© by PSP Volume 30– No. 09/2021 pages 10568-10575 Fresenius Environmental Bulletin

THE EFFECTS OF PICNIC AREAS ON EPIPHYTIC LICHEN DIVERSITY AT ABIES FORESTS IN ULUDAG NATIONAL PARK, TURKEY

Saban Guvenc*, Hulya Ozturk Kula

Department of Biology, Faculty of Arts and Sciences, Bursa Uludag University, Nilufer, Bursa, Turkey

ABSTRACT

The study was conducted on *Abies* trees located in Kirazlıyayla - Sarıalan camping and daily picnic areas in the Uludağ National Park. The epiphytic lichen diversity decreases due to differences in microclimate and intensive use of picnic areas by people. Relative humidity and bark surface moisture decreased due to an increase in the amount of light in picnic areas. Relative humidity in Sarıalan picnic areas significantly affects the epiphytic lichen diversity and causes a significant decrease in lichen species. Relative humidity and light are the most important factors affecting the diversity and structure of epiphytic lichen.

KEYWORDS:
Anthropogenic, diversity, epiphytic lichen, microclimate, Uludağ, National Park

INTRODUCTION

Unlike vascular plants, which take nutrients mainly from the soil through roots, lichens only depend on the atmosphere for nutrition. For this reason, they respond directly to atmospheric pollutants and they have been successfully used for biomonitoring of air pollution. Lichens are valuable bioindicators for evaluating the consequences of human activities. Epiphytic lichen diversity is strongly affected by altered microclimate resulting from changes in the forest structure and anthropogenic effects on forest ecosystems. Species diversity decreases with the intensity of management, while lichen composition also exhibited considerable variations. Nitrophytic species are clearly associated with more intensive management regimes, whereas non-nitrophytic species favored abandoned dehesas [1]. The epiphytic lichen vegetation is markedly different between the forest interior and the forest edge. It is stated that land use as compared to the changing microclimate has a stronger effect on lichen diversity along the forest interior and the forest edge [2]. The effect of edge conditions on lichen diversity depends on land-use intensity, climate, atmospheric deposition of nutrients or toxic substances, gap size, and the functional traits of the relevant epiphyte species [3]. One marked effect of the presence of hiking trail in forest was increased number of some sun-loving species and decreased number of shade-tolerant species. The presence of a hiking trail has indirectly influenced epiphytic lichen community and diversity by altering microclimate along the trail [4]. Variation in species composition in National Parks which is related to the environmental variables and habitat management was found to negatively influence species richness and alter the composition of lichen community [5]. The age of a forest stand is the main factor influencing lichen species richness [6]. Light availability and water supply are other important factors affecting the occurrence of epiphytic lichens. The lichen species richness is increased along with decreasing tree density [7]. Total species richness increases as a result of increasing number of eutrophication tolerant species that is due to the increase in land usage intensity [8]. The growth rate of epiphytic lichens is influenced by humidity, light, substrate pH, nutrient-availability and temperature [9]. In addition, the epiphytic lichen diversity is also influenced by environmental factors (humidity and light), the basic trunk of the trees, and some substrate characteristics such as bark moisture and tree size [10].

The aim of study is to analyse how picnic areas influence epiphytic lichen diversity on the trunk of *Abies* trees in Uludağ National Park.

MATERIALS AND METHODS

The study area. The Uludağ mountain is one of the largest winter sports centers in Turkey. It is the highest mountain of the Marmara region (2543 m). Uludağ was declared a National Park in 1961. Uludağ National Park is located at 40°04' N latitudes and 29°12' E longitudes which is 36 km to the south of Bursa in the southeastern part of the Marmara region of Turkey. There are different vegetation types depending on the type of climate and altitude in Uludağ Mountains. As a result of the altitudinal gradient and various geological conditions, the different vegetation types, changes from Mediterranean to Euro-Siberian, and Alpine can clearly be seen from

the bottom to the top of the mountains. While the mean annual temperature in Bursa (155 m) is 14.5 °C, it decreases to 4.8 °C in Uludağ (1878 m). The mean annual rainfall is 681.3 mm in Bursa and is 1453 mm in Uludag [11]. The mean annual temperature at Kirazlıyayla and Sarıalan plateaus which were selected as the study areas is 5.8˚C. The mean annual rainfall at Kirazıyayla is 1217.4 mm and is 1331.8 mm at Sarıalan [12].

