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The Epiphytic Bryophyte Vegetation of *Buxus sempervirens* L. forests in the Firtina Valley (Rize, Turkey)

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ABSTRACT

The Firtina Valley forests are of the 100 forests in the world whose conservation is a priority due to the natural old forests they have. In this study, the epiphytic bryophyte vegetation of the *Buxus sempervirens* L. forests located in the Firtina Valley (Rize, Northern Turkey), which is one of the nine hotspots in Turkey and Turkey's only boxwood forest, was investigated. The relevés taken from living tree trunks in 2020 were analyzed according to the Braun-Blanquet methodology, and ordinated and classified using the Detrended Correspondence Analysis (DECORANA) and the Two-Way Indicator Species Analysis (TWINSPAN). As a result of the analyses, *Exsertotheco crispae-Alleniellum besseri* ass. nov. subass. *typicum* and *leucodontetosum sciuroidis* subass. nov., and *Alleniello besseri-Palamocladietum euchloronis* ass. nov. were described and characterized. All syntaxa were presented by analyzing them in terms of their ecological and floristic classifications.

KEY WORDS
Turkey,
bryosociology,
community,
DECORANA,
TWINSPAN,
syntaxa.

RÉSUMÉ

Végétation de bryophytes épiphytes des forêts de Buxus sempervirens L. dans la vallée de Firtına (Rize, Turquie).

Les forêts de la vallée de Firtına font partie des 100 forêts du monde dont la conservation est prioritaire en raison des vieilles forêts naturelles qu'elles abritent. Dans cette étude, la végétation des bryophytes épiphytes des forêts de *Buxus sempervirens* L. situées dans la vallée de Firtına (Rize, nord de la Turquie), qui est l'un des neuf hotspots de Turquie et la seule forêt de buis de Turquie, a été étudiée. Les relevés effectués sur des troncs d'arbres vivants en 2020 ont été analysés selon la méthodologie Braun-Blanquet, puis ordonnés et classés à l'aide de l'analyse des correspondances en tendance (DECORANA) et de l'analyse des espèces indicatrices à deux voies (TWINSPAN). Les analyses ont permis de décrire et de caractériser *Exsertotheco crispae-Allenielletum beseri* ass. nov. subass. *typicum* et *leucodontetosum sciuroidis* subass. nov., et *Alleniello beseri-Palamocladietum euchloronis* ass. nov. Tous les syntaxons ont été présentés en les analysant du point de vue de leur classification écologique et floristique.

MOTS CLÉS
Turquie,
bryosociologie,
communauté,
DECORANA,
TWINSPAN,
syntaxons.

INTRODUCTION

Biodiversity hotspots are regions that have both high rates of endemism, characterized by serious habitat loss, and where the most urgent conservation actions are needed (Marchese 2015). Although these hotspots cover only 2.3% of the world's terrestrial area, they contain 50% of the world's endemic plant diversity (Satar & Güneş 2014).

The Firtına Valley is one of the nine hotspots in Turkey, which is among the 25 priority areas that need to be protected in the world. In addition, according to the WWF (World Wildlife Fund), the Firtına Valley is one of the 200 important ecological regions worldwide in terms of biodiversity, and has been identified as one of the hundred forests in need of urgent protection in Europe (Zaman 2008).

The Firtına Valley is home to many rare species, displaying a unique botanical diversity, as it covers all the main habitats specific to the region due to its geological and topographic diversity; the area is home to 2500 different plant species, of which 116 are endemic (Satar & Güneş 2014). *Buxus sempervirens* L., which has a very wide distribution in the Euro-Siberian plant geography, forms remarkable tree communities in this valley. Moreover, *B. sempervirens* forests are found only here in Turkey (Kurdoğlu & Yüksek 2006; Satar & Güneş 2014). Furthermore, the high richness of bryophytes, especially epiphytic bryophytes, in these forests, enabled the area to be selected as a bryosociological study area. A total of *c.* 142 bryophyte taxa (\pm 116 mosses and \pm 26 liverworts) have been reported from the Firtına Valley in Rize Province so far (Papp 2004; Abay *et al.* 2006).

Bryofloristic studies in Turkey have progressed rapidly in recent years. According to some recent surveys on Turkish bryoflora, the bryophyte taxa determined in Turkey are around \pm 1056 (Erata & Batan 2020; Kürschner & Frey 2020; Ellis *et al.* 2021a, b; Erata *et al.* 2021; Kırmacı *et al.* 2021; Özçelik *et al.* 2021; Ursavaş *et al.* 2021; Abay *et al.* 2022; Özenoğlu & Kırmacı 2022; Uygur *et al.* 2022). Despite the progress in floristic studies, the knowledge does not progress at the same speed with regard to epiphytic flora and vegetation. According to the results of the studies on the epiphytic bryophyte

vegetation, a total of 68 syntaxa belonging to three classes have been determined in the country so far; among them, four associations and one sub-association belong to the class *Cladonio digitatae-Lepidozietea reptantis* Ježek & Vondráček, 1962; 15 associations and ten sub-associations belong to the class *Neckeretea complanatae* Marstaller, 1986, and 19 associations and eight sub-associations belong to the class *Frutlanio dilatatae-Leucodontetea sciuroidis* Mohan, 1978. Also, eleven remain at the community level due to their unknown syntaxonomical status (Alataş 2018; Alataş *et al.* 2019a, b, c, 2021, 2022; Kara & Taşpınar 2022; Ezer *et al.* 2022).

