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EPIPHYTIC BRYOPHYTE COMMUNITIES AND SUCCESSION ON *PLATANUS ORIENTALIS* TREES IN KADINCIK VALLEY (MERSIN/TURKEY)

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Abstract

In this study, epiphytic bryophytes of old-growth *Platanus orientalis* gallery forest in Kadıncık Valley (Mersin/Turkey) were studied. In total thirthy-three epiphytic bryophyte species were found (29 mosses, 4 liverworts) in 60 sample plots, each 20 x 20 cm in size. In order to evaluate the relative abundance of bryophyte communities in the epiphytic habitats on trunks, index of ecological significance (IES) was used. Multivariate statistical analyses (TWINSPAN and DECORANA) were also used to classify and to determine the epiphytic bryophyte community structures in successional stages. The multivariate statistical analyses results indicated that the sample plots were divided into two main clusters and five subclusters associated with gradient of successional satages. Vertical (tree height) and horizontal (tree diameter) distribution patterns of epiphytic bryophytes and their life forms were also observed along a gradient of height and the gradient of age of the *Platanus orientalis*. *Orthotrichum diaphanum*, *Eurhynchium striatum*, *E. angustirete* and *Brachythecium albicans* were only found on young trees, *Brachythecium rutabulum* and *Cinclidotus riparius* were only found on middle-aged trees, and *Cirriphyllum crassinervium* and *Cratoneuron filicinum* were only growing on old trees.

Key words: Bryophytes, Epiphytic, Succession, TWINSPAN, DECORANA, *Platanus orientalis*, Turkey.

Introduction

Gallery forests that occur as corridors along the margins of streams and rivers are one of the important refuge areas as vegetation formation. Especially, they have a wide range of ecosystem functions because of their microclimate and water holding capacity, and provide suitable habitats for local flora and fauna (Özbucak *et al.,* 2008).

Bryophytes are pioneer plants of different substrate types, and produce a major part of the biomass in several landscapes (Campos *et al.,* 2015). In addition, epiphytic bryophytes are a conspicuous and characteristic component of forest ecology. The community composition of epiphytic bryophytes is mainly regulated by environmental conditions. Environmental drought particularly is one of the factors that affect the distribution of species (Mazimpaka & Lara, 1995). In several studies, correlations between bryophyte communities in the epiphytic habitats and their phorophyte characteristics have been studied in Mediterranean Basin (Burgaz *et al.,* 1994; Lara & Mazimpaka, 1998; Draper *et al.,* 2003; 2005; Marques *et al.,* 2005; Mazimpaka *et al.,* 2009; 2010; Ezer *et al.,* 2009; Medina *et al.,* 2010; Ezer & Kara, 2013; Medina *et al.,* 2015; Calleja *et al.,* 2016). The previous studies had concluded that phorophyte species, tree exposure, tree age, height, forest stand type and tree canopy as well as climatic conditions were the most important variables influencing epiphytic bryophyte colonisation along trunk surfaces and succession in Mediterranean areas. There are quite limited studies on epiphytic bryophytes in the Turkey (Kürschner *et al.,* 2006; 2012; Düzenli *et al.,* 2009; Kara *et al.*, 2011; Alataş & Batan, 2014; 2015; Alataş *et al.,* 2015). Only two of these (Ezer *et al.,* 2009; Ezer & Kara, 2013) studied the succession of epiphytic bryophyte communities. Therefore, the knowledge of vertical distribution patterns and community structures of epiphytic bryophytes in successional stages is still fragmentary. Here, successional trends among epiphytic bryophytes of *Platanus orientalis* gallery forest in Kadıncık Valley were investigated using the index of ecological significance (IES). The present study was aimed to increase our knowledge about the successional gradients of epiphytic bryophyte communities in *Platanus orientalis* gallery forest in Turkey using of multivariate ordination techniques (TWINSPAN and DECORANA).

The study area: The Kadıncık Valley is located in the between border of the Tarsus and Çamlıyayla district of Mersin province in the eastern Mediterranean region of Turkey. It is characterized by V-shaped river valleys and situated in the C13 square in grid system of Turkey adopted by Henderson (1961) (Fig. 1). The climate in the region is semi-arid Mediterranean climate type characterized by dry and warm summers. There is no weather station in the study site. The nearest meteorological station is located in Çamlıyayla (Mersin). According to the data of the station, the mean annual rainfall is 555 mm, and the mean annual temperature is 11.8°C (Fig. 1). Lithologically, the area has got limestone bedrock, and has deep colluvial soil (Ok & Avşar, 2007).

The main types of vegetation in the study site is maquis. The red pines (*Pinus brutia* Ten.) are rarely occuring within the maquis. *Ceratonia siliqua* L., *Laurus nobilis* L., *Olea europaea* L. var. *sylvestris* (Mill.) Lehr., *Rhamnus alaternus* L., *Phillyrea latifolia* L., *Cercis siliquastrum* L. ssp. *siliquastrum*, *Arbutus andrachne* L., *Anagyris foetida* L., *Pistacia terebinthus* L. ssp. *palaestina* (Boiss.) Engler and *Daphne sericea* Vahl. and *Platanus orientalis* L. are main woody taxa in the study site (Ok & Avşar, 2007).

