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Epiphytic bryophyte vegetation of Beldibi and Babadağ forests (Zonguldak, Turkey)

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Abstract
In this study, epiphytic bryophyte vegetation of Beldibi and Babadağ forests has been studied in northwest Turkey (Zonguldak). A total of 55 sample plots were studied. Phytosociological data, obtained from sampe plots, were classified according to the Barun Balnquet method. And also sample plots were ordinated with Detrended Correspondance Analysis (DCA) and classified with two-way indicator species analysis (TWINSPAN). The results indicated that three bryosociological unit were determined from the forests. These; *Neckeretum crispae*, *Anomodonto viticulosi-Leucodontetum sciuroidis* and, *Orthotricho straminei-Pterigynandretum filiformis*. Amanog them *Neckeretum crispae* was reported for the first time from Turkey.
Key Words: Bryophyte, Epiphyte, Vegetation, Zonguldak, Turkey

Introduction

Bryophytes are a conspicuous and ecologically significant component of mountain forests, and grows on various substrates such as soil, rocks, living and dead trunks, branches. Nevertheless, studies of bryophyte communities from Turkey are lacking, although several studies on bryo-sociology have been carried out with successfully in Turkey as well as bryofloristic studies (Alataş et al. 2017; Alataş and Uyar 2017; Ezer 2017; Can Gözcü et al. 2018; Alataş 2018; Alataş et al. 2019). No study to classify the bryophyte vegetation of the Beldibi and Babadağ forests were made until now. The aim of this study was to reveal the epiphytic bryophyte vegetation of Beldibi and Babadağ forests using DCA and TWINSPAN multivariate analysis techniques as well as Braun-Blanquet method in nortwest Turkey. *Neckeretum crispae* which was reported for the first time from Turkey with the present paper, brings the total to 47 the number of epiphytic bryophyte syntaxa known from Turkey. Even so, further studies on this topic will be needed to determine and real composition and structure of the Turkish bryophyte vegetation.

Material and Methods

Study area

Beldibi and Babadağ forests (Zonguldak, Devrek), located in A2 grid-square according to the Henderson (1961), are located in Euxine zone of Euro-Siberian phytogeographic region (Anşin 1983). The study area, situated in the Western Black Sea Region, is located within the borders of Zonguldak province. There are Karabük district to the east of the study area, Ereğli district to the west, Zonguldak to the north, Bolu and Düzce provinces to the South (Fig. 1). Since the mountains in Zonguldak are

parallel to the coast, the climate from the coast to the inner part shows significant changes. Depending on these climate changes, different vegetation types such as Oceanic, Mediterranean and Sub-Mediterranean are seen from the north to the south of the area (Güvenç et al. 2009).

The average precipitation is 902 mm and the average annual temperature is 13.9 ºC in the study area. The hottest month of the year is July and the coldest month is January (URL,1). The annual precipitation regime of the study area is KSII. This situation indicates that the study area has a oceanic climate and it is located in a transitional zone of the sub-mediterranean bioclimatic region (Akman 2011).

The Black Sea Region is particularly suitable for the development of leafy forests. While the conifer *Pinus nigra* J.F.Arnold subsp. *nigra* var. *pallasiana* Schneid is the most dominant species in the study area, the deciduous species *Fagus orientalis* Lipsky. and *Carpinus betulus* L. are the co-dominant. And also, *Castane sativa* Miller., *Quercus petraea* (Mattuschka) Liebl., *Acer platanoides* L., *Tilia rubra* DC., *Salix caprea* L., *Cornus mas* L. and, *Platanus orientalis* L. are other common species in the study area.

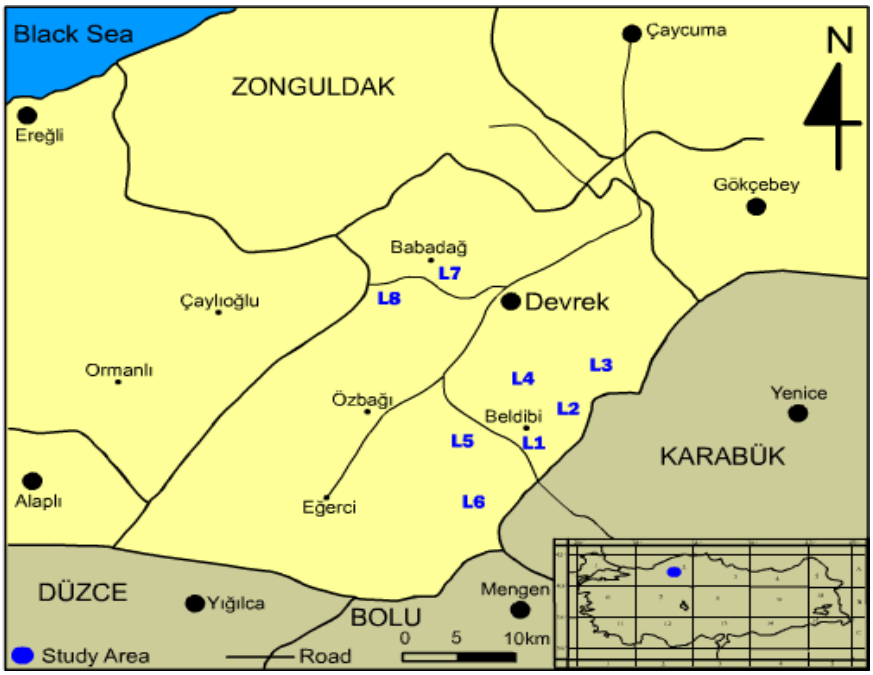

Figure 1. Grid system of Turkey adopted by Henderson (1961) and the study area.

