Acta Biologica Turcica 29 (1) 26-34, 2016

ACTA BIOLOGICA TURCICA

E-ISSN: 2458-7893, http://www.actabiologicaturcica.info

Seasonal distribution and diversity of epipelic algae in Köprüçay River (Turkey, Antalya)

Nezire Lerzan ÇİÇEK*, Ömer Osman ERTAN

Süleyman Demirel University, Eğirdir Fisheries Faculty, 32260, IspartA, Turkey.

*Corresponding author: lerzancicek@sdu.edu.tr

Abstract: Epipelic algae of the Köprüçay River were sampled monthly from four stations between February 2008 and January 2009. Epipelic algae were inspected in four stations on the stony river bed. Totally, 91 taxa belonging to Bacillariophyta (72), Chlorophyta (4), Cyanophyta (9) and Charophyta (6) were identified. Chrophyta was the dominant group in terms of both species diversity and the number of specimens obtained for each taxon. Frequency of occurrence and relative abundance were found in high frequency in such species as *Achnanthidium minutissimum* (Kützing) Czarnecki, *Nitzschia sigmoidea* (Nitzsch) W. Smith, *Gomphonema parvulum* (Kützing) Kützing, *Cocconeis placentula* Ehrenberg, *Cymatopleura solea* (Brébisson) W. Smith, *Cymbella affinis* Kützing, *Diatoma vulgaris* Bory, *Ulnaria ulna* (Nitzsch) P. Compère and *Nitzschia sigmoidea* (Nitzsch) W. Smith.

Keywords: Epipelic algae, Diversity, Diatom, Köprüçay River.

Introduction

Benthic algae (epilithic, epipelic, epipsammic, epiphytic etc.) are important primary producers in stream, lake and wetland ecosystems (Moss, 1969; Kingston et al., 1983; Stevenson et al., 1996). Epipelic algal flora are present on all types of sediment (peat, silt, sand etc.) (Stevenson et al., 1996; Round, 1973). Epipelic algae are one of the key groups of organisms recommended by the European Union Water Framework Directive 2000/60/EC (WFD) for assessment of ecological status of surface waters (CEC, 2000). Therefore, they are important to determine the benthic algal communities in freshwater environment. This study reperesents composition of epipelic algae and determine their seasonal variations and diversity in Köprüçay River (Turkey/Antalya).

Materials and Methods

Köprüçay River is located in in the Mediterranean Region of Turkey. Total length of the river is 156 km except for the tributaries and the total catchment area is 2498 km².

Four stations were chosen to study benthic algal flora of the Köprüçay River (Fig. 1). Epipelic algal flora was investigated in four stations because of the stony river bed. Samplings were done during the snow-free period from February 2008 to January 2009. Due to temperature increase, river bed ebbed low and the epipelic algae sampling area dried in July and August and as a result, samples were not obtained in these months. The population was sampled by means of a glass tube of 0.8 cm diameter x 100 cm height. The glass tube was moved in a circular direction on the surface and the thumb was slightly loosened to take up the sediment. The samples were collected in a collecting bottle and immediately transported to laboratory (Round, 1953). The laboratory process of samples were performed according to Round (1953) and Sladeckova (1962). Species identification were performed followed by Krammer and Lange-Bertaloth (1986; 1988; 1991a, b), Bourrlly and Couté (1991), John et al. (2005), Komárek (2000; 2008). The MVSP 3.1 (Multi Variate Statistical Package) was used for evaluation of the diversity (Simpson and Shannon Weaver Index) and similarity (Sorensen's Similarity Index) (Kovach, 1998).

Results

Epipelic Algal Flora: During the study period, a total of

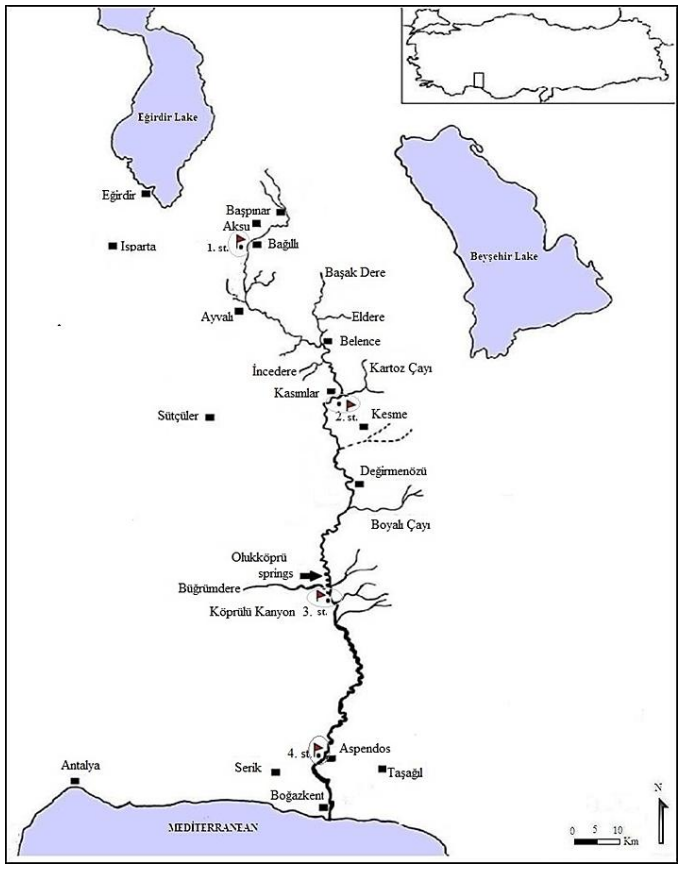

Figure 1. The maps showing the four stations selected along Köprüçay River.

