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Lichen diversity and ecology in five EU habitats of interest of the Sexten Dolomiten Natural Park (S Tyrol – NE Italy)

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Abstract – A survey on lichen diversity was carried out in five EU habitats of interest of the Sexten Dolomiten Natural Park (S Tyrol, NE Italy). The aim was to evaluate the importance of lichens for biodiversity conservation in an alpine environment. Five 20 × 20 m plots were located in different habitats (codes: 6170, 4060, 9410, 4070, 6520) along an altitudinal gradient in the Tre Cime di Lavaredo area, from the alpine to the montane belts. In each plot a complete floristic survey was carried out on different substrates. 154 infrageneric taxa were found. The main differences among habitats are due to elevation, geomorphology, substrates and eutrophication. The percentage of rare species is higher in natural grasslands above treeline, and in *Pinus mugo* and *Larix* formations.

lichens / flora / Dolomites

INTRODUCTION

The exploration of lichens in the Dolomites is not yet completed, even if a high number of taxa was reported from this area. The most important work was done by Ferdinand Arnold at the end of the XIX century (Arnold, 1876; Dalla Torre & Sarnthein, 1902). This author surveyed also areas presently included in the Sexten Dolomiten Natural Park. Also because of his intensive research, this is the Italian region with the highest lichen diversity (Nimis & Martellos, 2003). Recently, Nimis (1995) reported some new species found near Tre Cime di Lavaredo, while Nascimbene (2002, 2003) and Nascimbene & Caniglia (1998, 2000a, 2000b, 2002, 2003) gave additional records for the neighbouring Dolomiti d'Ampezzo Natural Park.

Lichens are largely employed for monitoring the impact of environmental alterations (e.g. Nimis *et al.*, 2002). Lichens have disappeared from heavily industrialized areas, while in the Alps they are still numerous. The Italian alpine area hosts more than 3/4 of the national lichen flora, 1/2 of which exclusive (Martellos *et al.*, 2004). Risks, however, could derive from habitat fragmentation, climate change, and long-distance transport of pollutants.

The EU 92/43 directive gives the main lines for biodiversity conservation politics in the European Community, pointing out the main habitats and species to be protected. Lichens and bryophytes are scarcely considered in this context.

This paper aims at evaluating the importance of lichens for biodiversity conservation in an alpine environment, as a contribute for re-considering the role of lichens in future Natura 2000 action plans.

DATA AND METHODS

Five 20 × 20 m plots were located in different EU habitats of interest, along an altitudinal gradient, in the Tre Cime di Lavaredo area (Dolomites – South Tyrol), from the alpine to the montane belt, as follows:

1) 2350 m (N 46°37′21″ - E 012°17′13,5″); *Carex firma* grassland (habitat code 6170) or *Salix reticulata* formations (habitat code 4060).

2) 2250 m (N 46°37′29,4″ - E 012°17′28″); *Salix reticulata* formations (habitat code 4060).

3) 1540 m (N 46°37′53,8″ - E 012°15′31,7″) subalpine *Larix-Picea abies* formation (habitat code 9410).

4) 1450 m (N 46°33′18,9″ - E 012°14′23,3″); brushwood of *Pinus mugo* and *Rhododendron ferrugineum* with some individuals of *Larix* (priority importance habitat, code 4070).

5) 1400 m (N 46°38′26,8″ - E 012°14′05,″); traditional agricultural environment (habitat code 6520).

In each plot a complete floristic survey was carried out on different substrates.

Lichen diversity takes into account both the n° of species in each plot and their rarity and/or exclusivity for the Italian alpine regions. Rare species are those considered very or extremely rare in Italy by NIMIS (2003).

The analysis of ecology of lichen communities is based on the ecological indicator values provided by the information system on italian lichens (NIMIS, 2003).

Nomenclature follows NIMIS & MARTELLOS (2003).

RESULTS

154 infrageneric taxa were found (Tab 1). 10% of them are exclusive of the alpine regions in Italy. 40% are crustose, 30% foliose, 23% fruticose and 7% squamulose; 41% are epiphytes, 37% are terricolous and 21% saxicolous. 10% of the species are extremely or very rare in Italy.

