Research Article

Turk J Bot
34 (2010) 449-456
© TÜBİTAK
doi:10.3906/bot-0905-12

Comparison of the epiphytic lichen communities growing on various tree species on Mt. Uludağ (Bursa, Turkey)

Şule ÖZTÜRK*, Şaban GÜVENÇ

Department of Biology, Faculty of Arts and Sciences, Uludağ University, 16059, Görükle Nilüfer, Bursa - TURKEY

Received: 12.05.2009
Accepted: 12.07.2010

Abstract: A total of 48 epiphytic lichen species were found on the various tree species (*Abies nordmanniana* (Stev.) Spach subsp. *bornmuelleriana* (Mattf.) Coode & Cullen, *Fagus orientalis* Lipsky, and *Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe) that formed communities on the north-west, extending from 1300 to 1600 m altitudes, of Mt. Uludağ in Bursa. Twenty-five epiphytic lichen species that occur on more than 4 sample trees were statistically analysed. The most frequent species were *Pseudevernia furfuracea* L. (Zopf.), *Hypogymnia tubulosa* (Schaer.) Hav., *Parmelia sulcata* Taylor, *Lecanora chlarotera* Nyl., and *Evernia prunastri* (L.) Ach., in descending order. Indicator species for *Fagus orientalis* were *Lecanora carpinea* L. (Vain.), *Lecidella elaeochroma* (Ach.) M.Choisy, *Melanelixia subaurifera* (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch, and *Parmelia sulcata*. *Pseudevernia furfuracea* is an indicator species for 2 other trees (*Abies nordmanniana* subsp. *bornmuelleriana* and *Pinus nigra* subsp. *pallasiana*). It was found that the differences in lichen communities on various tree species are statistically significant.

Key words: Community, lichen, Turkey, Uludağ

Uludağ (Bursa-Türkiye)'da çeşitli ağaç türleri üzerinde gelişen epifitik liken kommunitelerinin karşılaştırılması

Özet: Uludağ (Bursa)'ın kuzey-batı yönünde, 1300-1600 metre yükseklikler arasında, topluluk oluşturan çeşitli ağaç türleri üzerinde (*Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis* and *Pinus nigra* (L.) subsp. *pallasiana*) toplam 48 epifitik liken türü kaydedildi. Dörtten fazla örnek ağaç üzerinde bulunan 25 epifitik liken türü istatistik olarak değerlendirilmiştir. En sık bulunan türler sırasıyla; *Pseudevernia furfuracea* (L.) Zopf., *Hypogymnia tubulosa* (Schaer.) Hav., *Parmelia sulcata* Taylor, *Lecanora chlarotera* Nyl. and *Evernia prunastri* (L.) Ach. dir. *Fagus orientalis* için indikatör türler *Lecanora carpinea (*L.) Vain., *Lecidella elaeochroma* (Ach.) M.Choisy ve *Melanelixia subaurifera* (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch ve *Parmelia sulcata*' dır. *Pseudevernia furfuracea* ise, diğer iki ağaç türü için indikator türdür. Çeşitli ağaç türlerinde gelişen liken kommunitelerindeki faklılıkların istatistik olarak önemli olduğu bulunmuştur.

Anahtar sözcükler: Kommunite, liken, Türkiye, Uludağ

* E-mail: ozturks@uludag.edu.tr

Introduction

Lichens are poikilohydric organisms very sensitive to changes in microclimate, and lichen diversity in forests is controlled by environmental conditions (Rheault et al., 2003; Giordani, 2006). Composition of epiphytic lichen species varies with temperature and moisture resulting from environmental differences and the age, height, and structure of host tree species (McCune et al., 2000; Eversman et al., 2002; Temina et al., 2009). In addition, the composition of an epiphytic lichen community is also probably controlled by the climate of the region (Müller et al., 2003). Many studies have been carried out on the diversity and community structures of epiphytic lichens in coniferous forests of the Boreal zone of Europe (Hyvarinen et al., 1999; Kivistö & Kuusinen, 2000; Liu et al., 2000; Juriado et al., 2003, Coppins & Coppins, 2006). The community structure of the epiphytic lichen vegetation on coniferous and deciduous broadleaved forests in the Mediterranean region was investigated in various studies (Pirintsos et al., 1993, 1995, 1996; Giordani, 2006; Incerti & Nimis, 2006). The aim of the present study was to investigate the epiphytic diversity of lichens growing on different tree species (*Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis*, and *Pinus nigra* subsp. *pallasiana*) on Mt. Uludağ, which has a rich flora.