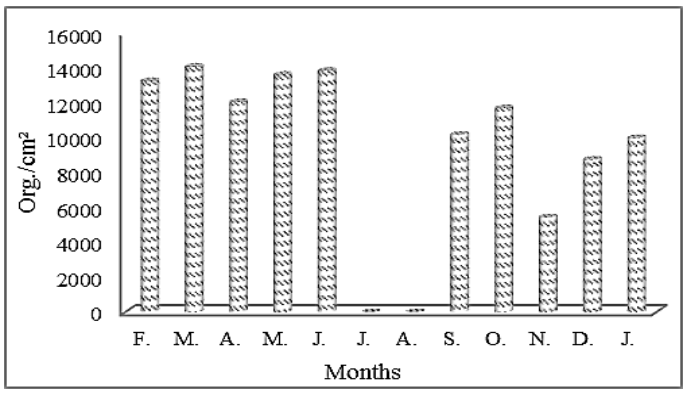

Figure 2. Seasonal changes in the total epipelic community.

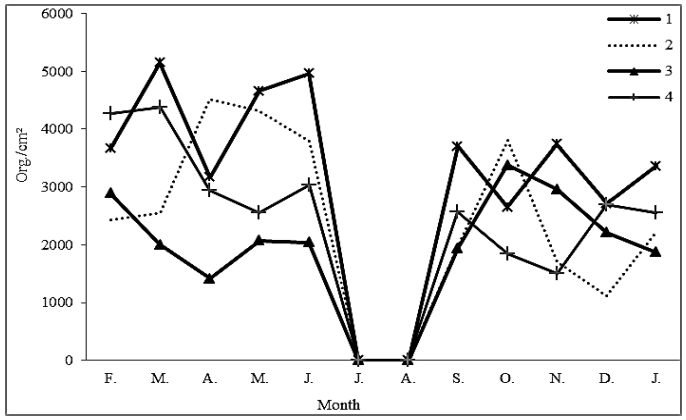

Figure 3. The abundance of epipelic density of the community at stations

91 taxa were identified; 72 of them belonged to Bacillariophyta, 4 to Chlorophyta, 9 to Cyanophyta, 6 to Charophyta (Table 1). The taxa belonging to Bacillariophyta were predominant and constituted 79.12 % of the epipelic community. However, the members of the Cyanophyta, and *Phormidium formosum*, became dominant only at station 2 in November. *Navicula* taxa (Ochrophyta) have been represented the highest species quantity. *Achnanthidium minutissimum*, *C. placentula*, *C. solea*, *N. palea*, *N. sigmoidea* and *U. ulna* were common taxa in epipelic community. *Achnanthidium minutissimum*, *N. palea*, *G. parvulum* and *U. ulna* at the station 1; *A. minutissimum*, *C. placentula*, *N. sigmoidea*, *C. affinis*, *U. ulna* and *C. solea* at the station 2; *C. placentula*, *N. sigmoidea* and *U. ulna* at the station 3; *C. affinis*, *D. vulgaris* and *U. ulna* at the station 4 were continuously observed. The frequencies and list of epipelic algae are shown in Table 2.

There were in monthly variability in the total density of the epipelic community. While the highest numbers of the total density was observed 14069 org/cm^2 in March, the lowest density was 5434 org/cm^2 in November (Fig. 2). The highest abundance was recorded at station 1 in March (5114 org/cm^2), the lowest one was recorded at station 2 in December (1121 org/cm^2) (Fig. 3).

The dominating taxa in the epipelic algal flora differed from each other at all stations. *Cocconeis placentula* and *D. moniliformis* were dominant at all stations. U. ulna were dominant station 1, 3, 4 and *C. minuta* and *A. minutissimum* at station 1, 2, 3, *N. palea*; at station 1, 2, 4, *C. affinis*; at station 2, 3, 4, *C. silesiaca*; at station 2, 3, *N. cryptocephala, C. solea* were dominant only at station 1 and *N. fonticola* and *A. veneta* only at station 3, *C. amphicephala* was dominant only at station 4 and *Phormidium phormosum* only at station 2. Dominance values (%) of some taxa were given Figure 4. The highest abundance of taxa has differed according to stations and month (Fig. 5). *D. moniliformis* reached its highest abundant (1396.5 org/cm^2) in March, *U. ulna* (2245.7 org/cm^2) in February, *A. minutissimum* (2000.4 org/cm^2) in March, *C. affinis* (2302.4 org/cm^2) in February, *C. silesiaca* (641.6 org/cm^2) in June.

