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Epiphytic lichen diversity on *Populus tremula* L. (European aspen) in Uludağ mountain (Bursa)

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Abstract

A total of 40 epiphytic lichen species were found on *Populus tremula*. A total of 30 species were collected from the trunk base and 37 species from on the tree trunk at 150 cm above the ground. The most common species with the frequency of occurrence on the trees, respectively were *Lecidella elaeochroma, Melanohalea exasperatula, Caloplaca Cerina, Bacidia subincompta, Phlyctis argena, Physcia leptalea, Hypogymnia tubulosa* and *Lecanora hagenii*. The differences in the epiphytic lichen diversity between the base and trunk of *Populus tremula* is statistically significant, but is not statistically significant depending on the direction and circumference of tree trunk.

Keywords : Epiphytic lichens, diversity, community, Uludağ, *Populus tremula*

INTRODUCTION

As lichens are poikilohydric, they are not very efficient in controlling their water content or light capture efficiency and are, therefore, very sensitive to changes in microclimate [1, 2]. Recently, the epiphytic lichen communities has been found to be influenced by various factors as location, topography, climate, pollution, vegetation structure and composition [3, 4].

Epiphytic lichen diversity and species composition varies according to the structural diversity of the area, such as the different tree species in the same area, the age and viability of trees, cover, and microclimate [5, 6, 7]. The development of epiphytic lichens typically depends on the structural and chemical properties of the bark of trees on which they are grown [8, 9].

Lichen abundance in forests is controlled by environmental conditions, due to the influence of microhabitat conditions such as diameter, height and architecture [10]. Epiphytic lichen vegetation is strongly affected by altered microclimate, resulting from rapid changes in forest structure [11, 12]. The diversity of epiphytic species vary significantly, depending on the change of microclimatic parameters towards the inner part of the Mediterranean forest [13].

The aim of this study was to determine the differences in the species diversity and composition of the epiphytic lichens by the northern, southern, eastern and western direction on the base and trunk of *Populus tremula*. At the same time, variation in species diversity and composition were compared with the trunk base and trunk.

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. 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.

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 [14].

Populus tremula L. is a tree species in the Euro-Siberian element that grow naturally in open areas in the forest, and is distributed up to 2000 (-2300m) above sea level in Turkey [15]. It shows the distribution in open areas in the forest zone of *Abies nordmanniana* (Stev.) Spach subsp. *bornmuelleriana* (Mattf.) Coode & Cullen, *Castanea sativa* Mill., *Fagus orientalis* Lipsky from 350 to 2100 m on the northern slopes of Uludag mountain [16].

Sample collection

The study was conducted on 10 randomly selected *Populus tremula* in the location (40°06'39-42" N and 29°05'28-36"E) with an elevation of 1560-1600m at Kirazlıyayla in Uludag Mountain. Epiphytic lichen samples on the base and trunk of *Populus tremula* were collected using the methods specified by Asta et al. [17]. Lichen samples were collected from five quadrat subunits, each one has a 10x10 cm2 surface area and placed on the north, south, east and west side on the base and 150 cm above the ground of the tree trunk. Sampling was performed for a total of 40 subunits per tree.

Statistical analysis

The data matrix of 40 species × 80 samples and importance values (IV) of lichens were used for statistical evaluation. The cover and frequency of occurrence of lichen species were calculated according to the north, south, east, west side on the base and trunk for individual aspen trees [18].

$$\%Frequency(F_i) = \frac{\text{the number of subunits from which species i was recorded}}{\text{the total number of guadrat subunits examined on trees}} x100$$

$$\%Cover\ (C_i) = \frac{\text{the total cover of subunits from which species i was recorded}}{\text{the total cover of guadrat subunits examined on trees}} x100$$

$$Importance\ Value\ (IV) = \%F_i + \%C_i$$

The species present at least twice on the sampling trees were evaluated statistically. A one-way analysis of variance (ANOVA) was used to test whether there is a difference in epiphytic lichen diversity on the base and trunk of *Populus tremula* and also the north, south, east and west side. Standard statistical analyses were performed using SPSS for Windows (Version 22). In all tests, the level of significance was p≤0.05. The ordination graphs according to the direction and the base-trunk of the samples were obtained with a detrended correspondence analysis (DCA). The epiphytic lichens diversity and its relationship to determined parameters (base-trunk, directions of tree trunk, circumference of tree trunk) were obtained with a canonical correspondence analysis (CCA), using the CANOCO 4.5 package [19]. The relationship between species diversity and determined parameters was determined by a Monte Carlo permutation test (495 permutations).

