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Diversity and ecology of lichens and lichenicolous fungi in «Aigüestortes i Estany de Sant Maurici» National Park (Pyrenees, Catalonia, Spain)

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Abstract

334 lichenized fungi and 13 lichenicolous fungi were reported from «Aigüestortes i Estany de Sant Maurici» National Park. The diversity of growth-forms was distributed as follows: 59.4 % crustose, 20.2 % foliose, 10.7 % fruticose, 3.7 % squamulose and 2.3 % leprose. Lichenicolous fungi count for 3.7 % of the catalogue. Alpine belt was the richest with the 48 % of found taxa, subalpine belt was the second richest with 37.9 % and the montane belt was the poorest with only 14.1 % of taxa. However, this belt had the highest proportion of crustose taxa, with a 63.5 %. In addition, subalpine belt contained more foliose taxa with a 29 % of the taxa present in that belt, and there was also found the higher proportion of fruticose lichens (12.4 %). Crustose lichens were the main growth form on all the substrates. Otherwise, growth forms are in a similar proportion on ground and plant debris. The patterns of diversity and ecological distribution were similar to the ones found in mid-latitude mountains from Europe (Alps, Apennines, Cantabrian Range) or North America (Rocky Mountains). European mountain localities were richer in crustose species, while North American sites had a higher proportion of foliose and fruticose taxa. Moreover, corticolous taxa showed to be more abundant in European areas, on the other hand terricolous taxa were more frequent in North American mountains.

Key words: biodiversity, lichenized Ascomycota, mid-latitude mountains.

Resum

Diversitat i ecologia dels líquens i els fongs liquenícoles del Parc Nacional d'Aigüestortes i Estany de Sant Maurici (Pirineus, Catalunya, Espanya)

334 fongs liquenificats i 13 fongs liquenícoles han estat identificats al Parc Nacional d'Aigüestortes i Estany de Sant Maurici. La diversitat morfològica dels tal·lus observats mostra que els líquens crustacis representen el 59,4 %, els tal·lus foliacis el 20,2 %, els tal·lus fruticulosos el 10,7 %, els esquamulosos el 3,7 % i els leprarioides el 2,3 %. Els fongs liquenícoles representen el 3,7 % del catàleg. L'estatge alpí ha resultat ser el més ric amb el 48 % dels tàxons, seguit de l'estatge subalpí amb el 37,9 %. L'estatge montà amb només el 14,1 % dels tàxons ha resultat ser el més pobre. Tot i així, aquest estatge presenta la major proporció de líquens amb tal·lus crustaci (63,5 %). Per altra banda, l'estatge subalpí hostatja una major proporció de tal·lus foliacis (29 %) i també de tal·lus fruticulosos (12,4 %). Els líquens crustacis són els més abundants a tots els substrats. Però sobre sòl i restes vegetals, les proporcions de líquens crustacis, foliacis i fruticulosos són molt semblants. Els patrons de distribució de la diversitat i de les afinitats ecològiques a Aigüestortes són molt semblants als que trobem a altres muntanyes situades a latituds mitjanes d'Europa (Alps, Apenins, Serralada Cantàbrica) i d'Amèrica del Nord (Rocky Mountains). Les localitats europees contenen una major proporció de tal·lus crustacis, mentre que les localitats nord-americanes presenten una major abundància d'espècies foliàcies i fruticuloses. A més, les espècies corticícoles i lignícoles són més abundants a les muntanyes europees. En canvi, a les muntanyes nord-americanes són més abundants els líquens terrícoles.

Paraules clau: biodiversitat, Ascomicets liquenificats, regió temperada, muntanyes.

Introduction

Lichenological studies in the Spanish Pyrenees have concentrated on the western sector of the range, with some notes in the central sector (Etayo, 1990, 1994, 1995a, 1995b, 2010a, 2010b; Etayo & Boom, 1995; Etayo & Breuss, 1994, 1996; Etayo & Diederich, 1995, 1996a, 1996b, 1998; Etayo *et al*., 1993, 1995¸ Masson, 2008, 2010; Vondrák & Etayo, 2007). Otherwise, the eastern part of the range has been scarcely studied. The first mention to lichen taxa collected in eastern French sector was done by Nylander (1873, 1891), lately few references were provided by Séguy (1950, 1952),

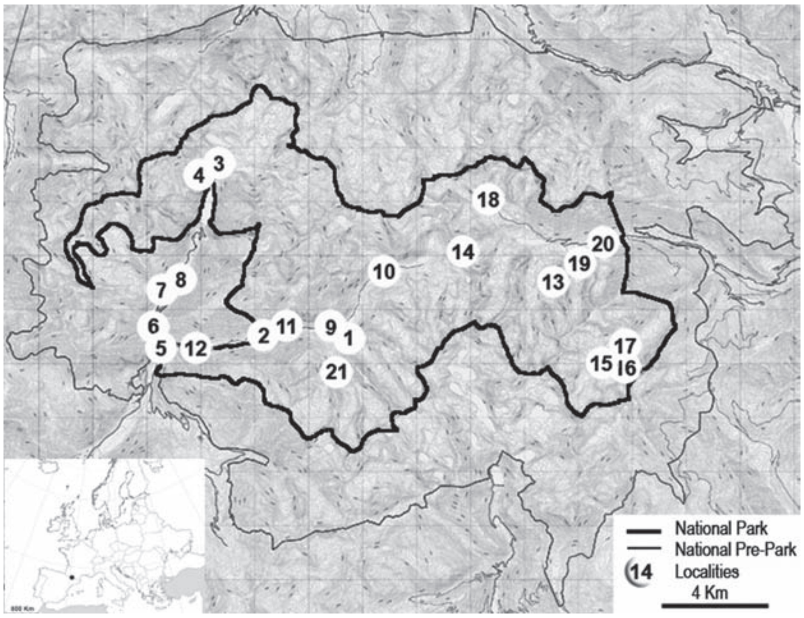

Figure 1. Location of the stations in the «Aigüestortes i Estany de Sant Maurici» National Park.

and the most recent work by Roux (2011). Mentions to lichen taxa from the Spanish eastern Pyrenees are rather scarce, saxicolous lichens growing on calcareous rocks in Núria Valley (Navarro-Rosinés & Hladun, 1990; Gaya & Navarro-Rosinés, 2008), species lists from Aran Valley (Azuaga & Gómez-Bolea, 1996), Planes de Son and Mata de València (Llop *et al*., 2010) and from Andorra (Azuaga & Gómez-Bolea, 2000; Llimona, 1979), a revision of the terricolous species in the genus *Cladonia* on the alpine belt in Andorra (Azuaga *et al.*, 2001). There are also few works dealing with the lichen biota on Pre-Pyrenean ranges, like Port del Compte (Longán *et al*., 2004), or the Cadí-Moixeró (Llop & Aymerich, 2014, and references herein).