The five habitats are different in lichen flora and ecology, mainly due to climate, substrate availability, geomorphology and eutrophication (Tab. 1; Fig. 1). Each plot has a peculiar component; especially *Carex firma/Salix reticulata* formations and the anthropic habitat have a high number of exclusive species (Tab. 1).

Climatic differences related to elevation can explain differences in ecologic strategies such as reproduction and type of photobiont. In the two alpine habitats (plots 1 and 2), lichens with sexual reproduction are prevalent (Tab. 2). Nimis & Martellos (2003) reported that in the alpine belt of Italy only 9% of lichens reproduce with soredia. In cold and dry environments the lack of sorediate lichens is interpreted by Nimis (1999) on the basis of the low vitality of soredia. He hypothesizes that sexual reproduction in the alpine lichen flora could be an adaptive response for a faster colonization of new territories after ice melting. A prevalent vegetative reproduction was observed in the other habitats at low elevation in which both a higher air humidity (plots 3 and 4) and eutrophication (plot 5) could favour the development of soredia. Non trentepohlioid green algae are the most common photobionts in these five habitats. Only in the environment

Table 1. Lichen species found in the five surveyed habitats: Plot 1 - *Carex firma* formation; Plot 2 - *Salix reticulata* formation; Plot 3 - Subalpine *Larix-Picea* abies formation; Plot 4 - brushwood of *Pinus mugo* and *Rhododendron ferrugineum*; Plo 5 - traditional agricultural environment. The main features of lichen diversity are reported as well.

Plot n°	*1*	*2*	*3*	*4*	*5*
Total lichen flora in the plot (N° of species)	54	16	45	58	50
% on the grand total of species	35	10	29	38	32
% of exclusive species	69	31	22	40	58
% of exclusive alpine species in Italy	9	31	9	10	4
% of rare species	11	6	13	7	6
Acarospora glaucocarpa (Ach.) Körb.					+
Amandinea punctata (Hoffm.) Coppins & Scheid.			+	+	
Anaptychia ciliaris (L.) Körb.					+
Anaptychia crinalis (Schleich.) Vezda					+
Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw.			+	+	+
Buellia schaereri De Not.			+	+	
Calicium trabinellum (Ach.) Ach.			+		
Caloplaca alnetorum Giralt, Nimis & Poelt					+
Caloplaca biatorina (A.Massal.) J. Steiner	+				
Caloplaca cerina (Hedw.) Th. Fr.					+
Caloplaca cerina var. *muscorum* (A.Massal.) Jatta	+				
Caloplaca cfr. *arnoldii* (Wedd.) Zahlbr.	+				
Caloplaca cirrochroa (Ach.) Th. Fr.	+				
Caloplaca herbidella (Hue) H. Magn.			+		+
Caloplaca pyracea (Ach.) Th. Fr.					+
Caloplaca saxifragarum Poelt	+				
Caloplaca sinapisperma (Lam. & DC.) Maheu & A. Gillet		+		+	
Caloplaca stillicidiorum (Vahl.) Lynge	+				
Caloplaca tiroliensis Zahlbr.	+				
Candelariella aurella (Hoffm.) Zahlbr.	+				+
Candelariella xanthostigma (Ach.) Lettau					+
Catapyrenium cinereum (Pers.) Körb.	+				
Cetraria ericetorum Opiz	+				
Cetraria islandica (L.) Ach.	+	+	+	+	
Chaenotheca chrysocephala (Ach.) Th. Fr.				+	
Cladonia amaurocraea (Flörke) Schaer.				+	
Cladonia arbuscula (Wallr.) Flot. *s. lat.*	+		+	+	
Cladonia cenotea (Ach.) Schaer.			+	+	
Cladonia cfr. *subulata* (L.) F.H. Wigg.			+		
Cladonia coccifera (L.) Willd.				+	
Cladonia coniocraea (Flörke) Spreng.			+		
Cladonia crispata (Ach.) Flot.			+	+	
Cladonia digitata (L.) Hoffm.			+	+	
Cladonia fimbriata (L.) Fr.			+	+	
Cladonia furcata (Huds.) Schrad.			+	+	+
Cladonia macilenta Hoffm. ssp. macilenta				+	
Cladonia macroceras (Delise) Hav.				+	
Cladonia pleurota (Flörke) Schaer.				+	
Cladonia pocillum (Ach.) O.J. Rich.		+		+	+
Cladonia pyxidata (L.) Hoffm.	+	+	+	+	+
Cladonia rangiferina (L.) F.H. Wigg.			+	+	
Cladonia squamosa Hoffm. v. squamosa			+	+	
Cladonia stellaris (Opiz) Pouzar & Vezda				+	