According to the Simpson Index, the highest diversity

Table 1. Frequencies (%) and list of epipelic algae.

Taxa	Stations			
	1	2	3	4
Bacillariophyta				
Cocconeidales				
Achnanthidium minutissimum (Kützing) Czarnecki	100	90	60	70
Planothidium lanceolatum (Brébisson ex Kütz) Bukh.	30	-	-	-
Cocconeis placentula Ehrenberg	80	90	90	50
Mastogloiales				
Achnanthes exigua Grunow	20	-	-	-
Bacillariales				
Denticula kuetzingii Grunow	-	-	10	-
Hantzschia amphioxys (Ehrenberg) Grunow	60	10	-	-
Nitzschia fonticola (Grunow) Grunow	-	-	30	-
Nitzschia palea (Kützing) W.Smith	90	70	70	70
Nitzschia sigmoidea (Nitzsch) W.Smith	40	90	90	70
Cymbellales				
Encyonema minutum (Hilse) D.G.Mann	60	80	40	40
Encyonema silesiacum (Bleisch) D.G.Mann	-	30	30	30
Cymbella helvetica Kützing	-	10	-	30
Cymbella affinis Kützing	60	90	80	90
Cymbella lanceolata (C. Agardh) Mahoney & Reimer	-	20	-	40
Cymbella tumida (Brébisson) van Heurck	-	60	30	80
Cymbella laevis Nägeli	-	-	-	10
Cymbopleura amphicephala (Nägeli) Krammer	30	10	30	80
Encyonopsis microcephala (Grunow) Krammer	20	20	-	10
Gomphonema parvulum (Kützing) Kützing	100	10	50	40
Gomphonema truncatum Ehrenberg	50	-	-	-
Gomphonema olivaceum (Hornemann) Brébisson	20	50	-	30
Gomphonema angustum C.Agardh	-	-	-	20
Gomphonema minutum (C.Agardh) C.Agardh	10	20	-	-
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot	20	-	-	10
Eunotiales				
Eunotia praerupta Ehrenberg	10	10	-	-
Tabellariales				
Diatoma mesodon (Ehrenberg) Kützing	20	10	-	-
Diatoma moniliformis (Kützing) D.M.Williams	70	50	30	60
Diatoma vulgaris Bory de Saint-Vincent	40	40	10	90
Fragilaria constricta Ehrenberg	-	-	40	10
***Fragilaria* sp.**	10	-	-	40
Meridion circulare (Greville) C.Agardh	30	10	50	10
Licmophorales				
Ulnaria biceps (Kützing) P.Compère	-	-	10	-
Ulnaria ulna (Nitzsch) P.Compère	100	100	90	90
Melosirales				
Melosira varians C.Agardh	70	20	20	40
Naviculales				
Caloneis silicula (Ehrenberg) Cleve	50	60	20	50
Caloneis bacillum (Grunow) Cleve	10	-	-	-
Caloneis schumanniana (Grunow) Cleve	10	-	-	-
Craticula cuspidata (Kutzing) D.G.Mann	60	20	-	-
Gyrosigma acuminatum (Kützing) Rabenhorst	50	20	20	20
***Gyrosigma* sp.**	50	50	10	-
Gyrosigma scalproides (Rabenhorst) Cleve	-	50	30	60
Hippodonta capitata (Ehrenberg) Lange-Bertalot	10	-	-	-
Navicula cryptocephala Kützing	70	40	20	-
Navicula radiosa Kützing	60	60	-	80
Navicula viridula (Kützing) Ehrenberg	50	70	70	60

Table 1. Continued.