Uludağ National Park is highly preferred by visitors for camping, hiking and daily picnic activities during summer season and it is also well known for its winter tourism. Kirazlıyayla and Sarıalan which were selected as the study areas are the most preferred plateaus by visitors for daily picnic activities. Karabelen entrance gate of Uludağ National Park is 22 km after Bursa city center by road. Kirazlıyayla and Sarıalan picnic areas are further 3 km and 10 km away by road from entrance gate, respectively. Sarıalan can also be reached by cable car. Sarıalan carries an importance for its health tourism due to the presence of exclusive picnic, travel, hiking, tent areas and plateau houses. Kirazlıyayla is generally used as a daily picnic area. The number of visitors at Uludağ National Park increases every year. In 1986, the total number of visitors was 446,093. 56.7% of them came by road and 43.2% by cable car. In 1988, the total number of visitors was 507,652 [13]. Recently, per year approximately 800,000 visitors had visited Uludağ National Park. 75% of the visitors go to the national park by road and 25% preferred by cable car.

Collection of lichen samples. The study was conducted in Kirazlıyayla and Sarıalan picnic areas located in the Uludağ National Park between 04-08 May, 2017. Lichen samples were collected from *Abies nordmanniana* (Steven) Spach subsp. *börnmuelleriana* (Mattf.) Coode & Cullen from Kirazlıyayla and Sarıalan picnic areas in Uludağ National Park (Figure 1). Four sites were selected for sampling. A total of five trees were selected from the center and edge of Kirazlıyayla picnic area (40°06′45″ N, 29°05′24″ E, 1532 m) and five trees from the control area which is 500 m away from the edge (40°06′38″ N, 29°05′23″ E, 1555 m). Similarly, five trees were selected from the center of Sarıalan camping and daily picnic area (40°08′06″ N, 29°06′33″ E, 1631 m) and five trees from the control area which is 500 m away from the edge (40°07′52″ N, 29°06′53″ E, 1630 m).



FIGURE 1
Sampling areas of lichen samples collected from Kirazlıyayla (A and B) and Sarıalan (C and D). A and C: Picnic area, B and D: Control area

Lichen samples were collected using the methods suggested by Asta et al. [14]. The sample grids were placed on the North (N), East (E), South (S) and West (W) sides 150 cm above the ground on the tree trunk. For each Uludağ fir, lichen samples were collected for a total of 20 subunits from the trunk. All lichen species found in each subunit of the sample grid were recorded. The frequency of each species was computed as the number of subunits at trunk where it was present. A sum of frequencies of all lichen species for each aspect (north, east, south and west) on each tree at trunk was calculated; four sums for each tree. The lichen diversity value (LDV) is the sum of the frequencies calculated for each aspect on a tree. The LDV of the locality was the arithmetic mean of the sums of frequencies for each sampling tree in that locality. The bark surface moisture was measured using LaserLiner DampMaster Moisture Meter. Bark surface moisture was measured for each aspect (north, east, south, and west) on each tree from the sites where five trees were located. DampMaster Moisture Meter measuring rods were measured by embedding 0.5 cm from the bark surface of the tree. In addition, the relative humidity (%) and light (10xLux) at the sampling locality were measured using with environmental tester (PCE-EM 886). Relative humidity and light were measured five times from the sites where five trees were located.

Statistical analysis. Total frequency (TF) of each epiphytic lichen species on trunk was used for statistical evaluation. The total frequency was calculated as the sum of the frequencies at that height of a species on all four aspects of each sample tree. Standard statistical analyses were conducted using IBM SPSS Statistics 23. Ordination of the 10 sample trees based on lichen species on trunk using the indirect linear model with Principal Component Analysis (PCA) in CANOCO ver. 4.5 generated diagrams of trees noted by control and picnic areas [15]. To compare species diversity and significant differences in the control and picnic areas, Paired Samples T-Test were used. Correlations between species and sampling area or environmental parameters (Bark surface moisture, Relative humidity, Light) were assessed using the Pearson correlation coefficient (2-tailed).

