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The epiphytic bryophyte succession of *Picea orientalis* forests on the Kümbet High Plateau (Giresun-Turkey)

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ABSTRACT:
In this study, the epiphytic bryophyte succession of *Picea orientalis* forests on the Kümbet High Plateau (Giresun-Turkey) were studied. A total of 21 epiphytic bryophyte species were determined (16 mosses and 5 liverworts). The epiphytic bryophyte communities were sampled in 60 sample plots taken from the trunks of *Picea orientalis*, each of which was 20 × 20 cm in size. The Index of Ecological Significance (IES), based on a combination of the relative frequency and mean cover of epiphytic bryophytes, was used to evaluate the abundance of bryophyte communities in epiphytic habitats on the tree trunks. In addition, multivariate classification techniques (TWINSPAN and DECORANA) were used to classify the community structures in successional stages. TWINSPAN divided the 60 sample plots into two main groups: a) the lower base communities (LB) and b) the middle-upper zone communities (MU). Moreover, the middle-upper zone communities (MU) were divided into two sub-groups associated with the successional gradient (MU1 and MU2). DECORANA classified these communities along the ordination axes 1 and 3 related to the height gradient of *Picea orientalis* and the moisture (from mesic to xeric) gradient of the epiphytic habitat. While *Exsertotheca crispa, Cynodontium fallax, Lewinskya striata*, and *Habrodon perpusillus* were only found on old spruce trees, *Drepanium fastigiatum* was only found on young trees and *Lophocolea heterophylla* was only found on middle-aged trees.

Keywords:
Bryophytes, epiphytic, succession, TWINSPAN, DECORANA, Turkey.

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INTRODUCTION

Bryophytes, which are one of the earliest and most diversified groups of land plants, are pioneer plants in the early successional stages (Gensel 2008; Song *et al*. 2015; Ezer 2017; Ezer *et al*. 2019). They grow on several substrate types and have a wide variety of habitats in almost all the climates of the earth from tropical regions to the poles (Ezer *et al*. 2019)

Bryophytes, which are poikilohydric, are non-vascular plants which absorb water and water-soluble minerals directly through their surfaces via diffusion, making them sensitive to environmental changes in their habitats (Song *et al*. 2012, 2015). The species composition and spatial distribution of epiphytic bryophyte communities within the epiphytic habitat are shaped by microclimate characteristics, phorophyte species, tree age, height gradients, and forest stand type (Mazimpaka & Lara 1995; Ariyanti *et al*. 2008; Song *et al*. 2015; Ezer 2017). Drought is one of the most important abiotic factors affecting the colonization of bryophytes on trunk surfaces and epiphytic bryophyte succession (Mazimpaka & Lara 1995; Ezer 2017; Ezer *et al*. 2019).

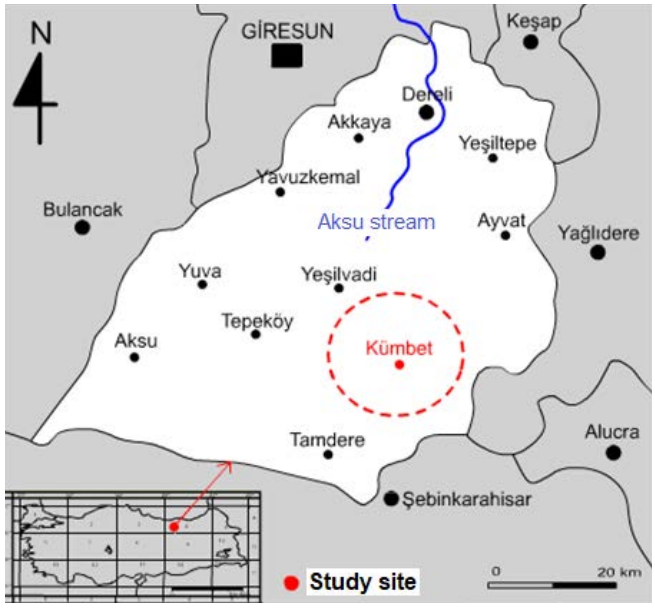

Fig. 1. Grid system of Turkey adopted by Henderson (1961) and the study area

Few studies, such as those carried out by Ezer & Kara (2013), Ezer (2017), and Ezer *et al.* (2019), have focused on the succession of epiphytic bryophyte communities in Turkey. Therefore, the present study aims to provide information about the community structures of epiphytic bryophytes in successional stages and to further contribute to bryophyte ecology studies in Turkey.

