Pak. J. Bot., 42(4): 2661-2670, 2010.

ANALYSIS OF THE DISTRIBUTION OF EPIPHYTIC LICHENS IN THE ORIENTAL BEECH (*FAGUS ORIENTALIS* LIPSKY) FORESTS ALONG AN ALTITUDINAL GRADIENT IN ULUDAG MOUNTAIN, BURSA – TURKEY

SULE OZTURK*, SEYHAN ORAN, SABAN GUVENC AND NURHAYAT DALKIRAN

Department of Biology, Faculty of Arts and Sciences, Uludag University,16059 Görükle – Bursa / Turkey

Abstract

A study of the diversity and distribution of epiphytic lichens were compared along an altitudinal gradient (900–1400 m) in the Fagetum zone of Uludag Mountain. Twenty four species of epiphytic lichens were analyzed. The most frequent species were *Lecanora argentata, Lecanora carpinea, Lecanora chlarotera, Lecanora intumescens, Lecidella elaeochroma, Melanelixia subaurifera, Parmelia sulcata* and *Scoliciosporum umbrinum.* The distribution of epiphytic lichens was significantly related to altitude. The species composition of epiphytic lichens at high altitudes was distinctly different than that of at low altitudes. The effect on the distribution of epiphytic lichens of altitude was statistically significant.

Introduction

Lichens are an important part of the ecosystem providing substrate or later successional species, microhabitats and food for herbivores. More importantly for recovering ecosystems, many lichen species have cyanobacterial photobionts or cyanobacteria closely associated with them and are therefore important in nitrogen cycling (Romagni & Gries, 2000).

Lichens are widespread in many forest ecosystems where they may constitute an important component of the total biodiversity (Dettki & Esseen, 2003). Epiphytic lichens have several important functional roles in forest ecosystems. They increase structural complexity, modify canopy water regimes, influence nutrient cycling and provide habitat, food and nest material for many animals (Galloway, 1992; Rhoades, 1995). Environmental conditions such as climate, substrate, light and moisture play important roles in the distribution of lichen (Kershaw, 1985). Lichen species with similar distribution models tend to have similar ecological requirements. Boundreault *et al.*, (2008) found that the dominance of bryophytes at trunk base and the dominance of lichens at breast height are related to different humidity levels along a tree. So bark structure influences epiphyte colonization and growth.

The bioindicator features of lichens are suitable for determining special ecological conditions such as substrate and air pollution. In recent years, studies done on these issues have indicated that community structure and diversity of epiphytic lichens vary due to the differences in the environmental conditions and the preferences to substrate of lichens (Pirintsos *et al*., 1993; Burgaz *et al*., 1994; Pirintsos *et al*., 1995; Loppi *et al.,* 1997). However, the lichen biodiversity growing on beeches from Turkey is poorly known (Yıldız & John, 2002; Yıldız *et al*., 2002).

*Corresponding author E-mail: ozturks@uludag.edu.tr, Fax: +90 224 294 18 99

Uludag is one of the important National Parks in Turkey. Uludag is an important winter tourism destination and heavy visitation and increasing construction demands pose significant conservation problems. So, Uludag is under legal protection. Some studies exist on the lichen biodiversity of Uludag and the surrounding Bursa province (Steiner, 1916; Szatala, 1940; Versegy, 1982; Öztürk, 1990, 1992; Yazıcı, 1999; Güvenç & Öztürk, 2004; Oran & Öztürk, 2006; Yazıcı & Aslan, 2006). The effect on the distribution of epiphytic lichens of sulphur dioxide (SO_2) pollution in the city of Bursa was investigated by Oztürk *et al*., (1997). However, there was no study the species composition and community structure of epiphytic lichen in Uludag Mountain.

The aim of the present study was to analyze the diversity and distribution of epiphytic lichens grown on *Fagus orientalis* forests along an altitudinal gradient in Uludag Mountain in Bursa, Turkey.

Materials and Methods

Study area: Uludag, formerly known as Olympos Mysios, Bithynian Olympos or Kesis Dagı, is the highest mountain of the Marmara region. Its highest point is 2543 m. It is located to the South of Bursa at latitude 40°N, longitude 29°E. This mountain is bordered by Nilüfer stream to the west and south and by Bursa city and Inegöl to the north and east.

The climate of Uludag changes from lower to higher altitudes. Uludag is influenced by a Mediterranean climate. A moist microthermic climate replaces the Mediterranean climate at higher altitudes. The summit of the mountain is affected by a Mediterranean climate type and remain frozen in winter. The mean annual temperature is $4.6^{o}C$. The mean annual rainfall is 1484 mm between 2000 and 2500 m, with the maximum rainfall in December and the minimum in August. Uludag, in the north, has a humid climate and hosts many formations belonging to the Black Sea region (Akman, 1990).

