Species diversity of lichens in the sacred groves of Epirus (Greece)

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Abstract: Muggia, L., Kati, V., Rohrer, A., Halley, J. & Mayrhofer, H. 2018. Species diversity of lichens in the sacred groves of Epirus (Greece). – Herzogia **31**: 231–244.

The sacred groves in the mountains of Epirus in NW Greece have been established during the Ottoman period and consist of locally adapted systems set apart from the surrounding intensively managed, anthropogenic landscape. We inventoried eight sacred groves and compared them with nearby control (managed) forests. In total, 166 taxa of lichens and five of lichenicolous fungi were recorded. The most common lichen species were *Anaptychia ciliaris*, *Phlyctis argena* and *Lecidella elaeochroma*. Seven species are new for Greece: *Calicium quercinum*, *Chaenotheca ferruginea*, *Chaenotheca trichialis*, *Chaenothecopsis nana*, *Leptogium hibernicum*, *Parvoplaca nigroblastidiata* and *Rinodina orculata*. The sacred groves appeared not very different from the control forests; more pronounced differences were observed between deciduous oak evergreen oak and pine forests. Localities characterized by deciduous oak forest hosted the highest number of taxa belonging to the order Peltigerales, the most frequent were: *Nephroma laevigatum*, *Collema subflaccidum*, *Leptogium lichenoides* and *Lobaria pulmonaria*, but also rare species such as *Polychidium muscicola*, *Koerberia biformis* and *Degelia atlantica* were recorded.

Zusammenfassung: Muggia, L., Kati, V., Rohrer, A., Halley, J. & Mayrhofer, H. 2018. Flechtendiversität heiliger Haine in Epirus (Griechenland). – Herzogia **31**: 231–244.

Die heiligen Haine in den Bergen von Epirus im Nordwesten Griechenlands wurden während der Osmanischen Herrschaft errichtet und bestehen aus lokal adaptierten Gebieten, die sich deutlich von der umgebenden intensiv genutzten anthropogenen Landschaft unterscheiden. Acht heilige Haine wurden untersucht und mit benachbarten bewirtschafteten Wäldern verglichen. 166 Flechten und 5 lichenicole Pilze wurden gefunden. Die häufigsten Arten waren *Anaptychia ciliaris*, *Phlyctis argena* und *Lecidella elaeochroma*. Sieben neue Arten werden für Griechenland nachgewiesen: *Calicium quercinum*, *Chaenotheca ferruginea*, *Chaenotheca trichialis*, *Chaenothecopsis nana*, *Leptogium hibernicum*, *Parvoplaca nigroblastidiata* und *Rinodina orculata*. Die heiligen Haine waren nicht sehr verschieden von den Vergleichswäldern. Größere Unterschiede wurden zwischen sommergrünen Eichen-, immergrünen Eichen- und Kiefernwäldern beobachtet. Die Fundorte mit sommergrünen Eichenwäldern beherbergen die größte Zahl an Peltigerales-Arten, von den am häufigsten sind *Nephroma laevigatum*, *Collema subflaccidum*, *Leptogium lichenoides* und *Lobaria pulmonaria*. Auch seltene Arten wie *Polychidium muscicola*, *Koerberia biformis* und *Degelia atlantica* wurden gefunden.

Key words: Biodiversity, conservation, frequency, old growth forest, Peltigerales, species richness.

Introduction

Cryptogams are widely used in conservation surveys of old-growth forests, as many species are perennial and often occur on old trees and dead wood, as essential component of these environments (McComb & Lindenmayer 1999). Among this group of organisms, lichens are of

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significant conservation concern, being both biologically diverse (Dietrich & Scheidegger 1997) and functionally important in forest ecosystems (Gunnarsson et al. 2004). Clearly and detailed lichen inventories are usually performed for woodlands and old-growth forests in order to estimate the associated lichen assemblages in terms of the inherent characteristics of particular tree assemblages, community age and structure, ecological continuity, and spatial distribution of different epiphytic species (Edwards et al. 2004). In particular old-growth, unmanaged woodlands offer niches to rare lichen species, which take many years to establish (Seaward 2008). These include macrolichens, having foliose and fruticose growth form, and microlichens, having crust-like growth form and which have often adapted to phorophyte hosts, the microclimatic and ecological conditions. However, when ecological conditions change, lichens can react extremely fast, so that inventories of lichen biodiversity can be used to estimate shifts of lichen communities, and to predict the potential fragility of lichen assemblages to changed woodland structures (Nascimbene 2013).