The study area. The Kümbet Plateau (Giresun/Dereli), which is in the Colchic zone of the Euro-Siberian phytogeographical region, is located on the slopes of the Giresun Mountains facing the Black Sea. According to Henderson's grid-square system for Turkey, the plateau is located in the A4 square (Henderson 1961; Anşin 1983) (Fig. 1).

While the northern border of the plateau, where the average altitude is 1640 meters, lies on the Calba, Kaçkayas and Cımbırtılık Streams, the western border is located in the Aymaç, Çin, Kertboğazı and Düdlek Hills. The southern border of the plateau is on Katankaya Hill, while the eastern border is situated in the Tıngırık and Taşbaşı Hills (Aydınözü & Solmaz 2003).

Lithologically, the valleys of the Kümbet Plateau generally have the appearance of a high plateau deeply split by rivers, and are narrow and deep. The plateau and its surroundings are covered with a thick layer of andesitic-basaltic lavas and tuffs (Ardel 1963).

The Kümbet Plateau is, in general, under the influence of the Black Sea climate. However, the transitional climate prevails between the continental climate and the Black Sea climate due to its distance from the coast (Aydınözü & Solmaz 2003). The average annual rainfall is 867 mm, and the average annual temperature is 12.7°C. The hottest month of the year is August, and the coldest month is January (https://en.climate-data.org/).

Mixed forests consisting of *Picea orientalis* (L.) Link, *Fagus orientalis* Lipsky., *Carpinus betulus* L., *Acer platanoides* L., *Alnus glutinosa* L., *Corylus avellana* L., and various *Quercus* species constitute the vegetation of the area. These forests are seen in the plateau between 1000-1500 meters. In addition, pure spruce forests, which begin at about 1500 m, also cover the area, especially along the valley slopes of the Çamkotu Stream. In the Alpine Belt over 2000 meters, various types of herbs and flowers contribute to a very rich alpine flora (Aydınözü & Solmaz 2003).

MATERIALS AND METHODS

Field procedures. The bryophyte specimens were collected from the trunks of *Picea orientalis* on the Kümbet Plateau during the field studies in 2019. Only one tree species (*P. orientalis*) was deliberately chosen in order to avoid ecological variations caused by different phorophyte bark structures and heterogeneity (Moe & Botnen 2000). The sampling sites were also selected within the homogeneous parts of the study area and ecotones were avoided. The details of the sampled localities are given in Table 1.

According to tree density and factors of environmental homogeneity, a total of 20 trees of *P. orientalis* of different ages were sampled within the mixed forest.

Each tree was divided into the lower base zone (0–40 cm from the ground), the middle zone (40–120 cm), and the upper zone (120–180 cm), according to Moe & Botnen (2000).

Each sample plot taken from the tree zones was defined as 20 × 20 cm quadrat only on the trunks of the pyrophytes depending on the species diversity within the stratified area to be sampled.

The spruce trees were divided into three age classes using an indirect method as young (dbh 150-180 cm, 15 sampling plots), middle-aged (dbh 200-220 cm, 21 sampling plots), and old trees (dbh 224-270 cm, 24 sampling plots). A total of 60 sampling plots were taken from each tree zone on 20 tree trunks. The percentage cover of

Table 1. Details of the sampled localities

Site	GPS Coordinate	Altitude (m)
L1	N 40°35'20.73" E 38°26'55.07"	1283
L2	N 40°35'21.67" E 38°26'56.10"	1276
L3	N 40°35'24.40" E 38°26'57.04"	1268
L4	N 40°35'26.89" E 38°26'55.81"	1271

the species was visually estimated within each sample plot, and species percentage cover and ecological data were also recorded. The species nomenclature follows Ros *et al*. (2007, 2013) and Hodgetts *et al*. (2020) (Table 2). The habitat affinities of the epiphytic bryophytes were determined following Mazimpaka & Lara (1995) and Draper *et al*. (2003). The life forms of the species were determined according to Magdefrau (1982). The voucher specimens were stored in the herbaria of Karadeniz Technical University and Niğde Ömer Halisdemir University.

