A lichen survey in the western Dolomites: Schlern Nature Park (S Tyrol – NE Italy)

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Abstract

The exploration of lichens in the Dolomites is not yet completed, and recent surveys demonstrated the need of further research for a better evaluation of the role of lichen communities in shaping the diversity and composition of the biota of alpine habitats. This paper aims at improving lichen floristics in the Dolomites as a basis for developing further research and improving a near-to-nature management of environmental resources. Lichens were surveyed in 17 selected sites, representing the main habitats in the Schlern Nature Park, providing relevant information on alpine lichens and improving floristics both at a local and regional level. On the basis of both bibliographical and new data, 37% of the species occurring in Trentino-Alto Adige, and 26% of those occurring in the Italian Alps are now listed for the Schlern area, including several nationally rare species mainly centred in subalpine forests where the presence of old trees and CWD (coarse woody debris) should be enhanced in the future. Also the presence of scattered old traditional buildings made up by wood and stones provided an interesting lichen habitat in the mountain agricultural landscape. In freshwaters, a generalized habitat protection is a prudent approach that may compensate for poor floristic and taxonomic knowledge.

Keywords: Alps, conservation, forests, freshwaters, habitats, rare species

1. Introduction

The most important work on the lichens of Trentino-Alto Adige was carried out by F. Arnold (1828-1901) in the last years of the 19th century. He surveyed South Tyrol, including the area of the Schlern Nature Park in the western Dolomites (Arnold 1869). Arnold published the results of his surveys in the famous series *Lichenologische Ausflüge* in Tyrol (1868-1897). Also because of his intensive research, this is the Italian region with the highest lichen diversity (Nimis & Martellos 2003). The lichen records from South Tyrol until 1901 were then summarized by Dalla Torre & Sarnthein (1902) which still represents the main source of data.

However, the exploration of lichens in the Dolomites is not yet completed, even if a high number of taxa was reported from this area. Recent surveys demonstrated the need of further research for a better evaluation of the role of lichen communities in shaping the diversity and composition of the biota of alpine habitats in the Dolomites (Nascimbene et al. 2006a, Thor & Nascimbene 2007). Nascimbene et al. (2007c) provided a checklist of the epiphytic lichens of Südtirol, which could support further research and improve the effectiveness of management of natural resources in biodiversity conservation.

The Italian Alps host more than 3/4 of the national lichen flora, including 50% of species which in Italy are exclusive of this area (Martellos et al. 2004). Risks for long-term

conservation of lichen diversity could however derive from habitat fragmentation, forest management, climate change, and long-distance transport of pollutants.
The EU 92/43 directive provided the main lines for biodiversity conservation politics in the European Community, indicating the main habitats and species to be protected. Lichens are scarcely considered and further contribution are needed to support a re-consideration of their role in future Natura 2000 action plans. Recently, several papers focused on this topic in the Italian Alps, evaluating the importance of different habitats for lichen diversity (Nascimbene et al. 2006a), the effects of forest management on lichen communities (Nascimbene et al. 2007a), and the importance of coarse woody debris for biodiversity conservation (Nascimbene et al. 2008).
This paper aims at improving lichen floristics in the Dolomites as a basis for developing further research and improving a near-to-nature management of environmental resources.

2. Materials and methods

2.1 Lichen survey

Lichens were surveyed in 15 selected sites, representing the main habitats in the Schlern Nature Park (South Tyrol – western Dolomites; NE Italy; Table 1). Two additional sites were surveyed during the "biodiversity day" in 2006 (Tires) and 2007 (Sasso Piatto; Table 1, sites a and b, Nascimbene 2006b, 2007).
In each site a floristic survey was carried out considering all the available substrates which are indicated in Table 1. In site n° 2, only freshwater lichens were surveyed in a cobble spring.
Species that were not identified in the field were sampled to be identified under the stereomicroscope and the dissecting microscope.

2.2 Data analysis

The species ecological traits were evaluated indirectly, using the ecological indicator values defined by Nimis (2003). These values indicate, on a 5-class ordinal scale, the ecological requirements of each species for (a) pH of the substrate (1 = on very acid substrata; 2 = on acid substrata; 3 = on subacid to subneutral substrata; 4 = on slightly basic substrata; 5 = on basic substrata); (b) eutrophication (1 = no eutrophication; 2 = very weak eutrophication; 3 = weak eutrophication; 4 = rather high eutrophication; 5 = very high eutrophication); (c) light (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); (d) moisture (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).

Table 1: Substrate types on which lichens were surveyed in the selected sites

		Sampled substrates														
		bark														
Site	Habitat	*Larix*	*Picea*	*Abies*	*Pinus c.*	*Pinus m.*	*Pinus s.*	*Fraxinus*	*Alnus*	*Sorbus*	Coarse woody debris	Inundated rock	Calcareous/dolomitic rock	Siliceous rock	Vulcanic rock	Soil/plant debris
1	Alpine grasslands on calcareous substrates															+
2	Alpine fen (spring)											+				
3	Shaded dolomitic rocks												+			+
4	Calcareous rubble												+			+
5	Vulcain rocks and sediments														+	+
6	*Pinus mugo* formation	+				+					+					+
7	Cut meadows										+		+			+
8	Grazed *Larix* forest	+									+		+	+		+
9	*Picea* forest	+	+	+							+		+			+
10	*Pinus sylvestris* forest						+				+					+
11	Burnt forest						+				+					
12	mixed *Picea-Abies* forest	+	+	+						+	+		+			+
13	Well lit dolomitic rocks					+					+		+			+
14	Humid habitats						+				+			+		+
15	Alpine rivers		+					+	+		+	+	+	+		
a	Grazed *Larix* forest	+	+	+												
b1	*Nardus*-formation										+			+		
b2	*Salix reticulata*-formation															+
b3	*Pinus cembra* forest	+			+						+					+