Vegetation sampling

According to the Braun-Blanquet method (Braun-Blanquet, 1964), a total of 55 phytosociological relevés were taken from the lower (0-0,5 m) and middle (0,5-2m) zones of the trunks of trees which found in the different localities of the Beldibi and Babadağ forests during the different vegetation periods of 2014 (Table 1). The relevés were selected depending on the minimal area concept. For the relevés, abundance-coverage scale of Frey and Kürschner was used (Frey and Kürschner 1991; Table 2).

Phytosociological data, obtained from relevés, were evaluated in accordance with the classical method of Braun-Blanquet (1964). In addition, multivariate analysis techniques such as Two Way Indicator Species Analysis (TWINSPAN; Hill, 1979b) and Detrended Correspondance Analysis (DECORANA; Hill 1979a) were used for classification and ordination respectively. Bryophyte associations were arranged by diagnostic species (Braun-Blanquet 1964) and named according to Weber et al. (2000).

Table 1. The list of localities.

Number of relevés	Localities	Altitude (m)	Phorophyte	Date	GPS Coordinates
1-5	1	451	*Q.p.*	19.05.2014	N 41º06' 42.52" E 032º01'02.00"
6-11	2	566	*T.r., F.o., C.b.*	19.05.2014	N 41º07' 20.91" E 032º01'47.11"
12-18	3	539	*C.b., A.p., T.r., F.o., Q.p.*	20.05.2014	N 41º08'02.19" E 032º01'42.57"
19-24	4	485	*C.b., A.p., F.o.*	26.06.2014	N 41º07'54.02" E 032º01'16.86"
25-36	5	357	*P.o.*	27.06.2014	N 41º07'27.87" E 031º59'42.49"
37-45	6	495	*C.m., S.c., Q.p., C.b., F.o.*	28.06.2014	N 41º06'25.06" E 031º59'09.62"
46-51	7	583	*Q.p., C.b., F.o.*	12.09.2014	N 41º13'16.68" E 031º51'06.18"
52-57	8	669	*Q.p., C.b.*	13.09.2014	N 41º12'48.86" E 031º50'10.82"

F.o.; Fagus orientalis, C.b.; Carpinus betulus, T.r.; Tilia rubra, Q.p.: Quercus petraea, A.p.: Acer platanoides, S.c.: Salix caprea, C.m.: Cornus mas, P.o.: Platanus orientalis

Table 2. Abundance-coverage scale used for bryophytes.

scale	Abundance-coverage	scale	Abundance-coverage
+	< % 1	3	% 12,1-25,0
1	% 1,1-6,0	4	% 25,1-50,0
2	% 6,1-12,0	5	% 50,1-100

The determination of the associations in the present study was carried out via comparison with related associations in Marstaller (2006) and classified with the aid of published studies. For the identification of the epiphytic bryophyte specimens, different floras, monographies and revisions were used (Nyholm 1981; Hedenäs 1992; Smith 2004; Zander 1993; Paton 1999; Cortini Pedrotti 2001, 2006; Heyn and Herrnstadt 2004; Frey et al. 2006; Guerra and Cros 2007; Casas et al. 2009; Kürschner and Frey 2011, Plášek et al. 2015; Lara et al. 2016).

Results and Discussion

Classification of Braun-Blanquet method

As a results of phytosociological data obtained from total 55 relevés, three epiphytic bryophyte associations were determined using Braun-Blanquet (1964) method. These; *Neckeretum crispae* (Kaiser 1926) Herzog et Höffler 1944, *Anomodonto viticulosi-Leucodontetum sciuroidis* Wisn. 1930 and, *Orthotricho straminei-Pterigynandretum filiformis* Gillet 1986. The *Neckeretum crispae* was reported for the first time from Turkey.

Floristic and ecological features of these syntaxa are given below in accordance with Marstaller's (2006) sequence.

Class: *Neckeretea complanatae* Marst. 1986
Order: *Neckeretalia complanatae* Jez. and Vondr. 1962
Alliance: *Neckerion compalanatae* Sm. and Had. ex Kl. 1948
Associations: *Anomodonto viticulosi-Leucodontetum sciuroidis* Wisn. 1930
Neckeretum crispae (Kaiser 1926) Herzog et Höffler 1944
Class: *Frullanio dilatatae-Leucodontetea sciuroidis* Mohan 1978
Order: *Orthotrichetalia* Had. in Kl. and Had. 1944
Alliance: *Ulotion crispae* Barkm. 1958
Association: *Orthotricho straminei-Pterigynandretum filiformis* Gillet 1986

Description of the syntaxa

Anomodonto viticulosi-Leucodontetum sciuroidis Wisn. 1930 (Table 3)

The association was first described by Wisniewski in Poland and later recorded in Eastern Germany, Estonia, Sweden and the Netherlands respectively (Barkman 1958). Later, it was recorded by Goia and Schumacker (2004) in Romania. The association which is also the type association of the *Anomodonto-Leucodontenion sciuroidis* suballiance, wide-spreads on tree trunks in of shade, alkaline and very humid areas (Barkman 1958; Marstaller 2006).

