Increasing the knowledge on the epiphytic lichens of South Tyrol: a contribution from a three-years project

Juri Nascimbene

Abstract

This study summarizes the floristic results of a lichen survey carried out in 98 forest plots representing the main forest types of South Tyrol. Two-hundred species (193 lichens and 7 non lichenized fungi) were found, including several new records for South Tyrol and Italy. *Rinodina papillata*, found in oak forests, is newly reported for Europe. Several species are of conservation concern, being included in the national red list. The huge amount of data and specimens retrieved with this research project provided a first structured database on the distribution of the lichen species, that was almost completely lacking.

Keywords: forest management, forest types, lichen database, red-listed species, *Rinodina papillata*

1 Introduction

A research project started in 2011 in South Tyrol to investigate the effect of climatic and management-related factors on the distribution of epiphytic lichens in mountain forests (Nascimbene et al. 2012). Epiphytic lichens are a functionally important and species-rich component of alpine forests, including several species of conservation concern (e.g. Nascimbene et al. 2013). In this perspective, the project on the epiphytic lichens of South Tyrol was conceived in three sub-projects addressing three main topics: 1) to test the effect of forest type on patterns of epiphytic lichen diversity in a typical Alpine region by sampling the main forest types occurring in the survey area, also assessing the influence of factors related to forest structure and climatic conditions (submitted manuscript); 2) to evaluate the effects of both intensification of management practices and of abandonment on the biodiversity of Alpine larch grasslands (Nascimbene et al. *in press*); 3) to analyzed the patterns of epiphytic lichen diversity along steep elevation gradients covering the whole range of managed spruce-dominated forests in an Alpine region (submitted manuscript).

A further subproject was dedicated to elucidate small scale patterns and drivers of distribution of some selected species (Ackermann 2012). Floristic data retrieved by this subproject were already published in Nascimbene (2013).

To contribute to the implementation of the lichen database of South Tyrol, this study summarizes the floristic results of the three first subprojects described above, emphasizing the occurrence of newly recorded species and of species of conservation concern.

2 Materials and methods

2.1 Study area and forest types

The study was carried out in South Tyrol (N Italy) that has an area of 7400 km^2. The climate is largely influenced by elevation, ranging from humid warm-temperate conditions in the Adige valley area, with mean annual temperature of 11-12 °C, to alpine conditions above 1700 m, with mean annual temperatures of 2-3 °C. The amount of precipitation is variable across the region (<600-1400 mm y-1) according to topography.
The landscape between 600-2100 m is dominated by forests that cover an area of 370.000 ha (AA.VV., 2010). Pure coniferous forests are the most widespread throughout the region (88 % of the forest surface). Spruce forests are the main forest type (55 %) between 900 and 1900 m, representing the most important forest type for economic exploitation. Larch-stone pine forests are the second forest type per area (27 %), ranging between 1900 and 2100 m, followed by scotch pine forests (11 %) between 900 and 1600 m, and silver fir forests (1 %) between 900 and1600 m. Grazed larch forests are scattered in small patches between 1300 and1800 m. Deciduous forests cover only 5 % of the forest area, mainly beech forests between 700 and 1200 m and coppiced oak forests between 400 and 700 m. Riparian forests, scattered in small patches between 700 and1200 m, are mainly included in small protected biotopes.

