Botanica SERBICA 42 (2): (2018) 157-171

Original Scientific Paper

Epiphytic bryophyte vegetation of the Samanlı Mountains (Sakarya-Kocaeli-Yalova-Bursa) in Northwest Turkey

Merve Can Gözcü[1], Güray Uyar[1]*, Mevlüt Alataş[2], Tülay Ezer[3] and Muhammet Ören[4]

1 Department of Biology, Polatlı Faculty of Science and Arts, Ankara Hacı Bayram Veli University, Ankara, Turkey
2 Department of Bioengineering, Faculty of Engineering, Munzur University, Tunceli, Turkey
3 Department of Biology, Faculty of Science and Arts, Niğde Ömer Halisdemir University, Niğde, Turkey
4 Department of Biology, Faculty of Science and Arts, Bülent Ecevit University, Zonguldak, Turkey

ABSTRACT: In the present study, epiphytic bryophyte vegetation of the Samanlı Mountains (northwest Turkey) was investigated on the basis of 191 relevés taken from the trunks of trees by the Braun-Blanquet method between 2015 and 2016. Nine epiphytic bryophyte associations and three subassociations were determined as a result of this investigation. Among them, two associations and two subassociations, viz., *Neckero - Anomodontetum viticulosi*, *Neckero - Anomodontetum viticulosi - anomodontetosum viticulosi*, *Syntrichietum laevipilae*, and *Syntrichietum laevipilae - orthotrichetosum lyellii*, were recorded for the first time in Turkey. In addition, epiphytic bryophyte vegetation was classified and ordinated using multivariate analysis techniques such as two-way indicator species analysis and detrended correspondence analysis. Besides that, the life form and life strategies of the species within syntaxa were analysed. As a result, it is established that while perennial stayers with a high sexual reproductive effort were dominant within the epiphytic bryophyte vegetation comparatively, the most abundant life form was the mat rough type.

Keywords: association, bryophyte, epiphytic vegetation, life forms, life strategies, Samanlı Mountains, Turkey

Received: 26 April 2018 Revision accepted: 16 June 2018

UDC: 582.32:581.526.44(23.042)(560 Samanli)
DOI: 10.5281/zenodo.1468239

INTRODUCTION

Although bryophytes are one of the most primitive and diversified groups of green terrestrial plants, they were not considered a priority group for study by Turkish botanists until the late 1980s. However, bryophytes can survive under a wide variety of environmental conditions, such as growing forests, wetlands, dirt and rock habitats, etc. Moreover, they often form a significant part of ecosystems in spite of their small size and simple structure. Unfortunately, regardless of the efforts of both native and foreign bryologists over the past 30 years, the bryophyte flora and vegetation of Turkey are still incompletely known because not enough field studies have yet been performed in the southern and eastern parts of Turkey, or in many bryophyte-rich local areas in other regions of the country. One of these regions is that of the Samanlı Mountains, which were chosen as a study area in the Marmara region of Turkey. Even if this region seems to be the most studied area in Turkey according to the literature (Çetin 1999a, b; Papp & Sabovljevic 2003; Uyar & Ören 2005; Ören *et al*. 2007; Ursavaş *et al*. 2009; Tonguç Yayintaş 2013), no detailed study of the bryophyte flora or vegetation of the Samanlı Mountains has

*correspondence: gurayuyar@hotmail.com

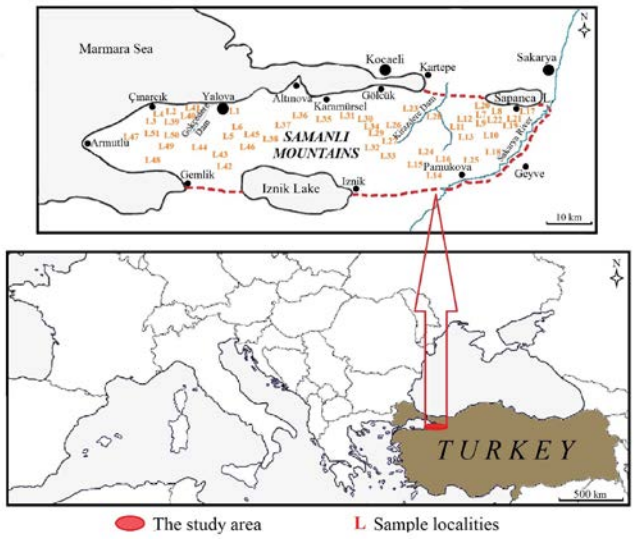

Fig. 1. Study area and sampling localities.

been performed until now. Obviously, the bryophyte flora and vegetation of Turkey still need to be investigated in greater detail. In the future, increasing bryofloristic and bryosociological studies in Turkey will unquestionably lead to the discovery of a number of new bryophyte records and associations.

The study area. The Samanlı Mountains, which extend from the western edge of the Armutlu Peninsula in Yalova Province to Geyve Strait of Sakarya Province, are located in northwest Turkey (Fig. 1). This mountain range is a transitional region between the humid mild climatic conditions of the Black Sea and Mediterranean climatic conditions. Its situation is clarified by the presence of Mediterranean-originated vegetation elements in the given area, which is located in the Euxine part of the Euro-Siberian phytogeographic region. At the same time, the studied mountain range is especially covered with deciduous forests (*e.g.*, beech, hornbeam, chestnut, oak, etc.) on its northern slopes, and by conifers and maquis vegetation on the southern slopes and in higher parts of the area. The mean annual temperature in the study area varies between 13.1 and 15.4°C. The highest monthly mean temperature is 29.4°C in July or August, and the lowest is 2.5°C in January. The average annual precipitation varies between 480.5 and 801.3 mm. The amount of precipitation increases and temperatures decrease toward the higher part of the mountains. According to bioclimatic synthesis, the study area can therefore be said to have a semiarid and humid Mediterranean climate (Akman 1999; TSMS 2016).

MATERIALS AND METHODS

Our bryosociological analysis was carried out using the plant sociological method of Braun-Blanquet (1964). The study material consisted of 191 phytosociological relevés collected from selected tree trunks at different localities and habitats of the Samanlı Mountains on field trips during different growing seasons in 2015 - 2016 (Table 1). Trees with different trunk cross-section areas (25, 50 or 100 dm^2) were selected for the relevés according to the minimal area concept and depending on composition of the bryoflora on the trunks. Relevés were established on the sampled trees, which were divided into two parts, namely the basal zone (10-99 cm above the ground) and the upper zone (100-200 cm). The cover of each taxon was estimated based on the following values: + (<1%), 1 (1-10%), 2 (10.1-25%), 3 (25.1-50%), 4 (50.1-75%), and 5 (75.1-100%) (Frey & Kürschner 1991a). In the present study, the methods proposed by Marstaller (2006) and Weber *et al.* (2000) were primarily utilized for syntaxonomic arrangement. In addition, 191 relevés established using Braun-Blanquet's method were analysed with the Community Analysis Software Package (version 5.0), which utilizes the DECORANA (detrended correspondence analysis) and TWINSPAN (two-way indicator species analysis) methods (Hill 1979a, b).