Although the bryosociological studies have made progress in recent years, more research is needed to reveal Turkey's richness. The present study aimed to reveal the syntaxonomic units of epiphytic bryophytes on epiphytic habitats of *Buxus sempervirens*.

MATERIAL AND METHODS

STUDY AREA

The Firtına Valley is located within the borders of Rize province in the Eastern Black Sea Region of Turkey. It is located within the A4 square according to the grid-square system of Henderson (1961), and is in the colchic zone of the Euro-Siberian Phytogeographic Region (Anşin 1983; Fig. 1).

The Firtına Valley, geomorphologically, consists of a land deeply divided by rivers and high mountain areas where glaciations were effective. "V" and "U" profile valleys with sharp and steep slopes form the characteristic topographic view of this area up to an altitude of approximately 2000-2200 m. The topography in the valley breaks down just before the coastal plain, and the elevation suddenly decreases from 2000-2200 m to 150-200 m. From here onwards, the land is deeply cleaved by stream valleys that get narrower. Both the main streams and the tributaries formed by these streams have fragmented the land and made it steep and uneven. In the valley, the Firtına Stream is divided into branches at various degrees, and forms the Tunca, Hala, Palovit, Haçıvanak and Hemişin Streams (Anşin 1983) (Figs 1; 2).

The lands in the Firtina Valley are evaluated as agriculture, pasture, forest and settlement in terms of use, and the forest areas are the most important type of land use with a rate of 49.5% (Zaman 2008). The forest formation in the valley has a lush structure due to favorable precipitation and temperature conditions (Inandık 1969). This forest cover, dominated by deciduous broad-leaved species, loses its colchic structure with increasing altitude, and leaves the place to mixed forests and then to coniferous forests. The upper limit of the forest is at approximately 2200 m, and after this altitude, different belts distinguished as subalpine and alpine meadows are formed (Erinç 1945).

The altitude range of the valley between 500-1000 m is the richest belt in terms of trees. There, *Alnus glutinosa* (L.) Gaertn. subsp. *barbata* (C.A.Mey.) Yalt., *Carpinus betulus* L., *Castanea sativa* Mill., *Fagus orientalis* Lipsky., *Picea orientalis* (L.) Link., and *Tilia rubra* DC. subsp. *caucasica* (Rupr.) V.Engl. form mixed forests (Aksoy 1995, 1998; Avcı & Özhatay 2005; Abay *et al.* 2006; Zaman 2008).

The *Buxus sempervirens* forests, where the study was carried out, are spread along the Firtina Stream and its tributaries between 900-1300 m in the valley. These forests are found forming large patches, especially on the banks of the streams and on the slopes, and form pure populations along the Çamlıhemşin-Meydan road and in Şimşirlik locality, where the Kito Forests and the Palovit Valley are located. The *B. sempervirens* trees present in these forests are about 5-6 m tall and 35-40 cm in diameter.

In the Firtina Valley, a semi-oceanic and semi-continental climate generally prevails. The climate is temperate and rainy in all seasons, but there are some temperature and precipitation differences between the coast and the inland, depending on local and geographical conditions. While a mild rainy climate is observed in the areas up to 1000 m from the coast, the temperate conditions gradually decrease in the area between 1000 and 2000 m. In the high area above 2000 m, semi-continental mountain climate is observed (Özçağlar *et al.* 2006). In the study area, the average annual rainfall is 2192 mm, whereas the average annual temperature is 8.3°C. The hottest month of the year is August, whereas the coldest month is January (Climate Data 2021). The annual rainfall regime type in the form of SKYI and the absence of dry season indicate that the study area is under the influence of Oceanic climate (Akman 2011).

SAMPLING

The study is based on 23 bryophyte relevés taken from the base (0-0.5 m) and middle (0.5-2 m) parts of the trunks of the *Buxus sempervirens* trees, from different localities of the Firtina Valley with varying ecological characteristics, during the year 2020 (Table 1).

The relevés were carried out according to the minimal area concept (Braun-Blanquet 1964). For the relevés, the abundance-coverage scale of Frey & Kürschner (1991) was used.

The relevés were evaluated using the classical sigma-tiste methodology of Braun-Blanquet (1964) as well as by



FIG. 1. — Location of the study area. The red point indicates the Firtina Valley. The black rectangle indicates the Rize Province, and the black points indicate the Rize districts. The numbers indicate the nine localities sampled (see Table 1).

Multivariate ordination techniques such as DECORANA (Detrended Correspondence Analysis) and TWINSpan (Two-Way Indicator Species Analysis) (Seaby *et al.* 2004). The plant associations were arranged by diagnostic species (Braun-Blanquet 1964), and named according to Weber *et al.* (2000). The determination of the associations in the present study was carried out via comparison with related associations in Marstaller (2006) and classified with the help of published studies. For the identification of the bryophyte specimens, different floras, monographies and revisions were used (Nyholm 1981; Hedenäs 1992; Zander 1993; Paton 1999; Cortini Pedrotti 2001, 2006; Smith 2004; Heyn & Herrnstadt 2004; Frey *et al.* 2006; Brugués *et al.* 2007; Casas *et al.* 2009; Kürschner & Frey 2020). The nomenclature of the species follows Hodgetts *et al.* (2020). The classifications of the ecological characteristics of the species (xerophyllous, mesophyllous, etc.) and of the environments (neutral, semi-neutral, alkaline, etc.) were determined according to Dierßen (2001).

