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Epiphytic bryophyte communities of forests dominated by *Alnus glutinosa* (L.) Gaertner in Altindere Valley National Park (Trabzon, Turkey)

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ABSTRACT

The epiphytic bryophyte communities of the Altindere Valley (Maçka, Trabzon, Turkey) were studied. A total of 59 relevés, taken from living tree trunks in different vegetation periods of 2018 and 2020, were analysed according to the Braun-Blanquet methodology, and the relevés were also ordinated and classified using the Detrended Correspondence Analysis (DECORANA) and the Two-Way Indicator Species Analysis (TWINSPAN). As a result of the analyses, *Alleniella besseri*-*Leucodontetum immersi* as. nov., *Plagiomnium undulati*-*Raduletum lindbergianae* typicum and *P.-R. leucodontetosum sciuroidis* subas. nov. (*Neckerion complanatae*) were described and characterised as a new epiphytic. *Mnietum cuspidati*, *Homalothecio sericei*-*Neckeretum besseri* and *Brachythecietum populei*-*isothecietosum alopecuroidis* were also described as new to Turkey, whereas *Brachythecietum populei* typicum was recorded for the second time in Turkey.

KEY WORDS

Communities,
epiphytic bryophytes,
phytosociology,
TWINSPAN,
DECORANA.

RÉSUMÉ

Communautés de bryophytes épiphytes des forêts dominées par Alnus glutinosa (L.) Gaertner dans le parc national de la vallée d'Altindere (Trabzon, Turquie).

Les communautés de bryophytes épiphytes de la vallée d'Altindere (Maçka, Trabzon, Turquie) ont été étudiées. Un total de 59 relevés, prélevés sur des troncs d'arbres vivants à différentes périodes de végétation de 2018 et 2020, ont été analysés selon la méthodologie de Braun-Blanquet, et les relevés ont également été ordonnés et classés à l'aide de l'analyse des correspondances tendues (DECORANA) et de l'analyse des espèces indicatrices à deux voies (TWINSPAN). Ces analyses permettent aux auteurs de décrire et caractériser les nouvelles associations épiphytes : *Alleniella besseri-Leucodontetum immersis* as. nov., *Plagiomnium undulati-Raduletum lindbergianae* typicum et *P-R. leucodontetosum sciuroidis* subas. nov. (*Neckerion complanatae*). *Mnietum cuspidati*, *Homalothecio sericeae-Neckeretum besseri* et *Brachythecietum populei-isothecietosum alopecuroidis* ont également été décrits comme nouveaux en Turquie, tandis que *Brachythecietum populei typicum* a été enregistré pour la deuxième fois en Turquie.

MOTS CLÉS
Communautés,
bryophytes épiphytes,
phytosociologie,
TWINSPAN,
DECORANA.

INTRODUCTION

Nutrient-rich tree bases, cracks in tree barks, irregular surfaces in branches, and depressions in branch bases are suitable habitats for epiphytic bryophytes (Schofield 2001). Especially, trunks of *Alnus glutinosa* (L.) Gaertner – which is the most dominant tree species in the Altindere Valley – provide a suitable habitat for epiphytic bryophytes because of their bark structures. *Alnus glutinosa* has a dark-green, thin and non-cracked bark when it is young, whereas its bark is dark-grey, thick and cracked when it is old (Mamikoğlu 2007). This cracked and rough bark structure leads to the formation of micro-habitats with different characteristics.

Floristic studies on bryophytes, which is one of the most important components of Turkish biodiversity, have advanced quickly in the last decade (Batan *et al.* 2016, 2019 ; Uyar *et al.* 2018; Ellis *et al.* 2019, 2020; Ursavaş & Keçeli 2019; Ursavaş & Işın 2019; Erata & Batan 2020; Unan *et al.* 2020; Ursavaş *et al.* 2020; Erata *et al.* 2021). A total of ± 1044 bryophyte taxa (± 44 mosses, ± 196 liverworts and ± 4 hornworts) have been reported in Turkey (Erdağ & Kürschner 2017; Kürschner & Frey 2020). Thus, the Turkish bryoflora is the richest among Southwest Asian countries (Kürschner & Frey 2020).

Although floristic studies on bryophytes in Turkey progress quickly, phytosociological studies have been rather limited. Among these, studies targeting epiphytic bryophyte communities have increased rapidly over the last decade (Alataş *et al.* 2016, 2017, 2019a, b, c; Ezer 2017; Can Gözcü *et al.* 2018). Nevertheless, more studies need to be conducted in order to reveal the phytosociological situation in Turkey.

A number of epiphytic bryophyte communities have recently been recorded for Turkey (Alataş 2018; Alataş *et al.* 2019a, b, c), but the epiphytic bryophyte vegetation of many regions of the country is still unknown.

According to the results of the studies on the epiphytic bryophyte vegetation, a total of 45 syntaxa have been determined in Turkey so far. Among them, 38 are at the association and sub-association levels, and seven are at the

community level due to their unknown syntaxonomical status (Alataş 2018).

The bryophytes of the Altindere valley were listed 24 years ago (Baydar & Özdemir 1996), but nearly nothing was known on the epiphytic bryophyte communities of this *Alnus glutinosa* dominant forest. In this context, the present study aims to contribute to our knowledge on the bryosociological diversity of the valley and northern Turkey.

STUDY AREA

The Altindere Valley, which is in the A4 square according to the grid-system of Turkey adopted by Henderson (1961), is in the colchic zone of the Euro-Siberian phytogeographic region (Anşın 1983: fig. 1). The valley was declared as a national park in 1987 (situated in Maçka District of Trabzon Province, with 4800 ha). It extends to a distance of approximately 20 km to the southeast direction, following the district centre, and can be geographically described as a narrow and deep canyon. The east and west walls of the valley ascend abruptly, creating very steep slopes. The geological structure consists of three layers belonging to the Mesozoic, Eocene and Oligocene epochs. The main rock consists of trachea andesite and basalt.

Two types of vegetation dominate the area: forest vegetation up to 1900–2000 m altitude, and alpine vegetation above this altitude. It is possible to gather the stands in the forest vegetation in three groups. These are pure spruce stands, mixed stands of spruce and deciduous species, and mixed stands formed by deciduous species. In addition to *A. glutinosa*, the most important taxa of natural vegetation in the study area are *Picea orientalis* (L.) Link, *Fagus orientalis* Lipsky., *Castanea sativa* Miller., *Abies nordmanniana* (Stev.) Spach., *Pinus sylvestris* L., *Carpinus betulus* L., *Ulmus minor* Mill., *Salix alba* L., *Tilia tomentosa* Moench., *Rhododendron ponticum* L. and *Lonicera caucasica* Pallas.

