4% formalin and deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (catalog number: MEUFC-18-11-101). Morphometric and meristic characters of this specimen are given in Table 1 and the sampling point of the species in the Mediterranean coast of Turkey is presented in the map (Figure 1). A photograph of the caught specimen is shown in Figure 2.

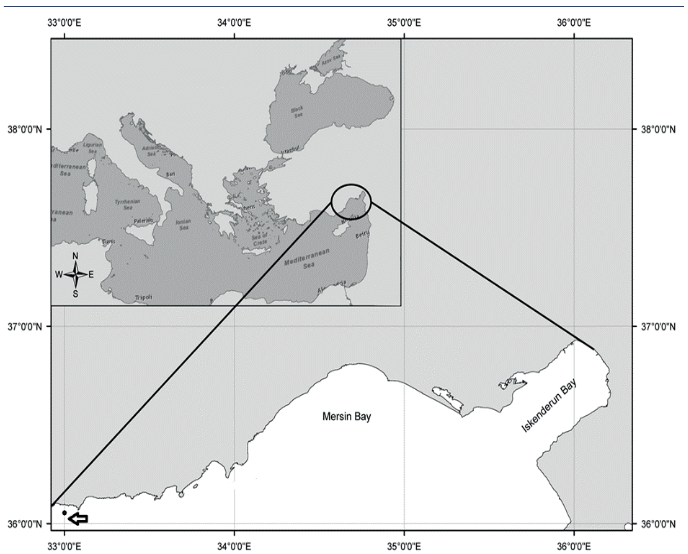

Figure 1. The black circle indicates the location where the specimen was caught.

RESULTS AND DISCUSSION

In this study, a female individual (total size of 122 cm, weighing 80 kg) of *M. mola* was caught from the Bozyazı coast in June 2018. Some morphometric and meristic measurements of this individual were made and are presented in Table 1. Morphometric and meristic measurements of the captured individual were compared with the measurements of a large individual of *M. mola* which was caught off the coast of Spain by Ahuir-Baraja et al. (2017), (Table 1). The historical captured record of the species in the Mediterranean and the Black Sea is documented in Table 2.

Figure 2. Specimen of *Mola mola* caught from Mersin Bay (Bozyazı coast).

Ocean sunfish have a large body that is compressed and ovular. The scaleless body is covered with extremely thick, elastic skin and irregular patches of tubercles over their body (Hutchins, 2004; Wheeler, 1969; Smith, 1965). The dorsal and anal fins of ocean sunfish are tall, and the pectoral fins point toward the dorsal fin. The caudal fin is replaced by a rudder-like structure called 'clavus'. Its mouth is very small and its teeth are fused to form a beak-like structure (Hutchins, 2004). Gill openings are reduced to a small hole at the base of the pectoral fins.

Adult ocean sunfish do not possess a lateral line, and only one gill opening is visible on each side, located near the base of the pectoral fins (Hutchins, 2004; Smith & Heemstra, 1986). Adults do not have a caudal fin or caudal peduncle. Instead, they have a clavus, which is a truncated tail, used more like a rudder than for propulsion. The clavus reaches from the rear edge of the dorsal fin to the rear edge of the anal fin (Wheeler, 1969; Hutchins, 2004). There is no swim bladder in adults.

Ocean sunfish vary in coloration, though the head, back, tips of the anal and dorsal fins and clavus are generally a mixture of dark grey-brown and dark silvery grey (Hutchins, 2004; Humann & Deloach, 2002). They have a white belly and sometimes have white splotches on their fins and dorsal side (Humann & Deloach, 2002).

Molas are distinguished by their distinct morphological characteristics, which include reduced/fused caudal elements, presence of a clavus in place of the caudal fin, absence of a swim bladder, and a degenerate, cartilaginous skeleton (Pope et al., 2010). Adults are found on slopes adjacent to deep water where they come in for shelter and for seeking cleaner fishes (Kuiter & Tonozuka, 2001). They swim upright and close to the surface. The dorsal fin often protrudes above the water (Pope et al., 2010). Molas may contain the same toxin as puffers and porcupine fish (Parsons, 1986; Bayhan & Kaya, 2015).

Table 1. Comparison of *Mola mola* individuals in terms of morphometric and meristic measurements.

Morphometric Characters (cm)	Present Study	Ahuir-Baraja et al. (2017)
Total length	122	240
Standard length	97	-
Head length (Head bump) length	16	18
Snout length	10	-
Maximum body depth (total body depth)	175	260
Body width (body depth)	67	122.5
Upper jaw length	7	-
Lower jaw length	5.5	-
Distance between dorsal and anal fin tip	64	-
Preorbital length	18	-
Preopercular opening length	35	-
Eye diameter (horizontal)	5.5	9
Eye diameter (vertical)	4	-
Eye ball diameter	2.5	-
Mouth diameter	9	10.1
Inter-orbital distance	28	-
Length of gill opening	3.2	-
Distance between eye and operculum	14	-
Operculum height	7.5	-
Pectoral fin base	8.5	-
Pectoral fin height	15	-
Pectoral fin length	18	18.4
Dorsal fin base	29	-
Dorsal fin height	27	-
Dorsal fin length	60	81
Anal fin base	28	-
Anal fin height	26.5	-
Anal fin length	53	74
Distance between dorsal and anal fin mid base	55	-
Distance between snout and dorsal fin origin	72	-
Distance between snout and anus	73	-
Distance between snout and pectoral fin	40	-
Distance between anus and anal fin origin	10	-
Prepectoral fin distance	38	-
Predorsal fin distance	65	-
Preanal fin distance	61	-
Clavus width	59	-
Meristic Characters		
Clavus rays	12	-
Clavus ossicles	8	-
Clavus lobes	8	-
Pectoral fin rays (left)	12	-
Dorsal fin rays	15	-
Anal fin rays	14	-

Table 2. Previous capture records of *Mola mola* in the Mediterranean and Black Sea in 1781-2018.

Author(s)	Year(s)	Location	Country	Depth	Total Length, TL (cm)	Weight (kg)
Basusta & Erdem (2000)	1994-1996	Karatas coast, Eastern Mediterranean	Turkey	25	133.2	105
Saad (2005)	1996-1999	Syrian coast, Eastern Mediterranean	Syria	-	-	-
Dulcic et al. (2007)	1781-2006	Adriatic coasts, Adriatic Sea	Croatia	-	-	-
Ahuir-Baraja et al. (2017)	February 2007	Almazora, Castellon, western Mediterranean Sea	Spain	surface	240	-
Öztürk & Özbulut (2016)	March 2016	Rize coast, Black Sea	Turkey	surface	>130-150	-
This study	June 2018	Bozyazı coast, Mersin Bay (North Eastern Mediterranean	Turkey	393	122	80

To date, there is little information available about the habitat, ecology, and population of *M. mola*. This species is listed as Vulnerable (VU) in the Global Red List by the International Union for Conservation of Nature, IUCN (IUCN, 2018; Liu et al., 2015) and considered as Data Deficient (DD) in the Mediterranean Sea (Abdul Malak et al., 2011). Marine ecosystems are greatly affected by bottom trawling in Turkish coasts, which destroys benthic and pelagic fauna (Abdul Malak et al., 2011). The coastal bottom of the Bozyazı coast, located in the northeastern Mediterranean Sea, is suitable for trawl fishing. According to Sims & Southall (2002) and Houghton et al. (2006), sightings of *M. mola* at temperate latitudes are more common in summer months. Therefore, populations of *M. mola* can be said to increase in higher seawater temperatures in this region (Turan, Erguden, & Gurlek, 2016). Furthermore, as Turkey's Mediterranean coast provides suitable areas for feeding, it is a migration destination for *M. mola*.

CONCLUSION

Although *M. mola* is not a commercial target species, taken as by-catch during commercial trawling, it is important for the biodiversity of Mersin Bay and Turkish ichthyofauna. Besides, this record is significant because the last capture record of *M. mola* in the region was made over 34 years ago in the Mediterranean coastal waters of Turkey. Therefore, the species is considered as exceptionally rare in the Mediterranean region of Turkey.

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: Ethics committee approval is not required.

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Original Article

Effects of Organic Materials Obtained from Different Tree Species on Some Chemical Parameters of Water Quality (Study Case of Andirin-Akifiye Forest Management Unit)

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ABSTRACT

Mineral substance concentrations are very important in terms of the levels of chemical quality in drinking water. A highly important source of minerals in water comes from the litter layer of the forest floor which is also a source of organic matter. This research investigates the contribution of organic litter formed in pure pine, cedar and beech forests to the quality parameters of water in the Andirin District of Kahramanmaraş province. A total of 90 organic matter samples were systematically collected from three different forest ecosystems. Some chemical properties of water solution were obtained from the organic matter using the ICP-OES device. This revealed that aluminum, boron, zinc, iron, cadmium, calcium, cobalt, magnesium, manganese, nickel and potassium parameters were present in the water. In addition, pH, EC and temperature measurements were taken. The results revealed lower amounts of chemicals in the waters obtained from the dead vegetation covers of the beech forests, showing elements such as aluminum, iron, magnesium, cobalt, and nickel levels to be 0.146 mg; 0.114 µg; 5.54 mg; 0.0006 µg and 0.0054 µg, respectively, compared to waters obtained from cedar and pine forest ecosystems. It was found that different organic materials had significantly different mineral concentrations affecting the chemical quality of the water. However, waters affected by the dead vegetation cover of the forest ecosystem were determined to comply with the standards of drinking and irrigation water according to current regulations.

Keywords: Forest ecosystems, forest litter layer, hydrological function, water quality

INTRODUCTION

One of the most important environmental problems in the world is water scarcity and water pollution (Costanza & Jorgensen, 2002; Bulut, Atay, Uysal, Köse, & Çınar, 2010; Tokatli, Solak, & Yılmaz, 2020). Forest ecosystems play an active role in solving both of these problems. These roles, undertaken by the ecological functions of forests, can be protected by increasing social awareness on this issue. Blanco & Lo (2012) defined forests as open systems with social, economic and ecological functions. Plant species, soil and climate factors constitute the main components of these relationships in ecosystems (Kantarcı, 2003). There are strong relationships and interactions between forests and drinking and irrigation water quality (Altun, Kezik, Kara, & Babur, 2016). In addition to meeting the demand for drinking and irrigation water as a hydrological function, forest ecosystems also contribute to wastewater treatment (Gray & Deneke, 1986; Altun et al., 2016). In a catchment basin, land use types (forest, pasture, agriculture, settlement, etc.), vegetation types (coniferous or leafy tree species, meadow, openness), geology, climate, physical, chemical, and biological soil properties, etc. all affect the quantity and quality of water (Gerrits, Pfister, & Savenije, 2010; Altun et al., 2016; Babur & Kara, 2017).

Forest ecosystems allow quality minerals to reach underground water by letting rainwater flow into surface water by infiltration, without letting it flow into the surface and thereby into dead vegetation and soil. Altun et al. (2016) stated that forests play an important role in providing quality water and the cost of treatment is lower in waters supplied from forests. Particularly in forests, the organic material that covers the soil's surface absorbs even the most severe rains, prevents superficial erosion and contributes positively to the mineral composition of the water. In a study by Özhan (2004), the needle leaf litter of a forest containing decayed mull or more types of humus can easily be filtered by draining heavy rain (150 mm/h) into the soil. It is of great importance in the infrastructure and installation stages to identify the resources from which drinking-irrigation water will be provided and to ensure its sustainability. Of particular importance is the need for drinking water dams to be installed far away from anthropogenic effects, in the upper parts of the catchment basin, and near the forest and pasture borders. It is well known that there are important differences in water quality and quantity of micro basins, which consist of different types of land use, belonging to drinking dams installed on the upper parts of the basin (Tobon-Marin, Bouten, & Sevink, 2000; Gerrits et al. 2010; Altun et al. 2016). The studies which have so far been conducted generally show the effect of rainfall on forest ecosystems with different coverage rates: surface flow rate, infiltration capacity, groundwater, and amount of interception. However, there has not yet been enough study on the interaction of the rain reaching the stand surface through organic matter and mixing with the soil, nor on that obtained from groundwater (Li, Niu, & Xie, 2013).

Organic matter is an organic composite formed by the accumulation of the components of plants such as dead leaves, branches, shells, flowers, and cones on the soil surface. The role of organic matter in forests is of great importance in terms of substance cycles in the ecosystem. Thus, organic matter contributes to the hydrological cycle and the food cycle of the ecosystem, it provides protection of soils against erosion, reducing soil temperature and decreasing the amount of evaporation, and it is a nutrient source of soil organisms enabling slow infiltration of precipitation into the soil (Bussiere & Cellier, 1994; Muria, 2000; Sato, Kumagai, Kume, Otsuki, & Ogawa, 2004). It plays an important role in changing the physical, chemical and biological properties of the soil by mixing with the soil as a result of the decomposition of the litter layer over time (Sayer, 2006; Kara, Babur, Altun, & Seyis, 2016; Babur, 2019; Babur & Dindaroğlu, 2020). In addition, besides forming the decomposed vegetation cover, and thus providing food and energy sources such as carbon, nitrogen, phosphorus and other elements for living creatures in rivers and dams, organic matter in forests is also known to improve the quality of groundwater as a function of the aquatic ecosystem (Cummins et al., 1983; Dorney, 1986; Meyer, Wallace, & Eggert, 1998). Although forest ecosystems and organic matters are very important in terms of the supply of drinking water from freshwater sources, insufficient measurement and evaluation techniques have led to a poor understanding of the role of dead vegetation covers in the hydrological cycle (Lundberg, Eriksson, Halldin, Kellner, & Seibert, 1997; Gerrits, Savenije, Hoffmann, & Pfister, 2007). Studies have been conducted on the maximum water holding capacities and interception capacities of dead vegetation covers (Pitman, 1989; Putuhena & Cordery, 1996; Sato et al. 2004). Another study, an investigation was made into the effects of different types of organic matter on the drinking and irrigation water quality of dams (Duan, Amon, & Brinkmeyer, 2014).

This study was carried out in the Andirin-Akifiye Forest management Unit of Kahramanmaraş Province to investigate the effects of organic matter obtained from different forest ecosystems on some water quality parameters.

