

Seasonal variation and occurrence of algal turf community in Lake Ladik, Turkey

Faruk Maraşlıoğlu^{1*}, Elif Neyran Soylu² and Arif Gönüloğlu³

¹Hitit University, Faculty of Arts and Science, Department of Biology, 19030, Çorum, Turkey.

²Giresun University, Faculty of Arts and Science, Department of Biology, 28000, Giresun, Turkey.

³Ondokuzmayıs University, Faculty of Arts and Science, Department of Biology, 55139, Samsun, Turkey.

*Corresponding Author email : fmaraslioglu@hotmail.com

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Abstract

The composition and seasonal variation of the algal turf of Lake Ladik were studied using samples collected from one station between June 2000 and May 2001. 50 taxa of diatoms were identified in the epiphyton. *Navicula veneta*, *N. halophila*, *Nitzschia fonticola* and *Aulacoseira distans* were particularly important on turf community. During the October month several *Navicula* species become progressively more important. *Gomphonema lateripunctatum* was particularly notable. Other diatoms were occasionally abundant, including *Cymbella affinis*, *C. silesiaca*, *Navicula cryptocephala*, *Gomphonema olivaceum* and *Cyclotella ocellata*. Also *Navicula lanceolata* and *Anomoeoneis brachysira* were conspicuous, owing to their large size, but were never numerically abundant. *Fragilaria ulna* and *Nitzschia palea* were found in low numbers in study area and this pointed out there has not been a remarkable abundance of algal pollution in Lake Ladik. The associations between July and August with bonds to June, January and February with bonds to April were most significant in the study period obtained by cluster analysis. Shannon diversity and evenness presented small variations during the study period. Lake Ladik presented low values of species richness particularly during summer period and highest values were recorded in April. According to canonical correspondence analysis, there was association between some *Navicula* and *Nitzschia* species with PO_4^{3-} , NH_3-N . Also the multivariate analysis showed, temperature as the most important factor in the distribution and abundance of diatoms on turf biomass.

Key words

Seasonal variation, Lake Ladik, Algal turf, Canonical correspondence analysis

Introduction

Algae inhabit widely different environments. Due to their undemanding nutritional habits, simple structure, fast growth and both sexual and asexual reproduction algae have a great capacity of adapting to extreme ecological conditions. Algae are often found in the environments where other organisms cannot survive (Mulec *et al.*, 2007). Electrical conductivity, pH, calcium content and the carbonate-bicarbonate system have a major impact on the development and structure of algal communities, affecting particularly the development and structure of diatom and desmid communities (Dell'uomo *et al.*, 1993). Spatial and time changes of physical and chemical factors affect the occurrence and relative

abundance of individual algal species and thus have an impact on the specific composition of algal communities (Rauch *et al.*, 2006).

Turf algal communities are comprised of a variety of algal species, diatoms, cyanophyta, detritus and micrograzers. Turfs not only influence large-scale habitats but are habitats in and of themselves. The dominant algae are often covered by many species of smaller algae (epiphytes) and provide protection for micrograzers and diatoms, trap sediments, and are one of the most productive habitats on coral reefs.

Several algal turf growth forms have been described in some investigations. Most of the observed variation in

these growth forms is considered to be a response of the algae to different environmental conditions (Airoldi, 2001). Turf-forming species have high morphological plasticity and adjust their growth form in accordance with varying levels of environmental disturbances such as different levels of grazing and physical stresses such as desiccation. Thallus morphology can change from arbustive, with loose and sparse branching patterns, to thalli that are shorter, more erect, and more highly branched and compacted. Also in Lake Ladik (Turkey), seasonal variations of phytoplankton, epilithic diatoms and epiphytic diatoms on *Cladophora glomerata* were investigated by Maraşlıoğlu et al. (2005a, b; 2007)

The objective of the present study was to determine the structure of diatom assemblages epiphytic on turf considering the environmental factors affecting diatom abundance, and determine the temporal changes in the diversity and richness of the epiphytic diatoms in the Lake Ladik.