The Altindere Valley is under oceanic climate, like all parts of north-eastern Anatolia. The average annual rainfall is 771 mm and the average annual temperature is 13°C. The

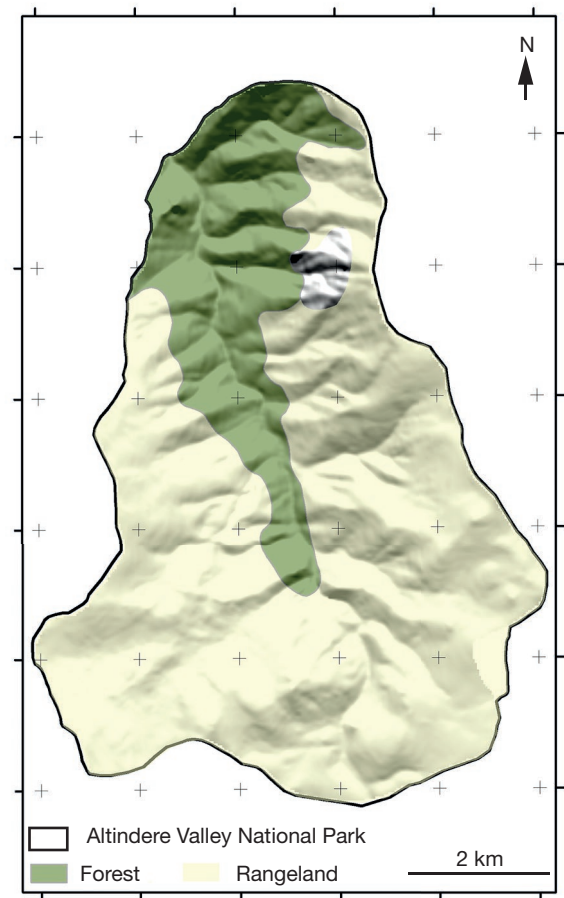


Fig. 1. — Location of the study area.

TABLE 1. — List of localities. Abbreviations: *A.g.* (*Alnus glutinosa*), *C.b.* (*Carpinus betulus*), *P.o.* (*Picea orientalis*), *C.s.* (*Castanea sativa*).

Number of relevés	Localities	Altitude (m)	Phorophyte	Date	GPS Coordinates
1-7	1	594	<i>A.g.</i>	04.V.2018	40°45'14.92"N, 39°37'22.40"E
8-12	2	655	<i>A.g.</i>	05.V.2018	40°44'56.80"N, 39°37'49.97"E
13-15	3	769	<i>A.g.</i>	13.VII.2018	40°44'02.53"N, 39°38'01.59"E
16-19	4	836	<i>A.g.</i>	14.VII.2018	40°43'25.35"N, 39°38'28.50"E
20-28	5	862	<i>A.g.</i>	07.IX.2018	40°43'01.81"N, 39°38'40.56"E
29-32	6	897	<i>A.g.</i>	08.IX.2018	40°42'44.34"N, 39°38'52.01"E
33-37	7	1107	<i>A.g.</i>	05.V.2020	40°41'31.91"N, 39°39'37.93"E
38-44	8	955	<i>A.g.</i>	06.V.2020	40°42'16.49"N, 39°39'01.25"E
45-47	9	782	<i>A.g.</i> , <i>C.b.</i>	22.VI.2020	40°43'52.21"N, 39°38'10.70"E
48-50	10	841	<i>A.g.</i>	23.VI.2020	40°43'15.34"N, 39°38'36.37"E
51-52	11	885	<i>A.g.</i>	24.VI.2020	40°42'50.99"N, 39°38'51.30"E
53-55	12	920	<i>A.g.</i> , <i>P.o.</i>	25.VIII.2020	40°42'33.43"N, 39°38'53.14"E
56-57	13	956	<i>P.o.</i> , <i>C.s.</i>	26.VIII.2020	40°42'15.75"N, 39°39'01.01"E
58-59	14	960	<i>A.g.</i> , <i>P.o.</i>	27.VIII.2020	40°42'13.71"N, 39°39'02.24"E

hottest month of the year is August, whereas the coldest month is January (CD 2020). The annual rainfall regime type in the form of SKIY and the absence of dry season indicate that the study area is under the influence of the Oceanic climate (Akman 2011). Besides, the area has a very humid climate (Çepel 1995).

MATERIAL AND METHODS

The research materials included 59 relevés and 466 bryophyte specimens collected from the lower (0-0.5 m) and middle (0.5-2 m) parts of the trunks of the trees in the Altındere Valley during the years between 2018 and 2020 (Table 1).

TABLE 2. — *Brachythecietum populei* Hagel ex Phil 1972; **a**, - *typicum*, **b**, - *isothecietosum alopecuroidis* Lauer 2002.

–	a						–	b						–
Successive number of relevés	1	2	3	4	5	6		7	8	9	10	11	12	
Number of relevés	39	41	31	29	34	18		20	33	22	44	23	27	
Altitude (m)	955	955	897	897	1107	836		862	1107	862	955	862	862	
Size of relevés (dm ²)	12	12	12	12	12	12		12	12	12	12	12	12	
Phorophyte	<i>Alnus glutinosa</i>							<i>Alnus glutinosa</i>						
Trunk (m)	2.9	2.7	2.6	2.5	3	2.4		2.8	2.7	2.6	2.9	2.6	2.5	
Exposition	N	N	N	N	N	N		N	N	N	N	N	N	
Position of relevés	NE	N	N	N	N	NW		N	N	NW	NE	N	NE	
Covering (%)	95	90	88	91	85	99		95	93	90	98	95	90	
Canopy cover (%)	100	100	100	100	100	80		90	100	90	100	90	90	
Base (B) / Trunk (T)	T	T	T	B	T	T		T	T	T	T	T	T	
Number of species	7	9	8	9	8	12		9	9	5	9	8	7	
Characteristic and differential species														
<i>Sciuro-hypnum populeum</i>	4	4	4	4	3	3		V	2	2	–	2	2	V
<i>Isothecium alopecuroides</i>	–	–	–	–	–	1		I	3	2	3	3	3	V
<i>Lejeunea cavifolia</i>	–	–	–	–	1	–		I	–	1	–	–	1	III
Ch- all <i>Neckerion complanatae</i>														
<i>Anomodon attenuatus</i>	–	–	2	–	3	2		III	–	2	3	–	2	–
<i>Alleniella complanata</i>	–	–	–	–	–	–		–	2	–	–	3	4	–
<i>Metzgeria furcata</i>	1	–	–	–	–	1		III	–	–	–	–	–	1
<i>Exsertotheca crispa</i>	3	–	–	–	–	3		III	–	–	–	–	–	–
Ch- Suball. <i>Brachythecio populei</i> - <i>Homalium trichomanoides</i>														
<i>Thuidium delicatulum</i>	2	2	–	–	–	–		III	–	–	–	2	–	–
<i>Plagiomnium cuspidatum</i>	–	–	–	–	–	–		–	3	–	–	–	–	–
Ch- Cl. <i>Neckeretea complanatae</i> and Ch O <i>Neckeretalia complanatae</i>														
<i>Radula complanata</i>	1	1	1	1	–	–		IV	1	1	–	–	1	–
<i>Metzgeria conjugata</i>	–	–	–	–	1	–		I	1	–	–	–	–	–
<i>Alleniella besseri</i>	–	3	–	–	–	2		III	–	–	–	–	–	–
<i>Plagiochila porelloides</i>	3	1	2	2	–	–		IV	2	2	–	2	–	–
<i>Hypnum andoi</i>	–	3	2	3	3	1		V	3	3	3	2	2	3
<i>Porella platyphylla</i>	–	1	–	–	–	1		III	–	–	–	–	–	–
Others														
<i>Ctenidium molluscum</i>	–	–	–	2	2	–		III	–	–	–	–	–	–
<i>Dicranum scoparium</i>	–	–	–	1	–	–		I	–	–	–	–	–	–
<i>Frullania tamarisci</i>	–	–	–	1	–	–		I	2	–	–	–	2	–
<i>Plagiomnium ellipticum</i>	–	–	–	–	–	2		I	–	–	–	–	–	–
<i>Plagiomnium undulatum</i>	–	–	–	–	–	2		I	–	–	–	–	–	–
<i>Ptychostomum moravicum</i>	–	–	–	–	1	–		I	–	1	–	–	–	–
<i>Tortella tortuosa</i>	–	–	1	–	–	–		I	–	–	–	–	–	–
<i>Ulotia crispa</i>	–	–	–	1	–	–		I	–	–	–	–	–	–
<i>Radula lindenbergiana</i>	–	–	–	–	–	1		I	–	–	2	1	–	1
<i>Plagiothecium nemorale</i>	3	2	–	–	–	–		III	–	–	–	3	–	–
<i>Eurhynchium angustirete</i>	–	2	–	–	–	–		I	–	–	–	–	–	–
<i>Brachythecium rutabulum</i>	–	–	2	–	–	–		I	–	–	–	–	–	–
<i>Pseudoleskeella catenulata</i>	–	–	–	–	2	2		III	–	–	–	–	–	–
<i>Leucodon sciuroides</i>	–	–	–	–	–	–		–	3	–	3	–	–	III