Taxa	Stations			
	1	**2**	**3**	**4**
Navicula cari Ehrenberg	60	40	70	50
Navicula sp.	10	-	50	30
Navicula capitatoradiata Germain	10	40	20	30
Neidium affine (Ehrenberg) Pfizer	10	-		-
Neidium productum (W.Smith) Cleve	-	-	30	-
Neidium dubium (Ehenberg) Cleve	-		20	
Neidium ampliatum (Ehrenberg) Krammer	10	-	-	20
Pinnularia dactylus Ehrenberg	20	-	-	-
Pinnularia viridis (Nitzsch) Ehrenberg	30	-	-	-
Pinnularia microstauron (Ehrenberg) Cleve	-	-	-	10
Stauroneis sp.	10	-	-	-
Stauroneis anceps Ehrenberg	40	-	-	10
Stauroneis smithii Grunow	30	-	-	-
Sellaphora pupula (Kützing) Mereschkovsky	50	30	10	40
Rhopalodiales				
Epithemia adnata (Kützing) Brébisson	-	10	-	-
Epithemia turgida (Ehrenberg) Kützing	10	-	-	-
Rhopalodia gibba (Ehrenberg) Otto Müller	50	-	-	-
Surirellales				
Cymatopleura solea (Brébisson) W.Smith	80	90	60	70
Cymatopleura elliptica (Brébisson) W.Smith	40	20	-	60
Cymatopleura solea* var. *apiculata (W.Smith) Ralfs	-	-	-	10
Surirella angusta Kützing	80	50	40	60
Surirella minuta Brébisson	80	70	60	60
Surirella linearis W.Smith	-	-	-	10
Surirella tenera W.Gregory	-	20	-	20
Thalassiophysales				
Amphora ovalis (Kützing) Kützing	10	70	70	80
Amphora veneta Kützing	10	-	50	10
Thalassiosirales				
***Cyclotella* sp.**	10	-	-	-
Chlorophyta				
Sphaeropleales				
Pseudopediastrum boryanum Turpin) E.Hegewald	10	-	-	-
Pediastrum boryanum var .cornutum (Raciborski) Sulek	10	-	-	-
Scenedesmus communis E.Hegewald	20	-	-	-
Scenedesmus sp.	-	10	-	-
Cyanophyta				
Chroococcales				
***Chroococcus* sp.**	10	-	-	-
Nostocales				
***Nostoc* sp.**	10	-	-	-
Synechococcales				
Merismopedia glauca (Ehrenberg) Kützing	-	-	40	-
***Merismopedia* sp.**	10	-	-	-
Oscillatoriales				
Oscillatoria nitida Schkorbatov	10	-	-	-
***Oscillatoria* sp.**	10	-	-	-
Microcoleus amoenus (Gomont) Strunecky, Komárek & J.R.Johansen	20	-	-	-
Phormidium limosum (Dillwyn) P.C.Silva	50	-	10	-
Phormidium formosum (Bory de Saint-Vincent ex Gomont) Anagnostidis & Komárek	50	10	-	-
Charophyta				

Table 1. Continued.

Taxa	Stations			
	1	**2**	**3**	**4**
Desmidiales				
***Closterium* sp.**	20	30	-	-
Closterium costatum Corda ex Ralfs	10	-	-	-
***Cosmarium*s p.**	10	-		-
Cosmarium obtusatum (Schmidle) Schmidle	-	10	10	40
Zygnematales				
***Spirogyra* spp.**	-	-	-	10
***Zygnema* sp.**	-	-	-	10

