Epiphytic Mosses Growing on *Abies nordmanniana* subsp. *bornmuelleriana* Trees in Ilgaz Forests of Turkey

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Abstract
We studied the diversity of epiphytic mosses in the Uludağ fir *Abies nordmanniana* (Stev.) Spach. subsp. *bornmuellerina* (Mattf.) Coode et Cullen consisting of pure and mixed type forests in Ilgaz Mountain National Park and Yenice Forests located in the south parts of the park. After evaluating the collected mosses from Uludağ fir, we determined 38 epiphytic moss taxa and 26 genera belonging to 19 families. *Dicranum* and *Orthotrichum* genera were noticed as the richest corticolous moss species. According to the life-forms analysis, 8 different life forms were determined. Among them, tall turf (tT) was dominant. Weft (We) and Mat (Ma) were seen as the second life forms in the studied area. The samplings were made from tree base up to stand basal area. Generally, the effect of forestry practices was touched on composition, richness and cover of epiphytic bryophyte assemblages in managed and unmanaged forests. Negative effects of construction and tourist' behaviors on the diversity of epiphytic bryophyte species in protected areas, such as national parks, were also mentioned.
Keywords: Bryophytes, Mosses, Life-forms, Uludağ fir, Ilgaz Mountains

Introduction

Biological indicators as bryophytes (mosses, liverworts and hornworts) are used for assessing the conservation value of forest stands (Vanderpoorten et al., 2004). Epiphytic mosses are an important cryptogam in the increase of forest continuity (Ek et al., 2002; Mežaka et al., 2008). The diversity and composition of epiphytic flora is correlated with the different forest composition, age and structure. Many epiphytic cryptogams are very sensitive to forest management practices (Hannerz and Hånell, 1997; Aude and Poulsen, 2000; McGee and Kimmerer, 2002; Newmaster and Bell, 2002; Ross-Davis and Frego, 2002; Vanderpoorten et al., 2004; Holz and Gradstein, 2005; Király and Ódor, 2010). Therefore, old-growth forests and protected areas are favored in comparison with the managed ones. Epiphytic bryophytes clearly differ from the other cryptogams by the presence of communities and with their local composition driven by micro-environmental conditions (de Oliveira et al., 2009). Mežaka et al. (2008) and their cited references indicate that the substrate is an important factor in determining the distribution of epiphytic species and tree bark pH as well as bark crevice depth are affecting the bryophyte distribution. Gradstein and Culmsee (2010) reported the trees with fissured bark tended to be richer in bryophyte species than those with smooth bark. Also, Barkman (1958) express that epiphytic bryophytes vary depending on tree species and trees' bark chemical and physical properties. In addition, the ecology of mosses can vary from an area to another (Vanderpoorten et al., 2004).

Abies nordmanniana (Stev.) Spach. subsp. *bornmuellerina* (Mattf.) Coode et Cullen is an endemic, evergreen coniferous tree species, from the family Pinaceae and is only distributed in Turkey (Yaltırık and Akkemik, 2011). Although the fir taxon has been subjected to different kinds of research, only one study on epiphytic mosses and liverworts for Uludağ fir (Alataş et al., 2012a) has been carried out up to now. Also, this study may provide interesting information about the environment of the Ilgaz Mountains, because bryophytes, especially as bioindicators, are often valuable components of forests.

Bryophytes including mosses and liverworts have wide distribution within the Ilgaz forest ecosystem, particularly on north-facing slopes (Akman et al., 1983). Mosses, one of the cryptogam plants, are found in various habitats on forest floor, for example

on soil and rock. Also, this cryptogam grows on tree bark as epiphytes. The epiphytic mosses characteristically found on living or dead trees contribute to the plant diversity of forest ecosystem. In addition, they can live in water as embedded.

While the studies on moss and liverwort floristic are continuing in Turkey for more than 30 years, distribution patterns of epiphytic bryophytes are still scarce. In recent years, there have been several studies on the epiphytic bryophytes in our country (Kürschner et al., 1998; 2006; Kürschner, 1999; Ezer et al., 2009; 2010; Düzenli et al., 2011; Alataş et al., 2012a; 2012b). In this study, we determined the epiphytic mosses found on Uludağ fir growing in pure or mixed stands in Ilgaz forests.