Table 1. *(suite)* Lichen species found in the five surveyed habitats: Plot 1 - *Carex firma* formation; Plot 2 - *Salix reticulata* formation; Plot 3 - Subalpine *Larix-Picea* abies formation; Plot 4 - brushwood of *Pinus mugo* and *Rhododendron ferrugineum*; Plo 5 - traditional agricultural environment. The main features of lichen diversity are reported as well.

Plot n°	*1*	*2*	*3*	*4*	*5*
Cladonia sulphurina (Michx.) Fr.		+	+	+	
Cladonia symphycarpia (Flörke) Fr.	+	+	+	+	
Cladonia uncialis (L.) F.H. Wigg. ssp. *uncialis*				+	
Clauzadea immersa (Weber) Hafellner & Bellem.	+				
Collema cfr. *tenax* (Sw.) Ach.	+				
Collema polycarpon Hoffm. ssp. *polycarpon*	+				
Collema undulatum Flot.	+			+	+
Cyphelium tigillare (Ach.) Ach.				+	
Dacampia hookeri (Borrer) A.Massal.	+	+			
Dermatocarpon miniatum (L.) W. Mann	+				+
Diplotomma epipolium auct. non (Ach.) Arnold	+				
Evernia divaricata (L.) Ach.			+		
Evernia mesomorpha Nyl.				+	
Evernia prunastri (L.) Ach.			+	+	+
Farnoldia jurana (Schaer.) Hertel ssp. *jurana*	+				
Fuscopannaria praetermissa (Nyl.) M. Jørg.		+			
Gyalecta foveolaris (Ach.) Schaer.	+				
Gyalecta jenensis (Batsch) Zahlbr.				+	
Hymenelia melanocarpa (Kremp.) Arnold	+				
Hypocenomyce scalaris (Ach.) M. Choisy				+	
Hypogymnia austerodes (Nyl.) Räsänen				+	
Hypogymnia bitteri (Lynge) Ahti				+	
Hypogymnia farinacea Zopf			+		
Hypogymnia physodes (L.) Nyl.			+	+	+
Hypogymnia tubulosa (Schaer.) Hav.			+		+
Icmadophila ericetorum (L.) Zahlbr.			+		
Imshaugia aleurites (Ach.) S L.F. Meyer			+	+	
Lecania cfr. *nylanderiana* A. Massal.	+				
Lecanora argentata (Ach.) Malme					+
Lecanora cadubriae (A. Massal.) Hedl.			+		
Lecanora carpinea (L.) Vain.					+
Lecanora chlarotera Nyl.			+		+
Lecanora circumborealis Brodo & Vitik.			+	+	+
Lecanora dispersa (Pers.) Sommerf.					+
Lecanora epibryon (Ach.) Ach.	+				
Lecanora flotowiana Spreng.	+				
Lecanora hagenii (Ach.) Ach.	+				
Lecanora leptyrodes (Nyl.) Degel.					+
Lecanora perpruinosa Fröberg	+				
Lecanora symmicta (Ach.) Ach.					+
Lecanora varia (Hoffm.) Ach.					+
Lecidella elaeochroma (Ach.) M. Choisy					+
Lecidella pulveracea (Schaer.) P. Syd.					+
Leptogium lichenoides (L.) Zahlbr.					+
Leptogium saturninum (Dicks.) Nyl.					+
Letharia vulpina (L.) Hue				+	
Megaspora verrucosa (Ach.) Hafellner & V. Wirth	+				
Melanelia exasperatula (Nyl.) Essl.			+	+	
Melanelia subaurifera (Nyl.) Essl.			+		
Mycobilimbia berengeriana (A.Massal.) Hafellner & V. Wirth	+				
Mycobilimbia hypnorum (Lib.) Kalb & Hafellner				+	