Materials and Methods

Study area: Lake Ladik (36°01' 15" E, 41°03' 45" N) is located in the North of Turkey. It is near the Ladik-Tasova highway which is 10 km away from Ladik-Samsun (Fig. 1). The lake is 2 km wide and 5 km long. The total surface area of the lake is about 10 km² and the average depth is 2.5 to 3 m.

The sampling station was located in the north of Gölbaşı restaurant, 30 m away from Ladik-Tasova highway. In this study, we chose one sampling station only because this place was the most turf-forming area near south central part of the lake.

The lake habitat composed of alluvial sediments supplied by tributaries from the north slope of Ak mountain. Ladik includes volcanic aglomera belonging to Mesozoic age, konglomera sandstone and chipping belonging to Neocene age. The climate regime in the area is a mixed one characterised by the transition from the climate of the Middle

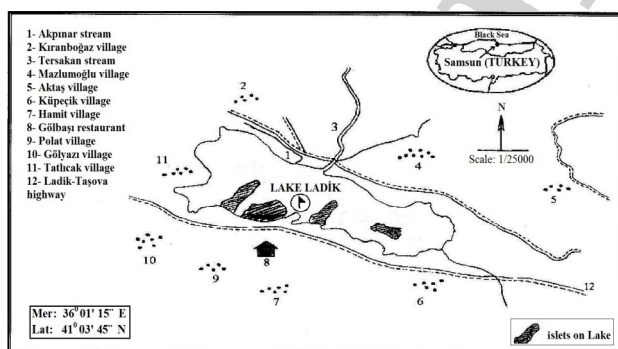


Fig. 1 : Lake Ladik and sampling station

Black Sea Region to that of Central Anatolia (Aydın, 1997).

Sampling : The turf was sampled on a monthly frequency, at one sampling station from a known surface of lake bottom between June 2000 and May 2001. Samples were collected monthly at 0.3-1 m depth from the shallow littoral zone. Turf samples were placed in a plastic container and shaken for 60 sec to remove algae. This procedure removed at least 80 % of the diatoms, based on microscopic analysis, and was to be the most effective technique for separating intact the diatoms from turf community (Blinn et al., 1995). Turf diatom samples were first fixed with 4% formaldehyde and then analyzed for taxa identification. The diatoms were examined after preparation according to Schaumburg et al. (2004). At least 600 diatom valves per slide were counted and identified under oil immersion at 1000X magnification on a Nikon microscope. Taxa written in necessary sources were used for identification (Krammer and Lange-Bertalot, 1999a, b; 2004a, b; Guiry and Guiry, 2009).

At the time of sampling, the water temperature, pH and conductivity were measured *in situ* with C 534 multi-parameter analyser (Consort nv, Belgium). Other chemical analyses were measured by C 200 multiparameter ion specific meter.

The data set was analysed by a cluster analysis (complete linkage method) applied to a dissimilarity matrix obtained from the calculation of the Bray-Curtis index. The shannon diversity (log 10 base) and evenness calculated by the Biodiversity Professional 2.0 (Wilsey and Potvin, 2000). The species richness was represented as the total number of taxa presented within the samples. The spatial variation in limnological properties and algal community on the turf sediments were analyzed by the ordination method CCA (Canonical Correspondence Analysis). Calculations were performed by the Multi-Variate Statistical Package.

Results and Discussion

The water temperature varied between 7 and 28 °C; the maximum water temperature (28 °C) was observed in July and the minimum temperature (7 °C) in December, January, February. The pH fluctuated between 6.9 and 8.5, indicating a slightly alkaline character. The nitrate reached maximal values in winter months (1.01 mg l⁻¹) and minimal values (0.35 mg l⁻¹) in summer months. Although phosphorus was very low (0.001 mg l⁻¹) during summer, it's concentration increased (0.22 mg l⁻¹) in December. The total hardness in the lake varied between 122 and 198 mg l⁻¹ CaCO₃.

50 taxa were identified in the epiphytic diatoms of Lake Ladik. The total numbers of epiphytic algae on turf peaked in October (15440 cells cm⁻²) and reached lowest value in March (400 cells cm⁻²) and December (640 cells cm⁻²).