2.2 Lichen sampling

The following main forest types were sampled: 1) spruce forests, 2) larch-stone pine forests, 3) silver-fir forests, 4) scotch-pine forests, 5) grazed larch forests, 6) riparian forests, 7) oak forests, and 8) beech forests. Since spruce forests span a wide elevation range, they were split into three different subtypes: (1) low elevation forests (900-1200 m), (2) intermediate elevation forests (1400-1600 m), and (3) high elevation forests (1800-1900 m). Similarly, grazed larch forests were split into three categories depending on management intensity: (1) intensively managed stands that are mown and fertilized twice per year (max. 10 Mg ha^{-1} stall manure per year, corresponding to c. 230 kg ha^{-1} N per year), (2) extensively managed stands that are either mown and fertilized (max. 3 Mg ha^{-1} stall manure per year corresponding to c. 70 kg ha^{-1} N per year) once per year or used for grazing, and (3) abandoned stands, in which forest succession is allowed to proceed on larch grasslands that were abandoned 20-50 years ago. Altogether, 12 different forest types were therefore considered (Table 1, 2) with a total of 98 sampling plots (Table 2). The selection of the sampling plots was performed according to the aims of three sub-projects shortly described in the introduction. The same plot size (circular plots of 13 m radius), the same number of sampled trees (five in each plot), and comparable sampling techniques (Asta et al. 2002), were used for all plots. However, the number of plots for each forest type may differ among them according to specific requirements associated with each sub-project.

Table 1: Information on the 98 sampling plots. For each plot, locality, geographic position (UTM system), elevation, forest type, and the species of the trees selected for the lichen survey are reported.

Plot N°	Locality	N	E	Elevation (m)	Forest type	Sampled tree species
2	Trodena	5132130	681092	1140	Silver_fir_forest	Silver fir
3	Vallarsa	5142486	683084	713	Silver_fir_forest	Silver fir
42	Dobbiaco, Particella 21	5178495	748331	1520	Silver_fir_forest	Silver fir
69	Grissiano	5155635	665589	1200	Silver_fir_forest	Silver fir
70	Grissiano	5155010	667117	912	Silver_fir_forest	Silver fir
7	Favogna	5128700	667953	1134	Beech_forest	Beech
8	Favogna	5128710	668187	1110	Beech_forest	Beech
66	Caldaro	5137693	671419	878	Beech_forest	Beech
67	Caldaro	5138442	671110	745	Beech_forest	Beech
68	Caldaro, strada per Passo Mendola	5144452	671246	900	Beech_forest	Beech
89	Malga Melago - Val Lunga	5187202	627653	1995	Larch-Stone pine_forest	Larch
90	Maso Corto - Val Senales	5177897	636747	1920	Larch-Stone pine_forest	Larch
92	Zirmboden - Obereggen	5139847	696111	2020	Larch-Stone pine_forest	Larch
93	Alpe di Siusi	5155544	707179	2050	Larch-Stone pine_forest	Larch
97	Alpe di Fanes	5164483	731876	2140	Larch-Stone pine_forest	Larch
73	Dobbiaco	5184362,254	745810,0554	1696	Larch_pasture_abandoned	Larch
79	Stern	5163915,344	724179,1376	1802	Larch_pasture_abandoned	Larch
80	Stern	5162578,627	725282,0284	1840	Larch_pasture_abandoned	Larch
86	Vigil	5170091,783	718260,6793	1724	Larch_pasture_abandoned	Larch
87	Dobbiaco	5184486,687	746560,4743	1804	Larch_pasture_abandoned	Larch
88	Dobbiaco	5184182,942	746266,3838	1791	Larch_pasture_abandoned	Larch
95	Innichen	5178432,004	757141,2401	1835	Larch_pasture_abandoned	Larch
71	Dobbiaco	5184070,015	747505,9639	1694	Larch_pasture_non intensive	Larch
74	Dobbiaco	5184338,676	745889,5693	1755	Larch_pasture_non intensive	Larch
75	Toblach	5178322,178	746993,4066	1525	Larch_pasture_non intensive	Larch
77	Innichen	5178570,311	756722,7969	1869	Larch_pasture_non intensive	Larch
83	Vigil	5172198,514	724590,4179	1795	Larch_pasture_non intensive	Larch
84	Vigil	5168721,873	724596,1321	1902	Larch_pasture_non intensive	Larch
94	Innichen	5178132,292	757248,4148	1836	Larch_pasture_non intensive	Larch
72	Dobbiaco	5184208,775	745817,3845	1670	Larch_pasture_intensive	Larch
76	Innichen	5174333,889	756586,6181	1484	Larch_pasture_intensive	Larch
78	Innichen	5175734,815	758686,1666	1623	Larch_pasture_intensive	Larch
81	Stern	5162566,003	724912,0183	1815	Larch_pasture_intensive	Larch
82	Stern	5159927,957	726690,2155	1705	Larch_pasture_intensive	Larch
85	Stern	5158704,279	718016,7931	1735	Larch_pasture_intensive	Larch