Vegetation of Uludag shows variation depending on altitude and climate types. Mediterranean vegetation such as maquis and frigana is present up to 350 m on Uludag Mountain. This vegetation is composed of *Cistus* sp., *Coryllus avellana, Erica arborea, Laurus nobilis, Juniperus oxycedrus, Olea europea, Pinus brutia. Arbutus unedo, Carpinus betulus, Cercis siliquastrum, Cornus mas, Crataegus monogyna, Daphne pontica, Fagus orientalis, Phillyrea latifolia, Pinus nigra* subsp. *nigra* var. *caramanica, Populus tremula* and *Ulmus minor* where *Castanea sativa* is absent and these are present from 350 m to 700 m (Çetin, 1999). At altitudes of 700–1500 m, although *Fagus orientalis* is dominant, *Castanea sativa, Cornus mas, Crataegus monogyna, Quercus petraea, Pinus nigra* subsp. *nigra* var. *caramanica* are locally found in this zone. *Abies bornmuelleriana* is dominant between 1500–2100 m. This zone consists of *Carpinus betulus, Daphnea pontica, Fagus orientalis, Juniperus communis* subsp. *nana, Pinus nigra* subsp. *nigra* var. *caramanica, Salix caprea,* and *Vaccinium myrtillus*.

The South side of Uludag mountain is covered with rainless forests. The biodiversity of Uludag is very rich. Uludag harbours 30 endemic taxa for Uludag and 107 endemic taxa for Turkey (Kaynak *et al*., 2005). The reason for this rich biodiversity is that Uludag lies between the Mediterranean and Euro–Siberian floristic regions. The flora of Uludag consists of 63% Euro–Siberian elements, 31% Mediterranean elements and 6% Irano–Turanian elements.

Sample collection: The study was carried out on the oriental beech in 6 sites at alteration from 900 m to 1400 m in the Fagetum Zone of Uludag Mountain. The study sites were located at altitudes of 900 m (40°08′16″ N-29°01′29″ E), 1000 m (40°07′54″ N-29°02′15″ E), 1100 m (40°07′26″ N-29°02′27″ E), 1200 m (40°07′03″ N-29°02′55″ E), 1300 m (40°06′50″ N-29°04′26″ E), and 1400 m (40°06′44″ N-29°04′36″ E). The lichen samples were taken from 10 trees which exist close to each other in each site. Lichens were sampled using 20 x 40 cm quadrat divided into 8 subunits of 10 x 10 cm placed at breast height on the north side of tree trunks. In total, the lichen samples were collected from 480 sample units. During the sample collection process, the height and circumference of each tree were recorded for each of the sampling localities.

Lichen samples were quantitatively analyzed for cover and frequency. In data analysis, the importance value is used. The importance value used here is the sum of relative frequency and relative cover. Relative frequency (RF) and relative cover (RC) were determined following Printsos *et al*., (1993, 1995). In brief, RF = 100 x (frequency of species *i* /sum of frequency values of all species), and RC = 100 x (cover of species i / sum of cover values of all species).

Statistical analysis: We studied the relationships between the distribution of the epiphytic lichen and altitude. Total 38 species were recorded on the sample trees, but 24 species with occurrence on more than one site were evaluated in statistical analysis (Table 1). The data matrix of 24 species x 60 samples was investigated to detect the distribution and community structure of epiphytic lichen along the altitudinal gradient by Detrended Correspondence Analysis (DCA) using the CANOCO for Windows 4.5 (Ter Braak & Smilauer, 2002) and using multivariate classification techniques (Two Way Indicator Species Analysis= TWINSPAN) (Hill, 1979; Hugh & Gauch, 1982).

The significant differences between the importance values of species with altitude were determined by one-way ANOVA with Bonferroni correction. Pearson's correlation coefficient were performed to compare environmental variables (altitude and circumferences of the trunks of trees) and response variables (DCA axis scores, Shannon's diversity based on species density in each of the sampling tree and richness (number of lichen species in each of the sampling tree) (Table 2). All statistical analyses were performed using SPSS for Windows (Version 11.5) and assessed at the 95% confidence level.