The association occurs exclusively in the eastern and southern parts of the study area. It was determined within the total of 10 sample plots between 357-539 meters. The sample plots are situated on tree trunks that are spread on moist and shaded habitats in the eastern and southern parts of the study area. The association is similar to the European association in terms of ecological characteristics. It spreads on deciduous tree trunks in European localities such as *Carpinus betulus*, *Tilia ulmifolia*, *T. cordata*, *Fraxinus excelsior*, *Ulmus montana*, *Salix caprea*, *Acer platonoides*, *Fagus sylvatica*, *Quercus robur* and, *Alnus glutinosa* (Barkman 1958). Similarly, it occurs on *Fagus orientalis*, *Platanus orientalis*, *Cornus mas*, *Tilia rubra* and, *Quercus petraea* trunks in the study area (Fig. 2).

Table 3. *Anomodonto viticulosi-Leucodontetum sciuroidis* Wisn. 1930.

Number of relevés	**37**	**38**	**33**	34	**36**	**17**	**40**	**41**	**18**	**31**
Altitude (m)	495	495	357	357	357	539	495	495	539	357
Size of relevés (dm2)	9	4	12	12	16	12	6	9	8	16
Phorophyte	C.m.	C.m.	P.o.	P.o.	P.o.	T.r.	Q.p.	Q.p.	F.o.	P.o.
Trunk (m)	1,2	1,1	1,7	7,7	5,5	1,5	0,8	0,9	2	1,5
Exposition	K	K	K	K	K	K	KB	KB	K	K
Position of relevés	K	K	K	K	K	K	K	K	K	K
Covering (%)	88	95	90	98	92	93	90	95	91	90
Closure (%)	80	80	70	70	70	90	80	80	90	70
Base (B) / Trunk (T)	B	B	T	T	B	T	B	B	B	T
Number of species	7	5	6	6	7	7	6	7	9	5
Characteristic species										
Anomodon viticulosus (Hedw.) Hook. & Taylor.	2	3	1	3	3	2	2	2		
Leucodon sciuroides (Hedw.) Schwägr.	3	2	3	3	3	3	4	4	2	4
Characteristic species of the Neckerion complanatae alliance										
Alleniella besseri (Lobarz.) S.Olsson, Enroth & D.Quandt.	2									
Homalia trichomanoides (Hedw.) Brid.									1	
Anomodon attenuatus (Hedw.) Huebener.									1	
Characteristic species of the Neckeratalia complanatae order and Neckeretea complanatae class										
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt.	4	4	2		2	4		2	4	3
Homalothecium sericeum (Hedw.) Schimp.	2	3	4	4	4	2	3	3	1	3
Porella platyphylla (L.) Pfeiff.	2	2								
Radula complanata (L.) Dumort.	1			1		1			2	
Hypnum cupressiforme var.*cupressiforme* Hedw.			2	2			2	2		2
Isothecium alopecuroides (Lam. ex Dubois) Isov.									1	
Others										
Frullania tamarisci (L.) Dumort.						2	3		2	
Ptychostomum moravicum (Podp.) Ros & Mazimpaka.				1						
Pulvigera lyellii (Hook. & Taylor) Plášek, Sawicki & Ochyra.							2			
Frullania dilatata (L.) Dumort.			1		1			1		
Hypnum resupinatum (Taylor) Schimp.					2					
Zygodon rupestris Schimp. ex Lorentz.										1

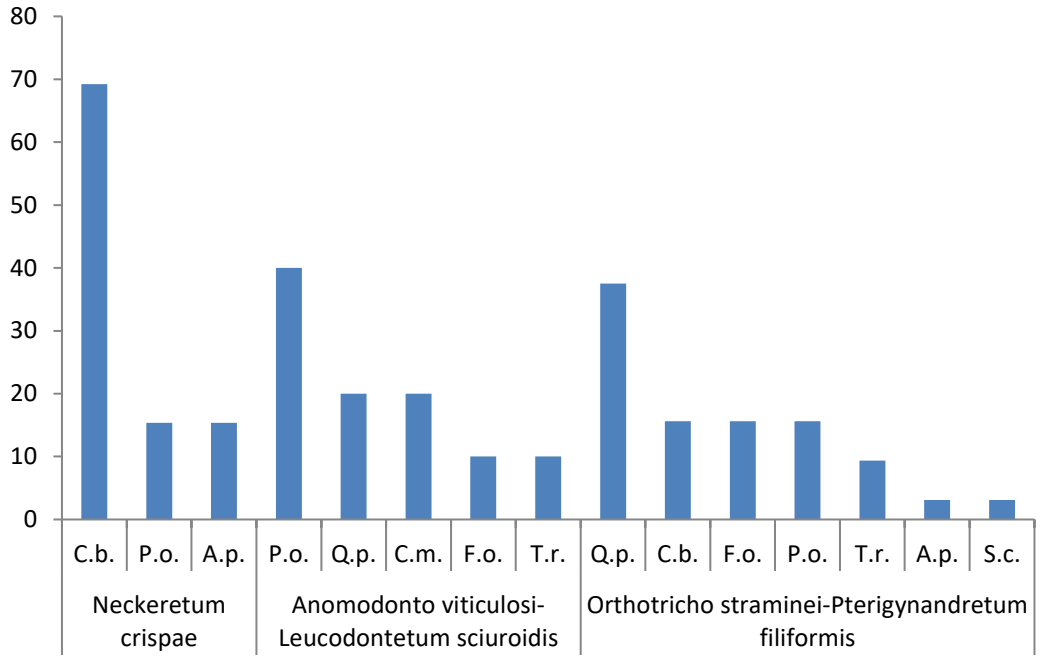

Figure 2. The tree preferences of the syntaxa.