MATERIALS AND METHODS

This study was carried out in the even aged pure larch, cedar and beech forests within the boundaries of the Andirin-Akifiye Forest Management Unit in Kahramanmaraş Regional Directorate of Forestry (Figures 3a, 3b and 3c). The aim of this study was to determine the effects of the dead vegetation cover under different forest tree species (pure beech, cedar and black pine stands) on water quality. For this reason, we selected close forest sections 115, 116, 132 and 134 where stand establishment, closure, stand age, geological, climatological and geomorphological features were similar. The research area covers a total area of ~ 100 hectares in typical karstic mountain basins in the rugged topography of the Mediterranean Region (36° 17′ 00″- 36° 18′ 40″ E longitude, 37° 43′ 05″- 37° 44′ 10″ N latitudes). The research area is approximately 90 km from Kahramanmaraş Province and the average elevation of the area is 1500m, with the general aspect being south facing and the average slope being a 45% incline. The general location study sites are shown in Figure 1 and a forest stand types map is shown in Figure 2.

Silvicultural properties (closure and stand type) of beech, cedar, and pine species are given in Table 1.

Field study

During the sample collection, care was taken not to mix litter layers with mineral soil. In order to prevent the samples from losing moisture, they were placed in polyethylene bags (Figures 4a-c).

Laboratory analysis

A suspension of 1/20 (organic matter / pure water) was prepared using powdered samples of different types, which were prepared

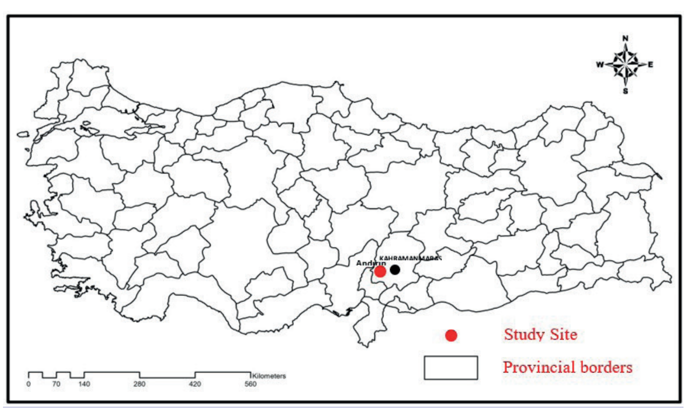

Figure 1. Location of the study area on the map of Turkey.

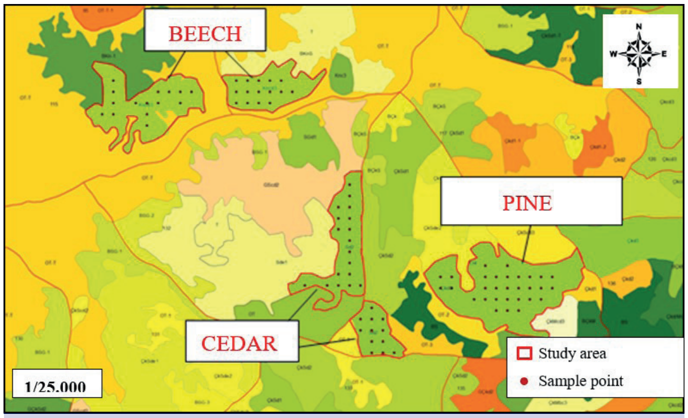

Figure 2. The location of beech, cedar and black pine stands on the Forest Management map (Anonymous, 2014).

Table 1. Silvicultural characteristics in stands of research area (Anonymous 2014).

Tree Species	Stand Type	Closure %	
Beech	Kncd3	3	70-100
Cedar	Sd2-3	3	70-100
Pine	Çkd3	3	70-100

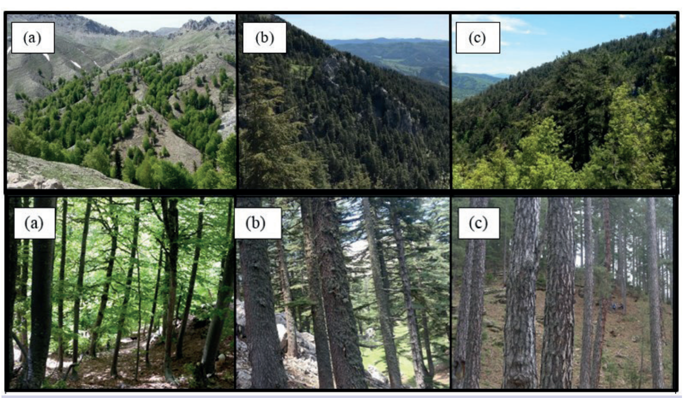

Figure 3. View of (a) beech, (b) cedar and (c) pine stands in the research areas (Photo: Emre Babur 2017).

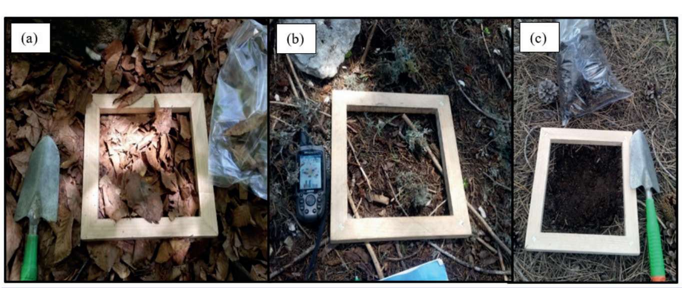

Figure 4. Collection of organic matter samples (a) beech, (b) cedar and (c) pine (Photo: Emre Babur 2017).

by sieving through a 1 mm sieve, being shaken in a shaker for 30 minutes and then resting for 24 hours. All samples were filtered through a membrane using Whatman Grade 42 paper (2.5 μm pore size) and then stored at 4 °C before analysis. Temperature, pH, and Electrical Conductivity (EC) were measured using the obtained saturation with a thermometer, pH meter and EC meter, respectively (Gülçür, 1974). The Calibration standards for determined elements were prepared using single element NIST traceable standards. All measurements were performed using an Agilent 5100 SVDV ICP-OES configured with an SPS 4 auto-sampler by preparing high purity standards and stock solutions of different concentrations for 11 elements: Al, B, Zn, Fe, Cd, Ca, Co, Mg, Mn, Ni and K (EPA, 2001). This instrument contains Dichroic Spectral Combiner (DSC) technology and captures the axial and radial viewings of the plasma in one reading. In total, 16 Multi-elemental calibration standards, ranging from 0.005 ppm to 100 ppm, were prepared. All calibration standards, Quality Control (QC) checks, and internal standards were prepared and matrix matched with 7% HNO3 + 3% ethanol (Anonymus, 2017).

Statistical analysis

ANOVA and Duncan tests were performed using the SPSS 15.0 program on the mineral substance concentration values determined as a result of some chemical analyses on water samples obtained from 90 organic litter layer samples collected from systematically determined points from different forest ecosystems.

RESULTS AND DISCUSSION

Average values and standard errors of some chemical quality parameters of the water samples are shown in Table 2. The values determined as a result of the study were compared with the drinking water quality standards set by the Turkish Standards Institute (TS-266) which produced some regulations such as Regulation on Control of Water Pollution, Surface Water Quality Management Regulation, Recommended Value, Maximum Permissible Value and Regulation on Waters for Humanitarian Consumption.

Extracts prepared from different organic material were measured under laboratory conditions, and there was no statistical difference between the average temperature values. The lowest water temperature (21.0° C) was found in dead vegetation covers of beech extract, while the highest was found in black pine extract at 21.5° C (Table 2).

In terms of temperature, according to the relevant regulations, extracts were included in Class I, and extracts according to TS-266 were included in the recommended values (Table 3). Since water temperature is effective in the physical, chemical and biological properties of water, it directly affects the water quality (Çetinkaya, 2003).

Levels of pH decrease with the increase of hydrogen ion concentrations in waters (acidic waters), while these levels rise with the decrease of this concentration (basic waters) (Göksu, 2003). In the pH measurements made in the extracts obtained, the highest pH average value was found to be 7.40 in beech water and the lowest pH value was 6.28 in pine water (Table 2). The pH values in beech and cedar waters, according to RCWP and SWQMR, were Class I and II respectively, while in pine water it was class III.

Table 2. Some measured water quality parameters.

Physical and inorganic-chemical parameters	Source of organic litter		
	Beech	**Pine**	**Cedar**
Temperature (°C)	21.0±0.02 a	21.5 ±0.04 a	21.2±0.01 a
pH (H_2O)	7.40±0.54 b	6.28±0.03 a	7.37±0.33 b
Electrical conductivity (µS cm $^{-1}$)	364.2 ±21.13 b	428.75±36.17a	396.38±32.17a
Aluminum (mg Al / L)	0.146±0.02 a	0.688±0.11 b	0.534±0.21 b
Boron (µg B / L)	0.085±0.01 a	0.089±0.01 a	0.112±0.01 b
Zinc (µg Zn / L)	0.0288±0.00 a	0.0506±0.01 b	0.0388±0.01 ab
Iron (µg Fe / L)	0.114±0.01 a	0.380±0.04 b	0.111±0.03 a
Cadmium (µg Cd / L)	0.002±0.00 a	0.002±0.00 a	0.003±0.00 a
Calcium (mg Ca^{+2} / L)	29.83±2.02 a	43.30±2.39 b	61.10±5.71 c
Cobalt (µg Co / L)	0.0006±0.00 a	0.0013±0.00 a	0.0014±0.00 a
Magnesium (mg Mg^{+2} / L)	5.54±0.40 a	8.70±0.53 b	7.61±0.67 b
Manganese (µg Mn^{+2} / L)	0.529±0.15 a	0.359±0.13 a	1.119±0.75 a
Nickel (µg Ni / L)	0.0054±0.00 a	0.021±0.00 c	0.013±0.00 b
Potassium (µg K / L)	27.76±2.34 a	79.20±4.55 b	46.06±11.62 a

Average value of 30 samples ± standard error. Different letters show that there are different groups and there are differences ($p < 0.05$).

Table 3. Regulations about Water Quality Parameters (Anonim, 2016a; 2016b; 2016c; TSE, 1997).

Water Quality Parameters	RCWP, SWQMR Water Quality Classification				TS-266		RWHC
A) Physical and chemical parameters	**I**	**II**	**III**	**IV**	**RV**	**MVP**	
1) Temperature (°C)	25	25	30	>30	12	25	-
2) pH	6.5-8.5	6.5-8.5	6.0-9.0	>6.0-9.0	6.5-8.5	6.5-9.2	≤6.5-9.5≤
3) Conductivity (µs / cm)	-	-	-	-	400	2000	2500
B) Inorganic contamination parameters							
1) Aluminum (mg Al / L)	0.3	0.3	1	>1	0.05	0.2	0.2
2) Boron (µg B / L)	1000^e	1000^e	1000^e	>1000^e	<1000^e	1	1
3) Zinc (µg Zn / L)	200	500	2000	>2000	100	5000	-
4) Iron (µg Fe / L)	300	1000	5000	>5000	50	200	200
5) Cadmium (µg Cd / L)	3	5	10	>10	≤3	10	5
6) Calcium (mg Ca^{+2} / L)	-	-	-	-	100	200	-
7) Cobalt (µg Co / L)	10	20	200	>200	-	-	-
8) Magnesium (mg Mg^{+2} / L)	-	-	-	-	30	50	-
9) Manganese (µg Mn^{+2} / L)	100	500	3000	>3000	20	50	50
10) Nickel (µg Ni / L)	20	50	200	>200	-	50	20
11) Potassium (mg K^{+} / L)	-	-	-	-	10	12	-

RCWP: Regulation on Control of Water Pollution, SWQMR: Surface Water Quality Management Regulation, RV: Recommended Value, MVP: Maximum Value Permissible, RWHC: Regulation on Waters for Humanitarian Consumption

In addition, according to TS-266 and RWHC, beech and cedar water were found to be within the recommended limits for drinking water (Tables 2 and 3).

The total amount of resistance ions in water or the resistance of the solution to electrical conduction is called electrical conductivity (EC) (Güler, 1997). The average electrical conductivity value in the pine water was found to be 428.75 µs/cm and the lowest was found in beech water (364.2 µs/cm) (Table 2). Average EC values were within the optimal limits according to TS-266 and RWHC (Table 3).

Ca^{+2}, Mg^{+2} and K^{+} values were analyzed in extracts obtained from organic matter under different forest ecosystems. The highest amount of Ca^{+2} was in cedar water as 61.10 mg Ca^{+2}/L and the lowest was 29.83 mg Ca^{+2}/L in the beech water (Table 2). The amount of Mg^{+2} was found to be the highest in the pine water as 8.70 mg Mg^{+2}/L and the lowest in beech water as 5.54 mg Mg^{+2}/L.

The highest amount of K^+ was found in the pine water as 79.20 µg K/L and the lowest amount in the beech water as 27.76 µg K/L (Table 2). Ca^{+2}, Mg^{+2} and K^+ values in extract waters were found to be below the limit values in related regulations and TS-266 (Tables 2 and 3). Ca^{+2}, Mg^{+2} and K^+ concentrations should be at determined levels in drinking water for human health. Calcium concentration in drinking water affects blood clotting, the permeability of the cell membrane, muscle movements and neural activity. On the other hand, a daily dose of magnesium should be at least 35 mg in adults for bone, muscle and neural tissues (Güler, 1997). Where there is potassium deficiency, nausea, anorexia, and digestive disorders are observed. Therefore, it has been reported that a daily dose of 2-4g of potassium should be taken by adults (Atabey, 2015).

Hardness in water is caused by the concentration of calcium and magnesium ions . Also, hardness refers to the soap's resistance to foaming. American, German, French and Russian hardness are used throughout the world. French hardness is used in Turkey (Rose, 1997). While the average total hardness amount was found to be highest with 68.71 mg/L in water samples obtained from cedar dead vegetation covers, the lowest hardness level was found in waters obtained from beech dead vegetation covers with 35.37 mg/L. The hardness value of pine water was found to be 52.00 mg/L (Table 2). Atabey (2015) stated in his study that there are important positive relationships between the hardness of water and cardiovascular diseases.

