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The Epiphytic Lichens on Anatolian Black Pine [*Pinus nigra* Arnd. subsp. *pallasiana* (Lamb.) Holmboe] in Mt. Uludag (Bursa–Turkey)

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ABSTRACT

Twenty epiphytic lichen species was found on *Pinus nigra* along the altitudinal gradient in the northwestern parts of Mt. Uludag (Bursa-Turkey). The most common species were *Hypogymnia farinacea* and *Pseudevernia furfuracea*. The community structure of epiphytic lichens at 1300m was found different when compare with 1200 and 1400m depend on altitude factor.

Key Words: Altitude, community, epiphytic lichen, *Pinus nigra,* Uludag

INTRODUCTION

Lichens as a poikilohydric organisms are very sensitive to changes in microclimate [1] and lichen diversity in forests is controlled by environmental conditions [2, 3]. Composition of epiphytic lichen species varies with temperature and moisture resulting from environmental differences or age, height and structure of host tree species [4, 5]. Also, the composition of epiphytic lichen community is probably controlled by climate of the region [6]. Many studies were done on the diversity and community structures of epiphytic lichens on conifer trees [7-9].

Mt. Uludag is one of the important winter sports centers and National Parks in Turkey. Although the lichen biodiversity of Mt. Uludag was well studied, there was no studied on the species composition and community structure of epiphytic lichen [10, 11].

The aim of this study is to determine the distribution and the community structure of the epiphytic lichens on *Pinus nigra* depend on the altitudinal gradient in Mt. Uludag. This research is the first report on the species composition and community structure of epiphytic lichen from Turkey.

MATERIALS AND METHODS

Description of the Study Area

Mt. Uludag is the highest mountain in the Marmara region where Europe meets Asia around the Marmara Sea, and which includes the whole of European Turkey and North Western Anatolia. The mountain previously known as Olympus Misius, Bithynian Olympus and Kesis Dagı was renamed Uludag in 1925. The summit of Uludag located at the southern side of the city of Bursa is 2543m. The mountain range is about 40km long and 15-20km wide. Geologically, it is formed of a nucleus consisting largely 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 northwestern parts made up of granites [12].

The region has a mild climate. In general, the Mediterranean climate with very cold winters is modified by the climatic conditions of the Black Sea region and also the Inner Anatolian region. According to the data of 3 meteorological stations on Uludag, the mean annual temperature is 10°C, decreasing to 3-4°C at higher altitudes (2000-2500m). Mean annual rainfall is 1180mm in Yesilkonak (1025m), 1330mm in Sarıalan (1620m) and 1550mm. in Zirve (1920m). Rainfall reaches a maximum in December and a minimum in August [13].

Various vegetation types occur depending on climate types and altitude. As a result of the altitudinal gradient and various geological conditions, the changes from Mediterranean to Euro-Siberian and alpine in vegetation of Uludag can be seen clearly from the bottom to the top of the mountain. Mt. Uludag has a rich biodiversity with many endemic species and several well distinguished vegetation types [14-16]. Five different vegetation zones are present at Mt. Uludag. These are Lauretum (up to 350m), Castanetum (350-700m), Fagetum (700-1500m), Abietum (1500-2100m) and Alpinetum (2000–2453m) [17].

Sample Collection

The study was carried out on Anatolian black pine in 3 localities on the northwestern slopes of Mt. Uludag. The study sites were located at elevations of 1200m (40°07′44″ N-29°02′39″ E), 1300m (40°05′41″ N-29°05′06″ E) and 1400m (40°06′35″ N-29°04′39″ E). The lichen samples were taken from eight trees which exist close to each other in each site. Lichens were collected using 20 x 40 cm quadrat divided into 8 subunits of 10 x 10 cm placed at 150cm above ground level on the north side of tree trunks in September and October, 2004. In total, the lichen samples were collected from 192 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 [18, 19]. 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). The maximum value of this index is 200 when all species display 100% cover in all of the sampling units.