RESULTS

In this study, a total of 74 species were found from Kirazlıyayla and Sarıalan. A total of 58 species were found from Kirazlıyayla. Of these, only 16 were in the control area, 25 in the picnic area, and 17 were in both the control and picnic areas. A total of 57 species were found in another research area in Sarıalan. Of these, only 24 were in the control area, 12 in the picnic area, and 21 were in both the control and picnic areas (Table 1). The most common species in the control area of Kirazlıyayla were *Bryoria capillaris, Bryoria fuscescens, Evernia prunastri, Hypogymnia tubulosa, Lecanora intumescens, Parmelia sulcata, Phlyctis argena, Pseudevernia furfuracea, Ramalina farinacea, Usnea filipendula* and *U. glabrescens*, while those in the picnic area were *Candelariella xanthostigma, Hypogymnia tubulosa, Lecanora carpinea, L. chlarotera, L. cinereofusca, Lecidella elaeochroma, Melanohalea laciniatula, Pseudevernia furfuracea* and *Scoliciosporum chlorococcum*. The most common species in the control area of Sarıalan were *Bryoria capillaris, Hypogymnia tubulosa, Lecanora intumescens, Lecanora subcarpinea, Lecidella elaeochroma, Parmelia sulcata, Phlyctis argena, Pseudevernia furfuracea, Rinodina capensis* and *Usnea glabrescens*, while those in the picnic area were *Candelariella xanthostigma, Lecanora cinereofusca, L. subcarpinea, Lecidella elaeochroma* and *Melanohalea laciniatula*.

The PCA results based on lichen diversity on the trunk of sample trees in Kirazlıyayla and Sarıalan were shown in Figure 2. For Kirazlıyayla camping and daily picnic area, the first two axes of the PCA was represented 75.8% of the total variance. The first axis was associated with difference between control and picnic area. Trees in the control area were located at the left side and trees in the picnic area were on the right side of the first axis. Tree number 6 which has the lowest lichen diversity value was located at the position from edge towards the center of the picnic area, while the others were at the edge of the Kirazlıyayla picnic area (Figure 2A). For Sarıalan camping and daily picnic area, the first two axes of the PCA was represented 75.9% of the total variance (Figure 2B). Trees no 7 and 8 were close to each other on the roadside in the center of the picnic area, although trees no 9 and 10 were close to each other but they were located on the opposite side of the road in the center. Tree number 6 was farthest from the center. The lowest species diversity was found in tree no 8.

Ldv, bark surface moisture and relative humidity were decreased in picnic areas compared to control areas in both Kirazlıyayla and Sarıalan, whereas light exposure was increased. Decrease in relative humidity in picnic areas in both regions was significant, especially in Sarıalan $p<0.001$. Shannon diversity and Ldv values in Sarıalan were significantly decreased in picnic area compared to control area. This change was not significant in Kirazlıyayla (Table 2).

Bryoria capillaris, Bryoria fuscescens, Evernia prunastri, Lecanora intumescens, Parmelia sulcata, Ramalina farinacea, Usnea filipendula and *U. glabrescens* were the indicator species of the control area in both Kirazlıyayla and Sarıalan. *Biatora globulosa, Lecanora subcarpinea, Nephromopsis chlorophylla, Phlyctis argena, Ramalina* fraxine and Usnea

TABLE 1
Mean frequency values of epiphytic lichens species collected from Kirazlıyayla or Sarıalan picnic areas and control areas.