The life forms, life strategies, and habitat affinities of each taxon suggested by Hill *et al.* (2007), During (1979), Frey & Kürschner (1991b), and Draper *et al.* (2003) were taken into account for the synecological analysis. Furthermore, ecological characteristics of the taxa such as humidity, light, and acidity were assessed after conducting land observations in accordance with DierSSen (2001). Different published floras, monographs, and revisions (Nyholm 1981; Hedenäs 1992; Zander 1993; Paton 1999; Cortini Pedrotti 2001, 2006; Heyn & Herrnstadt 2004; Smith 2004; Frey *et al.* 2006; Guerra & Cros 2007; Casas *et al.* 2009; Kürschner & Frey 2011; Plasek e*t al.* 2015; Lara *et al.* 2016) were used to identify bryophyte specimens. The examined exsiccates were deposited in the private Uyar herbarium maintained by the Department of Biology, Polatlı Science and Arts Faculty of Gazi University.

RESULTS AND DISCUSSION

In this study, nine epiphytic bryophyte associations and three subassociations were determined within a total of 191 phytosociological relevés. Among them, the following two associations and two subassociations, which are arranged in two community tables (Tables 2 and 3), are new in Turkey: *Neckero - Anomodontetum viticulosi* (Wiśniewski 1929) Philippi 1965, *Neckero - Anomodontetum viticulosi -anomodontetosum viticulosi* Marst. 1980, *Syntrichietum laevipilae* Ochsn. 1928, and *Syntrichietum laevipilae -orthotrichetosum lyellii* Duv. ex Lec. 1975. Furthermore, *Pterigynandretum filiformis* Hil. 1925, *Orthotricho straminei-Pterigynandretum filiformis* Gillet 1986, and *Lewinskyetum affinis* Alataş & Uyar 2017 are here recorded for the second time in the country.These syntaxa

were previously recorded from the Abant Mountains of Turkey by Alataş & Uyar (2017).

All syntaxa are given below using Marstaller's (2006) sequence. The floristic composition, ecological characteristics, and phytosociological aspects of only the syntaxa new for Turkey are discussed in detail so as to avoid repetition in the present paper. The other syntaxa are briefly mentioned.

Class: *Neckeretea complanatae* Marst. 1986
Order: *Neckeretalia complanatae* Jez & Vondr. 1962
Alliance: *Neckerion compalanatae* Sm. & Had. ex Kl. 1948
Association: *Pterigynandretum filiformis* Hil. 1925
Association: *Homalothecio sericei - Porelletum platyphyllae* Storm. ex Duda 1951
Subassociation: *-leucodontetosum sciuroidis* Marst. 1992
Association: *Neckero - Anomodontetum viticulosi* (Wiśniewski 1929) Philippi 1965
Subassociation: *-anomodontetosum viticulosi* Marst. 1980
Class: *Frullanio dilatatae-Leucodontetea sciuroidis* Mohan 1978 em. Marst.1985
Order: *Orthotrichetalia* Hadač in Klika et Hadač 1944
Alliance: *Ulotion crispae* Barkman 1958
Association: *Orthotrichetum lyellii* All. ex Lec. 1975
Association: *Orthotrichetum striati* (Gams 1927) Marst. 1985
Association: *Lewinskyetum affinis* Alataş & Uyar 2017
Association: *Orthotricho straminei - Pterigynandretum filiformis* Gillet 1986
Association: *Pterigynandro filiformis - Orthotrichetum speciosi* Guerra 1982
Alliance: *Syntrichion laevipilae* Ochsner 1928
Association: *Syntrichietum laevipilae* Ochsn. 1928
Subassociation: *-orthotrichetosum lyellii* Duv. ex Lec. 1975

Pterigynandretum filiformis HIL. 1925

Pterigynandretum filiformis was determined in 17 relevés in a deciduous forest where *Fagus orientalis* is dominant at altitudes ranging from 220 to 1375 m a.s.l.(above sea level) in the Samanlı Mountains. The association is dominated by facultative epiphytes such as *Pterigynandrum filiforme* and *Alleniella complanata*. This association generally prefers shady, semi-arid, and humid environments in the study area.

Homalothecio sericei - Porelletum platyphyllae Storm. ex Duda 1951 and *-leucodontetosum sciuroidis* Marst. 1992

The association was determined in 18 relevés. It is mostly found on the base and middle parts of the trunk of *Platanus orientalis* in the study area. It was dominated by pleurocarpous moss species. The subassociation *-leucodontetosum sciuroidis* was determined in 12 relevés in the western region at altitudes ranging from 130 to 1110 m a.s.l. in the study area. *Fagus orientalis* is the tree most preferred by the subassociation. These syntaxa were spread throughout shaded, semi-arid, and humid habitats in the study area. The association and the subassociation were previously recorded from the Amanos and Abant Mountains in Turkey (Kara 2008; Alataş & Uyar 2017).

Neckero - Anomodontetum viticulosi (Wiśniewski 1929) Philippi 1965 and *-anomodontetosum viticulosi* Marst. 1980

The association was determined in nine relevés made at an altitude of 220 a.s.l. It was mostly found on the middle parts of large trunks of *Platanus orientalis* near a creek under humid, low–light, and acid-rich conditions in a deciduous forest. Plane trees usually have thick and cracked barks. The strongly competitive moss species *Alleniella complanata* and *Anomodon viticulosus* are noteworthy as being dominant on trunks of *P. orientalis*. Moreover, both these species are diagnostic species of the association and facultative epiphytes. Due to the mesophytic and hygro-tolerant character of species of this association, it is possible to find it in both epiphytic and epilithic habitats in shady and semiarid environments.

The overall covering of the association varies between 91 and 100% (Table 2). The average number of taxa in the association is six. In addition, the total number of taxa in the association is 21. Among them, six taxa are liverworts and 15 are mosses, 11 of which are pleurocarpous, the remaining four acrocarpous.

The subassociation was determined with seven relevés made at altitudes of between 220 and 450 m a.s.l. The overall covering of the subassociation varies between 78 and 100% (Table 2). The average number of taxa is six. A total of 22 taxa were found in the subassociation. Among them, five taxa are liverworts and 17 are mosses, 13 of which are pleurocarpous, while four are acrocarpous. The subassociation is mostly found on the lower base of *Platanus orientalis* trunks. The most characteristic species of this subassociation is the hygro- tolerant *Anomodon viticulosus*. In addition, *Exsertotheca crispa* and the cortico-saxicolous liverwort *Porella arboris-vitae* are notably dominant within the subassociation. It can therefore be said to be cortico-saxicolous, meso-hygrophitic, and widespread in more humid habitats than the association.

Ecologically, this association and subassociation can be classified as mountainous, cortico-saxicolous, hygrophytic, sciophytic, and acidophytic. They are characterized by pleurocarpous mosses, which are generally widespread in shady and humid habitats.