Statistical Analysis

Total twenty species were recorded on the sample trees, but 13 species with at least two occurrences on the sampling trees were evaluated in statistical analysis. The data matrix of 13 species x 24 samples was used to standard multivariate ordination and classification techniques (DCA and TWINSPAN). The structure of epiphytic lichen community due to the altitude were detected with a Detrended Correspondence Analysis (DCA) using the CANOCO for Windows 4.5 [20] and using multivariate classification techniques (Two Way Indicator Species Analysis=TWINSPAN) [21,22].

Standard statistical procedures were computed using SPSS for Windows, Version 11.5 [23] and assessed at the 95% confidence level. Before performing parametric tests, data were checked for normal distribution and for homogeneity of variance. Data were not normally distributed and not homogeneity of variance. The significance of differences was determined by a non-parametric Kruskal–Wallis test.

RESULTS

20 lichen species was found on the sample trees (Table 1). Most lichens were crustose lichens (10 species) followed by 6 fruticose and 4 foliose. The most common species were *Hypogymnia farinacea* and *Pseudevernia furfuracea* which appeared in more than 95% of total sample trees.

Table 1. Mean importance values ±SE of epiphytic lichen species on *Pinus nigra* from the three different altitudes in Mt. Uludag. (Kruskal-Wallis test ; *df* = 2; levels of significance : * $P \leq 0.01$; ** $P \leq 0.001$, n=8)

Altitude (m)		1200	1300	1400
Mean height of trees (m)		11.10±1.20	15.90±0.32	15.80±3.19
Mean circumference (cm)		135.30±13.37	136.00±20.96	127.70±23.68
Name of species	**Abbreviation**			
Bryoria fuscescens	Bryo fus	-	1.40±0.92	-
Buellia disciformis	Buel dis	4.80±3.88	-	1.33±1.33
Buellia erubescens	Buel eru	4.91±3.92	-	3.24±1.65
Buellia griseovirens	Buel gri	2.76±2.76	1.68±1.10	-
Caloplaca holocarpa +		0.74±0.74	-	-
Evernia prunastri	Ever pru	-	0.69±0.69	3.78±1.93
Fellhanera bouteillei +		-	0.84±0.84	-
Fuscidea arboricola **	Fusc arb	-	16.36±3.31	-
Hypogymnia farinacea	Hypo far	44.30±3.93	41.60±3.62	30.54±5.77
Hypogymnia physodes	Hypo phy	-	2.98±2.29	2.16±1.48
Hypogymnia tubulosa	Hypo tub	-	2.69±2.00	1.98±1.30
Lecanora subintricata	Leca sub	-	2.91±1.92	-
Lecanora subrugosa +		-	-	1.06±1.06
Melanelixia subaurifera +		1.50±1.5	-	-
Mycocalicium subtile	Myco sub	-	-	1.70±1.16
Pertusaria amara +		-	1.21±1.21	-
Pseudevernia furfuracea *	Pseu fur	59.34±9.15	38.83±5.04	81.01±10.21
Usnea glabrescens	Usne gla	-	1.40±0.92	-
Usnea hirta +		-	0.69±0.69	-
Usnea subfloridana +		-	0.73±0.73	-
Number of species		7	14	9

+ : the species found only once on the sampling trees was not evaluated in statistical analysis.

The other common species, Fuscidea arboricola, occured on 7 of total sample trees (29.1%). The other lichens such as Caloplaca holocarpa, Fellhanera bouteillei, Melanelixia subaurifera, Pertusaria amara, Usnea hirta and Usnea subfloridana were rare and were found only once on the sample trees. Therefore, these species were not evaluated in statistical analysis.

The epiphytic lichen vegetation at 1300m was clearly different than that of the other altitudes. DCA of the samples from three different altitudes resulted in eigenvalues of 0.26 (21.3%) and 0.15 (33.6%) for the first two axes. Two different groups were appeared by the DCA of samples. The samples from 1300m located on the upper part of the ordination diagram; while the samples from 1200m and 1400m located on the lower part of the ordination diagram (Fig. 1). There is a significant correlation between two groups ($r=0.459$, $p<0.05$, $n=24$).