Growth forms, reproductive strategies, substrate requirements, and rarity of each species at national level were retrieved from Nimis (2003). Foliose lichens include both those with narrow (*Physcia*-like) and large (*Parmelia*-like) lobes; fruticose lichens include both those with filamentous and non-filamentous thalli; crustose lichens include true crustose and squamulose species. Reproductive strategies are classified as: (a) mainly sexual reproduction by ascospores, mainly asexual reproduction by (b) isidia, (c) soralia, and (d) thallus fragmentation.

Species rarity at national level was estimated on the basis of: (a) number of samples in the TSB lichen herbarium, (b) number of literature records, (c) expert judgement. Eight commonness-rarity classes were used, from extremely rare to extremely common. The 'extremely rare' status is given only to taxa known from less than 5 localities in Italy, or to those that were not mentioned in the literature in the last fifty years. Recently-described or dubious taxa are excluded from this category. In the present work, very rare and extremely rare species were merged into a single category, and labelled as 'rare'. Nomenclature follows Nimis & Martellos (2003).

2.3 Bibliographic data

Historical data on the lichens of the Schlern area were available in Dalla Torre & Sarnthein (1902). Recent bibliographic data were available in Nascimbene (2005) where the results of a one-day survey near Bad Ratzes and St. Konstantin were reported.
Bibliographic data were used to summarize the knowledge on lichen floristics in the study area.

3. Results

A total of 279 species were found (Table 2). Among them, 62% are crustose, 23% are foliose, and 15% are fruticose lichens. Most of them reproduce sexually by ascospores (65%), 24% by soredia, 6% by isidia, and 4% by thallus fragmentation. The photobiont is mainly a coccoid green alga (87%), while cyanobacteria and *Trentepholia* are rare (7% and 4% respectively).
On bark (mostly acid bark of conifers), 101 species were found; on coarse woody debris (mostly stumps) 59, on carbonatic rocks 87, on acid-subacid rocks 49, and 78 species were found on soil or plant debris.
The ecology of the species reflects the features of the surveyed habitats (Fig. 1): most of them prefer intermediate and well-lit conditions, intermediate moisture conditions, and avoid eutrophicated habitats. Species preferring humid habitats were mainly found in the mixed *Picea-Abies* site, while species preferring aridity were found on exposed dolomitic rocks. Species tolerating eutrophication were mostly found on exposed dolomitic rocks, on traditional buildings in cut meadows, and on larch in grazed forests.
As far as substrate pH is considered, epiphytic lichens are mainly acidophilous, while saxicolous species are mainly basiphilous, according to the main sampling substrates (acid bark of conifers and dolomitic rocks).
Among epiphytic species related to forest ecosystems, 8 are considered extremely sensitive to human disturbance (Nimis 2003): *Calicium glaucellum, Calicium trabinellum, Cetrelia olivetorum, Ramalina obtusata, Ramalina thrausta, Schismatomma pericleum, Tuckneraria laureri, Usnea ceratina*. Overall, 153 species are scarcely tolerant to human disturbance, 83 being strongly untolerant to eutrophication.
Twenty-two species are nationally rare (Table 3), two of them (*Ramalina obtusata* and *Tuckneraria laureri*) being included in the European red list of macrolichens (Sérusiaux 1989).

Table 2: Species list and species occurrence in the selected sites.

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Acarospora cervina A.Massal.					+														+
Acarospora fuscata (Schrad.) Th.Fr.					+			+									+		
Acarospora glaucocarpa (Ach.) Körb.							+	+					+						
Acrocordia salweyi (Nyl.) A.L.Sm												+							
Agonimia tristicula (Nyl.) Zahlbr.	+				+				+				+						
Alectoria ochroleuca (Hoffm.) A.Massal.																		+	
Amandinea punctata (Hoffm.) Coppins & Scheid.						+		+											
Arthonia radiata (Pers.) Ach.												+			+				
Aspicilia caesiocinerea (Malbr.) Arnold					+														
Aspicilia calcarea (L.) Mudd var. *calcarea*							+						+						
Aspicilia contorta (Hoffm.) Kremp.					+		+						+						
Bacidina inundata (Fr.) Vezda															+				
Baeomyces placophyllus Ach.																		+	
Bryoria capillaris (Ach.) Brodo & D.Hawksw.																+			
Bryoria fuscescens (Gyeln.) Brodo & D.Hawksw.						+		+	+							+			+
Buellia griseovirens (Sm.) Almb.								+	+	+			+						
Buellia schaereri De Not.												+				+			
Calicium glaucellum Ach.										+				+					
Calicium trabinellum (Ach.) Ach.						+		+		+		+							+
Calicium viride Pers.									+							+			
Caloplaca ammiospila (Wahlenb.) H.Olivier	+		+	+									+						
Caloplaca arnoldii (Wedd.) Zahlbr.				+															
*Caloplaca cerin*a (Hedw.) Th.Fr. var. *cerina*						+													
Caloplaca cerina (Hedw.) Th.Fr. var. *chloroleuca* (Sm.) Th.Fr.	+						+	+										+	
Caloplaca cerina (Hedw.) Th.Fr. var. *muscorum* (A.Massal.) Jatta	+		+	+	+			+										+	
Caloplaca cirrochroa (Ach.) Th.Fr.			+																
Caloplaca citrina (Hoffm.) Th.Fr.									+										
Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth.									+										
Caloplaca herbidella (Hue) H.Magn.												+			+	+			
Caloplaca proteus Poelt			+						+				+						
Caloplaca saxicola (Hoffm.) Nordin				+			+		+										
Caloplaca saxifragarum Poelt	+			+														+	
Caloplaca scrobiculata H.Magn.				+															