Analysis of life strategies, indicates that these syntaxa fall into one of three main categories, viz., colonists (C), perennial shuttle species (PeS), and perennial stayers (PS) (Fig. 2, Table 4). In the case of *Neckero* -

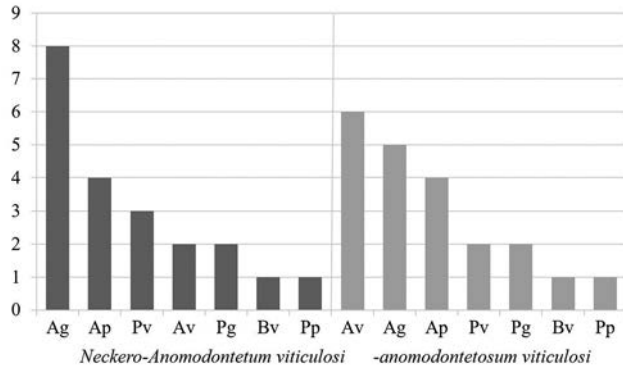

Fig. 2. Spectrum of life strategies of the syntaxa *Neckero - Anomodontetum viticulosi* and - *anomodontetosum viticulosi*.

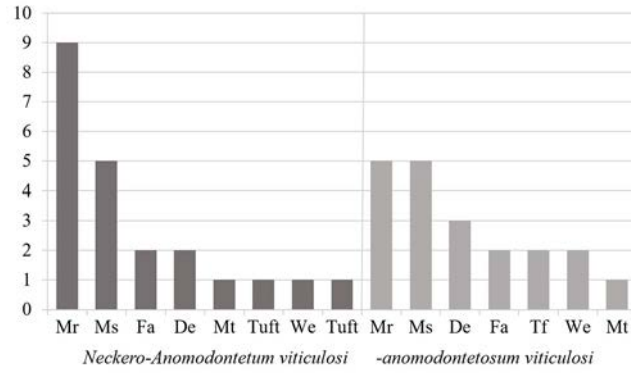

Fig. 3. Spectrum of life forms of the syntaxa *Neckero - Anomodontetum viticulosi* and - *anomodontetosum viticulosi*.

Anomodontetum viticulosi, perennial stayers comprised 66%, perennial shuttle species 29%, and colonists 5%. In that of -*anomodontetosum viticulosi*, the perennial stayers (Ag, Ap, Av) constituted 72%, perennial shuttle species (Pv, Pg, Pp) 23%, and colonists (Bv) 5%. Due to the dominance of perennial stayers and the presence of small numbers of colonists, it can be said that these syntaxa are close to the climax. The results of life form analysis show that rough mat (43%) was dominant and smooth mat (24%) was second in the association, while rough mat and smooth mat (24%) were co-dominant in the subassociation (Fig. 3, Table 4). The prevailing life form of the colonists were cushion and turf, whereas the dominant life forms of the perennial stayers were dendroid, fan, mat, and weft (Kürschner & Frey 2012). Thus, general features of the study area and ecological characteristics of the syntaxa are compatible.

According to the characteristic species, the association and subassociation new for Turkey occupy to the following syntaxonomical hierarchical position: the *Neckerion complanatae* alliance of the *Neckeretalia complanatae* order and *Neckeretea complanatae* class.

***Orthotrichetum lyellii* All. ex Lec. 1975**

The *Orthotrichetum lyellii* epiphytic association was determined in 22 relevés in the northeast and southeast regions at altitudes ranging from 130 to 1110 m a.s.l. in the Samanlı Mountains. *Fagus orientalis, Carpinus betulus*, and *Quercus ilex* were the phorophyte species preferred by the association. The association was dominated by xerophytic acrocarpous moss species. Although this association generally shows xeric characteristics, it mostly spreads in shaded, semi-arid, and humid habitats in the study area. The association was previously recorded from the Nif, Amanos, and Abant Mountains of Turkey (Walther 1979; Kara 2008; Alataş & Uyar 2017).

***Orthotrichetum striati* (Gams 1927) Marst. 1985**

Orthotrichetum striati was determined in 38 relevés usually taken in semi-arid habitats at altitudes ranging from 273 to 1220 m a.s.l.. *Quercus petraea* was the phorophyte species preferred by the association in the study area. The association was previously recorded from the Amanos Mountains, Abant Mountains, and *Quercus vulcanica* Boiss. & Heldr. ex Kotschy forests of Turkey (Kürschner *et al.* 2006; Ezer 2008; Kara 2008; Alataş & Uyar 2017).

***Lewinskyetum affinis* Alataş & Uyar 2017**

Lewinskyetum affinis was determined in 15 relevés mostly taken from trunks of *Platanus orientalis* and *Alnus glutinosa* in a deciduous forest and on the banks of a creek at altitudes ranging from 190 to 985 m a.s.l. The association generally prefers shady and humid environments in the area. It was first described from the Abant Mountains in Turkey (Alataş & Uyar 2017) and is here reported for the second time.

***Orthotricho straminei - Pterigynandretum filiformis* Gillet 1986**

The association was determined in 10 relevés mostly taken from trunks of *Fagus orientalis*, which is usually widespread in humid and low-light habitats in southern regions of the study area at altitudes ranging from 595 to 1375 m a.s.l. It was previously recorded from the Abant Mountains in Turkey (Alataş & Uyar 2017).

***Pterigynandro filiformis - Orthotrichetum speciosi* Guerra 1982**

The association was determined in 13 relevés and found in shady and humid areas at altitudes ranging from 235 to 1110 m a.s.l. in the study area. *Fagus orientalis* was the phorophyte species preferred by the association. The association was previously recorded from the Amanos and Abant Mountains in Turkey (Kara 2008; Alataş & Uyar 2017).

***Syntrichietum laevipilae* Ochsn. 1928 and -*orthotrichetosum lyellii* Duv. ex Lec. 1975**

This association was identified as epiphytic in 10 relevés usually taken from urban habitats close to roads domi-

Table 1. List of sampling localities (L: Locality number).

L	Localities	Alt. (m)	GPS	Date
1	Plane tree way	80	40°38'28"N; 29°13'41"E	03.04.2015
2	Teşvikiye	130	40°36'41"N; 29°04'18"E	03.04.2015
3	City forest	450	40°35'17"N; 29°01'35"E	03.04.2015
4	Kapılıçınar	220	40°33'14"N; 29°13'11"E	04.04.2015
5	Kurtköy road	300	40°34'19"N; 29°13'57"E	04.04.2015
6	Kartepe	1200	40°39'31"N; 30°05'56"E	25.05.2015
7	Dumanlıkaya vicinity	650	40°40'10"N; 30°07'21"E	26.05.2015
8	SisliVadi vicinity I	900	40°39'25"N; 30°07'09"E	26.05.2015
9	SisliVadi vicinity II	950	40°39'24"N; 30°07'25"E	26.05.2015
10	Suadiye village	800	40°39'06"N; 30°02'55"E	26.05.2015
11	Pazarçayırı village	700	40°38'50"N; 30°02'20"E	26.05.2015
12	Karpuzdere	450	40°37'21"N; 30°03'02"E	26.05.2015
13	Erciova plateau road	985	40°33'16"N; 30°00'17"E	27.05.2015
14	Erciova plateau	1110	40°33'34"N; 29°59'29"E	27.05.2015
15	North of Inönü plateau	1060	40°34'07"N; 30°00'14"E	27.05.2015
16	Istanbulderestreet	129	40°40'32"N; 30°14'49"E	28.05.2015
17	Soğucak plateau	1075	40°36'21"N; 30°11'27"E	28.05.2015
18	İstanbuldere	360	40°38'33"N; 30°13'59"E	28.05.2015
19	Aygır creek	273	40°41'00"N; 30°07'34"E	6.09.2015
20	Yanık Creek vicinity	650	40°39'36"N; 30°09'06"E	6.09.2015
21	Kuzuyayla Nature Park	1375	40°38'48"N; 30°07'01"E	6.09.2015
22	Karaaslan camping area	190	40°38'22"N; 29°56'15"E	7.09.2015
23	South of Inönü plateau	1069	40°34'08"N; 30°00'15"E	8.09.2015
24	Sıcakdere	761	40°35'24"N; 29°53'03"E	9.09.2015
25	Servetiyecamii village	870	40°34'33"N; 29°54'52"E	9.09.2015
26	Kazandere vicinity	595	40°37'47"N; 29°57'17"E	9.09.2015
27	Eskiferhadiye village	850	40°36'50"N; 29°50'58"E	10.09.2015
28	Eriklidüzü	1050	40°35'32"N; 29°48'47"E	10.09.2015
29	Eriklitepe Nature Park	940	40°36'07"N; 29°47'40"E	10.09.2015
30	Betonbina location	1030	40°35'49"N; 29°50'26"E	10.09.2015
31	Paşa neighbourhood	775	40°32'29"N; 29°51'59"E	11.09.2015
32	Başdeğirmen location	235	40°38'33"N; 29°36'18"E	26.10.2015
33	Karadere vicinity	150	40°37'26"N; 29°27'51"E	27.10.2015
34	İlyasköy vicinity	285	40°36'52"N; 29°26'44"E	27.10.2015
35	Çukurköy vicinity	245	40°36'39"N; 29°25'31"E	27.10.2015
36	Ortaburun pond vicinity	405	40°36'44"N; 29°07'27"E	28.10.2015
37	Hasanbaba vicinity	270	40°37'12"N; 29°07'25"E	28.10.2015