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Plot n°	*1*	*2*	*3*	*4*	*5*
Mycobilimbia lurida (Ach.) Hafellner & Türk	+				
Ochrolechia alboflavescens (Wulfen) Zahlbr.			+	+	
Ochrolechia androgyna (Hoffm.) Arnold				+	
Parmelia saxatilis (L.) Ach.			+	+	
Parmelia sulcata Taylor			+	+	+
Parmeliopsis ambigua (Wulfen) Nyl.			+	+	+
Parmeliopsis hyperopta (Ach.) Arnold			+	+	
Peltigera aphthosa (L.) Willd.				+	
Peltigera canina (L.) Willd.				+	
Peltigera lepidophora (Vain.) Bitter		+			
Peltigera leucophlebia (Nyl.) Gyeln.				+	
Peltigera malacea (Ach.) Funck	+				+
Peltigera polydactyla (Neck.) Hoffm.			+		
Peltigera rufescens (Weiss) Humb.	+	+			+
Pertusaria amara (Ach.) Nyl.			+		
Phaeophyscia orbicularis (Neck.) Moberg					+
Physcia adscendens (Fr.) H. Olivier					+
Physcia caesia (Hoffm.) Fürnr. var. *caesia*	+			+	
Physcia dubia (Hoffm.) Lettau	+				+
Physcia stellaris (L.) Nyl.					+
Physcia tenella (Scop.) DC.					+
Physconia muscigena (Ach.) Poelt var. *muscigena*	+				
Platismatia glauca (L.) W.L. Culb. & C.F. Culb			+		
Polyblastia ventosa Arnold	+				
Protoblastenia terricola (Anzi) Lynge				+	
Protopannaria pezizoides (Weber) M. Jørg. & S. Ekman		+			
Pseudevernia furfuracea (L.) Zopf var. *furfuracea*			+	+	+
Psora decipiens (Hedw.) Hoffm.	+				
Ramalina farinacea (L.) Ach.					+
Ramalina fastigiata (Pers.) Ach.					+
Ramalina obtusata (Arnold) Bitter			+	+	
Rhizocarpon umbilicatum (Ramond) Flagey	+				
Rinodina pyrina (Ach.) Arnold					+
Rinodina roscida (Sommerf.) Arnold	+				
Sarcogyne regularis Körb. var. *regularis*	+			+	
Solorina bispora cfr. ssp. *macrospora* (Harm.) Burgaz & I. Martinez	+				
Solorina octospora (Arnold) Arnold	+	+			
Solorina saccata (L.) Ach.	+	+		+	
Solorina spongiosa (Ach.) Anzi		+			
Squamarina cartilaginea (With.) P. James					+
Squamarina gypsacea (Sm.) Poelt	+				
Staurothele areolata (Ach.) Lettau	+	+			
Thamnolia vermicularis (Sw.) Schaer. var. *vermicularis*	+				
Toninia candida (Weber) Th. Fr.				+	
Toninia sedifolia (Scop.) Timdal		+			
Toninia tumidula (Sm.) Zahlbr.	+				
Trapeliopsis granulosa (Hoffm.) Lumbsch				+	
Tuckermannopsis chlorophylla (Willd.) Hale			+	+	
Tuckneraria laureri (Kremp.) Randlane & Thell			+		
Usnea ceratina Ach.			+	+	
Verrucaria caerulea DC.	+				

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Plot n°	*1*	*2*	*3*	*4*	*5*
Verrucaria nigrescens Pers.					+
Verrucaria tristis (A. Massal.) Kremp.	+				
Vulpicida pinastri (Scop.) J.E.Mattsson & M. J. Lai			+	+	+
Vulpicida tubulosus (Schaer.) J.E.Mattsson & M.J. Lai	+				
Xanthoria candelaria (L.) Th. Fr.					+
Xanthoria elegans (Link) Th. Fr. ssp. *elegans*	+				+
Xanthoria parietina (L.) Th. Fr.					+
Xanthoria polycarpa (Hoffm.) Rieber					+
Xanthoria sorediata (Vain.) Poelt	+				

with a long-time snow covering cyanolichens are numerous, probably due to an higher water availability; liquid water is indeed necessary to cyanolichens' metabolism (Nash, 1996). *Trentepohlia* species, typical of warm, humid and protected habitats, are uncommon in alpine lichens (Nimis, 1999). The only two trentepohlioid species were collected in humid and sheltered micro-habitats.

