Epipsammic diatoms of diatoms of Kelkit Creek (Tokat/Turkey)

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Abstract

In this study, diatoms in epipsammic samples, which were taken from two stations selected in Kelkit Creek (Tokat/Turkey) between March and December 2018, were analyzed. During the study, a total of 25 taxa belonging to diatoms were recorded. The diatom species represented by the highest number of taxa were *Cymbela* (4 taxa), *Nitzschia* (4 taxa), and *Navicula* (3 taxa). Sorensen similarity index between the diatoms at both stations was found as 78.04%.

Keywords: Kelkit Creek-Turkey, Eipsammic, Diatom, Sorensen Similarity Index

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Introduction

Streams are of high importance considering the fact that they are used in industry and agriculture, they provide energy, they are consumed as drinking water, they are used in aquaculture production, and most importantly, they are the sources feeding lakes. Therefore, in recent years, stream systems are particularly important for ecologists, hydrologists, various engineering branches and limnologists.

When it comes to nutrients in waters, fish and other aquaculture products come to mind. In this sense, identification of algae and understanding their importance in waters is necessary to be able to develop and protect the populations of aquaculture products in our inland waters. Algae are organisms with quite rich content of carbohydrates, proteins and especially fatty acids. Microalgae, which have high nutritional value, are the most important sources of nutrients, vitamins and trace elements for aquatic living beings. Microalgae, which have a very important place in aquatic ecosystems in terms of food chain, are one of the groups that should be examined in order to determine biodiversity in ecosystems. Especially, algae in phytoplankton are the vital part of the system supporting aquatic life as they produce organic matters from inorganic ones through photosynthesis, provide oxygen for the environment and form the nutrients of other consumer organisms (Ahıska and Atıcı, 2005).

Studies on identification of algal species in the aquatic systems of our country (lakes, ponds, dam lakes and streams) intensively started in the 1980's and there are many studies on this topic (Altuner and Gürbüz, 1991; Gönülol and Arslan 1992; Şen *et al*. 1996; Kolaylı *et al*. 1998; Ertan and Morkoyunlu 1998; Kara and Şahin 2001; Dere *et al*. 2002; Atıcı *et al*. 2003; Sıvacı and Dere, 2007; Pala and Çağlar, 2008; Kalyoncu *et al*. 2009; Mumcu *et al*. 2009; Tokatlı and Dayıoğlu 2011; Fakıoğlu *et al*. 2012; Solak *et al*. 2012; Çiçek and Ertan 2015; Pala *et al*. 2017; Pala *et al*., 2018). Some studies on algae in lotic habitats are becoming increasingly important.

Algae, which spread over very different ecosystems (water, soil, snow, etc.) in the world, have indicator species indicating the structure of their environment. Many scientific studies on ecological and limnological characteristics of rivers in the world (Al-Saadi *et al*., 2000; Vasconcelos and Cerqueria, 2001; Domitrovic, 2002; Ha *et al*., 2002; Bellos *et al*., 2004; Marvan *et al*., 2004; Marshall, 2009) have been carried out.

In our country, which is quite rich in terms of inland water resources, identification of the algae present in the environment is necessary in order to make more efficient use of our inland waters and to turn them into a source of food and income. This study aims to analyze the epipsammic diatoms of

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Kelkit Creek (Tokat) and to contribute to the productivity of our inland waters.

Materials and methods

Niksar is a district of Tokat province located in the inner part of the Central Black Sea Section of the Black Sea Region. Niksar, the surface area of which is 955 km^2, is located on 40°35' north latitude and 36°54' east longitude. Its altitude above sea level is approximately 350 m, and it is surrounded by Erbaa in the northwest, Tokat in the southwest, Almus in the south, Başçiftlik in the southeast, and Akkuş in the north. The lands of Niksar, which are quite rich in streams, are watered by Kelkit Creek and its large and small tributaries (Fig. 1). Niksar Plain, which is watered by Kelkit Creek and made much more fruitful by alluvium it carries, is one of the most important plains of the Black Sea Region. Niksar has a transition climate between the Central Black Sea climate and Central Anatolia climate. Winters are usually mild and rainy while summers are hot. The average annual rainfall of the district, which receives rainfall every month, is 475.2 m^3; and its average annual temperature is 14.7°C (URL, 1).