Since 2000 there has been a survey on the lichen flora in the «Aigüestortes i Estany de Sant Maurici» National Park (N. P.), one of the well preserved areas in the axial sector of the Pyrenees, but poorly studied from a lichenological point of view. The study began in the «Reserva Integral Muntanyó de Llacs» (Gómez-Bolea *et al.*, 2001), where a catalogue with 136 lichens and 10 lichenicolous fungi was produced. It has continued with the establishment of a network of stations to monitorize human impact in the environmental quality of the park (Barbero *et al.*, 2003).

The knowledge of lichens on several habitats from the N. P. has lead to study relationships between altitudinal distributions, exposure, substrate selection and growth forms, in order to establish patterns of diversity and ecological distribution of lichens in the examined area and to compare them with high mountains in middle latitudes from Europe and North America.

Material and Methods

The «Aigüestortes i Estany de Sant Maurici» N. P. is placed in the north of the Iberian Peninsula, in the axial zone of the Pyrenees, with an extension of 141 km^2, plus a pheripherical surrounding area of 267 km^2. Most of the area, about the 70 % of the park, represents granite rocks; the rest is occupied by limestones, which used to have been metamorphosed, and schists (Vilaplana, 2002).

Due to the latitude of the park and the arrangement of the Pyrenees, there are two very distinct climates depending on the slope. The northern slope has an Atlantic climate, with regular precipitation and fogs that determine a higher humidity. On the other hand, the south slope is more continental, increasing the continentality south- and eastwards, achieving a clearly Mediterranean influence in the southern valleys (Vide, 2002).

Orography, lithology and climatic diversity generate a wide range of microhabitats with a large variety of plant communities and landscapes. Due to the altitudinal range of the park, from ca. 1300 to 3029 m, three vegetation belts can be established: montane, subalpine and alpine (Ozenda, 1994). The montane belt is characterized by deciduous (*Fagus sylvatica*, *Quercus* spp.) and *Pinus sylvestris* forests. Forests of *Pinus mugo* subsp. *uncinata* dominate the upper subalpine belt while forests of *Abies alba*, *Fagus sylvatica* or *Pinus sylvestris*, occasionally generating mixed forests, dominate the lower subalpine belt. Grasslands and heaths predominate in the alpine belt. The highest peaks and crests can be designated to the subnival belt with scattered grasslands, rupicolous and snowfield communities, but we have included in the alpine belt as they scarcely exceed the limit proposed by Ozenda (1994).

21 stations (Fig. 1) were selected according to three main criteria, 1) to include the most representative plant communities from the area, and 2) to show the main microclimate environments from different altitudinal belts, and 3) to encompass the diversity of lithological substrates. Each station has been characterised in terms of latitude, longitude, altitude, exposure, and plant communities or substrate (Table 1).

Table 1. Characterization of surveyed localities, with latitude, longitude, altitude, exposure and plant community or lithological substrate. Belt: M = Montane, S = Subalpine, A = Alpine.

Station	*Latitude (N)*	*Longitude (E)*	*Altitude (m)/Belt*	*Exposure*	*Plant community/Substrate*
1	42º32'51.4"	0º55'14.1"	1827/S	NW	*Abies alba* forest with *Rhododendron ferrugineum*
2	42º33'00"	0º53'35.6"	1667/S	NNW	Mixed decideous forest
3	42º36'18.6"	0º51'45.1"	1939/S	W	*Pinus mugo* ssp. *uncinata* forest with *Rhododendron ferrugineum*
4	42º36'5.7"	0º51'46.1"	1945/S	W	*Pinus mugo* ssp. *uncinata* forest with *Rhododendron ferrugineum*
5	42º32'55"	0º 50'19"	1507/M	E	*Quercus pubescens* forest with *Buxus sempervirens*
6	42º32'1.7"	0º50'14.5"	1366/M	E	*Quercus pubescens* forest with *Buxus sempervirens*
7	42º33'53,4"	0º50'16,9"	1700/S	SE	*Fagus sylvatica* forest mixed with *Abies alba*
8	42º33'55.8"	0º50'33.4"	1541/M	E	Mixed forest with *Fraxinus excelsior*, *Quercus petraea* and *Abies alba*
9	42º33'5.9"	0º54'56.9"	1805/S	S	*Abies alba* forest with *Rhododendron ferrugineum*
10	42º34'19.0"	0º56'10.9"	1905/S	SSE	*Pinus mugo* ssp. *uncinata* forest with *Juniperus communis*
11	42º33' 4.0"	0º53'39.3"	1627/S	S	*Fagus sylvatica* forest
12	42º32'39.7"	0º50'58.0"	1418/M	N	On rocks (carbonate schist)
13	42º34'10.3"	1º00'57.1"	2745/A	N	On rocks (porphyry and limestone)
14	42º34'43.9"	0º58'24.7"	2420/A	NE	On rocks (granite)
15	42º32'36.9"	1º02'25.8"	2380/A	N	*Pinus mugo* ssp. *uncinata* forest with *Juniperus communis*
16	42º32'33,4"	1º02'50,1"	2355/A	NNE	On rocks (granite)
17	42º32'49.8"	1º02'49.6"	2314/A	SW	*Pinus mugo* ssp. *uncinata* forest with *Rhododendron ferrugineum*
18	42º35'44.6"	0º59'3.3"	2250/A	SSW	*Pinus mugo* ssp. *uncinata* forest with *Rhododendron ferrugineum*
19	42º34'57"	1º01'36.2"	1817/S	S	*Pinus sylvestris* forest
20	42º34'57.7"	1º02'07.8"	1728/S	E	*Abies alba* forest
21	42º31′42.7″	0º54′54″	2200/A	NNE	Meadows mixed with heath and outcrops

The number of stations is proportional to the area covered by each belt: 4 stations in montane belt, 10 in subalpine belt, and 7 in alpine belt.

Specimens were identified according to Clauzade & Roux (1985, 1987), Clauzade *et al*. (1989), Smith *et al*. (2009) and Wirth *et al*. (2013). Some samples have been analyzed for secondary substances using thin layer chromatography according to Elix & Ernst-Russell (1993). Taxon nomenclature and authorities follow Nimis (2016). Samples are stored in the herbarium BCN-lich.

Relationships between growth forms, substrate, altitude, belt, and exposure have been analysed. In terms of growth form the species have been differentiated in crustose, foliose (distinguishing between narrow and broad), fruticose, leprose, and squamulose. Substrates with lichens available have been grouped in corticolous, where we have distinguished between deciduous and coniferous, saxicolous, which were differentiated between calcareous and siliceous, terricolous and lichenicolous. Altitude values have been converted into belts according to Ozenda (1994). Correlation analyses have been carried out with the statistical software R (R Core Team, 2017).