Materials and methods

Study area

Uludağ is the highest mountain in the Marmara region, where Europe meets Asia around the Marmara Sea, and which includes the whole of Thrace and North-west Anatolia of Turkey. The mountain, previously known as Olympus Misius, Bithynian Olympos, and Keşiş Dağı, was renamed Uludağ in 1925. The summit of Uludağ, located to the south of the city of Bursa is at 2543 m. The mountain range is about 40 km long and 15-20 km wide. Geologically, its core largely consists of granite, gneiss, and marble of Paleozoic age, and Mesozoic ophiolite. This mountain has an interesting geomorphological structure with southern slopes of calcareous rocks and the north-western parts made up of granites (Rehder et al., 1994).

It has a Mediterranean climate with very cold winters and modified by the climatic conditions of the Black Sea region and the Inner Anatolian region. According to the data of the meteorological stations at Sarıalan (1620 m) on Uludağ, the mean annual temperature is 10 °C and mean annual rainfall is 1330 mm (Çetin, 1999).

Various vegetation types occur depending on climate type and altitude on Mt. Uludağ. As a result of the altitudinal gradient and various geological conditions, the changes from Mediterranean to Euro-Siberian and alpine in the vegetation of Uludağ can clearly be seen from the bottom to the top of the mountain. Canopy tree species in Mt. Uludağ are conifers (*Abies nordmanniana* subsp. *bornmuelleriana* at elevations of 1500-2100 m and *Pinus nigra* subsp. *pallasiana* at elevations of 1300-1400 m) and deciduous broad-leaved species (*Fagus orientalis* at elevations of 700-1500 m).

Sample collection

The study was carried out in the forest zone of *Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis*, and *Pinus nigra* subsp. *pallasiana* on the northern slopes of Mt. Uludağ. The study sites are located at altitudes of 1500-1600 m (40°06′34″N–29°05′48″E) in *Abies* forest, at altitudes of 1300-1400 m (40°06′44″N–29°04′36″E) in *Fagus* forest, and at altitudes of 1300-1400 m (40°05′41″N-29°05′26″E) in *Pinus* forest (Figure 1). Twenty sample trees were randomly selected at each study site. The mean breast-height circumference of the sampled trees is 119.55 ± 6.03 cm for *Abies*, 82.85 ± 2.80 cm for *Fagus*, and 131.85 ± 4.96 cm for *Pinus*. The mean height of the sample trees was 14.75 ± 0.48 m for *Abies*, 12.00 ± 0.40 m for *Fagus*, and 15.85 ± 0.49 m for *Pinus*.

Lichens were sampled using a 20 × 40 cm quadrat divided into 8 subunits of 10 × 10 cm and placed at breast-height on the northern side of the tree trunks. It is known that lichen diversity is rich on the northern side of tree trunks because of high humidity. In total, lichen samples were collected from 480 sample units (Pirintsos et al., 1993). Lichen samples were quantitatively analysed for cover and frequency. In data analysis, the importance value is used. The importance value used here was the sum of relative frequency and relative cover. Relative frequency (RF)