The coordinates of the first and second stations selected from Kelkit Creek are as follows: The first station is between 40°35'34" north latitude and 36°54'29" east longitude; and the second station is between 40°36'23" north latitude and 36°53'59" east longitude.

A photo of the stations selected from Kelkit Creek is shown in Figure 1.

The temperature of the water at the stations was measured by calibrated mercury thermometer with 1°C gradation, and oxygen was measured by portable YSI 55 DO digital oxygen meter, in situ.

In this study, samplings from two different parts of Kelkit Creek were made to identify the epipsammic algae in the creek (Fig. 1).

Figure 1: A satellite photo of the stations chosen from Kelkit Creek (URL, 2).

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The first station was chosen from the downside of the settlement area while the second station was chosen from the downside of the agricultural areas. Sampling started in March (2018) and continued till December (2018). The method developed by Round (1953) was used to collect the epipsammic algae. For this, a glass rod of 1 cm in diameter and 100 cm in length was used. Permanent preparations from epipsammic samples were made for the exact identification of diatoms. Nikon-branded microscope was used for species identification and counting of the diatoms whose permanent preparations was made. The counting in the permanent preparations was based on relative density and the results are given as "organism%".

Relative density (Rd)= N_A/N x100 N_A =Total number of A species individuals

N=Number of all species individuals (Kocataş, 1999).

Bourelly (1968, 1972), Germain (1981), Patrick and Reimer (1966, 1975) and Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) were benefited from for the species identification of diatoms detected in Kelkit Creek.

The Sorensen Similarity Index was applied to determine the similarity between the epipsammic algae at the stations.

The Sorensen Similarity Index: Q= 2J/ +B

A= Total number of species in the first sample

B= Total number of species in the second sample

J= Number of common species in both samples (Sorensen, 1948).

Results

The monthly changes of temperature and oxygen at the stations selected from the research area are shown in Table 1.

The temperature and oxygen values at the first and second stations were in parallel with each other. At the first station, the lowest temperature (16.3^{o}C) was recorded in March while the highest temperature (20.0^{o}C) was recorded in June, July and August; and at the second station, the lowest temperature (16.0^{o}C) was recorded in December while the highest temperature (20.5^{o}C) was recorded in June. Dissolved oxygen values were the lowest (7.2 mg/L) in July and the highest (8.9 mg/L) in March at the first station while they were the lowest (7.3 mg/L) in June and the highest (8.8 mg/L) in March at the second station.

A total of 25 taxa belonging to epipsammic diatoms were recorded at both stations selected from Kelkit Creek. The monthly changes in the relative densities of epipsammic diatoms recorded at the first station are shown in Table 2.

Looking at Table 2, it is seen that there is not big differences between the relative densities of diatoms. During the study, while the diatom recorded with the lowest relative densities (3-4%) was *Sellaphora bacillum*, the diatom recorded with the highest relative

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densities (8-10%) was *Ulnaria ulna*. The relative densities of the other diatoms ranged between about 4-8%. It was remarkable that all diatoms were recorded at the same frequency and with similar relative densities.

Table 1: Monthly changes of temperature and oxygen at the first and second stations

	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.sta./temperature (^{o}C)	16.3	16.8	18.8	20.0	20.0	20.0	18.0	17.0	17.0	16.7
1.sta./oxygen (mg/L)	8.9	8.7	8.2	7.4	7.2	7.6	8.1	8.3	8.5	8.8
2.sta./temperature (^{o}C)	17.0	18.0	19.0	20.5	20.4	20.0	19.0	18.0	18.0	16.0
2.sta./oxygen (mg/L)	8.8	8.6	8.0	7.3	7.4	7.4	8.1	8.0	8.2	8.7

Table 2: Monthly changes in the relative densities of epipsammic diatoms recorded at the first station in Kelkit Creek (downside of the settlement area)