Results

In this study, 24 epiphytic lichen species were analyzed on the 60 sampling trees at six altitudes (Table 1). The most common species were *Lecanora argentata, L. carpinea, L. chlarotera, L. intumescens, Lecidella elaeochroma, Melanelixia subaurifera, Parmelia sulcata,* and *Scoliciosporum umbrinum*. *Lecanora carpinea* and *Parmelia sulcata* have a high importance value at all of the sampling sites. Although *Lecanora argentata* and *L. intumescens* were found with low importance values at all of the sampling sites, these species were not statistically significant (Table 1). *Amandinea punctata,, Lecania cyrtellina, Lecanora glabrata, L. sambuci, L. umbrina, Lepraria incana, Pleurosticta acetabulum, Rinodina pyrina* and *Scoliciosporum chlorococcum* were shown to distribution up to 1200 m. On the contrary, *Hypogymnia tubulosa, Platismatia glauca, Pseudevernia furfuracea* and *Rinodina exigua* were shown to distribution above 1200 m. The distribution depend on altitude of some species such as *Amandinea punctata, Lecania cyrtellina, Lecanora sambuci, Platismatia glauca, Pleurosticta acetabulum, Pseudevernia furfuracea* and *Rinodina pyrina* were not statistically significant (Table 1).

Table 1. Mean values ±SE, F and P-value (one-way ANOVA with Bonferroni Corr.) of the importance values of the species along the altitudinal gradient in Uludag mountain. Mean differance is significant at $p<0.05$. Results of Bonferroni Corr. are in italic (df = 5, n = 10).

Altitude (m)	**900**	**1000**	**1100**	**1200**	**1300**	**1400**		
Mean height of tree (m)	**12.00 ± 0.94**	**11.10 ± 0.99**	**7.70 ± 1.06**	**6.80 ± 0.42**	**10.90 ± 1.10**	**13.10 ± 1.73**	**One-way ANOVA**	
Mean circumference of tree trunks (cm)	**87.60 ± 6.02**	**108.30 ± 21.50**	**75.60 ± 6.31**	**61.10 ± 4.77**	**73.60 ± 10.00**	**92.10 ± 6.37**		
Name of species	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**F**	**Sig.**
Amandinea punctata	0.39 ± 0.39	0.44 ± 0.44					0.80	0.554
Buellia disciformis	1.83 ± 1.22			2.76 ± 2.36		0.47 ± 0.32	1.16	0.341
Buellia griseovirens	2.24 ± 0.96				6.15 ± 2.31	1.78 ± 0.79	5.01	0.001**
Evernia prunastri	1.01 ± 0.68	0.98 ± 0.69	0.48±0.48			11.06 ± 2.55	14.77	0.000***
Hypogymnia tubulosa					6.26 ± 4.30	28.14 ± 4.85	18.11	0.000***
Lecania cyrtellina	6.72 ± 3.92	1.80 ± 1.80	2.61±2.20				1.77	0.136
Lecanora argentata	0.27 ± 0.27	3.66 ± 2.01	0.52±0.52	0.38 ± 0.38	0.68 ± 0.68	0.37 ± 0.37	2.04	0.087
Lecanora carpinea	79.67 ± 3.89	78.67 ± 6.56	67.56±5.59	89.95 ± 8.51	18.84 ± 4.26	17.77 ± 2.63	33.11	0.000***
Lecanora chlarotera	2.21 ± 1.23	4.99 ± 1.71	1.89±1.55	5.95 ± 1.93	2.54 ± 1.70	24.45 ± 3.58	17.29	0.000***
Lecanora glabrata		1.44 ± 0.77	4.95±1.75	2.43 ± 2.43			2.44	0.046*
Lecanora intumescens	4.12 ± 2.12	3.44 ± 2.03	1.58±1.22	12.54 ± 4.07	4.82 ± 2.62	7.56 ± 2.31	2.33	0.055
Lecanora sambuci	0.54±0.54	1.12 ± 0.58	0.39±0.39	0.46 ± 0.46			1.05	0.401
Lecanora umbrina		2.19 ± 1.12	4.35±2.27	4.22 ± 2.10			2.46	0.044*
Lecidella elaeochroma	5.05 ± 2.32	31.04 ± 4.16	21.38±4.48	40.10 ± 4.62	8.97 ± 3.30	12.23 ± 2.11	14.09	0.000***
Lepraria incana	0.39 ± 0.39	3.50 ± 1.63					4.22	0.003**
Melanelixia subaurifera	1.77 ± 1.19	14.49 ± 4.81	24.48±3.62	0.79 ± 0.53	35.81 ± 6.82	23.42 ± 4.31	11.08	0.000***
Parmelia sulcata	28.54 ± 6.53	13.69 ± 4.41	28.28±8.26	5.68 ± 2.67	99.40 ± 12.77	58.96 ± 7.54	20.21	0.000***
Platismatia glauca					1.04 ± 1.04	0.27 ± 0.27	0.90	0.486
Pleurosticta acetabulum	0.75 ± 0.75		1.16±1.16				0.82	0.543
Pseudevernia furfuracea					1.43 ± 1.43	0.76 ± 0.76	0.84	0.531
Rinodina exigua					0.37 ± 0.37	2.64 ± 0.86	7.66	0.000***
Rinodina pyrina			2.83 ± 1.61	3.45 ± 2.05			2.35	0.053
Scoliciosporum chlorococcum	18.45 ± 4.23	0.49 ± 0.49	0.76 ± 0.76				17.77	0.000***
Scoliciosporum umbrinum	44.19 ± 7.90	37.84 ± 5.07	34.63 ± 3.46	23.32 ± 5.25	1.37 ± 0.95	0.66 ± 0.45	16.48	0.000***

Significance for the altitude is given as follows: * $p<0.05$, ** $p<0.01$, ***$p<0.001$.