Data description. The relative abundance of each species within the sample plots was calculated using the Index of Ecological Significance which is mathematical estimation tool developed by Lara & Mazimpaka (1998), Albertos *et al*. (2001) and Mazimpaka *et al*. (2009). The formula is as follows:

$$IES = F (1 + C)$$

F (relative frequency) = 100 x / n, and C (species cover) = Σ ci / x

where **x** represents the number of sampling plots with the species, **n** is the total number of sampling plots, and **ci** is the cover class assigned to the species in each sampling plot. The cover classes of the species were established using the Lara & Mazimpaka (1998) scale [0.5(<1%), 1(1–5%), 2(6–25%), 3(26–50%), 4(51–75%), and 5(76–100%]. The IES values were combined in the following abundance classes: very scarce (< 25), scarce (26–50), moderately abundant (51–100), abundant (101–200), and dominant (> 200).

The multivariate statistical technique has been widely used recently by ecologists to determine the relationship between communities and the ecological factors of their habitats (Ahmad & Yasmin 2011).

The ordination and classification of the epiphytic bryophyte communities were determined through the TWINSPAN and DCA methods based on the IES abundance classes as pseudospecies (Hill 1979).

TWINSPAN and DECORANA were applied to the matrix of cover estimates of 21 species in 60 sampling plots using the CAP software package (Community Analysis Package-III) by (Seaby *et al*. 2004).

Table 2. List of the epiphytic bryophytes found at the study site and their families, life form types and habitat affinity

Species	Families	Life Forms	Habitat affinity
MOSSES			
Isothecium alopecuroides (Lam. ex Dubois) Isov.	Lembophyllaceae	mat	Cortico-saxicolous
Leucodon sciuroides (Hedw.) Schwaegr.	Leucodontaceae	tail	Customary epiphyte
Pterigynandrum filiforme Hedw.	Pterigynandraceae	tail	Cortico-saxicolous
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt	Neckeraceae	fan	Cortico-saxicolous
Neckera pumila Hedw.	Neckeraceae	fan	Cortico-saxicolous
Ulota crispa (Hedw.) Brid.	Orthotrichaceae	cushion	Customary epiphyte
Hypnum cupressiforme Hedw.	Hypnaceae	mat	Indifferent
Lewinskya striata (Hedw.) F.Lara, Garilleti & Goffinet	Orthotrichaceae	cushion	Customary epiphyte
Exsertotheca crispa (Hedw.) S. Olsson, Enroth & D. Quandt	Neckeraceae	fan	Cortico-saxicolous
Hypnum andoi A.J.E. Sm.	Hypnaceae	mat	Cortico-saxicolous
Paraleucobryum longifolium (Hedw.) Loeske	Dicranaceae	tT	Indifferent
Pseudoleskeella nervosa (Brid.) Nyholm	Leskeaceae	mat	Cortico-saxicolous
Cynodontium fallax Limpr.	Rhabdoweisiaceae	sT	Cortico-saxicolous
Habrodon perpusillus (De Not.) Lindb.	Pterygynandraceae	mat	Customary epiphyte
Drepanium fastigiatum (Hampe) C.E.O.Jensen	Hypnaceae	mat	Cortico-saxicolous
Platygyrium repens (Brid.) Schimp.	Pylaisiadelphaceae	weft	Cortico-saxicolous
LIVERWORTS			
Frullania tamarisci (L.) Dumort.	Frullaniaceae	mat	Cortico-saxicolous
Frullania dilatata (L.) Dumort.	Frullaniaceae	mat	Customary epiphyte
Metzgeria furcata (L.) Corda	Metzgeriaceae	mat	Indifferent
Radula complanata (L.) Dumort.	Radulaceae	mat	Customary epiphyte
Lophocolea heterophylla (Schrad.) Dumort.	Lophocoleacea	mat	Indifferent

RESULTS

As a result of the identification of 422 bryophyte specimens within 60 sample plots taken from the trunks of *P. orientalis*, a total of 21 species were determined. Among them, 16 were mosses (12 pleurocarpous and 4 acrocarpous), and 5 were liverworts. Neckeraceae and Hypnaceae were the most common families on the sampled spruce trunks with three species on each one (Table 2).

Seven life forms were identified. Mats (52.3%) were the predominant life form due to the dominance of large pleurocarpous mosses such as *Isothecium alopecuroides* and *Hypnum andoi*, and the majority of the liverwort species. Short turf, tall turf and weft were the scarcest life forms with 4.7% (Table 2). Cortico-saxicolous are the most frequent species (11 species), followed by customary epiphytes (6 species) and indifferent (4 species).