Aulacoseria distans, *Nacivula veneta*, *N. halophila*, *N. cryptocephala* and *Nitzschia fonticola* were especially prominent diatoms and ranged between 6 and 12 % of algal cells in all samples throughout the year. *Gomphonema lateripunctatum*, (up to 6 %) and *Fragilaria ulna* (up to 8 %) were important during spring especially in October. *Navicula lanceolata* (up to 31 %) and *Anomoeoneis brachysira* (up to 33 %) peaked only in May. *Gomphonema productum* composed 33 % of the diatom community in July. *Amphora ovalis*, *Cocconeis placentula* var. *euglypta*, *Cymbella cistula*, *C. parva*, *Epithemia adnata*, *Gomphonema affine*, *G. lanceolatum* var. *insignis*, *Navicula capitata* var. *hungarica*, *N. confervacea*, *N. laterostrata*, *N. menisculus*, *N. pseudoanglica*, *P. silvatica*, *P. microstauron* and *P. stomatophora* were registered in only one sample during the sampling period.

Shannon diversity and evenness presented small variations during the study period. Relative species abundance (evenness) around 0 indicates high single-species dominance. *Anomoeoneis brachysira* and *Navicula lanceolata* species formed 64 % of the density in May. The bloom pattern of this species with a resulting decrease of *H'*, also indicated low evenness. Lake Ladik presented low values of species richness particularly during summer period and other months of the study period the seasonal variations of species richness presented small modifications. The highest values were recorded in April.

The diagram obtained by cluster analysis indicated that at the lowest hierarchical level two clusters were separated in the station. The first one was a large cluster formed by summer, autumn except October and winter except December samples by the absolute prevalence of *Aulacoseria distans*, *Gomphonema olivaceum* and *Nitzschia fonticola*. The second group included spring except April, October and December samples characterised by the dominance of *Navicula halophila*, *N. veneta* together with *Cymbella affinis*. The associations between July and August with bonds to June, January and February with bonds to April were most significant in the study period.

Among the variables analyzed, only nine of twelve were included in the model by forward selection (temperature, pH, NH₃-N, NO₃⁻, PO₄⁻, SO₄⁻, Na⁺, Ca⁺⁺ and CaCO₃). The first two axes accounted for 47.3 % of the variance (axis 1: 25.9%; axis 2: 21.4). The first eigenvalue indicated that abiotic factors were significantly correlated with both axis. The diplot of the species and environmental variables according to the first two axes is shown in Fig. 2. The taxa illustrated were selected taking in to account their abundance, frequency of occurrence along the study period and their fitness to the environmental variables included in the model. The first axis was mainly defined by a combination of Ca⁺⁺, NO₃⁻, SO₄⁻ and CaCO₃ (intra-set

correlation coefficients: 0.81; -0.72; -0.71; -0.68 respectively). Axis 2 was mainly correlated with Na⁺ (intra-set correlation coefficients: 0.64). While most of the species were ordinated towards the left side of the figure, some species such as *Cymbella affinis* (5), *C. lanceolata* (6), *Gomphonema productum* (14), *Navicula gregaria* (20), *Nitzschia fonticola* (25), *Cyclotella ocellata* (4), *Aulacoseira distans* (2) and *Gomphonema olivaceum* (16) were plotted towards the right side. There was an association between some *Navicula* (18, 19, 24) and *Nitzschia* (26, 27) species with PO₄⁻, NH₃-N. In this analysis, *Anomoeoneis brachysira* (1), *Pinnularia silvatica* (29), *Navicula lanceolata* (22) and *Gomphonema productum* (14) were not correlated with abiotic factors and other species (Fig. 2).

The persistence and survival of diatoms on turf under natural conditions seems to depend on a variety of factors (temperature, sunlight and predation). Despite substantial research into relationships between diatoms and temperature, studies have shown little evidence of direct temperature control over diatoms (Anderson, 2000). However, temperature can affect diatom density indirectly by changing water quality, diatom microhabitat and various catchment factors (Weckström and Korhola, 2001). The oxygen level is related to temperature, salinity, current, photosynthetic activities (algae and macrophytes), and atmospheric pressure in natural waters (Atıcı and Obalı, 2010). In the study area, the multivariate analysis showed that temperature as the most important factor in the distribution and abundance of diatoms.