Taxa	Months									
	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Amphora ovalis (Kützing) Kützing	6.77	7.14	7.40	7.07	6.37	6.49	5.24	7.00	7.00	6.38
Cymbella affinis Kützing	5.08	6.42	6.34	6.63	5.97	6.13	5.64	7.00	5.73	5.31
Cymbella cistula Ehrenberg O.Kirchner	5.93	7.14	6.34	6.19	6.77	6.13	6.04	6.07	5.09	6.38
Cymbella parva W. Smith Kirchner	7.62	6.42	5.82	7.07	7.17	6.13	7.66	6.54	6.36	7.44
Cymbella proxima Reimer	5.08	5.00	7.76	5.30	5.57	6.13	6.85	5.14	5.09	4.25
Diatoma vulgaris Bory	6.77	7.14	6.34	6.63	5.97	5.77	6.04	5.60	4.45	6.38
Gomphonema gracile Ehrenberg	6.77	5.00	5.29	5.75	6.37	6.49	6.85	7.00	8.28	7.44
Gomphonema olivaceum (Hornemann Brebisson	5.08	5.71	5.82	6.19	5.57	5.77	5.24	5.60	6.36	4.25
Navicula cincta Ehrenberg Ralfs	7.62	7.85	6.87	6.19	6.77	6.85	6.85	7.00	7.64	7.44
Navicula radiosa Kützing	6.77	7.14	7.40	7.07	6.77	6.85	6.45	6.54	6.36	6.38
Navicula tripunctata (O.F Miller) Bory	6.93	5.00	5.82	5.75	5.97	6.13	6.45	6.07	5.73	5.31
Nitzschia amphibia Grunow	6.93	5.71	6.87	6.63	7.17	6.49	6.45	6.54	6.36	7.44
Nitzschia linearis W Smith	6.77	5.71	6.34	6.19	6.77	6.85	6.85	7.00	7.00	7.44
Nitzschia sigmoidea (Nitzsch) W Smith	5.08	5.71	5.82	5.75	5.17	5.05	4.83	4.20	4.45	4.25
Sellaphora bacillum Ehrenberg D.G Mann	3.38	3.57	4.23	3.09	3.18	3.97	3.62	3.27	3.18	3.19
Ulnaria ulna (Nitzsch)Compere	9.32	9.28	8.46	8.40	8.36	8.66	8.87	9.34	10.08	10.06

The monthly changes in the relative densities of epipsammic diatoms recorded at the second station are shown in Table 3.

Looking at Table 2, it is seen that the number of species in the second station samples taken from the downside of the agricultural areas are more compared to the first station. At this station, the lowest relative density (1.08%) belonged to *Stephanodiscus astrea* in December, and the highest relative density (7.60%) belonged to *Ulnaria ulna* again in December. The relative density of *Ulnaria ulna* throughout the study period did not fall below 5.9%. This shows that this diatom makes use of the environmental conditions better than the other diatoms. The relative densities of the other diatoms appearing at the second station, on the other hand, varied between 2-6% on average.

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Table 3: Monthly changes in the relative densities of epipsammic diatoms recorded at the second station in Kelkit Creek (downside of the agricultural areas).