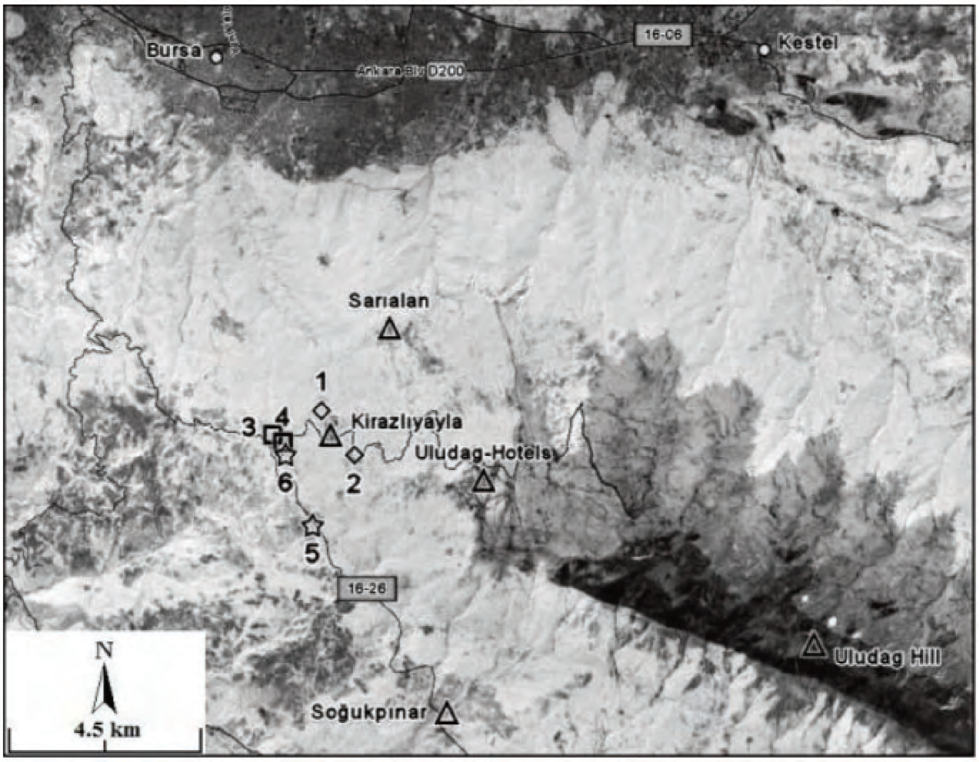

Figure 1. The study area.
◇: *Abies nordmanniana* subsp. *bornmuelleriana* (1: 1500 m, 2: 1600 m).
□: *Fagus orientalis* (3: 1300 m, 4: 1400 m).
☆: *Pinus nigra* subsp. *pallasiana* (5: 1300 m, 6: 1400 m).

= 100 × (frequency of species/sum of frequency values of all species), and relative cover (RC) = 100 × (cover of species/sum of cover values of all species) (Pirintsos et al., 1993, 1995).

Statistical analysis

Twenty-five species were recorded on the sample trees with occurrence on more than 4 sample trees (Table 1). The data matrix of 25 species × 60 samples was used for standard multivariate ordination and classification techniques (DCA and TWINSPAN). The differences in lichen communities on different tree species were detected with a Detrended Correspondence Analysis (DCA) using the CANOCO for Windows 4.5 (ter Braak & Smilauer, 2002) and using multivariate classification techniques (Twinspan = Two Way Indicator Species Analysis) (Hill, 1979; Hugh & Gauch, 1982).

Standard statistical procedures were performed using SPSS for Windows Version 11.5 (SPSS Inc., 2002) and assessed at the 95% confidence level. The significant differences between the importance values of species growing on different tree species were determined by one-way ANOVA with Bonferroni correction. Pearson's correlation coefficient was used to compare different tree species with selected variables (circumferences of the trunks, DCA axis scores, Shannon's diversity, richness, and number of lichen growth forms on each sample tree).

Results

A total of 48 epiphytic lichen species were found on *Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis* Lipsky, and *Pinus nigra* subsp. *pallasiana* on Mt. Uludağ. Twenty-five lichen species that occurred on more than 4 sample trees were statistically analysed (Table 1).

Table 1. The mean ± SE relative frequency (RF) and relative cover (RC) of 25 lichen species with occurrence on more than 4 sample trees. The significant differences in lichen communities on different tree species were determined by one-way ANOVA with Benferroni cor. (n = 20, df = 2).