Sites	Kirazlıyayla		Sarıalan	
Sampling area	**Control area**	**Picnic area**	**Control area**	**Picnic area**
Bark surface moisture (%)	11.0	9.5	11.0	8.5
Relative humidity (%)	40.0	38.8	40.9	37.9
Light (10xLux)	1929.3	2213.4	731.8	5880.4
Shannon diversity	2.8	2.9	2.9	2.5
Lichen diversity value (Ldv)	172.0	145.2	164.0	121.2
Amandinea punctata	-	-	-	0.2
Anaptychia ciliaris	-	2.0	1.0	4.2
Arthonia radiata	-	-	0.2	0.2
Bacidia circumspecta	-	-	-	1.0
Biatora globulosa	5.6		2.4	-
Bryoria capillaris	16.6		12.4	-
B. fuscescens	9.8	0.6	6.0	-
B. nadvornikiana	4.6		1.2	-
Buellia disciformis	-	2.2	0.4	-
B. griseovirens	0.8	0.8	1.6	2.6
Caloplaca cerina	-	3.4	-	1.6
C. flavorubescens	-	3.8	-	-
C. haematites	-	2.2	-	-
C. herbidella	0.2	-	2.4	0.4
Candelaria concolor	-	1.4	-	0.4
Candelariella vitellina	-	3.2	-	-
C. xanthostigma	-	8.2	1.0	9.2
Evernia prunastri	11.6	0.8	6.2	-
Huneckia pollinii	-	-	-	0.6
Hypogymnia physodes	3.6	-	0.8	-
H. tubulosa	13.6	7.4	12.4	5.8
Lecania cyrtella	-	0.6	-	-
L. fuscella	-	-	-	1.0
Lecanora allophana	-	0.4	-	-
L. carpinea	0.2	16.4	-	-
L. chlarotera	-	7.2	-	-
L. cinereofusca	1.4	8.0	2.2	16.4
L. circumborealis	-	-	0.6	0.8
L. glabrata	-	-	0.8	-
L. hagenii	-	3.6	-	-
L. intumescens	12.4	-	11.6	-
L. saligna	-	-	0.2	0.4
L. subcarpinea	3.4	-	10.2	12.6
L. varia	-	-	1.6	-
Lecidella elaeochroma	5.4	13.6	7.8	16.0
Lepra albescens	0.6	-	0.8	-
Lepraria jackii	1.8	-	-	-
Melanelixia glabra	-	-	-	0.2
M. glabratula	2.2	0.6	1.2	-
M. subaurifera	2.2	-	1.6	-
Melanohalea elegantula	-	0.8	-	-
M. exasperatula	-	3.8	0.6	0.8
M. laciniatula	-	9.0	0.4	16
Micarea prasina	-	-	1.6	-
Nephromopsis chlorophylla	1.8	-	0.2	-
Parmelia sulcata	12.6	2.8	10.8	2.0
Parmelina tiliacea	0.6	-	-	-
Pertusaria coccodes	-	-	0.4	-
P. flavida	-	-	0.2	-
Phaeophyscia orbicularis	-	0.8	-	-

Phlyctis argena	17.0	0.2	10.8	6.6
Physcia adscendens	-	1.0	-	-
P. aipolia	-	-	-	0.2
P. leptalea	-	4.6	0.2	0.4
P. tenella	-	1.6	-	-
Physconia distorta	0.6	2.4	-	2.4
P. enteroxantha	-	2.2	-	0.2
P. perisidiosa	-	1.8	-	1.0
Pleurosticta acetabulum	1.4	2.0	-	2.2
Pseudevernia furfuracea	12.0	7.6	16.8	6.0
Ramalina canariensis	-	-	0.6	-
R. farinacea	8.6	0.6	5.2	0.2
R. fastigiata	0.4	-	-	-
R. fraxinea	1.8	0.4	0.8	-
R. pollinaria	-	1.6	0.2	-
Rinodina capensis	3.4	4.4	7.0	5.6
R. sophodes	-	0.2	2.4	3.8
Scoliciosporum chlorococcum	-	8.4	-	-
S. umbrinum	-	0.4	-	-
Usnea filipendula	7.2	-	4.0	-
U. glabrescens	7.6	-	9.6	-
U. hirta	1.2	3.6	2.0	0.6
U. rigida	0.8	-	0.4	-
Varicellaria hemisphaerica	-	-	0.4	-

TABLE 2
Paired samples correlations of species diversity and environmental parameters between control and picnic areas in Kirazlıyayla and Sarıalan camping and daily picnic area.