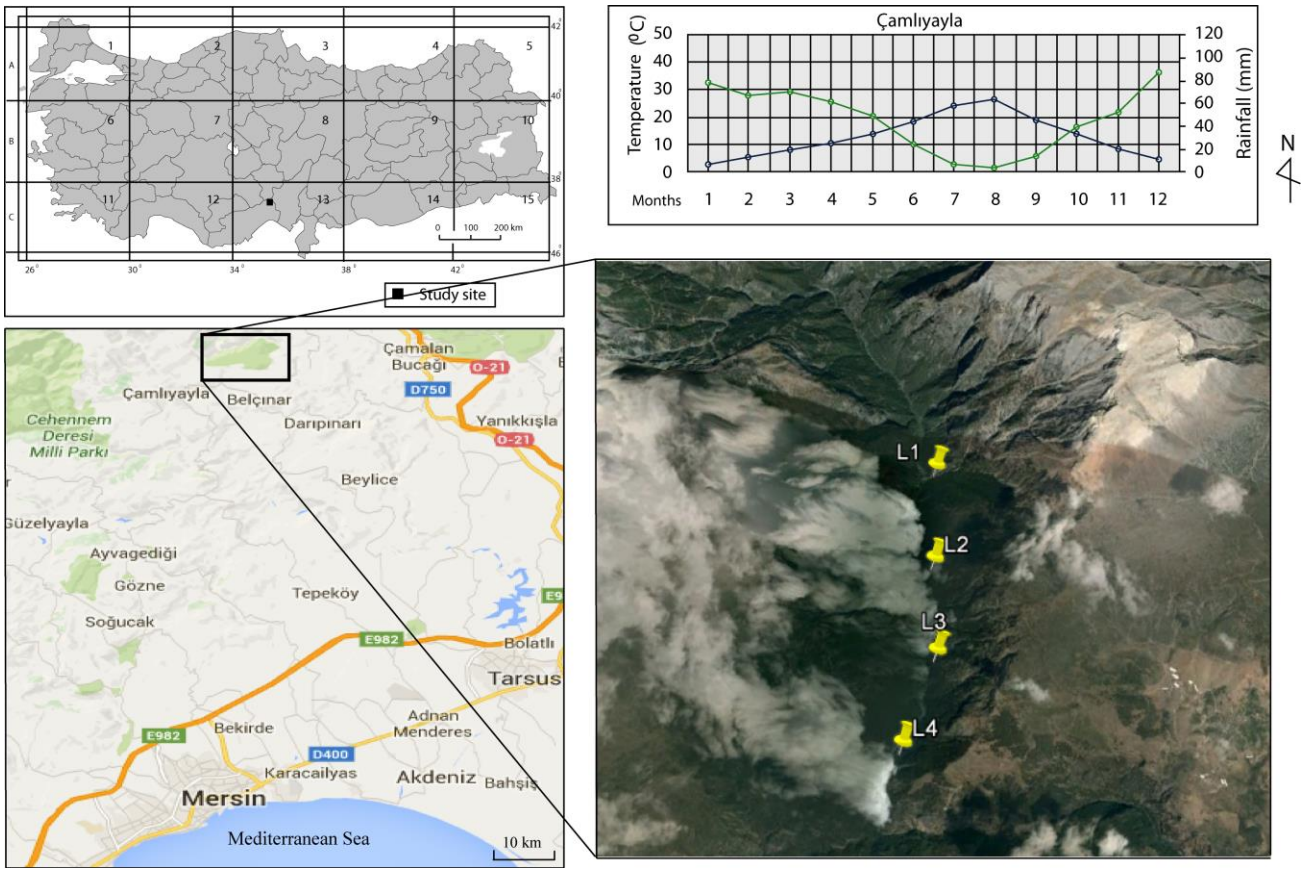

Fig. 1. Localization of the study site and ombrothermic diagram of Çamlıyayla.

Materials and Methods

Field sampling procedure: The epiphytic bryophytes were collected from the bark of *Platanus orientalis* in the Kadıncık Valley during land studies in 2015. Only the *P. orientalis* was chosen as a porophyte species in order to avoid ecological variations caused by different bark structures (Moe & Botnen, 2000). Four sites in the deciduous old-growth gallery forest were selected. Details of the sampled localities are given in Table 1. According to the homogenous tree density, a total of 20 plane-trees of different ages were sampled within the gallery forest. Plane-trees were divided into three age classes using the an indirect method as young (dbh 140–180 cm, 21 sampling plots), middle-aged (dbh 195–210 cm, 21 sampling plots), and old trees (dbh 230–400 cm, 18 sampling plots).