Species name	Freq.(%)	*Abies nordmanniana* subsp. *bornmuelleriana*		*Pinus nigra* subsp. *pallasiana*		*Fagus orientalis*		ONE WAY ANOVA	
		RF	**RC**	**RF**	**RC**	**RF**	**RC**	**F**	**Sig.**
Bryoria capillaris	33.3	14.09 ± 1.36	14.45 ± 2.31	-	-	-	-	65.56	0.000***
Bryoria fuscescens	31.7	3.90 ± 0.89	1.52 ± 0.45	2.73 ± 1.60	2.47 ± 1.41	-	-	2.71	0.075
Buellia griseovirens	18.3	-	-	0.65 ± 0.44	0.29 ± 0.20	3.04 ± 0.99	0.93 ± 0.35	6.19	0.004**
Evernia prunastri	45.0	6.14 ± 1.58	8.17 ± 2.38	2.35 ± 0.82	0.87 ± 0.30	3.16 ± 1.03	2.37 ± 0.90	5.50	0.007**
Fuscidea arboricola	15.0	-	-	8.31 ± 2.35	2.08 ± 0.71	-	-	12.23	0.000***
Hypogymnia farinacea	31.7	-	-	30.72 ± 2.90	24.65 ± 4.76	-	-	61.65	0.000***
Hypogymnia physodes	18.3	1.24 ± 0.56	0.93 ± 0.62	2.35 ± 0.96	1.71 ± 0.86	-	-	2.79	0.070
Hypogymnia tubulosa	58.3	8.88 ± 1.14	4.65 ± 1.01	3.50 ± 1.39	1.45 ± 0.66	8.86 ± 2.06	8.34 ± 2.09	4.82	0.012*
Lecanora argentata	8.3	0.59 ± 0.35	0.11 ± 0.10	-	-	0.34 ± 0.25	0.18 ± 0.13	1.21	0.305
Lecanora carpinea	46.7	1.59 ± 0.50	0.13 ± 0.05	-	-	12.21 ± 1.38	6.10 ± 1.21	49.00	0.000***
Lecanora chlarotera	20.0	-	-	-	-	7.79 ± 1.65	5.70 ± 1.71	18.16	0.000***
Lecanora intumescens	15.0	-	-	-	-	3.30 ± 0.94	2.90 ± 0.83	12.81	0.000***
Lecanora saligna	28.3	5.58 ± 1.07	2.18 ± 0.59	-	-	-	-	22.82	0.000***
Lecidella elaeochroma	30.0	0.21 ± 0.21	0.01 ± 0.01	-	-	7.46 ± 1.16	3.14 ± 0.96	28.79	0.000***
Melanelia glabratula	13.3	1.21 ± 0.37	0.51 ± 0.17	-	-	0.92 ± 0.64	1.51 ± 1.04	11.37	0.000***
Melanelixia subaurifera	30.0	-	-	-	-	17.16 ± 2.17	7.11 ± 2.67	50.25	0.000***
Parmelia sulcata	51.7	4.60 ± 1.38	4.85 ± 1.65	-	-	27.63 ± 4.15	51.55 ± 5.19	68.08	0.000***
Phlyctis argena	31.7	12.61 ± 1.94	14.44 ± 3.01	-	-	1.36 ± 0.71	0.76 ± 0.43	30.57	0.000***
Pseudevernia furfuracea	70.0	14.47 ± 1.57	23.98 ± 2.74	42.59 ± 4.00	64.80 ± 5.55	0.86 ± 0.62	0.24 ± 0.18	86.66	0.000***
Ramalina farinacea	20.0	3.19 ± 0.86	2.30 ± 0.66	-	-	0.66 ± 0.56	0.72 ± 0.60	13.39	0.000***
Ramalina fraxinea	10.0	1.06 ± 0.41	2.12 ± 0.88	-	-	-	-	6.19	0.004**
Rinodina capensis	21.7	3.47 ± 0.74	0.21 ± 0.06	-	-	-	-	21.60	0.000***
Rinodina oleae	13.3	0.12 ± 0.12	0.01 ± 0.01	-	-	1.27 ± 0.44	0.24 ± 0.09	7.24	0.002**
Usnea glabrescens	23.3	3.36 ± 0.88	4.43 ± 1.53	0.53 ± 0.36	0.25 ± 0.22	-	-	9.60	0.000***
Usnea rigida	23.3	3.54 ± 0.74	7.11 ± 1.69	-	-	-	-	22.22	0.000***
Number of species		19		9		15			

Levels of significance: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Freq. (%): Frequency in percent of 60 sample trees. The results of one-way ANOVA with Benferroni correction are shown in italics (The mean difference is significant at the 0.05 level).

Twenty-three lichen species that occurred on fewer than 4 sample trees were not statistically analysed. *Arthonia didyma* Körb., *Arthonia mediella* Nyl., *Bryoria implexa* (Hoffm.) Brodo & D.Hawksw., *Evernia divaricata* (L.) Ach., *Leproloma vouaxii* (Hue) J.R.Laundon, *Pertusaria albescens* (Huds.) M.Choisy & Werner, *Pleurosticta acetabulum* (Neck.) Elix & Lumbsch, *Ramalina pollinaria* (Westr.) Ach., *Tuckermanopsis chlorophylla* (Willd.) Hale, *Usnea cavernosa* Tuck., and *Usnea filipendula* Stirt. are only found on *Abies*. *Buellia erubescens* Arnold, *Fellhanera bouteillei* (Desm.) Vězda, *Lecanora conizaeoides* Nyl. ex Cromb., *Lecanora subintricata* (Nyl.) Th.Fr., *Lecanora subrugosa* Nyl., *Mycocalicium subtile* (Pers.) Szatala, *Usnea hirta* (L.) Weber ex F.H.Wigg., and *Usnea subfloridana* Stirt. are only found on *Fagus*. *Platismatia glauca* (L.) W.L.Culb. & C.F.Culb. and *Scoliciosporum umbrinum* (Ach.) Arnold are only found on *Pinus*. *Buellia disciformis* (Fr.) Mudd is found on *Abies* and *Pinus*, and *Pertusaria amara* (Ach.) Nyl. is found on *Abies* and *Pinus*.