For the relevés, the abundance-coverage scale of Frey and Kürschner was used (Frey & Kürschner 1991).

These relevés were evaluated using the classical Braun-Blanquet (1964) method, as well as multivariate ordination techniques such as DECORANA (Detrended Correspondence Analysis) and TWINSpan (Two-Way Indicator Species Analysis) (Seaby *et al.* 2004). The associations were arranged by diagnostic species and named according to Weber *et al.* (2000). The associations in the present study were determined via comparison with related associations in Marstaller (2006) and classified with the use of previously published studies. For the identification of the bryophyte specimens, different floras, monographs and revisions were used. The moss specimens

were identified using Nyholm (1981), Hedenäs (1992), Zander (1993), Cortini Pedrotti (2001, 2006), Smith (2004), Heyn & Herrnstadt (2004), Frey *et al.* (2006), Brugués *et al.* (2007), Plásek *et al.* (2015), and Lara *et al.* (2016) and the liverwort specimens were identified using Paton (1999), Heyn & Herrnstadt (2004), Frey *et al.* (2006), and Casas *et al.* (2009).

RESULTS AND DISCUSSION

As a result of the evaluation of the phytosociological data three communities are newly described and three are recorded as new for Turkey, among a total of seven epiphytic bryophyte

communities found in the area: *Brachythecietum populei-isothecietosum alopecuroidis*, *Mnietum cuspidati* and *Homalothecio sericei-Neckeretum besseri* are recorded as new to Turkey, whereas *Alleniella besseri-Leucodontetum immersi*, *Plagiomnium undulati-Raduletum lindbergianae* typicum and *P.-R. leucodontetosum sciurooidis* subas. nov. are also defined as a new syntaxon from Turkey.

The floristic features of these syntaxa are given below in accordance with Marstaller (2006).

Class *Neckeretea complanatae* Marst. 1986

Order *Neckeretalia complanatae* Jeř. & Vondr. 1962

Alliance *Neckerion complanatae* Sm. & Had. ex Kl. 1948

Subassociation typicum *Brachythecietum populei* Hagel ex Phil. 1972

Subassociation *B.p. isothecietosum alopecuroidis* Lauer, 2002

Association *Mnietum cuspidati* Felf. 1941

Association *Homalothecio sericei-Neckeretum besseri* Jeř. & Vondr. 1962

Association *Alleniella besseri-Leucodontetum immersi* as. nov.

Subassociation typicum *Plagiomnium undulati-Raduletum lindbergianae* subas. nov.

Subassociation *P.-R. leucodontetosum sciurooidis* subas. nov.

DESCRIPTION OF THE SYNTAXA

Brachythecietum populei

Hagel ex Phil. 1972

(Table 2a)

It was determined by a total 6 relevés between 836–1107 m of the study area. The typical subassociation occurs on the northern surface of the *A. glutinosa* trunks and northern slopes in the study area. While the general coverage varies between 85% and 99%, the canopy cover in the area where *Brachythecietum populei* is located varies between 80% and 100%. From 26 taxa that constitute the association, 8 are liverworts and 18 are mosses. Half of the mosses are pleurocarpous, while half of them are acrocarpous. Both the coverage percentages and the numbers of the acrocarpous and pleurocarpous species show that the study area has humid and semi-arid habitats.

The mesophyte species *Sciuro-hypnum populeum*, the characteristic species of the community, has the highest frequency, and its constancy is 100% within the relevés. *Sciuro-hypnum populeum*, which prefers humid and shade habitats, grows epiphytically on trunks and epilithically on acidic rock surfaces. The average number of the taxa in the subassociation typicum is 8.

Synhierarchically, due to the fact that *Brachythecietum populei* contains the characteristic species of the *Neckeretea complanatae*, *Neckeretalia complanatae*, and *Neckerion complanatae*, it was classified within these higher taxonomical units. The class *Neckeretea complanatae* is characterized by both epiphytic and epilithic species which prefer humid and shade habitats in alkaline environments (Table 2a).

Brachythecietum populei has similar floristical and ecological characteristics with its previously published examples by Marstaller (2006, 2010), Germany (Springer 2012, 2013) and Turkey (Alataş et al. 2019b). It shares common characteristics such as *Brachythecium rutabulum*, *Plagiomnium cuspidatum*, *Isothecium alopecuroides*, *Lejeunea cavifolia*, *Ptychostomum moravicum*, *Hypnum* sp. and *Thuidium* sp.

Brachythecietum populei Hagel ex Phil.

1972-*isothecietosum alopecuroidis* Lauer, 2002

(Table 2b)

The sub-association is represented by a total of 6 relevés collected from alder trunks between 862–1107 m in the study area. While the general coverage varies between 90% and 98%, the canopy cover in the area varies between 90% and 100%. The number of the taxa in the relevés varies between 5–9. *B.p. isothecietosum alopecuroidis* is characterized by 17 taxa. Among them, seven are liverworts, while ten are mosses. Among the mosses, two are acrocarpous and eight are pleurocarpous.