Table 1. Details of sampled localities.

Site	GPS coordinate	Altitude (m)
L1	N 37°14'53.61" EO 34°37'43.56"	926
L2	N 37°14'11.25" EO 34°37'58.76"	890
L3	N 37°13'30.24" EO 34°38'17.63"	840
L4	N 37°12'45.92" EO 34°38'17.50"	780

Each plane tree was divided into the basal zone (0–40 cm from the ground), the middle zone (40–120 cm), and the top zone (120–180 cm) as proposed by Moe & Botnen (2000). Sample plots from tree zones were defined by 20 × 20 cm quadrats. Samples were not taken from the phorophyte branches in the present study. A total of 60 sampling plots, consisting of 20 sampling plots taken from each tree zones were analysed. The percentage cover of species was visually estimated. Species percentage cover and ecological data were also registered in each sampling plots.

Nomenclature of the epiphytic bryophyte species found in the quadrats follows Ros *et al.* (2013) for mosses, and Ros *et al.* (2007) for liverworts (Table 2). Habitat affinity of bryophytes was established following Mazimpaka & Lara (1995) and Draper *et al.* (2003). Life form types of plants were determined as described by Magdefrau (1982). Voucher specimens were identified and stored in the herbarium of Ömer Halisdemir University.

Data analysis: The relative frequency of each species was determined by the Index of Ecological Significance designed by Lara & Mazimpaka (1998), Albertos *et al.* (2001) and Mazimpaka *et al.* (2009) expressed as:

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

where F is relative frequency (100 x / n), and C is cover of the species (Σ ci / x). x represents the number of sampling plots with the species, n is total number of sampling plots, and ci is cover class assigned to the species in each sampling plot. Cover classes of bryophyte species were established using the six-point Lara & Mazimpaka (1998) scale. The IES values have been combined in the following abundance classes: very scarce (< 25), scarce (26–50), moderately abundant (51–100), abundant (101–200), and dominant (> 200).

Table 2. List of bryophytes recorded in epiphytic habitats.

Species	Families	Life-form type	Habitat affinity
Mosses			
Homalothecium sericeum (Hedw.) Schimp.	Brachytheciaceae	mat	Indifferent
Anomodon viticulosus (Hedw.) Hook. & Taylor	Anomodontaceae	tail	Cortico-saxicolous
Leucodon sciuroides (Hedw.) Schwaegr.	Leucodontaceae	tail	Customary epiphyte
Palamocladium euchloron (Müll.Hal.) Wijk & Margad.	Brachytheciaceae	tail	Cortico-saxicolous
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt	Neckeraceae	fan	Cortico-saxicolous
Zygodon rupestris Schimp. ex Lorentz	Orthotrichaceae	cushion	Customary epiphyte
Leptodon smithii (Hedw.) F. Weber & D. Mohr	Leptodontaceae	fan	Cortico-saxicolous
Hypnum cupressiforme Hedw.	Hypnaceae	mat	Indifferent
Orthotrichum speciosum Nees	Orthotrichaceae	cushion	Customary epiphyte
Homalothecium philipheanum (Spruce) Schimp.	Brachytheciaceae	mat	Indifferent
Cryphaea heteromalla (Hedw.) D.Mohr	Cryphaeaceae	tail	Customary epiphyte
Homalothecium lutescens (Hedw.) H.Rob.	Brachytheciaceae	mat	Indifferent
Plagiomnium undulatum (Hedw.) T.J.Kop.	Mniaceae	tall-turf	Indifferent
Brachythecium glareosum (Bruch ex Spruce) Schimp.	Brachytheciaceae	weft	Indifferent
Brachythecium rivulare Schimp	Brachytheciaceae	weft	Indifferent
Amblystegium serpens (Hedw.) Schimp	Amblystegiaceae	weft	Indifferent
Habrodon perpusillus (De Not.) LIndb.	Pterygynandraceae	mat	Customary epiphyte
Scorpiurium circinatum (Bruch) M.Fleisch. & Loeske	Brachytheciaceae	mat	Preferantially not corticolous
Orthotrichum diaphanum Schrad. ex Brid.	Orthotrichaceae	cushion	Customary epiphyte
Oxyrrhynchium hians (Hedw.) Loeske	Brachytheciaceae	weft	Indifferent
Brachythecium rutabulum (Hedw.) Schimp.	Brachytheciaceae	weft	Preferantially not corticolous
Cinclidotus riparius (Host ex Brid.) Arn	Pottiaceae	tall-turf	Cortico-saxicolous
Eurhynchium striatum (Hedw.) Schimp.	Brachytheciaceae	weft	Indifferent
Cirriphyllum crassinervium (Taylor) Loeske & M.Fleisch.	Brachytheciaceae	weft	Indifferent
Eurhynchium angustirete (Broth.) T.J.Kop.	Brachytheciaceae	weft	Indifferent
Brachythecium albicans	Brachytheciaceae	mat	Indifferent
Cratoneuron filicinum (Hedw.) Spruce	Amblystegiaceae	weft	Indifferent
Orthotrichum urnigerum Myrin	Orthotrichaceae	cushion	Customary epiphyte
Schistidium apocarpum (Hedw.) Bruch & Schimp.	Grimmiaceae	cushion	Preferantially not corticolous
Liverworts			
Porella platyphylla (L.) Pfeiff.	Porellaceae	mat	Cortico-saxicolous
Frullania dilatata (L.) Dum.	Frullaniaceae	mat	Customary epiphyte
Metzgeria furcata (L.) Dumort.	Metzgeriaceae	mat	Indifferent
Radula complanata (L.) Dum.	Radulaceae	mat	Customary epiphyte

