DETERMINATION OF LICHEN DIVERSITY VARIATIONS IN HABITAT TYPE OF MEDITERRANEAN MAQUIS AND ARBORESCENT MATORRAL

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(Received 15th Apr 2019; accepted 13th Jun 2019)

Abstract. In this study, it was aimed to determine the epiphytic and non-epiphytic lichen diversity variations in Mediterranean maquis and arborescent matorral habitats. One of Turkey's national parks, Altınbeşik Cave National Park in Antalya, Turkey, was chosen as the research area as this habitat type is very common in the park. In this research, lichen diversity was calculated according to the data of species richness and species frequency. For identify possible variations of the lichen species composition in this habitat type, this research was planned on three major hills in the park. In addition, localities were selected from four different slope directions and tops of the hills. Statistical tests were used to analyze whether there was a difference or similarity on data. Moreover, the statistical relationships between the data of grouped localities with the data of diversity calculation classes were investigated. As a result of this study; lichen diversity of Mediterranean maquis and arborescent matorral habitats was put forth. Secondly, species richness and frequency of northern localities of Mediterranean maquis and arborescent matorral habitats were found to be significantly higher and community composition of northern localities was found to be much different than other localities.
Keywords: *Altınbeşik Cave National Park, biodiversity, community composition, Eastern Mediterranean, four cardinal directions, Turkey*

Introduction

Lichens are sensitive to even weak changes in their environments (Rose and Hawksworth, 1981; Ellis et al., 2007; Johansson, 2008; Nascimbene et al., 2012). Their sensitivity to environmental changes has been subject to numerous investigations (Gombert et al., 2004; Svoboda et al., 2010; De Guevara et al., 2014; Branquinho et al., 2015). When a change occurs in the environment of lichens, species richness and community composition changes to ones that are suitable for new conditions and replace previous lichen (Gadsdon et al., 2010; Johansson et al., 2012; Lang et al., 2012). This characteristic of the lichens is the reason why they are indicators of different ecosystem and habitat diversity (McCune, 2000; Rogers and Ryel, 2008; Nascimbene et al., 2012). In addition, by monitoring changes in lichen diversity, forest health can be determined (McCune, 2000; Thormann, 2006; Fenn et al., 1998; Geiser and Neitlich, 2007; McMurray et al., 2015). In order to determine the ecological condition of the areas according to the lichen diversity, it should be known which lichen composition is seen in which habitat.

Many researches have been done on lichen diversity variations of forests until now (Rogers and Ryel, 2008; McMullin et al., 2010; Koch et al., 2013; Bartels and Chen., 2015). There is also a large number of studies on the determination of the lichen richness in Mediterranean habitats (John, 1996; Litterski, 1997; Nimis and John, 1998;

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_1017310193

Christensen and Svane, 2007; Ravera et al., 2011; Sipman and Raus, 2015). However, there are very few studies including variations of lichen diversity in the habitat composition of Mediterranean maquis and arborescent matorral (Aragón et al., 2006).

Mediterranean maquis and arborescent matorral habitat type is found across the entire Mediterranean biogeographical zone (Portugal, Spain, France, Italy, Sardinia, Sicily, Malta, Croatia, Macedonia, Montenegro, Serbia, Bulgaria, Greece, Crete, Aegean Islands, Cyprus, Turkey and Northern Africa) (EEA, 2016). According to the habitat types of EUNIS, this habitat has evergreen sclerophilous or lauriphyllous shrub vegetation which forms a dense enclosed canopy with or without emergent trees (EEA, 2017). In this habitat type there are matorrals that are covered top to bottom with leaves that hides the stem and some of these are arborescent that are sociologically isolated, with non-competitive root system (Tomaselli, 1977). *Quercus coccifera* L., *Pistacia palaestina* (Boiss) Engl., *Olea europaea* L. var. *sylvestris* (Mill.) Brot., *Phillyrea latifolia* L., *Juniperus excelsa* M. Bieb., *Pinus brutia* Ten are examples of Mediterranean arborescent matorrals. Although *J. excelsa* and *P. brutia* are originally forest trees but they are also found as arborescent matorrals within maquis in Mediterranean biogeography. This interesting habitat composition may suggest that its lichen diversity is unusual.

In this study, it was aimed to determine the epiphytic and non-epiphytic lichen diversity in Mediterranean maquis and arborescent matorral habitats. Therefore, one of Turkey's national parks, Altınbeşik Cave National Park, was chosen to determine lichen diversity of Mediterranean maquis and arborescent matorral habitats of park. Besides, there is a study showing that the vegetation type of park is suitable for this research (Çinbilgel and Gökçeoğlu, 2010a). Lichen diversity in this study was calculated according to the data of species richness and species frequency. The obtained data was used not only to examine the lichen diversity in Mediterranean maquis and arborescent matorral habitats but also to examine the existing differences or similarities of lichen diversity at different directions, altitudes, and substrates (epiphytic and non-epiphytic) in this habitat type. For identify possible variations of the lichen species composition, localities were selected on three major hills (Altınbeşik Hill, İnönü Hill, Kale Hill) and from four different slope directions, tops of the hills. Moreover, the statistical relationships between the data of grouped localities (according to directions, tops and hills) with the data of diversity classes (total richness, total frequency, epiphytic and non-epiphytic richness, epiphytic and non-epiphytic frequency) were investigated.

Materials and methods

Study area

Altınbeşik Cave and surrounding area were declared as national park in 1994; located between 37°01.19' to 37°04.37' N, and 31°35.49' to 31°38.52' E (*Fig. 1*). The park covers 1156 ha area, where the lowest altitude is 380 m, and the highest is 1165 m. The study was conducted on three major hills (Altınbeşik, İnönü and Kale) in the national park. The park is located in the rainy Mediterranean bioclimate zone according to the Emberger quotient (Çinbilgel and Gökçeoğlu, 2010b). The park generally covers with maqius and arborescent matorral habitats due to Mediterranean climate and karstic geomorphological structure of the area. *Quercus coccifera* L., *Pistacia palaestina* (Boiss) Engl., *Olea europea* L. var. *sylvestris* (Mill.) Brot., *Phillyrea latifolia* L., *Juniperus excelsa* M. Bieb., *Pinus brutia* Ten. are the most common members of the

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_1017310193

park vegetation. In addition, although the surface geology of Altınbeşik Cave National Park is generally calcareous, there are also siliceous rocks on the area.