When the heavy metal contents of the waters obtained from different organic materials are examined, in terms of aluminum, the highest concentration was found to be 0.688 mg/L in water obtained from pine and the lowest was found to be 0.146 in beech water. In cedar water, this value was found to be 0.534 mg Al/L. There was a statistically significant difference in Al content ($p < 0.001$; Table 2). If aluminum is taken with drinking water in high amounts, it has been reported that it causes dementia (Atabey, 2015). From the Al values in the waters obtained from the dead vegetation covers of all three forest ecosystems in this study, beech water complies with the TS-266 values, while the others are in the III quality class (RCWP and SWQMR) (Table 3).

In terms of boron concentrations, statistical differences were found in waters obtained from different organic matter types ($p<0.001$). While beech and pine waters are in the same group, cedar water is in a different group. The highest boron concentration was found in cedar water as 0.112 µg B/L, and the lowest was found in beech water as 0.085 µg B/L (Table 2). Boron performs important tasks in the body. In particular, it helps to protect and effectively use vitamin D in the body with calcium, magnesium and phosphorus minerals. It also contributes to the protection of dental and bone health, and improves mineral brain functions. It supports the work of the estrogen hormone and reduces bone resorption. Another feature of the boron mineral is that it is a natural antibiotic. Boron is widely used in medicine especially in the treatment of osteoporosis, migraine, nervous diseases, fatigue and cancer. The amount of boron that should be taken daily by adults is 13 mg (Anonymous, 2019). In this study, the boron concentration in the waters obtained from different organic matters was below the limit values. Although cedar water is not very rich in boron minerals, necessary for the body's overall health, it can also be taken into the body as an additional nutrient.

In terms of the amount of iron and manganese in the waters studied, 0.14 µg Fe/L and 0.529 µg Mn^{+2}/L were found in beech water, respectively. In pine water, the finding was 0.380 µg Fe/L and 0.357 µg Mn^{+2}/L respectively, and in cedar water it was 0.111 µg Fe/L and 1.119 µg Mn^{+2}/L respectively (Table 2). No difference was found in terms of manganese concentrations of water obtained from different organic matters ($p> 0.05$). However, iron concentrations in the waters obtained from different organic materials were found different to be from each other ($p <0.001$). Alemdar, Ağaoğlu, Alişarlı, & Dede (2007) found the following results in a study conducted in the Van province where manganese and iron concentrations were found to be 50 and 200 µg/L in river water, 50 and 150 µg/L in spring waters, and 60 and 100 µg/L in tap water respectively. Another study found manganese 7-15 µg/L, iron 1-180 µg/L in drinking and tap waters in Van city center (Atasoy, Mercan, Alacabey, & Kul, 2011), and they found manganese and iron to be 3.88 and 6.67 µg/L in drinking water in the city center of Bitlis. High iron concentration in drinking water causes an increase in the number of microorganisms in network waters (Avşarer, Tüfekçi, Elmaslar, & Şahin, 2005). While iron excess in the body causes liver failure, low amounts of iron cause jaundice, anemia, shortness of breath and excessive fatigue. Manganese is quite poisonous. In its excess, it causes negative effects on the brain and lungs (Atabey, 2015). The waters we obtained in this study were within the limits in first class water quality in terms of iron and manganese according to the RCWP and SWQMR and below the limits specified in TS-266, and RWHC (Table 3).

In the water obtained in this study from dead vegetation covers under the beech forest ecosystem, zinc, cadmium, cobalt, and nickel values were found to be 0.0288 µg Zn/L, 0.002 µg Cd/L, 0.0006 µg Co/L, 0.0054 µg Ni/L respectively. In the water obtained from the pine organic litter layer, the levels were 0.0506 µg Zn/L, 0.002 µg Cd/L, 0.0013 µg Co/L, 0.021 µg Ni/L respectively, and in the water obtained from the cedar dead vegetation cover the levels were 0.0388 µg Zn/L, 0.003 µg Cd/L, 0.0014 µg Co/L, 0.013 µg Ni/L, respectively (Table 2). According to the results of the analysis conducted in drinking and tap water in Van city center, zinc values were 30-400 µg/L, nickel values were 12-46 µg/L, and cobalt values were 7-14 µg/L (Atasoy et al. 2011). The average zinc concentration in drinking water of Bitlis province was found to be 28.2 µg / L (Kahraman, Alemdar, Alişarlı, & Ağaoğlu, 2012). In our study, while cobalt, nickel and zinc average values were below the optimal limits according to TS-266, these waters have first class water quality characteristics according to RCWP and SWQMR. Cobalt is found in the component of vitamin B12 and is effective in body's resistance and prevents anemia, provides relief of digestion difficulty, fatigue, and muscle fatigue. Nickel, which has a toxic effect, causes an allergic reaction on the skin. Zinc causes health problems if it is above 3 mg/L in drinking water (Atabey, 2015).

CONCLUSION

In summary, different organic materials in forest ecosystems affect water quality at different rates. In addition to the fact that people obtain the nutrients necessary for their bodies by eating solid foods, the waters obtained by filtering through organic matter formed under different forest ecosystems also have a huge influence on the body's health, and thus organic matter from forests plays an important part in water production.

The findings of this study into certain chemical properties found in the water which passes through organic material of different types of forest trees show that all of these waters were in the 1st class water quality class according to RCWP and SWQMR, while the pH value of pine water was found to be water quality class III. Moreover, all these values, except for the pine pH value, were found to be close to the values specified in RWHC and TS-266 and were within the optimal limits.

The results showed that there are no negative chemical parameters to be found in the drinking water to be supplied from the region. The waters are within the optimal limits according to current regulations. In the future, it is predicted that there will be significant decreases in water potential and quality throughout the world and also in Turkey. Forest ecosystems have great potential in the sustainability of water supply and quality. It is particularly important that the functional efficiency of hydrological function forests should be maintained, and we recommend that the production and silvicultural activities in these areas should be included in forest management plans.

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Original Article

Investigation of the Effects of Land Use on Chemical Water Quality Parameters; A Case Study of Başkonuş-Meydan Dam Lake in Kahramanmaraş

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ABSTRACT

Water quality is in constant interaction with and changed according to time and place through natural and anthropogenic factors. It is also known that land use has a significant impact on water quality parameters. In this study, it was aimed to determine the effects of different land-use types (Forest, range and riparian) on water quality and which land-use type supports the most suitable drinking water for watersheds in the Başkonuş Plateau in Kahramanmaraş Province. The field studies were carried out in May 2019, and 2 sampling points were selected from each of the land-use types. Chemical properties (pH, EC) and some element concentrations (19 elements such as Al, As, Cu, B, Zn, Fe, P, Cd, Ca, Co, Cr, Pb, Mg, Mn, Mo, Ni, K, Na, and S) were investigated by using an ICP-OES. According to the results, the water obtained from forest areas is more suitable for drinking, having drinking water quality standards with a high pH value (7.59), and the Sulfur concentration of water obtained from range area (26.72 µg S /L) exceeded and did not comply with drinking water quality standards. When the chemical characteristics of the Meydan Dam were examined according to the regulated water quality standards declared in water pollution laws, it is clear that the dam basin has a high water quality standard (Class I). Therefore, a larger dam that can be built in this basin would be able to supply quality water that the Kahramanmaraş metropolitan municipality needs. Consequently, before deciding on the construction of the dam for drinking water, land-use maps would be created in the basins, and the selection of basins that have dense and qualified forestland would provide quality water.

Keywords: Chemical water quality, forest, Kahramanmaraş, Land use, parameters, range, riparian

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INTRODUCTION

Water quality is in constant interaction with and changed by natural and anthropogenic factors. Among the natural phenomena, the amount of precipitation, river bed and basin characteristics (slope, length, etc.), geological structure, soil type, plant species, and stand closure are major factors that significantly affect water quality. Many of these factors are also changed by humans, causing negative effects on water quality in rivers or lakes. For example, conversion of forests to agriculture or settlements prevents access to quality water due to using pathogens, pesticides, domestic waste, heavy metals, oils, salts, and road construction in agriculture and settlements areas.

Land-use types in a catchment basin significantly affect the water quality of the basin. It is well-known that there is a strong relationship between land use (agriculture, range, forest, settlement, etc.) and water quality. Moreover, some studies have reported that forest land increases the water quality and quantity in a watershed basin (Altun, Kezik, Kara, & Babur, 2016; Babur & Kara, 2017). On the other hand, the studies investigating the relationship between land use and water quality due to the need for quality and a sufficient amount of water are gradually increasing as a result of pollution or the reduction of water resources because the increase in human activities in different land-use leads to changes in water quality (Sliva & Williams, 2001; Ngoye & Machiwa, 2004; Tokatli, Solak, & Yılmaz, 2020). However, land-use changes (such as removal or change of vegetation) and management practices (the establishment of road and settlement areas, agricultural management, etc.) are also important factors affecting water quality (Yong & Chen, 2002). Guo, Ma, & Zhang (2009) revealed that land use and vegetation cover the effects of water quality. This study stated that there is a significant amount of total nitrogen and phosphorus transitions from meadows to streams. Cao, Li, Wang, Zhao, & Wang (2012) examined the relationship between land-use type and water quality. They noticed that there are significant differences in the water quality parameters of cultivated areas, meadows, and forest areas in terms of TN (total nitrogen), TP (Total phosphate) coliform bacteria. Huang et al. (2013) found significant differences in some water quality indicators among settlement areas, meadows, and forests in their study. In all of these studies, the effects of land use in watersheds on water quality were specifically investigated.

Several studies have emphasized that land use has a significant impact on the chemical properties of water quality (Peierls, Caraco, Pace, & Cole, 1991; Hunsaker & Levine, 1995; Puckett, 1995; Howarth et al., 1996; Allan, Erickson & Fay, 1997). For example, the nitrogen and nitrate concentrations in water increased due to the increase of meadow areas in a basin (Jordan, Correl, & Weller, 1997). However, Allan et al. (1997) stated that the best properties in terms of habitat quality and biotic integrity are in agricultural land. Urbanization and intensive agricultural practices is a large portion of the negative relations between land use and water quality (Baker, 2005). The decrease of plant communities covering the soil surface in an area increases the sediment loss with the surface flow in the catchment basin while decreasing the infiltration capacity (Walling & Fang, 2003). Considering that such studies are lacking in developing countries, it is important to develop models that reveal the relationships between land use and water quality.

Kahramanmaraş/Başkonuş Plateau has great importance for the region in terms of climate, ecology, natural beauty, and very rich vegetative biodiversity. Since the areas where the research was conducted are far from anthropogenic effects, they can be used as drinking water basins if needed in the future. In this study, it was aimed to determine the effects of different land uses on water quality and which land-use type support the most suitable drinking water for the watershed in the Başkonuş Plateau in Kahramanmaraş Province. It was investigated how the rainfall drained from litters and soils formed under different land uses affect the water quality during infiltration. For this purpose, soil sections with a certain surface area were taken from the lands and placed in suitable drainage containers. The water filtered as a result of an artificial sprinkler applied to the soil sections was collected and prepared for analysis. From the data obtained as a result of this study, the most suitable land-use type will be determined, and the study will contribute to the preference of water collection basins through the construction of drinking water reservoirs.

MATERIALS AND METHODS

Study area

The field study was carried out in the forest, range and riparian areas around the Meydan pond located within the boundaries of the Başkonuş Forest Operation of Kahramanmaraş Forest Regional Directorate (Figure 3a, 3b, and 3c). The research area is approximately 50 km from Kahramanmaraş Province. In this study, the areas where topographic, geological, climatological, and geomorphological features are similar were chosen to reveal the effects of different land uses on water quality. The water collection basin of the study site, which is selected from typical karstic areas, covers an area of 105 hectares in total (37° 34′ 12″–37° 34′ 51″ N; 36° 35′ 13″–36° 35′ 22″ E). The average elevation of the area is 1200 m, the general aspect is north, and the average slope is 50%. The study site is shown on the map in Figure 1.

The vegetation type of the research area consists of black pine (*Pinus nigra* Arn.), fir (*Abies cilicica subsp. cilicica*), and cedar (*Cedrus libani* A. Rich.) forest trees. There are Salvia, Trifolium, Cynodon plants, etc in range areas and reeds in riparian areas (Anonymous, 2012). The field studies are shown in Figure 2.

Field study and sampling

In this research, field studies were carried out in May 2019. In order to carry out this research, 2 sampling points were selected from each of the forest, range, and riparian areas. At the sample points, a 25x25x15 soil section was removed without disturbing the litter layer and structure and placed in the fit size plastic containers with bottom leaking filters (Figure 3 and 4). 2 lt of ultra-pure distilled water was added to each soil section with an artificial rain system. Then, the water leaking into the boilers placed under the buckets was collected. Afterward, the water samples were filtered in such a way as to make their volumes to 100 ml with ultra–pure distilled water.

Chemical and elemental parameters

The pH values of water samples were measured with an Orion 250A meter, electrical conductivity (EC) with an Amber Science

Figure 1. Location of the study site.

Figure 2. The appearance of forest, range and riparian zones in the research areas (Photo: Emre Babur, 2019).

Figure 3. The process of taking soil sections from the field (Photo: Emre Babur, 2019).

Figure 4. Soil sections taken from different land-use types (Photo: Emre Babur, 2019).

2052 meter with the method of glass electrode (Gülçür, 1974). The element levels (Al, As, Cu, B, Zn, Fe, P, Cd, Ca, Co, Cr, Pb, Mg, Mn, Mo, Ni, K, Na, and S) in the samples were determined by using the "Agilent 5100 ICP-OES" device at the East Mediterranean Transitional Zones Agricultural Research Institute. The element analyses were recorded as means triplicate measurements (EPA, 1998; 2001).

Statistical analysis

The average, maximum, and minimum values and standard errors of the water samples values were determined by using the SPSS 15.0 program. The average values of different water samples obtained from the different land-use types were compared by using ANOVA and Duncan test.

RESULTS AND DISCUSSION

The mean values and standard errors of the chemical properties of water samples obtained from different land uses have been determined (Table 1). Comparisons and classifications of the mean values of water chemical parameters were made based on the Surface Water Quality Management Regulation, Water Pollution Control Regulation, Maximum Permissible Value, Recommended Value, and Regulations on Human Consumption Water.