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Caloplaca sinapisperma (Lam. & DC.) Maheu & A. Gillet							+	+					+						
Caloplaca tiroliensis Zahlbr.	+		+	+														+	+
Caloplaca xantholyta (Nyl.) Jatta									+			+	+						
Candelariella aurella (Hoffm.) Zahlbr.			+	+			+	+							+				+
Candelariella unilocularis (Elenkin) Nimis				+															
Candelariella vitellina (Hoffm.) Müll.Arg.					+	+	+	+					+	+			+		+
Candelariella xanthostigma (Ach.) Lettau								+											
Carbonea vitellinaria (Nyl.) Hertel					+												+		
Catapyrenium cinereum (Pers.) Körb.	+			+			+											+	
Cetraria aculeata (Schreb.) Fr.	+																		
Cetraria ericetorum Opiz	+																	+	
Cetraria islandica (L.) Ach.	+		+	+		+	+					+	+					+	+
Cetrelia olivetorum (Nyl.) W.L.Culb. & C.F.Culb.															+	+			
Chaenotheca chrysocephala (Ach.) Th.Fr.									+	+		+		+	+	+			+
Chaenotheca ferruginea (Sm.) Mig.									+	+		+		+	+				
Chaenotheca furfuracea (L.) Tibell						+			+			+		+		+			
Chaenotheca stemonea (Ach.) Müll.Arg.												+							
Chaenotheca trichialis (Ach.) Th.Fr.						+			+	+		+		+	+	+			
Chaenothecopsis pusilla (Ach.) A. F. W. Schmidt								+		+		+							+
Chrysothrix candelaris (L.) J.R.Laundon									+			+				+			
Cladonia arbuscula (Wallr.) Flot. subsp. *arbuscula*	+							+						+				+	+
Cladonia carneola (Fr.) Fr.								+			+			+					
Cladonia cenotea (Ach.) Schaer.						+		+	+	+		+				+			+
Cladonia coniocraea (Flörke) Spreng.						+		+		+	+	+	+	+	+	+			+
Cladonia crispata (Ach.) Flot.													+	+					
Cladonia digitata (L.) Hoffm.						+		+	+	+		+	+	+	+	+			+
Cladonia fimbriata (L.) Fr.						+	+			+				+	+	+			+
Cladonia furcata (Huds.) Schrad.						+			+	+		+	+	+	+			+	+
Cladonia macilenta Hoffm. subsp. *macilenta*								+					+	+		+			
Cladonia macroceras (Delise) Hav.	+			+		+	+						+					+	+
Cladonia parasitica (Hoffm.) Hoffm.								+											
Cladonia pleurota (Flörke) Schaer.						+			+										
Cladonia pocillum (Ach.) O.J. Rich.	+			+								+							+
Cladonia pyxidata (L.) Hoffm.	+		+			+	+	+	+	+		+	+	+	+	+	+		
Cladonia rangiferina (L.) F.H.Wigg.										+		+	+						+
Cladonia squamosa Hoffm. var. *squamosa*									+				+	+					
Cladonia subulata (L.) F.H.Wigg.													+	+					