Plot N°	Locality	N	E	Elevation (m)	Forest type	Sampled tree species
96	Innichen	5174065,331	756384,6319	1522	Larch_pasture_intensive	Larch
9	Prato allo Stelvio	5162345	619806	1110	Spruce_forest_low elevation	Spruce
10	Prato allo Stelvio	5162469	620332	1110	Spruce_forest_low elevation	Spruce
11	Prato allo Stelvio	5161459	622573	1800	Spruce_forest_high elevation	Spruce
12	Prato allo Stelvio	5161320	622881	1820	Spruce_forest_high elevation	Spruce
13	Prato allo Stelvio	5162072	624199	1590	Spruce_forest_intermediate_ elevation	Spruce
14	Prato allo Stelvio	5162245	623312	1430	Spruce_forest_intermediate_ elevation	Spruce
15	Silandro	5163000	635082	1200	Spruce_forest_low elevation	Spruce
16	Silandro	5162611	634668	1180	Spruce_forest_low elevation	Spruce
17	Silandro	5161170	635274	1850	Spruce_forest_high elevation	Spruce
18	Silandro	5161127	635388	1900	Spruce_forest_high elevation	Spruce
19	Silandro	5162296	635636	1490	Spruce_forest_intermediate_ elevation	Spruce
20	Laces	5162204	641304	936	Spruce_forest_low elevation	Spruce
21	Laces	5161980	641417	1167	Spruce_forest_low elevation	Spruce
22	Silandro	5162355	635399	1525	Spruce_forest_intermediate_ elevation	Spruce
23	Laces	5160659	641430	1900	Spruce_forest_high elevation	Spruce
24	Laces	5160638	642534	1820	Spruce_forest_high elevation	Spruce
25	Laces	5161444	641098	1580	Spruce_forest_intermediate_ elevation	Spruce
26	Laces	5160964	643795	1530	Spruce_forest_intermediate_ elevation	Spruce
29	Tires	5150109	699258	1803	Spruce_forest_high elevation	Spruce
30	Tires	5150144	699191	1822	Spruce_forest_high elevation	Spruce
31	Tires	5149667	698973	1540	Spruce_forest_intermediate_ elevation	Spruce
32	Tires	5150942	697744	1540	Spruce_forest_intermediate_ elevation	Spruce
33	Tires	5150350	693112	1170	Spruce_forest_low elevation	Spruce
34	Tires	5150456	693073	1188	Spruce_forest_low elevation	Spruce
36	Valdaora (Monguelfo)	5181455,222	732688	1190	Spruce_forest_low elevation	Spruce
37	Valdaora (Monguelfo)	5181554,475	732517	1170	Spruce_forest_low elevation	Spruce
38	Monguelfo particella 18	5180961,69	736177	1520	Spruce_forest_intermediate_ elevation	Spruce
39	Valdaora (Monguelfo)	5178676,379	733952,958	1870	Spruce_forest_high elevation	Spruce
40	Valdaora (Monguelfo)	5178634,238	734018	1880	Spruce_forest_high elevation	Spruce
41	Monguelfo	5181763,913	735702	1480	Spruce_forest_intermediate_ elevation	Spruce
44	Selva dei Molini-Bruggerhoff	5196417	719695	1525	Spruce_forest_intermediate_ elevation	Spruce