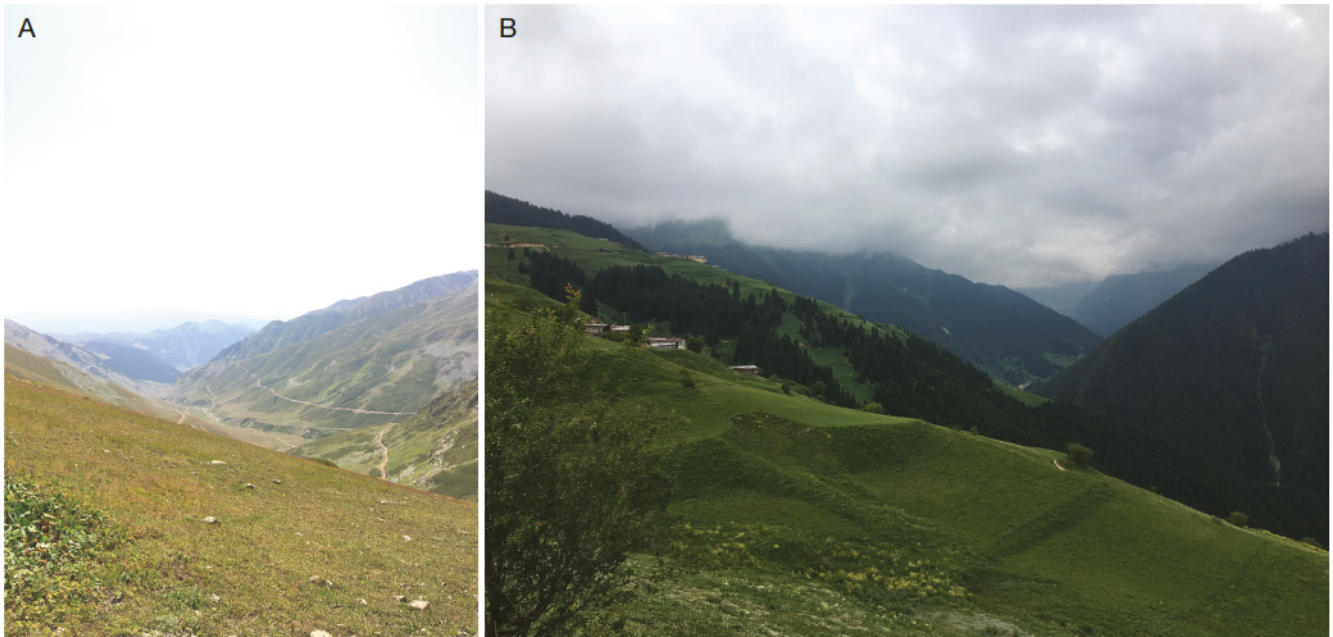


FIG. 2. — V (B) and U (A) profile valleys in Firtina Valley.

RESULTS AND DISCUSSION

REMARKS

As a result of the evaluation of the relevés taken from the *Buxus sempervirens* trunks in the study area, within the Neckeretea complanatae class, two associations, one of them with two subassociations, were recognized as new epiphytic syntaxa. Thus, the number of the epiphytic bryophyte syntaxa reported for Turkey increases to 71.

The floristic and ecological features of the new syntaxa are given below in accordance with the Marstaller's (2006) sequence.

Class Neckeretea complanatae Marst., 1986

Order Neckeretalia complanatae Jež. & Vondr., 1962

Alliance Neckerion complanatae Šm. & Had. in Kl., 1948

Alleniello besseri-*Palamocladietum euchloronis*

Ezer, Alataş, Erata & Batan, ass. nov.

(Table 2)

HOLOTYPE. — Turkey. Rize Province, Firtina Valley, 1004 m, *Buxus sempervirens* forest.

NOMENCLATURAL TYPE. — Table 2, relevé no. 17, holotype.

CHARACTERISTIC SPECIES. — *Alleniella besseri*, *Palamocladium euchloron*.

COMMENTS

The association, which occurs in the northern part of the Firtina Valley, was determined by a total of six relevés, taken mostly from the middle parts of the *Buxus sempervirens*

trunks, at an altitude between 956 and 1018 m. While the general bryophyte coverage varies between 86% and 99%, the canopy cover, in the forest where it was found, was 100%. The association consists of a total of 16 taxa. Of these, two are liverworts and 14 are mosses. Thirteen of the mosses are pleurocarpous and one is acrocarpous. The average number of taxa within the community is eight. Both the coverage percentages and the number of acrocarpous and xerophyllous species and meso-hygrophylous pleurocarpous mosses show that the study area has humid and semi-arid habitats. In addition, based on the ecological characteristics (Dierßen 2001) of the taxa belonging to the association, it can be stated that the syntaxon spreads in semi-neutral shaded areas with meso-hygrophylous character.

Alleniella besseri (Lobarz.) S.Olsson, Enroth & D.Quandt and *Palamocladium euchloron* (Bruch ex Müll.Hal.) Wijk & Margad., the main characteristic species of the association, have the highest frequency, and the species are 100% constant in the relevés. Both species generally grow on tree trunks in semi-arid and semi-neutral environments (Dierßen 2001). They also grow as epilithics on rock surfaces.