Acidic water or basic water occurs with increasing or decreasing hydrogen ion concentrations in water (Göksu, 2003). It has been determined that there is a significant difference in the pH of the water obtained from different land uses (p<0.001). While the highest pH value was found in riparian areas with a value of 7.63, the lowest pH value was found in range areas with a value of 7.38. However, the pH value of the water samples taken from the Meydan pond was determined to be lower (7.08) compared to other land uses (Table 1). The pH is the most important factor for chemical and biological systems in water ecosystems (Atay and Pulatsü, 2000). According to the inland water quality standards, the high-quality water limits given for the pH parameter are between 6.5 and 8.5 (Table 2). The pH values of water obtained from all three landuse types were determined to be in the I. and II. water quality classes of the RCWP and SWQMR. Also, all of these water samples are suitable for drinking-use according to TS-266 and RWHC (Tables 1 and 2).

According to electrical conductivity (EC), the mean EC values of water samples obtained from the different land-use types were found significantly different (p<0.001). The highest EC value was found in riparian areas with a value of 248.74 µs/cm, and the lowest was found in forest areas with a value of 53.25 µs/cm (Table 1). The EC values of water samples were found to be in the I. and II. water quality classes, and they are suitable for drinking-use according to TS-266 and RWHC (Tables 1 and 2).

The Ca^{+2}, Mg^{+2}, and K^{+} values of the water samples were found statistically different from each other. In terms of Ca^{+2} average values, 62.47 mg Ca^{+2} / L, the highest value, was found in the range and 14.39 mg Ca^{+2}/L, the lowest, in the forest areas. The concentration of Mg^{+2} was found to be the highest in the riparian areas with a value of 9.27 mg Mg^{+2} / L and the lowest concentration in forest areas with a value of 2.03 mg Mg^{+2} / L. The K^{+} concentration was found to be the highest in the forest area with a value of 4.98 µg K^{+} / L and the lowest in the riparian area with a value of 1.93 µg K^{+} / L (Table 1). Ca^{+2}, Mg^{+2}, and K^{+} concentrations of water samples are below the maximum limit values in all regulations and TS-266 (Table 1 and 2). In terms of human health, Ca^{+2}, Mg^{+2}, and K^{+} concentrations should be at the recommended levels in drinking water.

In terms of total hardness in the water samples (Ca + Mg), the highest mean value was found in range areas with a value of

Table 1. Some chemical water quality parameters measured from different land-use types.

Chemical parameters	Land use types			
	Riparian	Range	Forest	Dam pond
$pH_{(H2O)}$	7.63±0.15 b	7.38±0.20 ab	7.59±0.28 b	7.08±0.14 a
EC (µS cm^{-1})	248.74 ±69.21 b	229.75±56.25 a	53.25±12.18 a	166.00±15.13 ab
Alüminium (mg Al/L)	0.106±0.07 ab	0.129±0.09 ab	0.211±0.08 b	0.044±0,02 a
Arsenic (µg As/L)	0.110±0.01 a	0.100±0.01 a	0.108±0.01 a	0.363±0.05 a
Copper (µg Cu/L)	0.0085±0.01 ab	0.147±0.01 b	0.0026±0.00 a	0.001±0.00 a
Boron (µg B/L)	0.024±0.01 a	0.030±0.01 a	0.029±0.01 a	0.015±0.01 a
Zinc (µg Zn/L)	0.0245±0.03 a	0.0387±0.04 b	0.0035±0.00 ab	0.0006±0.00 a
Iron (µg Fe/L)	0.093±0.06 a	0.131±0.04 ab	0.218±0.06 b	0.0373±0.02 a
Phosphorus (µg P/L)	0.116±0.03 a	0.406±0.31 a	0.451±0.28 a	0.087±0.01 a
Cadmium (µg Cd/L)	0.003±0.00 c	0.002±0.00 bc	0.001±0.00 ab	0.000±0.00 a
Calcium (mg Ca^{+2} /L)	49.59±13.55 a	62.47±21.39 b	14.39±9.81 a	22.84±9.74 a
Cobalt (µg Co/L)	0.0001±0.00 a	0.0004±0.00 b	0.0003±0.00 ab	0,0002±0.00 ab
Chromium (µg Cr/L)	0.0008±0.00 ab	0.0010±0.0 ab	0.0012±0.00 b	0.0004±0.00 a
Lead (µg Pb/L)	0.0052±0.01 a	0.0089±0.00 a	0.0063±0.00 a	0.0033±0.00 a
Magnesium (mg Mg^{+2} /L)	9.27±0.40 bc	6.92±0.53 ab	2.025±0.67 a	13.82±1.25 c
Manganese (µg Mn^{+2} /L)	0.0063±0.00 a	0.123±0.01 a	0.0105±0.01 a	0.0044±0.00 a
Molybdenum (µg Mo/L)	0.00±0.00 a	0.00±0.00 a	0.00±0.00 a	0.00±0.00 a
Nickel (µg Ni/L)	0.021±0.02 a	0.013±0.01 c	0.0035±0.00 b	0.0008±0.00 a
Potassium (µg K/L)	1.93±0.34 a	7.30±0.55 b	4.98±0.83 a	1.057±0.32 a
Sodium (mg Na/L)	4.07±0.06 ab	6.56±0.09 b	1.90±0.05 a	4.27±0.07 ab
Sulfur (µg S/L)	8.74±2.28 b	26.72±3.12 c	0.76±0.01 a	1.70±0.14 a

EC: electrical conductivity. Values are means ± SE and letters denote significant differences among land-use type ($p \le 0.05$) based on a Duncan test (n=30).

69.39 mg / L while the lowest hardness level was found in water obtained from forest areas with a value of 16.42 mg / L. The mean hardness value of the water samples of the riparian areas was found to be 59.29 mg / L (Table 1). According to the French hardness level, the most suitable water was determined to be the water obtained from the forests. This is thought to be since the cation exchange capacity and the amount of organic matter of the forest soils are higher than other land uses. On the other hand, domestic wastes and agricultural areas are known to increase the hardness of water and level of pollutants in Turkey (Bulut, Atay, Uysal, Köse, & Çınar, 2010).

Statistically significant differences were found in phosphorus concentrations of the water samples according to the different land uses ($p<0.05$). The highest amount of phosphorus was found in water samples obtained from forest areas (0.451 µg P / L), while the lowest amount of phosphorus was found in riparian areas (0.116 µg P / L). Phosphorus concentrations in the range (0.406 µg P/L) is of an average value close to those in forest areas. According to the regulation classes, water samples obtained from riparian areas are in 2nd quality class, and samples obtained from rangeland and forests are in the 3rd quality class in terms of phosphorus. It is well known, high concentrations of nitrogen and phosphorus cause eutrophication in water (NSTC, 2003). Therefore, it is important to keep the phosphorus concentration in drinking water below the eutrophication threshold value (Pers, 2005). The sources of phosphorus in the catchment basin are materials of organic origin. Therefore, there is no inorganic phosphorus entry into the area, the lower concentration of phosphorus determined in the basin. Otherwise, using organic phosphate fertilizers, cadmium should be accumulated on the soil surface and also be moved to groundwater resources (Emiroğlu et al., 2013).

In terms of the concentrations of some heavy metals in water samples, the mean aluminum (Al) amount was found the highest in the forest area with a value of 0.211 mg / L and the lowest in the riparian areas with a value of 0.106 mg / L. This value in rangeland areas was found to be 0.129 mg / L. These values showed that land-use types statistically effect Al contents ($p<0.001$; Table 1). Also, it was determined that the Al values of water samples obtained from all land-use types are in the 1st water quality class with all regulations such as TS-266, RCWP, and SWQMR (Table 2).

No statistically significant difference was found in boron concentrations of water samples from different land uses ($p>0.05$). Boron concentrations of water were very close to each other. Boron amounts in the water samples obtained from riparian, rangeland, and forest areas are 0.024, 0.030, and 0.029 µg B / L, respectively (Table 1). The boron concentration in water samples were found below drinking water threshold values shown in TS-266 and RWHC (Table 2).

Significant differences were found in iron concentrations of water samples in different land uses ($p<0.001$). While the highest Fe concentration was found in forest areas with a value of 0.218 µg Fe / L, the lowest concentration (0.093 µg Fe / L) was found in riparian areas. However, no significant difference was found be-

Table 2. Regulations about Water Quality Parameters (Anonymous 2016a; 2016b; 2016c; TSE, 1997).

Water quality parameters	RCWP, SWQMR Water quality classification				TS-266		RWHC
A) Chemical parameters	**I**	**II**	**III**	**IV**	**RV**	**MPV**	
1) pH $_{(H2O)}$	6.5-8.5	6.5-8.5	6.0-9.0	>6.0-9.0	6.5-8.5	6.5-9.2	≤ 6,5-9,5≤
2) EC (µs/cm)	-	-	-	-	400	2000	2500
B) Inorganic chemical parameters							
1) Aluminium (mg Al/L)	0.3	0.3	1	> 1	0.05	0.2	0.2
2) Arsenic (µg As/L)	20	50	100	>100			10
3) Copper (µg Cu/L)	20	50	200	>200	20	200	20
4) Boron (µg B/L)	1000[e]	1000[e]	1000[e]	>1000	<1000[e]	1	1
5) Zinc (µg Zn/L)	200	500	2000	> 2000	100	5000	-
6) Iron (µg Fe/L)	300	1000	5000	> 5000	50	200	200
7) Phosphorus (mg P/L)	0,02	0,16	0,65	>0,65			
8) Cadmium (µg Cd/L)	3	5	10	>10	≤3	10	5
9) Calcium (mg Ca^{+2} /L)	-	-	-	-	100	200	-
10) Cobalt (µg Co/L)	10	20	200	> 200	-	-	-
11) Chromium (µg Cr^{+6}/L)	Çok az	20	50	>50	Çok az	50	0,05
12) Lead (µg Pb/L)	10	20	50	>50	10	50	10
13) Magnesium (mg Mg^{+2} /L)	-	-	-	-	30	50	-
14) Manganese (µg Mn^{+2} /L)	100	500	3000	> 3000	20	50	50
15) Molybdenum (µg Mo/L)	-	-	-	-	-	-	-
16) Nickel (µg Ni/L)	20	50	200	> 200	-	50	20
17) Potassium (mg K+ /L)	-	-	-	-	10	12	-
18) Sodium (mg Na/L)	125	125	250	>250	<250	250	200
19) Sulfur (µg S/L)	2	2	10	>10			

RCWP: Regulation on Control of Water Pollution, SWQMR: Surface Water Quality Management Regulation, RV: Recommended Value, MPV: Maximum Permissible Value, RWHC: Regulation on Waters for Humanitarian Consumption

tween manganese concentrations and land use differences (P>0.05). In water samples, manganese concentrations were observed from highest to lowest in rangeland, forest, and riparian areas, respectively (Table 1). The iron, manganese, and potassium concentration in water samples found are in the 1st water quality class for drinking water according to all regulations like TS-266, RCWP, SWQMR, and RWHC (Table 2).

As a result of comparing average values of arsenic, copper, zinc, cadmium, cobalt, molybdenum, nickel, chromium, and lead of the water samples obtained from different land uses; the concentrations of copper, zinc, cadmium, cobalt, nickel, and chromium are affected by land-use differences, but those of arsenic, lead, and molybdenum are not.

The highest heavy metal concentrations were found in the riparian area with values of 0.003 µg Cd/L, 0.110 µg As/L, and 0.021 µg Ni/L; these values in rangeland were 0.147 µg Cu/L, 0.039 µg Zn/L, 0.0004 µg Co/L, and 0.0089 µg Pb/L, and the value in forest land was 0.0012 µg Cr/L (Table 1). All these heavy metal values comply with the average values reported in the international water quality regulations and TS-266. This study noticed that the water samples obtained from different land-use types were found in the1st water quality class in terms of the heavy metal concentrations (TS-266, RCWP, SWQMR, and RWHC). Tokatli (2019) noticed that some heavy metals such as cadmium, lead, and arsenic were found to be the highest ecological risk factors for the basin reservoirs in the Thrace Part of the Marmara Region of Turkey. This situation was caused by the medicines and fertilizers used in agricultural areas from land use in the basin. Also, they are known as agricultural origin toxicants. Cd is one of the most present toxicants because many fertilizers used in Turkey were found to be over the limit values (Tokatli, 2019). Since there is no agricultural land in our study area, heavy metal concentrations were found low in all water samples.

It has been determined that different land uses statistically affect sodium and sulfur concentrations from chemical water quality parameters ($p<0.001$). The highest concentrations of sodium (6.56 µg Na / L) and sulfur (26.72 µg S / L) were found in water samples obtained from range areas while the lowest amounts (1.90 µg Na / L and 0.76 µg S / L) were found in forest areas. The Na concentration in the water samples obtained from all three land-use types is in the 1st water quality class. The sulfur concentration of water samples obtained from the forests is I. quality water, but riparian areas are found in class III water quality. However, it was found to have an intense concentration above the quality standards in the rangeland water sample. Increased sulfur concentration causes the taste and smell of the water to deteriorate and not to be of the standard of drinking and utilities (Öztürk & Fakıoğlu, 2017).

Usta (2011) found the effects of different land use on water quality in the Galyan Watershed Basin. The study stated that the pH, EC, TN, TP, Ca^{++}, Mg^{++} and Na^{+} amounts in the waters decrease with the increase of range areas in a basin. Also, the pH, EC, Ca, and Mg amounts in the water decrease when the Coniferous Forest areas increase. However, it was stated that pH, EC, TN, Ca, Mg, and Na in water increased with the increase in the broadleaf forest areas. As mentioned earlier, several anthropogenic activities (tillage, fertilization, etc.) in the agriculture area firstly change the soil characteristics, and then this change is reflected in the stream water (Tong & Chen, 2002). Bhat, Jacobs, Hatfield, & Prenger (2006) noticed that the amounts of TN carried to stream water are expected to be high in broadleaf forest. More organic matter and microorganism activities in forest areas cause more element transition to soil and water (Türüdü, 1981).