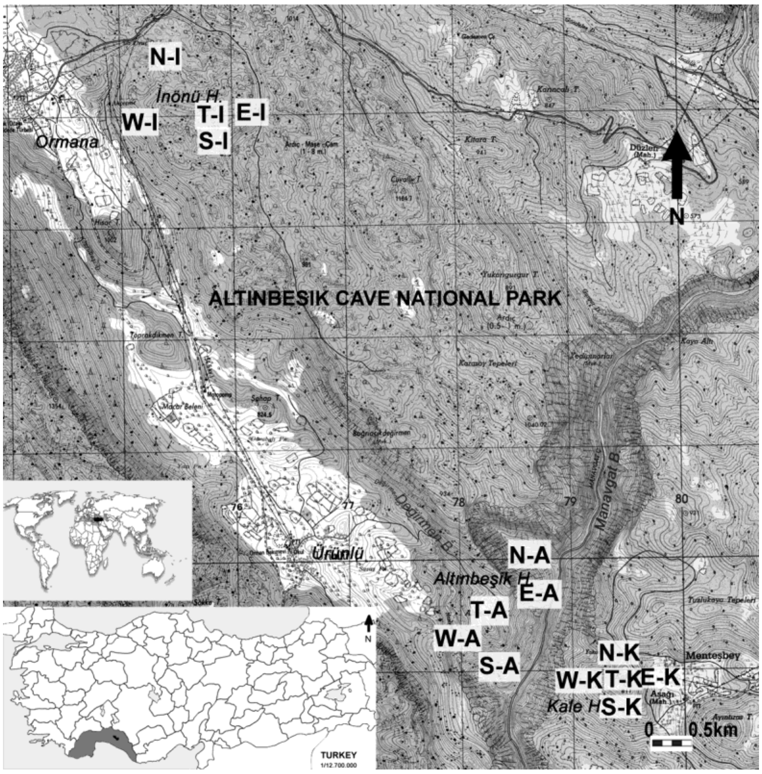

Figure 1. *Maps of Altınbeşik Cave National Park and studied localities (created with Adobe Photoshop 7.0). Abbreviations: -A: Altınbeşik Hill. E: East slopes.-I: İnönü Hill. -K: Kale Hill. N: North slopes. S: South slopes. W: West slopes T: Tops*

Sampling and data collection techniques

The lichen samples have been collected in April 2017, January 2019 and deposited in O. Tufan-Çetin's private fungarium in Akdeniz University. Field studies were carried out in 15 localities (sampling area approximately 1.5 ha) (*Table 1; Fig. 1*). The localities were selected from four different directions and tops of the 3 hills (Altınbeşik, İnönü and Kale; *Fig. 1*) and contain same habitat patterns (maquis and arborescent matorral habitat) and same superficial geological structure. The hills represent three different altitude groups: Altınbeşik (500-700 m), Kale (700-900 m), İnönü (900-1100 m). Detail information and the abbreviated names of all localities were listed in *Table 1*. Sampling for richness and frequency data of lichens were recorded in 5 × 25 cm quadrats with five units (5 × 5 cm) for both epiphytic and non-epiphytic lichens. Frequency data was determined that based on the ratio of occurrence of the species in quadrats (Asta et al., 2002a, b). Epiphytic lichens were obtained from the trunks or stems of *J. excelsa*, *P. latifolia, P. palaestina* and *Q. coccifera* that found on all localities. Six individuals of each four plant species were selected and quadrats were placed 1 m above the ground and on four sides of the trees in each locality (Asta et al., 2002a). Also; non-epiphytic lichens from ground and rocks (calcareous and siliceous) were sampled 96 times.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_1017310193

Table 1. *Information of studied localities in Altınbeşik Cave National Park (İbradı, Antalya, Turkey)*

Abbr.	Localities	Coordinates	Altitude (Approx.)
N-A	Manavgat Creek edges, North slopes of Altınbeşik Hill	37°02'18'' N 31°37'55'' E	585 m
E-A	Entrance of Altınbeşik Cave, East slopes of Altınbeşik Hill	37°02'15'' N 31°37'56'' E	537 m
S-A	South slopes of Altınbeşik Hill	37°01'49'' N 31°37'53'' E	598 m
W-A	West slopes of Altınbeşik Hill	37°01'53'' N 31°37'44'' E	560 m
T-A	Top of Altınbeşik Hill	37°02'05'' N 31°37'56'' E	653 m
N-I	North slopes of İnönü Hill	37°04'33'' N 31°35'46'' E	982 m
E-I	East slopes of İnönü Hill	37°04'22'' N 31°36'26'' E	996 m
S-I	South slopes of İnönü Hill	37°04'17'' N 31°36'02'' E	1066 m
W-I	West slopes of İnönü Hill	37°04'21'' N 31°35'35'' E	912 m
T-I	Top of the İnönü Hill	37°04'21'' N 31°36'06'' E	1089 m
N-K	North slopes of Kale Hill	37°01'40'' N 31°38'40'' E	747 m
E-K	East slopes of Kale Hill	37°01'35'' N 31°38'46'' E	745 m
S-K	South slopes of Kale Hill	37°01'33'' N 31°38'40'' E	757 m
W-K	West slopes of Kale Hill	37°01'32'' N 31°38'32'' E	703 m
T-K	Top of the Kale Hill	37°01'36'' N 31°38'41'' E	784 m

Abbr.: Abbreviation of localities; Approx.: Approximately

Identification of samples

Dried samples were examined by using a light microscope for microscopic characters; and a stereoscopic zoom microscope for macroscopic characters. For identification of the species, the following literature has been used: Moberg (1977), Goward et al. (1994), Fryday and Coppins (1997), Tucker and Thiers (1998), Giralt (2001), Wasser and Nevo (2005), Wetmore (2005), Smith et al. (2009), Wirth et al. (2013) and McCune (2016). When required spot tests, ultra violet light (UV) tests and thin layer chromatography (TLC) have also been carried out.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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Data analysis

The relations in recorded richness and frequency data from Altınbeşik Cave National Park were analyzed by correlation tests. First, the normality of the data was examined by the Shapiro-Wilk test. Pearson correlation test was used for normal distribution data set where Spearman's rho was used in other cases. The significance of all rankings was calculated by linear regression analysis. As of species richness and frequency data were not normally distributed, the Kruskal Wallis test (Kruskal and Wallis, 1952) was used to determine whether there is a difference within the data obtained from the localities. Since the variances were found unequal, Tamhane's T2 post-hoc test was applied to determine which localities differ from the others. All these analyses were performed by SPSS 23.0.

In terms of the lichen richness data, similarity of localities was calculated by Sørensen (Bray-Curtis) similarity index with group average algorithm (UPGMA). On the other hand, differences of community composition on maquis and arborescent matorral habitats were analyzed with non-metric multidimensional scaling (NMS) (McCune et al., 2002) using "medium" autopilot mode with the Sørensen (Bray-Curtis) distance measurement. The relationship of diversity calculation classes (joint plots) with the community composition was also investigated. Joint plots (total richness, total frequency, epiphytic and non-epiphytic richness, epiphytic and non-epiphytic frequency) were included in NMS analysis. By multi-response permutation procedure (MRPP) analysis (McCune et al., 2002), community composition of four slope directions and tops of hills, also separately three hills were compared on PC-ORD 6.08.

Results

Total 123 lichen taxa were identified from 15 selected Mediterranean maquis and arborescent matorral habitat localities in Altınbeşik Cave National Park. They are listed in *Table 2* in alphabetic order. New lichen taxa for Antalya Province of Turkey are highlighted by an asterisk (*) in this list. Also, the list includes average frequencies of epiphytic and non-epiphytic taxa and their total average frequencies (total frequency) and total richness data. Total frequency and total richness data for each locality were examined and were not found normally distributed. Therefore, Spearman's rho test was used to determine whether there is any relationship between total frequency and total richness data. As a result; a strong linear relationship was found between total frequency and total richness of each localities in the positive direction ($p = 0.000$, $r = 0.991$).