Species diversity and environmental parameters	Kirazlıyayla	Sarıalan
Shannon diversity	0.274	-0.827**
Lichen diversity value (Ldv)	-0.389	-0.771**
Bark surface moisture	-0.312	-0.644*
Relative humidity	-0.655*	-0.937***
Light	0.251	0.752*

* P<0.05 ** P<0.01 *** P<0.001

rigida have a high correlation for control area of Kirazlıyayla, while *Hypogymnia physodes, H. tubulosa* and *Pseudevernia furfuracea* for control area of Sarıalan. *Candelariella xanthostigma* and *Melanohalea laciniatula* have a high correlation for the picnic area in both Kirazlıyayla and Sarıalan. *Caloplaca cerina, C. flavorubescens, Lecanora carpinea* and *Scoliciosporum chlorococcum* are the only indicator species of Kirazlıyayla picnic area, whereas *Lecanora cinereofusca* and *Lecidella elaeochroma* are indicators of Sarıalan picnic area (Table 3).

DISCUSSION

Uludağ National Park is highly preferred by visitors for camping, hiking and daily picnic activities during the summer season and it is also well known for its winter tourism. Kirazlıyayla and Sarıalan which were selected as the study areas are mostly preferred plateaus by visitors for daily picnic activities. The most common species of the control area in both Kirazlıyayla and Sarıalan are *Bryoria capillaris, B. fuscescens, Evernia prunastri, Hypogymnia tubulosa, Parmelia sulcata, Phlyctis argena, Pseudevernia furfuracea, Ramalina farinacea, Usnea filipendula* and *U. glabrescens*. These species were previously detected as common in the interior of *Abies* forests in Uludag National Park [16].

The epiphytic lichen vegetation in the Uludag national park was markedly different between the control and picnic areas. Possible reasons for this difference include the presence of roads, hiking trails and camping sites in picnic areas and intense use of these areas by the public. Epiphytic lichen diversity decreases as a result of intensive use of picnic areas by people. Similarly, habitat management was found to negatively influence species richness and alter the lichen community composition. Management-induced disturbance significantly decreased lichen species richness in forest landscapes with long stand continuity [5].

It has been shown that the anthropo-zoogenic effect on the epiphytic lichen vegetation varies between individual forest stands and is related to the density of nomadic households that make summer camps around the forest [2]. Due to the burning of

charcoal and the exhaust gases from the vehicles are partially pollute the air in the picnic areas. It has been determined that the spatial distribution and abundance of lichens are inversely proportional to the concentration of CO in the air [17].

The total species richness decreases with the intensity of forest management and abandoned habitats harbor more species than the more densely managed habitats. Especially, nitrophytic species clearly associated with more intensive management regimes [1]. Therefore, it is not surprising that some nitrophytic species [18] such as *Caloplaca cerina, C. flavorubescens, C. haematites, Candelaria concolor, Candelariella vitellina, C. xanthostigma, Phaeophyscia orbicularis, Physcia adscendens, P. aipolia, P. tenella, Physconia enteroxantha, P. perisidiosa* and *Scoliciosporum chlorococcum* were found only in picnic areas in this study. Whereas, Parmeliaceae (*Bryoria, Hypogymnia, Parmelia, Pseudevernia, Usnea*) species which are abundant in the forest interior, were found with high frequency in both Kirazlıyayla and Sarıalan control areas. It has been determined that there was a significant decrease in vegetation diversity especially lichen diversity in regions close to walking paths [19].

Significant differences occur in microclimate of picnic areas compared to control areas. Relative humidity and bark surface moisture decreases due to the increase in the amount of light in picnic areas. In particular, relative humidity in Sarıalan significantly affects the epiphytic lichen diversity and causes a significant decrease in picnic areas (Table 4). *Bryoria capillaris, B. fuscescens, Evernia prunastri, Hypogymnia physodes, H. tubulosa, Lecanora intumescens, Nephromopsis chlorophylla, Parmelia sulcata, Phlyctis argena, Pseudevernia furfuracea, Ramalina farinacea, Usnea filipendula* and U. glabrescens were positively correlated with relative humidity, while *Candelariella xanthostigma, Lecanora cinereofusca, Lecidella elaeochroma, Melanohalea laciniatula* and *Physcia leptalea* were

TABLE 3
Indicator species for control and picnic areas in Kirazlıyayla and Sarıalan camping and daily picnic areas (N=10).