The mesophyte taxon *Isothecium alopecuroides*, which is the differential species that differentiates *B.p. isothecietosum alopecuroidis* from the typical subassociation, has the highest frequency, and its constancy is 100% within the relevés (Table 2b). *I. alopecuroides* grows on tree trunks and rock surfaces. It also prefers sub-neural and shady habitats.

Mnietum cuspidati Felf. 1941

(Table 3)

Mnietum cuspidati, which spreads in the northern part of the study area, was determined by a total of 8 relevés, all of which were taken from *A. glutinosa* trunks, between 594–955 m. While the general bryophyte coverage varies between 85% and 95%, the canopy cover in the forest where it was found, varies between 80% and 100%. The association consists of a total of 23 taxa. Of these, 8 are liverworts and 15 are mosses. 7 of the mosses are pleurocarpous and 8 are acrocarpous. The average number of taxa within the community is 7. The similar number of pleurocarpous and acrocarpous taxa shows that the area where the association is distributed is characterized by a combination of moist and semi-arid habitats. As a matter of fact, acrocarpous taxa indicate the presence of arid and semi-arid habitats, whereas pleurocarpous taxa indicate the presence of humid and shady habitats.

The determined association is similar to the syntaxon determined in Germany by Marstaller (1993, 2006, 2010) and by Anishchenko (2016) in Russia in terms of floristic composition and ecological characteristics. However, the association determined in the present study, is more comprehensive than the syntaxon determined in other countries in terms of both floristic composition and relevés. This situation increases the validity of the present study.

TABLE 3. — *Mnietum cuspidati* Felf. 1941.

Successive number of relevés	1	2	3	4	5	6	7	8	Constancy Class
Number of relevés	7	17	11	25	26	43	3	40	
Altitude (m)	594	836	655	862	862	955	594	955	
Size of relevés (dm²)	12	12	12	12	12	12	12	12	
Phorophyte	Alnus glutinosa								
Trunk (m)	0.9	1.4	1.3	1.2	1.5	1.5	1.4	1.6	
Exposition	N	N	N	N	N	N	N	N	
Position of relevés	N	N	N	N	N	N	N	N	
Covering (%)	91	95	93	90	95	95	95	85	
Canopy cover (%)	90	80	100	90	90	100	90	100	
Base (B) / Trunk (T)	B	T	T	B	T	T	T	T	
Number of species	9	8	7	8	8	8	7	6	
Characteristic species									
<i>Plagiomnium cuspidatum</i>	3	4	4	4	3	4	2	1	V
<i>Brachythecium rutabulum</i>	2	–	3	–	–	–	3	–	II
Ch- All- <i>Neckerion complanatae</i>									
<i>Alleniella complanata</i>	3	3	–	–	–	3	4	–	III
<i>Anomodon attenuatus</i>	–	–	–	2	–	–	–	–	I
<i>Metzgeria furcata</i>	–	–	2	1	–	–	–	2	II
<i>Frullania tamarisci</i>	–	–	–	–	2	2	–	–	II
Ch- Suball- <i>Brachythecio populei</i> - <i>Homalium trichomanoides</i>									
<i>Thuidium delicatulum</i>	–	–	–	–	3	3	–	3	II
Ch- Cl- <i>Neckeretea complanatae</i> and Ch- O- <i>Neckeratalia complanatae</i>									
<i>Radula complanata</i>	1	–	1	1	–	–	1	1	IV
<i>Hypnum andoi</i>	3	2	–	–	3	3	2	–	IV
<i>Porella platyphylla</i>	–	–	2	–	–	2	–	–	II
<i>Plagiochila porelloides</i>	–	–	–	2	–	2	–	–	II
<i>Metzgeria conjugata</i>	–	–	–	–	–	2	–	–	I
<i>Zygodon rupestris</i>	–	–	–	–	–	–	1	–	I
Others									
<i>Dicranum tauricum</i>	–	–	–	–	1	–	–	–	I
<i>Frullania dilatata</i>	–	–	2	2	–	–	2	–	II
<i>Orthotrichum pallens</i>	1	–	–	–	–	–	–	–	I
<i>Plagiomnium ellipticum</i>	–	2	–	–	–	–	–	–	I
<i>Ulota crispa</i>	1	–	–	1	1	–	–	–	II
<i>Radula lindenbergiana</i>	–	1	–	–	–	–	–	–	I
<i>Plagiothecium nemorale</i>	–	2	–	–	2	2	–	3	III
<i>Pseudoleskeella catenulata</i>	1	–	–	–	–	–	–	–	I
<i>Isothecium alopecuroides</i>	–	2	–	–	2	–	–	–	II
<i>Plasteurhynchium striatulum</i>	–	–	–	–	–	–	–	2	

Homalothecio sericei-Neckeretum besseri

Jež. & Vondr. 1962

(Table 4)

The community only found on the trunks of the alder trees was determined with 9 relevés between 655–1107 m. The general bryophyte coverage ranges from 85% to 99%, while the canopy cover in the area where the association is spread ranges from 80% to 100%. *Homalothecio sericei-Neckeretum besseri* consists of a total of 27 taxa. Of these, 8 are liverworts and 19 are mosses. 13 of the mosses are pleurocarpous, whereas 6 are acrocarpous.

The average number of taxa is 7. Both the percentage of the coverage and the high proportion of the pleurocarpous taxa indicate that the association is a meso-hygrophyte syntaxon spreading in shadow areas.

The xerophyte taxa *Homalothecium sericeum* and *Alleniella besseri*, the main characteristic species of the association, have the highest frequency, and the species are 89% constant in the relevés. Both species generally grow on tree trunks. They also grow on epilithic environments such as rock surfaces.

Synhierarchically, due to the fact that *Homalothecio sericei-Neckeretum besseri* contains the characteristic species of the *Neckeretea complanatae*, *Neckeretalia complanatae*, and *Neckerion complanatae*, it was classified within these upper syntaxonomical units (Table 4).

In terms of floristic composition and ecological characteristic, the Turkish association is similar to the associations identified by Marstaller (2006) and Springer (2009) in Germany, and by Ragulina (2012) Gapon & Gapon (2018) in Ukraine. Therefore, *Homalothecio sericei-Neckeretum besseri* was classified within the same upper syntaxonomic units.

Alleniella besseri-Leucodontetum immersi

Ezer, Alataş & Batan as. nov.

(Table 5)

HOLOTYPE. — Prov. Trabzon, Altindere Valley, 594 m, *Alnus glutinosa* forest.

NOMENCLATURE TYPE. — Table 6, relevé no. 5, holotypus.

CHARACTERISTIC SPECIES. — *Alleniella besseri*, *Leucodon immersus*.

TABLE 4. — *Homalothecio sericei-Neckeretum besseri* Jeř. & Vondr. 1962.