Based on the data of total frequency and total richness of each locality, the graph in *Figure 2* was formed (The altitude of the localities are also shown in the graph). As shown in the graph, each localities were sorted from high to low total richness as follows N-A > N-K > S-A > T-A > T-K > N-I > E-I > W-K > S-I > S-K > T-I > W-A > E-A > W-I > E-K ($r = 0.868$) and according to total frequency; from high to low: N-A > N-K > W-K > S-A > T-K > S-I > T-I > T-A > S-K > N-I > E-A > W-I > E-I > W-A > E-K ($r = 0.852$). In terms of total richness and frequency, the highest results were obtained from northern slopes of Altınbeşik Hill (N-A), whereas lowest results were from eastern slopes of Kale Hill (E-K). In addition, while data of N-A constitutes 16.11% of the total frequency and 21.14 of the total richness, data of E-K constitutes 2.60% of the total frequency and 10.57% of the total richness. It can be seen from the *Figure 2* while the northern slopes show the highest variation in lichen diversity in maquis and arborescent matorral habitats, the eastern slopes show least. On the other hand, in terms of data of species richness and species frequency, at least one locality was found significantly different than the other localities,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_1017310193

statistically (Kruskal Wallis, p = 0.000). Since all variances are not homogeneous, non-parametric Tamhane's T2 post-hoc test was preferred to understand which localities are different. According to richness and frequency data, especially two north localities N-A and secondly N-K are different than other 13 localities. The post-hoc test results of both localities are given at *Table 3*. While the similarity of localities was examined, a Sørensen dendogram based on species richness was obtained (*Fig. 3*). According to dendrogram, lichen richness of same slope directions is similar and also tops localities show similarity. The northern localities are in a separate similarity group the rest being in another similarity group; top localities and western localities are also in separate similarity groups.

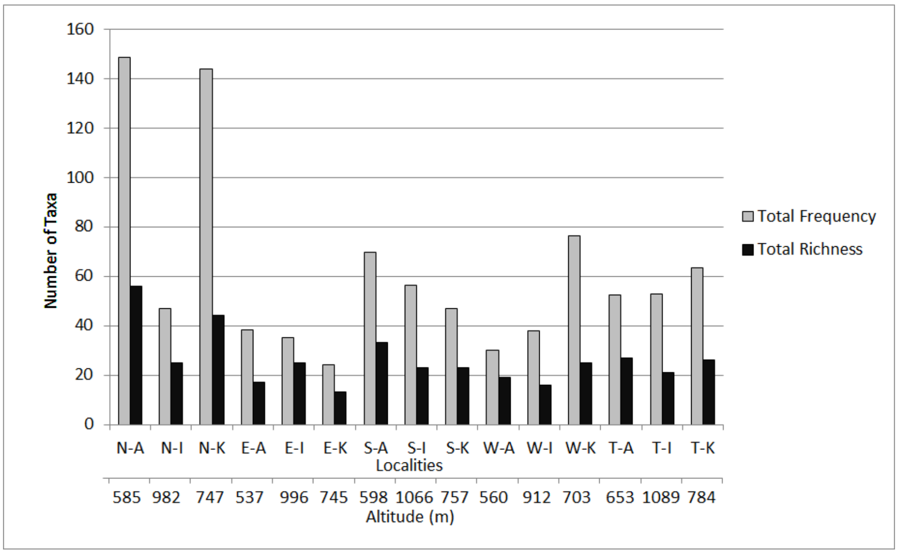

Figure 2. *Graphs about total frequency and total richness data based on all localities (created with Excel 2010). Abbreviations: -A: Altınbeşik Hill. E: East slopes. -I: İnönü Hill. -K: Kale Hill. N: North slopes. S: South slopes. W: West slopes T: Tops*

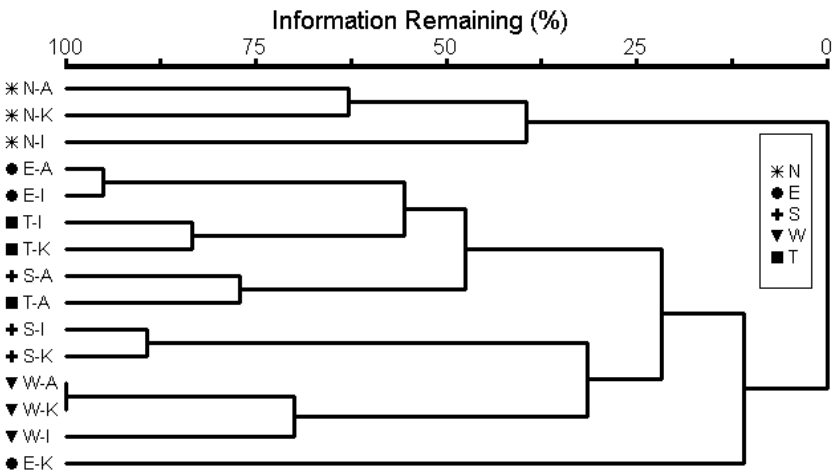

Figure 3. *Sørensen similarity dendrogram of all localities based on species richness in Altınbeşik Cave National Park (created with PC-ORD 6.08). Abbreviations: -A: Altınbeşik Hill. E: East slopes.-I: İnönü Hill. -K: Kale Hill. N: North slopes. S: South slopes. W: West slopes T: Tops*

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Table 2. *List of determined epiphytic and non-epiphytic lichen taxa with distribution of the average of frequencies data according to localities (the total average of frequencies and the total richness were added to the bottom of each taxa group lists)*

Epiphytic Taxa on *P. palaestina*		**N-A**	**N-I**	**N-K**	**E-A**	**E-I**	**E-K**	**S-A**	**S-I**	**S-K**	**W-A**	**W-I**	**W-K**	**T-A**	**T-I**	**T-K**
Anaptychia ciliaris (L.) Körb. ex A.Massal.			4.00	5.67												
Athallia cerinella (Nyl.) Arup. Frödén & Søchting				3.67	0.33											
Caloplaca cerina (Ehrh. ex Hedw.) Th.Fr.				2.67											0.67	
Gyalolechia flavorubescens (Huds.) Søchting. Frödén & Arup				0.33					3.67							
Lecanora chlarotera Nyl.		1.00		1.00					1.00					1.00		
Lecidella elaeochroma (Ach.) M.Choisy				0.33												1.33
Melanohalea exasperatula (Nyl.) O. Blanco et al.												1.00				
Parmelina quercina (Willd.) Hale						0.33			3.00		0.33		4.00			
Phaeophyscia ciliata (Hoffm.) Moberg							1.33			3.33		2.00				
Physcia leptalea (Ach.) DC.									1.00							
Physconia distorta (With.) J.R.Laundon		2.00	3.00	1.33					3.00			3.67				
Rinodina exigua (Ach.) Gray								2.00		0.33						
Xanthoria parietina (L.) Th.Fr.			2.33	3.67					0.67				1.33			
Total Frequency of Taxa		3.00	9.33	18.67	0.33	0.33	1.33	2.00	12.34	3.66	0.33	6.67	5.33	1.00	0.67	1.33
Total Richness of Taxa		2	3	8	1	1	1	1	6	2	1	3	2	1	1	1
Epiphytic Taxa on *Q. coccifera*		**N-A**	**N-I**	**N-K**	**E-A**	**E-I**	**E-K**	**S-A**	**S-I**	**S-K**	**W-A**	**W-I**	**W-K**	**T-A**	**T-I**	**T-K**
Athallia holocarpa (Hoffm.) Arup. Frödén & Søchting								3.67								
Caloplaca cerina (Ehrh. ex Hedw.) Th.Fr.				3.33											2.33	
Candelariella xanthostigma (Pers.) Lettau															0.67	
Collema furfuraceum (Arnold) Du Rietz		5.67						1.33	3.00							
Evernia prunastri (L.) Ach.		4.00							3.00	2.33						
Lecanora carpinea (L.) Vain.														0.33	1.33	1.33
Lecidella elaeochroma (Ach.) M.Choisy		0.67			2.33											
Leptogium furfuraceum (Harm.) Sierk		1.33														
Melanohalea exasperatula (Nyl.) O. Blanco et al.									2.00							
Melanohalea laciniatula (Flagey ex H.Olivier) O.Blanco et al.	*	1.33														
Ochrolechia balcanica Vers.			0.33									1.33	2.00			
Physcia adscendens (Fr.) H.Olivier		5.67		4.33		0.67			2.00	2.33	1.33		5.33			
Physcia aipolia (Ehrh. ex Humb.) Hampe		3.00														
Physcia biziana (A.Massal.) Zahlbr.		1.33						2.00	2.00							

APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 17(4):10173-10193.
http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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Physcia leptalea (Ach.) DC.		1.00				0.33			1.33							
Pleurosticta acetabulum (Neck.) Elix & Lumbsch									3.33							
Ramalina farinacea (L.) Ach.		3.33							3.00	1.33						
Rinodina capensis Hampe		1.33														
Xanthoria parietina (L.) Th.Fr.		6.57					0.67		0.67	4.33	1.33		2.00			
Total Frequency of Taxa		35.23	0.33	7.66	2.33	1.00	0.67	7.00	20.33	10.32	2.66	1.33	9.33	0.33	4.33	1.33
Total Richness of Taxa		12	1	2	1	2	1	3	9	4	2	1	3	1	3	1
Epiphytic Taxa on *J. excelsa*		**N-A**	**N-I**	**N-K**	**E-A**	**E-I**	**E-K**	**S-A**	**S-I**	**S-K**	**W-A**	**W-I**	**W-K**	**T-A**	**T-I**	**T-K**
Candelariella efflorescens R.C.Harris & W.R.Bucks.		0.67			1.00	0.67								1.33	4.00	
Candelariella xanthostigma (Pers.) Lettau					0.67		0.33						3.67	2.00		0.33
Hypogymnia tubulosa (Schaer.) Hav.			2.00	6.00												
Lecidella elaeochroma (Ach.) M.Choisy								0.67								
Parmelina tiliacea (Hoffm.) Hale		6.00		5.00	2.00	1.33			2.33							
Pertusaria albescens (Huds.) M.Choisy & Werner		3.67														
Polycaulina polycarpa (Hoffm.) Frödén. Arup & Søchting	*		1.33	2.00												
Total Frequency of Taxa		10.34	3.33	13.00	3.67	2.00	0.33	0.67	2.33	0	0	0	3.67	3.33	4.00	0.33
Total Richness of Taxa		3	2	3	3	2	1	1	1	0	0	0	1	2	1	1
Epiphytic Taxa on *P. latifolia*		**N-A**	**N-I**	**N-K**	**E-A**	**E-I**	**E-K**	**S-A**	**S-I**	**S-K**	**W-A**	**W-I**	**W-K**	**T-A**	**T-I**	**T-K**
Collema nigrescens (Huds.) DC.		4.67		2.00				2.33		0.67				0.33		
Collema subnigrescens Degel.		5.33			0.33									1.33		
Fuscopannaria olivacea (P.M.Jørg.) P.M.Jørg.		1.00		5.67										4.00		
Lecidella elaeochroma (Ach.) M.Choisy											0.33			2.33		
Leptogium brebissonii Mont.	*	1.33														
Leptogium cyanescens (Rabenh.) Körb.		0.67														
Melanelixia glabra (Schaer.) O. Blanco et al.				3.00												
Nephroma laevigatum Ach.		2.00														
Parmelina tiliacea (Hoffm.) Hale								2.00						4.67		
Pectenia plumbea (Lightf.) P.M.Jørg.. L.Lindblom. Wedin & S.Ekman		2.00												1.33		
Pertusaria albescens (Huds.) M.Choisy & Werner										0.33	1.00	2.33		1.33		
Phaeophyscia ciliata (Hoffm.) Moberg								3.00								
Phaeophyscia orbicularis (Neck.) Moberg								1.33		3.67			2.67	0.67	1.67	2.33
Phlyctis argena (Sprengel) Flot.		2.00		4.67												
Physcia aipolia (Ehrh. ex Humb.) Hampe				4.33				1.33						0.67		

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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	N-A	N-I	N-K	E-A	E-I	E-K	S-A	S-I	S-K	W-A	W-I	W-K	T-A	T-I	T-K
Physcia biziana (A.Massal.) Zahlbr.													3.00		
Physcia leptalea (Ach.) DC.							1.33					4.00	0.67		
Physconia distorta (With.) J.R.Laundon	2.00		1.33				2.33				3.67				
Physconia venusta (Ach.) Poelt	5.33	3.33	5.67										3.67		
Pleurosticta acetabulum (Neck.) Elix & Lumbsch							2.00								
Ramalina fastigiata (Pers.) Ach.		1.33	2.33												
Total Frequency of Taxa	26.33	4.66	29.00	0.33	0	0	15.65	0	4.67	1.33	6.00	6.67	24.00	1.67	2.33
Total Richness of Taxa	10	2	8	1	0	0	8	0	3	2	2	2	12	1	1
Non-Epiphytic Taxa	**N-A**	**N-I**	**N-K**	**E-A**	**E-I**	**E-K**	**S-A**	**S-I**	**S-K**	**W-A**	**W-I**	**W-K**	**T-A**	**T-I**	**T-K**
Acarospora cervina (Ach.) A.Massal.															2.00
Aspicilia cheresina (Müll.Arg.) Hue														2.33	
Aspicilia farinosa (Flörke) Flagey				1.33	0.67		1.00		4.00	3.67	1.00		1.33	2.33	3.67
Bagliettoa calciseda (DC.) Gueidan & Cl.Roux					1.33		2.00		2.00	1.00	3.00				
Bagliettoa marmorea (Scop.) Gueidan & Cl.Roux	2.33	0.67		5.67	1.00		1.00					3.67		1.33	
Bagliettoa parmigera (J.Steiner) Vězda & Poelt			5.67										3.67	4.00	
Blennothallia crispa (Huds.) Otálora. P.M.Jørb. & Wedin			2.00												
Caloplaca adriatica (Zahlbr.) Servit							1.00	3.67						2.00	
Caloplaca atroflava (Turner) Mong													1.33		1.00
Caloplaca erythrocarpa (Pers.) Zwackh			3.00	2.00								3.00			
Caloplaca velana (A.Massal.) Du Rietz								4.00	3.67			2.00			2.00
Catapyrenium daedaleum (Kremp.) Stein	0.33	1.33	1.00					2.00	1.00	3.67		2.33			
Circinaria calcarea (L.) Mudd			5.67		0.67						0.33	5.67			
Circinaria contorta (L.) A. Nordin. Savić & Tibell subsp. *contorta*					0.67				2.33					1.33	1.00
Circinaria contorta subsp. *hoffmanniana* S.Ekman & Fröberg ex R.Sant.		2.00	6.00		1.33		1.00		1.00						5.33
Circinaria coronata (A.Massal.) B.de Lesd.			2.00												
Cladonia convoluta (Lam.) Anders			5.67				1.00			3.67	3.67				
Cladonia fimbriata (L.) Fr.	4.00	1.33				3.00									
Cladonia pocillum (Ach.) Grognot			3.00												
Cladonia pyxidata (L.) Hoffm.	1.00			1.00		1.33									
Cladonia rangiformis Hoffm.	5.67		4.67			1.00									
Clauzadea immersa (Hoffm.) Hafellner & Bellem.	6.00		4.00		2.00								3.67		
Dermatocarpon miniatum (L.) W.Mann	5.00	3.67												3.00	6.00