A total of twelve species were determined on the lower bases of the young trees of *P. orientalis* (5 trees). Among them, *Isothecium alopecuroides* was the most frequent and the most dominant species with an IES value of 400, and *Hypnum andoi* was co-dominant with the second highest IES value (240). *Frullania tamarisci, F. dilatata* and *Radula complanata* were the abundant liverwort species on the lower bases of the young spruce trees, respectively. *Drepanium fastigiatum* was another moderately abundant species on the lower bases of the young trees with the relatively lowest IES value (80) (Table 3). Mat was the most dominant life form at 75%. The fan type was the second important life form on the lower bases at 16.6%. The most common species from the lower bases of the young trees were cortico-saxicolous at 66.6% (Table 3).

Eleven bryophyte species were collected from the lower base of middle-aged *P. orientalis* (total seven trees).

Table 3. IES values in each tree-size group

	Young trees (dbh 150-180 cm)			Middle aged trees (dbh 200-220 cm)			Old trees (dbh 224-270 cm)		
Species	**Lower base**	**Middle zone**	**Upper zone**	**Lower base**	**Middle zone**	**Upper zone**	**Lower base**	**Middle zone**	**Upper zone**
Mosses									
Isothecium alopecuroides (Lam. ex Dubois) Isov.	400	180	80	385	86	43	380	100	50
Leucodon sciuroides (Hedw.) Schwaegr.	-	-	220	-	43	114	25	138	113
Pterigynandrum filiforme Hedw.	80	100	320	57	143	228	125	212	200
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt	80	140	160	43	154	100	113	175	163
Neckera pumila Hedw.	60	200	280	128	314	328	125	325	245
Ulota crispa (Hedw.) Brid.	-	40	140	28	71	114	25	100	63
Hypnum cupressiforme Hedw.	60	-	40	-	43	43	88	125	-
Lewinskya striata (Hedw.) F.Lara, Garilleti & Goffinet	-	-	-	-	-	-	-	25	-
Exsertotheca crispa (Hedw.) S. Olsson, Enroth & D. Quandt	-	-	-	-	-	-	38	-	50
Hypnum andoi A.J.E. Sm.	240	300	120	385	257	271	275	225	338
Paraleucobryum longifolium (Hedw.) Loeske	-	-	40	-	28	100	63	25	50
Pseudoleskeella nervosa (Brid.) Nyholm	60	40	120	28	57	128	50	50	100
Cynodontium fallax Limpr.	-	-	-	-	-	-	25	-	25
Habrodon perpusillus (De Not.) Lindb.	-	-	-	-	-	-	-	25	-
Drepanium fastigiatum (Hampe) C.E.O.Jensen	80	-	-	-	-	-	-	-	-
Platygyrium repens (Brid.) Schimp.	-	-	-	-	86	28	-	75	50
Liverworts									
Frullania tamarisci (L.) Dumort.	180	340	240	271	214	243	212	175	212
Frullania dilatata (L.) Dumort.	120	160	160	71	185	185	112	175	75
Metzgeria furcata (L.) Corda	40	-	80	28	28	-	100	75	75
Radula complanata (L.) Dumort.	160	220	220	143	171	185	150	200	200
Lophocolea heterophylla (Schrad.) Dumort.	-	-	-	-	28	-	-	-	-

Isothecium alopecuroides and *Hypnum andoi* were the most frequent and dominant species with an IES value of 385. *F. tamarisci* was co-dominant with the second highest IES value (271). Mat was the predominant life form at 63.63%, and fan co-dominant at 18.18%. Also, on the lower bases of the middle-aged spruce trees, cortico-saxicolous species were dominant at 63.63% (Table 3).

Sixteen epiphytic bryophytes were determined on the lower bases of the old spruce trees (8 trees). *Isothecium alopecuroides* was still the most dominant species with an IES value of 380, and *H. andoi* was the co-dominant moss with the second highest IES value (275). Mat was the predominant life form at 50%, followed by fan (18.75%) and tail (12.5%) (Table 3). Cortico-saxicolous species were the most frequent (56.25%), followed by customary epiphytes at 25% (Table 3).