38	Teşvikiye forest road I	753	40°34'33"N; 29°02'57"E	28.10.2015
39	Teşvikiye forest road II	495	40°36'35"N; 29°06'51"E	28.10.2015
40	Şahinyurdu vicinity	650	40°28'42"N; 29°11'30"E	30.10.2015
41	Şahinyurdu village way	525	40°29'38"N; 29°12'27"E	30.10.2015
42	Gemlik forest road I	600	40°30'58"N; 29°08'49"E	30.10.2015
43	Şahinyurdu village way	525	40°29'38"N; 29°12'27"E	30.10.2015
44	Gemlik forest road II	600	40°30'58"N; 29°08'49"E	30.10.2015
45	Kurtköy forest road I	471	40°33'04"N; 29°13'42"E	21.04.2016
46	Kurtköy forest road II	530	40°32'40"N; 29°13'06"E	21.04.2016
47	Taz Mountain foothills	460	40°32'13"N; 28°54'07"E	22.04.2016
48	Karacaali	361	40°30'20"N; 29°03'09"E	23.04.2016
49	Karacaali forest road	510	40°31'28"N; 29°03'52"E	23.04.2016
50	Haydariye forest road I	742	40°32'20"N; 29°04'20"E	23.04.2016
51	Haydariye forest road II	750	40°32'36"N; 29°03'47"E	23.04.2016

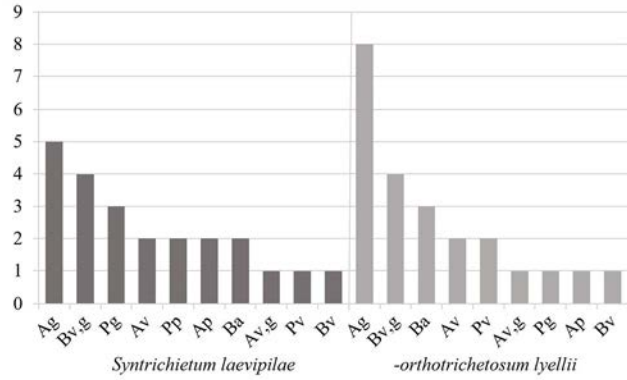

Fig. 4. Spectrum of life strategies of the syntaxa *Syntrichietum laevipilae* and - *orthotrichetosum lyellii*.

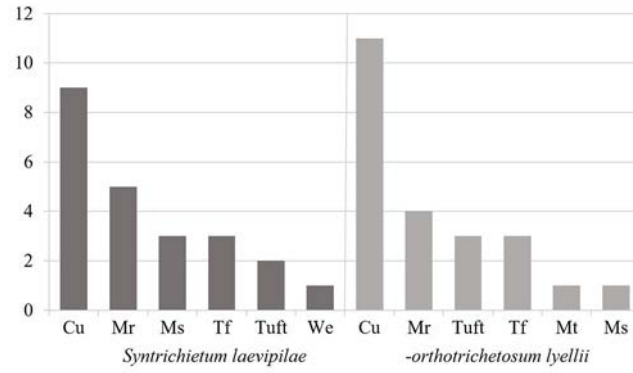

Fig. 5. Spectrum of life forms of the syntaxa *Syntrichietum laevipilae* and - *orthotrichetosum lyellii*.

nated by *Platanus orientalis,* occasionally in grassy areas of forests on northern, northwestern, and northeastern facades of the bottom part of trees, at altitudes ranging from 80 to 985 m a.s.l. in the Samanlı Mountains, whereas the subassociation was represented with 13 relevés taken from shaded and humid stems of *Platanus orientalis* and *Fraxinus angustifolia* at altitudes of between 150 and 800 m a.s.l. in the research area (Table 3).

The characteristic species of the association was *Syntrichia laevipila*, which was 100% permanent in the relevés, and the mesophyte taxon *Pulvigera lyellii*, which was the characteristic species of the subassociation and has the highest repetition rate, with a permanence ratio of 100% in the relevés. *Syntrichia laevipila* is a species that usually spreads on tree trunks and grows in semi-neutral environments under shady and humid conditions. For its part, *Pulvigera lyellii* is a species that grows in semi-neutral and semi-arid environments under shady and humid conditions, sometimes in open areas. It usually spreads on tree trunks and occasionally on rock surfaces. Ecological factors characteristic of the association were low-light, semi-dry, and humid sub-neutral conditions, whereas the subassociation prefers acid-rich semi-neutral habitats that are more arid and open compared to those of the association.

While overall coverage of the association varied between 75 and 97%, these figures were between 50 and 90% for the subassociation. The closure rate of the environment where the association exists varied between 20 and 90%, whereas it ranged between 10 and 90% for the subassociation. The covering size of the relevés ranged from 25 to 100 dm^2, and the number of taxa per relevé in both syntaxa varied from three to 10. Consequently, according to its ecological requirements, while the association can be classified as hygro-mesophytic, sciophytic, and subneutrophytic, the subassociation is hygro-xe-

Table 2. Analytical table of the association: a - *Neckero - Anomodontetum viticulosi* (Wiśniewski 1929) Philippi 1965; b - *anomodontetosum viticulosi* Marst. 1980 (P.o: *Platanus orientalis*, C.b: *Carpinus betulus*, F.o: *Fagus orientalis*).