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Cladonia sulphurina (Michx.) Fr.												+				+			+
Cladonia symphycarpa (Flörke) Fr.			+				+	+					+	+					
Collema auriforme (With.) Coppins & J.R.Laundon									+										
Collema cristatum (L.) F.H.Wigg.			+					+	+										+
Collema multipartitum Sm.													+						
Collema polycarpon Hoffm. subsp. *polycarpon*																			+
Collema tenax (Sw.) Ach.					+														
Collema undulatum Flot.				+			+		+				+						+
Cyphelium tigillare (Ach.) Ach.																+	+		+
*Dacampia hooker*i (Borrer) A.Massal.			+	+															
Dermatocarpon miniatum (L.) W.Mann					+		+	+	+			+	+						+
Dibaeis baeomyces (L. fil.) Rambold & Hertel							+											+	
Dimelaena oreina (Ach.) Norman					+														
Dimerella pineti (Ach.) Vezda														+		+			
Diploschistes gypsaceus (Ach.) Zahlbr.												+	+						
Diploschistes muscorum (Scop.) R.Sant.																			+
Diploschistes scruposus (Schreb.) Norman														+					
Diplotomma epipolium auct. non (Ach.) Arnold			+																+
Diplotomma nivale (Bagl. & Carestia) Hafellner			+	+															
Evernia divaricata (L.) Ach.												+				+			
Evernia mesomorpha Nyl.								+								+			
Evernia prunastri (L.) Ach.								+	+			+		+	+	+			
Farnoldia hypocrita (A.Massal.) Fröberg													+						
Farnoldia jurana (Schaer.) Hertel subsp. *jurana*			+	+									+						+
Farnoldia micropsis (A.Massal.) Hertel				+			+												
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell	+			+														+	
Flavocetraria nivalis (L.) Kärnefelt & Thell	+			+														+	+
Flavoparmelia caperata (L.) Hale								+						+					
*Flavopunctelia flaventio*r (Stirt.) Hale														+					
Fuscidea kochiana (Hepp) V.Wirth & Vezda								+											
Fuscopannaria leucophaea (Vahl) M.Jørg.									+										
Fuscopannaria praetermissa (Nyl.) M.Jørg.	+				+														
Graphis scripta (L.) Ach.												+							
Gyalecta foveolaris (Ach.) Schaer.	+																		
Gyalecta geoica (Ach.) Ach.																		+	
Gyalecta hypoleuca (Ach.) Zahlbr.													+						
Gyalecta jenensis (Batsch) Zahlbr.			+						+			+	+		+				

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Gyalecta leucaspis (A.Massal.) Zahlbr.									+			+	+						
Gyalidea roseola (Arnold) Lettau												+							
Hymenelia coerulea (DC.) A.Massal.			+	+															
Hymenelia epulotica (Ach.) Lutzoni			+										+						
Hymenelia ochrolemma (Vain.) Gowan & Ahti					+														
Hypocenomyce caradocensis (Nyl.) P.James & Gotth.Schneid.										+									
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. *erysibe* (Ach.) Mudd									+				+						
Lecanora agardhiana Ach. subsp. *agardhiana*				+															
Lecanora cadubriae (A.Massal.) Hedl.						+													+
Lecanora carpinea (L.) Vain.												+				+			
Lecanora cenisia Ach.					+		+										+		
Lecanora circumborealis Brodo & Vitik.								+								+			+
Lecanora crenulata Hook.			+	+			+								+				
Lecanora dispersa (Pers.) Sommerf.								+							+				
Lecanora epibryon (Ach.) Ach.	+		+	+			+											+	+
Lecanora flotowiana Spreng.				+															+
Lecanora hagenii (Ach.) Ach. var. *fallax* Hepp	+			+															
Lecanora hagenii (Ach.) Ach. var. *hagenii*							+												
Lecanora leptyrodes (Nyl.) Degel.															+				
Lecanora muralis (Schreb.) Rabenh. subsp. *muralis*					+			+									+		
Lecanora perpruinosa Fröberg			+	+	+														+
Lecanora polytropa (Hoffm.) Rabenh. var. *polytropa*					+			+						+			+		
Lecanora rupicola (L.) Zahlbr. subsp. *rupicola* var. *rupicola*								+									+		
Lecanora saligna (Schrad.) Zahlbr.								+				+	+						
Lecanora symmicta (Ach.) Ach.						+		+											
Lecanora varia (Hoffm.) Ach.						+	+	+		+	+		+				+		+

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Lecidea confluens (Weber) Ach.																	+		
Lecidea turgidula Fr.								+		+									+
Lecidea umbonata (Hepp) Mudd				+															
Lecidella carpathica Körb.					+			+						+					
Lecidella elaeochroma (Ach.) M.Choisy												+			+				
Lepraria caesioalba (de Lesd.) J.R.Laundon	+				+														
Lepraria cfr. *nivalis* J.R.Laundon	+																		
Leptogium lichenoides (L.) Zahlbr.	+						+	+	+				+						+
Letharia vulpina (L.) Hue						+										+	+		+
Megaspora verrucosa (Ach.) Hafellner & V.Wirth var. *verrucosa*	+		+	+														+	+
Melanelia exasperatula (Nyl.) Essl.						+		+					+						+
Melanelia subargentifera (Nyl.) Essl.															+				
Melanelia subaurifera (Nyl.) Essl.								+				+			+	+			
Menegazzia terebrata (Hoffm.) A.Massal.												+							
Micarea lignaria (Ach.) Hedl. var. *lignaria*										+	+		+						
Micarea melaena (Nyl.) Hedl.										+									+
Micarea peliocarpa (Anzi) Coppins & R.Sant.										+			+						
Micarea prasina Fr.									+	+									
Microcalicium disseminatum (Ach.) Vain.						+			+										
Mycobilimbia lurida (Ach.) Hafellner & Türk							+	+											
Mycoblastus affinis (Schaer.) T.Schauer									+										
Myxobilimbia lobulata (Sommerf.) Hafellner	+		+	+									+						+
Myxobilimbia sabuletorum (Schreb.) Hafellner												+							
Neofuscelia pulla (Ach.) Essl. s.lat.														+					
Nephroma expallidum (Nyl.) Nyl.																		+	
Normandina pulchella (Borrer) Nyl.															+				
Ochrolechia alboflavescens (Wulfen) Zahlbr.						+		+					+			+			+
Ochrolechia androgyna (Hoffm.) Arnold																+			
Ochrolechia arborea (Kreyer) Almb.																+			
Ochrolechia microstictoides Räsänen								+											
Ochrolechia szatalaensis Verseghy													+		+	+			
Ochrolechia upsaliensis (L.) A.Massal.	+			+															
Opegrapha dolomitica (Arnold) Torrente & Egea									+			+	+						
Opegrapha vulgata Ach.												+							
Parmelia saxatilis (L.) Ach.						+		+	+	+		+	+	+	+	+	+		
Parmelia submontana Hale									+						+				
Parmelia sulcata Taylor					+	+		+		+	+	+	+		+	+			+