Substrates availability as well causes the main differences among the two more elevated habitats and the others. In plot 1 and 2 the epiphytes are yet absent.

The influence of geomorphology is evident in plot 2, where the lowest number of species was recorded; this is due to snow covering that favours the occurrence of hygrophytic species (Fig. 1).

Eutrophication explains the main differences among the anthropic environment, characterized by a traditional agriculture, and the other habitats. Here lichen diversity is high, but nitrophytic species are prevalent (Fig 1).

Among the five habitats, the percentage of rare species is higher in the *Carex firma/Salix reticulata* vegetation and in the coniferous forest (Tab.1). In the only priority importance habitat (the brushwood of *Pinus mugo* and *Rhododendron ferrugineum*) *Cladonia stellaris*, an extremely rare lichen of cold-humid environments, represents a peculiar subject for conservation issues, since in Italy it is exclusive of the subalpine area of the Alps.

Another element for lichen diversity conservation is represented by the alpine specialists component (Tab. 1). Several species that in Italy are exclusive of the alpine regions grow in habitats with a persistent snow covering, while exposed or forested habitats host a lower percentage of alpine specialists.

DISCUSSION AND CONCLUSIONS

One of the main reasons for the lack of a European law devoted to lichen conservation and for the marginal mention of this group in the "Habitat" directive (EU 92/43) is the applicability of IUCN criteria (IUCN, 2001) to lichens (Scheidegger & Goward, 2002). These are mainly based on the concepts of individual and of population size and are determined according to a variety of parameters (IUCN, 2001).