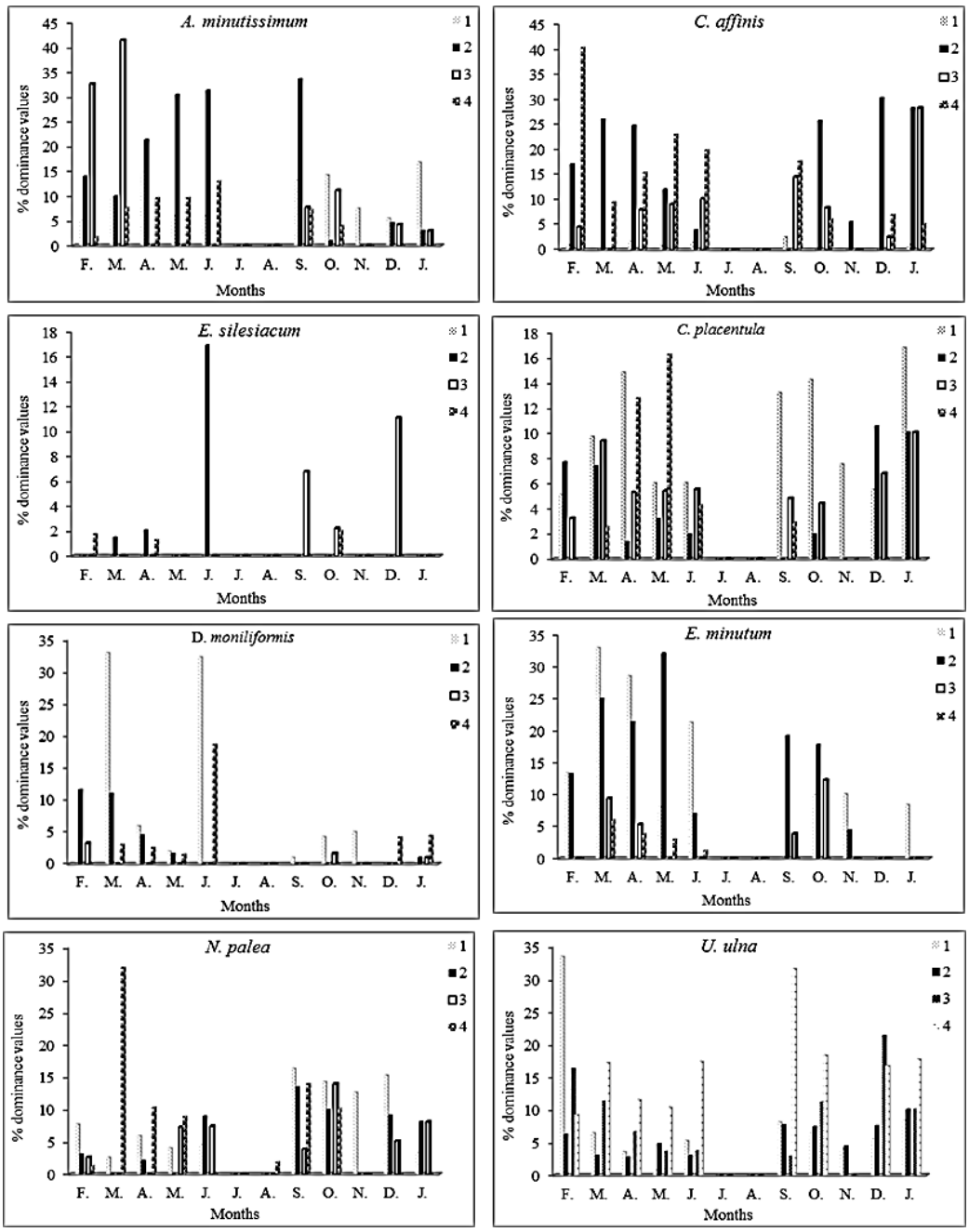

Figure 4. Dominance values (%) of some taxa.

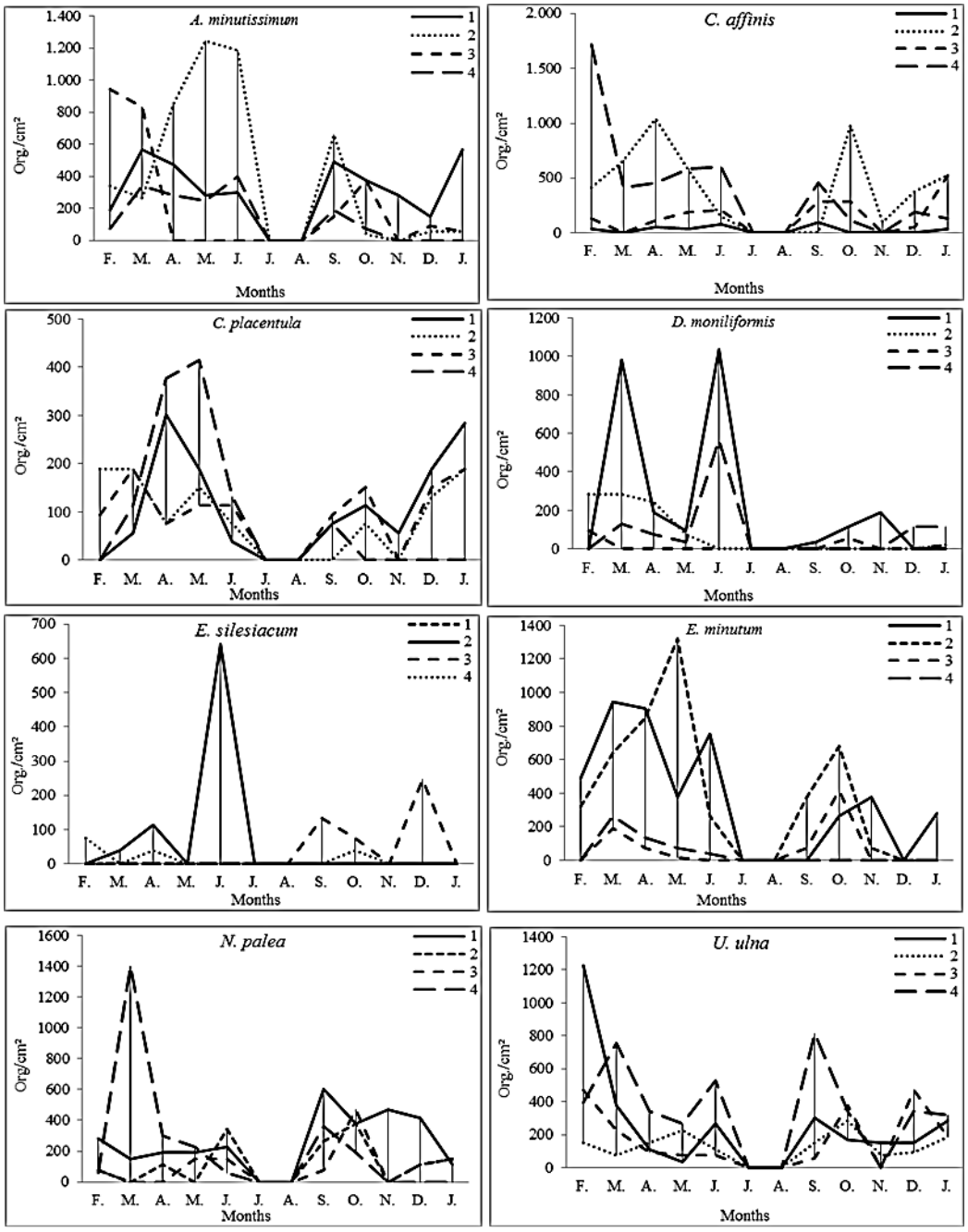

Figure 5. Seasonal changes in the density of dominant epipelic algae.