Successive number of relevés	1	2	3	4	5	6	7	8	9	Constancy Class
Number of relevés	15	24	12	19	21	16	36	13	37	
Altitude (m)	769	862	655	836	862	836	1107	769	1107	
Size of relevés (dm²)	12	12	12	12	12	12	12	12	12	
Phorophyte	<i>Alnus glutinosa</i>									
Trunk (m)	1.8	1.7	1.2	1.7	1.9	1.7	2.1	1.7	2.3	
Exposition	N	N	N	N	N	N	N	N	N	
Position of relevés	NE	NW	N	N	N	NE	N	N	N	
Covering (%)	97	99	90	90	90	85	88	85	91	
Canopy cover (%)	90	90	100	80	90	80	100	90	100	
Base (B) / Trunk (T)	B	B	T	T	T	T	T	B	T	
Number of species	10	8	6	5	8	7	9	7	8	
Characteristic species										
<i>Alleniella besseri</i>	3	3	3	3	4	3	–	2	4	V
<i>Homalothecium sericeum</i>	3	4	3	4	3	–	4	3	2	V
<i>Pseudoleskeella catenulata</i>	–	–	–	–	–	2	2	–	2	I
<i>Schistidium trichodon</i>	–	–	–	–	–	–	1	–	–	
<i>Leucodon sciurioides</i>	–	–	–	–	–	–	3	–	–	
Ch. All. Neckerion complanatae										
<i>Alleniella complanata</i>	–	–	–	–	–	3	–	–	–	
<i>Anomodon attenuatus</i>	–	–	–	–	–	–	–	–	3	
<i>Anomodon viticulosus</i>	–	–	–	–	–	3	–	–	–	
<i>Metzgeria furcata</i>	–	–	–	–	–	–	1	–	2	I
<i>Frullania tamarisci</i>	–	–	–	–	2	–	–	–	–	
Ch. Suball. <i>Brachythecio populei</i> - <i>Homalium trichomanoides</i>										
<i>Isoetecium alopecuroides</i>	–	–	–	–	1	–	–	–	–	
Ch. Cl. <i>Neckeretea complanatae</i> and Ch. O. <i>Neckeretalia complanatae</i>										
<i>Radula complanata</i>	1	1	2	1	1	1	1	1	–	V
<i>Pseudoamblystegium subtile</i>	1	2	–	–	–	–	–	–	–	I
<i>Hypnum andoi</i>	3	3	–	–	2	–	2	3	–	II
<i>Porella platyphylla</i>	–	–	–	2	–	2	2	–	–	I
<i>Metzgeria conjugata</i>	1	–	–	–	1	–	–	–	–	I
<i>Plagiochila porelloides</i>	–	–	–	–	2	–	–	–	–	
<i>Lejeunea cavifolia</i>	–	–	–	–	–	–	–	1	–	
<i>Plasteurhynchium striatulum</i>	–	–	3	–	–	–	–	–	2	I
Others										
<i>Brachytheciastrum velutinum</i>	2	–	–	–	–	–	–	–	–	
<i>Frullania dilatata</i>	–	–	3	2	–	–	–	–	–	I
<i>Brachythecium rutabulum</i>	–	3	–	–	–	–	–	–	–	
<i>Plagiomnium undulatum</i>	2	–	–	–	–	–	–	3	–	I
<i>Ptychostomum moravicum</i>	1	1	–	–	–	–	1	–	1	II
<i>Tortella tortuosa</i>	–	–	–	–	–	–	–	–	1	
<i>Ulota crispa</i>	–	1	1	–	–	–	–	1	–	I
<i>Plagiomnium ellipticum</i>	2	–	–	–	–	–	–	–	–	

Alleniella besseri-*Leucodontetum immersus* is represented by a total of 15 relevés taken from the *A. glutinosa* trunks. It is spread between 594–1107 m, especially in the northern parts of the study area. The general bryophyte cover of the association varies between 65% and 97%, while the canopy cover varies between 90% and 100%. The number of the taxa in the relevés varies between 3 and 10. The community consists of a total of 36 taxa. Among them, 9 are liverworts and 27 are mosses (19 pleurocarpous, 8 acrocarpous). Both the coverage percentages and the high proportion of the pleurocarpous taxa indicate that humid habitats in the area are more abundant than semi-arid habitats.

Within the relevés, the xerophyte *Alleniella besseri*, with a constancy of 93%, together with *Leucodon immersus*, with a constancy of 100%, are the main characteristics of the association and the taxa with the highest frequency. Both species

generally grow on tree trunks and on rock surfaces. They are widespread in semi-arid and semi-neutral habitats.

There are class, order and alliance characteristics such as *Alleniella complanata*, *Radula complanata*, *Pseudoamblystegium subtile*, *Metzgeria furcata*, *Metzgeria conjugata*, *Anomodon attenuatus*, *A. viticulosus*, *Porella platyphylla*, *Frullania tamarisci*, *Homalothecium sericeum* and *Pseudoleskeella catenulata* in the *Alleniella besseri*-*Leucodontetum immersus*. Therefore, the new association was synhierarchically classified in the *Neckeretea complanatae*, *Neckeretalia complanatae*, and *Neckerion complanatae* (Table 5).

Alleniella besseri and *Leucodon immersus*, the characteristic species of the community, grow in epiphytic and epilithic habitats. This situation is highly compatible with the class *Neckeretea complanatae* which spreads in both epiphytic and epilithic environments in the world.

TABLE 5. — *Alleniella besseri*-*Leucodontetum immersum* Ezer, Alataş & Batan as. nov.