In Greece, little is known on lichens and their presence and abundance in old-growth forests. Of particular interest and still poorly known are those old-growth forests bearing religious backgrounds which are located in the mountains of Epirus (NW Greece). Such forests are known as sacred groves and were established during the Ottoman period (1479–1912). They consist of locally adapted management systems that have succeeded in preserving old-growth forests until today. They have been hardly studied before but are very important locally and belay their history as part of the intensively managed, anthropogenic landscape. Until the 20th century the majority of the land was cultivated and the tree cover has been reduced to remnant patches and managed silvopastures (Grove & Rackham 2001). The human population of this area needed to maintain tree cover for a multitude of reasons and to manage tracts of wooded land for communal benefits. This was carried out by taking advantage of the agency of religious prohibitions imposed by the Orthodox Church during the years of the Ottoman occupation. As breaking religious rules was believed to cause misfortune, disease or even death to the trespasser (Chandran & Hughes 2000), mature woods and groves have been effectively maintained. Some of these groves were later "excommunicated" in order to be protected even more efficiently, as anyone "touching" the grove would have been automatically excommunicated from the Church (Stara et al. 2012). In Epirus they are known as *"klisiast'ka"* (literally meaning "belonging to the Church") or "vakuf" (a synonym of Arabic origin). The sacred groves are usually located above settlements and have functioned as protective forest belts, which shielded the settlements from landslides and torrents. Smaller groves around chapels functioned also as aesthetic value, being protective and green festive places of the villages during social events. In prewar aerial photographs the sacred groves contrast dramatically with the surrounding overgrazed and deforested landscape; though, the today's abandoned cultural landscape makes their presence less prominent.

The term 'sacred' has been used to define things under religious life (Durkheim 1995), which remain protected (woods and groves in case of Epirus) and set apart from profane things. Recently the International Union for Conservation of Nature (IUCN) has defined "Sacred Natural Sites" as those areas of land or water having special spiritual significance to people and communities (Oviedo & Ieanrenaud 2007, Wild & McLeod 2008). This description well applies to the sacred groves sites of Epirus.

This study is a survey of the lichen species diversity recorded in 16 plots represented by eight sacred groves and eight managed forests in Epirus (NW Greece). We aimed (a) to increase knowledge regarding the distribution of lichen species in NW Greece, (b) to investigate the lichen diversity patterns among different sites in terms of vegetation type and sacred character.

Material and Methods

Sampling: Lichens and lichenicolous fungi were collected in 16 localities, which included eight sacred groves and eight control sites, the latter are represented by managed forested areas which underwent silvopasture (Table 1, Fig. 1). The sites are located in the region of Zagori, in the National Park of Northern Pindos and in the valley of Konitsa; both areas belong to the Pindus Mountain Range. The sacred groves and their corresponding control sites were located up to 3 km far from each other. In each site one sampling plot was randomly selected and this was used to survey also plants, fungi, birds and insects (Avtzis et al. in prep.). The lichen sampling addressed presence/absence of the species and it was performed always and only on tree trunks up to 2 m above the ground, on all different tree species present in the plot; at least 5 trees of the same species were visited, if they were present. The sampling followed a random time-constrained and species recovery-constrained strategy: in each locality we collected until we were not able to identify additional new species in the field. Due to logistic planning, the collecting sites were visited only once for a time which averaged 3 hours for each site. The identification of the lichen material was carried out using dissecting and compound microscopes. Standard chemical spot tests based on K, C, and P, and thin layer chromatography according to Orange et al. 2001) were applied. The nomenclature follows mainly Wirth et al. (2013). For determination we used Clauzade & Roux (1985), Nimis (1987), Smith et al. (2009), Wirth et al. (2013) and monographs, e.g. Kukwa (2011). The specimens are stored in the herbarium GZU.

Fig. 1. A. Sacred grove of Livadakia-Vitsa (1s), deciduous oak forest. **B.** Panoramic view of the Konitsa plane, where part of the study sites are located. **C.** Control site of Molista (8s), pine forest.