It is known that nutrients are important for the physiological and growth activities of all organisms. In the surface water of Lake Ladik, nitrate values varied between 0.35 and 101 mg l⁻¹ while phosphate values were between 0.001 and 0.22 mg l⁻¹. These high values were probably because of the fact that the research area is located between urban areas and excessive usage of fertilizers in the surrounding agricultural areas. Nutrients in municipal waste water may have had a positive effect on Turf biomass.

The level of nutrients (ammonia-nitrogen and potassium) and ions (chlorine, sodium and calcium) was low in Lake Ladik. Also, the conductivity values were normal (≤ 1000) and weren't important to the occurrence of algal Turf. According to the pH values that varied between 6.9 and 8.5, the lake was slightly alkaline. pH values ranged between 6 and 9 in natural lakes and streams (Tanyolaç, 2000). Algal growth can decline with pH (Leavitt *et al.*, 1999). Likewise in the study area, total cell numbers were found to be low in August as pH value was also low in this month. But in few months (October, April), although pH values were low, total Bacillariophyta cell numbers reached high.

As a result, in the present study, the pH variable was not statistically significant and was not included in ecological research.

Navicula cryptocephala, *N. veneta*, *N. halophila*, *Nitzschia fonticola* and *Aulacoseria distans* were the most abundant and common diatoms in Lake Ladik. *Navicula* (12 sp.) and *Gomphonema* (10 sp.) species were found in high numbers in the lake and it supports that these species were observed widely in the neutral and the slightly alkaline waters (Atıcı and Obalı, 2010). *Nitzschia palea*, *Fragilaria ulna* and *Phormidium* spp. were the indicator species showing pollution of algae on the aquatic habitats (Klemencic and Toman, 2010). These diatoms were not found to be abundant in the study area and in the other Turkish lakes which have similar characteristics (Soylu et al., 2011; Sahin, 2002). It has pointed that the algal pollution has not been remarkable abundance yet in Lake Ladik. *Cyclotella* species were not found widely in some eutrophic lakes (Soylu et al., 2011; Soylu and Gönülol, 2006) and in our

research. Therefore, *Cyclotella* species usually occur in oligotrophic lakes.

Authors have long argued that species abundance and proportional diversity are simply and directly related to species richness (Stirling and Wilsey, 2001). Species richness was surprisingly low for algal turf community in our study. This may be due to competition between turf and macrophytes. Shannon diversity and evenness also presented small variations during the study period. The diversity index (H) ranged from 0.69 to 1.17 bits mm^{-3} . Higher species diversity index (H) and richness were registered in April, coinciding with the higher rainfall values and lower macrophyte cover, which, probably, caused the algal suspension of the sediment and the periphyton removal, increasing the specific richness as well as the possibility to collect a higher number of species than during the dry season. High species diversity values usually indicate diverse, well-balanced communities, while low values indicate stress or impact. So, the potential for such a high