While the general cover of the epiphytic bryophyte species within the association ranges from 88% to 98%, canopy cover is 70%-90%. A total of 17 taxa were recorded in sample plots. 4 of them are liverworts, 13 of them are mosses (3 acrocarpous, 10 pleurocarpous). An average number of taxa are 6 within the association. The high proportions of pleurocarpous species, more sensitive to drought than acrocarpous, suggests that the association is generally spread in moist habitats in the study area.

The permanency of *Anomodon viticulosus*, one of the diagnostic species of the association, is 80% in the sample plots. The permanency of another diagnostic species *Leucodon sciuroides* is 100 %. The mesophyte taxon *Anomodon viticulosus* generally grows on trunks as epiphytically and, on stone, wall and, rock as epilithically in shady semi-arid and semi-neutral environments. The mesophyte-xerophyte taxon *Leucodon sciuroides*, generally grows as epiphytically and epilithically, spreads on acidic and semi-neutral habitats in open areas. Therefore, it can be said that both diagnostic species are strongly compatible with the characteristics of the upper syntaxonomic units (class, ordo, alliance).

This association is characterized by facultative epiphytes with large proportion (41 %). The percentage of obligate epiphytes is 35% in the association. Indifferent species were represented by low percentage (24%) respectively (Fig. 3). In this situation, it can be say that the determined syntaxon in the study area is facultative epiphyte.

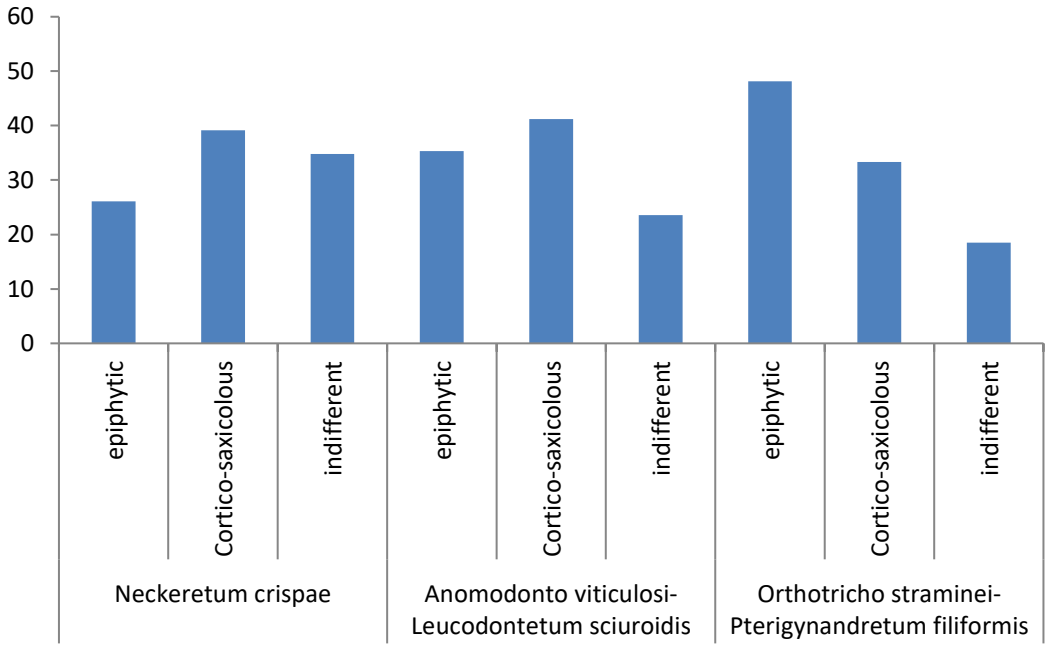

Figure 3. The habitat affinities spectrum of the species of syntaxa.

Syntaxonomically, *Anomodonto viticulosi-Leucodontetum sciuroidis* Wisn. 1930 was classified in the alliance *Neckerion complanatae* Sm. & Had. ex Kl. 1948, the ordo *Neckeretalia complanatae* Jez. & Vondr. 1962 and, the class *Neckereta complanatae* Marst. 1986 due to it includes of characteristic species of the upper units (Table 3).

The association, determined in the study area, show some floristic and ecologic similarity to Romanian association previously determined by Goia and Schumacker (2004). *Leucodon sciuroides*, *Porella platyphylla* and, *Homalothecium sericeum* are characteristic species of both associations.

Neckeretum crispae (Kaiser 1926) Herzog et Höffler 1944 (Table 4)

The association was determined with a total 13 sample plots between 357 to 539 meters of the study area. The association occurs mainly northern parts of the lower base and middle zone of trees. The trees are widespread in shade and open areas in the mesic southern and eastern slopes of the study area. *Carpinus betulus* is the most preferred tree species by the association in the study area (Fig. 2).

While the general bryophyte cover within the association ranges from 85% to 97%, canopy cover is 70%-100%. A total of 23 taxa were recorded in the sample plots belonging to the association. Among them, 7 are liverworts and, 16 are mosses (3 acrocarpous, 13 pleurocarpous). The average taxa numbers are 7 within the association.