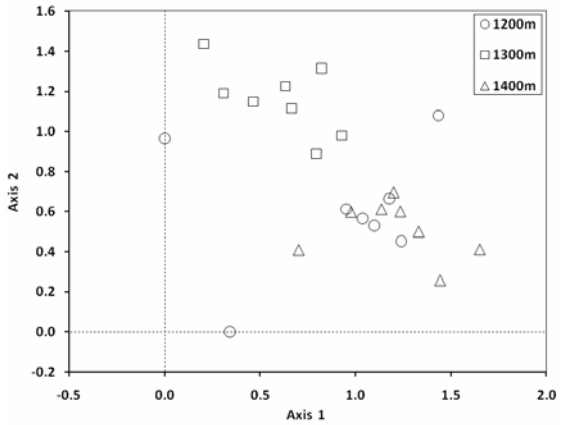

Figure 1. DCA ordination of 24 sample trees at three different altitudes depending on the variation of importance value of lichens with at least two occurrences on sampling trees (13 species). Total inertia in species data: 1.237, Eigenvalues: 0.26 (axis 1), 0.15 (axis 2), Length of gradient: 1.65 (axis 1), 1.44 (axis 2).

The results of DCA analysis of the samples is similar to the results of Twinspan. Grouping of samples using Twinspan was given in Figure 2. Cut levels were set at the importance values 0, 8, 16, 32 and 50. Two rather weakly differentiated groups were recognized. The group on the left side of the dendrogram was formed with a few samples from 1200m and all of the samples from 1300m with indicator species as *Fuscidea arboricola*. The group on the right side of the dendrogram was composed of the samples both 1200 m and 1400 m with indicator species as *Buellia erubescens*.

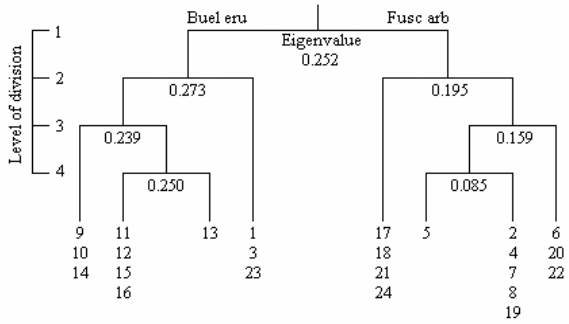

Figure 2. Twinspan dendrogram of twenty four samples in three different altitudes. Numbers of samples in each altitude as follow: 1-8: 1200m; 9-16: 1300m; 17-24: 1400m.

As similar to the results of DCA of samples, the two different groups were appeared by DCA of lichen species (Fig. 3). The negative end of axis 1 revealed the site at an altitude of 1200m, while the positive end of axis 1 revealed the site at an altitude of 1400m. The first group in the upper and left side of ordination diagram is a group composed of the species from 1200 to 1300m. The second group in the right side of ordination diagram is a group composed of the species from 1200 to 1400m. *Hypogymnia fa rinacea* and *Pseudevernia furfuracea* which appeared in all of the sample trees located in the center of the ordination diagram.

The species on the upper part of the ordination diagram such as *Bryoria fus cescens*, *Fuscidea arboricola, Lecanora subintricata* and *Usnea glabrescens* were characterized by site at an altitude of 1300m.

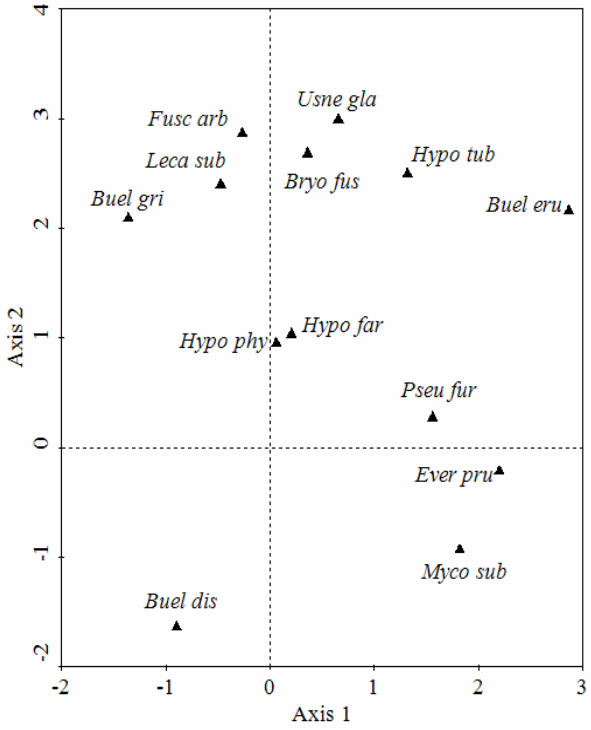

Figure 3. The DCA ordination of lichen species.