Kirazlıyayla		Sarıalan	
Control area	**Cor.**	**Control area**	**Cor.**
Biatora globulosa	-0.825**	*Bryoria capillaris*	-0.977***
Bryoria capillaris	-0.984***	*B. fuscescens*	-0.815**
B. fuscescen	-0.924***	*Caloplaca herbidella*	-0.720*
Evernia prunastri	-0.963***	*Evernia prunastri*	-0.827**
Lecanora intumescens	-0.853**	*Hypogymnia physodes*	-0.768**
L. subcarpinea	-0.820**	*H. tubulosa*	-0.894***
Nephromopsis chlorophylla	-0.670*	*Lecanora intumescens*	-0.892**
Parmelia sulcata	-0.851**	*Parmelia sulcata*	-0.783**
Phlyctis argena	-0.977***	*Pseudevernia furfuracea*	-0.849**
Ramalina farinacea	-0.759*	*Ramalina farinacea*	-0.840**
R. fraxine	-0.893**	*Usnea filipendula*	-0.771**
Usnea filipendula	-0.638*	*U. glabrescens*	-0.951***
U. glabrescens	-0.817**		
U. rigida	-0.633*		
Picnic area	**Cor.**	**Picnic area**	**Cor.**
Caloplaca cerina	0.773**	*Candelariella xanthostigma*	0.828**
C. flavorubescens	0.785**	*Lecanora cinereofusca*	0.946***
C. haematites	0.706*	*Lecidella elaeochroma*	0.914***
Candelariella xanthostigma	0.910***	*Melanohalea laciniatula*	0.990***
Lecanora carpinea	0.966***		
L. chlarotera	0.748*		
L. cinereofusca	0.692*		
Lecidella elaeochroma	0.725*		
Melanohalea exasperatula	0.756*		
M. laciniatula	0.862**		
Physcia leptalea	0.667*		
Physconia enteroxantha	0.718*		
Ramalina pollinaria	0.661*		
Scoliciosporum chlorococcum	0.862**		

Cor.: Correlation * P<0.05 ** P<0.01 *** P<0.001

TABLE 4
Pearson correlation coefficients of epiphytic lichen species associated with environmental parameters (bark surface moisture, relative humidity, light) in Kirazlıyayla or Sarıalan control and picnic areas.

	Kirazlıyayla			Sarıalan		
	BSM	**RH**	**Light**	**BSM**	**RH**	**Light**
Control X Picnic areas	-0.312	-0.655*	0.251	-0.644*	-0.937**	0.752*
Relative humidity	0.438	1	-0.601	0.703*	1	-0.922**
Light	-0.216	-0.601	1	-0.747*	-0.922**	1
Shannon diversity	-0.009	0.363	-0.313	0.579	0.738*	-0.597
Ldv	0.244	0.594	-0.381	0.642*	0.793**	-0.776**
Bryoria capillaris	0.195	0.641*	-0.214	0.685*	0.923**	-0.749*
B. fuscescens	0.314	0.735*	-0.411	0.595	0.809**	-0.614
Caloplaca haematites	0.029	-0.650*	0.316	0.507	0.782**	-0.742*
Candelariella xanthostigma	-0.177	-0.633*	0.085	-0.434	-0.733*	0.545
Evernia prunastri	0.246	0.675*	-0.313	0.414	0.760*	-0.641*
Hypogymnia physodes	-	-	-	0.613	0.726*	-0.560
H. tubulosa	-	-	-	0.386	0.814**	-0.628
Lecanora cinereofusca	-	-	-	-0.507	-0.808**	0.572
Lecanora intumescens	-	-	-	0.638*	0.815**	-0.686*
Lecidella elaeochroma	-0.334	-0.642*	0.661*	-0.500	-0.780**	0.537
Melanohalea laciniatula	-	-	-	-0.553	-0.904**	0.680*
Nephromopsis chlorophylla	0.472	0.667*	-0.324	-	-	-
Parmelia sulcata	0.682*	0.714*	-0.283	0.559	0.806**	-0.660*
Phlyctis argena	0.309	0.637*	-0.183	-	-	-
Physcia leptalea	-0.358	-0.658*	-0.003	-	-	-
Pseudevernia furfuracea	-	-	-	0.324	0.821**	-0.638*
Ramalina farinacea	0.316	0.768**	-0.628	0.455	0.762*	-0.625
Usnea filipendula	-	-	-	0.569	0.765**	-0.594
U. glabrescens	-	-	-	0.576	0.888**	-0.727*