Plot N°	Locality	N	E	Elevation (m)	Forest type	Sampled tree species
45	Selva dei Molini	5196320	719842	1550	Spruce_forest_intermediate_ elevation	Spruce
46	Selva dei Molini	5196929	721423	1200	Spruce_forest_low elevation	Spruce
47	Selva dei Molini	5195540	720226	1870	Spruce_forest_high elevation	Spruce
48	Selva dei Molini	5195583	720088	1815	Spruce_forest_high elevation	Spruce
49	Selva dei Molini	5196980	721352	1180	Spruce_forest_low elevation	Spruce
52	Racines	5192807	679049	1470	Spruce_forest_intermediate_ elevation	Spruce
53	Racines	5192956	679442	1505	Spruce_forest_intermediate_ elevation	Spruce
54	Racines	5194529	682547	1015	Spruce_forest_low elevation	Spruce
55	Racines	5191479	677855	1800	Spruce_forest_high elevation	Spruce
56	Racines	5191995	679161	1800	Spruce_forest_high elevation	Spruce
57	Racines	5194563	682508	990	Spruce_forest_low elevation	Spruce
60	Val di Funes	5167778	709278	1496	Spruce_forest_intermediate_ elevation	Spruce
61	Val di Funes	5167781	709392	1545	Spruce_forest_intermediate_ elevation	Spruce
62	Val di Funes	5168080	701652	950	Spruce_forest_low elevation	Spruce
63	Val di Funes	5166974	711080	1845	Spruce_forest_high elevation	Spruce
64	Val di Funes - Malga Zannes	5167289	711178	1860	Spruce_forest_high elevation	Spruce
65	Val di Funes	5168629	700742	900	Spruce_forest_low elevation	Spruce
1	Aldino-Nova Lev	5139555	682640	1305	Scotch pine_forest	Scotch pine
5	San Genesio	5156739	677517	1260	Scotch pine_forest	Scotch pine
35	Fiè allo Sciliar	5153572	694257	1165	Scotch pine_forest	Scotch pine
50	Brunico - San Giorgio	5189232	723227	860	Scotch pine_forest	Scotch pine
91	Renon	5159616	687728	1470	Scotch pine_forest	Scotch pine
4	Costa	5146662	680687	667	Oak_forest	Oak
6	Passeggiata S. Osvaldo	5152996	681089	440	Oak_forest	Oak
58	Rablà	5171170	657158	615	Oak_forest	Oak
59	Terlano	5158218	671302	585	Oak_forest	Oak
98	Monticolo	5141908	675041	620	Oak_forest	Oak
27	Ontaneta di Cengles	5164231	625299	900	Riparian_forest	Alder
28	Ontaneta di Sluderno	5167579	621090	910	Riparian_forest	Alder
43	Lago di Dobbiaco	5176625	746039	1280	Riparian_forest	Willow
51	Gais - Val Aurina	5192740	725073	845	Riparian_forest	Alder

Table 2: List of the species in alphabetical order. For each species, the total frequency in each forest type is reported. Frequency values range between 0 and1200 in spruce forests, and between 0 and 700 in larch pastures and between 0 and 500 in the other forest types. For each forest type, the total number of species and red-listed species are reported.
SF = Silver-fir forests; B = Beech forests; LSP = Larch-Stone pine forests; A = abandoned; E = extensively managed; I = intensively managed; H = high elevation; In = intermediate elevation; L = low elevation; SP = Scotch pine forests; O = oak forests; R = riparian forests.