Table 2. Pearson's Correlation coefficients between DCA axes and selected variables.

	AX1	AX2	ALT	CIR	DIV	RIC	GR	CRU	FOL	FRU
AX2	-0.035									
ALT	0.785(**)	0.327(*)								
CIR	0.033	0.005	-0.257(*)							
DIV	0.101	0.430(**)	0.062	0.279(*)						
RIC	0.193	0.415(**)	0.130	0.304(*)	0.956(**)					
GR	0.848(**)	0.299(*)	0.932(**)	0.040	0.189	0.269(*)				
CRU	-0.377(**)	0.448(**)	-0.218	0.166	0.636(**)	0.595(**)	-0.193			
FOL	0.702(**)	0.015	0.478(**)	0.205	0.542(**)	0.580(**)	0.619(**)	-0.125		
FRU	0.502(**)	0.188	0.367(**)	0.275(*)	0.298(*)	0.375(**)	0.505(**)	-0.180	0.471(**)	
LEP	-0.172	0.076	-0.201	0.481(**)	-0.018	-0.024	-0.081	-0.034	-0.094	0.032

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

ALT= altitude; **CIR**= circumferences of the trunks of the sampling trees; **GR**= the groups result from twinspan analysis; **DIV**= Shannon's diversity based on species density in each of the sampling tree; **RIC**=number of species of lichens in each of the sampling tree; **CRU**; number of crustose lichen species; **FOL**; number of foliose lichen species; **FRU**; number of fruticose lichen species; **LEP**; number of leprose lichen species.

Arthonia arthonioides, A. punctiformis, Bacidia globulosa, Buellia erubescens, Caloplaca holocarpa, Hypogymnia physodes, Lecanora hagenii, Melanelixia glabratula, Melanohalea exasperatula, Ochrolechia arborea, Parmelina quercina, P. tiliacea, Phlyctis argena and *Ramalina farinacea* were occurred only in one sampling site. These species were not evaluated in statistical analysis.

The DCA ordination of lichen samples and species are shown in Figs. 1 and 2, respectively. The eigenvalues of the first two axes for DCA analysis are 0.48 (axis 1) and 0.17 (axis2), explaining together 26.9% of variance that methods based on unimodal responses were appropriate (Ter Braak & Smilauer, 2002).

DCA ordination showed four groups that the lichen vegetation of low altitudes was clearly different than that of high altitudes (Fig. 1). The lichen vegetation of low altitudes which is the samples from 900 m to 1200 m located on the left side of the ordination diagram. This cluster is divided into two groups. The first group consist of the samples at 900 m are located on the lower part of this cluster. The second group consists of the samples from 1000 m to 1200 m is present on upper part of first cluster. Characteristic species of low altitudes were *Lecanora carpinea, L. umbrina, Lecidella elaeochroma, Lepraria incana, Scoliciosporum chlorococcum* and *S. umbrinum.* The second cluster that the lichen vegetation of high altitudes is composed of the samples from 1300 m 1400 m and is appeared on the right side of the ordination diagram. The second cluster is divided into two groups. The samples at 1400 m are located on the upper part while the samples at 1300 m are present on the lower part of second cluster. The third group consists of the samples at 1300 m while fourth group consists of the samples at 1400 m. Characteristic species of high altitudes were *Buellia griseovirens, Evernia prunastri, Hypogymnia tubulosa, Lecanora chlarotera* (Table 1).

Grouping of samples using TWINSPAN is given in Fig. 2. The cut levels used in the TWINSPAN analysis were set at percentage of importance values 0, 3, 7, 13 and 24. The samples are divided into two clusters at the first level. The first cluster consists of the samples from 1300 and 1400 m with indicator species *Parmelia sulcata* while the second cluster consists of the samples from 900 m to 1200 m with indicator species *Lecanora carpinea* and *Lecanora umbrina*. At the second level, the first cluster is divided into two groups. The first group consists of the samples from 1400 m with indicator species *Evernia prunastri, Hypogymnia tubulosa* and *Lecanora chlarotera.* The second group consists of the samples from 1300 m with indicator species *Buellia grisovirens*. The second cluster at the first level is divided into two groups. Third group contains from 1000 m to 1200 m with indicator species *Lecanora umbrina* and *Lecidella elaeochroma* while fourth group contains from 900 m with indicator species *Lecania cyrtellina* and *Scoliciosporum chlorococcum*. As a result of TWINSPAN analysis, four groups were determined for samples. This result is similar to result of DCA analysis.