The most frequent species were *Pseudevernia furfuracea* (70%), *Hypogymnia tubulosa* (58.3%), *Parmelia sulcata* (51.7%), *Lecanora chlarotera* (46.7%), and *Evernia prunastri* (45%). The total number of epiphytic lichen species per tree species was 19 on *Abies nordmanniana* subsp. *bornmuelleriana*, 15 on *Fagus orientalis*, and 9 on *Pinus nigra* subsp. *pallasiana*. While *Bryoria capillaris, Lecanora saligna* (Schrad.) Zahlbr., *Ramalina fraxinea* (L.) Ach., *Rinodina capensis* Hampe, and *Usnea rigida* Vain. were only found on *Abies nordmanniana, Fuscidea arboricola* Coppins & Tønsberg and *Hypogymnia farinacea* Zopf. were only found on *Pinus nigra* and were characteristic of *Pinus nigra*. *Lecanora chlarotera, Lecanora intumescens* (Rebent.) Rabenh., and *Melanelixia subaurifera* were only found on *Fagus orientalis*. More than half of the 25 epiphytes found on *Abies, Fagus*, and *Pinus* occurred on 2 or more tree species (Table 1).

Bryoria capillaris (Ach.) Brodo & D.Hawksw., *Evernia prunastri, Lecanora saligna, Melanelixia glabratula* (Lamy) Essl., *Phlyctis argena* (Ach.) Flot., *Ramalina farinacea* L. (Ach.), *R. fraxinea, Rinodina capensis, Usnea glabrescens* (Nyl. ex Vain.) Vain., and *U. rigida* were more typical for *Abies*, whereas *Buellia griseovirens* Turner & Borrer ex Sm.) Almb., *Hypogymnia tubulosa, Lecanora carpinea, L. chlarotera, L. intumescens, Lecidella elaeochroma*, *Melanelixia subaurifera, Parmelia sulcata*, and *Rinodina oleae* Bagl. were characteristic of *Fagus*. Furthermore, *Fuscidea arboricola* and *Hypogymnia farinacea* were characteristic of *Pinus*. *Pseudevernia furfuracea* was the most common species both on *Abies* and *Pinus* (Table 1).

The composition of the epiphytic lichen community growing on *Fagus* compared to those of *Abies* and *Pinus* was considerably different. The epiphytic lichen communities of *Abies* and *Pinus* were very similar (Figure 2). In this ordination, DCA axis 1 shows 30.6% of the variation in species composition. DCA axis 2 shows 5.9% variation; both axes together thus indicate 36.6% variation in the species composition.

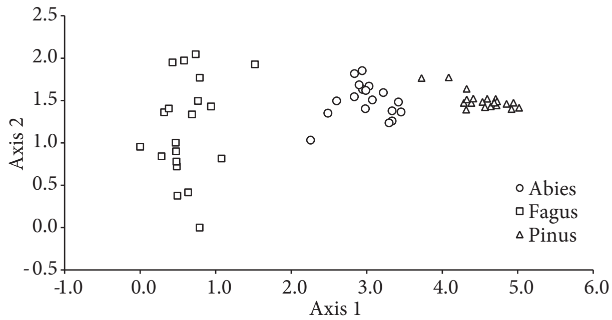

Figure 2. DCA ordination of 60 sample trees of *Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis* and *Pinus nigra* subsp. *pallasiana* depending on the variation of importance value of 25 lichen species with occurrence on more than 4 sample trees. Total inertia in species data: 2.74. Eigenvalues: 0.84 (axis 1), 0.16 (axis 2). Length of gradient: 5.02 (axis 1), 2.05 (axis 2).