Ten bryophyte species were collected from the middle zones of young trees of *P. orientalis*. *Frullania tamarisci* was the most dominant with the highest IES value (340) and *Hypnum andoi* was co-dominant with an IES value of 300 (Table 3). Mat was the predominant life form at 60%, and fan was co-dominant at 20%. Cortico-saxicolous species prevail on the middle zones of the young trees (Table 3).

A total of 16 bryophytes were found on the middle zones of the middle-aged trees. *Neckera pumila* was the most common with an IES value of 314, and *Hypnum andoi* was co-dominant with the second highest IES value (257). Mat (56.25%) was still the most dominant life form, and cortico-saxicolous species (50%) also prevail on the middle zones of the middle-aged trunks (Table 3). The slender leafy liverwort *Lophocolea heterophylla* was found only in these plots.

The middle zones of old *P. orientalis* show the highest species diversity with a total of 17 species. *Neckera pumila* was the most dominant and constant with the highest IES value (325), while *Hypnum andoi* was co-dominant (225 IES value). The colonizer moss *Pterigynandrum filiforme* was abundant and frequent with a relatively high IES value (212). *Habrodon perpusillus,* with a low IES value (25), was only found in these plots. Mat life forms prevail (53%), and cortico-saxicolous species (47%) were still the most common, followed by customary epiphytes (35%) (Table 3).

A total of 14 bryophyte species were found on the upper zones of the young spruce trunks. *Pterigynandrum filiforme*, which shows a high asexual reproduction effort, was the most common and dominant with the highest IES value (320), while *Neckera pumila* was co-dominant with an IES value of 280 (Table 3). Mat life forms were still predominant at 57% on the upper zones of the old *Picea orientalis* trees; cortico-saxicolous species were still the most common at 50% and customary epiphytes were the second most common at 28.5% (Table 3).

Fourteen epiphytic bryophytes were recorded on the upper zones of both the middle-aged and young spruce trees. *Neckera pumila* and *H. andoi* were the most dominant species with the highest IES values (328 and 271 respectively). Mat (50%) was the most dominant life form; cortico-saxicolous species (57%) were the most common, followed by customary epiphytes (28.5%) (Table 3).

Sixteen bryophyte species were collected from the upper zones of old trees of *P. orientalis*. Among them, *Hypnum andoi* was the most dominant species with the highest IES value (338), followed by *Neckera pumila* with an IES value 245. Mat life forms (43.75%), cortico-saxicolous species (62.5%) and customary epiphytes (25%) also still prevail in these plots (Table 3).

TWINSPAN classification. TWINSPAN classification techniques on the cover estimates of the 21 species recorded within the 60 sample plots classified two major communities at the second level according to the successional gradient. TWINSPAN also divided one of the major communities into two sub-communities (Fig. 2). These epiphytic bryophyte communities were named according to the first two dominant species within the community.

Epiphytic bryophyte communities. The first major community is the lower base community (LB). The community was named *Isothecium alopecuroides-Hypnum andoi* according to the two dominant species. It was determined on the basal zones of the spruce trunks. The community was characterized by dominant *Isothecium alopecuroides,* co-dominant *Hypnum andoi,* moderately abundant *Drepanium fastigiatum,* and very scarce *Exsertotheca crispa* (Fig. 2). The LB community was represented by a total of 20 sample plots from the lower bases of the middle-aged trees (Fig. 3). The LB community, which included a total of 18 species, was mostly composed of cortico-saxicolous and large pleurocarpous species. The liverwort *Lophocolea heterophylla* was only found within the lower base community. *Isothecium alopecuroides* was the leading cortico-saxicolous species, together with *Hypnum andoi*. Both species are mesophytic and show the highest IES value on the basal part of the spruce trees which had more moisture and nutrient-rich elements than the middle and upper zones due to their proximity to the soil. Mat was the most dominant life form due to the highest occurrence and cover percentage of *Isothecium alopecuroides, Hypnum andoi,* and *Frullania tamarisci*.

The second major community is the middle-upper zone community (MU). The community was characterized by dominant *Neckera pumila, Hypnum andoi,* and *Frullania tamarisci* and abundant *Pterigynandrum filiforme*. The MU community was divided into two sub-communities by TWINSPAN, MU1 and MU2 (Fig. 2).