Taxa	Months									
	Mar.	**Apr.**	**May.**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Amphora ovalis (Kützing)Kützing	3.61	3.68	4.34	4.30	4.38	4.35	4.42	4.95	5.07	4.34
Cymbella affinis Kützing	4.64	4.50	4.34	4.55	4.84	4.79	4.66	4.64	4.29	5.43
Cymbella cistula Ehrenberg o.Kirchner	4.12	4.09	4.65	4.30	4.61	4.35	4.17	4.33	3.90	4.89
Cymbella parva W. Smith Kirchner	5.15	5.73	4.96	5.06	4.61	4.57	4.24	4.03	3.90	4.34
Cymbella proxima Reimer	4.64	4.09	3.72	3.79	3.92	3.48	3.43	3.71	3.51	4.34
Cymbopleura lata (Grunow ex Cleve) Krammer	3.61	3.27	3.41	3.29	3.46	3.70	3.93	4.33	3.90	2.71
Diatoma elongatum Lyngbye C Agardh	4.12	2.86	3.10	3.09	3.23	3.26	3.19	3.09	3.12	3.80
Diatoma vulgaris Bory	3.61	3.68	3.72	4.05	4.38	4.35	4.42	4.64	4.68	4.34
Encyonema leibleinii (C.Agardh) W.J.Silva, R.Jahn, T.A.V.Ludwig, & M.Menezes	4.64	4.50	3.10	4.30	3.69	4.13	3.68	3.09	3.51	3.80
Encyonopsis microcephala (Grunow) Krammer	4.64	4.91	5.27	4.81	5.08	5.01	4.66	4.95	5.07	5.43
Gomphonema gracile Ehrenberg	4.64	4.50	4.34	4.30	4.15	3.48	3.43	2.78	3.12	3.80
Gomphonema olivaceum (Hornemann Brebisson	4.12	4.09	3.10	3.79	3.92	4.35	4.42	3.40	2.73	3.80
Lindavia comta (Kützing) Nakov, Gullory, Julius, Theriot & Alverson	3.09	3.68	4.03	4.05	3.46	3.05	2.45	2.78	2.73	2.71
Lindavia glomerata (H.Bachmann) Adesalu & Julius	2.58	2.86	2.79	3.03	3.00	3.26	2.70	3.40	3.12	2.17
Navicula cincta Ehrenberg Ralfs	4.64	4.91	4.65	4.55	4.84	5.22	5.40	5.26	5.46	5.43
Navicula gregaria Donkin	2.58	2.86	3.41	3.54	3.69	3.70	3.19	3.40	3.12	1.63
Navicula radiosa Kützing	5.15	5.73	5.59	5.56	5.31	5.44	5.40	5.57	5.07	4.89
Navicula tripunctata(O.F Miller) Bory	4.64	4.50	4.34	4.05	4.15	4.13	4.17	4.64	4.68	4.34
Nitzschia amphibia Grunow	4.12	4.09	4.61	4.55	4.61	4.13	5.40	5.26	5.07	5.43
Nitzschia linearis W Smith	3.61	3.68	4.41	4.30	4.38	3.92	4.17	4.64	5.07	4.34
Nitzshcia sigmoidea (Nitzsch) W Smith	3.09	3.27	3.10	3.29	3.46	3.70	4.66	4.02	3.51	2.71
Sellaphora bacillum Ehrenberg D.G Mann	3.61	2.86	3.10	2.27	1.61	1.74	2.21	1.85	2.73	3.26
Stephanodiscus astrea (Kützing) Grunow	2.06	2.04	2.17	2.27	2.30	2.61	2.70	2.78	2.73	1.08
Ulnaria acus (Kütz.) Aboal	2.58	3.27	2.79	2.78	2.77	3.05	2.45	2.16	2.73	3.26
Ulnaria ulna (Nitzsch)Compere	6.70	6.14	5.90	6.07	6.00	6.10	6.14	6.19	7.03	7.60

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Discussion

Among the epipsammic algae in Kelkit Creek, diatoms were detected in every season and they are dominant compared to the other algae in terms of both their number of individuals and frequency of appearance; and due to this fact, the other algae was ignored. During the study, a total of 25 taxa belonging to diatoms were recorded. A total of 16 taxa were recorded at the first station while a total of 25 taxa were recorded at the second station. Since the second station was selected from the downside of the agricultural areas, it is thought that nutrient salts carried from agricultural lands by rain water increase the number of taxa. At the first station in Kelkit Creek, centric diatoms such as *Lindavia glomerata*, *Lindavia comta*, *Stephanodiscus astrea*, and pennate diatoms such as *Encyonopsis microcephala*, *Encyonema leiblenii*, *Cymbopleura lata*, *Diatoma elongatum*, *Gomphonema olivaceum*, *Navicula gregaria* and *Ulnaria acus* were not found. These diatoms were found only at the second station. In addition to this, *Diatoma vulgaris*, which was recorded at the first station, was not found at the second station. It can be inferred from this finding that diatoms prefer some substrates to hold on. In their study on the algal flora of Hereke Brook, Morkoyunlu *et al*. (2018) reported that diatoms were the algae appearing in every season, and the number of diatoms slightly increased especially in the spring and autumn. Among epipsammic algae of Kelkit Creek, diatoms were also dominant compared to the other algae and they were recorded in all months.

Among those species, which were reported to be spread in clean waters (*C. affinis*, *C. placentula*, *A. minutissimum*) in the literature (Tornés *et al*., 2007; Omar, 2010), only C. affinis species were found in Kelkit Creek while Cocconeis placentula and Achnanthes minutissimum species were not detected. This shows that the stations selected from Kelkit Creek are polluted by the flows from the agricultural lands and the sewage from the settlement areas.

In the study they carried out in Yukarı Porsuk Creek (Kütahya), Akanıl (Bingöl) *et al*. (2007) analyzed the epilithic diatom flora. They identified a total of 58 diatom taxa. *Nitzschia*, *Navicula* and *Cymbella* members were found to be dominant. And in this study conducted in Kelkit Creek, *Ulnaria*, *Nitzscia*, *Navicula* and *Cymbella* members were found to be dominant.