Table 1. List of the 16 sampling sites. Site code (1–8 = site number, s = sacred groves, c = control sites), site name, vegetation types, type of managing, number of species per site and geographic coordinates are reported.

Site code	Site name	Main vegetation type	Type of management: sacred/ control	Total N. species	Geographic origin data (Greece, Epirus)
1s	Livadakia-Vitsa	Oak (*Quercus cerris*, *Q. coccifer*a, *Q. frainetto*)	Sacred	56	Municipality of Zagori, central/west Zagori, 750 m a.s.l., 39°50.815'N, 20°44.458'E, 03.VI.2013, Muggia & Rohrer
1c	Livadakia-Vitsa	Oak (*Q. cerris*, *Q. coccifer*a, *Q. frainetto*, *Q. pubescens*)	Control	40	Municipality of Zagori, central/west Zagori, 750 m a.s.l., 39°51.206'N, 20°43.954'E, 03.VI.2013, Muggia & Rohrer
2s	Mesovouni	Oak-evergreen oak (*Q. coccifera*, *Q. frainetto*, *Q. pubescens*)	Sacred	25	Municipality of Zagori, central/west Zagori, 620 m a.s.l., 39°55.957'N, 20°37.578'E, 07.VI.2013, Muggia & Rohrer
2c	Mesovouni	Oak-evergreen oak (*Q. coccifera*, *Q. pubescens*, *Q. trojana*)	Control	37	Municipality of Zagori, central/west Zagori, 570 m a.s.l., 39°55.902'N, 20°37.823'E, 07.VI.2013, Muggia & Rohrer
3s	Panagia-Mazi	Oak (*Q. frainetto*, *Q. trojana*) and *Phillyrea*	Sacred	48	Municipality of Konitsa, W of Konitsa plain, 630 m a.s.l., 40°02.690'N, 20°39.908'E, 07.VI.2013, Muggia & Rohrer
3c	Panagia-Mazi	Oak (*Q. coccifera*, *Q. frainetto*), *Phillyrea* and *Cotinus*	Control	33	Municipality of Konitsa, W of Konitsa plain, 540 m a.s.l., 40°02.848'N, 20°40.243'E, 05.VI.2013, Muggia & Rohrer
4s	Panagia Aiodonolalousa	Oak (*Q. cerris*, *Q. frainetto*, *Q. pubescens*)	Sacred	51	Municipality of Konitsa, S of Konitsa plain, 830 m a.s.l., 40°02.100'N, 20°36.170'E, 05.VI.2013, Muggia & Rohrer
4c	Panagia Aiodonolalousa	Oak (*Q. frainetto*, *Q. pubescens*, *Q. trojana*)	Control	43	Municipality of Konitsa, S of Konitsa plain, 820 m a.s.l., 40°02.233'N, 20°36.297'E, 05.VI.2013, Muggia & Rohrer
5s	Anilia-Kato Pedina	Evergreen oak (*Q. coccifera*)	Sacred	19	Municipality of Zagori, central/west Zagori, 890 m a.s.l., 39°52.681'N, 20°40.683'E, 04.VI.2013, Muggia & Rohrer
5c	Anilia-Kato Pedina	Evergreen oak (*Q. coccifera*)	Control	25	Municipality of Zagori, central/west Zagori, 970 m a.s.l., 39°52.350'N, 20°40.609'E, 04.VI.2013, Muggia & Rohrer
6s	Kri Panagias -Elafotopos	Evergreen oak (*Q. coccifera*) and *Phillyrea*	Sacred	22	Municipality of Zagori, central/west Zagori, 735 m a.s.l., 39°54.235'N, 20°39.127'E, 04.VI.2013, Muggia & Rohrer
6c	Kri Panagias -Elafotopos	Evergreen oak (*Q. coccifera*)	Control	18	Municipality of Zagori, central/west Zagori, 730 m a.s.l., 39°54.472'N, 20°39.169'E, 04.VI.2013, Muggia & Rohrer