Forest type	SF	B	LSP	Larch pasture			Spruce			SP	O	R
Sub-type				A	E	I	H	In	L			
Total Number of species	**55**	**20**	**40**	**52**	**57**	**56**	**80**	**87**	**61**	**30**	**35**	**43**
Number of Red listed species	**5**	**0**	**2**	**2**	**2**	**1**	**9**	**7**	**6**	**2**	**2**	**3**
Lichenized species												
Agonimia opuntiella (Poelt & Buschardt) Vezda	.	.	.	.	.	.	.	.	.	.	27	27
Alectoria sarmentosa (Ach.) Ach.	.	.	2	.	.	.	.	.	.	.	.	.
Allocetraria oakesiana (Tuck.) Randlane & Thell	13	.	.	.	.	.	.	17	.	.	.	.
Amandinea punctata (Hoffm.) Coppins & Scheid.	.	.	.	2	2	59	.	.	102	.	16	16
Anisomeridium polypori (Ellis & Everh.) M.E.Barr	13	18	.	.	.	.	.	.	9	.	.	.
Aplotomma turgida (A.Massal.) A.Massal.	9	.	7	1	1	.	3	17	16	1	.	17
Arthonia apatetica (A.Massal.) Th.Fr.	.	.	.	.	.	.	.	2	.	.	.	.
Arthonia didyma Körb.	6	69	.	.	.	.	.	1	3	.	.	9
Arthonia mediella Nyl.	4	.	.	2	.	.	.	.	.	.	.	.
Arthonia radiata (Pers.) Ach.	.	40	.	.	.	.	.	.	.	.	.	.
Bacidia arceutina (Ach.) Arnold	.	.	.	.	.	.	.	.	.	.	.	2
Bacidia circumspecta (Vain.) Malme	.	.	.	.	.	.	.	.	.	.	.	7
Bacidina phacodes (Körb.) Vězda	.	.	.	.	.	4	.	.	.	.	.	.
Biatora chrysantha (Zahlbr.) Printzen	2	.	.	.	.	2	47	29	.	.	.	.
Biatora efflorescens (Hedl.) Räsänen	.	.	.	.	.	4	.	.	.	.	.	.
Biatora nylanderi Anzi	.	.	.	4	5	.	.	.	.	.	.	.
Bryoria fuscescens (Gyeln.) Brodo & D.Hawksw.	.	.	37	.	.	.	525	10	.	.	.	.
Bryoria implexa (Hoffm.) Brodo & D.Hawksw.	.	.	.	.	.	.	24	.	.	.	.	.
Bryoria nadvornikiana (Gyeln.) Brodo & D.Hawksw.	.	.	.	.	.	.	411	11	.	.	.	.
Bryoria subcana (Nyl. ex Stizenb.) Brodo & D.Hawksw.	.	.	22	17	202	49	.	42	.	.	.	.
Buellia schaereri De Not.	5	.	34	39	37	14	272	253	12	.	.	.
Calicium abietinum Pers.	.	.	.	5	.	.	.	.	.	.	.	.
Calicium pinastri Tibell	.	.	.	2	2	.	.	.	.	23	.	.
Calicium trabinellum (Ach.) Ach.	.	.	2	.	.	.	8	.	.	.	.	.
Calicium viride Pers.	8	.	5	.	1	.	456	49	.	.	.	.
Caloplaca cerina (Hedw.) Th.Fr. v. cerina	.	.	.	.	.	.	.	.	.	.	1	3
Caloplaca cerinella (Nyl.) Flagey	.	.	.	.	.	.	.	.	.	.	.	11
Caloplaca cerinelloides (Erichsen) Poelt	.	.	.	.	.	2	.	.	.	.	.	.
Caloplaca herbidella (Hue) H.Magn.	.	.	.	.	.	.	.	.	.	.	.	28
Caloplaca pyracea (Ach.) Th.Fr.	.	.	.	.	.	.	.	.	.	.	1	18
Candelaria concolor (Dicks.) Stein	.	4	.	.	.	.	.	.	.	.	158	201
Candelariella efflorescens auct. eur.	.	.	.	.	.	.	.	.	.	.	9	9
Candelariella lutella (Vain.) Räsänen	.	.	.	.	.	.	.	.	.	.	.	13
Candelariella reflexa (Nyl.) Lettau	.	51	.	.	.	7	.	.	.	.	79	135
Candelariella xanthostigma (Ach.) Lettau	.	.	.	.	.	4	.	.	.	.	65	67