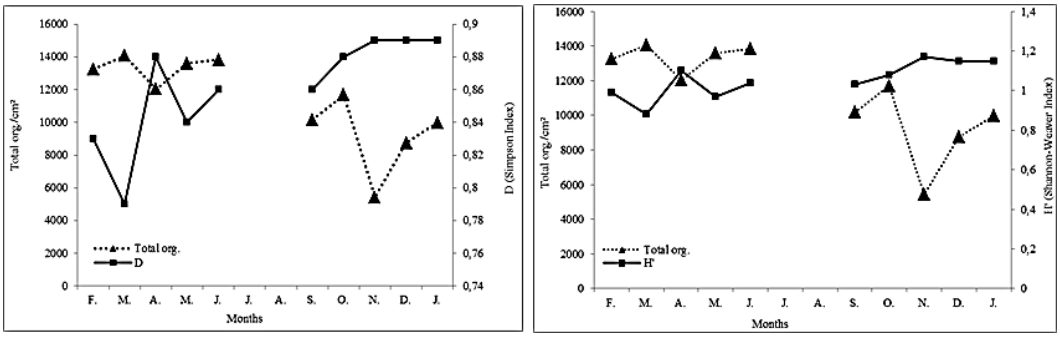

Figure 6. The seasonal variations in the total organisms and diversity of the epipelic algae.

Figure 7. UPGMA dendrogram for four stations.

value was calculated as 0.89 (in November, December and January) while the Shannon Weaver Index was estimated as 2.3 (in November, December and January); the lowest index value for either Simpson or Shannon-Weaver was observed as 0.8 (March). According to Sorensen's Similarity Index, the highest similarity was observed between station 2 and station 3 (73%), the lowest one was observed between station 2 and station 5 (52%) (Fig. 7). There was positive relationship between total number of species and index values (Fig. 6).

Discussion

Atotal of 91 taxa belonging to epipelic algae were identified from Köprüçay River (Antalya). Diatoms constituting 79.12 % of the total epipelic community were predominant group. Results with regard to epipelic algae taxon were similar to ones that had been documented in other studies, in rivers and lakes (Moore, 1974; Antoine and Evens, 1986; Kara and Şahin, 2001; Kolaylı et al., 1998; Şahin, 2003; Atıcı et al., 2005).

In Köprüçay River (Antalya), *A. minutissimum, C. placentula, C.solea, C. affinis, D. vulgaris, G. parvulum, N. palea, N. sigmoidea* and *U. ulna* were found to be the common taxa. *U. ulna* was also reported to be common in Değirmendere River (Kara and Şahin, 2001). *A. minutissimum, C. affinis, C. placentula* and *U. ulna* were common algae in the freshwater systems (Winter and Duthie, 2000; Şahin, 2003; Špačková et al., 2009). Various researchers had reported that *A. minutissimum, N. palea, C. placentula, C. solea, C. affinis, D. vulgaris, U. ulna, N. sigmoidea and G. parvulum* are frequently observed in epipelic flora (Aykulu, 1982; Altuner, 1988; Ertan and Morkoyunlu, 1997; Aksın et al., 1999; Çetin and Yavuz, 2001; Yıldırım et al., 2003; Sıvacı and Dere, 2006). The epipelic flora of stream or river consists mainly of diatoms, which are the most common algal group in freshwater systems (Round, 1981; Wehr and Sheat, 2003).

According to the stations and months, the abundance of epipelic algae had shown variability. The highest quantity for total density was 5114 org/cm^2 in March (staiton 1), the lowest quantity for total density was 1121 org/cm2 in December (station 2).The same result was reported by the studies which were related to epipelic algae (Şahin, 2004; Kıvrak and Gürbüz, 2005).

Cocconeis placentula, D. moniliformis, U. ulna, C. minuta, A. minutissima, N. palea, C. affinis, C. silesiaca, N. cryptocephala, C. solea, N. fonticola, A. veneta, C. amphicephala and *Phormidium phormosum* were dominant taxa in the epipelic commonity. Some studies have been reported that dominating of *A. minutissium, N. palea, U. ulna, D. vulgaris, N. cryptocephala, C. minuta, C. affinis* and *C. placentula* (Kolaylı et al., 1998; Kara and Şahin, 2001; Sivaci et al., 2007; Kıvrak and Gürbüz, 2010). Round (1981) reported that Achnanathes, Amphora were dominant in freshwater flora. Members of Cyanophyta, Charophyta and Chlorophyta were not important in the epipelic population. One taxa belonging to Cyanophyta, *Phormidium phormosum* was only dominant in November. Kıvrak and Gürbüz (2005) reported that these taxa were dominant in epipelic flora.