Number of relevés	**31**	**37**	**39**	**45**	**46**	**47**	**50**	**63**	**48**	**38**	**40**	**80**	**30**	**32**	**33**	**34**
Altitude (m)	220	220	220	220	220	220	220	220	220	220	220	450	220	220	220	220
Size of relevés(dm²)	100	100	100	25	100	100	100	100	100	100	100	100	100	100	100	100
Phorophyte	P.o	P.o	C.b	P.o	P.o	P.o	P.o	P.o	C.b	C.b	C.b	F.o	P.o	P.o	P.o	P.o
Trunk (m)	3	8	6	1	7	7	5	4	3	5	2	2	3	4	6	6
Position of relevés	N	S	S	N	N	NW	NW	N	N	N	SW	N	S	S	N	S
Covering (%)	91	100	100	90	96	100	98	100	100	100	100	98	78	87	87	96
Canopy closure of vegetation (%)	70	80	80	80	75	75	80	75	75	85	90	85	70	70	80	80
Base (B)/Trunk (T)	B	B	T	T	T	T	B	B	T	T	T	B	B	T	B	B
Number of species	5	4	9	4	5	7	7	7	6	9	5	7	4	7	5	5
					a								**b**			
Ch.Ass.																
Alleniella complanata	1	3	1	3	1	1	3	5	5	.	.	.	.	.	.	.
Anomodon viticulosus	3	5	1	1	3	2	1	2	1	1	1	5	5	1	2	5
Ch.All. Neckerion complanatae																
Homalothecium philippeanum	.	1	5	.	5	1	.	.	.	3	.	.	.	.	.	2
Metzgeria furcata	.	.	+	.	.	.	.	.	.	1	1	+	.	.	.	.
Exsertotheca crispa	.	.	.	.	.	.	.	.	.	4	3	.	.	.	.	.
Ch.Cl. Neckeretea complanatae and Ch.O. Neckeratalia complanatae																
Porella arboris-vitae	.	.	3	.	.	.	.	1	.	2		3	.	.	.	2
Cirriphyllum crassinervium	.	.	.	5	.	1	5	.	.	.	.	.	.	.	.	.
Homalothecium sericeum	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Radula complanata	1	.	1	1	.	.	1	.	3	.	.	1	1	1		1

Lejeunea cavifolia	1	.	1		1	.	1	1	.	1	.	1	.	1	.	.
Hypnum cupressiforme var. *Cupressiforme*		.		.	.	.	.	1	.	.	.	.	.	.	.	.
Plasteurhynchium striatulum	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Others																
Ptychostomum moravicum	.	.	3	.	.	.	.	.	.	.	5	.	.	.	.	.
Alleniella besseri	.	.	+	.	.	1	.	.	.	.	.	2	.	4	.	1
Kindbergia praelonga	.	.	.	.	.	5	1	1	.	.	.	.	.	.	.	.
Mnium hornum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Rhynchostegiella tenella	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Thamnobryum alopecurum	.	.	.	.	.	3	.	3	.	.	.	.	.	.	4	.
Brachytheciastrum velutinum	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Brachythecium mildeanum	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	.
Oxyrrhynchium schleicheri	5	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Cololejeunea rossettiana	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Hygroamblystegium varium var. *Humile*			.	.	.	.	.	.	.	.	.	.	.	.	1	.
Palamocladium euchloron	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Plagiomnium affine	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Rhizomnium punctatum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Rhynchostegiella litorea	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
Frullania dilatata	.	.	.	.	.	.	.	.	1	.	.	2	.	.	.	.
Hypnum cupressiforme var. *Resupinatum*			.	.	.	.	.	.	.	.	.	1	.	.	.	.
Isothecium myosuroides	.	.	.	.	.	.	.	.	1	.	4	.	2	.	.	.
Leptodon smithii	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.

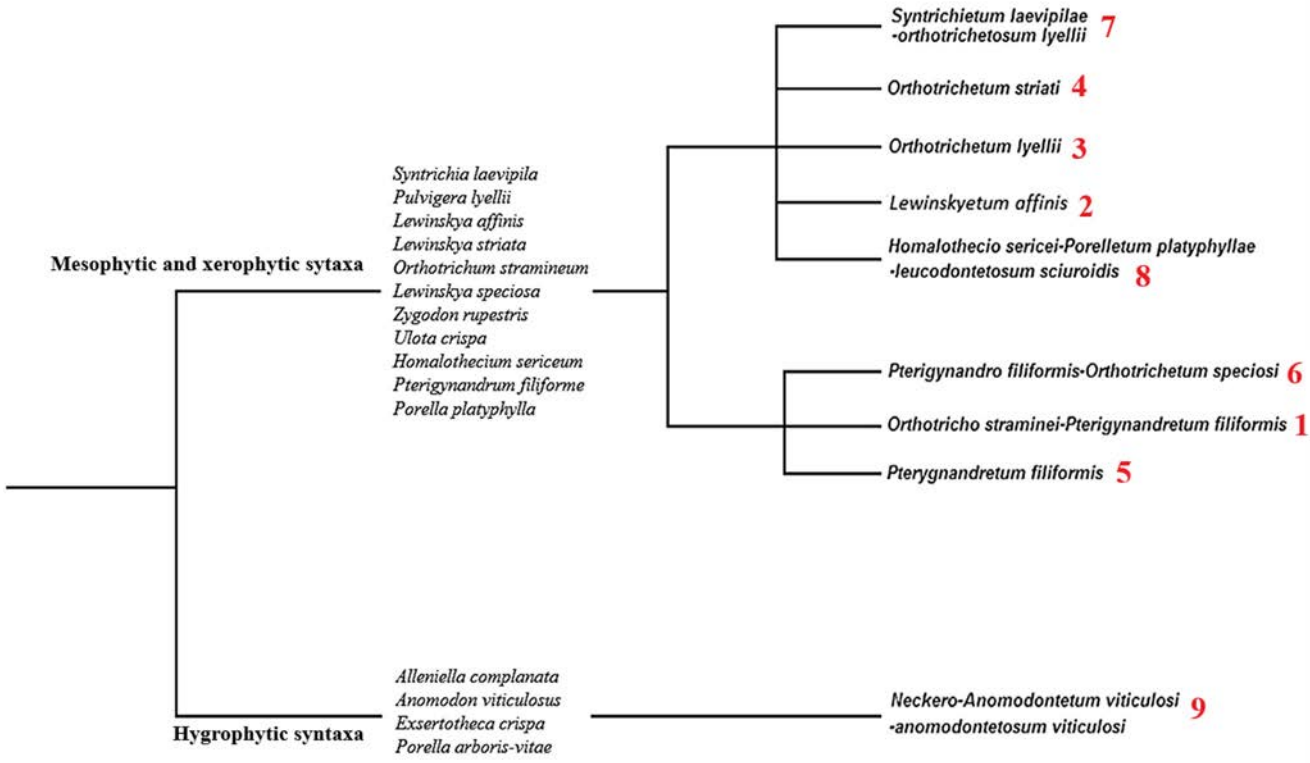

Fig. 6. Dendrogram of communities obtained by TWINSPAN.