The diversity and ecology of lichens from of our study area have been compared with available information from mid-latitude high mountains from Europe (Alps, Apennines, Cantabrian Range and Pyrenees) and North America (Rocky Mountains). Data from Pyrenees refer to available data from the Valle del Tena in the central part of the range (J. Etayo, L. G. Sancho and A. Gómez-Bolea, unpublished data). The area from the Cantabrian Range is the Integral Reserve of Muniellos (Pérez-Ortega, 2004). The Alps regions were Hochschwab-Massiv (Hafellner *et al*., 2005) and Alta Valle del Torre (Castello *et al*., 1990; Tretiach & Castello, 1993), from Apennines were selected Monti del Partenio (Aprile *et al*., 2002-2003a) and Matese (Aprile *et al*., 2002-2003b), the North American selected areas were Glacier N. P. (DeBolt & McCune, 1993), Grand Teton N. P. (Eversman, 1998) and Yellowstone N. P. (Eversmann *et al*., 2002). The localities were grouped in mountain chain and continent. Data on diversity and ecology from the selected areas were compared using Mann-Whitney test. A principal component analysis (PCA) has been done in order to determine the relationships between the sites and their patterns of diversity and distribution of the lichens. The PCA was carried on a dataframe containing the percentage of growth forms and ecology for each site. The ordination was based on a covariance matrix. Data were standardized, but not scaled. Analyses have been carried out with the statistical software R (R Core Team, 2017).

Results

From the studied area 347 taxa have been identified; from which 334 correspond to lichenized fungi and 13 to lichenicolous fungi (Table 2). The growth form of the lichen taxa is distributed as follows: 59.4 % crustose, 20.2 % foliose, 10.7 % fruticose, 3.7 % squamulose and 2.3 % leprose (Table 3). Lichenicolous fungi represent the 3.7 % of the identified taxa.

Growth form does not show a clear correlation with environmental features such as substrate, altitudinal belt, or exposure, neither with substrate (Table 4). However, and concerning the substrate, stone surfaces were the richest (35.9 % of saxicolous lichens), follow by tree bark (32.7 % of corti-

Table 2. List of 347 taxa (334 lichens and 13 lichenicolous fungi) from «Aigüestortes i Estany de Sant Maurici» National Park. Second column gives the number of station where the taxa has been found as they are listed in Table 1. Columns 3-7 give the belt in each substrate in which the taxa occurs, except for lichenicolous species. Dec = deciduous trees; Con = coniferous trees; Cal = calcareous rocks; Sil = siliceous rocks; Ter = terricolous including those species growing in bryophytes and plant debris. M = montane belt. S = subalpine belt. A = alpine belt. Species nomenclature follows Nimis (2016).

Taxon	*Station*	*Dec*	*Con*	*Cal*	*Sil*	*Ter*
Acarospora fuscata (Nyl.) Arnold	14, 21				A	
A. impressula Th. Fr.	21				A	
A. veronensis A. Massal.	12			M		
Agonimia tristicula (Nyl.) Zahlbr.	1, 21		S			A
Alectoria sarmentosa (Ach.) Ach.	9		S			
Amygdalaria consentiens (Nyl.) Hertel, Brodo & May. Inoue	21				A	
A. punctiformis (Pers.) Ach.	6, 8	M				
A. radiata (Pers.) Ach.	2, 5, 6, 7, 8	M-S				
A. stellaris Kremp.	9, 11, 20	S	S			
A. varians (Davies) Nyl.*	10, 11, 13, 16					
Arthopyrenia cerasi (Schrad.) A. Massal.	5	M				
A. cinereopruinosa (Schaer.) A. Massal.	8	M				
Aspicilia candida (Anzi) Hue	13			A		
A. cinerea (L.) Körb.	2, 11				S	
A. epiglypta (Norrl. ex Nyl.) Hue	11, 14, 21				S-A	
A. polychroma Anzi	12			M		
A. polychroma ssp. *hypertrophica* Asta & Cl. Roux	11				S	
A. supertegens Arnold	12				M	
A. verruculosa Kremp.	13			A		
Bacidia herbarum (Stizenb.) Arnold	9		S			
Baeomyces rufus (Huds.) Rebent.	1					S
Bellemerea alpina (Sommerf.) Clauzade & Cl. Roux	21				A	
Biatora vernalis (L.) Fr.	20		S			
Bilimbia lobulata (Sommerf.) Hafellner & Coppins	21					A
Blastenia ammospila (Ach.) Arup, Søchting & Frödén	13, 16, 17					A
B. ferruginea (Huds.) A. Massal.	2, 11	S				
B. herbidella (Hue) Servit	9, 20, 21		S-A			
B. hungarica (H. Magn.) Arup, Søchting & Frödén	1, 2, 5, 10, 15, 21		M-S-A			
Brodoa atrofusca (Schaer.) Goward	10, 16, 18, 21				S-A	A
B. intestiniformis (Vill.) Goward	14, 16				A	
Bryobilimbia hypnorum (Lib.) Fryday, Printzen & S. Ekman	15, 21					A
B. sanguineoatra (Wulfen) Fryday, Printzen & S. Ekman	21					A
Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw.	1, 9, 19		S			
Buellia aethalea (Ach.) Th. Fr.	14				A	
B. chloroleuca Körb.	1		S			
B. disciformis (Fr.) Mudd	7, 9, 10, 11, 15, 20	S	S-A			
B. schaereri De Not.	1	S				
Calogaya biatorina (A. Massal.) Arup, Frödén & Søchting	21			A		
Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr.	2, 7, 8 , 11	M-S	S			
C. stillicidiorum (Vahl) Lynge	13					A
Calvitimela armeniaca (DC.) Hafellner	14				A	
Candelariella aurella (Hoffm.) Zahlbr.	12, 21			M-A		
C. coralliza (Nyl.) H. Magn.	18, 21				A	A
C. plumbea Poelt & Vězda	13, 21			A		
C. vitellina (Hoffm.) Müll. Arg.	1, 3, 10, 11, 13, 14, 16, 17, 19, 21				S-A	S
C. xanthostigma (Ach.) Lettau	7, 8	S	M			
Carbonea latypizodes (Nyl.) Knoph & Rambold	10				S	
C. vitellinaria (Nyl.) Hertel	13, 14, 21					
C. vorticosa (Flörke) Hertel	15				A	
Catapyrenium cinereum (Pers.) Körb.	21					A
C. imbricatum (Nyl.) Clauzade & Cl. Roux	21			A		
C. latzelii (Zahlbr.) Breuss	21					A
Catillaria nigroclavata (Nyl.) Schuler	6, 8	M	M			
Cephalophysis leucospila (Anzi) H. Kilias & Scheid.	21			A		
Cetraria aculeata (Schreb.) Fr.	14, 21					A
C. ericetorum Opiz	21					A
C. islandica (L.) Ach.	14, 17, 21					A
Chaenotheca furfuracea (L.) Tibell	9		S			
C. trichialis (Ach.) Th. Fr.	9		S			
Chrysotrix candelaris (L.) J.R. Laundon	9				S	
Circinaria caesiocinerea (Malbr.) A. Nordin, Savić & Tibell	9, 19, 21				S-A	
C. calcarea (L.) A. Nordin, Savić & Tibell	21			A		
C. contorta (Hoffm.) A. Nordin, Savić & Tibell ssp. *contorta*	21			A		
C contorta ssp. *hoffmanniana* (R. Sant.) I. Zhdanov	12			M		
C. cupreogrisea (Th. Fr.) A. Nordin, Savić & Tibell	11				S	
Cladonia bellidiflora (Ach.) Schaer.	4					S
C. chlorophaea (Flörke ex Sommerf.) Spreng.	1, 2, 3, 5, 11, 18, 21					S-A