In this study, the highest diversity was observed in autumn and winter period (Simpson Index 0.89 and Shannon-Weaver Index 2.3), the lowest diversity was observed in spring period (Simpson and Shannon-Weaver Index 0.8). It was observed that diversity showed an inverse pattern with cell number in the Köprüçay River. Therefore species diversity was declining with the increase in total cell number. When *A. minutissimum* (830.36 org/cm^2 in March), and *E. minutum* (2038.16 org/cm^2 in March) were observed as the highest cell number, diversity was decreasing/diversity declined. *A. minutissimum* occupied 41.51% of the total epipelic flora and *E. minutum* occupied 33% in March. Kolaylı and Şahin (2009) had mentioned that the decrease in diversity index was caused by the high relative abundance of the dominant taxa. In November, December and January diversity index value had increased. In these months cell

numbers were small, dominant taxa, for example *A. minutissimum* had the lowest cell number (283.08 org/cm^2) in November. The lowest cell number (283.08 org/cm^2) was observed for *E. minutum* in January. Similar results were reported in the pevious studies (Şahin, 2004; Kolaylı and Şahin, 2009). The primary reproduction was less in winter, low rate of reproduction of the benthic diatoms were caused by the high turbidity of the water and another factor was the instability of the substratum, which can be washed away during rough weather (Hoek et al., 1995). These phenomena obviously supported the results obtained from epipelic algea in Köprüçay River. In the various previous studies, it was reported that the biomass and growth of algae were positively correlated with light intensity and temperature (Muller, 1994; Sıvacı and Dere, 2006; Kolaylı and Şahin, 2009).

Additionally, there were positive effect of water temperature and flood on the development of the epipelic algal flora in Köprüçay River.

Acknowledgement

The authors feel grateful to the Unit of Scientific Research Projects, Süleyman Demirel University (Proje No: 1534-D-07) for their financial support.

References

Aksın M., Çetin A.K., Yıldırım V. 1999. Algae of Keban Stream (Elazığ/Turkey). Science and Eng. Journal of Fırat University, 11(1): 59-65. (In Turkish)

Altuner Z. 1988. A Study of the Diatom Flora of the Aras River, Turkey. Nova Hedwigia, 46(1-2): 255-263.

Aykulu G. 1982. The Epipelic algal flora of the River Avon. British Phycological Journal, 17(1): 27-38.

Antoine S.E., Evans B.K. 1986. The Epipelic Algal Flora of the River Wye System, Wales, U.K. 2. Algal Phyla and Species Population Dynamics. Hydrobiology, 71(6): 813-839.

Bourrlly P., Couté A. 1991. Bibliotheca phycologica band 86, Desmidiées de Madagascar, Chlorophyta; Zygophyceae. Berlin-Stuttgart, 348p.

Çetin A.K., Yavuz O.G. 2001. Epipelic, epilithic and epiphitic algal flora of Cip Stream (Elazığ/Turkey). Science and Eng. Journal of Fırat University, 13(2): 9-14. (In Turkish)

CEC 2000. Council of European Communities Directive 2000/60/EEC of 23 October 2000 establishing a framework for community action in the field of water policy. Official Journal of European Communities, 327/1.

Ertan Ö.O., Morkoyunlu A. 1997. Epipelic algae of Aksu Stream (Eğirdir, Isparta-Turkey). OMÜ, Fen Edebiyat Fak. Fen Dergisi, 8(1): 31-53.

Hoek C.Van den., Mann D.G., Jahns H.M. 1995. Algae: Introduction to phycology, Cambridge University Press, 623 p.

John D., Whitton B.A., Brook A.J. 2005. The freshwater algal flora of the British Isles, an Identification Guide to Freshwater and Terrestrial Algae. Cambridge University Press, United Kingdom. 694 p.

Kara H., Şahin B. 2001. Epipelic and Epilithic Algae of Değirmendere River (Trabzon-Turkey). Turkish Journal of Botany, 25: 177-186.

Kıvrak G., Gürbüz H. 2005. The Benthic algal flora of Demirdöven Dam Resevoir (Erzurum, Turkey). Turkish Journal Botany, 29: 1-10.

Kıvrak E., Gürbüz H. 2010. Epipelic diatoms of Tortum Streams (Erzurum) and their relationship to some physicochemical features. Ekoloji, 19(74): 102-109. (In Turkish)

Kolaylı S., Baysal A., Şahin B. 1998. A study on the epieplic and epilithic algae of Şana River (Trabzon/Turkey). Turkish Journal of Botany, 22: 163-170.

Kolaylı S., Şahin B. 2009. Species composition and diversity of epipelic algae in Balıklı Resevoir, Turkey. Journal of Environmental Biology, 30(6): 939-944.

Kingston J.C, Love R.L, Eugene F.S, Theodore B.L. 1983. Spatial and temporal distribution of benthic diatoms in northern Lake Michigan. Ecology, 64(6): 1566-1580.