This association highly occurs on deciduous *Carpinus betulus*, *Acer platanoides* and *Platanus orientalis* mixed forests as epiphytically in moist slopes of the study area. At the same time, *Exsertotheca crispa*, the main diagnostic species of the association, is hygrophytic pleurocarpous taxon. Therefore, it can be said that the association is hygrophytic. The permanency of the main diagnostic species within the sample plots is 85%.

The percentage of cortico-saxicolous members in the association is 39%. On the other hand, the percentage of epiphytic members is 26%. Indifferent species were represented by highly proportion with 35% within the association (Fig. 3). Therefore, the association determined in the study area is facultative epiphyte.

Table 4. *Neckeretum crispae* (Kaiser 1926) Herzog et Höffler 1944.

Number of relevés	11	**20**	**25**	**12**	**13**	**14**	**21**	22	**23**	**24**	**26**	**45**	**42**
Altitude (m)	566	485	357	539	539	539	485	485	485	485	357	495	495
Size of relevés (dm2)	12	9	16	12	9	12	16	16	12	9	12	16	6
Phorophyte	C.b.	A.p.	P.o.	C.b.	A.p.	C.b.	C.b.	C.b.	C.b.	C.b.	P.o.	C.b.	C.b.
Trunk (m)	1,5	1,2	2,7	1,4	1,2	1,8	1,5	1,8	1,4	1,8	4,2	2,4	1,1
Exposition	K	K	K	K	K	K	K	K	K	K	K	KB	KB
Position of relevés	K	K	K	K	K	K	K	K	K	K	KD	K	K
Covering (%)	94	90	86	85	95	91	92	91	90	97	96	88	90
Closure (%)	100	80	70	90	90	90	80	80	80	80	70	80	80
Base (B) / Trunk (T)	T	B	T	T	T	T	T	T	T	T	T	T	B
Number of species	7	7	9	8	8	5	7	8	10	7	7	8	7
Characteristic species													
Exsertotheca crispa (Hedw.) S.Olsson, Enroth & D.Quandt	5	4	2	4	4	5	4	4	4	3	3		
Characteristic species of the Neckerion complanatae alliance													
Anomodon viticulosus (Hedw.) Hook. & Taylor.					2								
Anomodon attenuatus (Hedw.) Huebener.												2	
Characteristic species of the Neckeratalia complanatae order and Neckeretea complanatae class													
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt.	1	2	3				2		2	4	4	4	3
Homalothecium sericeum (Hedw.)Schimp.	1		3		2	2	3	2	2		4	2	3
Metzgeria furcata (L.) Dumort.	1						1				1		
Radula complanata (L.) Dumort.		1	1	2	1	1	2	1			1	2	1
Isothecium alopecuroides (Lam. ex Dubois) Isov.				1	1	3		1	1	1		1	1
Hypnum cupressiforme var.*cupressiforme* Hedw.		2	1	2	2			2	1	2	2	2	2
Cirriphyllum crassinervium (Taylor) Loeske & M.Fleisch.			2										
Porella arboris-vitae (With.) Grolle.									2	3	1		
Lejeunea cavifolia (Ehrh.) Lindb.				1	1		2	1	1			1	
Others													
Plagiomnium affine (Blandow ex Funck) T.J.Kop.				2	2	1		3					
Leucodon sciuroides (Hedw.)Schwägr.	3	2	2										
Pterigynandrum filiforme Hedw.		2					2			2			
Frullania tamarisci (L.) Dumort.	3			1				1	1	1		2	
Isothecium myosuroides Brid.	1												
Lophocolea heterophylla (Schrad.) Dumort.				1									
Bryum capillare Hedw.									1				
Brachythecium mildeanum (Schimp.) Schimp.			2										
Ptychostomum moravicum (Podp.) Ros & Mazimpaka.			1										
Frullania dilatata (L.) Dumort.													1
Antitrichia curtipendula (Hedw.) Brid.													4

The diagnostic species of the association are *Neckera complanata*, *Metzgeria furcata* and *Homalothecium sericeum*. These species which are diagnostic species of *Neckeretalia complanatae* are represented by high proportion in the syntaxon. Moreover, *Exsertotheca crispa*, grows on epiphytic and epilithic habitats, is the main diagnostic species of the facultative epiphyte association. It was therefore supported that the association is classified within the alliance *Neckerion complanatae*, the ordo *Neckeretalia complanatae* and the facultative epiphyte class *Neckereta complanatae* as syntaxonomically (Table 4).

The association, recorded for the first time from Turkey with the present paper, show floristic and ecologic similarity to Italian association previously determined by Cortini Pedrotti (1988) in the

Quercus ilex forests. *Neckera complanata, Metzgeria furcata* and *Homalothecium sericeum* are characteristic species of both associations and of the upper syntaxonomic units to which they are attached.

Orthotricho straminei-Pterigynandretum filiformis Gillet 1986 (Table 5)

The association is situated in a total of 32 sample plots on the north face of middle and basal parts of trunks of deciduous tree species which are spread on all localities within an elevation range of 357-669 meters in the study area.

The association was firstly described by Ochsner in 1928 with the name of *Ulotetum crispae*. Along with the changes in the syntaxonomical nomenclature, it was re-edited by Gillet under the name of *Orthotricho straminei-Pterigynandretum filiformis* Gillet 1986 and introduced to the world of science (Marstaller 2006).