Site code	Site name	Main vegetation type	Type of management: sacred/ control	Total N. species	Geographic origin data (Greece, Epirus)
7s	Kouri Konitsa	Pine (*Pinus nigra*, *Fraxinus ornus*)	Sacred	21	Municipality of Konitsa, Konitsa Kouri, 940 m a.s.l., 40° 02.831'N/20° 46.040'E, 06.VI.2013, Muggia & Rohrer
7c	Kouri Konitsa	Pine (*Pinus nigra*)	Control	32	Municipality of Konitsa, 10 km N of Konitsa, 940 m a.s.l., 40°03.323'N, 20° 47.105'E, 06.VI.2013, Muggia & Rohrer
8s	Molista	Pine and Oak (*Pinus nigra*, *Q. cerris*, *Q. petraea*)	Sacred	52	Municipality of Konitsa, N of Konitsa, 1210 m a.s.l., 40° 07.235'N/ 20° 49.038'E, 06.VI.2013, Muggia & Rohrer
8c	Molista	Pine (*Pinus nigra*, *Q. frainetto*, *Q. pubescens*)	Control	45	Municipality of Konitsa, N of Konitsa, 980 m a.s.l., 40°07.548'N, 20°49.347'E, 06.VI.2013, Muggia & Rohrer

Data analysis: Species richness (number of species) analysis was based on the lichen species only (lichenicolous fungi were excluded but are reported below). Species rank-abundance plot were obtained in Microsoft Excel 2010. The non-metric multidimensional scaling (NMDS) analysis was performed to objectively position sites in the two-dimensional space on the basis of their differential lichen species composition. The NMDS was applied using Sørensen binary distance (S8), after PCO selection, using CANOCO 5.0 (ter Braak & Šmilauer 2012). The plots were assembled in CorelDrawX3 for preparing the figure (Fig. 2).

Results

Lichen inventory: We recorded a total of 166 lichens (Table 2) and 5 lichenicolous fungi. We report seven species new for Greece: *Calicium quercinum*, *Chaenotheca ferruginea*, *Chaenotheca trichialis*, *Chaenothecopsis nana*, *Leptogium hibernicum*, *Parvoplaca nigroblastidiata* and *Rinodina orculata*. Lichenicolous fungal species are here listed (with their host) but were not used in any analysis: *Cercidospora xanthoriae* (*Xanthoria parietina*, site 2s), *Clypeococcum hypocenomycis* (*Hypocenomyce scalaris*, site 8c), *Lichenodiplis lecanorae* (*Caloplaca* spp., site 8s), *Phacographa zwackhii* (*Phlyctis argena*, site 3s and 4c) and *Toninia plumbina* (*Degelia atlantica*, site 3s).

Lichen diversity: In the sacred grove of Livadakia-Vitsa (1s) we reported the highest number of species (56), whereas in Kri Panagias - Elafotopos (6c) the lowest (18; Fig. 2a, Table 2). The sacred grove of Kri Panagias - Elafotopos was characterized by evergreen oak *Quercus coccifera*: it was therefore the most shaded site where tree trunks were majorly covered by bryophytes. The five sacred groves of the localities Livadakia-Vitsa (1), Panagia-Mazi (3), Panagia Aidonolalousa (4), Kri Panagia-Elafotopos (6) and Molista (8) were richer in species than their corresponding control forests. In general, the sacred groves are slightly richer in species than the control sites, but this cannot be statistically supported. Only in the locality Livadakia-Vitsa (1) we recorded in the sacred grove 16 more species than in the corresponding control site (Table 1).

Lichen community structure: The NMDS analyses evidences that sacred groves and control sites are rather homogenous in species composition; only the sites 5S, 7C and 7S, and 8S slightly set apart (Fig. 2b). This result is justified by the fact that they host pine forest and consequently different lichen species which are commonly found on conifers but not on deciduous or evergreen oaks. We do not report any statistical test as this would not be sensible having analyzed many different forest types.

Anaptychia ciliaris, *Lecidella elaeochroma* and *Phlyctis argena* were the most frequent species. Fifty eight species (35%) have been found only once and generate the 'long tailed' distribution evident in the species rank-abundance plot (Fig. 2c, Table 2). Also in this case the highest number of taxa reported only once is mainly related to the four localities characterized by pine forest, such as Molista (8) and Konitsa (7) (Table 1, Table 2). Localities characterized by deciduous oak forest were rather homogeneously rich in species and hosted in general the highest number of taxa belonging to the order Peltigerales. In particular, species such as *Nephroma laevigatum*, *Collema subflaccidum*, *C. furfuraceum*, *Lobaria pulmonaria*, *Lobarina scrobiculata*, and rare species such as *Polychidium muscicola*, *Koerberia biformis* and *Degelia atlantica* were recorded.