Materials and Methods

Site details

Ilgaz Mountains is a mountain range in the northwest Anatolia of Turkey. The northern slopes of the mountains are in Kastamonu and the southern slopes are in Çankırı province (URL1, 2012). One of the areas researched for epiphytic moss taxa is Ilgaz Mountain National Park (IMNP) and another one is Yenice Forests (YF). The national park has an area of 1,089 hectares; 751 ha of the park are situated within the province of Kastamonu, and 338 ha are within the boundaries of Çankırı Province (Abay and Çetin, 2003). YF constitute the south parts of the mountain range (Ursavaş and Abay, 2009) and are 11,585 hectares (Öner and Abay, 2005a; 2005b).

The northern slopes of Ilgaz Mountains are covered with dense forests (URL1, 2012). The low altitudes of northern slopes (600-800 m) are covered by *Pinus nigra*Arnold subsp. *pallasiana* (Lamb.) Holmboe, the middle levels (900-1,400 m) by *P. sylvestris* L. and the higher altitudes (1,000-1,800 m) by *A. nordmanniana* subsp. *bornmuelleriana* forests. Although the gymnosperms are rich on the Ilgaz Mountains, the deciduous forests are not widespread here. A great part of it is covered by Uludağ fir forests (Akman et al., 1983).

Field and office work

The materials of the study were collected from IMNP during excursions between 1998 and 2000 and also moss taxa from YF between 2006 and 2008 years. The moss samplings were made from tree base up to stand basal area. Unknown moss species were collected from the study areas and identified in the laboratory using various flora (Pedrotti, 2001; Smith, 2004; Heyn and Herrnstadt, 2004; Pedrotti, 2006). Nomenclature of the epiphytic moss taxa were arranged according to Hill et al. (2006).

Life form classification of the mosses follows Mägdefrau (1982) and Hill et al. (2007). The species are given alphabetically in order to help to reader (Table 1). Used abbreviations and symbols: Life-form: LF, on living tree trunk: LT, on dead tree trunk: DT, on living tree root: LR, on living dead tree root: DR, Weft: We, Annual: An, Tall turf: tT, Short turf: sT, Mat: Ma, Tail: Ta, Cushion: Cu.

Results and discussion

In total 38 epiphytic mosses belonging to 19 families were found on Uludağ fir in the studied localities and listed in Table 1. *Brachytheciaceae* was the richest epiphytic moss species family, with 7 species, representing 18.4% of all moss taxa recorded. The second and third richest species families were *Dicranaceae* and *Orthotrichaceae* with 5 and 4 species, respectively (Table 2). The genera *Dicranum* and *Orthotrichum* are the richest, with 4 species each. *Dicranum scoparium*, *D. tauricum*, *Herzogiella seligeri*, *Mnium marginatum*, and *Orthotrichum affine* were observed from different substratum. As seen in Table 1, some moss species were also found exclusively on one substratum.

Table 1. Epiphytic moss taxa occurrence on Uludağ fir and some of their ecological characters