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Diploschistes ocellatus (Vill.) Norman				5.33												
Diplotomma venustum (Körb. in Rabenh.) Körb.																1.00
Enchylium tenax (Sw.) Gray				1.00										1.00		4.00
Gyalolechia flavovirescens (Wulfen) Søchting. Frödén & Arup		2.00														
Gyalolechia fulgens (Sw.) Søchting. Frödén & Arup		4.00	1.33		1.00	1.33				2.67						
Gyalolechia subbracteata (Nyl.) Søchting. Frödén & Arup	*										1.00		1.33			
Lathagrium auriforme Otálora. P.M.Jørb. & Wedin		0.67										1.33	0.67			
Lathagrium cristatum Otálora. P.M.Jørb. & Wedin var. *cristatum*			5.00		5.67	2.33		5.67		0.33			3.00			2.00
Lathagrium cristatum var. *marginale* (Huds.) Degel.			0.33	0.67												
Lecanora bolcana (Pollini) Poelt					2.33	2.00					0.33	1.33	2.33	1.67	3.67	3.67
Lecanora campestris (Schaer.) Hue							0.67				1.33		3.00			
Lepraria incana (L.) Ach.						2.33		3.67								
Lepraria nivalis J.R.Laundon				4.00												
Leproplaca chrysodeta (Vain. ex Räsänen) J.R.Laundon						1.33		2.00		0.67						
Leproplaca xantholyta (Nyl.) Hue		4.00							3.67							
Lobothallia radiosa (Hoffm.) Hafellner				4.00		3.67	2.33	4.00		2.33	2.33	5.67	5.33		4.00	5.67
Neocatapyrenium rhizinosum (Müll.Arg.) Breuss				1.00												
Peltigera rufescens (Weiss) Humb.		1.33									0.33		1.00			
Petractis clausa (Hoffm.) Kremp.									0.33							
Placidium pilosellum (Breuss) Breuss				0.67								0.33				
Placidium squamulosum (Ach.) Breuss		0.33						0.33							0.33	1.33
Placopyrenium bucekii (Nádv. & Servít) Breuss		0.33														
Placynthium nigrum (Huds.) Gray					4.00	3.00	2.00									
Placynthium subradiatum (Nyl.) Arnold		1.33	3.33									0.67	0.67			
Protoparmeliopsis muralis (Schreb.) M.Choisy		5.33			2.33	2.33			1.33		1.67		0.33		2.33	1.33
Psora decipiens (Hedw.) Hoffm.		2.33		3.67		1.33		3.67						1.67		1.00
Psora vallesiaca (Schaer.) Timdal									1.33							3.67
Pyrenodesmia chalybaea (Fr.) A.Massal.					4.00	0.67										1.00
Pyrenodesmia variabilis (Pers.) A.Massal.			1.33	3.67	2.33	1.67	3.67									2.33
Rhizocarpon lecanorinum Anders											1.67		3.33			
Rinodina calcarea (Arnold) Arnold								2.33								6.33
Rinodina tunicata H.Mayrhofer & Poelt	*	1.00	0.67													
Sarcogyne regularis Körb.								1.00						1.33	0.67	

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Scytinium gelatinosum (With.) Otálora. P.M.Jørg. & Wedin		1.00									2.33		3.67			
Scytinium palmatum (Huds.) Gray		0.33		0.33												
Scytinium schraderi (Bernh.) Otálora. P.M.Jørg. & Wedin			1.33	2.33												
Solenopsora cesatii (A.Massal.) Zahlbr.						0.67		2.33								
Solenopsora marina (Zahlbr.) Zahlbr.		0.67														
Solenopsora olivacea (Fr.) H.Kilias subsp. *olbiensis* (Nyl.) Clauzade & Cl.Roux		4.00														
Solenopsora olivacea (Fr.) H.Kilias subsp. *olivacea*		1.33														
Squamarina cartilaginea (With.) P.James		5.67	2.33	4.00			1.67	5.00						4.00	3.67	
Squamarina gypsacea (Sm.) Poelt									1.33	2.67				3.33		
Synalissa ramulosa (Hoffm. ex Bernh.) Fr.																1.33
Toninia candida (Weber) Th.Fr.		1.33	0.67													
Toninia diffracta (A.Massal.) Zahlbr.			1.00	2.00				1.33								
Toninia physaroides (Opiz) Zahlbr.																1.00
Toninia sedifolia (Scop.) Timdal											1.33		4.00			
Trapelia coarctata (Turner ex Sm.) M.Choisy		1.33														
Varicellaria lactea (L.) I.Schmitt & Lumbsch		4.33				1.33		2.00								
Variospora aurantia (Pers.) Arup. Frödén & Søchting							4.67	1.67	3.67	3.00	1.33	3.33	6.00	0.67	4.00	
Variospora flavescens (Huds.) Arup. Søchting & Frödén		2.33	1.67													
Verrucaria dolosa Hepp	*	2.00														
Verrucaria macrostoma Dufour ex DC.								2.33				3.33				
Verrucaria nigrescens Pers.							1.33			2.67					3.33	
Verruculopsis lecideoides (A.Massal.) Gueidan & Cl.Roux																1.33
Xanthocarpia ochracea (Schaer.) A.Massal. & De Not.		2.33	1.33												3.67	
Total Frequency of Non-Epiphytic Taxa		73.63	29.32	75.35	31.66	31.66	21.67	44.33	21.33	28.34	25.66	23.99	51.33	23.67	41.99	57.99
Total Richness of of Non-Epiphytic Taxa		30	17	24	11	20	10	20	9	13	14	11	18	11	16	22
Total Frequency of Epiphytic Taxa		74.9	17.65	68.33	6.66	3.33	2.33	25.32	35	18.65	4.32	14	25	28.66	10.67	5.32
Total Richness of Epiphytic Taxa		26	8	20	6	5	3	13	14	10	5	5	7	16	5	4
General Total Frequency of All Taxa		148.5	46.97	143.7	38.32	34.99	24.00	69.65	56.33	46.99	29.98	37.99	76.33	52.33	52.66	63.31
General Total Richness of All Taxa		56	25	44	17	25	13	33	23	23	19	16	25	27	21	26