Correspondence analysis, a multivariate statistical technique, is widely used by the community ecologists to reveal the relationship between communities and their environment (Ahmad & Yasmin, 2011). Epiphytic bryophyte community structure and gradients were analysed with the quantitative classification (TWINSPAN) and ordination (DCA) methods based on the IES classes of abundance as pseudospecies (Hill, 1979). Ordination and classification were applied to the matrix of 33 species in 60 sampling plots according to the CAP (Community Analysis Package-III) computer programme (Seaby *et al.*, 2004).

Results

Floristical results: Thirty-three epiphytic bryophytes, of which 29 are mosses and 4 liverworts are recorded within 60 sample plots. Among the mosses, 27 species belong to the pleurocarpous, whereas only 6 species (*Zygodon rupestris*, *Orthotrichum speciosum*, *O. diaphanum*, *O. urnigerum*, *Cinclidotus riparius* and *Schistidium apocarpum*) belong to the acrocarpous. The families Brachytheciaceae (13 species, 39.39%) and Orthotrichaceae (4 species, 12.12%) were the most species-rich groups on the trunks of plane-tree (Table 2).

Ecological results: A total of 6 life form types and 4 habitat affinity categories were determined belonging to the species in the sample plots. The most abundant life form was the Mats with 33.33% due to the dominancy of pleurocarpous mosses and all liverwort species, whereas fans and tall-turfs were the most scarce life forms, repectively (Table 2). Indifferent type habitat affinity in the study site is the most frequent with 15 species, while customary epiphytes are second frequent with 9 species. The preferentially noncorticolous species were the least found with 3 species (Table 2). Species composition and distribution patterns of epiphytic bryophyte communities on plane-trees were investigated according to: (1) phorophyte diameter at breast height (dbh) and (2) age of the phorophyte (Table 3).

Table 3. IES values in each tree-size groups.

Species	Young trees (dbh 140-180 cm)			Middle aged trees (dbh 195-210 cm)			Aged trees (dbh 230-400 cm)		
	Lower base	Middle zone	Top zone	Lower base	Middle zone	Top zone	Lower base	Middle zone	Top zone
Mosses									
Homalothecium sericeum	43	171	-	157	228	29	200	200	-
Anomodon viticulosus	29	129	-	285	171	43	250	150	-
Leucodon sciuroides	-	214	285	-	271	314	-	217	300
Palamocladium euchloron	300	100	29	-	-	-	-	83	-
Alleniella complanata	271	43	171	71	-	43	-	33	-
Zygodon rupestris	-	29	200	-	57	159	-	33	200
Leptodon smithii	-	43	257	-	43	285	-	83	283
Hypnum cupressiforme	143	43	-	271	-	-	316	-	-
Orthotrichum speciosum	-	100	100	-	29	143	-	33	67
Homalothecium philipheanum	86	43	-	-	-	-	50	-	50
Cryphaea heteromalla	-	29	29	-	29	57	-	-	-
Homalothecium lutescens	-	-	-	-	29	29	50	33	-
Plagiomnium undulatum	71	-	-	-	-	-	50	-	-
Brachythecium glareosum	-	43	-	-	-	-	50	-	-
Brachythecium rivulare	43	-	-	43	-	-	-	-	-
Amblystegium serpens	114	-	-	129	-	-	133	-	-
Habrodon perpusillus	-	-	29	-	-	57	-	-	-
Scorpiurium circinatum	43	-	-	-	-	-	50	-	-
Orthotrichum diaphanum	-	29	29	-	-	-	-	-	-
Oxyrrhynchium hians	43	-	-	-	-	-	33	-	-
Brachythecium rutabulum	-	-	-	86	-	-	-	-	-
Cinclidotus riparius	-	-	-	71	-	-	-	-	-
Eurhynchium striatum	43	-	-	-	-	-	-	-	-
Cirriphyllum crassinervium	-	-	-	-	-	-	50	-	-
Eurhynchium angustirete	43	-	-	-	-	-	-	-	-
Brachythecium albicans	43	-	-	-	-	-	-	-	-
Cratoneuron filicinum	-	-	-	-	-	-	67	-	-
Orthotrichum urnigerum	-	-	-	-	-	29	-	-	-
Schistidium apocarpum	-	-	-	-	-	29	-	-	-
Liverworts									
Porella platyphylla	143	242	200	143	285	129	100	300	150
Frullania dilatata	-	71	214	-	86	271	-	133	200
Metzgeria furcata	-	29	-	-	29	-	-	-	33
Radula complanata	-	-	29	-	-	29	-	-	-