The species diversity and richness were shown positive correlation with the circumference of tree trunks. Similarly, foliose and fruticose lichens were shown positive correlation with an altitudinal gradient. Because of crustose lichens are dominant at all altitudes, the crustose lichens did not show a meaningful correlation with an altitudinal gradient (Table 2).

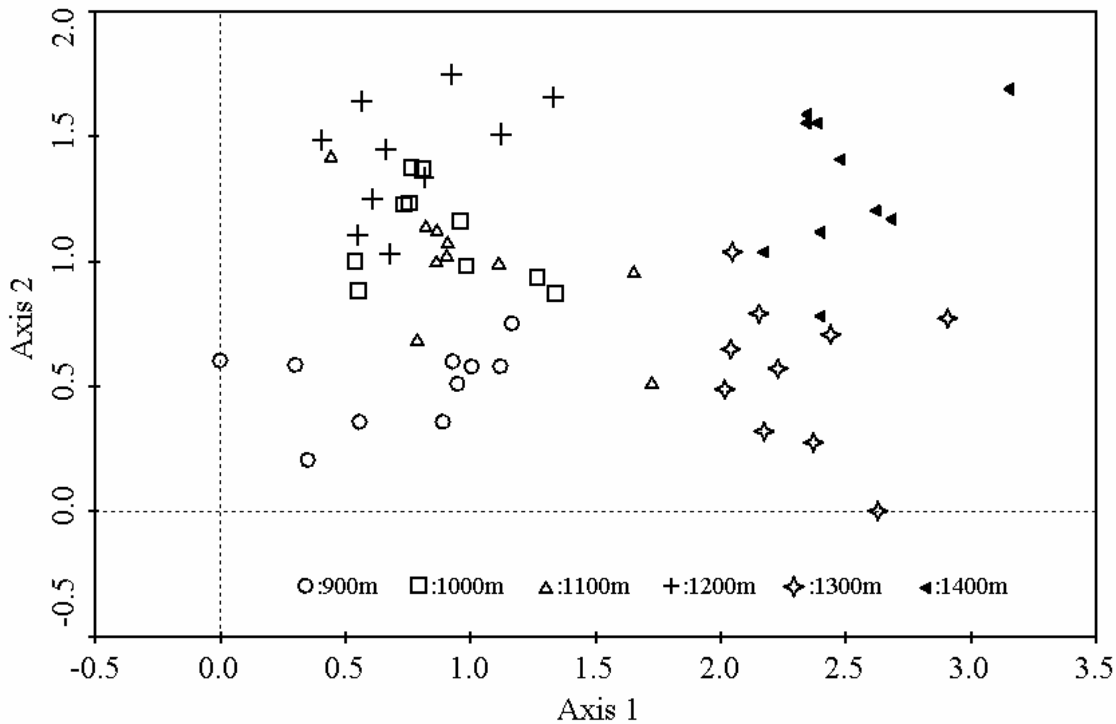

Fig. 1. DCA ordination of 60 sample trees at six different altitudes depending on the variation of importance value of lichens with at least two sites occurrences (24 species). Total inertia in species data: 1.79. Eigenvalues: 0.48 (axis 1), 0.17 (axis 2). Length of gradient: 3.16 (axis 1), 1.75 (axis 2).