Synhierarchically, due to the fact that *Alleniello besseri*-*Palamocladietum euchloronis* contains characteristic species, such as *Alleniella complanata* (Hedw.) S.Olsson, Enroth & D.Quandt, *Exsertotheca crispa* (Hedw.) S.Olsson, Enroth & D.Quandt and *Homalia trichomanoides* (Hedw.) Brid. of the Neckeretea complanatae, Neckeretalia complanatae, and Neckerion complanatae (Marstaller 2006), it was classified within these higher taxonomical units (Table 2). The class Neckeretea complanatae is characterized by both epiphytic and epilithic species which prefer humid and shaded habitats in alkaline environments (Dierßen 2001).

TABLE 1. — List of localities sampled. All the relevés were made on the *Buxus sempervirens* L. trunks.

Number of relevés	Localities	Altitude (m)	Date	GPS coordinates
1-2	1	1275	17.V.2020	40°51'48.95"N, 40°55'58.08"E
3-4	2	1231	17.V.2020	40°51'59.44"N, 40°55'46.26"E
5-6	3	1176	17.V.2020	40°52'13.82"N, 40°55'37.52"E
7-8	4	1108	26.VIII.2020	40°52'48.29"N, 40°55'43.37"E
9-11	5	1061	26.VIII.2020	40°53'20.49"N, 40°55'51.11"E
12-13	6	1026	26.VIII.2020	40°53'40.83"N, 40°56'31.71"E
14-16	7	1018	9.X.2020	40°54'18.08"N, 40°56'52.30"E
17-20	8	1004	9.X.2020	40°54'27.30"N, 40°56'53.71"E
21-23	9	956	9.X.2020	40°54'47.61"N, 40°56'52.38"E

TABLE 2. — Characteristics of *Alleniella besseri*-*Palamocladietum euchloronis* Ezer, Alataş, Erata & Batan, ass. nov.

Number of relevés	16	17	18	20	21	22	
Altitude (m)	1018	1004	1004	1004	956	956	
Size of relevés (dm ²)	11	17.5	17.5	11	11	11	
Phorophyte	<i>Buxus sempervirens</i>						
Tree trunk circumference (m)	0.30	0.40	0.45	0.30	0.40	0.30	
Exposition	N	N	N	N	N	N	
Position of relevés	N	N	N	NE	NE	NE	
Covering (%)	93	95	86	98	99	87	
Canopy cover (%)	100	100	100	100	100	100	
Heigh in the trunk (m)	0.70	0.60	0.80	0.60	0.70	0.35	
Base (B) / Trunk (T)	T	T	T	T	T	B	Constancy
Number of species	9	8	8	8	10	8	Class
Characteristic species							
<i>Alleniella besseri</i> (Lobarz.) S.Olsson, Enroth & D.Quandt	4	3	4	4	2	3	V
<i>Palamocladium euchloron</i> (Müll.Hal.) Wijk & Margad.	2	3	3	3	2	4	V
Characteristics of Alliance Neckerion complanatae							
<i>Anomodon attenuatus</i> (Hedw.) Huebener	2	2	–	–	2	–	
<i>Homalia trichomanoides</i> (Hedw.) Brid.	2	2	2	2	2	–	V
<i>Metzgeria furcata</i> (L.) Dumort.	–	–	–	–	–	1	I
Characteristics of Suballiance <i>Brachythecio populei</i> - <i>Homalienion trichomanoidis</i>							
<i>Isothecium alopecuroides</i> (Lam. ex Dubois) Isov.	–	–	1	1	–	2	III
<i>Sciuro-hypnum populeum</i> (Hedw.) Ignatov & Huttunen	–	–	–	–	1	–	I
<i>Thuidium delicatulum</i> (Hedw.) Schimp.	1	1	1	–	–	–	III
Characteristics of Class Neckeretea complanatae and Order Neckeretalia complanatae							
<i>Alleniella complanata</i> (Hedw.) S.Olsson, Enroth & D.Quandt	1	2	3	2	2	1	V
<i>Exsertotheca crispa</i> (Hedw.) S.Olsson, Enroth & D.Quandt	3	4	1	2	4	2	V
<i>Pseudoamblystegium subtile</i> (Hedw.) Vanderp. & Hedenäs	–	–	–	–	1	–	I
Others							
<i>Fissidens serrulatus</i> Brid.	–	–	1	–	–	–	I
<i>Hypnum andoi</i> A.J.E.Sm.	–	–	–	–	2	2	II
<i>Hypnum cupressiforme</i> var. <i>resupinatum</i> (Taylor) Schimp.	–	–	–	3	–	–	I
<i>Ctenidium molluscum</i> (Hedw.) Mitt.	1	1	–	–	–	–	II
<i>Radula lindenbergiana</i> Gottsche ex C.Hartm.	1	–	–	1	1	1	IV

Exsertotheca crispae-*Alleniellietum besseri* ass. nov.
typicum Alataş, Ezer, Batan & Erata, subass. nov.
 (Table 3A)

HOLOTYPE. — Turkey. Rize Province, Firtina Valley, 1026 m, *Buxus sempervirens* forest.

NOMENCLATURAL TYPE. — Table 3A, relevé no. 13, holotype.

CHARACTERISTIC SPECIES. — *Exsertotheca crispa*, *Alleniella besseri*.