CONCLUSION

In this study, the effects of land use differences on the chemical water quality were examined. The rain falls into the catchment basin where there are forest, range and riparian areas, and the rainwater mixes with groundwater by leaching organic and inorganic elements in the plant, root, litter layer and soil. These waters also join the drinking water reservoirs from here. When the chemical parameters of waters obtained from different land uses were examined, it was determined that the water obtained from the forest and riparian areas are more suitable for drinking and meet drinking water quality standards. However, the Sulfur concentration of water obtained from the range area (26.72 µg S /L) exceeded drinking water quality standards and cannot be considered as drinking water. When the chemical characteristics of the Meydan Dam were examined according to the regulated water quality standards declared in water pollution laws, it is clear that the dam basin has a high water quality standard (Class I). A larger dam that could be built in this basin which would be able to supply quality water to meet the needs of the Kahramanmaraş metropolitan municipality. Land-use maps of the basin should be created before choosing the location to build dams for drinking water. In the selection of the catchment basin, authorities need to choose natural areas with vast forest lands, specifically away from any mining sites. The management and sustainability of different land uses (forest, agriculture, range and settlement) should be taken jointly by the competent authorities by considering the integrated watershed management approach in the basins that are supposed to supply drinking water.

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Original Article

Sediment Radioactivity Levels of Deep-Water Fishery Grounds in Antalya Bay

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ABSTRACT

To evaluate the radiological load of the fisheries ground sediments of deep-water areas in the Antalya Bay, ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs activity concentration levels were measured with the Gamma Spectroscopy technique using a HighResolution Germanium Detector (HPGe). Sediment samples were collected from the seabed surface of five different depth ranges (between 400 – 800 m). Detected mean radionuclide activities of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were 16.53±2.41, 17.9±2.54, 371.44±18.44 and 3.91±1.27 Bq kg^{-1}, respectively. The effect of the Chernobyl Nuclear Power Plant disaster in deep water sediments of Antalya Bay was observed. However, the detected radionuclide concentrations are at acceptable levels according to the International Atomic Energy Agency (IAEA).

Keywords: Marine sediment, HPGe, Natural radioactivity, ^{137}Cs

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INTRODUCTION

Antalya, with a 2.4 million population, is the fifth most populated city in Turkey. Increasing population size also increases urbanization and industrialization pressures. Moreover, as a tourism hub, the area hosts an increased population density through the tourism season (KTB, 2019). In addition to regional pollutant factors, additional pressure arising from current systems and atmospheric flows were reported for the coastal areas of the region (Özhan et al., 2016). Domestic, industrial, and agricultural wastes and river discharges were known to be the main source (80-90%) of the marine pollution in the Mediterranean Sea coastline of Turkey (Yemenicioğlu, 2016). Moreover, offshore activities were considered to be the secondary sources of pollution (Yemenicioğlu, 2016).

Following the Chernobyl Nuclear Power Plant (Chernobyl NPP) disaster on 25 April 1986, a major radioactive (^{137}Cs) fallout was released into the environment. ^{137}Cs, as a common fission product, is one of the most problematic radioisotopes due to its high-water solubility, meaning it easily spreads in the environment. Radionuclides adversely affect biota in the impact area (Yilmaz and Özmen 2019; Özmen and Yilmaz 2020). As a response to the Chernobyl NPP disaster and increasing radioactivity levels in the Marmara region, a radiation monitoring program was launched by the Turkey Atomic Energy Agency (TAEK, 2004). Within the framework of this program, the detected ^{137}Cs activity was 15 Bq kg^{-1} from 0 – 5 cm layer of soil in the Antalya region in 1995.

Deep sea grounds of Antalya are important areas for commercial deep-water fishing activities. Several different fish (Deval et al., 2018) and invertebrate species (Deval and Kapiris, 2016; Deval et al., 2017) are caught from these fishing grounds and marketed in the local fisheries markets. Despite several studies having been carried out in the region to assess the state of the pollution in the marine environment (Türkmen et al., 2014; Özhan, 2015; Yilmaz, 2020), to the best of our knowledge, no literature information is available on the radionuclide activity levels of deep-sea sediments. The present study aims *i)* to evaluate the activity levels of natural (^{226}Ra, ^{232}Th, ^{40}K) and anthropogenic (^{137}Cs) radionuclide activities in the deep sea fishing grounds of Antalya Bay and *ii)* to create a reference database of radionuclide background activity for the region.

MATERIALS AND METHODS

Sampling and sample preparation for radionuclide activity detection

Surface sediment samples were collected to investigate the availability of natural (^{226}Ra, ^{232}Th, ^{40}K) and artificial (^{137}Cs) radionuclides at deep sea fishing areas (400 - 800 m) in Antalya. Sediments accumulated in the trawl net during the deep-sea trawl hauls were transferred to the laboratory for the subsequent radionuclide analysis.

Prior to spectrometric measurement, samples were dried (72 hours) at room temperature and homogenized by grinding. The samples were weighed and filled into cylindrical containers (r=3cm, h= 6 cm) by passing through a 2 mm sieve. Samples were stored for 30 days in an airtight manner in order to stabilize the Compton region and establish a radioactive equilibrium between ^{226}Ra and ^{222}Rn (Yaprak and Aslani, 2010).

Radionuclide analysis

Following the formation of radioactive equilibrium, the gamma spectroscopic measurements of the samples were performed by using an electrically cooled high purity Germanium detector (HPGe) of p-type coaxial, with a relative efficiency of 40% and 768 eV Full Width Half Maximum (FWHM) values at 122 keV for ^{60}Co and 1.85 keV FWHM at 1332 keV for ^{60}Co. The energy calibration of the gamma spectrometer system was carried out with point sources, and IAEA RGU-1, RGTh-1, and RGK-1 radioactive standards of the same geometry as the samples were used for activity measurement. A detailed description of the measurement system has been given by Özmen et al. (2013, 2014).

All samples were placed into the detector chamber and counted for 86400s. The ^{226}Ra activity concentrations of the samples were calculated by the 352 keV (^{214}Pb) and 609 keV (^{214}Bi) energy peaks released from the ^{238}U decay series. ^{232}Th activity concentrations were calculated by the 911 keV (^{228}Ac), 583 and 2615 keV (^{208}Tl) energy peaks. Both ^{40}K and ^{137}Cs activity concentrations were evaluated by the 1461 keV and 662 keV energy peaks, respectively. Background measurements were also performed with an empty sample container before and after measurements. To calculate the radionuclide activity concentrations, the following equation has been used;

$$A = \frac{N/t}{\varepsilon \, . I_{\gamma} . m}$$

A: activity of radionuclide (Bq kg^{-1}), *N*: net count of energy in total (background removed), ^{t}: live time (second), *ε*: efficiency of HPGe detector, *Iγ*: abundance of gamma ray and *m*; mass of sample in kg.

RESULTS AND DISCUSSION

The detected radioactivity levels of deep-sea sediment samples were ranged from 10.65 to 23.76 Bq kg^{-1} for ^{226}Ra, 11.63 to 24.15 Bq kg^{-1} for ^{232}Th, from 316.35 to 414.83 Bq kg^{-1} for ^{40}K, and from 1.48 to 8.58 Bq kg^{-1} for ^{137}Cs. Activity concentrations of radioisotopes (^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs) in sediments samples from different depths were given in Table 1.

Table 1. Radioactivity levels of the deep-sea sediments (Bq kg^{-1} dry weight).

Depth (m)	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
400	10.65	11.63	414.83	8.58
500	13.88	12.43	372.51	1.48
600	13.95	18.92	346.54	4.56
700	20.43	24.15	406.99	2.32
800	23.76	22.35	316.35	2.59

The correlations matrix of radioisotopes and depth were given in Table 2. A significant positive correlation between depth and concentrations of ^{226}Ra and ^{232}Th radioisotopes was observed ($p<0.05$). However, no clear correlation was observed for ^{40}K. For ^{137}C, with the exception of 500 m samples, a negative decreasing trend was observed with increasing depth. The correlation analysis between radioisotopes also revealed a positive strong relationship between ^{226}Ra and ^{232}Th isotopes.

Table 2. Correlations matrix of radioisotopes (^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs) and depth.

	^{226}Ra	^{232}Th	^{40}K	^{137}Cs	Depth
^{226}Ra	1				
^{232}Th	0.900*	1			
^{40}K	-0.700	-0.400	1		
^{137}Cs	-0.300	-0.400	0.200	1	
Depth	1.000**	0.900*	-0.700	-0.300	1

(*) significance level 0.05, (**) significance level 0.01

The detected activity levels of the naturally occurring radionuclide (^{226}Ra, ^{232}Th, ^{40}K) were consistent with the activity levels reported from different regions of Turkey's surrounding seas. Furthermore, the levels of these radionuclide were below the worldwide mean activity levels (^{226}Ra: 35 Bq kg^{-1}, ^{232}Th: 30 Bq kg^{-1}, ^{40}K: 400 Bq kg^{-1}). The regional activity levels of naturally occurring radionuclide were directly linked with the geochemical structure of the region and anthropogenic activities such as mining, oil, and gas exploration. Our results indicated that (for naturally occurring radionuclides) the study area could be classified as a normal area in a radiological point of view.

The main pathways of the naturally occurring radionuclide entrance into the marine environment were river transport, rain water, fallout, etc. Moreover, the activity concentration of these radionuclides was reported to be dependent on physicochemical parameters such as organic matter content and pH levels of sediments (Tripathi et al., 2013; Özmen, 2020). A slight decreasing trend of ^{226}Ra and ^{232}Th activity levels was reported with the increasing distance from shoreline and depth (coastal zone, max.

Table 3. Literature information on radioactivity of the deep-sea marine sediments (Bq kg^{-1} dry weight).

Region	Study Area		^{226}Ra	^{232}Th	^{40}K	^{137}Cs	Sampling Year	Literature
Mediterranean Sea	Antalya Bay	Mean±SEM	16.53±2.41	17.90±2.54	371.44±18.44	3.91±1.27	2019	Present Study
		Range	10.65-23.76	11.63-24.15	316.35-414.83	1.48-8.58		
	Marmara Sea	SPS <63 µm	10.97-20.16	13.97-27.25	341.4-683.0	8.58-67.92	2008	Kılıç & Cotuk, 2011
		SPS >63 µm	7.18-19.18	6.41-18.30	281.9-662.2	1.12-26.40		
	Izmit Bay		18±6	24±8	568±16	21±2	2008-2009	Ergül et al., 2013
	Greece		9.7±5.4	7.8±3.0	132±54	3.3±2.0	*NA*	Papaefthymiou et al., 2017
			18-86	20-31	368-610	0.7-3.8	*NA*	Pappa et al., 2016
	Egypt		10.3-21.8	11.9-34.4	268-401	2.7-15.9	2002	El-Reefy et al., 2010
	Spain		12.1	15.0	188	*NA*	2006	González-Fernández et al., 2012
Arabian Peninsula Coastline	Oman Sea		11.83-22.68	11.83-22.68	222.89-535.07	0.14-2.8	2011	Zare et al., 2012
	Egypt (Red Sea)		*NA*	7.68 -22.70	160.0-356.8	1.11-7.92	2008	Dar & El-Saharty, 2012
	Kuwait		18.3-23.1	18.8-23.0	386-489	1.5-2.9	2016	Uddin & Behbehani., 2018
	Saudi Arabia		11.68±1.22	6.21±0.58	169.40±6.29	0.76±0.120	*NA*	El-Taher et al., 2018
Asia	Thailand		5-50	4-108	3-714	*BDL*	*NA*	Kritsananuwat et al., 2015
	India		34±15	75±38	782±233	*NA*	*NA*	Tripathi et al., 2013
South America	Venezuela		2.6-28.9	4.2-41.8	15-421.2	*BDL*	*NA*	Alfonso et al., 2014

BDL: Below the detection limits; *NA*: Not available; SPS: Sediment particle size

15 km from shore line) from South East India due to the weathering and denudation activity of land (Tripathi et al., 2013). However, in our case, a distinct positive correlation between these radionuclides and depth was observed. Both elements resistance to weathering effects and/or the elements contents of the crustal rock as the source of release could be the main drivers of the ^{226}Ra and ^{232}Th distribution pattern in the study area.

It is known that Uranium (U) (mother of Radium) and Th deposition on the seabed mainly originated from land sources. The amount adsorbed on particulates that transferred through river runoff to marine environment desorbs in the high salinity medium of the sea. Uranium (U) solubility was reported to be one of the Th sources in the marine environment (Valkovic, 2000). Mean U concentration in ocean water was given as 2.4 dpm L^{-1} (1.08 pCi L^{-1} or 3.25 µg L^{-1}). The produced Th by hydrolysis and adsorption processes is bound to the sinking particulate matter and ends up at the seabed. Our results revealed a significant correlation between depth and ^{232}Th - ^{226}Ra deposition. To understand the deposition dynamics of these radionuclides in the deep-water sediments, further investigation is needed.

The detected ^{137}Cs activity (mean: 3.91±1.27 Bq kg^{-1}) in the sediments of the study area indicate the effect of the Chernobyl NPP disaster in deep water sediments of Antalya Bay. Our results were relatively lower than reported activity levels from northern parts of Turkey. Both the distance of the study area from ground zero and the sampling time were possible factors that lead to the low activity levels in the sediment. Another aspect that needs to be emphasized is the annual sinking rate of ^{137}Cs in marine sediments. Results of radionuclide monitoring activities between 1986–2002 from the Finnish coastline indicated an annual 1 cm sink of ^{137}Cs (Ilus et al., 2008). Moreover, several other studies also reported up to 1 cm sedimentation rates in the Mediterranean Sea (Othman et al., 2000; Zuo et al., 1997; Petrinec et al., 2012; Evangeliou et al., 2013). Due to this phenomenon a relative decrease of ^{137}Cs activity in the marine surface sediment is expected through time.