The MU1 sub-community was represented by a total of 13 sample plots which were taken from the middle and upper zones of the spruce trunks. It was named *Neckera*

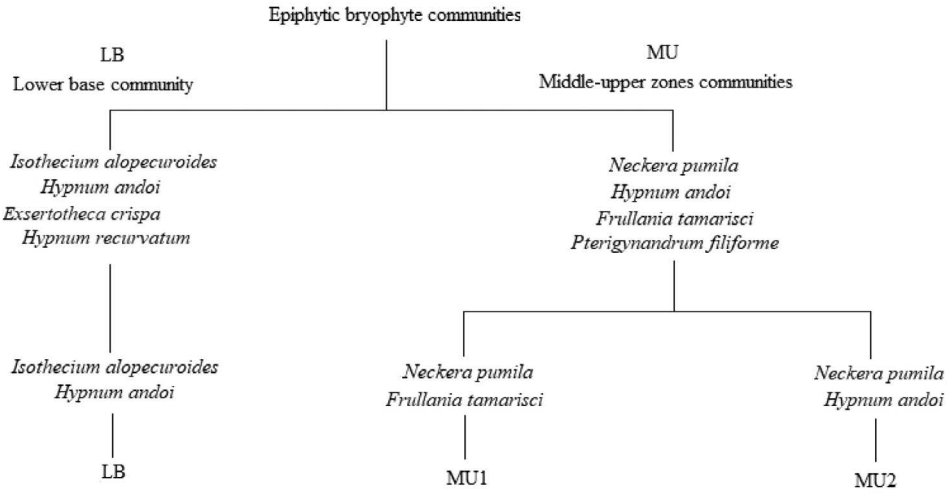

Fig. 2. TWINSPAN classification for 60 sample plots and 21 epiphytic bryophyte species

pumila-Frullania tamarisci according to the two dominant species. Within the sub-community, which included a total of 15 species, mats and cortico-saxicolous species were dominant; while customary epiphytes were co-dominant. *Ulota crispa*, a cushion-type species, was also found in the MU1 sub-community.

Lastly, the MU2 sub-community, characterized by *Neckera pumila* and *Hypnum andoi*, was represented by a total of 27 sample plots. This community, which included a total of 17 species, was widespread in the *Picea orientalis* forests. Mats and cortico-saxicolous species were still dominant, and customary epiphytes co-dominant. Cushion-type species *Ulota crispa* and customary epiphyte *Lewinskya striata* were also found in this sub-community.

Detrended Correspondence Analysis (DECORANA) Ordination. A matrix of 60 sample plots and 21 species was ordinated using Detrended Correspondence Analysis (DECORANA) (Fig. 3). The analysis revealed the relationships between the spatial pattern and species composition of the communities and ecological factors, especially the microclimatic factors of the habitat. According to this, DCA axis 1 was interpreted as the gradient of the height of the epiphytic habitat (from the lower base to the upper zone) on phorophytes, whereas axis 3 was interpreted as the gradient of moisture (from mesic to xeric) (Fig. 3). Axis 2 was not meaningful to the communities and ecological factors of the study site.

DISCUSSION

The general morphological physiognomy of all the epiphytic bryophyte communities on the trunks of *Picea orientalis* in the present study were mainly pleurocarpous mosses due to *Isothecium alopecuroides, Hypnum andoi,* and *Neckera pumila,* and the large leafy liverwort *Frullania dilatata*. This situation was not surprising for the study area which was under the influence of the oceanic climate at the macroclimate level since pleurocarpous mosses are generally more sensitive to drought than acrocarpous mosses and grow successfully in humid habitats. The development of epiphytic bryophytes is usually dependent on microclimatic factors, especially on moisture conditions (Draper *et al*. 2005). Also, the colonization of epiphytic bryophytes directly influenced by microenvironmental biotic and abiotic factors such as the bark characteristics of the phrophyte species as well as humidity (Barkman 1958; Burgaz *et al*. 1994; Lara & Mazimpaka 1998; Draper *et al*. 2003, 2005; Mazimpaka *et al*. 2009; Medina *et al*. 2010).