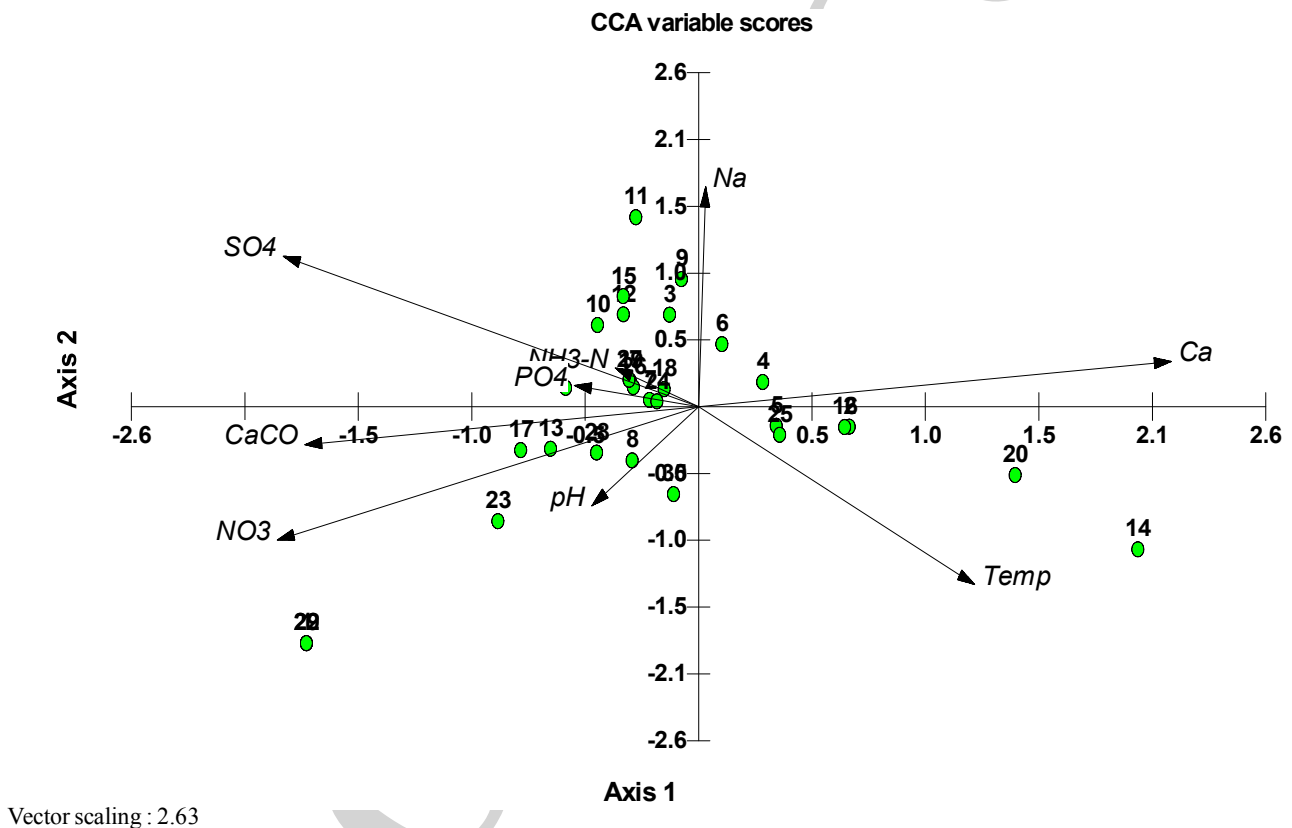


Fig. 2 : Species diplot based on the Canonical Correspondence Analysis (CCA) of the algal densities in the study area. Environmental variables are indicated by arrows. The selected species for CCA was displayed with a number. (1-*Anomoeoneis brachysira*, 2-*Aulacoseira distans*, 3-*Cocconeis pediculus*, 4-*Cyclotella ocellata*, 5-*Cymbella affinis*, 6-*C. lanceolata*, 7- *C. prostrate*, 8- *C. silesiaca*, 9- *Fragilaria ulna*, 10- *Gomphonema lateripunctatum*, 11-*G. longiceps* var. *subclavata*, 12- *G. olivaceum* var. *balticum*, 13-*G. parvulum*, 14-*G. productum*, 15- *G. ventricosum*, 16- *G. olivaceum*, 17- *Navicula cari*, 18- *N. cryptocephala*, 19-*N. cuspidate*, 20- *N. gregaria*, 21- *N. halophila*, 22- *N. lanceolata*, 23- *N. tripunctata*, 24- *N. veneta*, 25- *Nitzschia fonticola*, 26- *N. palea*, 27- *N. paleacea*, 28- *N. sublinearis*, 29- *Pinnularia silvatica*, 30- *Rhoicosphenia curvata*)

species diversity and evenness values in Lake Ladik indicate not yet a noticeable pollution.

In conclusion, Lake Ladik has been eutrophic characteristics because of the morphometric structure, physical and chemical properties of the water, and composition of the species. Temperatures were found to be the most important factor in explaining the seasonal variation observed in Lake Ladik.

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