The Twinspan classification was concluded at the second level with the separation of 3 tree species (Figure 3). The cut levels used in the Twinspan analysis were 0, 3, 6, 11, and 20 percentage of importance values. The initial Twinspan division separated the broad-leaved tree (*Fagus orientalis*) on the right-hand side of the dendrogram with indicator

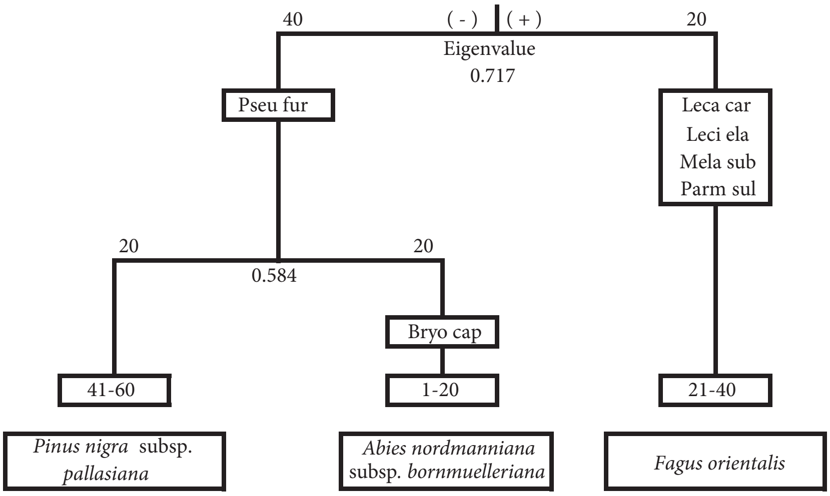

Figure 3. Dendogram of Twinspan analysis of 60 sample trees of *Abies nordmanniana* subsp. *bornmuelleriana*, *Fagus orientalis*, and *Pinus nigra* subsp. *pallasiana* depending on the variation of importance value of 25 lichen species with occurrence on more than 4 sample trees.

species *Lecanora carpinea*, *Lecidella elaeochroma*, *Melanelixia subaurifera*, and *Parmelia sulcata* from the coniferous trees (*Abies nordmanniana* subsp. *bornmuelleriana* and *Pinus nigra* subsp. *pallasiana*) on the left-hand side of the dendrogram with indicator species *Pseudevernia furfuracea*. At the second level, coniferous trees are divided into 2 subgroups. The subgroup on the left-hand side consists of *Pinus* and the subgroup on the right-hand side of *Abies* with indicator species *Bryoria capillaris*.

All selected variables are significantly related to DCA axis 1 score. Species diversity, richness (number of lichen species), and growth form of epiphytic lichens growing on 3 tree species were significantly related to tree species (Table 2). The total number of lichen species growing on *Abies*, *Fagus*, and *Pinus* were 19, 15, and 9, respectively (Table 1).

In total, of 25 lichen species 11 were crustose, 8 fruticose, and 6 foliose. Crustose species were negatively correlated with circumferences of the trunks of trees while fruticose species were positively correlated. Moreover, species diversity determined by the Shannon-Wiener index ranged from 1.39 to 2.34 for *Abies*, from 1.15 to 2.14 for *Fagus*, and from 0.54 to 1.60 for *Pinus*.

Discussion

Nine of the statistically analyzed 25 epiphytic lichens were found only on coniferous tree species. These species are *Bryoria capillaris, Bryoria fuscescens, Fuscidea arboricola, Hypogymnia farinacea, Hypogymnia physodes* L. (Nyl.)*, Ramalina fraxinea, Rinodina capensis, Usnea glabrescens*, and *Usnea rigida*. *Lecanora chlarotera, Lecanora intumescens*, and *Melanelixia subaurifera* were only found on *Fagus orientalis*.

Lecanora chlarotera, Lecidella elaeochroma, Melanelixia subaurifera, Parmelia sulcata, Ramalina farinacea, and *Rinodina oleae*, found on *Pinus nigra* in some districts of Bursa (Oran & Öztürk, 2006), were not observed on *Pinus nigra* in this study. Furthermore, only *Lecidella elaeochroma* and *Ramalina farinacea* and not *Lecanora chlarotera, Melanelixia subaurifera, Parmelia sulcata*, and *Rinodina oleae* were formerly found on *Pinus nigra* in Mt. Uludağ (Öztürk, 1992). On the other hand, similar species were found on *Abies* sp. and *Pinus* sp. in Aladağlar National Park (Niğde, Kayseri, and Adana Provinces) in Turkey (Halıcı & Aksoy, 2009).