Forest type	SF	B	LSP	Larch pasture			Spruce			SP	O	R
Sub-type				A	E	I	H	In	L			
Catillaria alba Coppins & Vezda	.	.	.	.	.	.	2	.	.	.	.	.
Catillaria nigroclavata (Nyl.) Schuler	.	.	.	.	.	.	.	.	.	.	16	60
Cetrelia cetrarioides (Zahlbr.) W.L.Culb. & C.F.Culb.	.	.	.	.	.	.	.	.	6	.	.	.
Cetrelia monachorum (Zahlbr.) W.L.Culb. & C.F.Culb.	.	.	.	.	.	.	.	2	.	.	.	.
Chaenotheca chlorella (Ach.) Müll.Arg.	.	.	.	.	.	.	.	.	5	.	.	.
Chaenotheca chrysocephala (Ach.) Th.Fr.	24	.	1	29	22	.	428	183	130	4	.	.
Chaenotheca ferruginea (Sm.) Mig.	.	.	.	12	5	1	18	8	2	11	.	.
Chaenotheca furfuracea (L.) Tibell	6	.	.	7	.	.	26	15	47	.	.	.
Chaenotheca gracilenta (Ach.) E.Mattson & Middelborg	.	.	.	.	.	.	.	1	85	.	.	.
Chaenotheca phaeocephala (Turner) Th.Fr.	.	.	.	.	.	.	7	.	.	.	.	.
Chaenotheca stemonea (Ach.) Müll.Arg.	.	.	.	1	.	.	34	14	9	1	.	.
Chaenotheca subroscida (Eitner) Zahlbr.	5	.	.	.	.	.	107	.	.	.	.	.
Chaenotheca trichialis (Ach.) Th.Fr.	26	.	.	18	10	.	484	167	247	.	.	.
Chrysothrix candelaris (L.) J.R.Laundon	104	.	.	.	.	.	118	379	598	.	.	.
Cladonia borealis S. Stenroos	.	.	.	.	.	.	2	.	.	.	.	.
Cladonia cenotea (Ach.) Schaer.	.	.	.	1	7	7	.	5	.	.	.	.
Cladonia chlorophaea (Florke ex Sommerf.) Sprengel	.	.	.	12	26	17	.	.	.	.	.	.
Cladonia coniocraea (Flörke) Spreng.	.	.	.	15	47	16	7	49	14	1	.	.
Cladonia digitata (L.) Hoffm.	.	.	21	53	132	26	37	39	1	15	.	.
Cladonia fimbriata (L.) Fr.	.	.	.	.	1	.	.	.	.	.	.	.
Cladonia macilenta Hoffm. subsp. macilenta	.	.	.	3	9	.	.	.	.	.	.	.
Cladonia pyxidata (L.) Hoffm.	.	.	.	.	.	.	10	19	.	.	.	.
Cliostomum corrugatum (Ach. Fr.) Fr.	.	.	.	.	.	.	27	.	.	.	.	.
Cyphelium inquinans (Sm.) Trevis.	.	.	.	.	.	.	2	.	.	.	.	.
Cyphelium tigillare (Ach.) Ach.	.	.	7	1	28	12	.	.	.	.	.	.
Dimerella pineti (Ach.) Vězda	3	.	.	.	.	.	16	6	94	4	.	.
Eopyrenula leucoplaca (Wallr.) R.C.Harris	.	.	.	.	.	.	.	.	.	.	94	94
Evernia divaricata (L.) Ach.	6	.	.	1	2	.	60	36	3	.	.	.
Evernia mesomorpha Nyl.	.	.	7	10	29	13	.	14	2	1	.	.
Evernia prunastri (L.) Ach.	4	.	.	.	5	8	.	64	47	.	.	3
Fellhanera bouteillei (Desm.) Vězda	24	.	.	.	.	.	.	.	.	.	.	.
Flavoparmelia caperata (L.) Hale	.	.	.	.	.	.	.	.	20	3	82	82
Flavopunctelia flaventior (Stirt.) Hale	.	.	.	.	.	.	.	.	.	4	41	41
Flavopunctelia soredica (Nyl.) Hale	.	.	.	.	.	.	.	.	.	.	3	3
Graphis scripta (L.) Ach.	21	370	.	.	.	.	.	.	.	.	.	.
Hyperphyscia adglutinata (Flörke) H.Mayrhofer & Poelt	.	7	.	.	.	.	.	15	.	.	245	289
Hypocenomyce scalaris (Ach.) M.Choisy	.	.	157	101	224	71	.	.	17	96	.	.
Hypogymnia austerodes (Nyl.) Räsänen	.	.	24	.	.	.	.	.	.	.	.	.
Hypogymnia bitteri (Lynge) Ahti	.	.	7	4	59	7	64	36	.	.	.	.
Hypogymnia farinacea Zopf	.	.	13	.	.	1	11	11	.	.	.	.
Hypogymnia physodes (L.) Nyl.	47	.	109	238	283	137	939	1151	228	65	.	8
Hypogymnia tubulosa (Schaer.) Hav.	3	.	2	39	27	14	43	65	.	1	.	.
Hypogymnia vittata (Ach.) Parrique	.	.	.	.	1	.	.	.	.	.	.	.
Hypotrachyna revoluta (Flörke) Hale	.	.	.	.	.	.	.	.	1	.	.	.
Imshaugia aleurites (Ach.) S L.F.Meyer	.	.	222	57	113	27	11	57	.	163	.	.