RESULTS

A total of 40 epiphytic lichen species were found on *Populus tremula*. Three species of them were collected only on the base of sampling trees, and ten species only on the tree trunk. Also, the 27 species were found on both the base and trunk of trees (Table 1). The most common species with the frequency of occurrence on the trees, respectively were *Lecidella elaeochroma*, *Melanohalea exasperatula*, *Caloplaca Cerina*, *Bacidia subincompta*, *Phlyctis argena*, *Physcia leptalea*, *Hypogymnia tubulosa* and *Lecanora hagenii*. The crustose growth type among the species determined is most abundant (57.5%) both the base and 150 cm above the ground on the tree trunk. The foliose growth type is 27.5% and the fruticose growth type is 15% of the determined species.

A total of 30 species were collected from the base of tree trunk. 3 species of them (*Buellia disciformis*, *Buellia Erubescens and Physconia enteroxantha*) were only found on the base of tree trunk. The species with the high level of importance value and the frequency of occurrence on the base of tree trunk, respectively were *Lecidella elaeochroma*, *Bacidia subincompta*, *Caloplaca Cerina*, *Phlyctis argena*, *Hypogymnia tubulosa*, *Melanohalea exasperatula*, *Lecanora hagenii* and *Rinodina exigua*. There are 23 species in the north and south of the base of tree trunk. It is to follow 17 species in the east and 20 species in the west. *Bacidia circumspecta*, *B. Subincompta, Caloplaca Cerina, Candelariella vitellina, Fellhanera Bouteillei, Hypogymnia tubulosa, Lecanora Chlarotera, L. hagenii, Lecidella elaeochroma, Melanohalea exasperatula, Phlyctis argena, Physcia leptalea and Rinodina exigua* are situated right in all directions on the base of trees.

A total of 37 species were collected from 150 cm above the ground on the tree trunk. 10 species of them (*Bryoria Fuscescens, Caloplaca holocarpa, Evernia prunastri, Micarea Melaena, Pertusaria Amara, Physcia aipolia, Physconia Distorta, Pleurosticta Acetabulum, Scoliciosporum Chlorococcum and Usnea glabrescens*) were only found on the tree trunk. The species with the high level of importance value and the frequency of occurrence on the tree trunk, respectively were *Lecidella elaeochroma*, *Melanohalea exasperatula*, *Physcia leptalea*, *Caloplaca Cerina*, *Lecanora hagenii*, *Hypogymnia tubulosa*, *Phlyctis argena*, *Bacidia subincompta*, *Pseudevernia furfuracea* and *Anaptychia ciliaris*. There are 28 species in the north on 150 cm above the ground on the tree trunk. It is to follow 26 species in the South, 21 species in the east and 27 species in the west. *Anaptychia ciliaris*, *Bacidia subincompta*, *Caloplaca Cerina*, *C. holocarpa*, *C. pollinii*, *Hypogymnia tubulosa*, *Lecania fuscella*, *Lecanora Chlarotera*, *L. hagenii, Lecidella elaeochroma*, *Melanohalea exasperatula*, *Phlyctis argena*, *Physcia leptalea* and *Pseudevernia furfuracea* are situated right in all directions on 150 cm above the ground on the tree trunk. The difference in epiphytic lichen diversity on the base and trunk of *Populus tremula* is not statistically significant depending on the direction.

The DCA analysis results of 80 quatrad subunits on the base and trunk of *Populus tremula* depending on the variation of importance value of 40 epiphytic lichen species are shown in Figure 1. The differences in the epiphytic lichen diversity between the base and trunk of *Populus tremula* is statistically significant, but is not different depending on the direction of the body of *Populus tremula*.

The DCA analysis results of the differences in the species diversity of the epiphytic lichens on the base and trunk of *Populus tremula* are shown in Figure 2. When compared with the species diversity between the base and trunk of *Populus tremula*, *Bacidia subincompta*, *Candelariella vitellina* and *Rinodina exigua* were statistically significant for the base. On the other hand, *Anaptychia ciliaris*, *Caloplaca holocarpa*, *Melanohalea exasperatula* and *Physcia leptalea* were significant with high importance value for the trunk. All of the fruticose species as *Anaptychia ciliaris*, *Bryoria capillaris*, *B. fuscescens*, *Evernia prunastri*, *Pseudevernia furfuracea* and *Usnea glabrescens* were found with the high importance value on the tree trunk. Generally, the foliose species on the trunk of *Populus tremula* have a higher importance values that than on the base of the tree.