Moss taxa	Altitude (m)	Locality	LF	Substratum			
				LT	DT	LR	DR
Brachythecium erythrorrhizon Schimp.	1800	Haydarın Hill	We	+			
Brachythecium glareosum (Bruch ex Spruce) Schimp.	1740	Şadımanın Hill	We	+			
Brachythecium salebrosum (Hoffm. ex F.Weber& D. Mohr) Schimp.	1800	Haydarın Hill	We	+			
Bryumalpinum With. var. *viride*Husn	2000	Karakeçilik Hill	sT	+			
Buxbaumiaviridis (Moug. ex Lam. DC.) Brid. exMoug. &Nestl.	1740	Şadımanın Hill	An		+		
Ceratodon purpureus (Hedw.) Brid.	1950	Kazançal Hill	sT	+			
Dicranella heteromalla (Hedw.) Schimp.	1500	Baldıran	tT			+	
Dicranum fuscescens Sm.	1430	Baldıran	tT	+			
Dicranum polysetum Sw.	1430	Baldıran	tT	+			
Dicranum scoparium Hedw.	1800	Haydarın Hill	tT	+	+		
	1609	Sarayseki Hill	tT				
*Dicranum tauricum*Sapjegin	1430	Baldıran	tT	+			+
	2098	Taşkınsırtı Hill	tT				
*Encalyptarhaptocarpa*Schwägr.	1900	Kazançal Hill	Tuft	+			
Habrodon perpusillus (De Not.) Lindb.	1420	Baldıran	Ta	+			
Herzogiella seligeri (Brid.) Z. Iwats.	1500	Baldıran	Ma	+		+	
	1879	Mıcık stream					
Homalothecium lutescens (Hedw.) H.Rob.	1430	Sarayseki Hill	Ma	+			
Homalotheciu msericeum (Hedw.) Schimp.	1916	Kubbe stream	Ma		+		
*Hypnum cupressiforme*Hedw. var. *lacunosum*Brid.	1400	Baldıran	We	+			
*Leucodon immersus*Lindb.	1340	Çatmalı spring	Ta	+			
Leucodon sciuroides (Hedw.) Schwägr.	1450	Baldıran	Ta	+			
Mnium marginatum (Dicks.) P.Beauv.	1900	Kazançal Hill	tT	+	+		
	1879	Mıcık stream					
Mnium spinosum (Voit) Schwägr.	1950	Kazançal Hill	tT	+			
Orthotrichum affine Schrad. exBrid.	1500	Baldıran	Cu	+		+	
	1264	Sarıçam seed stand					
Orthotrichum diaphanum Schrad. exBrid.	1450	Baldıran	Cu	+			
Orthotrichum speciosum Nees	1520	Baldıran	Cu	+			
Orthotrichum striatum Hedw.	1430	Sarayseki Hill	Cu	+			
Palustriella commutata (Hedw.) Ochyra	1452	Kızılyalak stream	We	+			
Plagiomnium affine (Blandow ex Funck) T.J.Kop.	1264	Sarayseki Hill	tT		+		
Plagiomnium undulatum (Hedw.) T.J.Kop.	1580	Baldıran	tT	+			
Plagiothecium platyphyllum Mönk.	1790	Zelikkırı spring	Ma			+	
Pseudoleskea incurvata (Hedw.) Loeske	2000	Karakeçilik Hill	Ma	+			
Pterigynandrum filiforme Hedw.	1520	Baldıran	Ma	+			
	1264	Sarıçam seed stand					
Rhizomnium punctatum (Hedw.) T.J.Kop.	1903	Tülü Hill	tT		+		
Rhynchostegium murale (Hedw.) Schimp.	1551	Belen gediği	We			+	
Rhytidiadelphus squarrosus (Hedw.) Warnst.	1916	Kubbe stream	tT		+		
Sanionia uncinata (Hedw.) Loeske	1800	Haydarın Hill	We	+			
	1673	Lower slopes of Evregin Hill					
Sciuro-hypnumpopuleum (Hedw.) Ignatov&Huttunen	1520	Baldıran	We	+			
Tetraphi spellucida Hedw.	1400	Baldıran	sT		+		
Tortella tortuosa (Hedw.) Limpr.	1580	Baldıran	tT	+			

Table 2. Distribution of epiphytic moss taxa according to the families and their percentage

Families	Taxa number	Distribution of taxa (%)
Brachytheciaceae	7	18.4
Dicranaceae	5	13.2
Orthotrichaceae	4	10.6
Pterygnandraceae	2	5.3
Plagiotheciaceae	2	5.3
Leucodontaceae	2	5.3
Mniaceae	2	5.3
Amblystegiaceae	2	5.3
Plagiomniaceae	2	5.3
Leskeaceae	1	2.6
Bryaceae	1	2.6
Buxbaumiaceae	1	2.6
Ditrichaceae	1	2.6
Encalyptaceae	1	2.6
Hypnaceae	1	2.6
Pottiaceae	1	2.6
Cinclidaceae	1	2.6
Hylocomiaceae	1	2.6
Tetraphidaceae	1	2.6