The *Isothecium alopecuroides-Hypnum andoi* community, found on the lower bases of the spruce trunks, was the most species-rich community with 18 species (85.7%). Although macroclimatic variables during spring and summer are the most important predictor of bryophyte richness, abundance is mostly related to forest structure and controlled by epiphytic habitat characteristics (Medina *et al*. 2014; Ezer 2017). The lower base zones of trees are more humid than the middle and upper zones, and the ecological factors are more diverse (Barkman 1958). Moreover, the basal parts of trees offer a larger colonization surface, moisture, nutrients, and shelter for epiphytic bryophytes, especially for liverworts and pleurocarpous mosses due to their proximity to terrestrial habitats (Mazimpaka *et al*. 2009; Ezer 2017; Ezer *et al*. 2019). Consequently, the diversity of the abiotic ecological factors of the basal substratum of the

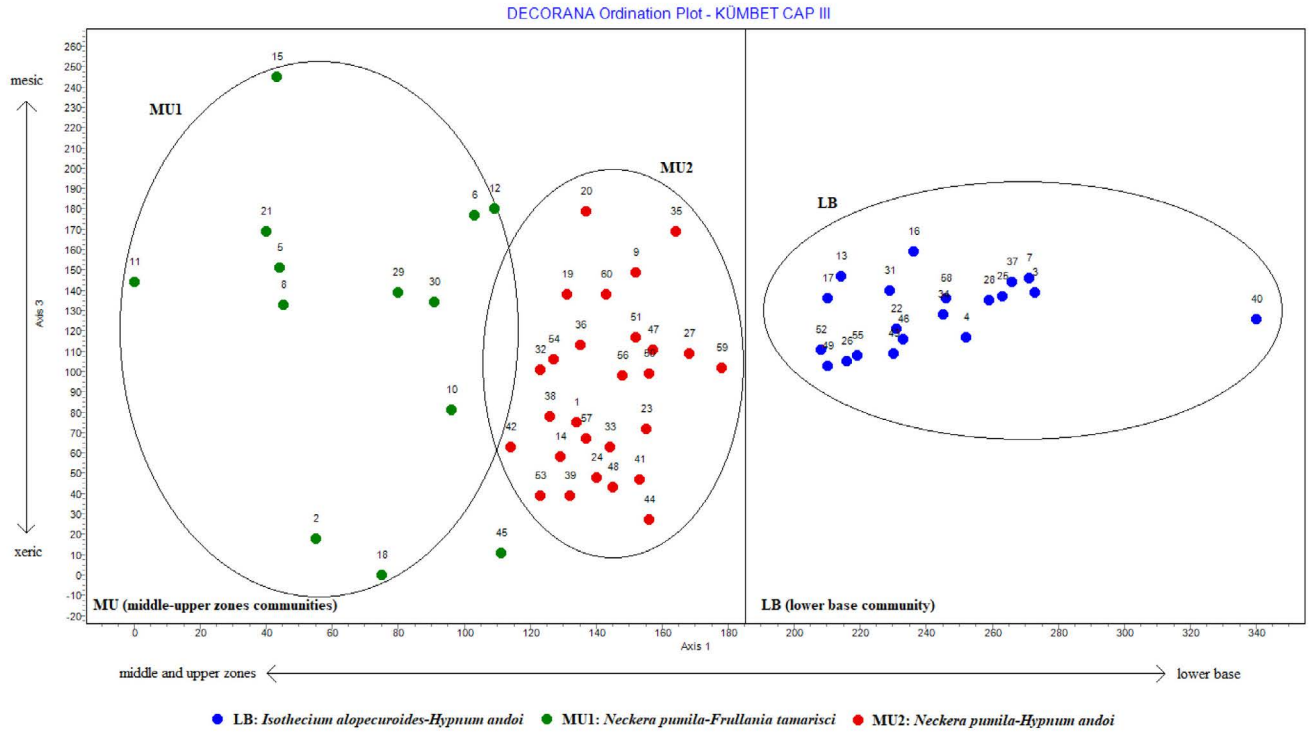

Fig. 3. DCA ordination for 60 sampling plots with TWINSPAN groups

trees may explain the epiphytic bryophyte richness on the lower base zones in the present study.

The middle-upper zone community *Neckera pumila-Frullania tamarisci* (MU1) includes 15 species, and *Neckera pumila-Hypnum andoi* (MU2) 17 epiphytic species. The middle and upper zones of the tree trunks are periodically exposed to more desiccation and higher insolation than the basal parts of the trunks, thus making the colonization of hygrophytic and mesophytic bryophytes quite difficult (Moe & Botnen 2000). Desiccation-tolerant bryophytes such as *Ulota crispa, Lewinskya striata*, *Leucodon sciuroides*, and *Paraleucobryum longifolium*, have a higher cover percentage within the middle-upper zone communities at the study site. Moreover, the strong competitor moss species *Pterigynandrum filiforme* and *Alleniella complanata* and the weak competitor customary epiphyte *Frullania dilatata* were also abundant with high cover percentages (Table 3).