The two axes are represented 87.8 % of cumulative variance of species-selected parameters relation in CCA ordination (Figure 3). According to the results of Monte Carlo permutation tests, there is a significant correlation at the base-trunk in the relationship between the epiphytic lichen diversity and selected parameters. The first axis was negatively correlated with base-trunk (F:3.41, p<0.01).

The species only found on the tree trunk are located on the left side of the second axis, while the species only found on the base are on the right side of the second axis of the CCA ordination plot. The species present on the base and trunk of the trees, and commonly species are located at the center of CCA ordination plot. Pearson correlation between the species and selected parameters are shown in Table 2. *Caloplaca holocarpa* and *Physcia leptalea* are on small diameter trees, while *Candelariella vitellina*, *Physconia enteroxantha* and *Rinodina exigua* are common on the large diameter trees. *Bacidia subincompta*, *Candelariella vitellina* and *Rinodina exigua* were statistically significant for the base. On the other hand, *Anaptychia ciliaris*, *Caloplaca holocarpa*, *Melanohalea exasperatula* and *Physcia leptalea* were significant for the trunk. *Bacidia subincompta*, *Candelariella vitellina* and *Rinodina exigua* at the base of *Populus tremula* have higher importance values than on the tree trunk depending on the directions. On the contrary, *Anaptychia ciliaris*, *Caloplaca holocarpa*, *Melanohalea exasperatula*, *Physcia adscendens*, *P. Leptalea* and *Scoliciosporum chlorococcum* have a high importance values on the tree trunk.

DISCUSSION

The epiphytic lichen diversity on *Populus tremula* in Uludag Mountain shows great similarity to those on *Populus tremula* in Gürgendagı Mountain which is located in the northern part of Western Anatolia [20], and in the Aladağlar National Park which is one of the largest national parks in the Mediterranean phytogeographical region of Turkey [21]. Similarly, the epiphytic lichen diversity on *Populus tremula* is very similar to previously detected on *Abies* in the same area [22].

The importance of light and humidity conditions for epiphytic vegetation is well known. At the tree level, relative humidity also tends to be higher at the trunk base and decreases with height on the tree trunk [23]. The dominance of lichens at breast height is related to different humidity levels. Except for the high humidity requires cyanolichens, lichens are more abundant in sunny environments [24]. *Caloplaca Cerina*, *C. holocarpa* and *Physcia aipolia* are characteristic indicators for xeric microclimatic conditions in sunny environments [25]. In our study, these species are found only on the tree trunk or with the high importance value on the tree trunk.

The epiphytic lichen diversity on stems and on branches was found to increase in relation to the age and diameter of the tree [26, 27]. The change in the composition of the lichen species on the tree trunks is determined by the trunk circumference on the different tree species [28, 29]. In our study, the largest differences in the epiphytic lichen diversity on *Populus tremula* were found between the trunk base and trunk.

Hypogymnia, lecanora, melanelia, parmelia and *physcia* are characteristic genera for sun-exposed habitats and are common genera on aspen in northern Sweden [30]. In this study, *bacidia, caloplaca, lecanora* and *physcia* are common genera on *Populus tremula*. Almost 40 species were characteristic of young aspen forest. Among them *Caloplaca Cerina*, *C. holocarpa*, *Lecanora hagenii*, *Melanelia Exasperata, Physcia aipolia and Xanthoria Parietina* [31].