Pala and Çağlar (2008) recorded 36 species in their study on epilithic diatoms of Peri Creek (Tunceli) and their seasonal changes. While *Gomphonema* (6 species), *Fragilaria* (5 species), *Cymbella* (4 species), *Pinnularia*, *Achnanthes* and *Navicula* (3 species) were the diatoms represented by the highest number of species in the research area, *Cymbella* spp., *Gomphonema* spp. and *Fragilaria* spp. were the most important diatoms in the epilithic diatom community, in terms of their frequency of appearance and the size of the populations they formed. Among the epipsammic algae of Kelkit

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Creek, on the other hand, *Fragilaria*, *Pinnularia* and *Achnanthes* species were not found. This finding may indicate that these algae cannot hold on in the benthic habitat due to the water flow rate.

In the study on the physico-chemical properties and epipelic algae of Tigris River, Yıldırım and Tanrıkulu (2011) analyzed the species composition and seasonal changes of the epipelic algal flora of Tigris River's part located within the provincial borders of Diyarbakır. In the study, a total of 44 taxa belonging to Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta divisions were determined. Diatoms (Bacillariophyta) were found to be the most remarkable division of benthic algae in terms of their frequency of existence and number of individuals. Among diatoms, *Cymbella cistula Diatoma vulgaris* and *Fragilaria ulna*, *Nitzscia palea*, and *Navicula cryptocephala* were the most important algae. Diatoms showed their best growth in spring, summer and autumn.

The relative densities of epipsammic diatoms recorded at the first station ranged from about 3 to 10%. The highest relative densities (8.36-10.08%) at this station belonged to *Ulnaria ulna* species. It can be suggested this finding shows that this diatom makes use of the conditions better than the other diatoms. The fact that diatoms are the dominant organisms of streams and brooks was also emphasized many times in other studies (Altuner and Gürbüz, 1991; Gönülol and Arslan, 1992; Ertan and Morkoyunlu, 1998; Pala and Çağlar, 2008; Sönmez and Asan, 2012; Çağlar and Pala, 2016; Çağlar *et al*., 2017). This finding is similar to the findings of our study.

In Kelkit Creek, the diatoms represented by the highest number of species at both stations were *Cymbella*, *Navicula* and *Nitzschia*. In winter months, the relative densities of the species recorded at both stations decreased. This may have resulted from the water flow rate the decrease in water temperature.

Amphora ovalis grow in waters ranging from organically less contaminated to moderately Contaminate ones (Cox, 1996). *Cymbella affinis* is found in the upper regions of the streams, in environments with a pH higher than 7 and in clean waters (Kelly, 2000; Çiçek *et al*., 2010; Cox, 1996). While *Amphora ovalis* species was recorded at higher relative densities (5.24-7.40%) at the first station, it was recorded at lower relative densities (3.61-5.07%) at the second station. *Cymbella affinis* species was also recorded at higher relative densities (5.08-7.00%) at the first station selected from the downside of the settlement area where the water is cleaner, which is in parallel with the above finding.

Cymbella spp., *Navicula* spp. and *Ulnaria* spp., which were recorded in the epipsammic diatoms of Kelkit Creek, were reported to be generally the typical benthic species of (Hutchinson, 1957). Chessman (1986) stated that the

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species *Navicula* and *Nitzschia* are cosmopolitan. The fact that the species *Navicula* and *Nitzschia* were found at both stations in Kelkit Creek supports this finding. In studies on identification of benthic algae in lakes, ponds, streams and dam lakes in other regions of our country, Centrales members known as planktonic forms were detected on sediments, though in negligible quantities (Altuner and Gürbüz, 1996; Şahin, 1998; Pala and Çağlar, 2006; Pala and Çağlar, 2008). Among the epipsammic diatoms of Kelkit Creek, Centrales members were found only at the second station (*Lindavia comta*, *Lindavia glomerata*, *Stephanodiscus astrea*).

The fact that diatoms are always present in benthic algal community and they are recorded with high numbers of individual's shows that they are cosmopolitan, they can adapt to any kind of substrates, and they can have a better ability of adaptation compared to the other algae. We believe that this type of studies will be important in consideration and management of streams.

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