Taxon	*Station*	*Dec*	*Con*	*Cal*	*Sil*	*Ter*
C. coccifera (L.) Willd.	3, 4					S
C. ecmocyna Leight.	21					A
C. fimbriata (L.) Fr.	1, 3, 5, 19, 21		M			S-A
C. furcata (Huds.) Schrad.	1, 2, 4, 5, 6, 9, 17, 20					M-S-A
C. macroceras (Delise) Hav.	21					A
C. macrophyllodes Nyl.	15, 17, 21					A
C. magyarica Vain. †	20					S
C. metacorallifera Asahina	17					A
C. novochlorophaea (Sipman) Brodo & Ahti	21					A
C. pleurota (Flörke) Schaer.	17		A			
C. pyxidata (L.) Hoffm.	1, 2, 3, 4, 9, 10, 11, 12, 15, 17, 18, 19, 20, 21		S	S		M-S-A
C. squamosa (Scop.) Hoffm.	2, 4, 9					S
C. subulata (L.) Weber ex F.H. Wigg	1, 2, 3, 5, 9, 20		S			M-S
C. umbricola Tønsberg & Ahti	17, 20		S			
Clauzadea monticola (Schaer.) Hafeller & Bellem.	21			A		
Cliostomum corrugatum (Ach.:Fr.) Fr.	9		S			
Coenogonium pineti (Ach.) Lücking & Lumbsch	1		S			
Collema flaccidum (Ach.) Ach.	2, 7, 8	M-S				
C. subflaccidum Degel.	8	M				
C. subnigrescens Degel.	2, 11	S				
Cornicularia normoerica (Gunnerus) Du Rietz	14, 16, 18				A	
Cyphelium tigillare (Ach.) Ach.	17		A			
Cystocoleus ebeneus (Dillwyn) Thwaites	9				S	
Dacampia hookeri (Borrer) A. Massal.*	21					
Dematocarpon luridum (With.) J.R. Laundon	21				A	
D. miniatum (L.) W. Mann.	21				A	
Dibaeis baeomyces (L. f.) Rambold & Hertel	12, 17					M-A
Dimelaena oreina (Ach.) Norman	16, 21				A	
Diploschistes muscorum (Scop.) R. Sant.	2, 10, 11	S				S
D. scruposus (Schreb.) Norman	8, 10				M-S	
Diplotomma epipolium (Ach.) Arnold	21			A		
Eiglera flavida (Hepp) Hafellner	21			A		
Enchylium polycarpon (Hoffm.) Otálora, P.M. Jørg. & Wedin	21			A		
Endocarpon pusillum Hedw.	21					A
Endococcus propinquus (Körb.) D. Hawksw.*	21					
E. rugulosus Nyl.*	21					
Ephebe lanata (L.) Vain.	16, 18				A	
Evernia divaricata (L.) Ach.	1, 9, 11, 19, 20	S	S			S
E. prunastri (L.) Ach.	2, 11, 20	S	S			
Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell	21					A
F. nivalis (L.) Kärnefelt & A. Thell	21					A
Flavoplaca polycarpa (A. Massal.) Arup, Frödén & Søchting	21			A		
Fuscidea lygaea (Ach.) V. Wirth & Vězda	16				A	
Glypholecia scabra (Pers.) Müll. Arg.	21			A		
Graphis scripta (L.) Ach.	8	M				
Gyalecta foveolaris (Ach.) Schaer.	13					A
Gyalolechia bracteata (Hoffm.) A. Massal.	13, 21			A		A
Hypogymnia farinacea Zopf	9, 10		S			
H. physodes (L.) Nyl.	1, 3, 9, 10, 11, 19, 20	S	S			
H. tubulosa (Schaer.) Hav.	10, 11	S	S			
Imshaugia aleurites (Ach.) S.L.F. Mey.	3, 4, 15, 17		S-A			
Ingvariella bispora (Bagl.) Guderley & Lumbsch	11				S	
Japewia subaurifera Muhr & Tønsberg	5		M			
Lasallia pustulata (L.) Mérat	18				A	
Lathagrium auriforme (With.) Otálora, P.M. Jørg. & Wedin	12			M		
L. cristatum (L.) Otálora, P.M. Jørg. & Wedin	21			A		
L. undulatum (Flot.) Poetsch	12, 21			M-A		
Lecania cyrtella (Ach.) Th. Fr.	8	M				
L. naegelii (Hepp) Diederich & P. Boom	6, 8	M	M			
Lecanora albellula (Nyl.) Th. Fr.	3, 4, 10, 18, 21		S-A			
L. bicincta Ramond	21				A	
L. carpinea (L.) Vain.	1, 2, 5, 6, 7,	M-S	M-S			
L. cenisia Ach.	1, 3, 11, 12, 19				M-S	
L. chlarotera Nyl.	2, 5, 6, 7, 8, 9, 11,	M-S	M-S			
L. circumborealis Brodo & Vitik.	15, 21		A			
L. dispersoareolata (Schaer.) Lamy	13				A	
L. epibryon (Ach.) Ach.	21					A
L. expallens Ach.	2		S			
L. horiza (Ach.) Linds.	6	M				
L. intricata (Ach.) Ach.	11, 14				S-A	
L. intumescens (Rebent.) Rabenh.	7, 8	M-S				
L. leptyrodes (Nyl.) Degel.	8, 9, 11	M-S	S			
L. mughicola Nyl.	15, 17, 21		A			

Table 2. Continuation.