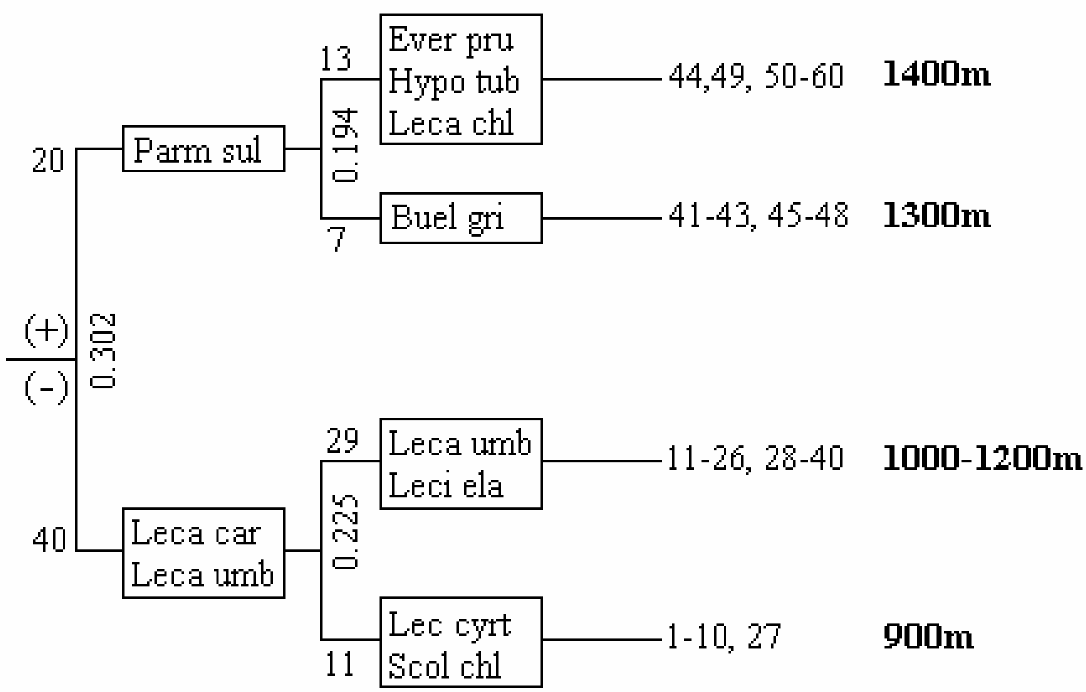

Fig. 2. Twinspan dendrogram of sixty samples in six different altitudes. Numbers of samples in each altitudes as follow:

1-10: 900 m, 11-20: 1000 m, 21-30: 1100 m, 31-40: 1200 m, 41-50: 1300 m, 51-60: 1400 m. **Buel gri:** *Buellia griseovirens,* **Ever pru:** *Evernia prunastri,* **Hypo tub:** *Hypogymnia tubulosa,* **Leca car:** *Lecanora carpinea,* **Leca chl:** *Lecanora chlarotera,* **Leca umb:** *Lecanora umbrina,* **Leci ela:** *Lecidella elaeochroma,* **Lec cyrt:** *Lecania cyrtellina,* **Parm sul:** *Parmelia sulcata,* **Scol chl:** *Scoliciosporum chlorococcum*

Discussion

In this study, 1811 lichen samples were collected from the 60 sampling trees from 6 different altitudes at Fagetum zone in Uludag Mountain. Twenty four species were analyzed to determine the distribution and community structure of the epiphytic lichen along the altitudinal gradient at Fagetum zone. The most frequent species were *Lecanora argentata, L. carpinea, L. chlarotera, L. imtumescens, Lecidella elaeochroma, Melanelixia subaurifera, Parmelia sulcata* and *Scoliciosporum umbrinum.* Similarly, the most common species on *Fagus sylvatica* in Mt. Olympos (Greece) were *Lecanora argentata, L. carpinea, L. chlarotera* and *Lecidella elaeochroma* (Pirintsos *et al.,* 1995; 1996). In our study, *Lecanora argentata, L. intumescens* and *Parmelia sulcata* were observed in all of the sampling localities. Also, these species were found most frequently on *Fagus sylvatica* in the humid mountains of southern Italy. In addition to these species, *Phlyctis argena* and *Ramalina farinacea* were the most common species on *Fagus sylvatica* forests in Italy (Incerti & Nimis, 2006). *Phlyctis argena* and *Ramalina farinacea* were found in low frequency and low importance value only from 1300 m and 1400 m in our study, respectively.

Climatic parameters (i.e., temperature, rainfall, humidity) are known to be closely related to altitude (Loppi *et al.,* 1997). There is a positive relationship between lichen biomass and location humidity (Caldız & Brunet, 2006). So, the change in species composition of the communities along the altitudinal gradient might reflect the different ecological conditions of the region besides forest nature and the age of tree.

The features of the Mediterranean climate along the altitudinal gradient in Uludag Mountain change due to the slightly lower temperatures and more abundant precipitation than those of the actual Mediterranean climate. The research areas located between 900 and 1400 m altitudes are affected by the moist microthermic Mediterranean climate. Thus, crustose species were found almost everywhere.

Evernia prunastri, Pleurosticta acetabulum and *Parmelina quercina* are the typical species of the montane belt and wetter habitats (Nimis, 1993; Purvis *et al.*, 1994; Wirth, 1995). So, *Evernia prunastri* has a high importance value at 1400 m while it has a low importance value from 900 m to 1100 m. Similarly, *Parmelina quercina* and *Pleurosticta acetabulum* were found with low importance values at 1400 m, 900 m and 1100 m, respectively. The fruticose lichen species such as *Pseudevernia furfuracea* and *Ramalina farinacea* were observed only at high altitudes.