Successive number of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Constancy Class
Number of relevés	6	35	4	5	8	9	14	38	32	28	1	2	30	10	42	
Altitude (m)	594	1107	594	594	655	655	769	955	897	862	594	594	897	655	955	
Size of relevés (dm²)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	
Phorophyte	Alnus glutinosa															
Trunk (m)	1.8	1.9	1.9	1.1	1.1	0.9	1.9	2.3	2.2	2.3	1.6	2.4	2.7	1.2	2.4	
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Position of relevés	N	N	NE	N	N	N	N	N	N	N	N	N	N	N	NE	
Covering (%)	65	97	96	93	94	90	93	95	96	83	90	91	90	83	90	
Canopy cover (%)	90	100	90	90	100	100	90	100	100	90	90	90	100	100	100	
Base (B) / Trunk (T)	T	B	B	T	B	B	T	T	T	T	T	T	B	T	B	
Number of species	3	8	8	7	8	6	10	9	8	7	7	8	6	8	7	
Characteristic species																
Alleniella besseri	4	4	2	3	3	3	4	4	2	2	2	2	2	1	.	V
Leucodon immersus	3	3	3	3	3	3	3	3	3	3	3	4	3	4	4	V
Ch. All. Neckerion complanatae																
Alleniella complanata	–	3	4	4	4	4	–	–	–	–	4	–	–	–	–	II
Anomodon attenuatus	–	–	–	–	–	–	–	2	2	–	3	2	2	–	–	II
Anomodon viticulosus	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	I
Homalothecium sericeum	–	–	3	–	–	–	3	–	–	–	–	–	–	–	–	I
Pseudoleskeella catenulata	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	I
Metzgeria furcata	–	–	–	–	–	–	–	–	–	–	2	1	–	1	–	I
Frullania tamarisci	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	I
Pterigynandrum filiforme	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	I
Ch. Suball. Brachythecio populei-Homalienion trichomanoidis																
Isoetecium alopecuroides	–	1	–	–	–	–	–	–	–	–	–	–	3	3	–	I
Thuidium delicatulum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	I
Ch. Cl. Neckeretea complanatae and Ch. O. Neckeratalia complanatae																
Radula complanata	–	–	2	1	1	1	1	1	2	–	1	1	–	2	1	IV
Pseudoamblystegium subtile	–	–	–	–	2	–	–	–	–	–	–	–	–	1	–	I
Hypnum andoi	–	–	3	–	–	–	–	3	3	3	–	–	3	–	–	II
Porella platyphylla	–	–	–	2	–	2	–	2	–	–	–	–	–	–	–	I
Orthotrichum pumilum	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	I
Metzgeria conjugata	–	2	–	–	–	–	2	–	–	–	–	–	–	–	–	I
Plagiochila porelloides	–	2	–	–	–	–	–	2	–	–	–	–	–	–	2	I
Lejeunea cavifolia	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	I
Plasteurhynchium striatulum	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	I
Others																
Frullania dilatata	–	–	2	–	–	2	–	–	–	–	2	–	–	2	–	II
Brachythecium rutabulum	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	I
Orthotrichum pallens	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	I
Plagiomnium undulatum	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	I
Ptychostomum moravicum	–	–	–	1	–	–	1	1	1	–	–	1	–	–	–	II
Tortella tortuosa	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	I
Ulota crispa	–	–	1	–	–	1	–	–	–	1	1	–	–	1	–	II
Plagiothecium curvifolium	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	I
Plagiomnium ellipticum	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	I
Plagiothecium nemorale	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	I
S.ciuuro-hypnum populeum	–	–	–	–	–	–	2	–	–	–	–	3	–	–	–	I
Dicranum tauricum	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2	I
Radula lindenbergiana	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	I
Exsertotheca crispa	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	I
Ctenidium molluscum	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	I

Plagiomnium undulati-*Raduletum lindbergianae*

Alataş, Ezer, Batan & Erata subas. nov.

(Table 6a)

HOLOTYPE. — Prov. Trabzon, Altındere Valley, 956 m, *Alnus glutinosa* forest.

NOMENCLATURE TYPE. — Table 6a, relevé no. 57, holotypus.

CHARACTERISTIC SPECIES. — *Plagiomnium undulatum*, *Radula lindenbergiana*.

The new typical subassociation is represented by a total of 8 relevés from tree trunks. It is spread between 782–960 m. The subas. typicum frequently occurs on the trunks of *Picea orientalis* at northern and north-western slopes of the study area.

The coverage of bryophytes varies between 85% and 99%, while the canopy cover varies between 90% and 100%. The community consists of a total of 27 taxa (17 mosses, 10 liverworts). Physiognomically, the subassociation typicum is dominated by pleurocarpous species, mixed with small pads of acrocarpous species.

TABLE 6. — *Plagiomnium undulati*-*Raduletum lindbergianae* Alataş, Ezer, Batan & Erata subas. nov. **a**, typicum **b**, *-leucodontetosum sciurioidis* Alataş, Ezer, Batan & Erata subas. nov.

	a										b							
Successive number of relevés	1	2	3	4	5	6	7	8	Constancy Class	9	10	11	12	13	14	15	Constancy Class	
Number of relevés	52	54	55	56	57	58	59	45		47	53	46	48	49	50	51		
Altitude (m)	885	920	920	956	956	960	960	782		782	920	782	841	841	841	885		
Size of relevés (dm²)	54	60	40	66	63	56	24	88		84	63	108	88	63	80	12		
Phorophyte	A.g.	P.o.	P.o.	P.o.	C.s.	P.o.	A.g.	A.g.		C.b.	A.g.	C.b.	A.g.	A.g.	A.g.	A.g.		
Trunk (m)	1.8	2.2	2.4	2.6	1.7	2.3	1.3	2.2		1.7	2.1	1.9	1.8	1.8	1.7	8		
Exposition	N	N	N	N	N	N	N	N		N	N	N	N	N	N	N		
Position of relevés	N	N	N	N	N	N	NE	N		NE	N	N	N	N	N	N		
Covering (%)	89	98	93	98	95	98	92	93		87	85	99	95	98	92	95		
Canopy cover (%)	100	100	90	100	100	90	90	90	100	100	90	100	100	100	100			
Base (B) / Trunk (T)	T	G	T	G	T	T	T	G	T	G	T	G	G	G	T			
Number of species	8	7	8	8	9	10	7	9	12	10	8	8	10	8	9			
Characteristic and differential species																		
<i>Plagiomnium undulatum</i>	3	3	3	2	1	2	2	1	V	1	2	2	2	–	–	2	IV	
<i>Radula lindenbergiana</i>	–	2	1	1	1	1	2	1	V	1	–	2	–	1	1	1	IV	
<i>Leucodon sciurioides</i>	–	–	–	–	–	–	–	–		3	2	3	2	3	4	3	V	
Ch. All. <i>Neckerion complanatae</i>																		
<i>Anomodon attenuatus</i>	–	–	–	–	–	–	–	–		1	–	4	–	2	2	–	III	
<i>Anomodon viticulosus</i>	–	–	–	–	3	–	–	–	I	3	–	–	–	–	–	–	I	
<i>Homalia trichomanoides</i>	1	–	–	–	2	–	–	–	II	1	–	–	1	–	–	–	II	
<i>Exsertotheca crispa</i>	4	–	–	–	4	–	–	–	II	–	–	–	–	–	–	–		
<i>Pterigynandrum filiforme</i>	2	–	–	–	–	–	–	–	I	–	2	–	–	2	1	–	III	
<i>Frullania tamarisci</i>	1	–	–	–	–	1	–	2	II	–	–	–	–	2	–	–	I	
Ch. Suball. <i>Brachythecio populei</i> - <i>Homalienion trichomanoidis</i>																		
<i>Isothecium alopecuroides</i>	–	–	3	2	2	–	3	4	IV	2	–	–	2	–	2	3	III	
<i>Sciuro-hypnum populeum</i>	–	–	–	–	–	–	–	–		1	–	2	–	–	–	–	II	
Ch. Cl. <i>Neckeretea complanatae</i> and Ch. O. <i>Neckeretalia complanatae</i>																		
<i>Alleniella complanata</i>	–	3	4	4	–	4	4	–	IV	1	3	–	–	–	–	–	II	
<i>Alleniella besseri</i>	–	–	–	–	2	–	–	–	I	–	–	–	–	–	–	–		
<i>Metzgeria conjugata</i>	1	2	1	1	–	1	–	–	IV	–	1	–	–	–	–	–	I	
<i>Radula complanata</i>	1	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–		
<i>Porella platyphylla</i>	–	–	–	–	–	–	–	–		2	–	1	–	–	–	–	II	
<i>Plagiochila porelloides</i>	–	3	2	–	–	–	–	–	II	–	2	–	–	–	2	–	II	
<i>Lejeunea cavifolia</i>	–	–	–	2	–	1	1	–	II	–	1	–	–	–	–	–	I	
Others																		
<i>Hypnum cupressiforme</i> var. <i>filiforme</i>	–	3	–	3	–	–	–	–	II	–	–	–	–	–	–	2	I	
<i>Hypnum cupressiforme</i> var. <i>resupinatum</i>	–	–	2	–	–	3	3	2	III	–	–	–	4	4	–	–	II	
<i>Hypnum andoi</i>	–	–	–	–	–	–	–	–		–	–	–	–	2	3	–	II	
<i>Dicranum tauricum</i>	–	–	–	–	–	–	–	1	I	–	–	–	–	–	–	–		
<i>Eurhynchium angustirete</i>	–	1	–	–	–	2	–	–	II	–	–	–	–	–	–	2	I	
<i>Fissidens taxifolius</i>	–	–	–	–	1	–	–	–	I	–	1	–	–	–	–	–	I	
<i>Frullania dilatata</i>	–	–	–	–	–	–	–	–		–	–	–	2	–	–	1	II	
<i>Lophocolea bidentata</i>	–	–	1	–	–	–	–	–	I	–	–	–	–	–	–	–		
<i>Lophocolea heterophylla</i>	–	–	–	–	–	–	–	1	I	–	–	–	–	–	–	–		
<i>Pedinophyllum interruptum</i>	–	–	–	–	–	–	2	–	I	–	–	–	–	–	–	–		
<i>Plagiochila asplenioides</i>	–	–	–	–	2	2	–	3	II	2	–	2	3	1	–	–	III	
<i>Plagiomnium affine</i>	–	–	–	–	–	–	–	2	I	–	–	–	–	–	–	–		
<i>Plagiothecium succulentum</i>	2	–	–	–	–	–	–	–	I	–	2	–	–	–	–	1	II	
<i>Platygyrium repens</i>	–	–	–	–	–	2	–	–	I	–	–	–	–	–	–	–		
<i>Pseudoleskeella nervosa</i>	–	–	–	2	–	–	–	–	I	–	–	1	–	1	–	–	II	
<i>Tortella tortuosa</i>	–	–	–	–	–	–	–	–		1	1	–	1	1	–	–	III	
<i>Ulota crispa</i>	–	–	–	–	–	–	–	–		–	–	–	–	–	1	2	II	