*The mean lichen taxa are new for Antalya province of Turkey
Total frequency data were calculated by the ratio of the total frequency of taxa to the number of occurrence of the taxa. In the list, the average frequencies of epiphytic taxa were divided according to each tree species on which the taxa were placed
-A: Altınbeşik Hill, -I: İnönü Hill, -K: Kale Hill, E: East slopes, N: North slope, S: South slopes, W: West slopes, T: Tops

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Table 3. *The most statistically different localities and multiple comparison results based on species richness and species frequency*

Localities		Taxa richness		Taxa frequency	
		Mean difference	**Sig.**	**Mean difference**	**Sig.**
N-A	N-I	.25203*	.002	.82569*	.002
	N-K	.09756	1.000	.03943	1.000
	E-A	.31707*	.000	.89602*	.000
	E-I	.25203*	.002	.92309*	.000
	E-K	.34959*	.000	1.01244*	.000
	S-A	.18699	.204	.64130	.119
	S-I	.26829*	.001	.74959*	.014
	S-K	.26829*	.001	.82553*	.002
	W-A	.30081*	.000	.96382*	.000
	W-I	.32520*	.000	.89870*	.000
	W-K	.25203*	.002	.58699	.446
	T-A	.23577*	.008	.78211*	.006
	T-I	.28455*	.000	.77943*	.008
	T-K	.24390*	.004	.69285	.076
N-K	N-I	-.09756	1.000	-.03943	1.000
	N-K	.15447	.516	.78626*	.007
	E-A	.21951*	.006	.85659*	.002
	E-I	.15447	.516	.88366*	.000
	E-K	.25203*	.000	.97301*	.000
	S-A	.08943	1.000	.60187	.278
	S-I	.17073	.234	.71016*	.043
	S-K	.17073	.234	.78610*	.007
	W-A	.20325*	.024	.92439*	.000
	W-I	.22764*	.003	.85927*	.002
	W-K	.15447	.516	.54756	.706
	T-A	.13821	.829	.74268*	.020
	T-I	.18699	.083	.74000*	.026
	T-K	.14634	.682	.65341	.183

*The mean difference is significant at the 0.05 level
After Kruskal Wallis analyses were used, at least one locality was found significantly different than the other localities. Since all variances are not homogeneous, non-parametric Tamhane's T2 post-hoc test was preferred
-A: Altınbeşik Hill, -I: İnönü Hill, -K: Kale Hill, E: East slopes, N: North slope, S: South slopes, W: West slopes, T: Tops

After these results were determined, total frequency and total richness data were grouped based on localities at different slope directions and tops of the hills (*Fig. 4*). Also; localities from three hills grouped separately and plotted accordingly (*Fig. 5*). As two comparison data showed normal distribution, Pearson test was used for correlation analysis of these. While there was a very strong linear relation in data of four slope directions and data of tops ($p = 0.008$, $r = 0.963$), no relation was found within the data of the three hills (and the three altitude groups). As seen from the graphs, the total

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frequency of different slope directions and tops is sorted from high to low as follows: North > South > Top > West > East (r = 0.885); total richness data as North > South > Top > East > West (r = 0.911). Total northern data were found to be significantly higher than other directions and tops (*Fig. 4*).

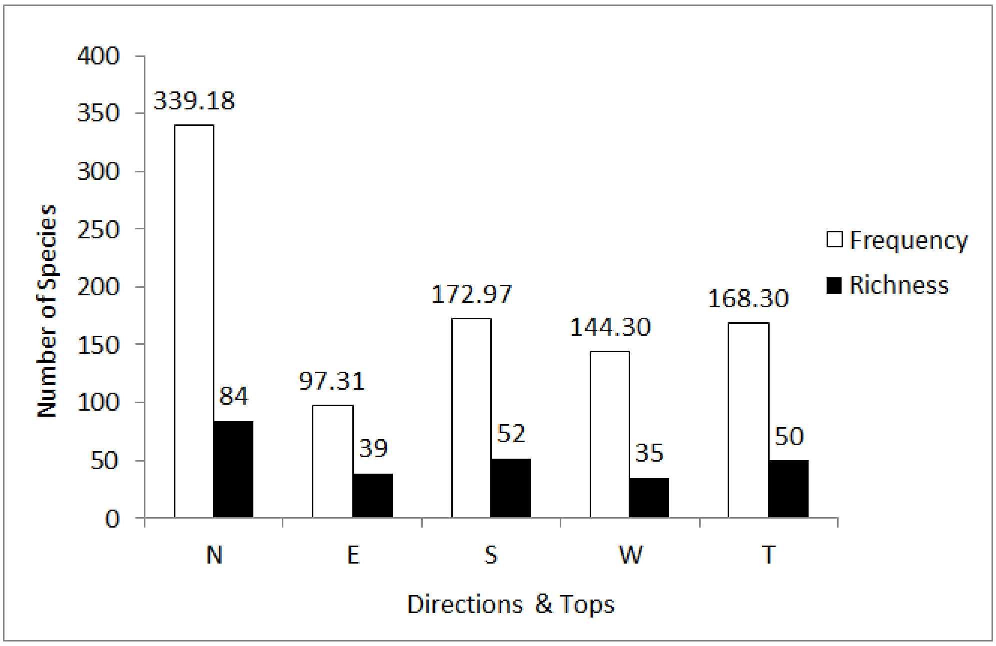

Figure 4. *Graphs about total frequency and total richness data based on localities of different slope directions and tops (created with Excel 2010). Abbreviations: E: East slopes, N: North slopes, S: South slopes, W: West slopes, T: Tops*

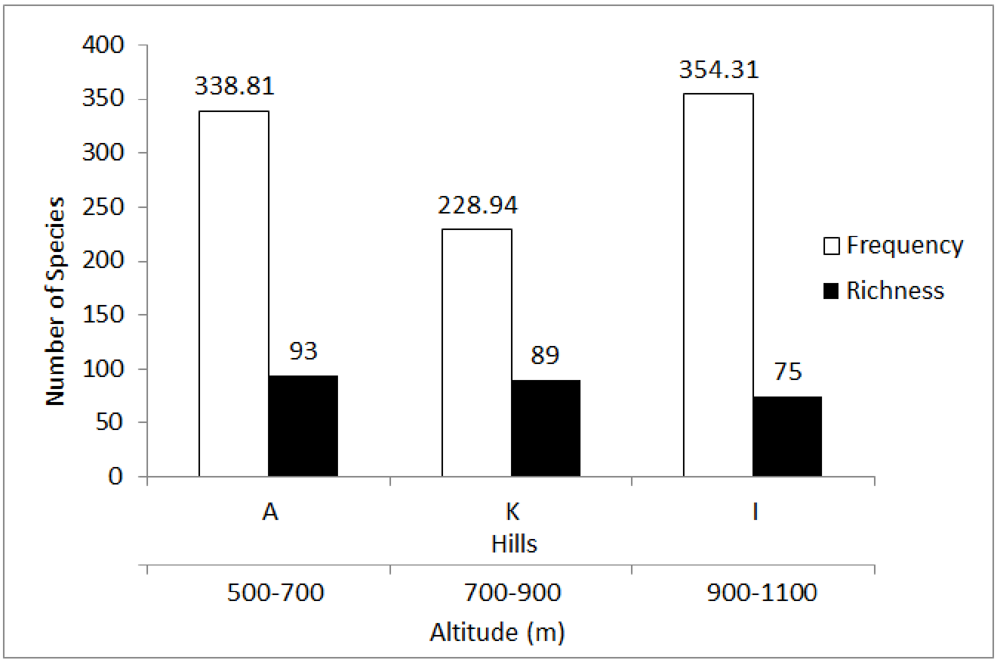

Figure 5. *Graphs about total frequency and total richness data based on localities of three hills (created with Excel 2010). Abbreviations: A: Altınbeşik Hill, I: İnönü Hill, K: Kale Hill*