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Table 1. Mean ± Standard deviation (SD) of the importance value (IV) and frequency (F) of occurrence of epiphytic lichen species on the base and trunk of *Populus tremula*. The results were obtained by one-way ANOVA (n=40, df=1)

Sampling location of tree trunk	Abbreviations of species name	BASE									TRUNK									One-Way	
Mean±SD of circumference of tree trunk		154±6,70									138±4,94										
Direction of tree trunk		North		South		East		West		IV	North		South		East		West		IV	ANOVA	
Species		F	IV	F	IV	F	IV	F	IV	Mean±SD	F	IV	F	IV	F	IV	F	IV	Mean±SD	F	Sig.
Anaptychia ciliaris	Anap cil	2	4,1	1	2,1					1,6±5,5	5	10,7	2	4,3	5	10,3	9	18,6	10,9±21,6	7,115	,009
Bacidia arceutina	Baci arc			3	6,0	1	2,0	1	2,0	2,5±8,1	1	2,0							0,5±3,2	2,131	,148
Bacidia circumspecta	Baci cir	2	4,0	1	2,0	1	2,0	1	2,0	2,5±6,7	1	2,0					2	4,0	1,5±5,4	0,552	,460
Bacidia subincompta	Baci sub	10	23,8	16	34,3	19	45,3	5	10,1	28,4±30,7	6	12,2	7	14,2	7	14,2	5	10,1	12,7±24,6	6,366	,014
Bryoria capillaris	Byro cap	2	4,1							1,0±4,5	6	13,7					1	2,2	3,9±18,8	0,930	,338
Bryoria fuscescens	Bryo fus										3	6,5	2	5,1			1	2,3	3,5±13,2	2,738	,102
Buellia disciformis	Buel dis	2	4,1			4	8,2			3,1±10,9										3,162	,079
Buellia erubescens	Buel eru	1	2,0	2	4,0					1,5±7,1										1,836	,179
Caloplaca cerina	Calo cer	7	14,1	11	22,2	8	16,1	13	26,2	19,6±23,9	11	22,1	15	30,2	7	14,1	14	28,2	23,6±26,9	0,496	,483
Caloplaca herbidella	Calo her			1	2,0					0,5±3,2			1	2,1					0,5±3,3	0,001	,981
Caloplaca holocarpa	Calo hol										6	12,1	6	12,1	2	4,0	3	6,0	8,5±16,9	10,148	,002
Caloplaca pollinii	Calo pol	1	2,0	4	8,1			2	4,0	3,5±12,0	2	4,0	5	10,1	5	10,1	2	4,0	7,1±14,8	1,370	,245
Candelariella vitellina	Cand vit	4	8,1	2	4,0	5	10,1	4	8,1	7,6±16,9	1	2,0							0,5±3,2	6,738	,011
Evernia prunastri	Ever pru												1	2,1	2	4,3			1,6±7,4	1,829	,180
Fellhanera bouteillei	Fell bou	1	2,0	3	6,1	4	8,1	3	6,1	5,6±12,1	1	2,0	3	6,1			1	2,0	2,5±8,2	1,708	,195
Hypogymnia tubulosa	Hypo tub	8	17,2	9	18,4	3	6,1	7	14,2	13,9±27,6	15	31,5	9	18,8	7	14,7	9	18,5	20,8±35,5	0,939	,336
Lecania fuscella	Leca fus			1	2,0	2	4,0	3	6,0	3,0±10,7	3	6,0	7	14,2	3	6,1	4	8,0	8,6±15,7	3,396	,069
Lecanora carpinea	Leca car	1	2,0					3	6,2	2,1±7,7	2	4,0					1	2,0	1,5±5,4	0,134	,715
Lecanora chlarotera	Leca chl	3	6,2	5	10,3	4	8,3	2	4,2	7,3±16,6	4	8,2	2	4,3	5	10,2	1	2,0	6,2±13,3	0,101	,752