Table 2. Lichen species list (in alphabetic order) and species occurrence [presence (1)/absence ()] in each site. (*) Species newly recorded for Greece. Site code: 1–8 = site number, s = sacred groves, c = control sites. This dataset was used in the analyses reported in Fig. 2.

N.	**Species name**	**Site code**															
		1c	**1s**	**2c**	**2s**	**3c**	**3s**	**4c**	**4s**	**5c**	**5s**	**6c**	**6s**	**7c**	**7s**	**8c**	**8s**
1	*Acrocordia gemmata*	1					1				1						
2	*Alyxoria varia*				1		1										
3	*Anaptychia ciliaris*	1	1	1	1	1	1	1	1	1	1	1		1		1	1
4	*Anaptychia setifera*	1	1	1		1	1										
5	*Arthonia radiata*									1							
6	*Bacidia arceutina*					1											
7	*Bacidea fraxinea*						1										
8	*Bacidia rosella*				1												
9	*Bacidia rubella*				1		1										
10	*Bacidina assulata*												1				
11	*Buellia erubescens*					1											
12	*Buellia griseovirens*															1	1
13	*Buellia schaereri*																1
14	*Calicium glaucellum*			1										1	1	1	1
15	*Calicium quercinum**		1														
16	*Calicium salicinum*													1		1	
17	*Calicium viride*																1
18	*Caloplaca alnetorum*		1			1	1	1	1					1	1		1
19	*Caloplaca cerina*		1				1	1	1					1	1		

N.	Species name	Site code															
		1c	1s	2c	2s	3c	3s	4c	4s	5c	5s	6c	6s	7c	7s	8c	8s
20	*Caloplaca cerinella*								1								
21	*Caloplaca coralliza*	1												1			
22	*Caloplaca ferruginea*							1		1							1
23	*Caloplaca haematites*							1	1					1	1		1
24	*Caloplaca herbidella*					1											
25	*Caloplaca hungarica*		1												1	1	1
26	*Caloplaca monacensis*				1				1								
27	*Caloplaca obscurella*																1
28	*Caloplaca pollini*			1		1	1							1			
29	*Caloplaca servitiana*													1			1
30	*Candelaria concolor*										1						
31	*Candelariella aurella*																1
32	*Candelariella vitellina*								1								
33	*Candelariella xanthostigma*																1
34	*Catinaria atropurpurea*			1													
35	*Chaenotheca chrysocephala*														1		
36	*Chaenotheca ferruginea**														1	1	
37	*Chaenotheca trichialis**														1		
38	*Chaenothecopsis nana**														1		
39	*Cladonia chlorophaea*													1			
40	*Cladonia coniocraea*		1							1				1			
41	*Cladonia conista*															1	
42	*Cladonia fimbriata*		1				1				1		1	1			1
43	*Cladonia pyxidata*						1				1						
44	*Coenogonium pineti*			1													
45	*Collema auriforme*										1						
46	*Collema fasciculare*			1				1	1								
47	*Collema flaccidum*		1	1	1		1		1								
48	*Collema furfuraceum*					1	1	1	1		1	1				1	
49	*Collema nigrescens*	1				1											1
50	*Collema subflaccidum*	1	1	1	1		1	1	1	1		1	1				
51	*Collema subnigrescens*			1		1	1	1				1					
52	*Degelia atlantica*						1										
53	*Degelia plumbea*		1	1	1			1		1			1				
54	*Evernia prunastri*	1	1	1					1	1		1					1