The bark pH of *Abies nordmanniana* subsp. *bornmuelleriana*, *Pinus nigra* subsp. *pallasiana*, and *Fagus orientalis* is 4.75, 4.53, and 5.31, respectively

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

	AX1	AX2	TRE	CIR	DIV	NS	CRU	FOL
AX2	0.373(**)							
TRE	0.387(**)	0.038						
CIR	0.673(**)	0.534(**)	0.170					
DIV	-0.356(**)	0.365(**)	-0.780(**)	0.056				
NS	-0.280(*)	0.365(**)	-0.841(**)	0.137	0.956(**)			
CRU	-0.669(**)	0.129	-0.596(**)	-0.354(**)	0.721(**)	0.671(**)		
FOL	-0.500(**)	0.140	-0.317(*)	-0.012	0.618(**)	0.572(**)	0.456(**)	
FRU	0.263(*)	0.386(**)	-0.674(**)	0.466(**)	0.642(**)	0.760(**)	0.079	0.143

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).
TRE: tree species; **CIR:** circumferences of the trunks of the sample trees; **DIV:** Shannon's diversity based on species density in each sample tree; **NS:** number of species of lichens in each sample tree; **CRU:** number of crustose lichen species; **FOL:** number of foliose lichen species; **FRU:** number of fruticose lichen species.

(Balaban & Uçar, 2001). *Pseudevernia furfuracea* is of great importance on coniferous trees compared with broad-leaved trees. It is strictly acidophytic (van Herk, 2001). *Evernia prunastri* and *Hypogymnia tubulosa* were found on both coniferous and broad-leaved trees. *Evernia prunastri* has a wide pH range in less polluted sites (van Herk, 2001). Both of these species have relatively high covers and frequency values on *Abies nordmanniana*. In addition, one of these species, *H. tubulosa*, has a relatively high cover and frequency value on *F. orientalis* as well.

Hypogymnia physodes was only found on coniferous trees with low frequency and cover values. These species are acidophytes (Wolseley et al., 2006). The above mentioned species together with *Hypogymnia farinacea* constitute the *Pseudevernion furfuraceae* alliance on pinewood (Coppins & Coppins, 2006). The species diversity on *Abies nordmanniana* subsp. *bornmuelleriana* is similar when compared with that on *Picea abies* (Kermit & Gauslaa, 2001). Similar results were found on *Fagus* sp. and *Pinus* sp. in the Mediterranean region. Four species, *Evernia prunastri Hypogymnia farinacea, H. physodes*, and *Pseudevernia furfuracea*, were common on *Pinus nigra* on Mt. Olympos in Greece (Pirintsos et al., 1993, 1996). *Lecanora carpinea, L. chlarotera*, and *Lecidella elaeochroma* were core species on *Fagus sylvatica* on Mt. Olympos in Greece (Pirintsos et al., 1995; 1996). Moreover, similar results were found in beech and pine forests in Italy (Incerti & Nimis, 2006).

Fruticose species are positively correlated with circumferences of the trunks (Table 2). This means that the light is an important factor for fruticose growth forms and there is a negative correlation between the irridance level and tree age. Gauslaa et al. (2008) concluded that the light is an important factor to establish the balance between the alectorioid and foliose lichens.

In summary, we found the highest species diversity on *Abies nordmanniana* subsp. *bornmuelleriana* on Mt. Uludağ. The community structure of epiphytic lichens shows differences depending on substrate type. Together, *Bryoria capillaris, Bryoria fuscescens* (Gyeln.) Brodo & D.Hawksw., *Fuscidea arboricola, Hypogymnia farinacea, H. physodes, Ramalina farinacea, R. fraxinea, Rinodina capensis, Usnea glabrescens*, and *U. rigida* constitute the *Pseudevernion furfuracea* alliance on coniferous trees. The community structure of epiphytic lichens on *Fagus orientalis* consists of *Lecanora carpinea*, *Lecidella elaeochroma*, *Melanelixia subaurifera*, and *Parmelia sulcata*.

Acknowledgements

This research project (Project no: 2002/49) was supported by the Uludag University, Unit of Scientific Research Projects.

References

Balaban M & Uçar G (2001). The correlation of wood acidity to its solubility by hot water and alkali. *Holz als Roh-und Werkst* 59: 67-70.

Coppins BJ & Coppins AM (2006). The lichens of the Scottish native pinewoods. *Forestry* 79: 249-259.