COMMENTS

The new typical subassociation is represented by a total of seven relevés from tree trunks. It occurs from 956 to 1061 m, and is mainly found on the central parts of trunks of *Buxus sempervirens* in the northern part of the study area. While the general bryophyte coverage varies between 83% and 97%, the canopy cover, in the forest where it was found, was 100%. The average number of taxa within the community varies from five to ten. The subassociation consists of a total of 18 taxa. Of these, two are liverworts and 16 are mosses. Fifteen of the mosses are pleurocarpous and one is acrocarpous.

TABLE 3. — Characteristics of *Exsertotheca crispae*-*Alleniellatum besseri* Alataş, Ezer, Batan & Erata, ass. nov.: **A**, *typicum* Alataş, Ezer, Batan & Erata, subass. nov.; **B**, *leucodontetosum sciuroidis* Alataş, Ezer, Batan & Erata, subass. nov.

Number of relevés	A							Constancy Class	B										Constancy Class
	12	15	11	13	14	19	23		1	2	3	4	5	6	7	8	9	10	
Altitude (m)	1026	1018	1061	1026	1018	1004	956		1275	1275	1231	1231	1176	1176	1108	1108	1061	1061	
Size of relevés (dm ²)	18	22	22	10	22.5	12	10		22.5	44	33	33	30	22	22	30	16.5	11	
Phorophyte	<i>Buxus sempervirens</i>								<i>Buxus sempervirens</i>										
Tree trunk circumference (m)	0.70	0.50	0.45	0.25	0.60	0.20	0.30		0.60	0.80	0.80	0.25	0.60	0.45	0.40	0.60	0.35	0.25	
Exposition	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N	N	N	
Position of relevés	N	N	N	N	NE	N	N		N	N	NE	N	N	N	N	NW	NW	N	
Covering (%)	97	83	98	91	93	90	83		98	94	98	90	96	99	88	92	99	94	
Canopy cover (%)	100	100	100	100	100	100	100		80	80	80	80	100	100	100	100	100	100	
Heigh in the trunk (m)	0.55	0.60	0.25	0.60	0.85	0.65	0.70		0.65	0.60	0.55	0.70	0.75	0.60	0.60	0.70	0.60	0.45	
Base (B) / Trunk (T)	T	T	B	T	T	T	T		T	T	T	T	T	T	T	T	T	B	
Number of species	8	8	10	9	6	8	5		9	9	11	8	10	8	9	11	10	9	
Characteristic species																			
<i>Exsertotheca crispae</i> (Hedw.)																			
S.Olsson, Enroth & D.Quandt	2	4	2	3	2	1	4	V	4	4	4	4	4	4	3	4	4	2	V
<i>Alleniella besseri</i> (Lobarz.) S.Olsson, Enroth & D.Quandt																			
	3	–	4	2	3	4	–	IV	2	2	2	2	1	3	2	2	2	3	V
<i>Leucodon sciuroides</i> (Hedw.) Schwägr.																			
	–	–	2	–	–	2	–	II	2	2	1	–	1	1	1	2	2	1	V
Characteristics of Alliance Neckerion complanatae																			
<i>Anomodon attenuatus</i> (Hedw.) Huebener																			
	2	2	1	2	1	–	–	IV	–	–	–	–	2	2	–	1	3	–	II
<i>Anomodon viticulosus</i> (Hedw.) Hook. & Taylor																			
	–	–	–	2	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–
<i>Homalia trichomanoides</i> (Hedw.) Brid.																			
	3	3	3	2	–	3	–	IV	–	–	–	–	–	–	–	–	–	–	–
<i>Frullania tamarisci</i> (L.) Dumort.																			
	–	–	–	–	–	–	–	I	–	1	–	–	–	1	–	–	–	–	I
<i>Metzgeria furcata</i> (L.) Dumort.																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	1	–	–	–	I
<i>Pterigynandrum filiforme</i> Hedw.																			
	–	–	1	–	–	–	–	I	–	–	2	2	1	–	–	–	–	–	II
Characteristics of Suballiance <i>Brachythecio populei</i> - <i>Homalienion trichomanoidis</i>																			
<i>Isothecium alopecuroides</i> (Lam. ex Dubois) Isov.																			
	–	2	–	2	–	2	3	III	3	2	–	2	2	2	2	2	–	–	IV
<i>Sciuro-hypnum populeum</i> (Hedw.) Ignatov & Huttunen																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	1	I
<i>Thuidium delicatulum</i> (Hedw.) Schimp.																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	2	I
Characteristics of Class Neckeretea complanatae and Order Neckeretalia complanatae																			
<i>Alleniella complanata</i> (Hedw.) S.Olsson, Enroth & D.Quandt																			
	4	2	2	3	4	3	3	V	3	3	3	3	2	2	–	2	3	4	V
<i>Radula complanata</i> (L.) Dumort.																			
	1	–	1	1	–	–	–	III	–	1	1	1	1	1	3	1	1	1	V
<i>Pseudoamblystegium subtile</i> (Hedw.) Vanderp. & Hedenäs																			
	1	–	1	–	–	1	1	III	–	–	–	–	–	–	–	–	–	–	–
<i>Sciuro-hypnum flotowianum</i> (Sendtn.) Ignatov & Huttunen																			
	1	1	1	–	2	–	–	III	–	–	–	–	–	2	1	–	1	–	II
<i>Hypnum cupressiforme</i> var. <i>cupressiforme</i> Hedw.																			
	–	–	–	–	–	–	–	I	2	2	2	–	–	–	–	–	–	–	II
<i>Orthotrichum pumilum</i> Sw. ex anon.																			
	–	–	–	–	–	–	–	I	1	1	1	–	–	–	–	–	1	1	III
Others																			
<i>Frullania dilatata</i> (L.) Dumort.																			
	–	–	–	–	–	–	–	I	–	–	1	1	–	–	–	1	1	–	II
<i>Fissidens serrulatus</i> Brid.																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–	1	–	–	I
<i>Palaeocladium euchloron</i> (Müll.Hal.) Wijk & Margad.																			
	–	–	–	–	–	–	–	I	–	–	–	–	3	–	3	–	–	–	I
<i>Hypnum cupressiforme</i> var. <i>resupinatum</i> (Taylor) Schimp.																			
	–	–	–	–	–	–	2	I	–	–	–	–	–	–	–	–	–	–	–
<i>Brachythecium rutabulum</i> (Hedw.) Schimp.																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–
<i>Ctenidium molluscum</i> (Hedw.) Mitt.																			
	–	1	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–
<i>Plagiomnium undulatum</i> (Hedw.) T.J.Kop.																			
	–	–	–	–	–	1	–	I	–	–	–	–	–	–	–	–	–	–	–
<i>Plagiothecium nemorale</i> (Mitt.) A.Jaeger																			
	–	1	–	–	2	–	–	II	–	–	–	–	–	–	–	–	–	–	–
<i>Plagiothecium succulentum</i> (Wilson) Lindb.																			
	–	–	–	–	–	–	1	I	1	–	–	–	–	–	–	–	–	–	I
<i>Radula lindenbergiana</i> Gottsche ex C.Hartm.																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	–	I
<i>Thamnobryum alopecurum</i> (Hedw.) Gangulee																			
	–	–	–	–	–	–	–	I	–	–	–	–	–	–	2	–	–	–	I
<i>Ulota crispae</i> (Hedw.) Brid.																			
	–	–	–	–	–	–	–	I	1	1	1	1	–	–	–	–	1	1	III