While the main route of atmospheric radioactivity transfer to the sea is fall out, groundwater and rivers are the secondary contributor factor of the deposition to the sea (Zielinski, 2018). The main load of global ^{137}Cs fall out reported to be deposited in the sea was approximately 603 PBq (63.6%). On the contrary, the total fall (85 PBq ^{137}Cs) out from the Chernobyl NPP disaster was reported to be mainly deposited over land (69 PBq) (UNSCEAR, 2000). About 2% of ^{137}Cs is known to be removed by runoff from land deposition to the sea (Yamagata et al. 1963). Due to this phenomenon it is expected to detect higher ^{137}Cs activity levels in the coastal areas. Consistent with this, our results indicated that ^{137}Cs activity in marine sediments decreased with the depth. This outcome could be the result of deposition to the relatively shallow areas due to the impact of runoff in the study area. Moreover, evaluation of water column ^{137}Cs profiles, even with the impact of the Chernobyl NPP disaster, exhibits a steady decrease of activity up to 1000 m (Aarkrog, 2005).

CONCLUSION

Available literature on radionuclide activities in marine sediments mostly covers coastal area sediments from relatively shallow zones. The main focus of previous works was to understand the vertical distribution of the anthropogenic radionuclides (^{137}Cs and ^{239,240} Pu) in the sediments to detect the state of pollution in the environment. The present study represents natural and artificial radionuclide activities of deep-sea surface sediments (400 – 800 m). Our results provide the background activity level of deep-sea sediments for the selected radionuclides. The detected activity levels for both naturally occurring and anthropogenic radionuclides in the deep-sea fishery areas of Antalya Bay were below the world average activity levels. It could be concluded that the consumption of seafood caught from these areas will not pose any radiological health risks. Further studies are needed to understand the active factors on the distribution dynamics of the radionuclides in deep sea areas.

Conflict of interests: There are no conflicts of interest to declare.

Ethics committee approval: Ethics committee approval is not required.

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Short Comminication

Subcutaneous Infiltrative Lipoma in a Cultured European Seabass (*Dicentrarchus labrax*)

Çiğdem Urku[1]

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ABSTRACT

Lipomas are soft tissue mesenchymal benign tumors divided into two groups: infiltrative and non-infiltrative. In an outside examination of the body of cultured European seabass (*Dicentrarchus labrax*) obtained from an inland fish farm located in the Turkish Aegean Coast One tumor-like structure was observed on the dorsal side of the back, leading to deformation of the skin surface. It had been not reported in clinical findings and data for diseases and mortality in the fish farm. In the histopathological examination, the tumor (neoplasia) was diagnosed as a subcutaneous infiltrative lipoma. Histologically, the mass was characteristic of a benign tumor, which constituted well-differentiated adipocytes, showing a tendency to invade the underlying musculature. This study described for the first time lipomas in cultured sea bass in Turkey, which could be used to extend the existing information about benign tumors.

Keywords: Seabass, *Dicentrarchus labrax*, lipoma, tumor, histopatholo

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INTRODUCTION

Lipomas are benign tumors of mesenchymal origin common in mammals in almost every organ (Colella, Lanza, Rossiello, & Rossiello, 2004; Ezirmik & Yildiz, 2011; Pricop et al., 2018; Tong, Seltzer, & Castle, 2020). In fish, they have been classified into two groups: infiltrative and non-infiltrative. The first one involves tumors, which characteristically infiltrate adjacent tissues, tend to recur after excision (Enzinger & Weiss, 2000) and are quite a rare type in fish (Schlumberger & Lucke, 1948; Martineau & Ferguson, 2006; Roberts, 2012). Usually, they have been reported in few species of freshwater and marine fish such as channel catfish, *Ictalurus punctatus* (McCoy, Bowser, Steeby, Bleau, & Schwedler, 1985); European eel, *Anguilla anguilla* (Easa, Faisal, Harshbarger, & Hetrick, 1989); cultured striped seabream, *Lithognathus mormyrus* (Volpatti et al., 1998) bluefin tuna, *Thunnus thynnus* (Marino, Monaco, Salvaggio, & Macrì, 2006); molly, *Poecilia velifera*, (Stefano, Bonfiglio, Montalbano, Giorgianni, & Lanteri, 2012) and Mediterranean seabass, *Dicentrarchus labrax* (Marino, Chiofalo, Mazzullo, & Panebianco, 2011).

European seabass is one of the most economically important fish species in the Mediterranean region (Afonso, Games, da Silva, Marques, & Henrique 2005; Alpbaz, 2005). According to 2018 TUIK data, seabass is in the first place, with 116.915 tons of aquaculture production (TUIK, 2018). In Turkey, inland fish farms known as aquaculture facilities producing marine fish are most commonly located in Aegean Region (Gullu, 2012). The inland fish farms located in the Muğla province are of great importance with regard to cultured marine fish (Ercan, Sunar, & Başer, 2012).

The present study aimed to provide a histological characterization of a subcutaneous infiltrative lipoma observed in the cultured European seabass from the Aegean Region in Turkey.

MATERIALS AND METHODS

An adult European seabass was obtained from the inland fish farm, located in the Turkish Aegean coast. The fish was transported in a conveying box to the laboratory of fish disease of the Faculty of Aquatic Science, Istanbul University for a histopathological examination of a recent tumor-like structure, located on the dorsal side of the back. It had been not reported in clinical findings and data for diseases and mortality in an inland pond by the management of the fish farm.

After the body weight and length were measured (approx. 100 g and 13 cm), the fish was prepared for histopathological analysis. Fixing (10 % buffered formalin) cut section of the tumor- like structure was soft. Pathological muscular tissue was processed for histopathology by fixing it in 10 % buffered formalin, and processed for paraffin embedding. The obtained sections (4-5 µm) were stained with hematoxylin and eosin (H&E), and examined by light microscopy for determination of the tumor- like structure (Bullock, 1978; Roberts, 2012).

RESULTS AND DISCUSSION

The characteristics described by histopathological examinations were consistent with a diagnosis of subcutaneous infiltrative lipoma in cultured European seabass in Turkey.

The European seabass had a single tumor-like structure on the dorsal side of the back, deforming the skin surface. Microscopically, thinning of the epidermis was detected, the mass consisted of well-differentiated adipocytes with single large fat vacuoles and flat nuclei, pushed to the periphery of the cells. The tumors were not encapsulated and frequently infiltrated between and around the subcutaneous skeletal muscle bundles (Figure1, Figure 2). Based on the characteristic histological features, the tumor-like structure was identified as a subcutaneous infiltrative lipoma.

Figure 1. Histological section of a lipoma from a seabass showing separation of the dermis from underlying trunk muscles a: adipocyte; c: scale, e: epidemis, sp: scale pocket, sm: skeletal muscle (H&E).

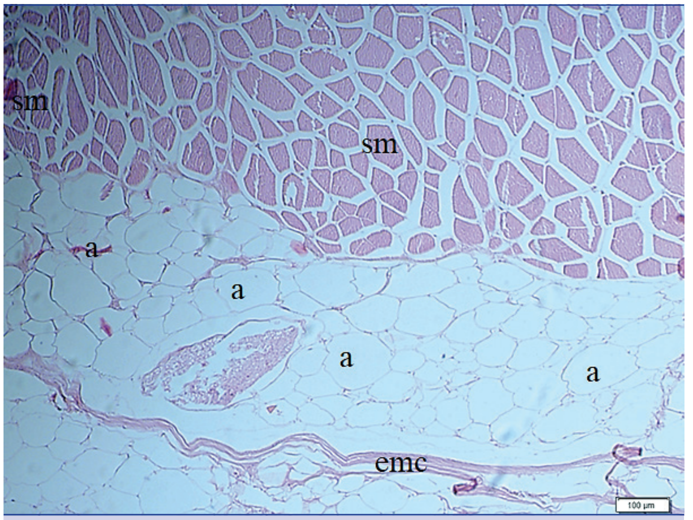

Figure 2. Entrapped muscle cells by well-differentiated adipocytes **a:** adipocytes, **emc:** entrapped muscle cells, **sm:** skeletal muscle (H&E).

Tumors are generally divided into malignant and benign tumors. The most prominent characteristic of benign tumors is that they do not metastasize (Roberts, 2012). In recent studies, there are reports of benign tumors such as lipomas, adenomas (Gumpenberger, Hochwartner, Loupal, 2004), osteomas (Lima, Souza, Mesquita, Souza & Chinelli, 2002), melanomas (Sweet et al., 2012) and papillomas (Akaylı, Bozkurt, and Urku, 2018) in fish. However, these tumors have been reported to affect a small proportion of the fish population (Marino et al., 2011; Akaylı et al., 2018). It is very important to determine which fish species and which tumors are seen before determining the factors causing tumor formation. It has been reported that the most used method for the purpose of identification is histological methods. Thus, the cellular structure can be observed, and information about the tumor can be obtained (Roberts, 2012). In aquaculture, much attention should be paid as tumors will provide disadvantages for fish. Therefore, there has been an increase in the number of studies on this subject.

Macroscopically, some of the tumors like lipoma detected in fish can be observed on the outer surface of the fish, such as the skin, without an autopsy process (Stefano et al., 2012); while others can only be seen in various internal organs like adenomas with an autopsy (Gumpenberger, Hochwartner, Loupal, 2004; Stilwell et al., 2018).

Marino et al. (2011) reported that there was a significant deformation in the skin of sea bass due to 3 large lipomas, and the epidermis was normal. While it was reported that these lipomas extended to the muscles in the sea bass (Marino et al., 2011); Stefano et al. (2012) reported that the lipomas in guppies have a thin capsule and do not infiltrate to the underlying muscles. In this study, the gross pathology, especially the skin deformation observed in our findings bears similarities to subcutaneous infiltrative lipomas in other fish species such as in cultured Mediterranean seabass *Dicentrarchus labrax* (Marino et al., 2011) and gold fish *Carassius auratus* (Sood et al., 2017). In addition, in this study, the lipoma extended to the muscles as described by Marino et al. (2011).

Comparing our findings with literature reports about lipomas in marine and freshwater fish, histologically; the tumor-like structure was identified as a benign tumor due to the well- differentiated, sharp tendency to infiltrate the surrounding tissues and non-metastatic characteristic according to the criteria previously described by McCoy et al. (1985) and Marino et al. (2011).

Generally, lipomas have been described in adult animals with the incidence increasing with age (Moulton, 1990). Marino et al. (2011) have reported multicentric lipomas seen in seabass. However, in the present study, the lipoma detected in the seabass had a monocentric characteristic. Therefore, we suggest that the number of lipomas may increase in parallel to weight gain in fish.

The etiology of lipoma development is unknown. There are several hypotheses and articles about the etiology of lipomas. There is little research on the possible causes such as an error in fat metabolism (Easa et al., 1989; Pulley & Stannard, 1990), endocrine or neurological dysfunctions (Easa et al., 1989) and also dysmetabolic syndrome (Marino et al., 2011). Unlike tuna (*Thunnus thynnus*), containing dense fat in their muscle, in this study, the dysmetabolic syndrome may induce the lipoma formation in sea bass, as reported by Marino et al. (2011). Although lipoma formation in culture fish is not a problem in terms of the fish production and frequency of the lipomas, comprehensive research should be carried out on the formation of lipomas.

CONCLUSION

There are no reports on subcutaneous infiltrative lipomas in cultured European sea bass originating from an inland fish farm located in the Aegean Region (Turkey). As a result of this study, for the first time, a subcutaneous infiltrative lipoma was detected in cultured European sea bass.

Conflict of interests: There are no conflicts of interest to declare.

Ethics committee approval: Ethics committee approval is not required.

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Short Comminication

First record of *Cotylorhiza tuberculata* (Macri, 1778) from the Sea of Marmara

Melek İşinibilir[1], Esin Yüksel[1], Cem Dalyan[2]

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ABSTRACT

Jellyfishes, which are one of the most important consumers in marine ecosystems, may have detrimental effects on fish stocks that have economic value. Therefore, identifying and monitoring jellyfish presence is important. We observed four individuals of symbiotic rhizostome scyphozoan *Cotylorhiza tuberculata* in the vicinity of the Princes' Islands Archipelago, in the Northeast Sea of Marmara, Turkey in September 2020. Although this species is a common member of gelatinous plankton in the Mediterranean Sea, the present study is the first record from the Sea of Marmara.

Keywords: *Cotylorhiza tuberculata*, rhizostomae, scyphomedusae, jellyfish, Sea of Marmara

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INTRODUCTION

Jellyfishes exhibit an important role in the marine food web as predators. Despite the fact that jellyfishes are low on the evolutionary tree, they generally feed high on marine food web, directly by eating fish eggs, larvae and juveniles and indirectly by competing with fishes for food (Mills, 2001; Purcell & Arai, 2001). In the blooming season they may even cause decreased depletion of fish stocks (Bilio & Niermann, 2004). Jellyfish blooms are possibly expedited by hypoxia, eutrophication, shipping, overfishing, bottom trawling, aquaculture, increased human activity on coastal regions, and global warming (Mills, 2001; Graham & Bayha, 2008; Boero, 2013). Jellyfish blooms are known to cause economic losses in fisheries and aquaculture by damaging nets, clogging the power plant cooling systems. Jellyfish blooms are also vectors of bacterial disease in aquaculture facilities and are responsible for harmful effects on tourism and human health (Ferguson et al., 2009; Nunes et al., 2015). Therefore, having knowledge of the exact distribution of jellyfish species is vital to draw up a strategy to prevent further damages.

In the Mediterranean Sea, there are six rhizostome jellyfish species. Among these jellyfishes, three of them are symbiotic, including *Cotylorhiza tuberculata* (Astorga, Ruiz, & Prieto, 2012). Symbiosis gives some advantages, such as nutrient support. This allows growth to be less dependent on the conditions of the surrounding environment for the zooxanthellae jellyfish. Furthermore, some fish species such as *Salpa salpa* and *Trachurus trachurus* use the tentacles of *C. tuberculata* as a habitat with the aim of protection and food supply (Öztürk et al., 2018).