The results clearly demonstrate that the species richness is different at low and high altitudes. While the 9 species such as *Amandinea punctata, Lecania cyrtellina, Lecanora glabrata, L. sambuci, L. umbrina, Lepraria incana, Pleurosticta acetabulum, Rinodina pyrina, Scoliciosporum chlorococcum,* were spread from 900 m to 1200 m and only 4 species such as *Hypogymnia tubulosa, Platismatia glauca, Pseudevernia furfuracea, Rinodina exiqua* were spread to1300 m and 1400 m.

Pinokiyo *et al*., (2008) reported a greater number of foliose species in the intermediate altitudes and fruticose lichens were absent from lower altitudes in India and among growth forms, crustose lichens accounted for 56% of the lichen flora, whereas foliose lichens represented 34% and fruticose lichens 8% and there is only one squamulose species. Similarly, our study indicated that among the lichen growth forms, crustose lichens (70,9% of all lichen species) were predominantly followed by foliose (16,6%), fruticose (12,5%). Epiphytic macrolichens are known for their drought tolerance and high light requirement (Pentecost, 1998). In addition to, Leppik & Jüriado (2008) indicated that more lichens of foliose and fruticose growth forms occurred in the open habitats than in the overgrown stands. The Fagetum zone of Uludag is closed forest form especially at low altitudes. So we think that, the irradiance at Fagetum zone isn't appropriate for growing foliose and fruticose lichens which needed high light requirement.

Consequently, we have determined that the distribution and species composition of epiphytic lichens grown on *Fagus orientalis* was changed and as related to altitudes. The distribution and species composition of epiphytic lichens at high altitudes was distinctly different from that of at low altitudes.

Acknowledgements

This study is a part of Research Project (Project no: 2002 / 49) which was supported financially by Unit of Scientific research Project, Uludag University. We thank Unit of Scientific Research Project, Uludag University for financial support.

References

Akman, Y. 1990. *İklim ve Biyoiklim* (Biyoiklim Metodları ve Türkiye İklimleri). Palme Yayın Dağıtım, Ankara.

Boudreault C., D.S. Coxson, E. Vincent, Y. Bergeron and J. Marsh. 2008. Variation in epiphytic lichen and bryophyte composition and diversity along a gradient of productivity in *Populus tremuloides* stands of northeastern British Columbia, Canada. *Ecoscience,* 15: 101-112.

Burgaz, A.R., E. Fuertes and A. Escudero. 1994. Ecology of cryptogamic epiphytes and their communities in deciduous forests in mediterranean Spain. *Vegetatio*, 112: 73-86.

Caldız, M.S. and J. Brunet. 2006. Litterfall of epiphytic macrolichens in Nothofagus forests of northern Patagonia Argentina: Relation to stand age and precipitation. *Austral Ecolog,* 31: 301-309.

Cetin, B. 1999. The Moss Flora of the Uludag National Park (Bursa/Turkey). *Turk. J. of Botany,* 23: 187-193.

Dettki, H. and P.A. Esseen. 2003. Modelling long-term effects of forest management on epiphytic lichens in northern Sweden. *Forest Ecology and Management,* 175: 223-238.

Hill, M.O. 1979. *TWINSPAN; A FORTRAN Program for Arranging Multivariate Data in on Ordered Two - Way Table by Classification of the individuals and Attributes.* Cornell University, Ithaca, New York.

Hugh, G. and J.R. Gauch. 1982. *Multivariate Analysis in Community Ecology*. Cambridge University Press, London.

Galloway, D.J. 1992. Biodiversity: a lichenological perspective. *Biodiversity and Conservation,* 1: 312-323.

Guvenc, S. and S. Ozturk. 2004. Lichens records from the alpine region of Uludağ (Olympos) mountain in Bursa, Turkey. *Turk. J. of Botany,* 28: 299-306.

Incerti, G. and P.L. Nimis. 2006. Biogeographical outline of epiphytic lichens in a Mediterranean area: Calabria (S Italy). *The Lichenologist,* 38: 355-371.

Kaynak, G., R. Daskın and O. Yılmaz. 2005. *Bursa Bitkileri.* T.C. Uludağ Üniversitesi Kent Tarihi ve Araştırmaları Merkezi, Bursa.

Kershaw, K.A. 1985. *Physiological ecology of lichens.* Cambridge Univ. Press, Cambridge.

Leppik, E. and I. Jüriado. 2008. Factors important for epiphytic lichen communities in wooded meadows of Estonia. *Folia Cryptog.,* 44: 75-87.