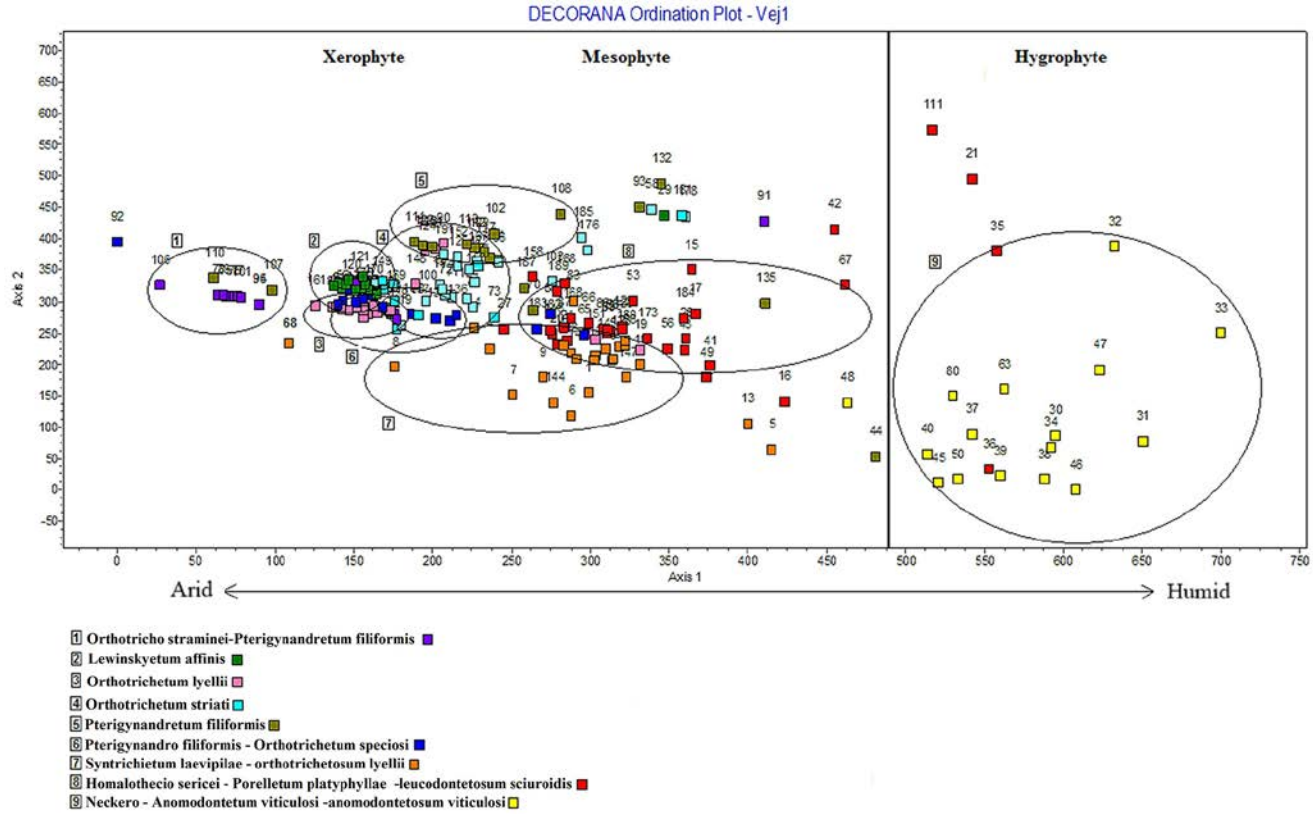

Fig. 7. Detrended correspondence analysis (DECORANA) ordination of 191 relevés.

Table 3. Analytical table of the association: a - *Syntrichietum laevipilae* Ochsn. 1928; b -*orthotrichetosum lyellii* Duv. ex Lec. 1975 (P.o: *Platanus orientalis*, F.a: *Fraxinus angustifolia*, Q.p: *Quercus petraea*).

Number of relevés	**14**	**144**	**83**	**147**	**68**	**1**	**2**	**4**	**13**	**180**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**141**	**142**	**143**	**145**
Altitude (m)	130	150	985	150	900	80	80	80	80	361	80	80	80	80	80	80	80	80	80	150	150	150	150
Size of relevés(dm²)	100	100	100	100	25	100	100	100	100	25	100	100	100	100	100	100	100	100	100	25	25	25	100
Phorophyte	P.o	F.a	Q.p	F.a	C.b	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	P.o	F.a	F.a	F.a	F.a
Trunk (m)	1,4	2	3	3	0,7	2,4	2,8	2,2	3	3	3	3	1,5	1,5	2,5	3	3	2,3	2,6	1,6	1,5	1,2	3
Position of relevés	NW	N	NW	N	N	N	E	NW	N	N	W	SW	N	N	NW	NW	N	NW	N	NE	NE	NE	NE
Covering (%)	76	75	95	97	90	75	85	90	77	95	61	90	83	87	70	50	83	60	88	73	56	69	64
Canopy closure of vegetation (%)	50	70	80	60	90	20	20	20	25	90	20	10	15	20	15	20	15	90	20	50	20	85	60
Base (B)/Trunk (T)	B	B	T	T	T	T	T	B	B	B	B	B	B	T	B	B	B	B	B	B	B	T	T
Number of species	9	3	5	5	5	4	6	5	6	8	9	6	6	4	5	6	7	8	10	6	4	7	8
	a										**b**												
Ch.Ass.																							
Syntrichia laevipila	1	4	+	4	2	4	1	3	1	1	1	3	4	5	1	1	1	1	2	1	1	2	1
Pulvigera lyellii	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	2	1	1
Ch.All. Ulotion crispae																							
Ulota crispa	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Metzgeria furcata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Orthotrichum stellatum	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lewinskya acuminate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Ch.All. Syntrichion laevipilae																							
Orthotrichum diaphanum	.	.	.	.	.	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1

Orthotrichum tenellum	.	4	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	3	.	.	.		
Orthotrichum pumilum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.		
Syntrichia papillosa	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.		
Ch.All. Fabronion pusillae																									
Habrodon perpusillus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Nogopterium gracile	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Ch.SubAll. Pterigynandrenion filiformis																									
Pterigynandrum filiforme	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Ch.Cl. Frullanio dilatatae -Leucodontetea sciuroidis and Ch.O. Orthotrichetalia																									
Frullania dilatata	2	.	.	1	1	.	.	1	.	1	.	1	.	.	.	.	.	.	2	2	.	1	1		
Leucodon sciuroides	4	.	.	1	.	3	.	.	.	3	1	.	.	.	.	.	1	.	1	.	.	.	.		
Homalothecium sericeum	3	1	4	5	.	3	2	3	3	5	4	.	.	.	.	1	5	5	4	4		4	4		
Lewinskya speciosa	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.		
Lewinskya affinis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1		
Others																									
Hypnum cupressiforme var. *Resupinatum*	.	.	.	.	.	.	5	4	1	.	.	1	1	3	2	3	.	1	1	.	4	.	.		
Ptychostomum moravicum	.	.	.	.	.	.	.	.	4	.	.	5	1	.	.	3	.	1	.	.	.	.	.		
Hypnum cupressiforme var. *Cupressiforme*	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.		
Orthotrichum anomalum	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2	.	.	.	.	.		
Lewinskya rupestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1		
Ptychostomum capillare	1	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.		
Dialytrichia mucronata	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Grimmia pulvinata	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.		

Table 4. Life form and life strategy of taxa within the syntaxa.