N.	**Species name**	**Site code**															
		1c	**1s**	**2c**	**2s**	**3c**	**3s**	**4c**	**4s**	**5c**	**5s**	**6c**	**6s**	**7c**	**7s**	**8c**	**8s**
55	*Flavoparmelia caperata*	1								1							
56	*Fuscopannaria ignobilis*	1		1													
57	*Fuscopannaria olivacea*			1		1			1				1				
58	*Hyperphyscia adglutinata*										1	1					
59	*Hypocenomyce friesii*															1	
60	*Hypocenomyce scalaris*															1	1
61	*Hypogymnia farinacea*																1
62	*Hypogymnia physodes*	1	1	1						1						1	1
63	*Hypogymnia tubulosa*	1								1						1	1
64	*Koerberia biformis*			1					1								
65	*Lecania naegelii*		1														
66	*Lecanora albella*								1								
67	*Lecanora allophana*								1								
68	*Lecanora argentata*		1													1	
69	*Lecanora carpinea*					1		1								1	
70	*Lecanora chlarotera*	1	1			1		1	1					1	1	1	1
71	*Lecanora glabrata*	1				1		1									
72	*Lecanora horiza*						1	1									
73	*Lecanora intumescens*	1	1					1						1		1	
74	*Lecanora persimilis*																1
75	*Lecanora symmicta*															1	1
76	*Lecidea turgidula*															1	
77	*Lecidella elaeochroma*	1	1	1		1		1	1	1		1	1	1	1	1	1
78	*Lecidella flavosorediata*													1			1
79	*Lepraria eburnea*										1						
80	*Lepraria elobata*																1
81	*Lepraria finkii*												1				
82	*Lepraria leuckertiana*												1	1			1
83	*Lepraria rigidula*													1	1		
84	*Lepraria vouauxii*	1	1				1										
85	*Leptogium brebisonii*			1													
86	*Leptogium cyanescens*			1	1		1										
87	*Leptogium gelatinosum*				1												
88	*Leptogium hibernicum**						1										
89	*Leptogium lichenoides*	1	1	1	1		1	1	1	1			1				

N.	Species name	Site code															
		1c	1s	2c	2s	3c	3s	4c	4s	5c	5s	6c	6s	7c	7s	8c	8s
90	*Leptogium pulvinatum*												1				
91	*Leptogium saturninum*	1		1				1		1							
92	*Lobaria pulmonaria*	1	1	1	1		1	1	1								
93	*Lobarina scrobiculata*	1	1	1			1	1									
94	*Megalaria grossa*	1													1		
95	*Megaspora verrucosa*																1
96	*Melanelixia glabra*	1	1		1	1	1	1	1				1			1	
97	*Melanelixia glabratula*	1	1					1	1				1		1	1	
98	*Melanohalea elegantula*															1	1
99	*Melanohalea exasperata*								1								
100	*Nephroma laevigatum*	1	1	1			1	1	1	1		1	1	1	1	1	
101	*Normandina pulchella*					1							1				
102	*Ochrolechia alboflavescens*															1	1
103	*Ochrolechia androgyna*					1									1		1
104	*Ochrolechia arborea*													1		1	
105	*Ochrolechia balcanica*		1	1				1	1							1	1
106	*Ochrolechia dalmatica*													1			
107	*Ochrolechia pallescens*		1				1										
108	*Ochrolechia turneri*		1						1								
109	*Ochrolechia szatalaensis*		1											1			
110	*Pannaria conoplea*				1		1		1	1			1	1	1		
111	*Parmelia saxatilis*			1						1						1	1
112	*Parmelia submontana*	1	1					1		1							
113	*Parmelia sulcata*	1	1	1			1		1	1				1		1	
114	*Parmelina carporrhizans*	1						1									
115	*Parmelina pastillifera*	1	1	1	1		1	1	1								
116	*Parmelina quercina*	1	1			1	1	1	1				1			1	
117	*Parmelina tiliacea*		1	1	1		1		1					1	1	1	
118	*Parmeliopsis ambigua*															1	
119	*Parmeliopsis hyperopta*															1	
120	*Parmotrema perlatum*	1	1	1		1		1		1	1					1	
121	*Parvoplaca nigroblastidiata**																1
122	*Peltigera collina*		1					1	1								
123	*Peltigera praetextata*						1		1								
124	*Pertusaria albescens*	1	1	1	1	1	1	1	1				1			1	1