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Parmelina pastillifera (Harm.) Hale								+											
Parmelina tiliacea (Hoffm.) Hale								+											
Parmeliopsis ambigua (Wulfen) Nyl.						+		+	+	+	+	+	+	+	+	+			+
Parmeliopsis hyperopta (Ach.) Arnold						+		+	+	+		+	+	+	+	+			+
Peltigera aphthosa (L.) Willd.	+					+							+					+	+
Peltigera didactyla (With.) J.R.Laundon	+																	+	
Peltigera horizontalis (Huds.) Baumg.												+							
Peltigera leucophlebia (Nyl.) Gyeln.			+										+						
Peltigera malacea (Ach.) Funck			+															+	
Peltigera membranacea (Ach.) Nyl.	+																		
Peltigera polydactyla (Neck.) Hoffm.										+									
Peltigera praetextata (Sommerf.) Zopf									+			+	+		+				+
Peltigera rufescens (Weiss) Humb.	+				+		+	+											+
Peltigera venosa (L.) Hoffm.																		+	
Pertusaria amara (Ach.) Nyl.									+			+				+			
Pertusaria coronata (Ach.) Th.Fr.									+										
Pertusaria hemisphaerica (Flörke) Erichsen																+			
Pertusaria lactea (L.) Arnold					+									+					
Phaeophyscia orbicularis (Neck.) Moberg							+	+											
Phaeorrhiza nimbosa (Fr.) H.Mayrhofer & Poelt	+																		
Phlyctis argena (Spreng.) Flot.												+			+	+			
Physcia adscendens (Fr.) H.Olivier								+			+								
Physcia caesia (Hoffm.) Fürnr. var. *caesia*			+	+	+		+	+											+
Physcia dubia (Hoffm.) Lettau			+	+	+		+	+									+		+
Physcia stellaris (L.) Nyl.															+				
Physconia muscigena (Ach.) Poelt var. *muscigena*	+		+	+	+		+											+	+
Placynthiella icmalea (Ach.) Coppins & P.James						+		+	+	+	+	+	+						+
Placynthiella oligotropha (J.R.Laundon) Coppins & P.James									+	+	+								
Placynthiella uliginosa (Schrad.) Coppins & P.James																+			
Placynthium nigrum (Huds.) Gray			+					+				+	+						+
Placynthium subradiatum (Nyl.) Arnold													+						
Platismatia glauca (L.) W.L.Culb. & C.F.Culb.						+		+					+			+			
Polyblastia ardesiaca (Bagl. & Carestia) Zschacke															+				
Polyblastia sendtneri Kremp.	+		+																
Polyblastia ventosa Arnold			+	+															

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Protoblastenia calva (Dicks.) Zahlbr.			+	+								+							+
Protoblastenia incrustans (DC.) J.Steiner var. *incrustans*			+	+															+
Protoblastenia rupestris (Scop.) J.Steiner							+		+				+						
Protoblastenia terricola (Anzi) Lynge			+																
Protopannaria pezizoides (Weber) M.Jørg. & S.Ekman									+									+	
Protoparmelia badia (Hoffm.) Hafellner																	+		
Pseudephebe pubescens (L.) M.Choisy																	+		
Pseudevernia furfuracea (L.) Zopf var. *ceratea* (Ach.) D.Hawksw.							+	+			+								+
Pseudevernia furfuracea (L.) Zopf var. *furfuracea*	+					+			+	+		+	+	+	+	+			
Psora decipiens (Hedw.) Hoffm.			+																
Punctelia subrudecta (Nyl.) Krog								+											
Pycnora sorophora (Vain.) Hafellner									+	+			+	+					+
Ramalina farinacea (L.) Ach.								+				+			+	+			
Ramalina fastigiata (Pers.) Ach.															+				
Ramalina obtusata (Arnold) Bitter									+			+				+			
Ramalina pollinaria (Westr.) Ach.															+				
Ramalina thrausta (Ach.) Nyl.																+			
Rhizocarpon badioatrum (Spreng.) Th.Fr.					+												+		
Rhizocarpon geographicum (L.) DC. subsp. *geographicum*					+			+						+			+		
Rhizocarpon umbilicatum (Ramond) Flagey			+	+			+						+						+
Rhizoplaca melanophthalma (DC.) Leuckert & Poelt																	+		
Rinodina mniaraea (Ach.) Körb. var. *cinnamomea* Th.Fr.	+																		
Sagiolechia protuberans (Ach.) A.Massal.													+						
Sarcogyne regularis Körb. var. *regularis*			+	+					+			+	+						+
Schismatomma pericleum (Ach.) Branth & Rostr.									+			+				+			
Solorina bispora Nyl. subsp. *bispora*	+		+										+						
Solorina saccata (L.) Ach.						+							+						+
Solorina spongiosa (Ach.) Anzi	+		+			+													
Squamarina cartilaginea (With.) P.James f. pseudocrassa Mattick			+	+									+						+
Squamarina gypsacea (Sm.) Poelt			+	+									+						
Squamarina lamarckii (DC.) Poelt																			+
Staurothele areolata (Ach.) Lettau							+												