The general bryophyte cover of the association ranges from 82% to 98%. The canopy cover of the forest where *Quercus petraea* is the most dominant tree species is 70%-100%. At the same time, *Quercus petraea* is the most preferred phorophyte species by the association with 38% (Fig. 2). The total number of species in this syntaxon was twenty seven. Among them, six are liverworts and the others are mosses (10 acrocarpous, 11 pleurocarpous). An average number of 7 species was recorded in the sample plots.

The main diagnostic species of association was aero-hygrophyte-mesophyte *Orthotrichum stramineum*. Although the permanency of the species is 41%, its cover within the association is very low. The permanency of strong competitive species *Pterigynandrum filiforme*, another diagnostic species of the association, is 75% and its cover is relatively higher.

Table 5. *Orthotricho straminei-Pterigynandretum filiformis* Gillet 1986.

Number of relevés	**1**	**3**	**6**	**7**	**46**	47	**48**	**53**	**54**	**55**	**57**	**4**	8	10	**49**	**50**	**52**	**51**	**2**	44	**19**	**32**	**39**	**56**	**43**	**9**	**16**	**29**	**35**	**5**	**27**	**30**
Altitude (m)	451	451	566	566	583	583	583	669	669	669	669	451	566	566	583	583	669	583	451	495	485	357	495	669	495	566	539	357	357	451	357	357
Size of relevés (dm2)	12	9	8	12	6	8	4	8	9	8	12	12	6	9	6	9	6	8	9	12	12	9	8	12	6	20	6	12	8	9	20	8
Phorophyte	Q.p.	Q.p.	T.r.	T.r.	Q.p.	Q.p.	Q.p.	Q.p.	Q.p.	C.b.	C.b.	Q.p.	T.r.	F.o.	Q.p.	C.b.	Q.p.	F.o.	Q.p.	C.b.	F.o.	P.o.	S.c.	C.b.	F.o.	F.o.	A.p.	P.o.	P.o.	Q.p.	P.o.	P.o.
Trunk (m)	0.8	1,1	1,2	1,2	0,9	0,8	0,7	0,8	0,9	1,5	1,6	1	1	1,8	1,1	1,2	0,9	1,7	0,9	1,4	1,9	3,6	1,6	1,8	1,5	2,7	0,7	1,8	2,4	1,2	2,1	1,4
Exposition	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	KB	K	K	K	K	KB	K	K	K	K	K	K	K
Position of relevés	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	KD	KD	KD
Covering (%)	90	90	93	82	91	98	85	91	93	95	96	93	80	83	95	86	93	84	95	98	98	93	96	91	98	90	90	95	97	96	88	88
Closure (%)	90	90	100	100	90	90	90	90	90	90	90	90	100	100	90	90	90	90	90	80	80	70	80	90	80	100	90	70	70	90	70	70
Base (B) / Trunk (T)	T	B	B	T	T	B	B	B	B	T	T	T	B	T	B	B	T	B	T	T	B	T	T	T	T	B	B	T	T	T	T	T
Number of species	8	7	7	7	10	8	7	7	10	7	9	7	5	5	7	7	6	7	7	9	5	6	10	8	10	6	6	6	6	5	5	6
Characteristic species																																
Pterigynandrum filiforme Hedw.			2	2	2	1		2	3	4	4			3	2	4	3	4	2	2	2	2	1	4	2	3	2	1	1			
Orthotrichum stramineum Hornsch. ex Brid.	*1*	*1*	*2*	*1*		1		1	1	1	2	*1*	*1*		1		1															
Characteristic species of the Ulotion crispae alliance																																
Metzgeria furcata (L.) Dumort.			2	3	1				1	1	2		2			1		1		2				1	2							
Hypnum andoi A.J.E.Sm.	2						2						3		3			3	3													
Lewinskya striata (Hedw.) F.Lara, Garilleti & Goffinet.				1	1	1	1	1	1					1		1		1														
Pulvigera lyellii (Hook. & Taylor) Plášek, Sawicki & Ochyra.								3	2		1			2			2								2	2						
Frullania tamarisci (L.) Dumort.		2										1							2	3	3							2				
Orthotrichum pallens Bruch ex Brid.																				1												
Characteristic species of the Orthotrichetalia order and Frullanio dilatatae-Leucodontetea sciuroidis class																																
Frullania dilatata (L.) Dumort.	2		2		2	2	1	2	2	2	2		2	3	2	2	3	2					1	2	2	3	2	2		2		2
Radula complanata (L.) Dumort.	1		1	2	1	2	1					1			1	1		2		1					2					1		1
Radula lindenbergiana Gottsche ex C. Hartm.		1																														
Leucodon sciuroides (Hedw.)Schwägr.	4	4	4	4	4	4	4	4	4	3	3	2	4	4	4	2	4		4	3	4	3	4	3		4	3	4	4	5	4	4
Homalothecium sericeum (Hedw.) Schimp.	2	2										4							2			4	2		3			3	4	2	3	3
Zygodon rupestris Schimp. ex Lorentz.																													1		2	1
Lewinskya affinis (Schrad. ex Brid.) F.Lara, Garilleti & Goffinet.																							1		1						1	
Others																																

Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt.																				3	4	3	3				4	2			3	
Porella platyphylla (L.) Pfeiff.			2	2	2	3	3	2	1	2	1	3							1		1	3	1	2	3							
Isothecium alopecuroides (Lam. ex Dubois) Isov.	1																	1														
Hypnum cupressiforme var.*cupressiforme* Hedw.					2	2			2		2					3				2			1					3				2
Hypnum cupressiforme Hedw. var. *lacunosum* Brid.																													2			
Hypnum resupinatum (Taylor) Schimp.		3										3													2					3		
Amblystegium confervoides (Brid.) Schimp.																									1							
Anomodon attenuatus (Hedw.) Huebener.																											2					
Ptychostomum moravicum (Podp.) Ros & Mazimpaka.					1																	1										
Syntrichia virescens (De Not.) Ochyra.										1	1													1								
Syntrichia latifolia (Bruch ex Hartm.) Huebener.																							1									
Orthotrichum pumilum Sw. ex anon.																								1		1						

The proportion of obligate epiphyte members within the association is the highest with 48%. Despite that the proportions of cortico-saxicolous (33%) and indifferent taxa (19%) are relatively lower within the association (Fig. 3). Therefore, it can be say that the association is epiphytic.

The association was classified into the alliance *Ulotion crispae* Barkman 1958, the ordo *Orthotrichetalia* Hadac in Klika & Hadac 1944 and, the class *Frullanio dilatatae-Leucodontetea sciuroidis* Mohan 1978, due to it included the diagnostic species of these upper sytaxonomic units (Table 5).

Additionally, the association, recorded for the first time from Turkey by Alataş and Uyar (2017), show floristic and ecologic similarity to previously determined association in the Abant Mountains, due to ecological characteristics and diagnostic species of both associations and of the upper syntaxonomic units are same.

Classification and ordination with multivariate analysis techniques

Two-Way Indicator Species Analysis (TWINSPAN) that classifies communities according to their floristic similarity, and Detrended Correspondence Analysis (DECORANA), as an ordination technique, were applied to the presence estimates of the recorded taxa in 55 sample plots. TWINSPAN classified epiphytic bryophyte vegetation into three clusters at third hierarchical level (Fig. 4). According to the indicator species clusters were as follows; *Orthotrichum stramineum* (cluster I), *Anomodon viticulosus* (cluster II) and, *Neckera crispa* (cluster III). The results obtained by TWINSPAN indicated that the classification of the communities are appropriate to that of Braun-Blanquet's table arrangements.

The Detrended Correspondance Analysis (DCA), an indirect gradient analysis technique, distributed the epiphytic communities on axis 1and axis 2 to three groups (I, II and III) according to the ecological characteristics of the epiphytic habitats (Fig. 5). The DCA ordination agreed well with TWINSPAN clusters. According to this; axis 1 clearly represented that the groups were distributed according to the humidity gradient of epiphytic habitats. The axis 2 was not so clear. But, for axis 2 could be said that the groups were distributed according to the height gradient (from lower base to upper zones) of epiphytic habitats on the phorophytes. Results obtained by DCA ordination showed that the spatial distribution of epiphytic bryophyte communies in the study area were affected by the ecological factors of the habitats. Especially humidity the most important ecological factor in community structures and distribution.