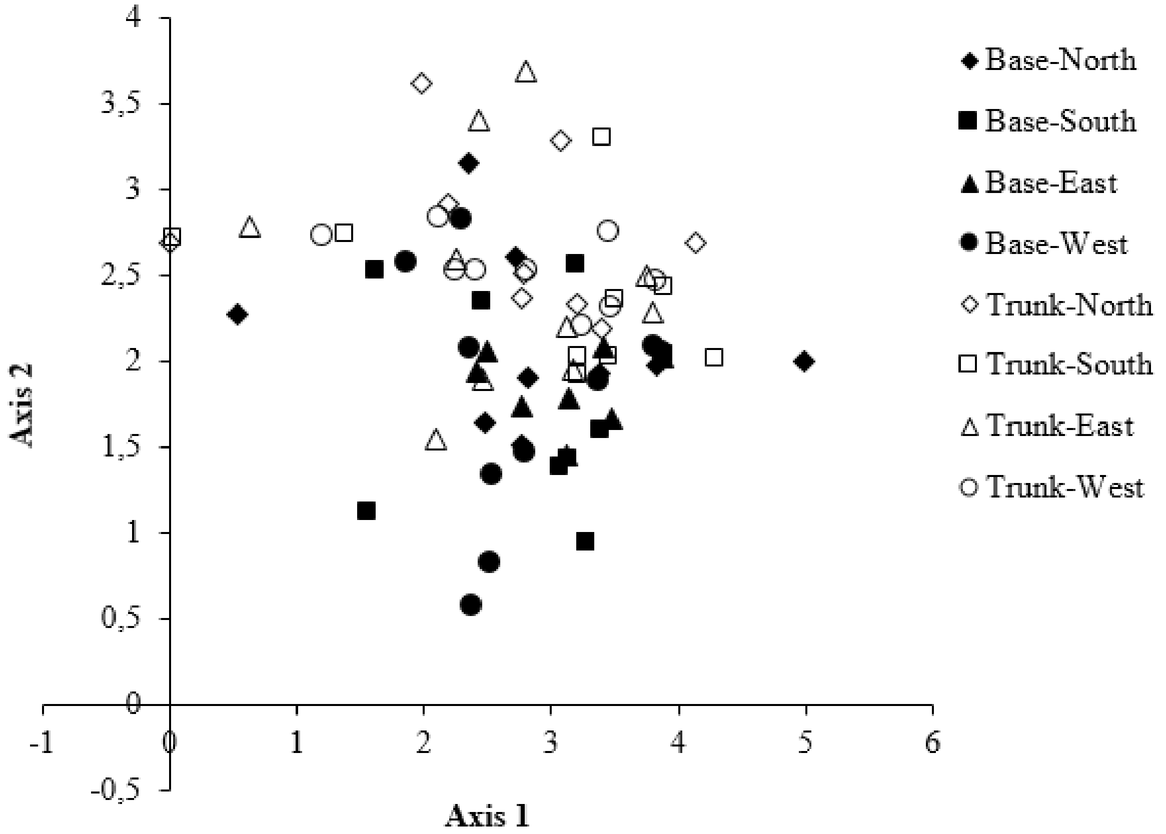
Lecanora hagenii	Leca hag	3	6,0	10	20,2	6	12,2	5	10,1	12,1±22,3	7	14,2	17	34,4	11	22,3	8	16,2	21,7±34,7	2,184	,143
Lecanora sym-micta	Leca sym	4	8,3	1	2,1					2,6±13,5			1	2,0					0,5±3,2	0,925	,339
Lecidella elaeo-chroma	Leci ela	14	28,9	22	44,7	20	40,6	14	28,5	35,7±31,4	19	38,4	24	49,0	19	38,5	20	40,7	42,7±29,2	1,070	,304
Melanelixia glabratula	Mela gla	3	6,1							1,5±7,2	1	2,0					1	2,3	1,1±4,8	0,109	,742
Melanohalea exasperatula	Melo exa	8	16,3	5	10,1	5	10,1	7	14,2	12,6±20,8	19	39,1	17	35,4	16	32,8	20	40,6	36,9±36,6	13,308	,000
Micarea melaena	Mica mel										3	6,1			1	2,0	3	6,0	3,5±13,6	2,694	,105
Parmelia sulcata	Parm sul					1	2,1			0,5±3,3	1	2,1					1	2,0	1,0±4,6	0,339	,562
Pertusaria amara	Pert ama										2	4,1					1	2,0	1,5±7,1	1,834	,180
Phlyctis argena	Phly arg	8	17,1	13	27,8	10	21,2	8	16,6	20,6±32,6	7	14,6	8	16,7	9	18,9	7	14,6	16,2±24,2	0,482	,489
Physcia adscen-dens	Phys ads							1	2,1	0,5±3,3			2	4,0	1	2,0	3	6,1	3,0±9,7	2,393	,126
Physcia aipolia	Phys aip												3	6,2	2	4,1			2,6±10,7	2,326	,131
Physcia leptalea	Phys lep	5	10,1	2	4,0	4	8,0	2	4,1	6,6±12,4	15	30,3	16	32,3	9	18,2	15	30,5	27,8±31,3	15,927	,000
Physconia distorta	Pyco dis												1	2,2			1	2,0	1,1±4,7	2,047	,157
Physconia entero-xantha	Pyco ent	1	2,0	1	2,0					1,0±4,5										2,053	,156
Pleurosticta acetabulum	Pleu ace										4	9,3	2	4,3					3,4±16,0	1,792	,185
Pseudevernia furfuracea	Pseu fur	5	10,4	3	6,1			1	2,0	4,6±17,8	5	12,6	8	16,4	4	8,8	6	12,8	12,6±31,2	1,993	,162
Rinodina capensis	Rino cap							2	4,0	1,0±6,4	2	4,0			1	2,0	1	2,0	2,0±7,6	0,412	,523
Rinodina exigua	Rino exi	4	8,1	6	12,1	10	20,1	1	2,0	10,6±22,8			1	2,0					0,5±3,2	7,661	,007
Scoliciosporum chlorococcum	Scol chl														3	6,1	1	2,0	2,0±7,6	2,793	,099