C. tuberculata conclusively exhibits an intense top-down control on the food chain by selective feeding on diatoms, ciliates, larvae of some mollusks, and copepods (Pérez-Ruzafa et al., 2002). Individuals of this species are commonly found in a high quantity in the Aegean Sea (Balık, 1973; Kikinger, 1992), the Mediterranean Sea (Pérez-Ruzafa et al., 2002) and the Adriatic Sea (Benovic & Lucic, 2001). After being reported for the first time in Izmir Bay, in the Aegean Sea (Balık, 1973), this jellyfish has been recorded in different regions of the Aegean coast of Turkey (e.g. Gulsahin & Tarkan, 2013) and even in the vicinity of the Strait of Çanakkale (Alparslan, Doğu, & Özalp, 2011). The key identifying characteristics of *C. tuberculata* are a flattened area throughout its margin and a cupola at the center of its bell which makes it look like a large fried egg from its dorsal side (see photos below). It also has lots of tentacles that have different lengths enclosing its eight lappets. Its numbers of tipped appendages with different colors ranging from bluish to purple are located between each of the oral arms. These oral arms are fragile, short and fused proximally and are typically eight in numbers in this species (Kikinger, 1992). The presence of unicellular symbiotic algae (i.e. zooxanthellae) give these colours to the jellyfishes. The medusae have sexual dimorphism, and instead of releasing individual sperm, it spawns spermatozeugmata. There is internal fertilization with embryogenesis which occurs inside the female oral arm canals. The life period of the medusae is generally about half a year due to decomposition of somatic tissue. The zooxanthellae-bearing medusae are potentially autotrophic and the only stage in the metagenetic cycle of the species that has no zooxanthellae is planula. The scyphistomae contain algal symbionts infection (Kikinger, 1992). Its size is generally up to 35-40 cm in diameter (Kramp, 1961). The present paper reports the first records of *C. tuberculata* from the Sea of Marmara.

The Sea of Marmara is an inland sea which constitutes a transition region between the Black Sea and the Mediterranean Sea through the Straits of Istanbul and Çanakkale. Due to the constant two-layered water system, the Sea of Marmara plays a pivotal role in biodiversity of the seas that it connects. In the last decade, the Sea of Marmara has been exposed to heavy changes that induce jellyfish bloom and mucilage generation. In the beginning of 1990, the ctenophore *Mnemiopsis leidyi* was introduced into the Sea of Marmara and it damaged all ecosystems drastically (Isinibilir, Tarkan, & Kideys, 2004). Since then, *Beroe ovata, Chrysaora hysoscella*, *Liriope tetraphylla, Aequorea vitrina and* other alien jellyfish species have been introduced to the region, respectively (İnanmaz, Bekbolet, & Kıdeyş, 2002; Isinibilir, Yilmaz, & Piraino, 2010; Yilmaz, Isinibilir, Vardar, & Dursun, 2017). Recent studies have proved that the numbers of jellyfishes have been growing in the Sea of Marmara lately (Isinibilir, Yilmaz, & Piraino, 2010; Yilmaz, Isinibilir, Vardar, & Dursun, 2017).

MATERIALS AND METHODS

On September 24th 2020, we observed and photographed four individuals of *C. tuberculata* (Figure 1) at about 1-2 m depth in the vicinity of the Büyükada, the Princes' Islands, in the Sea of Marmara, while scuba diving (Figure 2). The umbrella diameters of specimens were estimated as 30 cm and the sea surface temperature was 22°C.

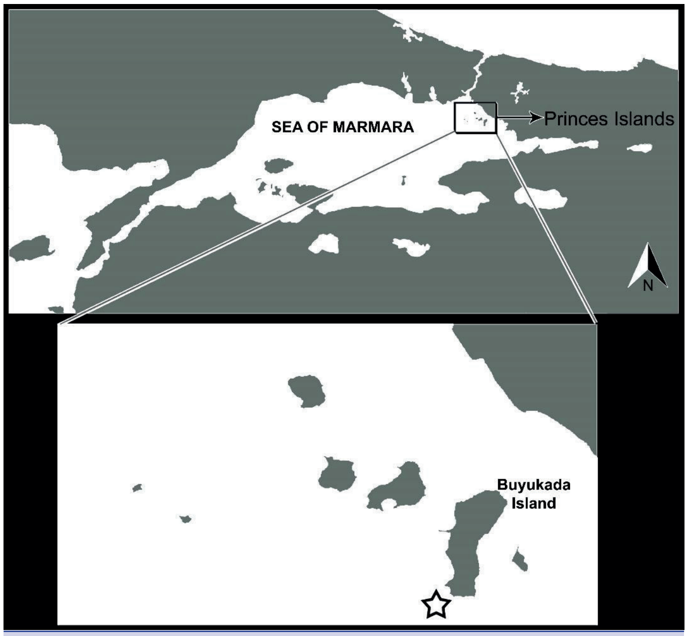

Figure 2. Sampling location of *Cotylorhiza tuberculata.*

RESULTS AND DISCUSSION

Cotylorhiza tuberculata was first reported in the Mediterranean Sea by Macrì in 1778. In recent decades, it has been occurring in exceedingly high abundance in some areas, particularly in the enclosed coastal areas and sub-basins of the Mediterranean Sea (Astorga, Ruiz, & Prieto, 2012). The main reason for the increasing number is warmer winter temperatures due to global warming (Prieto, Astorga, Navarro, & Ruiz, 2010). Although this species is a common member of gelatinous plankton in the Mediterranean Sea, the present study is the first record from the Sea of Marmara. The introduction of this species, which is already present in the

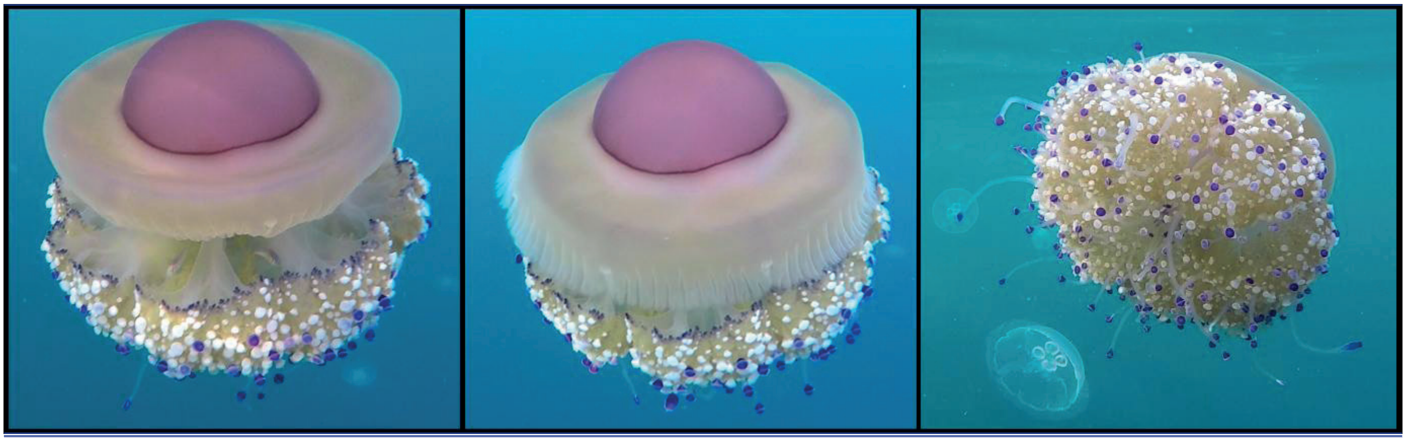

Figure 1. Live specimen of *Cotylorhiza tuberculata* in the Sea of Marmara (Photograph: Doğan Uğurlu).

Aegean Sea, presumably occurred either through the lower layer currents of the Çanakkale Strait or via the transportation of the ballast water from adjacent waters. There are two possible reasons why any polyps have not been found in the studies carried out in the Marmara Sea so far. It could be either due to *C. tuberculata* polyps' small size or their cryptic life habit even though the polyps persist longer than the more visible medusae (Prieto, Astorga, Navarro, & Ruiz, 2010). The presence of jellyfishes in great size in diameter could be explained by the fast size increase in *C. tuberculata,* which is more significant than the size increase in other rhizostome jellyfishes (Kikinger, 1992).

Jellyfishes are known as crucial consumers in all marine ecosystems, and thus they play an important role by reconstituting zooplankton communities (Mills, 2001). Their diet affects various fish species directly and indirectly (Brodeur, Suchman, Reese, Miller, & Daly, 2008). The Sea of Marmara is determined as a eutrophic sea (Tüfekçi, Balkis, Beken, Ediger, & Mantikci, 2010). High zooplankton abundance allows for a fast growth rate and large individuals of *Cotylorhiza tuberculata* (Kikinger, 1992). Moreover, eutrophic conditions in the Sea of Marmara may also lead to the occurrence of medusae in great sizes. Fast temperature increases in waters of the Marmara Sea have been occurring in the last several decades (Turan & Gürlek, 2016). Since *C. tuberculata* is a species that easily blooms in mild winters and long summers (Ruiz, Prieto, & Astorga, 2012), rising sea water temperature could precipitate its bloom in the Sea of Marmara. It has been reported in the studies conducted in the Sea of Marmara that some jellyfishes caused a shift in the temporal regime between jellyfish-dominated systems and crustacean-dominated systems, have caused the depletion of zooplankton, and have ultimately collapsed commercially important fish stocks (Yılmaz, 2015; Yılmaz & İşinibilir, 2016). *Cotylorhiza tuberculata* consume the microplanktonic food effectively until late autumn, when the degradation begins to occur because of the decreased photosynthetic process by reduced daylight period. Therefore, sub-umbrellar muscles weaken and decreased mesoglea flexibility leads to a reduction in the umbrellar pulsations thus reducing the food capture capacity of oral arms (Kikinger, 1992). In any *C. tuberculata* bloom event in the Sea of Marmara, we may observe a similar diet pattern which causes a reduction in the zooplankton community. As a consequence of increased jellyfish populations, fisheries and economies might be affected worldwide (Richardson, Bakun, Hays, & Gibbons, 2009). The Sea of Marmara is the second most important fisheries ground for Turkey (Yılmaz, Akay, & Gümüş, 2008). Therefore, any increasing effects on jellyfish populations could cause detrimental impacts on fisheries (Yılmaz & İşinibilir, 2016). In conclusion, monitoring the abundance and distribution of *C. tuberculata* in the Marmara Sea, which is considered to be a biological corridor or transition region between the Mediterranean and the Black Sea, is vital to understand better the changes it may cause in the pelagic food web.

Conflicts of interest: The authors have no conflicts of interest to declare.

Ethics committee approval: The authors declare that this study does not include any experiments with human or animal subjects.

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Short Comminication

Maximum size of Marbled spinefoot (*Siganus rivulatus* Forsskal & Niebuhr, 1775) for Aegean Sea

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ABSTRACT

This study presents the maximum size record of *Siganus rivulatus* for the Aegean Sea with some additional biological information. The biggest individual of *S. rivulatus* was caught in Akbük Bight, Gökova Bay (Southern Aegean Sea) at 15 m depth with trammel nets on 29.01.2018. Specimenof marbled spinefoot was 27.1 cm in total length and 414.8 g in total weight. The specimen was female with a gonad weight of 2.43 g and it was determined to be 9 years old. The total length of the mentioned individual is the longest for Aegean Sea among the reported studies so far and weight measurement displays the maximum value not only for Turkey but also for European waters.

Keywords: *Siganus rivulatus*, marbled spinefoot, maximum size

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INTRODUCTION

The marbled spinefoot (*Siganus rivulatus* Forsskal & Niebuhr, 1775) is a marine and reef associated fish, which inhabits shallow waters on rocky or sandy bottoms down to 30 m depth (Froese & Pauly, 2019). The *S. rivulatus* mostly occurs in the Western Indian Ocean, various localities in East Africa and from the Red Sea to the eastern Mediterranean. It was reported to be a Lessepsian migrant species (Ben-Tuvia, 1985) which invaded the Mediterranean and became one of the commercial alien fish for capture fishery (Saoud & Ghanawi, 2010). Although it has a high commercial importance in the Mediterranean and Southern Aegan coasts of Turkey, scientific studies focusing on the biology (Yeldan & Avşar, 2000; Bilecenoğlu & Kaya, 2002; Ergenler, 2016) and the fisheries of the species are limited.

Maximum length and weight (MLW) are useful and important parameters in fisheries management (Dulčić & Soldo, 2005). Information obtained from MLW measurements is directly or indirectly applied to most stock assessment models (Borges, 2001). Therefore updated information on MLW of commercial species has become very important (Navarro et al., 2012; Cengiz et al., 2019). Despite it's commercial importance and invasive character, no regulative tool has been applied on the fishery of *S. rivulatus* in Turkey.

This study presents the maximum size record of *S. rivulatus* for Aegean Sea with some additional biological information and the paper is considered to make a contribution to fisheries biology.

MATERIALS AND METHODS

The specimen was captured on 29 January 2018 in Gökova Bay, Southern Aegean Sea. Gökova Bay is located in the connection zone of the Aegean Sea and the Mediterranean which has been declared as "special environmental protection area -SEPA" in 1988 on account of its natural, historical and cultural significance. (GDPNA, 2014). The Maximum length sample was collected by trammel net by a fisherman thus ethic committee approval was not required for the study. The biggest individual of *S. rivulatus* was caught off Akbük Bight (37°01.851'N, 028°08.669'E) (Gökova Bay) (Figure 1) at 15 m depth with trammel nets. The Total length of the specimen was subsequently measured to the nearest mm and weighted to the nearest g, where total length is expressed as the projection length between the front end of the fish head and the end point of the longest ray of the caudal fin when the mouth is closed in commercial fishery regulations of Turkey (communique no: 2016/35). Age estimation was based on otolith examination and supported with scale readings. Sagittal otoliths were removed and prepared for age readings by profiling, rubbing, and polishing. They were embedded in polyester molds and sections were obtained by cutting the mold with an IsoMet Low Speed Saw. Then, otoliths sections were polished with sandpaper (types 400, 800, and 1200) and with 3, 1, and 1/4µ particulate alumina respectively (Metin & Kınacıgil, 2001). Age determination was carried out by a stereoscopic microscope under reflected light against a black background. Opaque and transparent rings were counted: 1 opaque zone, together with 1 transparent zone, was considered as the annual growth indicator.

Figure 1. Sampling location of the maximum size *Siganus rivulatus* from Gökova Bay, southern Aegean Sea.