The mesophytic and hygrotolerant preferences of the characteristic species (*Plagiomnium undulatum* and *Radula lindenbergiana*) of the new typical subsociation make it possible to find them on humid habitats, generally at the basal part of the trees. For this reason, the constancy of the species is relatively high (90-100%). The average number of taxa within the community is 8.

Both characteristic species grow on tree trunks and on rock surfaces, especially in humid and semi-neutral shaded habitats.

Syntaxonomically, *Plagiomnium undulati*-*Raduletum lindenbergianae* typicum can be classified within the *Neckerion complanatae* of the *Neckeretalia complanatae*.

Higher-ranked characteristic species, such as *Exsertotheca crispa*, *Frullania tamarisci*, *Isothecium alopecuroides*, *Alleniella complanata*, and *Lejeunea cavifolia* support the classification within the *Neckeretea complanatae* (Table 6a). *Neckeretea complanatae* generally includes epilithic bryophyte communities of vertical rock surfaces and epiphytic communities of tree roots, tree bases and lower tree trunks.

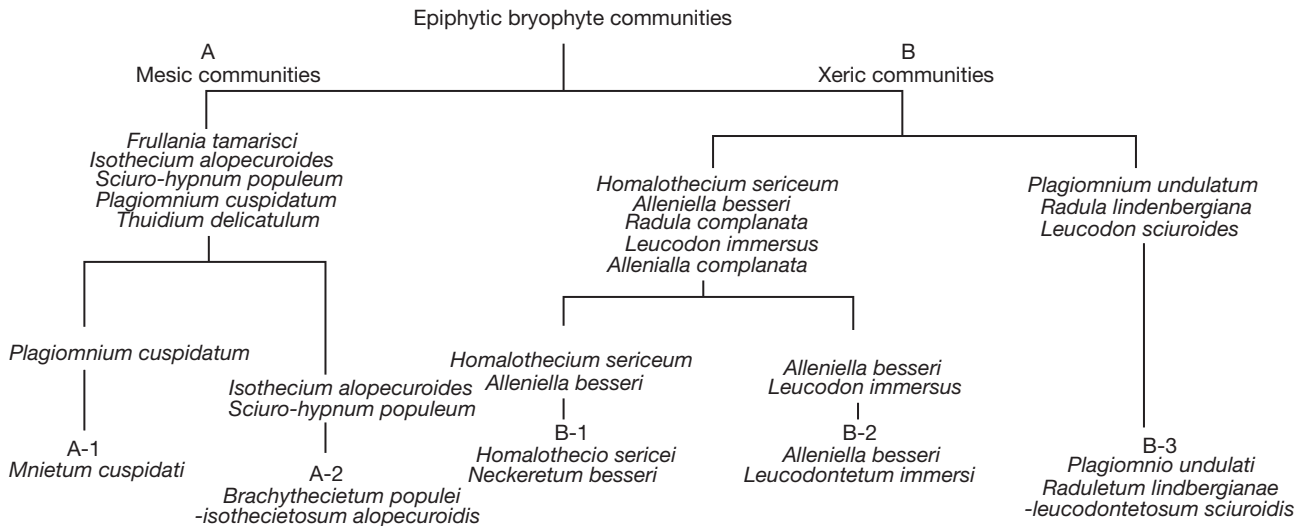


FIG. 2. — Epiphytic bryophyte communities classified by TWINSpan.

Plagiomnium undulati-Raduletum lindbergianae
-*leucodontetosum sciuroidis*

Alataş, Ezer, Batan & Erata subas. nov.
(Table 6b)

HOLOTYPE. — Turkey. Prov. Trabzon, Altındere Valley, 782 m, *Alnus glutinosa* forest.

NOMENCLATURAL TYPE. — Table 6b, relevé no. 47, holotypus.

DIFFERENTIAL SPECIES. — *Leucodon sciuroides*.

Plagiomnium-Raduletum leucodontetosum sciuroidis is represented by a total of 7 relevés collected from trunks between 782-920 m. While the subassociation typicum was found on the most humid lower base of the trunks, the new subassociation was frequently found on middle and upper parts of the *A. glutinosa* trunks. This new subassociation especially occurs on the northern parts of trunks and at the northern slopes of the Altındere Valley.

The coverage of the bryophytes within the subassociation varies between 85% and 99%, while the canopy cover varies between 90% and 100%. The community includes a total 26 taxa, of which 18 are mosses and 8 are liverworts. Pleurocarpous mosses are especially dominant in the *P-R. leucodontetosum sciuroidis*. The average taxa number within the subassociation is 9.