Çetin B (1999). The moss flora of the Uludağ National Park (Bursa/Turkey). *Turk J Bot* 23: 187-193.

Eversman S, Wetmore CM, Glew K & Bennet JP (2002). Patterns of lichen diversity in Yellowstone National Park. *Bryologist* 105: 27-42.

Gauslaa Y, Lie M & Ohlson M (2008). Epiphytic lichen biomass in a boreal Norway spruce forest. *The Lichenologist* 40: 257-266.

Giordani P (2006). Variables influencing the distribution of epiphytic lichens in heterogeneous areas: A case study for *Liguria*, NW Italy. *J Veg Sci* 17: 95-206.

Halıcı MG & Aksoy A (2009). Lichenized and lichenicolous fungi of Aladağlar National Park (Niğde, Kayseri and Adana Provinces) in Turkey. *Turk J Bot* 33: 169-189.

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

Hugh G & Gauch JR (1982). *Multivariate Analysis in Community Ecology*. New York: Cambridge University Press.

Hyvarinen M, Halonen P & Kauppi M (1999). Habitat type and primary colonisation of annual shoots of conifer saplings by epiphytic lichens. *Nord J Bot* 19: 505-511.

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

Juriado I, Paal J & Liira J (2003). Epiphytic and epixylic lichen species diversity in Estonian natural forests. *Biodivers Conserv* 12: 1587-1607.

Kermit T & Gauslaa Y (2001). The vertical gradient of bark pH of twigs and macrolichens in a *Picea abies* canopy not affected by acid rain. *The Lichenologist* 33: 353-359.

Kivistö L & Kuusinen M (2000). Edge effects on the epiphytic lichen flora of *Picea abies* in middle boreal Finland. *The Lichenologist* 32: 387-398.

Liu C, Ilvesniemi H & Westman CJ (2000). Biomass of arboreal lichens and its vertical distribution in a boreal coniferous forest in central Finland. *The Lichenologist* 32: 495-504.

McCune B, Rosentreter R, Ponzetti JM & Shaw DC (2000). Epiphyte habitats in an old conifer forest in western Washington, USA. *Bryologist* 103: 417-427.

Müller R, Nowicki C, Barthlott W & Ibisch PL (2003). Biodiversity and endemism mapping as a tool for regional conservation planning - Case study of the Pleurothallidinae (Orchidaceae) of the Andean rain forests in Bolivia. *Biodivers Conserv* 12: 2005-2024.

Oran S & Öztürk Ş (2006). Lichens of Gemlik, İznik, Mudanya and Orhangazi Districts in Bursa Province (Turkey). *Turk J Bot* 30: 231-250.

Öztürk Ş (1992). Uludağ'ın Kabuksu ve Dalsı Likenleri Üzerinde Bir Araştırma. *Doğa Tr J of Botany* 16: 405-409.

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

Pirintsos SA, Diamantopoulos J & Stamou GP (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 SA, Diamantopoulos J & Stamou GP (1996). Hierarchical analysis of the relationship between spatial distribution and abudance of epiphytic lichens (Mt. Olympos – Greece). *Vegetatio* 122: 95-106.

Rehder H, Gokceoglu M, Gebauer G & Guleryuz G (1994). Die Vegetation des Uludağ-Gebierges (Anatolien). *Phytocoenologia* 24: 167-192.

Rheault H, Drapeau P, Bergeron Y & Esseen PA (2003). Edge effects on epiphytic lichen in managed black spruce forests of eastern North America. *Can J For Res* 33: 23-32.

Temina M, Andrew MP, Barinova S & Nevo E (2009). The diversity and ecology of epiphytic lichens in "Evolution Canyon" II, lower Nahal Keziv, Upper Western Galilee, Israel. *Turk J Bot* 33: 263-275.

Ter Braak CJF & Smilauer P (2002). CANOCO reference manual and CanoDraw for Windows user's guide: Software to canonical community ordination (version 4.5), Biometris. Wageningen and Ceske Budejovice.

van Herk CM (2001). Bark pH and susceptibility to toxic air pollutants as independent causes of changes in epiphytic lichen composition in space and time. *The Lichenologist* 33: 419-441.

Wolseley PA, James PW, Theobald MR & Sutton MA (2006). Detecting changes in epiphytic lichen communities at sites affected by atmospheric ammonia from agricultural sources. *The Lichenologist* 38: 161-176.