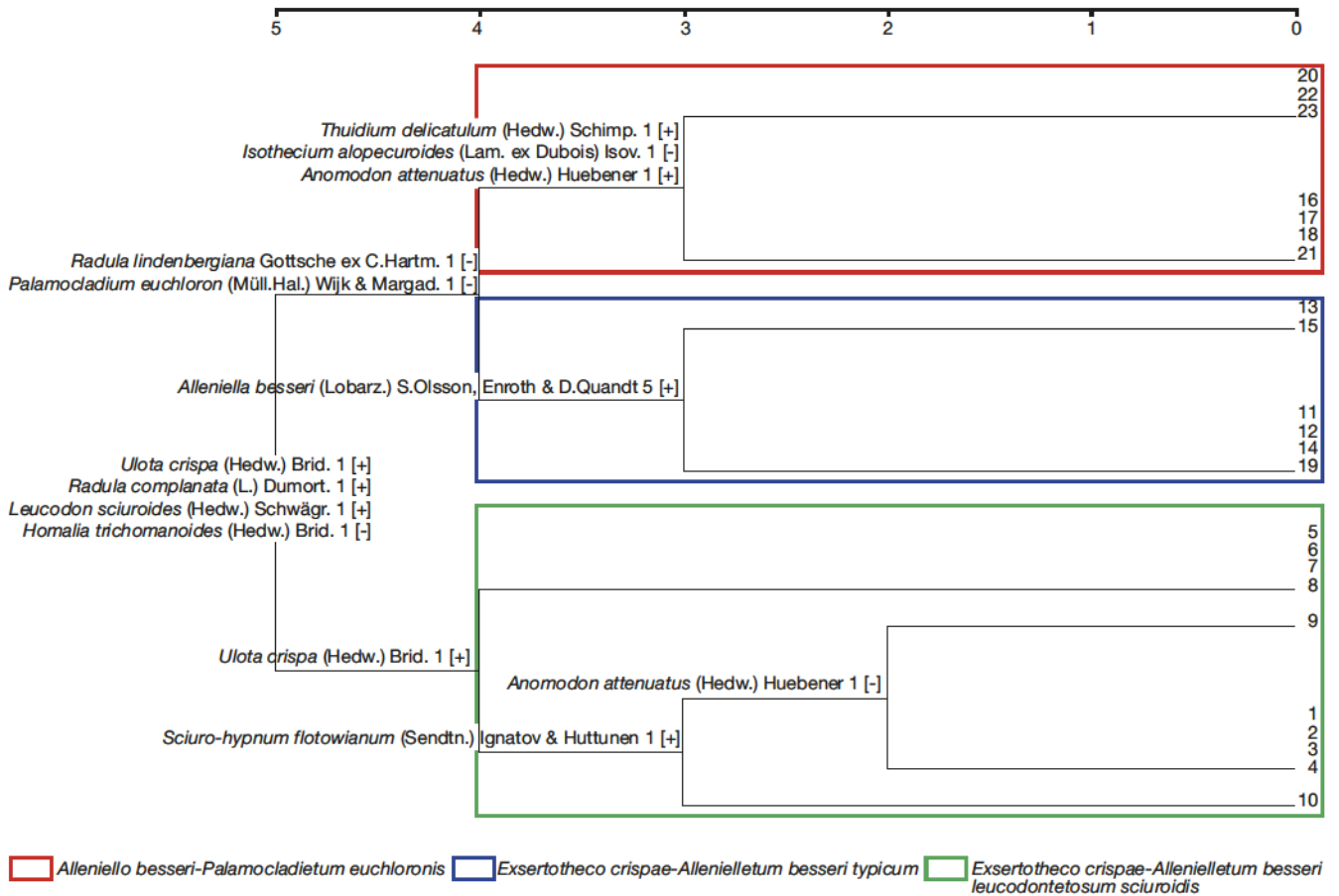


FIG. 3. — TWINSpan classification for the 23 relevés carried out in the studied area and 31 taxa found.