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Also; total frequency data results obtained from the three hills are as follows from high to low (These hills also represent different altitude groups): Altınbeşik (500-700 m) > Kale (700-900 m) > İnönü (900-1100 m) (r = 0.917); total richness data as: İnönü (900-1100 m) > Altınbeşik (500-700 m) > Kale (700-900 m) (r = 0.952) (*Fig. 5*). When Kruskal Wallis test was applied for data of species richness and species frequency of different slope directions and tops, at least one data group statistically differentiates from others (p = 0.000). In addition, according to Tamhane's T2 post-hoc test results; northern slopes data significantly differ from the data of other directions and tops (*Table 4*). When species richness and frequency data of the three hills were analyzed; difference is available for the frequency data (Kruskal Wallis, p = 0.033) and richness data (Kruskal Wallis, p = 0.011) of the three hill. Tamhane's T2 post-hoc test result showed; Inönü Hill (900-1100 m) is different from Altınbeşik Hill (500-700 m) based on species richness data and it is different from Altınbeşik and Kale (700-900 m) Hills based on frequency data (*Table 5*).

Table 4. *Multiple comparison results based on species richness and species frequency of data of slope directions and tops*

Directions & tops		**Species richness**		**Species frequency**	
		Mean difference	**Sig.**	**Mean difference**	**Sig.**
N	E	.36585*	.000	1.97724*	.000
	S	.26016*	.000	1.36211*	.001
	W	.39837*	.000	1.59520*	.000
	T	.27642*	.000	1.40008*	.001
E	N	-.36585*	.000	-1.97724*	.000
	S	-.10569	.596	-.61512	.111
	W	.03252	1.000	-.38203	.790
	T	-.08943	.793	-.57715	.219
S	N	-.26016*	.000	-1.36211*	.001
	E	.10569	.596	.61512	.111
	W	.13821	.211	.23309	.994
	T	.01626	1.000	.03797	1.000
W	N	-.39837*	.000	-1.59520*	.000
	E	-.03252	1.000	.38203	.790
	S	-.13821	.211	-.23309	.994
	T	-.12195	.366	-.19512	.999
T	N	-.27642*	.000	-1.40008*	.001
	E	.08943	.793	.57715	.219
	S	-.01626	1.000	-.03797	1.000
	W	.12195	.366	.19512	.999

*The mean difference is significant at the 0.05 level
After Kruskal Wallis analysis were used. At least one slope direction or top data was found significantly different than the other localities. Since all variances are not homogeneous. non-parametric Tamhane's T2 post-hoc test was preferred
E: East slopes. N: North slopes. S: South slopes. W: West slopes T: Tops

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Table 5. *Multiple comparison results based on species richness and species frequency of data of three hills*

Hills		Species richness		Species frequency	
		Mean difference	Sig.	Mean difference	Sig.
A	I	.14634*	.040	.90407*	.030
	K	.03252	.916	-.11520	.989
I	A	-.14634*	.040	-.90407*	.030
	K	-.11382	.166	-1.01927*	.021
K	A	-.03252	.916	.11520	.989
	I	.11382	.166	1.01927*	.021

*The mean difference is significant at the 0.05 level
After Kruskal Wallis analysis were used. At least one hill data was found significantly different than the other localities. Since all variances are not homogeneous. non-parametric Tamhane's T2 post-hoc test was preferred
A: Altınbeşik Hill, I: İnönü Hill, K: Kale Hill

When species community composition was summarized according to frequency data by non-metric multidimensional scaling (NMS), it was seen that 3 axes explained total variation with 82.89% (axis 1 48.20%; axis 2 21.81%; axes 3 12.88%). For 3-dimensional solution, the final stress rate was 12.41% and instability was 0.00000. At *Figure 6*, an ordination graph was given based on these NMS results with joint plot vectors (total richness, total frequency, epiphytic and non-epiphytic richness, epiphytic and non-epiphytic frequency). Examining Pearson correlation of axes and vectors; it was found that total richness ($r = 0.624$), epiphytic richness ($r = 0.610$), non-epiphytic richness ($r = 0.470$), epiphytic frequency ($r = 0.552$), non-epiphytic frequency ($r = 0.462$) and total frequency ($r = 0.556$) showed high positive correlations with axis 1. At axis 2; whereas all diversity vectors had descending relation, epiphytic richness ($r = 0.708$) and epiphytic frequency ($r = 0.715$) were associated with ascending gradient. It can be understood from the results and graph; the epiphytic richness and frequency are more related to the data from southern slopes than data from the top and other slopes. Furthermore, while all other vector parameters were associated with the northern slopes, *Figure 6* shows non-epiphytic richness and frequency are also associated with the data of tops of hills.

Lichen community composition of tops and four slope directions of hills were compared as small-scale with MRPP. The results were presented in *Table 6.* In a MRPP analysis, in case chance-corrected within-group agreement (*A*) value is higher than 0.3, this *A* value is enough to say the compositions are different (McCune et al., 2002). When the results of analysis were evaluated according to this information, species composition of northern slopes versus southern, eastern, western slopes and tops were found distinctly different as well as western slopes versus tops (*Table 6*). On NMS graph, also MRPP results are reflected (*Fig. 6*). Also it was experimented comparison of lichen community composition as large-scale with the data of three hills. In *Table 6*, MRPP comparison of lichen community composition of three hills is given separately. According to this table, no significant difference is observed in any pairwise comparison.