Krammer K., Lange-Bertaloth H. 1986. Bacillariophyceae. 1. Teil: Naviculaceae. In: H. Ettl, J. Gerloff, H. Heynig, U. Mollenha (Eds.). Süsswasser flora von Mitteleuropa, Band 2/1. Gustav Fischer Verlag: Stuttgart, New York. pp. 1-876.

Krammer K., Lange-Bertaloth H. 1988. Bacillariophyceae. 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. In: H. Ettl, J. Gerloff, H. Heynig, U. Mollenha (Eds.). Süsswasserflora von Mitteleuropa, Band 2/2. VEB Gustav Fischer Verlag: Jena, 1-596 pp.

Krammer K., Lange-Bertaloth H. 1991a. Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In: H. Ettl, J. Gerloff, H. Heynig, U. Mollenha (Eds.). Süsswasserflora von Mitteleuropa, Band 2/3. Gustav Fischer Verlag: Stuttgart, Jena, 1-576 pp.

Krammer K., Lange-Bertaloth H. 1991b. Bacillariophyceae. 4. Teil: Achnanthaceae, Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema, Gesamtliteraturverzeichnis Teil1-4. In: H. Ettl, J. Gerloff, H. Heynig, U. Mollenha (Eds.). Süsswasserflora von Mitteleuropa, Band 2/4. Gustav Fischer Verlag: Stuttgart, Jena, 1-437 pp.

Komárek J. 2000. Cyanoprokaryota 1. Teil: Chroococcales Süßwasserflora Von Mitteleuropa Band 19/1, Cyanoprokaryota 1. Teil: Chroococcales. Spectrum Akademischer Verlag Heidelberg, Berlin, 548p.

Komárek J. 2008. Cyanoprokaryota 2. Teil: Oscillatoriales.

Spectrum Akademischer Verlag Heidelberg, Printed in Germany.

Kovach W.L. 1998. MVSP-Multivariate Statistical Package for Windows, version 3.1 Kovach Computing Services, Pentraeth, Wales, U.K.

Moss B. 1969. Algae of towo somersetshire pools Standing crops of phytoplankton and epipelic algae as measured by cell numbers and chlorophyl-a. Journal Phycology, 5: 158-168.

Moore J.W. 1974. The Benthic Algae of Southern Baffin Island. I. Epipelic Communuties in Rivers. Journal of Phycology, 10: 50-57.

Muller U. 1994. Seasonal Development of epiphytic algae on Pragmites australis (Cav.) Trin. Ex Sten. On a eutrophic lake. Arc. Hydrobiology, 129: 273-292.

Round F.E. 1953. An Investigation of Two Benthic Algal Communities in Malharm Tarn, Yorkshire. Journal of Ecology, 41(1): 174-197.

Round F.E. 1973. The Biology of Algae. London Edward Arnold Ltd. 288 p.

Round F.E. 1981. The Ecology of Algae. Cambiridge University Press, Great Britain, 629 p.

Sıvacı R., Dere Ş. 2006. Seasonal Changes of Epipelic (Aksaray-Ihlara) Diatoms of Melendiz Stream. C.Ü. Journal of Science, 27(1): 1-12. (In Turkish)

Sıvacı E.R., Kılınç R., Dere Ş. 2007. Seasonal Changes in Epipelic Diatom and Ionic Composition of a Karstic Lake, Todurge, in Central Anatolia, Turkey. International Journal of Botany, 3(2): 196-201.

Sladeckova A. 1962. Limnogical Investigation Methods for the Periphyton (Aufwuchs) Community Botanical Review, 28(2): 286-350.

Špačková J., Hašler P., Štěpánková J., Pouličková A. 2009. Seasonal Succession of Epipelic Algae: A Case Study on a Mesotrophic Pond in a Temperature Climate. Fottea, 9(1): 121-133.

Stevenson R.J., Bothwell M.L., Lowe R.L. 1996. Algall Ecology: Freshwater Benthic Ecocystem. Academic Press, USA, 753 p.

Şahin B. 2003. Epipelic and Epilithic Algae of Lower Parts of Yanbolu River (Trabzon, Turkey). Turkish Journal Biology, 27: 107-115.

Şahin B. 2004. Species Composition and Diversity of Epipelic Alae in Çatal Lake (Şebinkarahisar-Giresun, Turkey). Turkish Journal of Biology, (28): 103-109.

Yıldırım V., Şen B., Çetin A.K., Alp M.T. 2003. Seasonal Variations in Nutrient and Solid Matter Concentrations in Kürk Stream flowing into Lake Hazar (Elazığ, Türkiye). Firat Unv. Journal of Science, 15(3): 329-336. (In Turkish)

Winter J.G., Duthie H.C. 2000. Stream Epilithic, epipelic and epiphytic diatoms: habitat fidelity and use in biomonitoring. Aquatic Ecology, 34: 345-353.

Wehr J.D., Sheath R.G. 2003. Freshwater Algae of North America: Ecology and Classification. Academic Press, USA, 917 p.