Taxon	*Station*	*Dec*	*Con*	*Cal*	*Sil*	*Ter*
L. polytropa (Ehrh. ex Hoffm.) Rabenh. var. *alpigena* (Ach.) Schaer.	14				A	
L. pulicaris (Pers.) Ach.	1, 3, 4, 5, 7, 9, 10, 11, 19, 21	S	M-S-A			
L. rupicola (L.) Zahlbr.	2, 10, 11,13, 14, 16, 19, 21				S-A	
L. saligna (Schrad.) Zahlbr.	15		A			
L. soralifera (Suza) Räsänen	14				A	
L. subintricata (Nyl.) Th. Fr.	1		S			
L. swartzii (Ach.) Ach.	14				A	
L. symmicta (Ach.) Ach.	5		M			
Lecidea atrobrunnea (Ramond ex Lam. & DC.) Schaer.	13, 14, 16, 21				A	
L. berengeriana (A. Massal.) Nyl.	15					A
L. confluens (Weber) Ach.	3, 9, 11				S	
L. lapicida (Ach.) Ach. var. *lapicida*	10, 11, 14, 15				S-A	
L. lapicida var. *pantherina* Ach.	2, 11, 14				S-A	
L. lithophila (Ach.) Ach.	17				A	
L. plana (J. Lahm) Nyl.	14				A	
L. praenubila Nyl.	13, 21				A	
L. promiscens Nyl.	14				A	
L. silacea Ach.	11, 14				A	
L. tessellata Flörke	12, 13, 21				M-A	
L. umbonata (Hepp) Mudd	21			A		
Lecidella asema (Nyl.) Knoph & Hertel	21			A		
L. carpathica Körb.	11, 14, 13, 19, 21			A	S-A	
L. elaeochroma (Ach.) M. Choisy	2, 5, 6, 7, 8, 9, 11, 20, 21	M-S	M-S-A			
L. patavina (A.Massal.) Knoph & Leuckert	13			A		
L. stigmatea (Ach.) Hertel & Leuckert	21			A		
L. wulfenii (Hep) Körb.	13					A
Lepra albescens (Huds.) Hafellner	1, 7, 11, 20	S	S			
L. amara (Ach.) Hafellner	9, 20		S			
L. corallina (L.) Hafellner	1, 9, 13				S-A	
Lepraria caerulescens (Hue) Botnen & Øvstedal	4, 15		A			S-A
L. diffusa (J.R. Laundon) Kukwa	21					A
L. elobata Tønsberg	3		S			
L. lobificans Nyl.	5, 6					M
L. neglecta (Nyl.) Erichsen	1, 5					M-S
L. rigidula (de Lesd.) Tønsberg	9, 10, 18		S		S	A
L. vouauxii (Hue) R.C. Harris	21					A
Leproplaca cirrochroa (Ach.) Arup, Frödén & Søchting	21			A		
Leptogium saturninum (Dicks.) Nyl.	2, 7, 8, 11	M-S				
Lichenoconium lecanorae (Jaap) D. Hawksw.*	21					
Lobaria pulmonaria (L.) Hoffm.	7	S				
Lobothallia radiosa (Hoffm.) Hafellner	12, 21			M-A		
Megaspora verrucosa (Ach.) Hafellner & V. Wirth	2, 21	S				A
Melanelia stygia (L.) Essl.	14, 16				A	
Melanelixia glabra (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	2, 11,	S				
M. glabratula (Lamy) Sandler & Arup	1, 7, 9, 11	S	S		S	
M. subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	1, 2, 5, 7, 8, 9, 11, 19, 20	M-S	M-S			
Melanohalea elegantula (Zahlr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	9, 19		S			
M. exasperata (De Not.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	11, 21	S	A			
M. exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	2, 20, 21		S-A			
M. laciniatula (H. Olivier) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	1, 9, 11	S	S			
Micarea prasina Fr.	9, 20		S			
Miriquidica garovaglii (Schaer.) Hertel & Rambold	13, 14, 15, 16, 18, 21				A	
Muellerella lichenicola (Sommerf.) D. Hawksw.*	21					
M. pygmaea (Körb.) D. Hawksw. var. *pygmaea**	14, 21					
M. pygmaea var. *athallina* (Müll. Arg.) Triebel*	13, 14					
Mycobilimbia carneoalbida (Müll. Arg.) Vitik., Ahti, Kuusinen, Lommi & T. Ulvine	2					S
Myriolecis dispersa (Pers.) Sliwa, Zhao Xin & Lumbsch	21			A		
M. semipallida (H. Magn.) Sliwa, Zhao Xin & Lumbsch	21			A		
Naetrocymbe punctiformis (Pers.) R.C. Harris	6	M				
Nephroma parile (Ach.) Ach.	2, 8, 20	S	S			M
N. resupinatum (L.) Ach.	2	S				S
Normandina pulchella (Borrer) Nyl.	2	S				
Ochrolechia alboflavescens (Wulfen) Zahlbr.	1		S			
O. dalmatica (Erichsen) Boqueras	9		S			
O. pallescens (L.) A. Massal.	2, 8, 11	M-S				