Within the relevés, the mesophylous *Exsertotheca crispae*, with a constancy of 100%, together with the mesophylous *Alleniella besseri*, with a constancy of 71%, are the main characteristics of the association and the taxa with the highest frequency. Both characteristic species grow on tree trunks and on rock surfaces, especially in humid and semi-neutral shaded habitats (Dierßen 2001).

There are class, order and alliance characteristic species such as *Alleniella complanata*, *Anomodon attenuatus* (Hedw.) Huebener, *A. viticulosus* (Hedw.) Hook. & Taylor, *Homalia trichomanoides*, *Isothecium alopecuroides* (Lam. ex Dubois) Isov., *Pseudoamblystegium subtile* (Hedw.) Vanderp. & Hedenäs, *Pterigynandrum filiforme* Hedw., *Radula complanata* (L.) Dumort. and *Sciuro-hypnum flotowianum* (Sendtn.) Ignatov & Huttunen in *Exsertotheca crispae*-*Allenielletum besseri*. Therefore, the new association was synhierarchically classified in the Neckeretea complanatae, Neckeretalia complanatae, and Neckerion complanatae (Table 3A).

Exsertotheca crispae-*Allenielletum besseri*
leucodontetosum sciuroidis

Alataş, Ezer, Batan & Erata, subass. nov.
(Table 3B)

HOLOTYPE. — Turkey. Rize Province, Firtina Valley, 1061 m, *Buxus sempervirens* forest.

NOMENCLATORIAL TYPE. — Table 3B, relevé no. 9, holotype.

CHARACTERISTIC SPECIES. — *Leucodon sciuroides*.

COMMENTS

Exsertotheca crispae-*Allenielletum besseri* *leucodontetosum sciuroidis* is represented by a total of 10 relevés collected mostly from the middle parts of the trunks, at an altitude between 1061 and 1275 m. The coverage of bryophytes within the subassociation varies between 88% and 99%, while the canopy cover varies between 80% and 100%.