Syntaxa			*Neckero - Anomodontetum viticulosi*	*-anomodontetosum viticulosi*	*Syntrichietum laevipilae*	*-orthotrichetosum lyellii*	Shortening
			%	%	%	%	
Life Form	Mat rough		43	24	22	18	Mr
	Mat smooth		24	24	13	4	Ms
	Fan		9	9	0	0	Fa
	Dendroid		9	14	0	0	De
	Turf		0	9	13	13	Tf
	Mat thalloid		5	5	0	4	Mt
	Tuft		5	5	9	13	Tuft
	Weft		5	10	4	0	We
	Cushion		0	0	39	48	Cu
Life Strategy	Colonists	Pauciennial colonists	0	0	9	13	Ba
		Colonists with high asexual reproductive effort	5	5	4	4	Bv
		Colonists with high sexual and asexual reproductive effort	0	0	17	18	Bv,g
	Perennial Shuttle	Perennial shuttle species with high asexual reproductive effort	14	9	4	9	Pv
		Perennial shuttle species with high sexual reproductive effort	10	9	13	4	Pg
		Perennial shuttle species with low sexual and asexual reproductive effort	5	5	9	0	Pp
	Perennial Stayers	Perennial stayers with high asexual reproductive effort	9	29	9	9	Av
		Perennial stayers with high sexual and asexual reproductive effort	0	0	4	4	Av,g
		Perennial stayers with high sexual reproductive effort	38	24	22	35	Ag
		Perennial stayers with low sexual and asexual reproductive effort	19	19	9	4	Ap

rophytic, sciophytic, and acidophytic-subneutrophytic. Both syntaxa were characterized by acrocarpous mosses, which were generally widespread in sunny and dry habitats.

These syntaxa show three main categories of life strategies: colonists (C), perennial shuttle species (PeS), and perennial stayers (PS) (Fig. 4, Table 4). In the case of *Syntrichietum laevipilae*, perennial stayers represent 44%, perennial shuttles 26%, and colonists 30%. In the case of *-orthotrichetosum lyellii*, on the other hand, perennial stayers represent by 52%, perennial shuttle species (Pv, Pg) 13%, and colonists (Ba, Bv, Bv,g) 35%. The perennial stayers, which are divided into four sub-categories (Ag, Ap, Av, Av,g), are dominant. To judge from these data, the syntaxa were progressing towards stability; however, they did not reach the climax.

Analysis of life forms indicates that the cushion type was dominant, both in the association (39%) and in the subassociation (48%). Cushions were dominant in dry and xeric sites exposed to the sun in the study area, while rough mats were dominant at shady, humid, and mesic to hydric sites. The rough mat type was the second

most prevalent life form in both syntaxa (Fig. 5, Table 4). Syntaxonomically, the association and the subassociation can be classified within the *Syntrichion laevipilae* alliance, *Orthotrichetalia* order, and *Frullanio dilatatae - Leucodontetea sciuroidis* class based on the existence of characteristics of the indicated class, order, and alliance in both syntaxa.

Analysis of epiphytic bryophyte vegetation by multivariate methods. Ordination techniques are widely used by ecologists to study the relationship between vegetation and the environment. The phytosociological data obtained from a total of 191 relevés, which were evaluated in accordance with the Braun-Blanquet approach, were ordinated by detrended correspondance analysis (DCA) and classified using two-way indicator species analysis (TWINSPAN).

TWINSPAN classification is a method widely used to analyse floristic data in plant ecology. It involves the sorting and arrangement of relevés or species in a hierarchical fashion into groups or classes possessing certain common characteristics or attributes (Ahmad *et al.* 2010). As a result of the conducted TWINSPAN analysis, epiphytic bryophyte vegetation was found to have nine groups at the third hierarchical level (Fig. 6). The TWINSPAN analysis shows results similar to those inferred by the Braun-Blanquet classification. The relevés were divided into arid and humid characters by TWINSPAN, which segregates communities of similar character into groups. Groups 5, 8, and 9 were classified within the class *Neckereta complanatae*, having a humid character, while groups 1, 2, 3, 4, 6, and 7 were classified within the class *Frullanio dilatatae - Leucodontetea sciuroidis*, having a xeric character.

Detrended correspondence analysis (DCA) was applied to identify environmental gradients and define the distribution of vegetation. A total of nine epiphytic bryophyte communities were analysed for ordination by DCA in the study area. The proximity of relevés constituting these groups is shown on the two-dimensional diagram of DECORANA according to the axis 1 and 2 abscissa-ordinate system (Fig. 7).

Ordination by means of DCA indicated a relationship between the distribution of species in the epiphytic communities and habitat characteristics. The first DCA axis was interpreted as a moisture gradient (from humid to arid). Groups 1, 2, 3, 4, and 6 (which belong to the *Ulotion crispae* alliance) and group 7 (which belongs to the *Syntrichion laevipilae* alliance) were dispersed according to the moisture gradient on axis 1. All of these groups belong to the Holarctic epiphytic class *Frullanio dilatatae - Leucodontetea sciuroidis*. Groups 5, 8, and 9 belong to the alliance *Neckerion complanatae* of the class *Neckeretea complanatae*, which has mesophytic communities that grow on tree trunks or basic rocks. The distribution of epiphytic communities on the second ordination axis is not yet clear, but it could be said that the groups were distributed according to a height gradient (from the lower base to the upper zones) on axis 2.

Acknowledgements — We gratefully acknowledge the financial support of the Turkish Scientific and Technical Research Council (TUBITAK, Project No. 114Z337).

REFERENCES

AHMAD SS, WAHID A & AKBAR KF. 2010. Multivariate classification and data analysis of vegetation along motorway M-2, Pakistan. *Pakistan Journal of Botany* **42**: 1173-1185.

Akman Y. 1999. *İklim ve Biyoiklim (Biyoiklim Metodları ve Türkiye İklimleri)*. Kariyer Press, Ankara.

ALATAŞ M & UYAR G. 2017. A new bryophyte community and three new records for the epiphytic bryophyte vegetation of Turkey. *Turkish Journal of Botany* **41**: 308-323.

Braun-Blanquet J. 1964. *Pflanzensoziologie Grundzüge der Vegetationskunde. 3. Aufl*. Springer, New York.

Casas C, Brugues M, Cros MR, Sergio C & Infante M. 2009. *Handbook of liverworts and hornworts of the Iberian Peninsula and the Balearic Islands*. Institutd'Estudis Catalans, Barcelona.

Cortini Pedrotti C. 2001. *Flora dei muschid'Italia, Sphagnopsida, Andreaopsida, Bryopsida (I parte)*. Antonio Delfino Editore Medicina-Scienze, Rome.

Cortini Pedrotti C. 2006. *Flora deimuschi d'Italia, Bryopsida (II parte)*. Antonio Delfino Editore Medicina-Scienze, Rome.

Çetin B. 1999a. The liverworts (Hepaticae) of Uludağ National Park (Bursa). *Turkish Journal of Botany* **23**: 277-280.

Çetin B. 1999b. The moss flora of Uludağ National Park. *Turkish Journal of Botany* **23**: 187- 193.

DierSSen K. 2001. *Distribution, ecological amplitude and phytosociological characterization of European bryophytes*. Bryophytorum Bibliotheca, Stuttgart.

Draper I, Lara F, Albertos B, Garilleti R & Mazimpaka V. 2003. The epiphytic bryoflora of the Jbel Bouhalla (Rif, Morocco), including a new variety of moss, *Orthotrichum speciosum* var. *brevisetum*. *Journal of Bryology* **25**: 271-280.