N.	Species name	Site code															
		1c	1s	2c	2s	3c	3s	4c	4s	5c	5s	6c	6s	7c	7s	8c	8s
125	*Pertusaria amara*	1	1														1
126	*Pertusaria coccodes*	1									1						1
127	*Pertusaria hemisphaerica*						1							1			1
128	*Pertusaria hymenea*						1										
129	*Pertusaria leioplaca*								1								
130	*Pertusaria pertusa*															1	1
131	*Phaeophyscia ciliata*		1		1		1	1	1	1		1	1	1			
132	*Phaeophyscia orbicularis*								1		1	1					
133	*Phlyctis agelaea*			1		1	1			1							
134	*Phlyctis argena*	1	1	1	1	1	1	1	1	1	1	1	1	1		1	
135	*Physcia adscendens*		1		1						1						1
136	*Physcia aipolia*		1		1	1	1	1	1					1			1
137	*Physcia leptalea*		1			1		1	1			1		1	1		1
138	*Physcia stellaris*								1								
139	*Physcia tenella*								1			1					
140	*Physconia detersa*		1						1								
141	*Physconia distorta*	1	1	1		1	1	1	1	1							
142	*Physconia venusta*		1	1	1	1		1	1			1	1				1
143	*Placynthiella icmalea*										1						1
144	*Placynthiella uliginosa*		1														
145	*Platismatia glauca*	1	1													1	1
146	*Pleurosticta acetabulum*	1	1			1	1	1	1				1				1
147	*Polychidium muscicola*				1												
148	*Pseudevernia furfuracea*	1	1				1			1	1					1	1
149	*Pseudosagedia aenea*										1						
150	*Ramalina calicaris*	1	1			1		1						1			
151	*Ramalina farinacea*	1	1	1	1	1	1					1			1	1	
152	*Ramalina fastigiata*		1	1		1	1	1	1	1		1	1			1	
153	*Ramalina fraxinea*							1	1								1
154	*Ramalina pollinaria*															1	
155	*Ricasolia amplissima*						1		1		1						
156	*Rinodina capensis*		1														1
157	*Rinodina freyi*																1
158	*Rinodina orculata**															1	1
159	*Rinodina pyrina*																1
160	*Rinodina sophodes*								1								

N.	Species name	Site code															
		1c	**1s**	**2c**	**2s**	**3c**	**3s**	**4c**	**4s**	**5c**	**5s**	**6c**	**6s**	**7c**	**7s**	**8c**	**8s**
161	*Scoliciosporum umbrinum* var. *corticolum*						1										
162	*Strigula affinis*											1					
163	*Tephromela atra*					1		1								1	
164	*Trapeliopsis granulosa*						1									1	
165	*Usnea florida*		1														
166	*Xanthoria parietina*		1		1	1	1	1	1		1	1		1	1	1	
		40	**56**	**37**	**25**	**33**	**48**	**43**	**51**	**25**	**19**	**18**	**22**	**32**	**21**	**45**	**52**