Taxon	*Station*	*Dec*	*Con*	*Cal*	*Sil*	*Ter*
O. szatalaensis Verseghy	1, 7, 9	S	S			
O. turneri (Sm.) Hasselrot	3, 4, 15, 17, 18, 20		S-A			
Ophioparma ventosa (L.) Norman	14				A	
Pannaria conoplea (Ach.) Bory	11	S				
Parabagliettoa dufourii (DC.) Gueidan & Cl. Roux	21			A		
Parmelia omphalodes (L.) Ach. var. *omphalodes*	21				A	
P. saxatilis (L.) Ach.	1, 3, 9, 10, 11, 14, 16, 18, 19, 20		S		S-A	S
P. submontana Nádv. ex Hale	11, 19	S	S			S
P. sulcata Taylor	1, 2, 7, 8, 9, 11, 19, 20, 21	M-S	S-A			S-A
Parmelina tiliacea (Hofm.) Ach.	2, 7, 8, 11	M-S				
Parmeliopsis ambigua (Wulfen) Nyl.	1, 2, 3, 4, 9, 10, 11, 15, 17, 18, 19, 20, 21	S	S-A			
P. hyperopta (Ach.) Arnold	1, 3, 9, 10, 15, 17, 19, 20		S-A			
Parvoplaca tiroliensis (Zahlbr.) Arup, Søchting & Frödén	13, 14, 21					A
Peltigera aphthosa (L.) Willd.	2, 9					S
P. canina (L.) Willd.	2, 11, 20					S
P. collina (Ach.) Schrad.	2, 8, 11	S				M-S
P. elisabethae Gyeln.	2, 11, 15, 21	S				S-A
P. horizontalis (Huds.) Baumg.	2					S
P. lepidophora (Nyl. ex Vain.) Bitter	14					A
P. leucophlebia (Nyl.) Gyeln.	20, 21					S-A
P. polydactylon (Neck.) Hoffm.	2					S
P. praetextata (Flörke ex Sommerf.) Zopf	5, 8, 21					M-A
P. rufescens (Weiss.) Humb.	2, 14, 21	S				S-A
Pertusaria coccodes (Ach.) Nyl.	1		S			
P. coronata (Ach.) Th. Fr.	1, 9, 15		S		A	
P. flavida (DC.) J.R. Laundon	1, 9		S			
Phaeophyscia endococcina (Körb.) Moberg	8, 21	M			A	
P. endophoenicea (Harm.) Moberg	7, 8, 11	M-S			S	
Phlyctis argena (Spreng.) Flot.	8, 9, 20	M	S			
Physcia adscendens (Fr.) H. Olivier	2	S				
P. aipolia (Her. ex Humb.) Hampe ex Fürnrohr	2, 7, 11	S				
P. dubia (Hoffm.) Lettau	7, 10, 21	S			S	A
P. stellaris (L.) Nyl.	8, 11, 19, 21	S	M-A		S	
Physconia distorta (With.) J.R. Laundon	2, 7, 9, 11, 16, 20	S	S			A
P. muscigena (Ach.) Poelt	13					A
Placidiopsis pseudocinerea Breuss†	13					A
Placynthiella icmalea (Ach.) Coppins & P. James	21					A
Placynthium dolichoterum (Nyl.) Trevis.	21				A	
P. nigrum (Huds.) Gray	21			A		
P. cf. *tantaleum* (Hep) Hue	21				A	
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	1, 9, 10		S			
Pleopsidium flavum (Bellardi) Körb.	14				A	
Polyblastia albida Arnold	21			A		
P. fuscoargillacea Anzi	21			A		
P. plicata (A.Massal.) Lönnr.	21			A		
Polysporina simplex (Davies) Vězda	13, 21			A	A	
P. urceolata (Anzi) Brodo	13				A	
Porpidia macrocarpa (DC.) Hertel & A.J. Schwab	1, 21				S-A	
P. speirea (Ach.) Kremp.	12			M		
Pronectria solorinae Lowen & R. Sant.*	21					
Protoblastenia rupestris (Scop.) J. Steiner	12			M		
Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman	21					A
Protoparmelia badia (Hoffm.) Hafellner var. *badia*	1, 3, 10, 13, 21			A	S-A	
P. badia var. *cinereobadia* (Harm.) Clauzade & Cl. Roux	14, 21				A	
Protoparmeliopsis laatokkensis (Räsänen) Moberg & R. Sant.	9				S	
P. muralis (Schreb.) M. Choisy	10, 11, 15, 19, 21			A	S-A	
Pseudephebe pubescens (L.) M. Choisy	14				A	
Pseudevernia furfuracea (L.) Zopf	1, 3, 4, 9, 10, 11, 15, 17, 18, 19, 20, 21	S	S-A			
Psora decipiens (Hedw.) Hoffm.	21					A
Psoroma hypnorum (Vahl) Gray	16, 20, 21					S-A
Pycnora xanthococca (Sommerf.) Hafellner	4		S			
Pyrenidium actinellum Nyl.*	21					
Pyrenodesmia variabilis (Pers.) A. Massal.	13, 21			A	A	
Ramalina capitata (Ach.) Nyl.	14				A	
R. farinacea (L.) Ach.	2, 11, 20	S	S			
R. fraxinea (L.) Ach.	7	S				
R. obtusata (Arnold) Bitter	1		S			
Rhizocarpon amphibium (Fr.) Th. Fr.	12				A	
R. badioatrum (Flörke ex Spreng.) Th. Fr.	10, 14				S-A	
R. carpathicum Runemark	11, 14				S-A	
R. disporum (Nägeli ex Hepp) Müll. Arg.	21				A	
R. distinctum Th. Fr.	11				S	

Table 2. Continuation.

Taxon	*Station*	*Dec*	*Con*	*Cal*	*Sil*	*Ter*
R. geographicum (L.) DC.	2, 9, 10, 11, 13, 14, 15, 16, 18, 19, 21				S-A	
R. lavatum (Fr.) Hazsl.	12				M	
R. lecanorinum Anders	21				A	
R. macrosporum Räsänen	1, 10, 11, 12, 19				M-S	
R. obscuratum (Ach.) A. Massal.	19				S	
R. papillatum Vězda & Poelt	21				A	
R. parvum Runemark†	13				A	
R. polycarpum (Hepp) Th. Fr.	11				S	
Rhizoplaca chrysoleuca (Sm.) Zopf	11, 14, 16, 21				S-A	
R. melanophthalma (DC.) Leuckert	13, 14, 16, 21				A	
Rimularia insularis (Nyl.) Rambold & Hertel	14, 19, 21					
Rinodina archaea (Ach.) Arnold	1, 9, 20		S			
R. bischoffii (Hepp) A.Massal. var. *castanomelodes* (H.Mayrhofer & Poelt) Giralt & Llimona	21			A		
R. capensis Hampe in A. Massal.	1, 9, 20		S			
R. conradii Körb.	21					A
R. milvina (Wahlenb.) Th. Fr.	11, 19				S	
R. mniaraea (Ach.) Körb. var. *mniaraea*	21					A
R. parasitica H. Mayrhofer & Poelt	19				S	
Rusavskia elegans (Link) S.Y. Kondr. & Kärnefelt	13, 16, 21			A	A	
R. sorediata (Vain.) S.Y. Kondr. & Kärnefelt	13				A	
Sagedia mastrucata (Wahlenb.) A. Nordin, Savić & Tibell	21				A	
Schaereria fuscocinerea (Nyl.) Clauzade & Cl. Roux	16				A	
Schismatomma pericleum (Ach.) Branth & Rostr.	1		S			
Scoliciosporum umbrinum (Ach.) Arnold	2, 11, 6		M		S	
Scytinium lichenoides (L.) Otálora, P.M. Jørg. & Wedin	8	M				M
S. tenuissimum (Hoffm.) Otálora, P.M. Jørg. & Wedin	21					A
Seirophora contortuplicata (Ach.) Frödén	13, 21					A
Solorina bispora Nyl.	13					A
S. saccata (L.) Ach.	21					A
Sphaerellothecium propinquellum Cl. Roux & Triebel†*	9					
Sporastatia polyspora (Nyl.) Gummann	21				A	
S. testudinea (Ach.) A. Massal.	13, 14, 16, 21				A	
Staurothele clopimoides (Arnold) J. Steiner	21			A		
Stenhammarella turgida (Ach.) Hertel	21			A		
Stigmidium peltideae (Vain.) R. Sant.*	1					
Tephromela atra (Huds.) Hafellner	2, 9, 11		S		S	
Thamnolia vermicularis (Sw.) Schaer. var. *vermicularis*	13, 14, 21					A
Thelenella muscorum (Fr.) Vain.	2	S				
Thelidium decipiens (Nyl.) Kremp.	21			A		
T. incavatum Mudd	21			A		
T. papulare (Fr.) Arnold	12			M		
T. cf. *pyrenophorum* (Ach.) Mudd	21			A		
Toninia candida (Weber) Th. Fr.	21					A
T. rosulata (Anzi) H.Olivier	21					A
T. taurica (Szatala) Oxner	21					A
Tremolecia atrata (Ach.) Hertel	14				A	
Tuckermannopsis chlorophylla (Willd.) Hale	1, 9		S			
Umbilicaria cylindrica (L.) Delise ex Duby	1, 3, 10, 13, 14, 15, 16, 17, 18, 21				S-A	
U. decussata (Vill.) Zahlbr.	13				A	
U. deusta (L.) Baumg.	1, 3, 10, 11, 15, 19, 20				S-A	
U. microphylla (Laurer) A. Massal.	14				A	
U. nylanderiana (Zahlbr.) H. Magn.	14				A	
U. pallens (Nyl.) Frey	14, 16				A	
U. subglabra (Nyl.) Harm.	14				A	
Usnea florida (L.) F.H. Wigg	19		S			
Varicellaria hemisphaerica (Flörke) I. Schmitt & Lumbsch	1, 9		S			
V. lactea (L.) I. Schmitt & Lumbsch	9, 15				S-A	S
Variospora australis (Arnold) Arup, Søchting & Frödén	21			A		
V. velana (A. Massal.) Arup, Søchting & Frödén	15, 21			A	A	
Verrucaria aethiobola Wahlenb.	21				A	
V. cf. *aranensis* McCarthy	21			A		
V. hochstetteri Fr.	21			A		
V. nigrescens Pers.	12			M		
Vouauxiella lichenicola (Linds.) Petr. & Syd.*	1					
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai	10, 18, 19, 20		S-A			
Xanthocarpia lactea (A. Massal.) A. Massal.	21			A		
Xanthoparmelia conspersa (Ach.) Hale	3, 8, 19				M-S	
X. glabrans (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch	19				S	
Xanthoria parietina (L.) Th. Fr.	11	S				
Xylographa vitiligo (Ach.) J.R. Laundon	3, 4		S			