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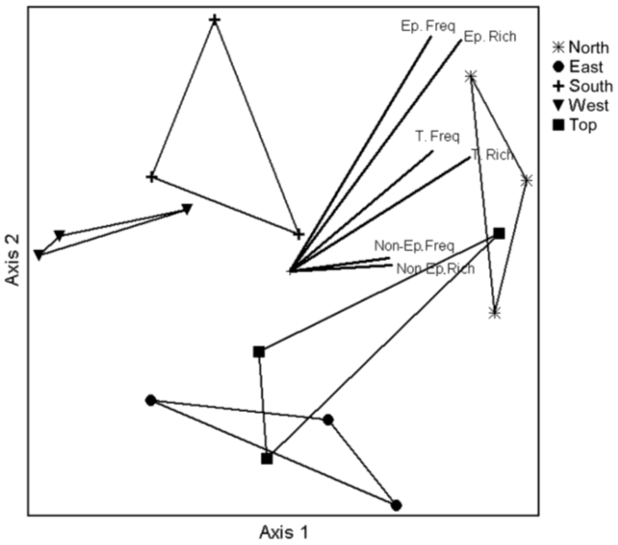

	Axis 1 r	Axis 2 r	Axis 3 r
Total Richness (T. Rich)	.624	.498	-.073
Total Frequency (T. Freq)	.556	.510	-.013
Non-Epiphytic Richness (Non-Ep. Rich)	.470	.128	-.033
Epiphytic Richness (Ep. Rich)	.610	.708	-.092
Non-Epiphytic Frequency (Non-Ep. Freq)	.462	.168	-.047
Epiphytic Frequency (Ep. Freq)	.552	.715	.016

Figure 6. *Ordination graph based on NMS results with diversity calculation classes (joint plot vectors) (created with PC-ORD 6.08)*

Table 6. *Pairwise comparison of lichen community composition of tops-four slope directions and separately hills with MRPP analysis*

	Directions & tops	
	***A* (MRPP)**	***p* (MRPP)**
N vs. E	0.41	0.02345
N vs. S	0.38	0.02852
N vs. W	0.43	0.02278
N vs. T	0.30	0.04784
E vs. S	0.24	0.05580
E vs. W	0.27	0.04174
E vs. T	0.11	0.16028
S vs. W	0.19	0.08800
S vs. T	0.25	0.03982
W vs. T	0.33	0.02374
	Hills	
	***A* (MRPP)**	***p* (MRPP)**
A vs. I	- 0.087	0.8898
A vs. K	0.014	0.3834
I vs. K	- 0.107	0.9607

A value is higher than 0.3, this A value is enough to say the compositions are different (McCune et al., 2002)
A: Altınbeşik Hill, A (MRPP): Chance-corrected within-group agreement, E: East slopes, I: İnönü Hill, K: Kale Hill, N: North slopes, p (MRPP): calculated probability, S: South slopes, vs.: versus, W: West slopes, T: Tops

Discussion

The study was carried out to determine the compositional diversity of lichen species in selected Mediterranean maquis and arborescent matorral habitats in Altınbeşik Cave National Park. Nascimbene et al. (2013) listed 35 articles examining lichen richness, diversity and composition of different habitats in different European countries. These articles were based on epiphytic lichens that live on forest trees. This study differentiates from those articles by examining epiphytic and non-epiphytic lichens on maquis and arborescent matorral habitats in the Mediterranean region. Therefore; it is the first research about lichen community composition subject on maquis habitats in Eastern Mediterranean Region.

Among the frequency and richness data of selected Mediterranean maquis and arborescent matorral habitats from tops and four slope directions of three hills in the northern data were found significantly higher and differ than others. According to results from Sorensen Similarity Index: slopes at same directions are similar, also top localities shows similarity within themselves. Among them northern localities shows the highest similarity. According to MRPP results; species composition of northern slopes is statistically different than southern, eastern, western slopes and top localities. In addition, it was found; all lichen diversity calculation classes (total richness, total frequency, epiphytic and non-epiphytic richness, epiphytic and non-epiphytic frequency) are related with the northern slopes according to NMS ordination test. Hence, it was concluded that all lichen diversity calculation classes are high in the northern localities. North slopes of hills are typically cool, shady and have high atmospheric humidity (Moser et al., 1979). As lichens are poikilohydric organisms, their water content changes according to the surrounding environmental conditions (Nash, 2008). After recurring hydration – drying cycles, they become metabolically active in humid air (Bidussi et al., 2013). In Mediterranean Region when temperature is sufficient for metabolic activity of lichens, humidity becomes more critical than light in terms of vitality (Aragón et al., 2010). Furthermore, dew is a very important water supply for lichens. Dew at Northern slopes has higher frequency and longer duration than the ones at the other directions (Kidron et al., 2002). All this information may be used to explain the reason for the higher similarities and diversities of the northern slopes in Mediterranean maquis and arborescent matorral habitats compared to the other localities observed in this study.

In a previous study, the response of lichen richness and abundance were examined according to land use intensity. According to this study; epilithic lichen diversity increases along the gradient of increase intensity of land use from forested to non-forested areas (Giordani et al., 2010). Similarly, according to NMS ordination test of current study; richness of non-epiphytic lichens, which lives on rocks and ground, was found to associate with the data of the tops of the hills which are the most non-vegetation areas of the Mediterranean maquis and arborescent matorral habitats. Besides, the epiphytic richness was determined to be more related to the southern slopes than other slopes. The most important environmental factor for epiphytic lichens is diffuse but fairly bright light (Rose, 1992; Renhorn et al., 1997; Sillett et al., 2000). This kind of light is mostly on the southern slopes. This may be one of the reasons to explain the relationship between southern slopes and epiphytic lichens in Mediterranean maquis and arborescent matorral habitats.

According to the results obtained from three hills in the Altınbeşik Cave National Park, least amount of lichen species richness but most frequency data were determined

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_1017310193

from İnönü Hill. While species frequency of this hill was found statistically different than other hills, species richness is different than only Altınbeşik Hill. As İnönü hill represents altitudes of 900-1100 m, this finding suggests; it is possible to find interesting lichen composition in Mediterranean maquis and arborescent matorral habitats at these altitudes in comparison to other altitudes.

Also lichen community composition of 3 hills was found similar according to NMS results. In a similar research on macro lichen diversity; the species richness and species abundance of areas were compared (Wiersma and McMullin, 2018). According to this study, it is reported that there is no difference in species richness or abundance in large-scale areas. This case suggests that similarity and difference measurements of lichen community compositions may be misleading on large-scale research areas. Similarly in this study, it was found that the composition of lichen in Mediterranean maquis and arborescent matorral habitats can show great variation in small-scale areas.

Conclusion

Mediterranean maquis and arborescent matorral habitat type is found across the entire Mediterranean biogeographical zone. In this study, it was aimed to determine the epiphytic and non-epiphytic lichen diversity in Mediterranean maquis and arborescent matorral habitats. Lichen diversity in this study was calculated according to the data of species richness and species frequency. In addition, it was examined the existing differences or similarities of lichen diversity at different directions, altitudes, and substrates (epiphytic and non-epiphytic) in this habitat type. Among the frequency and richness data of selected Mediterranean maquis and arborescent matorral habitats from tops and four slope directions of three hills, the northern data were found significantly higher and differ than others. According to results from Sorensen Similarity Index: slopes at same directions are similar, also top localities shows similarity within themselves. Among them northern localities shows the highest similarity. According to MRPP results; species composition of northern slopes is statistically different than southern, eastern, western slopes and top localities. In addition, it was found; all lichen diversity calculation classes (total richness, total frequency, epiphytic and non-epiphytic richness, epiphytic and non-epiphytic frequency) are related with the northern slopes according to NMS ordination test. In addition, richness of non-epiphytic lichens, which lives on rocks and ground, was found to associate with the data of the tops of the hills which are the most non-vegetation areas of the Mediterranean maquis and arborescent matorral habitats. Besides, the epiphytic richness was determined to be more related to the southern slopes than other slopes. Though it was found that lichen community composition shows great variation in Mediterranean maquis and arborescent matorral habitat, community composition of 3 hills was found similar according to NMS results. This result suggests that choosing large-scale areas for determining differences on lichen communities may have misleading results.

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