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Species	Alpine calcareous grasslands	Alpine fen (spring)	Shaded dolomitic rocks	Calcareous rubble	Vulcain rocks and sediments	*Pinus mugo* formation	Cut meadows	Grazed *Larix* forest	*Picea* forest	*Pinus sylvestris* forest	Burnt forest	mixed *Picea-Abies* forest	Well lit dolomitic rocks	Humid habitats	Alpine rivers	Grazed *Larix* forest	*Nardus*-formation	*Salix reticulata*-formation	*Pinus cembra* forest
Staurothele hymenogonia (Nyl.) Th.Fr.			+	+															
Staurothele succedens (Arnold) Arnold												+							
Tephromela atra (Huds.) Hafellner var. *atra*							+										+		
Thamnolia vermicularis (Sw.) Schaer. var. *vermicularis*	+		+	+															+
Thelidium aethioboloides Zsckacke		+																	
Thelidium decipiens (Nyl.) Kremp.		+		+															
Thelidium pyrenophorum (Ach.) Mudd			+																
Thelomma ocellatum (Körb.) Tibell							+										+		+
Toninia candida (Weber) Th.Fr.					+		+						+						
Toninia sedifolia (Scop.) Timdal			+		+														+
Toninia taurica (Szatala) Oksner													+						
Toninia tumidula (Sm.) Zahlbr.													+						
Trapeliopsis flexuosa (Fr.) Coppins & P.James								+											
Trapeliopsis granulosa (Hoffm.) Lumbsch								+						+					
Tuckermannopsis chlorophylla (Willd.) Hale						+		+								+			+
Tuckneraria laureri (Kremp.) Randlane & Thell						+		+								+			+
Umbilicaria cylindrica (L.) Duby var. *cylindrica*																	+		
Umbilicaria deusta (L.) Baumg.														+			+		
Umbilicaria nylanderiana (Zahlbr.) H.Magn.																	+		
Usnea cfr.*ceratina* Ach.								+		+						+			
Usnea hirta (L.) F.H.Wigg.						+		+		+									+
Verrucaria hochstetteri Fr.			+	+									+						
Verrucaria margacea (Wahlenb.) Wahlenb.		+																	
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	+																		
Xanthoparmelia somloensis (Gyeln.) Hale								+						+					
Xanthoria candelaria (L.) Th.Fr.							+	+									+		
Xanthoria contortuplicata (Ach.) Boistel				+															
Xanthoria elegans (Link) Th.Fr. subsp. *elegans*			+	+	+		+	+					+		+		+		+
Xanthoria parietina (L.) Th.Fr.							+	+											
Xanthoria sorediata (Vain.) Poelt			+	+									+						
Xylographa parallela (Ach.: Fr.) Behlen & Desberger						+		+			+		+						+

Fig. 1: Ecological requirements of the species represented by 4 indicator values ranging on a five-level ordinal scale (pH = substrate pH; L = light; H = moisture; E = eutrophication). For more detail see M & M section.

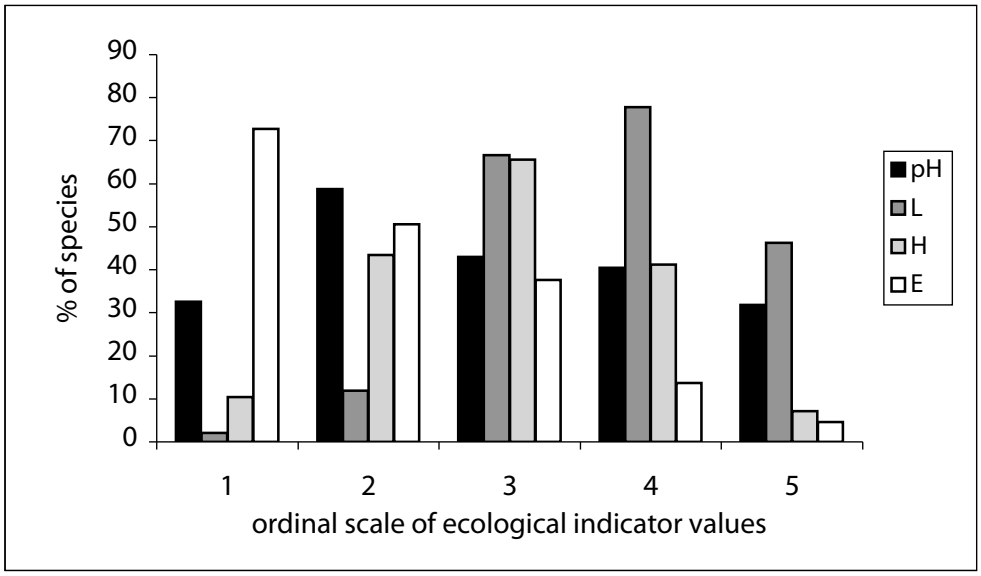

Table 3: Nationally rare species occurring in the selected sites.