During HJ. 1979. Life strategies of bryophytes: a preliminary review. *Lindbergia* **5**: 2-18.

Ezer T. 2008. *The investigation of bryophyte flora and epiphytic vegetation in the Southern Amanos Mountain (Mount Musa)*. PhD Thesis, Çukurova University, Institute of Natural and Applied Sciences, Turkey.

Frey W, Frahm JP, Fischer E & Lobin W. 2006. *The liverworts, mosses and ferns of Europe*. Harley Books, Colchester.

Frey W & Kürschner H. 1991a. *Crossidium laevipilum* Ther. Et. Trab. (Pottiaceae, Musci), eineigenstandiges,

Morphologisch und Standortökologisch Deutlich Unterscheidbares Taxon der Saharo Arabischen Floren region. *CryptogamieBryologie* **12**: 441-450.

Frey W & Kürschner H. 1991b. *Conspectus Bryophytorum orientalum et arabicorum. An annotated catalogue of the bryophytes of Southwest Asia*. Bryophytorum Bibliotheca, Stuttgart.

Guerra J & Cros M. 2007. *Flora briofítica Ibérica. Vol. 1.* Universidad de Murcia Sociedad Española de Briología, Murcia.

Hedenäs L. 1992. *Flora of Maderian pleurocarpous mosses (Isobryales, Hypnobryales, Hookeriales)*. Bryophytorum Bibliotheca Band 44, Stuttgart.

Heyn CC & Herrnstadt I. 2004. *The bryophyte flora of Israel and adjacent regions*. Israel Academy of Sciences and Humanities, Jerusalem, Israel.

Hill MO. 1979a. *DECORANA - A FORTRAN program for detrended correspondence analysis and reciprocal averaging*. Cornell University, New York.

Hill MO. 1979b. *TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes*. Cornell University, New York.

Hill MO, Preston CD, Bosanquet SS & Roy DB. 2007. *BRYOATT: Attributes of British and Irish mosses, liverworts and hornworts with information on native status, size, life form, life history, geography and habitat*. The Saxon Print Group, Norwich.

Kara R. 2008. *The investigation of bryophyte flora and epiphytic vegetation of the North Amanos Mountain (Hatay-Dörtyol)*. PhD Thesis, Çukurova University Institute of Natural and Applied Sciences, Turkey.

Kürschner H & Frey W. 2011. *Liverworts, mosses and hornworts of Southwest Asia*. Beiheft 139, Stuttgart.

Kürschner H & Frey W. 2012. Life strategies in bryophytes - a prime example for the evolution of functional types. *Nova Hedwigia* **96**: 83-116.

Kürschner H, Parolly G & Erdağ A. 2006. Life forms and life strategies of epiphytic bryophytes in *Quercus vulcanica* forests of Turkey. *Nova Hedwigia* **82**: 331-347.

Lara F, Garilleti R, Goffinet B, Draper I, Medina R, Vigalondo B & Mazimpaka V. 2016. *Lewinskya*, a new genus to accommodate the phaneroporous and monoicous taxa of *Orthotrichum* (Bryophyta, Orthotrichaceae). *Cryptogamie Bryologie* **37**: 361-382.

Marstaller R. 2006. *Syntaxonomischer Konspekt der Moosgesellschaften Europas und angrenzender Gebiete*. Haussknechtia Beiheft 13, Jena.

Nyholm E. 1981. *Illustrated moss flora of Fennoscandia. Fasc. 1-6. Lund*. Nordic Bryological Society, Sweden.

Ören M, Uyar G & Keçeli T. 2007. The bryophyte flora of Erdek, Bandırma, Manyas Districts (Balıkesir, Turkey). *International Journal of Botany* **3**: 1-14

Papp B & Sabovljevic M. 2003. Contributions to the bryoflora of Turkish Thrace. *Studia Botanica Hungarica* **34**: 43-54.

Paton J. 1999. *The liverwort flora of the British Isles*. Harley Books, Colchester.

Plasek V, Sawicki J, Ochyra R, Szczecinska M & Kulik T. 2015. New taxonomical arrangement of the traditionally conceived genera *Orthotrichum* and *Ulota* (Orthotrichaceae, Bryophyta). *Acta Musei Silesiae, Scientiae Naturales* **64**: 169-174.

Smith AJE. 2004. *The moss flora of Britain and Ireland*. Cambridge University Press, Cambridge.

Tonguç Yayintaş Ö. 2013. New moss records from western part of Turkey. *Bangladesh Journal of Botany* **42**: 371-375.

TSMS (Turkish State Meteorological Service). 2016. *Yalova weather station climate data (1950-2015)*. Research and Computing Department, Ankara.

Ursavaş S, Şahin A & Abay G. 2009. Türkiye'nin A1 karesinin karayosunları (Musci) kontrol listesi. *I. Ulusal Batı Karadeniz Ormancılık Kongresi, Bartın Orman Fakültesi Dergisi Özel Sayı* **22**: 604-612.

Uyar G & Ören M. 2005. *Isothecium holtii* Kindb. (Brachytheciaceae, Bryopsida), new to the moss flora of Turkey. *Cryptogamie Bryologie* **26**: 425-429.

Walther K. 1979. Die Epifitischen moosgesellschaften des Nif Dag bei İzmir, Westanatolien. *DocumentsPhytosociologique, Nouv. sér.* **4**: 943-950.

Weber HE, Moravec J & Theurillat JP. 2000. International code of phytosociological nomenclature. *Vegetation Science* **3**: 739-768.

Zander RH. 1993. *Genera of the Pottiaceae: mosses of harsh environments*. Buffalo Society of Natural Sciences, New York.

Botanica SERBICA

REZIME

Epifitska vegetacija mahovina Samanlı planine (Sakarya-Kocaeli-Yalova-Bursa) u severozapadnoj Turskoj

Merve Can Gözcü, Güray Uyar, Mevlüt Alataş, Tülay Ezer i Muhammet Ören

Epifitska vegetacija mahovina Samanlı planine u severozapadnom delu Turske je istraživana na osnovu 191 snimka uzetih Braun-Blanquet metodom sa stabla drveća tokom 2015. i 2016. godine. Kao rezultat ovih istraživanja, utvrđeno je prisustvo 9 epifitskih asocijacija mahovina i 3 subasocijacije. Među njima, 2 asocijacije i 2 subasocijacije, *Neckero - Anomodontetum viticulosi*, *Neckero - Anomodontetum viticulosi - anomodontetosum viticulosi*, *Syntrichietum laevipilae*, *Syntrichietum laevipilae - orthotrichetosum lyellii*, konstatovane su po prvi put na teritoriji Turske. Takođe, epifitska vegetacija mahovina je analizirana pomoću multivarijantskih analiza, a urađene su i analize životnih formi i životnih strategija vrsta unutar vegetacijskih jedinica. Kao rezultat, dok su dugoživeće višegodišnje jedinke sa visokim reproduktivnim potencijalom dominantne u epifitskoj vegetaciji mahovina, najčešća životna forma je gusta prostirka.

Ključne reči: asocijacija, mahovine, epifitska vegetacija, životne forme, životne strategije, Samanlı planina, Turska