Fifteen bryophyte taxa were recorded at the basal zone of young plane-tree. Among them, *Palamocladium euchloron* was the most frequent and the most dominant with 300 IES value. *Alleniella complanata* was co-dominant species with second higher IES value (271) on the base zone of young trees. While, abundant *Porella platyphylla* was the only liverwort species, *Eurhynchium striatum*, *E. angustirete* and *Brachythecium albicans*, with the lowest IES values (43), were only scarce on basal zones (Table 3). Mats were the most abundant with frequency of 40%. The second important life form were the Wefts, represented by pleurocarpic mosses, such as *Amblystegium serpens*, *Brachythecium rivulare*, *Eurhynchium striatum*, *E. angustirete* and *Oxyrrhynchium hians* (33.3%). In addition, indifferent species were the most common affinity of epiphytic habitats on the basal zone of young plane-trees (66.6%). Nine bryophytes species were recorded from the lower base of middle-aged plane-trees. *Anomodon viticulosus* was the most common with 258 IES value, whereas *Brachythecium rivulare* was scarce with lowest IES values (43). *Hypnum cupressiforme* was also co-dominant with second higher IES value (271) (Table 3). Both of mat and weft life forms (33.3%) were dominant on the base zone, while both of cortico-saxicolous and indifferent species were also dominant (44.4%). Thirteen species were collected on the basal zone of aged *P. orientalis*. *Hypnum cupressiforme* was the most dominant and the most common, with the highest IES value (316), while *Anomodon viticulosus* was co-dominant with second higher IES value (250) (Table 3). Mats (46.1%) and indifferent species (76.9%) were still the most common on the base of old *P. orientalis*. *Plagiomnium undulatum*, *Brachythecium rivulare*, *B. rutabulum*, *B. albicans*, *Amblystegium serpens*, *Scorpiurium circinatum*, *Oxyrrhynchium hians*, *Cinclidotus riparius*, *Cirriphyllum crassinervium*, *Eurhynchium angustirete*, *E. striatum* and *Cratoneuron filicinum* only occurred on the basal zones of the all age plane-tree in the study site (Table 3).

A total of sixteen bryophytes were recorded on the middle part of young plane-trees. Among them, *Porella platyphylla*, a leafy liverwort, (242) and the customary epiphyte *Leucodon sciuroides* (214) were the most frequent and the most abundant (Table 3). Mat life form (37.5%) and customary epiphytic species (37.5%) were wide-spread in this part. Eleven epiphytic bryophytes were collected on the middle part of middle-aged plane-trees. *Porella platyphylla* was still the most abundant and the most frequent with the 285 IES value. At the same time, *Leucodon sciuroides* (271) and *Homalothecium sericeum* (228) were co-dominant species having reletively high IES valeues on the middle-zone (Table 3). Mats (45.4%) and customary epiphytic species (45.4%) were still the most common on the middle part of middle-aged trunks as well as the young trunks. The middle part of the old plane-trees contained 11 epiphytic bryophyte taxa. The liverwort species *Porella platyphylla* was the most constant with the highest IES value (300). *Leucodon sciuroides* (217) was also co-dominant species and *Homalothecium sericeum* (200) was abundant (Table 3). Mat life form type (36.3%) was the most dominant on the middle zone of old plane-trees, while cortico-saxicolous species were the most common with the 45.4%. There are no species only occured in the middle part of all ages trees (Table 3).

12 epiphytic bryophytes have been recorded on upper zone of young plane-trees. *Leucodon sciuroides* was the most important species with the highest IES value (285) and higher cover percentage. Also, customary epiphyte *Zygodon rupestris* which is found within the all samples on the upper zone of young trees was the most frequent and abundant (Table 3). The mat type (33.3%) represents the dominant life fom and customary epiphytic species (66.6%) were wide-spread.

15 bryophyte species were collected from upper part of middle-aged plane-trees. Among them, *Leucodon sciuroides* (314), *Leptodon smithii* (285), *Frullania dilatata* (271) were the most abundant species (Table 3). Mat life form (40%) and customary epiphyte habitat affinity (53.3%) were still the most dominant among young trees. Eight epiphytic taxa were recorded on the upper part of old trees. *Leucodon sciuroides* (300) and *Leptodon smithii* (283) were the most dominant, whereas *Zygodon rupestris* (200) and *Frullania dilatata* (200) were abundant (Table 3). Mats (50%) and customary epiphytic species (50%) were dominant again on all top zones. *Habrodon perpusillus*, *Orthotrichum urnigerum* and *Schistidium apocarpum* were only found on top zone of all age plane-trees (Table 3).