The mesophyte-xerophyte *Leucodon sciuroides* differentiates the subassociation from the *Plagiomnium undulati-Raduletum lindbergianae* typicum. It has the highest frequency, and its constancy is 100% within the relevés (Table 6b). The large pleurocarpous moss *Leucodon sciuroides* grows on tree trunks and on rock surfaces. It also prefers acidic and semi-arid open habitats.

The new subassociation was classified within the alliance *Neckerion complanatae* of the order *Neckeretalia complanatae* (Table 6b).

CLASSIFICATION AND ORDINATION WITH
MULTIVARIATE ANALYSIS TECHNIQUES

As a result of the evaluation of the phytosociological data obtained from 59 relevés by means of classification and ordination techniques, the TWINSpan cluster analysis divided 59 relevés into two main vegetation groups and five sub-groups at level 2 (Fig. 2).

The TWINSpan dendrogram shows that the similarity structure among the clusters corresponds to the classification of Braun-Blanquet. The first epiphytic bryophyte community (A), with a majority of cortico-saxicolous species, is characterised by the dominant mesophytic-hygrophytic moss species *Plagiomnium cuspidatum*, and the pleurocarpous *Sciuro-hypnum populeum* and *Isothecium alopecuroides*. The second main vegetation group (B) is characterized by the xerophytic mosses *Alleniella besseri*, *Leucodon sciuroides*, and *Homalothecium sericeum*.

The TWINSpan vegetation sub-groups were named according to Braun-Blanquet as A-1, A-2, B-1, B-2, and B-3. Of these groups, two groups (A-1 and A-2) occupy mesic epiphytic habitats. The sub-group A-1 is characterised by the hygrophyte-mesophyte species *Plagiomnium cuspidatum*, whereas the sub-group A-2 is characterised by the mesophytes *Sciuro-hypnum populeum* and *Isothecium alopecuroides*. The other three groups occupy xeric epiphytic habitats; B-1 is dominated by the xerophyte moss *Homalothecium sericeum* and the co-dominant *Alleniella besseri*, whereas B-2 is dominated by *Alleniella besseri* and the xerophyte cortico-saxicolous *Leucodon immersus*. Although, group B-3 is included in the main group B, which includes xerophytic communities, it is dominated by the hygro-mesophytic species *Plagiomnium undulatum* and *Radula lindenbergiana*, and the co-dominated xero-mesophytic *Leucodon sciuroides* (Fig. 2). The reason why the B-3 group belongs to the main group B is that it

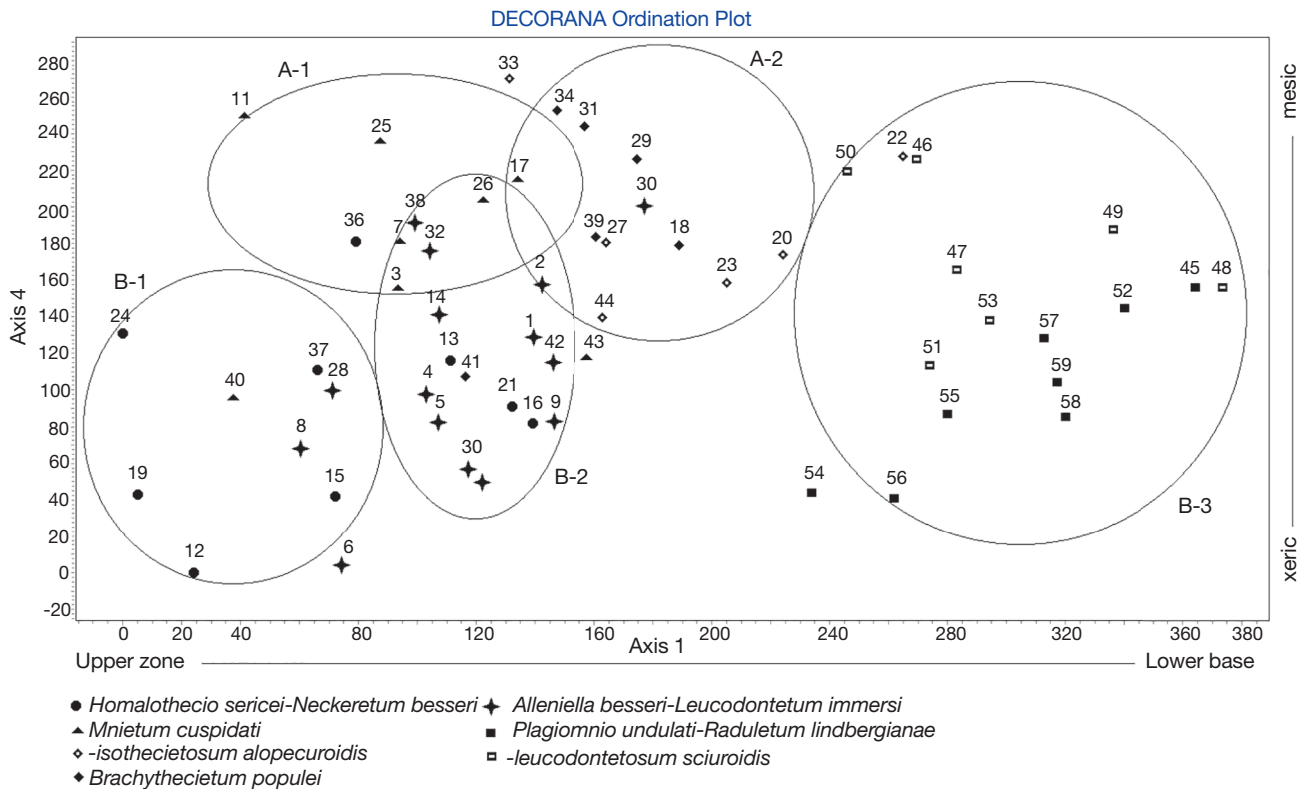


Fig. 3. — DCA ordination of epiphytic bryophyte communities for 59 relevés.

contains many meso-xerophytic taxa such as *Alleniella complanata*, *Exsertotheca crispa*, *Hypnum cupressiforme* var. *filiforme* and *H. cupressiforme* var. *resupinatum*. The meso-xerophytic taxa composing the group B-3 make it possible to find them on xeric habitats and the cover of the taxa is relatively high within the group.

Further analysis of the same data set (59 relevés and 55 species) by means of DECORANA showed a reasonable segregation between the groups (Fig. 3). Axis 1 of the DECORANA ordination is interpreted as a gradient of trunk height (from upper zones to lower base). The DCA axis 4 is interpreted as a moisture gradient (from xeric to mesic).

The results of both the TWINSpan and DECORANA analyses indicate that the humidity retained on the phorophyte is an important ecological factor to explain the spatial distribution and community composition of the epiphytic bryophyte communities, as it has been previously demonstrated (Gonzalez-Mancebo *et al.* 2003; Draper *et al.* 2007). Nevertheless, other factors such as altitude, type of host tree, or forest structure should be also taken into account to understand the composition and abundance of the epiphytic bryophyte communities (Wierzcholska *et al.* 2020).

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Declaration of interest statement

The authors declare that there is no conflict of interest.

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