†= species reported for the first time from Spain.
*= lichenicolous fungi.

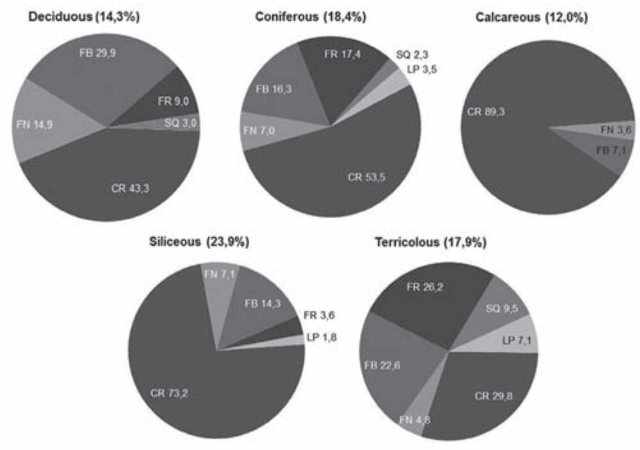

Figure 2. Distribution of growth forms based on each substrate. Corticolous lichens have been differentiated in deciduous and coniferous, and saxicolous lichens have been distributed in siliceous and calcareous. Number in brackets refers at the percentage of taxa present in each substrate. Growth form: CR = crustose; FB= broad foliose; FN= narrow foliose; FR= fruticose; SQ = squamulose; LP = leprose.

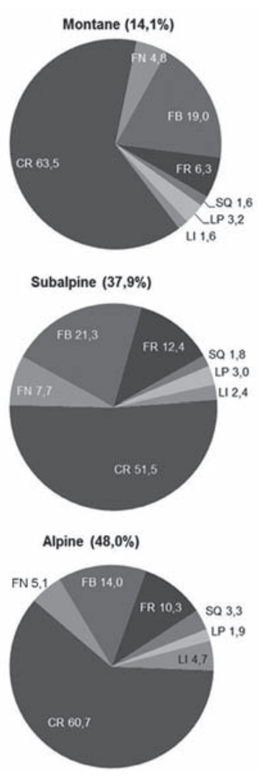

Figure 3. Distribution of growth forms on considered altitudinal belts. Number in brackets refers at the percentage of taxa present in each belt. Growth form: CR = crustose; FB= broad foliose; FN= narrow foliose; FR= fruticose; SQ = squamulose; LP = leprose; LI= lichenicolous fungi.

colous lichens) and soil (17.9 % of terricolous lichens) (Fig. 2). Crustose thalli are predominant in all kind of surveyed substrate. Among the corticolous taxa, crustose thalli represent close to the 50 %, both on deciduous (43.3 %) and coniferous (53.5 %). On the other side, crustose thalli are the most abundant on rocks, both siliceous (73.2 %) and calcareous (89.3 %). Foliose thalli, including narrow and broad foliose, constitute the secondary group in all the considered substrates, being better represented among corticolous lichens.

The altitudinal distribution of lichen diversity in belts falls as follow, 14.1 % are found in montane belt, 37.9 % in subalpine belt and 48 % in alpine belt (Fig. 3). The effect of belt on thallus distribution determines that crustose thalli are more abundant in all the belts, being more abundant in the montane belt (63.5 % of lichens). Foliose thalli constitute the secondary more frequent thallus growth on all the belts, ranging from the 19.1 % in the alpine to 29 % in the subalpine belt. In addition, lichenicolous fungi are well represented in alpine belt (4.7 %), in comparison with montane, where they are scarce (1.6 %), and subalpine belt, where lichenicolous taxa are the 2.4 % of the present taxa in that belt.

Patterns of diversity and ecology between selected localities from mid-latitude high mountains are not significantly different when comparing solely sites or mountain ranges applying Mann-Whitney test. Otherwise, when we compare European and North American mountains there are significant differences ($p < 0.05$) between both continents in terms of growth forms (crustose, foliose and fruticose) and substrate (corticolous and terricolous) (Table 3). The PCA shows a clear difference between American and European sites along the axis 1, which encompasses a 75.3 % of the variance (Fig. 4). Growth-form and substrate tell the difference between localities from both continents, except for Tena, which appears closer to American localities. Crustose taxa are highly associated to European mountain ranges than North American. On the other hand, foliose and fruticose lichens are more related to North American mountain than European. Similarly, European ranges have a higher proportion of corticolous taxa, when North American sites have more terricolous taxa.