	Sites																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	a	b1	b2	b3
Caloplaca herbidella												+			+	+			
Caloplaca scrobiculata				+															
Cetrelia olivetorum															+	+			
Chaenotheca ferruginea									+	+		+		+	+				
Cladonia subulata													+	+					
Gyalidea roseola												+							
Hymenelia ochrolemma					+														
Hypocenomyce caradocensis										+									
Lepraria caesioalba	+				+														
Menegazzia terebrata												+							
Mycoblastus affinis									+										
Nephroma expallidum																		+	
Ochrolechia szatalaensis													+		+	+			
Pycnora sorophora									+	+			+	+					+
Ramalina obtusata									+			+				+			
Ramalina thrausta																+			
Sagiolechia protuberans													+						
Schismatomma pericleum									+			+				+			
Squamarina lamarckii																			+
Tuckneraria laureri						+		+								+			+
Vulpicida tubulosus	+																		
Xanthoria contortuplicata				+															

Rare species were mainly found in forest habitats which in general are those with the higher number of species (Table 4). Also in site 13 (well lit dolomitic rocks) the lichen biota is rich in species, including 4 rare lichens.

Table 4: Species richness and rare species in the selected sites.

Site	Habitat	N° of species	% on the total	N° of rare species
1	Alpine grasslands on calcareous substrates	41	14,7	2
2	Alpine fen (spring)*	3	1,1	0
3	Shaded dolomitic rocks	48	17,2	0
4	Calcareous rubble	49	17,6	2
5	Vulcain rocks and sediments	30	10,8	2
6	*Pinus mugo* formation	43	15,4	1
7	Cut meadows	40	14,3	0
8	Grazed *Larix* forest	80	28,7	1
9	Picea forest	54	19,4	5
10	*Pinus sylvestris* forest	37	13,3	3
11	Burnt forest	14	5,0	0
12	mixed *Picea-Abies* forest	58	20,8	6
13	Well lit dolomitic rocks	77	27,6	4
14	Humid habitats	39	14,0	3
15	Alpine rivers	40	14,3	4
a	Grazed *Larix* forest	54	19,4	7
b1	*Nardus*-formation	27	9,7	0
b2	*Salix reticulata*-formation	25	9,0	1
b3	*Pinus cembra* forest	79	28,3	3

Nine species are new to Trentino-Alto Adige, including *Thelidium aethioboloides* Zschacke non (Nyl.) Vainio which is new to Italy and was recently found in the bordering provinces of Trento and Belluno. Eight species are new to South-Tyrol (Table 5). Among these species, *Nephroma expallidum* (Fig. 2) is a nationally extremely rare species which was known from Veneto (Dolomites) and Piedmont only (Nimis 2003).

Table 5: Species which are new to Trentino-Alto Adige (TAA) and South Tyrol (STy)

Species	**TAA**	**STy**
Acrocordia salweyi	1	
Bacidina inundata		1
Calicium glaucellum	1	
Caloplaca xantholyta		1
Chaenothecopsis pusilla		1
Diploschistes gypsaceus		1
Diplotomma nivale		1
Gyalidea roseola	1	
Hypocenomyce caradocensis	1	

Species	**TAA**	**STy**
Micarea prasina	1	
Nephroma expallidum	1	
Pertusaria hemisphaerica		1
Placynthiella oligotropha		1
Polyblastia ardesiaca	1	
Pycnora sorophora	1	
Ramalina fastigiata		1
Thelidium aethioboloides	1	

Fig. 2: *Nephroma expallidum* (Nyl.) Nyl.
It is an artic-alpine foliose lichen occurring on acid-sub-acid soil, among terricolous mosses in the alpine belt (Nimis 2003). In Italy it is an extremely rare species which was previously known for Piedmont and Veneto (Dolomites). In the study area it was found among *Salix reticulata* in a site which is covered by snow for a long period, near Sasso Piatto.

Fig. 3: *Caloplaca scrobiculata* H. Magn.
It is a crustose lichen typically forming rings on vertical, south-exposed carbonatic rocks in the alpine belt. In Italy it is known in Veneto and Trentino-Alto Adige only, being a very rare species. In the Schlern Nature Park it was found on the top of Mt. Pez where it forms large populations.

On the basis of bibliographical data, a high number of species were known to occur in the Schlern area: 300 were reported by Dalla Torre & Sarnthein (1902), and 108 by Nascimbene (2005). Among them, 124 and 40 were respectively found during this new survey. Overall, 468 species are now known for this area.