TWINSPAN classification: Five epiphytic bryophyte clusters were determined at the third level of TWINSPAN (Fig. 2). These clusters were named after the first two dominant species. Results of the TWINSPAN analysis were reported as two major clusters and five different subclusters according to the gradient of successional stages (Fig. 2). The first major cluster (group A) occured of basal zone communities. This cluster was characterised by dominant *Palamocladium euchloron*, abundant *Hypnum cupressiforme* and relatively abundant *Anomodon viticulosus* and *Alleniella complanata* (Fig. 2). The majority of the these species were cortico-saxicolous and pleurocarpous. The second major cluster (group B) comprised of middle and upper part communities. It was characterised by frequent *Porella platyphylla*, dominant *Homalothecium sericeum*, constant *Leucodon sciuroides*, *Anomodon viticulosus*, *Leptodon smithii*, and relatively abundant constant *Zygodon rupestris*.

Epiphytic bryophyte communities: The 5 subclusters, within 2 main clusters, were named as A1, A2, B1, B2, and B3. The A1 epiphytic bryophyte community was named as *Hypnum-Anomodon* due to highest presence of *Hypnum cupressiforme* and *Anomodon viticulosus*. The community was represented with 11 sampling plots, Both of species have the highest IES value on the basal part of middle-aged and old plane-trees (Table 2). The subcluster was co-dominated by *Porella platyphylla*. *Homalothecium sericeum* also occured frequently. While the dominant life form within the community was weft, indifferent species were also dominant.

The A2 community was characterised by *Palamocladium euchloron*, which was the leading cortico-saxicolous species, together with *Alleniella complanata* within the community on the lower base. This community was represented by total 9 samples, and also named as *Palamocladium-Alleniella*, which was found only on the basal part of young *P. orientalis*, where more humid and the more nutrient-rich caused by soil effect compared to the middle and top zones. *Porella platyphylla*, *Hypnum cupressiforme* and *Amblystegium serpens* were the co-dominant species. While, the wefts and indifferent species were the most dominant, fans and preferantially not corticolous species also very scarce appeared in this community.

The B1 subgroup was characterised by dominant liverwort taxon *Porella platyphylla* and relatively abundant moss taxon *Homalothecium sericeum.* It comprised 9 sampling plots comprising mostly drought-tolerant species. It was named as *Porella-Homalothecium*, which only occurred in the middle part of both middle-aged and aged plane-trees. Within the subgroup, the cushion-type species, *Orthotrichum speciosum*, a scarce species, and moderately abundant *Zygodon rupestris* were also found. Mats and cortico-saxicolous species were dominant.

The *Leucodon-Anomodon* group (B2) which only occurred on the middle zone of all age plane-trees was characterised by *Leucodon sciuroides* and *Anomodon viticulosus*. It was described by 10 relevés in the study site. In addition, mesophytic liverwort *Porella platyphylla* was also constant within the community while mats were stil dominant, customary epiphyte species were also dominant.

Lastly, the B3 community (*Leptodon-Zygodon*) was characterised by *Leptodon smithii* and *Zygodon rupestris*. The community was wide-spread in the Kadıncık Valley with total of 21 sample plots. It mainly occured on the top zone of all plane-trees (Fig. 2). The community was dominated by customary epiphyte species and acrocarpous cushion mosses co-dominant due to number of Orthotrichaceae members (4 species). The meso-xerophytic *Leucodon sciuroides* was also common, and *Porella platyphylla* was also constant. While the mat type represent the dominant life form, cushions were relatively impotant within the community.