Table 2. Pearson correlation coefficients between the species and selected parameters.

Species	Selected parameters		
	Circumference of tree trunk	**Base-Trunk**	**Direction of tree trunk**
Anaptychia ciliaris	-0.185	0.289**	0.278*
Bacidia subincompta	0.180	-0.275*	-0.275*
Caloplaca holocarpa	-0.269*	0.339**	0.239*
Candelariella vitellina	0.397**	-0.282*	-0.46*
Melanohalea exasperatula	-0.210	0.382**	0.330**
Physcia adscendens	-0.141	0.173	0.234*
Physcia leptalea	-0.259*	0.412**	0.330**
Physconia enteroxantha	0.338**	-0.160	-0.209
Rinodina exigua	0.293**	-0.299**	-0.281*
Scoliciosporum chlorococcum	-0.147	0.186	0.223*

Correlation is significant at the 0.01 level (**) and at the 0.05 level (*)

Figure 1. DCA ordination of 80 quatrad subunits on the base and trunk of *Populus tremula* depending on the variation of importance value of 40 epiphytic lichen species. Total inertia in species data: 4,40. Eigenvalues: 0.59 (axis 1), 0.38 (axis 2). Length of gradient: 4.99 (axis 1), 3.70 (axis 2).



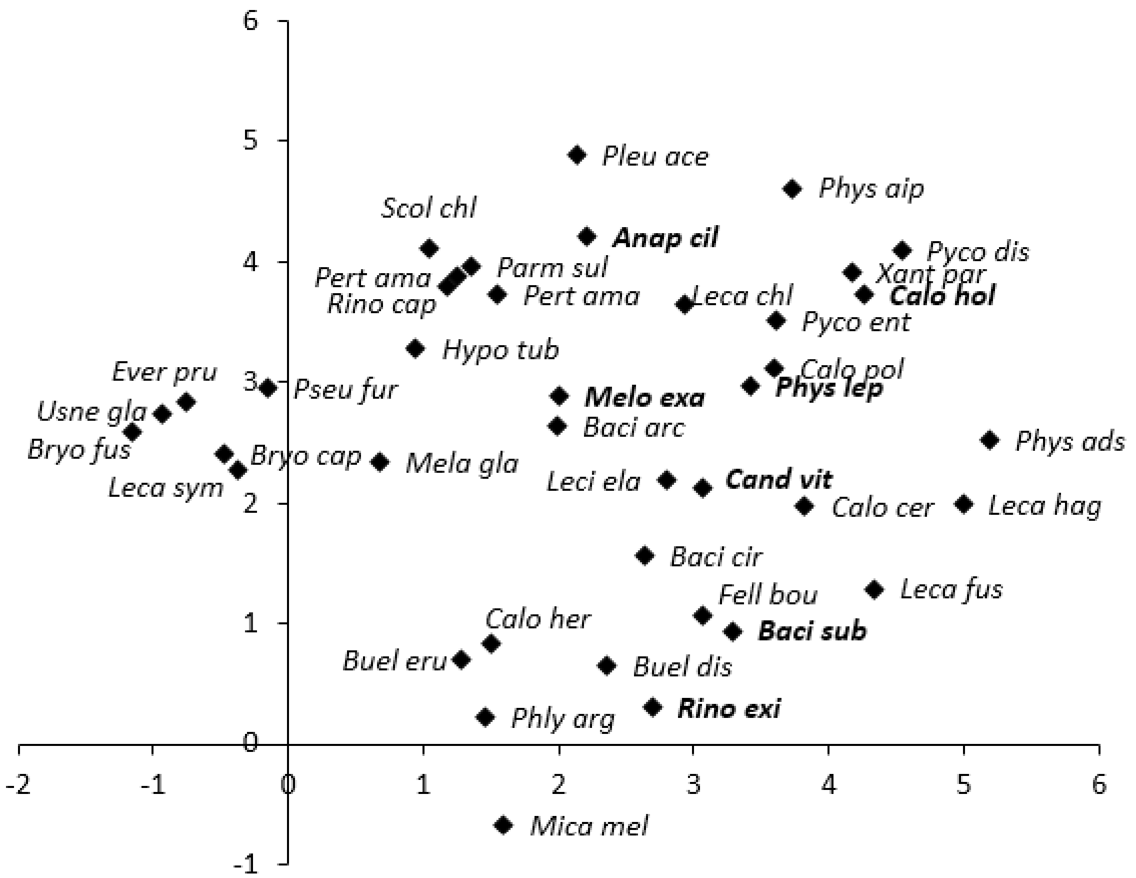


Figure 2. DCA ordination of epiphytic lichen species on the base and trunk of *Populus tremula*. Statistically significant species was indicated in bold type.

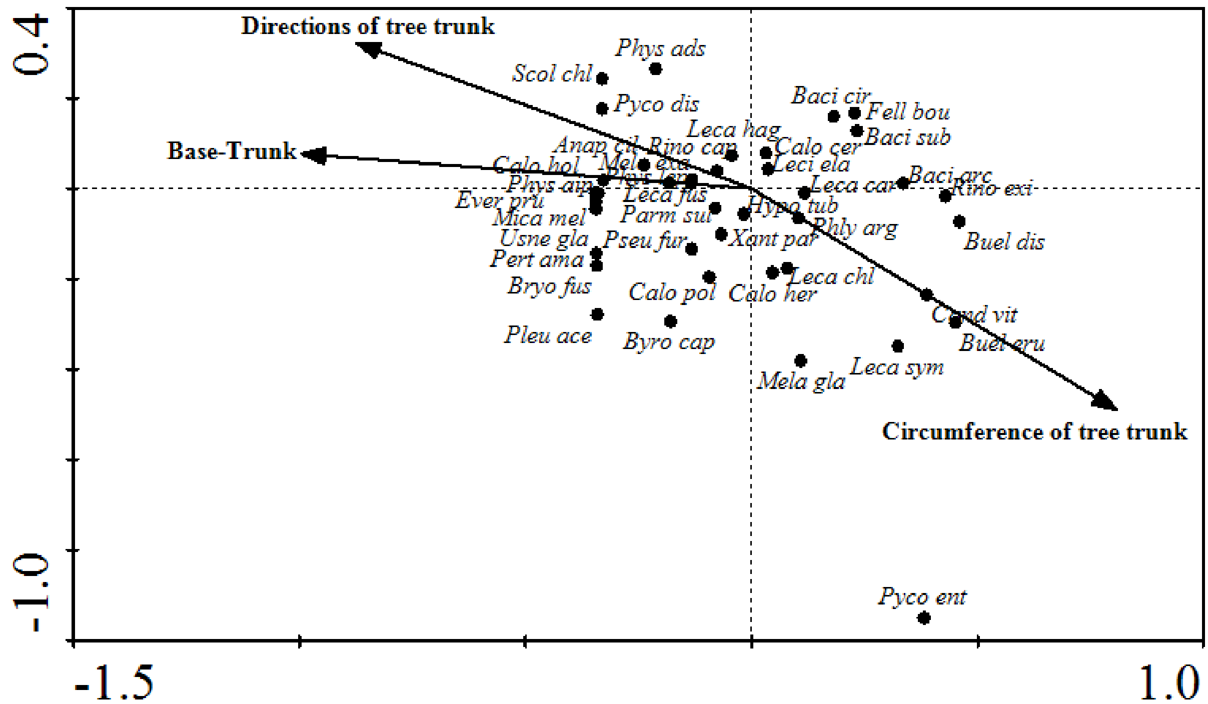


Figure 3. Canonical correspondence analysis (CCA) of lichen species and determined parameters biplot. Species abbreviations are provided in Table 1.