Correlation with significance at the 0.05 (*) and 0.01 (**) level (2-tailed).
BSM: Bark surface moisture, RH: Relative humidity

negatively correlated. *Bryoria capillaris, Caloplaca haematites, Lecanora intumescens, Parmelia sulcata, Pseudevernia furfuracea* and *Usnea glabrescens* were negatively correlated with light, whereas *Melanohalea laciniatula* was positively correlated.

The availability of light is an important factor controlling the within stand variation of epiphytic lichens. Generally, the epiphytic lichen diversity tend to rise with increasing moisture [9]. It was also determined that the air humidity is lower and the amount of light is higher at the edge of the path than the inner regions. The paths in the forests disrupt the microclimate of the forest, and the richness of epiphytic species and the number of drooping growth forms at the edge of the path decreases compared to the inner regions [4]. In this study, fruticose lichens such as *Bryoria capillaris, B. fuscescens, Evernia prunastri, Pseudevernia furfuracea, Ramalina farinacea, Usnea filipendula* and *U. glabrescens* were found with high frequency values in the control areas. It has been determined that the epiphytic lichen diversity on *Quercus petrea* in Uludag Mountain decreased when the amount of relative humidity and light in the environment and bark surface moisture decreased [10].

CONCLUSION

Strong degradation of the picnic area in the Uludag National Park is the probable cause of the reduced epiphytic lichen diversity compared with the control area. The decrease in species richness of the picnic area is probably due to different land use regimes and related differences in microclimate, not to differences in macroclimate. The determine the factors that limititing distribution of species to preserve biodiversity will be very important in developing appropriate methods for the forest management. A better understanding by the forest managers regarding environmental variables that affect the lichen diversity will contribute to the development of sustainable forest management strategies.

ACKNOWLEDGEMENTS

This work was supported by the Unit of Scientific Research Projects of Bursa Uludağ University (Project No: KUAP (F) 2018/4).

REFERENCES

[1] Aragon, G., Lopez, R. and Martinez, I. (2010) Effects of Mediterranean dehesa management on epiphytic lichens. Science of the Total Environment. 409, 116-122.

[2] Hauck, M., Javkhlan, S., Lkhagvadorj, D., Bayartogtokh, B., Dulamsuren, C. and Leuschner, C. (2012) Edge and land-use effects on epiphytic lichen diversity in the forest-steppe ecotone of the Mongolian Altai. Flora. 207, 450-458.

[3] Hauck, M. (2014) Edge effects on epiphytic lichen diversity in the forest-steppe of the Kazakh Altai. Plant Ecology & Diversity. 7(4), 473-483.

[4] Yan, X., Bao, W. and Pang, X. (2014) Indirect effects of hiking trails on the community structure and diversity of trunk-epiphytic bryophytes in an old-growth fir forest. Journal of Bryology. 36(1), 44-55.

[5] Ardelean, I.V., Keller, C. and Scheidegger, C. (2015) Effects of Management on Lichen Species Richness, Ecological Traits and Community Structure in the Rodnei Mountains National Park (Romania). PLoS One. 10(12), e0145808.