Loppi, S., S.A. Pirintsos and V.D. Dominicis. 1997. Analysis of the distribution of epiphytic lichens on *Quercus pubescens* along an altitudinal gradient in a mediterranean area (Tuscany, Central Italy). *Israel Journal of Plant Sciences,* 45: 53-58.

Nimis, P.L. 1993. *The Lichen of Italy: An annotated catalogue.* Mus. Reg. Sci. Nat., Torino.

Oran, S. and Ozturk, S. 2006. Lichens of Gemlik, İznik, Mudanya and Orhangazi district in Bursa Province (Turkey). *Turk. J. of Botany*, 30: 231-250.

Ozturk, S. 1990. Türkiye için yeni liken kayıtları. *Turk. J. of Botany,* 14: 87-96.

Ozturk, S. 1992. Uludağ'ın kabuksu ve dalsı likenleri üzerinde bir araştırma. *Turk. J. of Botany,* 16: 405-409.

Ozturk, S., S. Guvenc and A. Aslan. 1997. Distribution of epiphytic lichens and sulphur dioxide (SO_2) pollution in the city of Bursa. *Turk. J. of Botany*, 21: 211-215.

Pentecost, A. 1998. Some observations on the biomass and distribution of cryptogamic epiphytes in the upper montane forest of the Rwenzori Mountains, Uganda. *Global Ecology and Biogeography Letters*, 7: 273-284.

Pinokiyo, A., K.P. Singh and J.S. Singh. 2008. Diversity and distribution of lichen in relation to altitude within a protected biodiversity hot spot, north-east India. *The Lichenologist,* 40: 47-62.

Pirintsos, S.A., J. Diamantopoulos and G.P. Stamou. 1993. Analysis of the vertical distribution of epiphytic lichens on *Pinus nigra* (Mount Olympos, Greece) along an altitudinal gradient. *Vegetatio*, 109: 63-70.

Pirintsos, S.A., J. Diamantopoulos and G.P. Stamou. 1995. Analysis of the distribution of epiphytic lichens within homogenous *Fagus sylvatica* stands along an altitudinal gradient (Mount Olympos, Greece). *Vegetatio*, 116: 33-40.

Pirintsos, S.A., J. Diamantopoulos and G.P. Stamou. 1996. Hierarchical analysis of the relationship between spatial distribution and abundance of epiphytic lichens (Mt. Olympos – Greece). *Vegetatio*, 122: 95-106.

Purvis, O.W., B.J. Coppins, D.L. Hawskworth, P.W. James and D.M. Moore. 1994. *The Lichen Flora of Great Britain and Ireland.* The British Lichen Society Department of Botany, The Natural History Museum, London.

Rhoades, F.M. 1995. Nonvascular epiphytes in forest canopies: worldwide distribution, abundance and ecological roles. *In: Forest Canopies.* (Eds): M.D. Lowman and N.M. Nadkarni. Academic Press, pp. 353-408.

Romagni, J.G. and C. Gries. 2000. Post – fire recolonization of dominant epiphytic lichen species on *Quercus hypoleucoides* (Fagaceae). *American Journal of Botany,* 87: 1815-1820.

Steiner, J. 1916. Aufzahlung der von J. Bornmüller im Oriente gesammelten Flechten. *Anal Naturhist Mus.,* 30: 24-39.

Szatala, O. 1940. Contribution á la connaissance de la flore lichénologique de la Péninsula des Balkans et de l'Asie Mineure. *Borbasia Dissertationes Botanicae,* II: 33-50.

Ter Braak, C.J.F. and P. Smilauer. 2002. *CANOCO reference manual and CanoDraw for Windows user's guide: Software to canonical community ordination (version 4,5).* Ithaca, New York, USA.

Versegy, K.P. 1982. Beitrage zur Kenntnis der Türkischen Flechtenflora. *Studia Botanica Hungarica,* 16: 53-65.

Yazıcı, K. 1999. Lichen species in the north of Karacabey country, Bursa province, Turkey. *Turk. J. of Botany*, 23: 271-276.

Yazıcı, K. and A. Aslan. 2006. Lichen taxonomic composition from Mustafa Kemalpaşa, Bursa district (Turkey). *Acta Bot. Croat.*, 65: 25-39.

Yıldız, A. and V. John. 2002. Additional lichen records from Kastamonu province (Turkey). *Flora Meditterranea,* 12: 315-322.

Yıldız, A., V. John and E. Yurdakulol. 2002. Lichens from the Çangal Mountain (Sinop, Turkey). *Cryptogamie Mycologie*, 23: 81-88.

Wirth, V. 1995. *Die Flechten Baden – Württembergs Teil 1, 2.* Eugen Ulmer GmbH & Co., Stuttgart.

(Received for publication 29 January 2009)