Dead woods and roots were noticed in various decay stages in IMNP and YF. *Buxbaumia viridis*, *Dicranum scoparium*, *Herzogiella seligeri*, *Homalothecium sericeum*, *Mnium marginatum*, *Plagiomnium affine*, *Rhizomnium punctatum*, *Rhytidiadelphus squarrosus*, and *Tetraphis pellucida* were seen on decayed fir trunk. *Dicranum tauricum* was observed both on decayed fir root and trunk. These results indicate the conservation strategies aimed at preserving the different microhabitats' diversity in IMNP.

Life forms in bryophytes are important factors for successfully occupying different habitats (Kürschner, 2004). Light and water are the predominant factors on bryophyte life forms. Sufficient soil water provides that the occurring of life forms tT, Ma, We, Ta and Fa in various habitats. These life forms have crowded shoots with dense foliage structures (Mägdefrau, 1982; Glime, 2007). Figure 1 indicates that the tT, We and Ma life forms were the most preferred by the epiphytic mosses in IMNP and YF. These results generally give us the opinion that water capacity of soil in the IMNP (Abay, 2001) and YF is sufficient when looked at the whole season, except in mid-July until the end of September in YF (Ursavaş, 2008).

In our studied areas 8 life forms were determined. Thirty-one percent of all collected epiphytic moss species were "tT". The second and third life-forms are "We" and "Ma", representing 20% and 16%, respectively. Other life forms constitute 33% of all species (Figure 1). Epiphytic moss taxa having different life forms in the field can be correlated with moss samples collected in different seasons of the year.

If we compare and contrast the research on epiphytic mosses in Turkey; Alataş et al. (2012a) determined 30 epiphytic mosses on Uludağ fir trunk in Abant Mountains. According to the life form analysis of taxa in their study, seven different life forms were determined. We was determined as the most dominant life-form. Alataş et al. (2012b) found Cu as the most dominant life-form among the seven life-forms for bryophytes determined on *Fagus orientalis* Lipsky. On Abant Mountains. Ezer et al. (2009) stated that Ma were the most common one, especially preferred by the liverworts, recognized six life forms in the Turkish oak (*Quercus cerris* L.) forests on Mount Musa in the southern part of the Amanos mountain range in Mediterranean region. Ezer et al. (2010) found seven different life-forms of epiphytic bryophytes on Mount Musa and determined the "We" as the most dominant life-form.

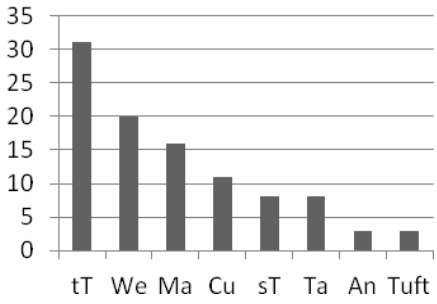

Figure 1. Life-forms preferred by moss taxa in the studied areas

Since mosses are known to be sensitive to microclimatic variations in a forest (Moe and Botnen, 2000; Marques et al., 2005), the diversity of life forms and distributions of epiphytic moss species in Ilgaz Forests can be expressed by the variability related to

humidity from north to south and west to east.

Yan et al. (2009) determined the long term effect of tourism on epiphytic bryophytes, species composition, coverage and biomass of the bryophyte community. Construction and tourist activities in the boundaries of IMNP are important environmental factors that can affect the epiphytic diversity and life forms in our study area. If we evaluate the works in order to found ecotourism venues and the behaviors of the tourists in those areas together, the epiphytic moss diversity and composition would be affected negatively.

Friedel et al. (2006) stated that forest management should enhance environment protection plans for big trees' sustainable life that are bigger than the targeted diameter in order to protect the epiphytic species composition. Also, the results of the studies of epiphytic species show that the quantity and mass of the species in unmanaged forests are more than in managed forests.

As a result one can say that the old growth forests and protected areas are richer in epiphytic species rather than the others.

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