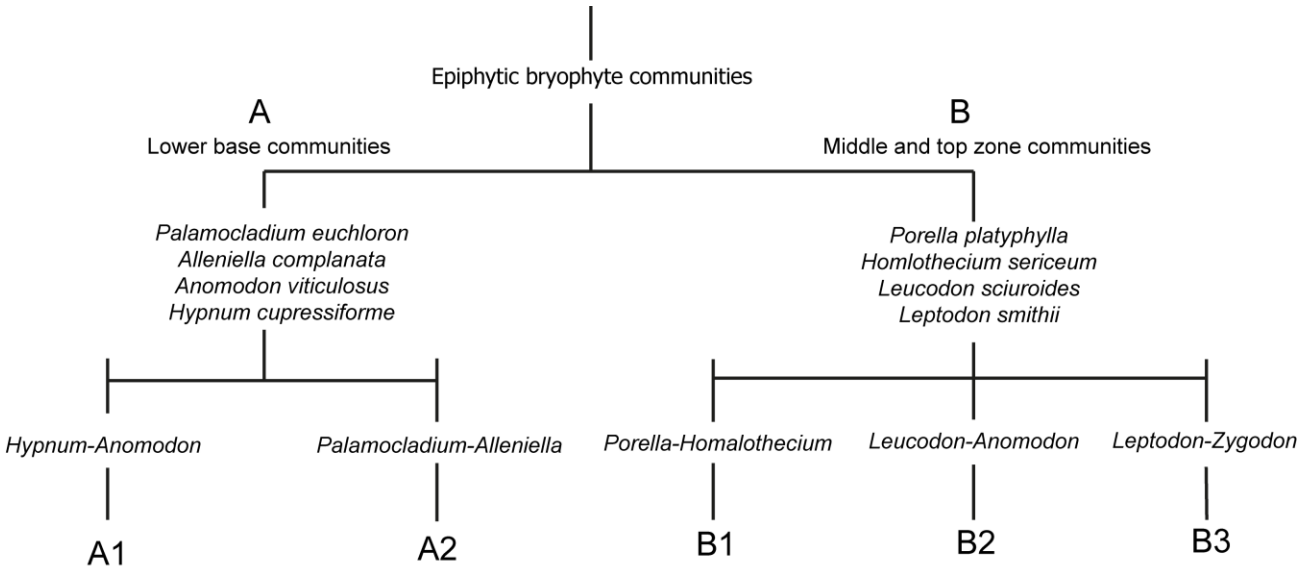

Fig. 2. TWINSPAN calssification for the 60 sample plots and 33 epiphytic bryophyte species.

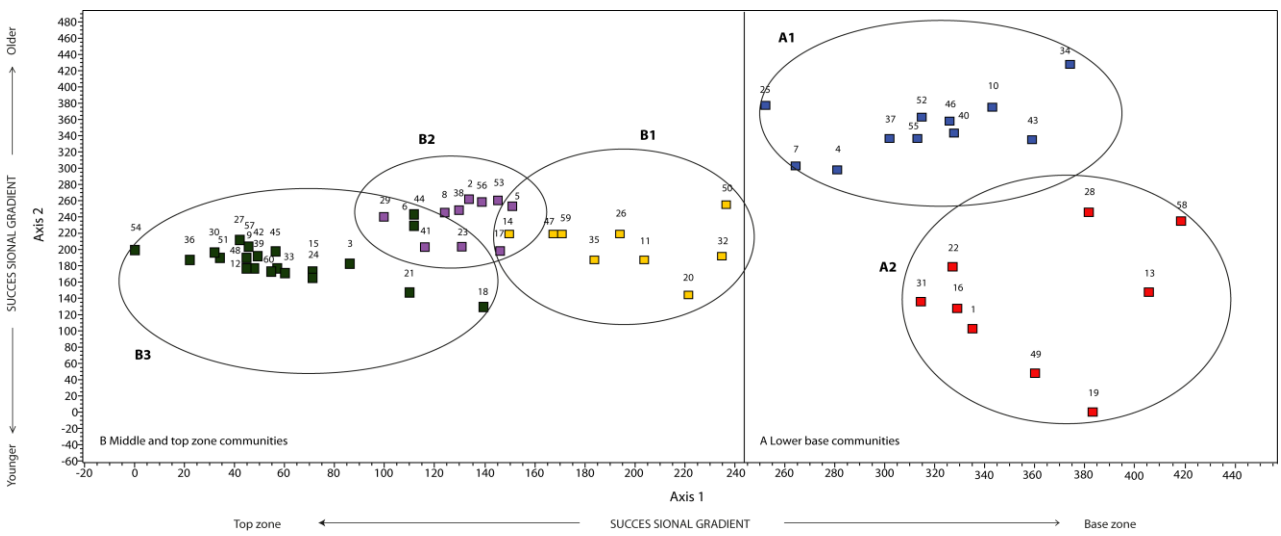

Fig. 3. DCA ordination for the 60 sampling plots with TWINSPAN clusters.

In conclusion, with regard to the morphological physiognomy of the epiphytic bryophyte communities in the study site; the group A (lower base communities) was comprised by mainly the pleurocarpic moss species *Palamocladium euchloron* and *Hypnum cupressiforme*. The group B (middle-top zone communities) was occured by the constant acrocarpous *Orthotrichum speciosum* and *Zygodon rupestris*. Besides, pleurocarpous *Leucodon sciuroides*, *Leptodon smithii* and *Homalothecium sericeum* were also dominant. The liverwort species *Porella platyphylla* was constantly present on all trunks.

Detrended correspondence analysis (DCA) was used to study the relationships between the species distribution pattern and the epiphytic bryophyte communities in the study site. For this purpose, a matrix of 33 species × 60 relevés resulting was subjected to Detrended Correspondence Analysis (DECORANA and TWINSPAN) (Fig. 3) where, the axis 1 is represented by a gradient in the tree height, and the axis 2 is represented with a gradient in the tree age.