4. Discussion and conclusions

This lichen survey in the western Dolomites provided relevant information on alpine lichens, improving floristics both at a local and regional level.
On the basis of both bibliographical and new data, 37% of the species occurring in Trentino-Alto Adige, and 26% of those occurring in the Italian Alps are now listed for the Schlern area, including several nationally rare species mainly centred in subalpine forests.
Despite the fact that differences in sampling sites and area hinder any direct comparison among bibliographical and new data, it's worthy to point out that two large macrolichens such as *Cladonia stellaris* and *Lobaria pulmonaria* were not found during this survey. The former is an extremely rare species which in Italy is exclusive of the Alps (Nimis 2003) and is related to subalpine shrub-dominated habitats. The latter is a flagship species whose populations have been drastically reduced in recent decades due to its sensitiveness to human disturbance being related to humid forests with old trees (Gauslaa 1985, 1995, Gu et al. 2001). *Lobaria pulmonaria* is often used as a model organism for studying conservation biology of lichens (e.g. Scheidegger et al. 1998, Zoller et al. 1999).
According to recent research in the Italian Alps (Nascimbene 2006a, Nascimbene et al. 2006b,), coniferous forests including grazed *Larix* formations, are potentially among the most lichen-rich habitats. Several epiphytic species establish on bark and wood, terricolous species establish on decayed stumps (Nascimbene et al. 2008) while the presence of outcrops enhance the establishment of saxicolous species.
Among the lichen-poor habitats, cut meadow are however interesting because of the presence of scattered old traditional buildings made up by wood and stones. Analogously to results from Scandinavia (Svensson et al 2005), these traditional buildings are suspected to be important lichen habitats in the mountain agricultural landscape of South Tyrol and their role for lichen diversity conservation would be worthy of further research at a regional level.
While high-elevation habitats are scarcely subjected to human activities and the conservation of their biota could mostly depend on large-scale phenomena (e.g. climate change), coniferous forests and freshwaters are those habitats where human disturbance could directly hinder long-term conservation of lichen communities. Therefore, some conclusive remarks are dedicated to these habitats.

Forests
Coniferous forests are important for biodiversity and are included among the habitats worthy of conservation in Europe (EU 92/43 Directive). However, in the Italian Alps their role for lichen conservation is still largely unknown (see e.g. Nascimbene et al. 2006b).
The results of several studies in boreal forests emphasized the importance of old trees for the conservation of red-listed epiphytic lichens and stated that trees hosting red-listed species

are often older than usually allowed in commercial forestry (e.g. Uliczka & Angelstam 1999, Thor 1998). Recently, Johansson et al. (2007) demonstrated that tree age and size have an important role in explaining tree-level species richness and composition.
Also CWD (coarse woody debris) proved to be a key habitat for several organisms such as fungi, bryophytes, lichens, invertebrates, and birds (Ohlson et al. 1997, Jonsell et al. 1998, Similä et al. 2003, Mengak & Guynn 2003, Ódor et al. 2006), and it is known to host several epixylic lichens, whose occurrence is related to the availability of logs, snags, stumps etc. in different decay stages. Several red-listed species are related to different phases of wood decay (Söderström 1988a), so that a great amount of dead wood is crucial for biodiversity conservation in forests (Ohlson et al. 1997, Jonsell et al. 1998, Similä et al. 2003, Clausen et al. 2005). In managed coniferous forests, the most important component of CWD biomass mostly consists of stumps, while logs and snags are rare (Motta et al. 2006). Although several studies demonstrated the importance of CWD for lichen conservation in N-Europe and N-America (Muhle & Le Blanc 1975, Söderström 1988a, 1988b, Daniels 1993, Crites & Dale 1998, Lõhmus & Lõhmus 2001, Caruso et al. 2007), the lichen biota on CWD was only recently studied in the Alps, confirming the importance of CWD for rare species (Nascimbene et al. 2008).
Despite the fact that many epiphytic lichens are strongly affected by forestry practices, particularly logging (e.g. Hyvärinen et al. 1992, Holien 1996, Neitlich & McCune 1997, Sillett & Goslin 1999, Humphrey et al. 2002), detailed information on the effects of forest management on lichens in the Alps is scanty. Management practices need to be evaluated in terms of their ability to sustain rich epiphytic lichen communities which should be included in the framework of indicators used to evaluate the effectiveness of forest management for biodiversity conservation.
Extensive management practices are probably suitable for enhancing the presence of old-growth structures which represent an important habitat for lichens. The general aims of near-to-nature forestry include biodiversity conservation. Hence, the presence of old trees and CWD should be enhanced in the future forest landscape of the Alps, especially in protected areas and Natura 2000 sites, where conservation purposes are explicitly included in the management guidelines.

Freshwaters
Lichens mostly colonise terrestrial habitats, but a few species are restricted to submerged or partially inundated rocks, such as in springs, rivers, and lakes. Freshwater lichens belong to a few genera, the most representative being *Verrucaria*. In spite of their limited number, they are often difficult to identify by non-specialists, taxonomical problems being a constraint for advances in ecological studies. Nascimbene & Nimis (2006) provided a review on freshwater lichens of the Italian Alps, underlining that further surveys are needed to clarify the role of this poorly known guilt in the freshwater habitats of the Alps. In terms of conservation, the main threats to freshwater lichens in the Alps are posed by hydroelectric plans involving water abstraction. However, traditional and tourist use of freshwaters can also lead to a reduction in freshwater lichen diversity if silting and nitrate-phosphate levels are increased. A generalized habitat protection is a prudent approach that may compensate for poor floristic and taxonomic knowledge, especially in protected areas. In their survey on alpine springs Nascimbene et al. (2007b) concluded that single springs host a surprisingly low number of species, while at regional level the entire pool of springs host a relevant aquatic lichen flora, suggesting that a biodiversity conservation plan for this habitat should be necessarily developed at a regional level.

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