DISCUSSION

A total of 20 lichen species was found on *Pinus nigra* from three altitudes. The highest number of species (14 species) was recorded from 1300m followed by 9 species from 1400m and 7 species from 1200m. The most common species were *Hypogymnia farin acea* and *Pseudevernia fu rfuracea*. *Pseudevernia fur furacea* has a high importance value on *Pinus nigra* in each sites and it is strictly acidophytic [24]. *Hypogymnia farin acea, H. physodes* and *Pseudevernia furfuracea* were determined to be the dominant species occurring on trunks and twigs of *Pinus* sp. in Finland and Greece [25, 26]. Similarly, wide ecological range such as *Bryoria fus cescens* and *Hypogymnia ph ysodes* and acidophytic species such as *Pseudevernia furfuracea, Hyp ogymnia farina cea* and *Buellia er ubescens* were identified as the most frequent lichens on *Pinus* sp. above 1000m in the Mediterranean region [27]. The principal ecological factors underlying the variation of the epiphytic flora were related to an altitudinal-climatical gradient. Altitudinal gradient is an important diagnostic factor for changes in the species composition and structure of epiphytic lichen vegetation [28].

Hypogymnia fa rinacea is observed with a high importance value at all of the sampling localities along the altitudinal gradient, while *Hypogymnia physodes* and *H. tubulosa* are found with a low importance value in the sampling localities at 1300m and 1400m. *Evernia prunastri, Hypogymnia farinacea, H. physodes* and *H. tubulosa* together with *Pseudevernia fur furacea* were constituted the *Pseudevernion furfuracea* alliance on pinewood [29].

Species richness, with fourteen species, is the highest at 1300m (Fig. 4). Differences in the number of the lichen growth forms indicated that the distribution of lichens is affected by the other ecological factors together with altitudinal gradient. Another factor affecting community structure and species composition is a direction [18]. In this study, the sampling localities chosen for investigation from *Pinus nigra* forest were located southern, northwest and southwest slopes of Mt. Uludag at 1200m, 1300m and 1400m, respectively. For this reason, the samples were taken from the north-faces of each tree trunks. When compared with the other sampling localities (sites), the higher species richness at 1300m may be related both the northwest slopes of Mt. Uludag and the higher air humidity.

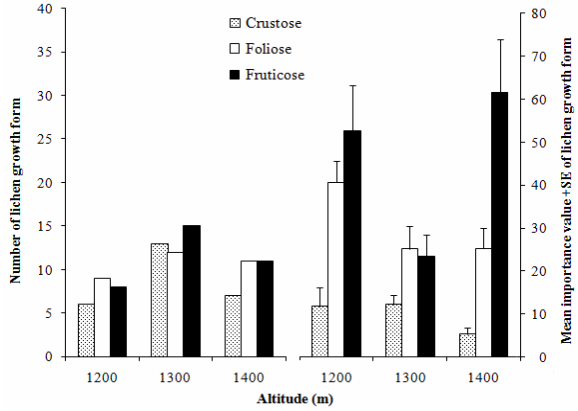

Figure 4. The number and mean importance value ± SE of lichen growth forms from the sampling localities.

In the relationship, between lichen growth forms and altitude, the importance value of the fruticose species was seem to increase from low to higher altitudes along the altitudinal gradient. In spite of the fact that the number of fruticose species was the highest at 1300m, the importance value was the lowest because the fruticose species in this sampling locality have a small thallus.

The distribution and species composition of epiphytic lichen was affected by environmental factors such as altitude, substrate, orientation and air humidity [30]. Altitudinal gradient is an important factor for changes in the distribution and species composition of epiphytic lichen. Consequently, we determined that the distribution and species composition of epiphytic lichen on *Pinus nigra* changed in related to altitudes.

Acknowledgements

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