Discussion

The higher proportion of lichens in the alpine belt does not relate with the diversity in available communities, which is higher in the subalpine belt (Table 1). The belt distribution of growth forms are similar to the distribution described by Sipman (1989) from Colombian Andes. Crustose and foliose taxa remain rather constant in all belts (Fig. 3), and fruticose species increase with elevation, however, they are in high proportion in subalpine belt than alpine, probably due to the decrease on air humidity. This different distribution of growth forms is also affected by the available substrate from each belt. Those areas including montane or lower subalpine belts usually have more corticolous species, as forest are more common, than areas mainly placed in upper subalpine or alpine belt. In upper areas, saxicolous lichens are more abundant and terricolous taxa are present in a higher proportion. Among corticolous taxa, crustose taxa amount close to the 50 % (47.8 %), while in the Swiss central Plateau and Pre-Alps it reaches the 70 % (Dietrich & Scheidegger, 1997). Otherwise, foliose lichens are more abundant, accounting for 42.4 % of epiphytic taxa, while in the Swiss study foliose lichens represent just a half (21 %). These values can agree

Table 3. Analysis of lichen flora from high-mountain localities in European and North American mid-latitude mountains. S = surface (Km[2]). A = Altitudinal range (m). N = Taxa, refers at the absolute number of lichens. Growth form: Cr = crustose. Fo = foliose. Fr = fruticose. Sq = squamulose. Le = leprose. Co = corticolous. Sa = saxicolous. Te = terricolous. All data on growth form is given as %.

	S	*A*	*N*	*%Cr (*)*	*%Fo (*)*	*%Fr (*)*	*%Sq*	*%Le*	*%Co (*)*	*%Sa*	*%Te (*)*
Aigüestortes (Pyrenees)	141	1366-2745	339	59.4	20.2	10.7	3.7	2.3	37.8	41.5	20.7
Valle del Tena (Pyrenees)	100	1100-2600	296	56.1	27.7	9.1	6.4	0.7	32.6	48.3	19.1
Muniellos (Cantabrian Range)	56	650-1675	471	57.3	20	7	12	3.6	47.5	37.2	15.3
Matese (Apeninnes)	1100	900-2050	382	66	20	8	5	1	57	42	1
Monti del Partenio (Apeninnes)	219	100-1600	146	58	26	10	5	1	47	43	10
Alta Valle del Torre (Alps)	54	500-1700	221	60.3	27.2	6.3	6.2	0	49.3	40.3	10.4
Hochschwab-Massiv (Alps)	753	492-2214	559	65.3	19.3	9.5	4.3	1.6	49.5	25.7	24.8
Glacier N. P. (Rocky Mountains)	5670	970-3190	425	43.9	28.7	21.3	5.1	1	34	35.9	29.1
Grand Teton N. P. (Rocky Mountains)	1870	2030-4150	216	43	33	16	8	0	23	49	28
Yellowstone N. P. (Rocky Mountains)	8984	1606-3202	359	44	34	14	6	2	25	41	34

(*) indicates those characters with a significance level at $p<0.05$ in the Mann-Whitney test between European and North American localities.

Table 4. Values of Pearson's correlation coefficient between growth form and environmental data of lichens from Aigüestortes i Estany de Sant Maurici National Park.

Growth form	*Belt*	*Exposure*	*Deciduous*	*Coniferous*	*Calcareous*	*Siliceous*	*Terricolous*
Crustose	–0.25	–0.70**	0.11	–0.70	0.79	–0.10	0.03
Narrow foliose	0.35	0.32	–0.01	0.77	–0.85	0.00	–0.13
Broad foliose	–0.12	0.26	0.75	0.99	–0.96	–0.75	–0.84
Fruticose	0.18	0.57**	–0.55	0.30	–0.42	0.54	0.43
Squamulose	–0.01	0.20	–0.95	–0.84	0.76	0.95	0.99
Leprose	–0.34	0.11	0.97	0.81	–0.72	–0.97	–0.99

** Correlations are significant at $p < 0.01$

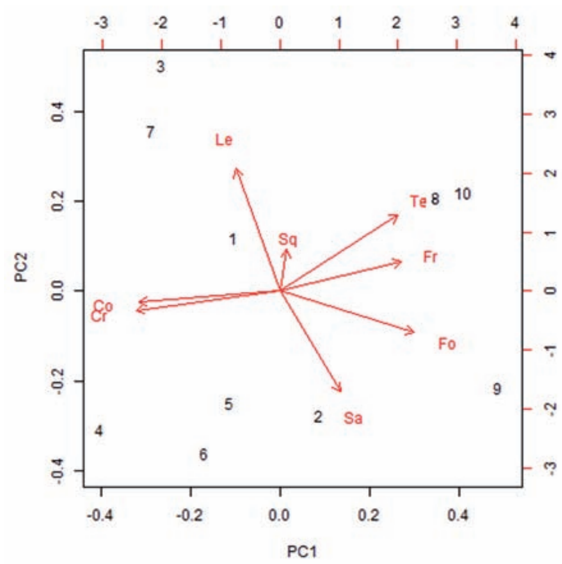

Figure 4. Diagram obtained from the principal component analysis of the examined localities from mid-latitude mountains in Europe and North America and the patterns of diversity and ecology showed by their lichen flora. European sites: 1 = Aigüestortes, 2 = Tena, 3 = Muniellos, 4 = Matese, 5 = Partenio, 6 = Torre, 7 = Hochschwab, North American sites: 8 = Glacier, 9 = Grand Teton, 10 = Yellowstone. Growth form: Cr = crustose; Fo = foliose; Fr = fruticose; Sq = squamulose; Le = leprose; Co = corticolous; Sa = saxicolous; Te = terricolous.

with the fact that most of the forested area in «Aigüestortes i Estany de Sant Maurici» N. P. have been scarcely disturbed, thus enhancing foliose taxa and diminishing crustose lichens (Rogers, 1990). Fruticose lichens do not show significant differences between eastern Pyrenees (8.5 %) and Swiss central Plateau and Pre-Alps (9 %) (Dietrich & Scheidegger, 1997).

The diversity and ecology of lichens between «Aigüestortes i Estany de Sant Maurici» N. P. and similar regions, both from Europe and North America, follow closer patterns, despite surface area and altitudinal range are not homogeneous (Table 3). In general terms, the distribution of growth forms has two patterns, in European regions crustose lichens are more abundant, about 60-65 %. On the other side, North American areas did not have such abundance of crustose lichens (40-45 %); despite crustose species still are the most frequent. Foliose lichens are the secondarily most abundant lichens in all the areas, being richer in the North American sites than in European ones. In addition, North American mountains content a higher number of fruticose lichens than European, related with a larger abundance of terricolous lichens. When considering colonizing substrates, corticolous taxa are more common in European ranges than North American. There are two main reasons. The first one is related with the altitudinal range; therefore in Alps and Apennine areas, where more submontane regions have been included in the studies, the proportion of corticolous taxa is higher than saxicolous. The second reason owes to the diversity in plant communities; while North American forests are less diverse, mostly of them are composed majority by coniferous (DeBolt & McCune, 1993; Eversman *et al*., 2002), European forests are more often composed of deciduous forests, sometimes mixed with coniferous, which generate a great diversity of microhabitats. On the other hand, saxicolous species dominate in North American mountains, as well as in Pyrenees. In addition, terricolous taxa increase in mountains with well represented alpine belts, such as Rocky Mountains, Pyrenees and Hochschwab-Massiv.

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