Discussion

With respect to species richness, the lower base of plane-trees in the study site was the most rich zone with 21 species (63.6%). Members of pleurocarpous moss type that spreads out horizontally very quickly on the substratum, were common on the basal parts, containing 18 out of a total of 21 species. Therefore, the life form weft was the most impotant on tree bases. Mesoscale climatic factors (e. g. climatic variables during spring and summer) were the most important predictors of bryophyte richness. However, abundance was mostly related to forest structure and, controlled by habitat characteristics (Medina *et al*., 2014). Basal substratum of trees for especially shade-tolerant epiphytic pleurocarpous mosses and liverworts provides larger colonization surface (area effect), nutrient, moisture, and good shelter than the other zones (Mazimpaka *et al.*, 2009; Ezer & Kara, 2013). The accumulation of decomposing organic matter in fissures near the tree base favours establishment of bryophytes. Morever, basal part of

trees are usually more humid and more nutrient-rich when compared with the middle and upper parts due to soil humidity, higher water retention capacity, accumulation of rain water, minor evapotranspiration rate, and low insolation. In this respect, the tree bases represents an extension of the forest floor environment (Mazimpaka *et al.*, 2009; Ezer *et al.*, 2009; Ezer & Kara, 2013). Consequently, the structure of lower base epiphytic bryophyte communities are influenced by a wide spectrum of biotic and abiotic factors. Bases provide a higher variations of especially abiotic ecological factors to indifferent pleurocarpous species in this study. That wide spectrum of ecological factors may also explain the species richness on lower base in the study site. Although forests characteristic of the Mediterranean areas dominated by broad-leaved sclerophyllous evergreen trees, deciduous forests offering a variety of microclimatic factors as light availability and air humidity for colonization of epiphytic bryophytes than evergreen coniferous forests (Ezer *et al.*, 2009; Király & Ódor, 2010; Ódor *et al.*, 2013). Therefore, only two acrocarpous mosses that tend to be more drought tolerant than pleurocarpous, (rheophytic *Cinclidotus riparius* and hygrophytic *Plagiomnium undulatum*) were only on basal part of the plane-trees in the gallery forest. Taxonomical diversity and epiphytic cover were very low on the middle and upper zones in the study site. Our results are quite similar to other studies (Lara & Mazimpaka, 1998; Lyons *et al.*, 2000; Draper *et al.*, 2005; Ezer *et al.*, 2009; Mazimpaka *et al.*, 2010; Bansal *et al.*, 2011; Ezer & Kara, 2013). While, the middle zone contains 17 species, the top zone contains 19 epiphytic species. During the Mediterranean-type summer months, the upper part of the trunks are periodically exposed to desiccation and higher insolation, that is too abrasive for the establishment of epiphytic bryophytes (Moe & Botnen, 2000). Therefore, upper zones on plane-tree trunks are occupied by desiccation-tolerant epiphytic bryophye communies in the study site, such as *Porella-Homalothecium, Leucodon-Anomodon* and *Leotodon-Zygodon*. Species, described as photophilous or heliophilous, are most common species within the middle and top zone communities (e.g. *Leucodon sciuroides, Zygodon rupestris, Leptodon smithii, Orthotrichum speciosum*). Especially, strong competitor liverwort species *Porella platyphylla* was noteworthy abundant in the middle parts on the all ages plane-trees. Whereas, weak competitor *Frullania dilatata* was abundant on the upper part (Table 3). With increasing tree diameter, the physical and chemical features of bark change continuously (Fridel *et al.*, 2006). Bark on young trees is smooth, grey and thin, while bark on older trees is deeply fissured, brownish and thick. These changes have a large impact on the species composition in succession of epiphytic communities. Therefore, meso-xerophytic liverwort species such as facultative epiphyte *Frullania dilatata* and small cushions of the xerophytic Orthotrichaceae members are often early coloniser species in the upper part of young trees in the early successional stages. However, mature *Platanus orientalis* usually has thick and cracked bark in the study site. Therefore, sometimes the remains of weak competitor species especially *Frullania dilatata*, *Radula complanata*, mat type liverworts, *Orthotrichum speciosum* and *Zygodon rupestris*, cushion type mosses, underneath the big pleurocarpous mosses such as *Anomodon viticulosus, Homalothecium sericeum, Leptodon smithii* and *Leucodon sciuroides* in the middle and advanced successional stages in the study site.

Several studies on the successional gradient of epiphytic bryophyte communities have demonstrated that changes of the epiphytic bryophyte composition in the per successional stages are closely related to tree diameter, tree age and changes of bark characteristics. Tree size and age are also relevant determinants of epiphyte diversity; larger and older trees maintain more diverse assemblages than younger ones, with many associated species. Therefore, successional trends of epiphytic species are fairly complex due to changes in the host tree and positive and negative interactions themselves within the epiphytic communities (Lara & Mazimpaka, 1998; Mazimpaka *et al.*, 2010; Ódor *et al.*, 2013; Bargali *et al.*, 2014). Finally, epiphytic communities in the early successional stage are dominated by desiccation tolerant small cushions of Orthotrichaceae members that they are obligate epiphyte. Whereas, the communities in the middle and advanced successional stages are dominated by mat type liverworts and large pleurocarpous mosses that facultatively colonise the epiphytic habitat.

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