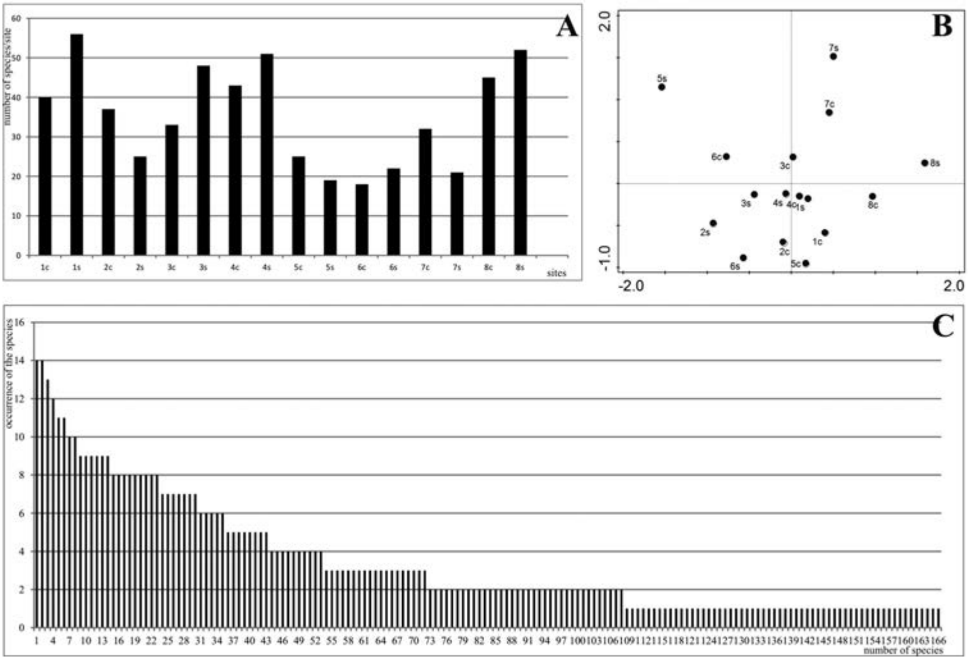

Fig. 2: Species rank-abundance plots and NMDS analysis. **A.** Species rank abundance recorded for each site (site code 1–8 = site number, s = sacred groves, c = control sites). **B.** Community composition shown by non-metric multidimensional scaling (NMDS) analysis, plots are coded as in (A) and Table 1. **C.** Species rank-abundance plot of lichen species recorded in the 16 sites (Table 2); species are ordered according to their frequency, from the most frequent to the rarest.

Discussion

Lichen diversity among sites: Old-growth forests preserved as sacred groves in NW Greece were considered here as case of study to compare the lichen biota with that occurring in neighbouring sites which underwent land management in the last centuries. The preservation of old-growth forest is considered as being of key importance in maintaining and assuring the survival of many lichen species associated to these niches (SEAWARD 2008). Our results, however, show that lichen diversity only slightly differs between sacred groves and managed sites, and differences of species richness among sites are mainly correlated to the different dominant vegetation type, rather than to the characters "sacred" or "managed". For instance, the sacred groves hosting very big trees and evergreen vegetation (*Quercus coccifera*) are shadier than young, managed, deciduous oak forests found in many control sites. Low light availability due to permanent leaf cover and the conspicuous moss cover on the tree trunks constrains the establishment of species-rich lichen communities, explaining in these cases why certain sacred groves were species poorer than their control sites. Also, deciduous oak forests host reasonably different lichen communities than pine forests. Furthermore, deciduous oak forests were rich in species belonging to the order Peltigerales. Here, the presence of *Lobaria pulmonaria* was pivotal to recover other, less common species and even rare taxa such as *Polychidium muscicola* and *Koerberia biformis*. *Lobaria pulmonaria* is known to be restricted to a set of forest types, it is regionally threatened and highly associated to old-growth forest (Scheidegger & Werth 2009). However, it has been shown that a continuing, multifunctional forest management in wooded pastures, with a more open forest structure due to grazing, maintains abundant population of *Lobaria pulmonaria* (Jüriado et al. 2011), as observed in the control sites here surveyed.

Lichen flora of Epirus: Concerning the lichen biota of Epirus, because we here record some new species, we take the opportunity to overview the literature available so far for this region. Christensen (1994) reported in his study on lichens associated with *Pinus nigra* on Mt. Trapezitsa and extracted data from four floristic contributions of Steiner (1894 sub Haláscy), Steiner (1898), Räsänen (1944) and Degelius (1956). Interestingly, some calicialean lichens (Caliciales) found on conifers were never reported before and here we can add as new records for Greece the four taxa *Calicium quercinum*, *Chaenotheca ferruginea*, *Chaenotheca trichialis* and *Chaenothecopsis nana*. A total of 261 lichen species were recorded by Abbott (2009) based on the above cited sources and the evaluation of both taxonomic studies [e.g., Henssen 1963 (not cited in Abbott 2009 and Arcadia 2018), Hertel 1967, Mayrhofer 1984, Tretiach et al. 2003 (also not cited in Abbott 2009 and Arcadia 2018)] and floristic contributions (e.g., Harmand & Maire 1909, Christensen & Svane 2009). The most recent publications including records from the Epirus region are those from Bilovitz et al. (2008), Christensen & Alstrup (2013), Christensen (2014) and Spribille et al. (2014). Nevertheless, the Epirus region still remains poorly investigated in comparison with the rest of the Greece and neighbouring countries, such as the Greek province of Macedonia (Abbott 2009, Arcadia 2018) or the former Yugoslav Republic of Macedonia (FYROM) (Mayrhofer et al. 2013, Malíček & Mayrhofer 2017). Our new records encourage further floristic studies in this region.

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