The physical and chemical properties of tree bark change as the diameter of the tree trunk increases over time (Fridel *et al.* 2006). The bark of young trees is grayish, thin and smooth. However, as the tree ages, the bark turns brownish, deep cracks occur, and the tree bark thickens (Ezer 2017). These changes occurring in tree bark over time significantly affect the spatial patterns and species composition of epiphytic communities. The results of several studies on epiphytic succession revealed that the floristic composition and spatial patterns of epiphytic bryophyte communities in the successional stages were closely related to phorophyte species, tree diameter, tree age, and changes in bark characteristics as well as microclimatic conditions (Lara & Mazimpaka 1998; Mazimpaka *et al.* 2010; Ódor *et al.* 2013; Bargali *et al.* 2014; Ezer 2017; Ezer *et al.* 2019). The meso-xerophytic facultative epiphyte *Frullania dilatata*, and the xerophytic *Ulota crispa* were the pioneer colonizers of the upper parts of the young spruce trees in the early successional stages in the present study. The bark of the old *Picea orientalis* trees in the study area had deep cracks and was thick. Therefore, weak competitor species such as *Metzgeria furcata*, *Radula complanata*, *Lewinskya striata*, *Ulota crispa*, and *Paraleucobryum longifolium* underlie the large and strong competitor pleurocarpous mosses such as *Pterigynandrum filiforme*, *Hypnum andoi*, and *Neckera pumila,* and the large mat liverwort species *Frullania tamarisci* in the advanced successional stages in the study area.

Finally, the colonization of epiphytic bryophyte communities in early successional stages begins with sparse small cushions of the xerophytic Orthotrichaceae species on the trunks of young trees. As the diameter of the tree trunks increases, so do the frequency and cover of the pioneer species, and new bryophytes appear, which have cushion and tail life forms, and this is related to the fact that, as the tree ages, the trunks create more diverse communities than younger ones with many associated

species. Conversely, in the advanced successional stages toward the climax stage, cushion-type mosses decline or disappear, and mat and tail type bryophytes and large pleurocarpous mosses become dominant.

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REZIME

Botanica SERBICA

Sukcesija epifitskih briofita u šumama *Picea orientalis* na visoravni Kümbet (Giresun-Turska)

Tülay Ezer, Mevlüt Alataş, Nevzat Batan i Hüseyin Erata

U ovoj studiji je istraživana sukcesija epifitskih briofita u šumama *Picea orientalis* na visoravni Kümbet (Giresun-Turska). Određena je ukupno 21 vrsta epifitskih briofita (16 mahovina i 6 jetrenjača). Zajednice epifitskih briofita su sakupljene sa 60 površina (svaka 20 × 20 cm) na stablima *Picea orientalis*. Indeks ekološke značajnosti (IES) baziran na kombinaciji relativne učestalosti i srednje pokrovnosti epifitskih briofita, korišćen je za procenu brojnosti njihovih zajednica u epifitskim staništima na stablima. Dodatno, multivarijantne klasifikacijske analize (TWINSPAN i DECORANA) su korišćene za klasifikaciju struktura zajednica u sukcesivne stadijume. Na osnovu TWINSPAN analize, 60 uzoraka je grupisano u sve glavne grupe: a) zajednice donje zone (LB); i b) zajednice srednje-gornje zone (MU). Šta više, zajednice srednje-gornje zone (MU) su podeljene u dve podgrupe povezane sa gradijentom sukcesije (MU1 i MU2). DECORANA je ove zajednice klasifikovala duž ordinacijske ose 1 i 3 kao povezane sa gradijentom visine *Picea orientalis* i gradijentom vlažnosti (mezični do kserični uslovi) epifitskog staništa. Dok su *Exsertotheca crispa, Cynodontium fallax, Lewinskya striata*, i *Habrodon perpusillus* pronađene isključivo na starim stablima smrče, *Drepanium fastigiatum* je pronađena samo na mladom drveću i *Lophocolea heterophylla* je pronađena samo na drveću srednje starosti.

Ključne reči: briofite, epifite, sukcesija, TWINSPAN, DECORANA, Turska