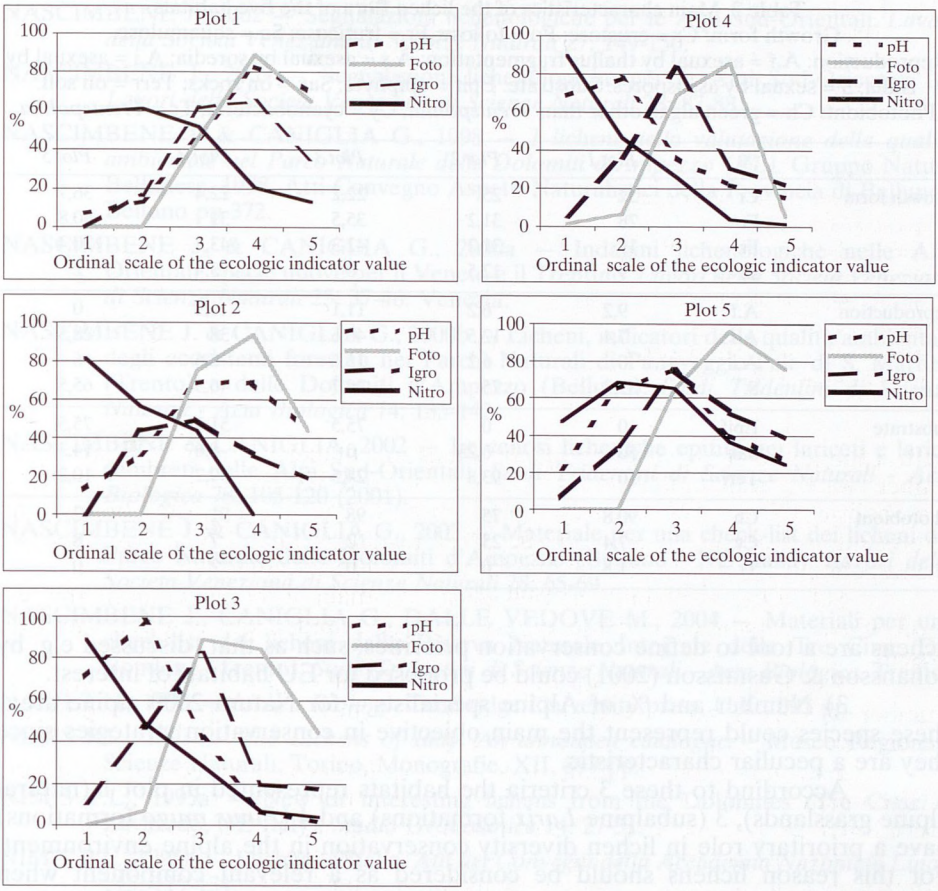

Fig. 1. Ecological indicators values of the lichen flora found in the five habitats, expressed on a five-classes ordinal scale. Plot 1 - *Carex firma* formation; Plot 2 - *Salix reticulata* formation; Plot 3 - Subalpine *Larix-Picea abies* formation ; Plot 4 - brushwood of *Pinus mugo* and *Rhododendron ferrugineum*; Plot 5 - traditional agricultural environment. The main characteristics of lichen diversity are as well reported.
pH = pH of the substratum (1 = on very acid substrata; 2 = on acid substrata; 3 = on subacid to subneutral substrata; 4 = on slightly basic substrata; 5 = on basic substrata).
Foto = Solar irradiation (1 = in very shaded situations; 2 = in shaded situations; 3 = in sites with plenty of diffuse light but scarce direct solar irradiation; 4 = in sun-exposed sites, but avoiding extreme solar irradiation; 5 = in sites with very high direct solar irradiation).
Igro = Humidity (1 = hygrophytic species; 2 = rather hygrophytic species; 3 = mesophytic species; 4 = xerophytic species living in dry situations, but absent from extremely arid stands); 5 = very xerophytic species.
Nitro = Eutrophication (1 = no eutrophication; 2 = very weak eutrophication; 3 = weak eutrophication; 4 = rather high eutrophication; 5 = very high eutrophication).

In our opinion, the following criteria could be considered for priority conservation:

1) Number of species.

2) Number and % of rare or red-listed species - Not only species number, but also their rarity are relevant for conservation. An approach in which red-listed

Table 2. Main characteristics of the lichen flora of the five habitats. Growth form: Cr = crustose; Fo = foliose; Fr = fruticose; Sq = squamulose. Reproduction: A.f = asexual by thallus fragmentation; A.s = asexual by soredia; A.i = asexual by isidia; S = sexual by ascospores. Substrate: Epif = epiphyte; Sax = on rocks; Terr = on soil. Photobiont: Ch = green algae other than *Trentepohlia*; Cy = cyanobacteria; Tr = *Trentepohlia*.

	%	*Plot 1*	*Plot 2*	*Plot 3*	*Plot 4*	*Plot 5*
growth form	Cr	52	25	22,2	22,4	36,7
	Fo	28	31,2	35,5	31	40,8
	Fr	11	31,2	42,3	43,1	20,4
	sq	9	12,5	0	3,4	2
reproduction	A.f	9,2	6,2	11,1	6,9	0
	A.s	7,4	12,5	46,6	38	28,5
	A.i	0	6,2	15,6	8,6	6
	S	83,3	75	26,7	46,5	65,5
substrate	Epif	0	0	75,5	51,7	75,5
	Sax	50	6,25	0	8,6	14,3
	Terr	50	93,8	24,5	39,7	10,2
photobiont	Ch	90,8	75	98	91	92
	Cy	7,4	25	2	7	8
	Tr	1,8	0	0	2	0

lichens are a tool to define conservation priorities, such as that discussed e.g. by Johansson & Gustafsson (2001) could be proposed for EU habitats of interest.

3) Number and % of Alpine specialists – for Natura 2000 alpine areas these species could represent the main objective in conservation strategies since they are a peculiar characteristic.

Accordind to these 3 criteria the habitats represented in plot 1 (natural alpine grasslands), 3 (subalpine *Larix* formations) and 4 (*Pinus mugo* formations) have a prioritary role in lichen diversity conservation in the alpine environment. For this reason lichens should be considered as a relevant component when planning the management or evaluating the incidence of human activities on these EU habitats of interest.

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