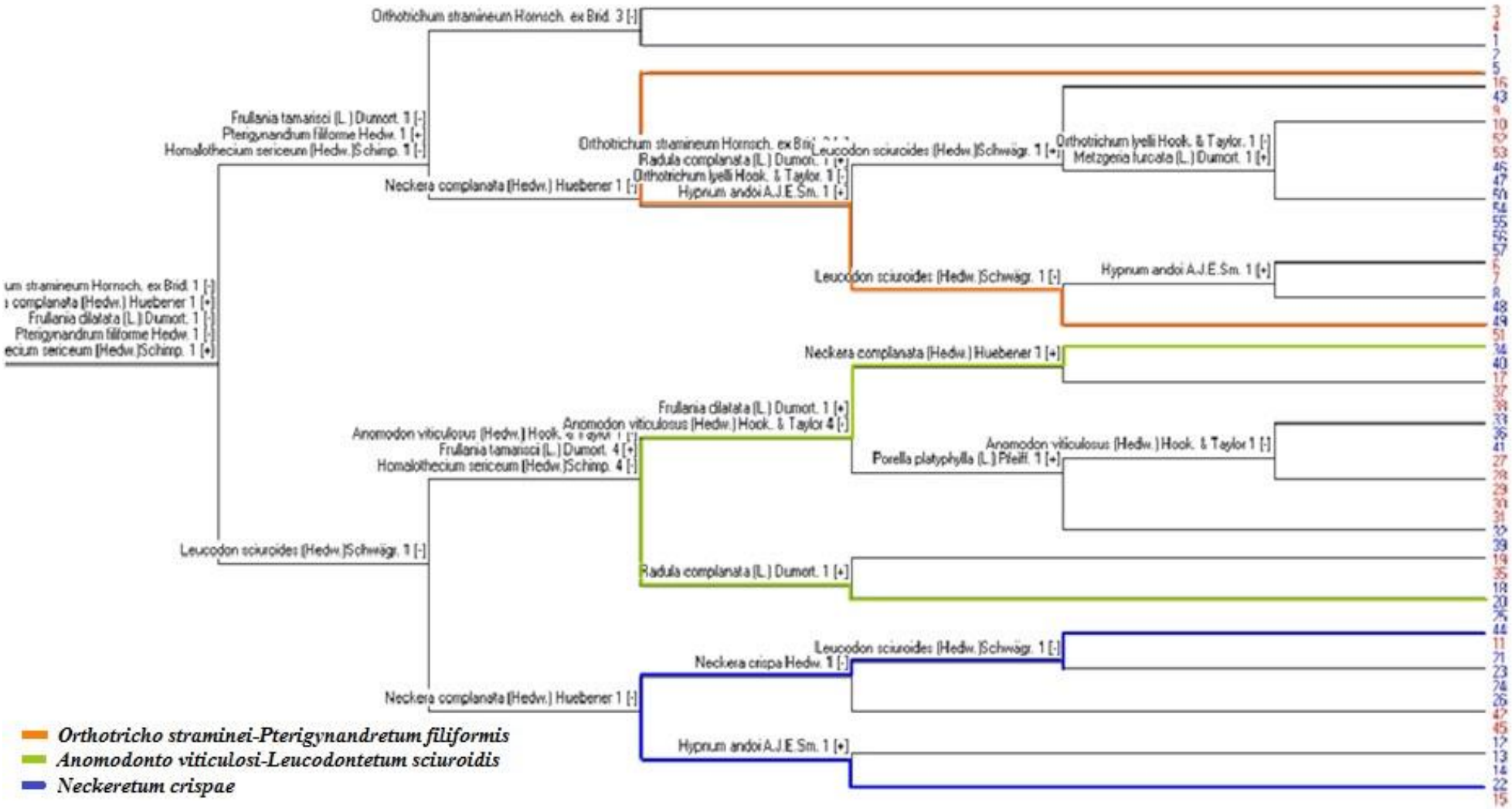

Figure 4. Dendrogram with clusters obtained by TWINSPAN.

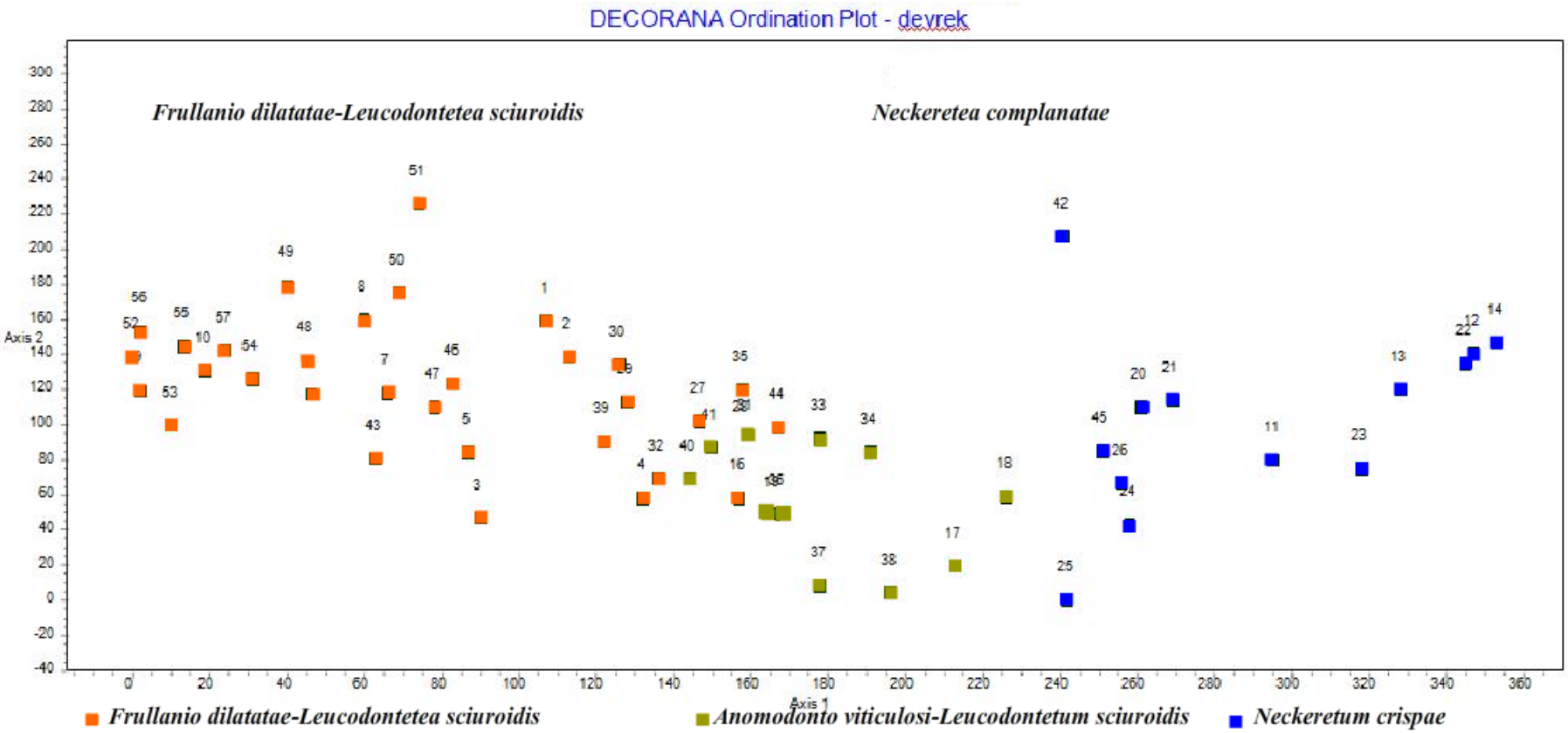

Figure 5.The demonstration of plots on DCA ordination diagram.

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