[6] Wolseley, P., Sanderson, N., Thus, H., Carpenter, D. and Eggleton, P. (2017) Patterns and drivers of lichen species composition in a NW-European lowland deciduous woodland complex. Biodivers. Conserv. 26, 401-419.

[7] Kubiak, D., Osyczka, P. and Rola, K. (2016) Spontaneous restoration of epiphytic lichen biota in managed forests planted on habitats typical for temperate deciduous forest. Biodivers. Conserv. 25, 1937-1954.

[8] Pinho, P., Bergamini, A., Carvalho, P., Branquinho, C., Stofer, S., Scheidegger, C. and Máguas, C. (2012) Lichen functional groups as ecological indicators of the effects of land-use in Mediterranean ecosystems. Ecological Indicators. 15, 36-42.

[9] Hauck, M. (2011) Site factors controlling epiphytic lichen abundance in northern coniferous forests. Flora 206, 81-90.

[10] Öztürk, Ş., Güvenç, Ş. and Oran, S. (2019) The determination of the changes in epiphytic lichen diversity at microclimatic conditions the Quercus petraea (Mattuschka) Liebl. Forest in the Uludağ Mountains (Bursa, Turkey). Nova Hedwigia. 109(3-4), 475-487.

[11] Öztürk, M.Z. (2010) Comparative climate of Uludağ (Zirve) and Bursa Meteorology Stations. Türk Coğrafya Dergisi. 55, 13-24 (in Turkish).

[12] Tolunay, D. (1992) The relationships between climate characteristics of Uludag and air pollution, and studies on the effects of this pollution on forest society. İ.Ü. Orman Fakültesi Dergisi (Seri B) 42(3-4), 119-130. (in Turkish)

[13] Doğaner, S. (1991) A geographical approach to Mountain Tourism: Tourism in Uludağ. Coğrafya Araştırması. 3, 137-157.

[14] Asta, J., Erhardt, W., Ferretti, M., Fornasier, F., Kirschbaum, U., Nimis, P.L., Purvis, O.W., Pirintsos, S., Scheidegger, C., van Haluwyn, C. and Wirth, V. (2002) Mapping lichen diversity as an indicator of environmental quality. In: Nimis, P.L., Scheidegger, C. and Wolseley, P.A. (eds.) Monitoring with Lichens-Monitoring Lichens. Nato Science Program - IV Vol. 7, Kluwer Academic Publisher, The Netherlands. 273-279.

[15] Ter Braak, C.J.F. and Smilauer, P. (2002). CANOCO Reference Manual and Cano Draw for Windows User's Guide: Software for Canonical Community Ordination (Version 4.5). Microcomputer Power, Ithaca, New York.

[16] Öztürk, Ş. and Güvenç, Ş. (2010) The distribution of epiphytic lichens on Uludag fir (Abies nordmanniana (Steven) Spach subsp. bornmuelleriana (Mattf.) Coode & Cullen) forests along an altitudinal gradient (Mt. Uludag, Bursa, Turkey). Ekoloji. 74, 131-138.

[17] Coghill, T.G., Kostadinovic, L., Micic, R., Nuhanovic, M., Avdic, P., Jahic, M. and Stojnic, M. (2015) Lichens as specific and cost-effective biological indicators of Urban Carbon Monoxide concentration. Fresen. Environ. Bull. 24(12), 4279-4284.

[18] Wolseley, P.A., James, P.W., Theobald, M.R. and Sutton, M.A. (2006) Detecting changes in epiphytic lichen communities at sites affected by atmospheric ammonia from agricultural sources. The Lichenologist. 38(2), 161-176.

[19] Jägerbrand, A.K. and Alatalo, J.M. (2015) Effects of human trampling on abundance and diversity of vascular plants, bryophytes and lichens in alpine heath vegetation, Northern Sweden. SpringerPlus. 4, 95.

Received: **02.02.2021**
Accepted: **01.05.2021**

CORRESPONDING AUTHOR

Saban Guvenc
Department of Biology,
Faculty of Arts and Sciences,
Bursa Uludag University,
16059 Gorukle Bursa – Turkey

e-mail: saban@uludag.edu.tr