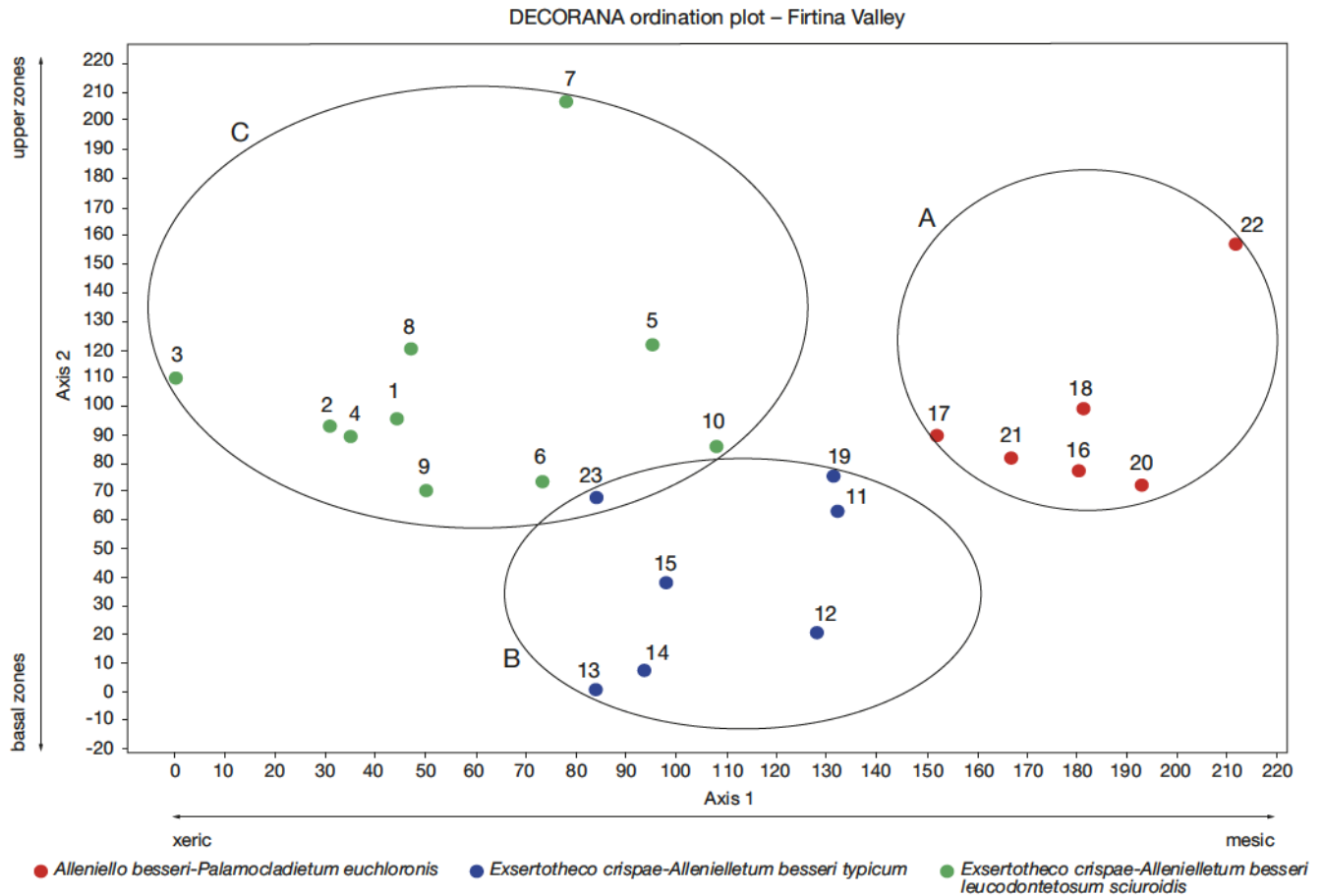


Fig. 4. — DECORANA ordination for the 23 relevés carried out in the study area with TWINSpan groups.

The community includes a total 22 taxa, of which 17 are mosses and five are liverworts. Pleurocarpous mosses are especially dominant. The average taxa number within this sub-association is nine. The high number of pleurocarpous and liverworts indicates that the community develops in more humid conditions than the sub-association *typicum*. Moreover, the low number of acrocarpous members indicates that the habitats are moist and shaded (Kürschner 2004).

The mesophylous-xerophylous *Leucodon sciuroides* (Hedw.) Schwägr. distinguished the sub-association from the *Exsertotheco crispae-Allenielletum besseri* subass. *typicum*. It has the highest frequency, and its constancy is 90% within the relevés (Table 3B). The large pleurocarpous moss *Leucodon sciuroides* grows on tree trunks and on rock surfaces. It also prefers acidic and semi-arid open habitats (Dierßen 2001).

As the typical sub-association, the *leucodontetosum sciuroidis* sub-association contains the characteristic species of *Neckeretea complanatae*, *Neckeretalia complanatae*, and *Neckerion complanatae* (Table 3B).

The large pleurocarpous moss *Palamocladium euchloron*, endemic to the forests of the Black Sea and Caspian Sea coasts (Hofmann 1997), distinguished *Alleniello besseri-Palamocladietum euchloronis* from *Exsertotheco crispae-Allenielletum besseri*. *Palamocladium euchloron*, the characteristic species of the new association, shows basiphytic and mesophylous affini-

ties (Dierßen 2001). While *Alleniello besseri-Palamocladietum euchloronis* was found on the north and northeast aspects of the trunks of relatively young boxwood trees (the maximum tree trunk circumference was 0.45 m), *Exsertotheco crispae-Allenielletum besseri* was mostly found on the northern aspect of the trunks of relatively middle-aged and old boxwood trees (the maximum tree trunk circumference was 0.70 m). Therefore, although both syntaxa are similar to each other in terms of floristic composition, *Alleniello besseri-Palamocladietum euchloronis* was described as a separate association in the present study due to both the presence of the characteristic species *P. euchloron* and its preference for relatively young boxwood trees.

The high number of pleurocarpous mosses and liverworts within *Exsertotheco crispae-Allenielletum besseri leucodontetosum sciuroidis* indicated that it developed in more humid conditions than in the subass. *typicum*. Moreover, the frequency and constancy of the large pleurocarpous and strong competitor moss *Leucodon sciuroides* within the sub-association distinguished it from the *Exsertotheco crispae-Allenielletum besseri typicum*. In addition, *Exsertotheco crispae-Allenielletum besseri typicum* is floristically similar to *Neckeretum crispae* (Kaiser, 1926) Herzog & Höffler, 1944 (syntaxa: *Anomodontoviticulosi-Leucodontetum sciuroidis* Wisniewski, 1930) determined from the trunks of the *Buxus sempervirens* trees

in Mount Musa (southern Turkey) by Ezer (2008). However, *Exsertotheco crispae*-*Alleniellatum besseri* is more sciophytic than *Neckeretum crispae*, and grows in more humid environments.

CLASSIFICATION AND ORDINATION WITH MULTIVARIATE ANALYSIS TECHNIQUES

The multivariate ordination techniques TWINSPLAN and DECORANA applied to the matrix of the cover estimates of 31 taxa within the 23 sample plots gave the next results. The TWINSPLAN divided the epiphytic bryophyte vegetation groups in the *Buxus sempervirens* forests into three clusters at the second level according to the indicator species compatible with the Braun-Blanquet vegetation units determined in the present study (Fig. 3). The TWINSPLAN groups were characterized mostly by pleurocarpous taxa which are more sensitive to drought than acrocarpous mosses (Kürschner 2004). Also, all of them were mostly found on the middle parts of the trunks of the boxwood trees. This situation was not surprising considering the mesoscale climatic factors and microclimate characteristics of the study area where a mild and rainy climate prevails in all seasons.

The DECORANA ordinated the three epiphytic bryophyte vegetation units on the axis 1 and the axis 2 according to the humidity gradient (from xeric to mesic) and height gradient (from basal zones to upper zones) (Fig. 4). Finally, the results of both the TWINSPLAN and DECORANA analyses indicate that the humidity of epiphytic habitats is the most important abiotic ecological factor for the epiphytic bryophyte colonisation, spatial distribution and composition of epiphytic bryophyte communities.

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