RESULTS AND DISCUSSION

The Captured individual of marbled spinefoot was 27.1 cm in total length (TL) and 414.8 g in total weight (TW) (Figure. 2). Some morphometric characters for *S. rivulatus* are given in Table 1. Sex of the specimen was female with a gonad weight of 2.43 g. Age of the specimen was determined to be 9 years (Figure 3). The number of scientific studies with regard to the biology and other aspects of *S. rivulatus* are unfortunately low in Turkey due to poor scientific interest in this species and difficulties during sampling. Therefore, length and weight records for *S. rivulatus* were given for all possible localities from Turkey instead of only from the Aegean Sea, in order to make a better comparison (Table 2).

Although our TL value is the highest for Aegean Sea among the reported studies so far, it was seen that, the maximum length record of the species for Turkish waters belonged to Ergenler, (2016) with a TL value of 29.5 cm. Even so, our individual weight measurement (414.8 g) is the highest value not only for Turkey but also for European waters. Discrepancies in weight measurements between two studies are attributable to sampling season which resulted in too much fat accumulation in our sample (Figure 2) to be used during the upcoming spawning season and stomach fullness.

The concept of maximum length is generally linked to overfishing. Individuals which are exposed to high fishing pressure will respond by reproducing at smaller sizes. This mechanism results in reducing the maximum size of the species. Furthermore, feeding habits of the species, prey-predator relationships and parameters such as nutrient availability, oxygen, salinity, temperature and pollution have serious effects on growth (Helfman et al.,

Figure 2. The maximum sized *Siganus rivulatus* and fat accumulation.

Table 1. Some morphometric characters for *Siganus rivulatus* captured from Gökova Bay, Southern Aegean Sea.

Morphometric characters	Value
Total length (cm)	27.1
Total weight (g)	414.8
Standard length (cm)	21.9
Fork length (cm)	25.2
Max. body depth (cm)	9.5
Girth (cm)	22.7
Head length (cm)	4.7
Preorbital length (cm)	1.8
Eye diameter (cm)	1.4
Predorsal lenght (cm)	4.9
Preanal length (cm)	11.9
Prepelvic lenght (cm)	6.4
Prepectoral fin length (cm)	4.8
Caudal peduncle minimal depth	1.2
Interorbital width	1.5
1. Length of Dorsal fin basis (cm)	13.2
2. Length of Dorsal fin basis (cm)	4.3
Total Dorsal Length	17.1
Length of anal fin basis	9.6
Gonad W (g)	2.4
Liver W (g)	16.8

Table 2. Reported maximum length and weight of *Siganus rivulatus* in Turkish waters in previous studies.

Author(s)	Sex	Area	N	Lmax (cm)	Wmax (g)
Yeldan and Avşar (2000)	♀	Mersin and İskenderun Bays	224	24.0	-
	♂		190	22.0	-
Taşkavak and Bilecenoğlu (2001)	∑	Mersin and İskenderun Bays	355	24.1	125.5*
Bilecenoğlu and Kaya (2002)	♀	Antalya Bay	292	21,5	128.7
	♂		229	20,6	101.3
Ergüden et al. (2009)	∑	İskenderun Bay	122	18.0	54.2
Ceyhan et al. (2009)	∑	Gökova Bay	56	23.0	152,1*
Ergenler (2016)	♀	İskenderun Bay	166	29.5	284,9
	♂		365	26.9	249,9
Present study	♀	Gökova Bay	1	27.1	414.8

*Values were calculated according to length-weight relationship of the given studies

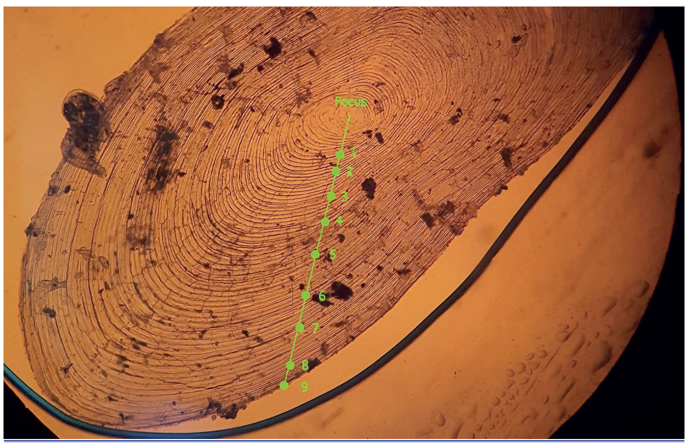

Figure 3. Age reading of the captured individual.

2009). Therefore, regional discrepancies in maximum length and weight values can be attributed to level of fishing pressure and environmental factors.

CONCLUSION

Consequently, the present study proves that this species can grow above the previously reported maximum length values in the Aegean Sea and presents the maximum weight record for Turkish waters. The information presented here is considered to make a contribution to fisheries biology and international scientific literature.

Conflict of interests: The authors have no conflicts of interest to declare.

Ethics committee approval: This study was conducted in accordance with ethics committee procedures of animal experiments.

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- Copyright Agreement Form,
- Author Contributions Form, and
- ICMJE Potential Conflict of Interest Disclosure Form (should be filled in by all contributing authors)

Preparation of the Manuscript

Title page: A separate title page should be submitted with all submissions and this page should include:

- The full title of the manuscript as well as a short title (running head) of no more than 50 characters,
- Name(s), affiliations, and highest academic degree(s) of the author(s) and ORCID ID (orcid.org)
- Grant information and detailed information on the other sources of financial support,
- Name, address, telephone (including the mobile phone number) and fax numbers, and email address of the corresponding author,
- Acknowledgment of the individuals who contributed to the preparation of the manuscript but who do not fulfil the authorship criteria.

Abstract: A Turkish and an English abstract should be submitted with all submissions except for Letters to the Editor. Submitting a Turkish abstract is not compulsory for international authors. Please check Table 1 below for word count specifications.

Keywords: Each submission must be accompanied by a minimum of three to a maximum of six keywords for subject indexing at the end of the abstract.

Manuscript Types

Original Articles: This is the most important type of article since it provides new information based on original research. The main text should contain Introduction, "Materials and Methods", "Result and Discussion", "Conclusion" and "References" sections.

Statistical analysis to support conclusions is usually necessary. Statistical analyses must be conducted in accordance with international statistical reporting standards. Information on statistical analyses should be provided with a separate subheading under the Materials and Methods section and the statistical software that was used during the process must be specified.

Units should be prepared in accordance with the International System of Units (SI).

After the Conclusion section and before references list, information regarding conflict of interest, financial disclosure, ethics committee approval and acknowledgement are given. These information are to be provided in the author form which must be submitted togather with the manuscript.

Conflict of interests: When you (or your employer or sponsor) have a financial, commercial, legal or professional relationship with other organizations or people working with them, a conflict of interest may arise that may affect your research. A full description is required when you submit your article to a journal.

Ethics committee approval: Ethical committee approval is routinely requested from every research article based on experiments on living organisms and humans. Sometimes, studies from different countries may not have the approval of the ethics committee, and the authors may argue that they do not need the approval of their work. In such situations, we consult COPE's "Guidance for Editors: Research, Audit and Service Evaluations" document and evaluate the study at the editorial board and decide whether or not it needs approval.

Financial disclosure: If there is any, the institutions that support the research and the agreements with them should be given here.

Acknowledgment: Acknowledgments allow you to thank people and institutions who assist in conducting the research.

Review Articles: Reviews prepared by authors who have extensive knowledge on a particular field and whose scientific background has been translated into a high volume of publications with a high citation potential are welcomed. These authors may even be invited by the journal. Reviews should describe, discuss, and evaluate the current level of knowledge of a topic in researches and should guide future studies. The main text should start with Introduction and end with "Conclusion" and "References" sections. Authors may choose to use any subheading in between those sections.

After the Conclusion section and before references list, information regarding conflict of interest and acknowledgement are given. These information are to be provided in the author form which must be submitted togather with the manuscript.

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Acknowledgment: Acknowledgments allow you to thank people and institutions who assist in conducting the research.

Short Communication: This type of manuscript discusses important parts, overlooked aspects, or lacking parts of a previously published article. Articles on subjects within the scope of the journal that might attract the readers' attention, particularly educative cases, may also be submitted in the form of a "Short Communication" Readers can also present their comments on the published manuscripts in the form of a "Short Communication". The main text should contain Introduction, "Materials and Methods", "Result and Discussion", "Conclusion" and "References" sections.

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Tables

Tables should be included in the main document, presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations used in the tables should be defined below the tables by footnotes (even if they are defined within the main text). Tables should be created using the "insert table" command of the word processing software and they should be arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should be supporting the main text.

Table 1. Limitations for each manuscript type

Type of manuscript	Page	Abstract word limit	Reference limit
Original Article	≤20	250	40
Review Article	≤25	250	60
Short Communication	≤5	250	20

Figures and Figure Legends

Figures, graphics, and photographs should be submitted as separate files (in TIFF or JPEG format) through the submission system. The files should not be embedded in a Word document or the main document. When there are figure subunits, the subunits should not be merged to form a single image. Each subunit should be submitted separately through the submission system. Images should not be labeled (a, b, c, etc.) to indicate figure subunits. Thick and thin arrows, arrowheads, stars, asterisks, and similar marks can be used on the images to support figure legends. Like the rest of the submission, the figures too should be blind. Any information within the images that may indicate an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. To prevent delays in the evaluation process, all submitted figures should be clear in resolution and large in size (minimum dimensions: 100 × 100 mm). Figure legends should be listed at the end of the main document.

All acronyms and abbreviations used in the manuscript should be defined at first use, both in the abstract and in the main text. The abbreviation should be provided in parentheses following the definition.

When a drug, product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in USA), should be provided in parentheses in the following format: "Discovery St PET/CT scanner (General Electric, Milwaukee, WI, USA)"

All references, tables, and figures should be referred to within the main text, and they should be numbered consecutively in the order they are referred to within the main text.

Limitations, drawbacks, and the shortcomings of original articles should be mentioned in the Discussion section before the conclusion paragraph.

References

While citing publications, preference should be given to the latest, most up-to-date publications. If an ahead-of-print publication is cited, the DOI number should be provided. Authors are responsible for the accuracy of references. List references in alphabetical order. Each listed reference should be cited in text, and each text citation should be listed in the References section. The reference styles for different types of publications are presented in the following examples.

Reference Style and Format

Aquatic Sciences and Engineering complies with APA (American Psychological Association) style 6th Edition for referencing and quoting. For more information:

- American Psychological Association. (2010). Publication manual of the American Psychological Association (6th ed.). Washington, DC: APA.
- http://www.apastyle.org

Accuracy of citation is the author's responsibility. All references should be cited in text. Reference list must be in alphabetical order. Type references in the style shown below.

Citations in the Text

Citations must be indicated with the author surname and publication year within the parenthesis.

If more than one citation is made within the same paranthesis, separate them with (;).

Samples:

More than one citation;
(Esin et al., 2002; Karasar, 1995)
Citation with one author;
(Akyolcu, 2007)
Citation with two authors;
(Sayıner & Demirci, 2007)
Citation with three, four, five authors;
First citation in the text: (Ailen, Ciambrune, & Welch, 2000) Subsequent citations in the text: (Ailen et al., 2000)
Citations with more than six authors;
(Çavdar et al., 2003)

Major Citations for a Reference List

Note: All second and third lines in the APA Bibliography should be indented.

- **A book in print:** Baxter, C. (1997). *Race equality in health care and education.* Philadelphia: Ballière Tindall. ISBN 4546465465
- **A book chapter, print version:** Haybron, D. M. (2008). Philosophy and the science of subjective well-being. In M. Eid & R. J. Larsen (Eds.), *The science of subjective well-being* (pp. 17-43). New York, NY: Guilford Press. ISBN 4546469999
- **An eBook:** Millbower, L. (2003). *Show biz training: Fun and effective business training techniques from the worlds of stage, screen, and song.* Retrieved from http://www.amacombooks.org/ (accessed 10.10.15)
- **An article in a print journal:** Carter, S. & Dunbar-Odom, D. (2009). The converging literacies center: An integrated model for writing programs. *Kairos: A Journal of Rhetoric, Technology, and Pedagogy, 14*(1), 38-48.
- **An article with DOI:** Gaudio, J. L. & Snowdon, C. T. (2008). Spatial cues more salient than color cues in cotton-top tamarins (saguinus oedipus) reversal learning. *Journal of Comparative Psychology*, https://doi.org/10.1037/0735-7036.122.4.441
- **Websites - professional or personal sites:** The World Famous Hot Dog Site. (1999, July 7). Retrieved January 5, 2008, from http://www.xroads.com/~tcs/hotdog/hotdog.html (accessed 10.10.15)
- **Websites - online government publications:** U.S. Department of Justice. (2006, September 10). Trends in violent victimization by age, 1973-2005. Retrieved from http://www.ojp.usdoj.gov/bjs/glance/vage.htm (accessed 10.10.15)
- **Photograph (from book, magazine or webpage):** Close, C. (2002). *Ronald.* [photograph]. Museum of Modern Art, New York, NY. Retrieved from http://www.moma.org/collection/object.php?object_id=108890 (accessed 10.10.15)
- **Artwork - from library database:** Clark, L. (c.a. 1960's). *Man with Baby.* [photograph]. George Eastman House, Rochester, NY. Retrieved from ARTstor
- **Artwork - from website:** Close, C. (2002). *Ronald.* [photograph]. Museum of Modern Art, New York. Retrieved from http://www.moma.org/collection/browse_results.php?object_id=108890 (accessed 10.10.15)

REVISIONS

When submitting a revised version of a paper, the author must submit a detailed "Response to the reviewers" that states point by point how each issue raised by the reviewers has been covered and where it can be found (each reviewer's comment, followed by the author's reply and line numbers where the changes have been made) as well as an annotated copy of the main document. Revised manuscripts must be submitted within 30 days from the date of the decision letter. If the revised version of the manuscript is not submitted within the allocated time, the revision option may be canceled. If the submitting author(s) believe that additional time is required, they should request this extension before the initial 30-day period is over.

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