Forest type	SF	B	LSP	Larch pasture			Spruce			SP	O	R
Sub-type				A	E	I	H	In	L			
Japewia tornoensis (Nyl.) Tønsberg	.	.	.	.	1	.	1	.	.	.	.	.
Lecania cyrtella (Ach.) Th.Fr.	.	.	.	.	.	.	.	.	.	.	.	26
Lecania hyalina (Fr.) R.Sant.	.	.	.	.	.	.	1	.	10	.	.	.
Lecania naegelii (Hepp) Diederich & Van den Boom	.	.	.	.	.	.	.	.	.	.	.	7
Lecanora albellula Nyl.	.	.	.	12	14	24	101	78	5	.	.	.
Lecanora argentata (Ach.) Malme	18	36	.	.	.	.	16	1	.	.	.	.
Lecanora cadubriae (A.Massal.) Hedl.	.	.	16	.	31	12	36	1	.	.	.	.
Lecanora carpinea (L.) Vain.	9	.	.	.	.	.	.	.	.	.	.	1
Lecanora chlarotera Nyl.	.	3	.	.	.	.	6	.	.	.	4	16
Lecanora circumborealis Brodo & Vitik.	.	.	.	.	.	.	1	.	.	.	.	.
Lecanora expallens Ach.	.	.	.	.	.	.	49	32	2	.	3	3
Lecanora impudens Degel.	.	.	.	.	.	.	4	10	.	.	.	43
Lecanora leptyrodes (Nyl.) Degel.	9	.	.	.	.	.	.	.	.	.	.	6
Lecanora pulicaris (Pers.) Ach.	.	.	.	5	3	7	1	2	.	.	.	.
Lecanora salicicola H.Magn.	.	.	.	.	15	2	48	.	.	.	.	.
Lecanora symmicta (Ach.) Ach.	.	.	.	.	1	2	.	.	7	.	.	.
Lecanora symmictiza (Nyl.) Hedl.	.	.	16	.	.	.	79	5	.	.	.	.
Lecanora varia (Hoffm.) Ach.	.	.	9	.	.	14	.	.	.	.	.	.
Lecidea pullata (Norman) Th.Fr.	.	.	.	.	.	.	13	.	.	.	.	.
Lecidea turgidula Fr.	.	.	.	.	2	.	.	.	.	.	.	.
Lecidella elaeochroma (Ach.) M.Choisy	4	29	.	.	.	.	.	.	.	.	29	86
Lecidella flavosorediata (Vězda) Hertel & Leuckert	.	.	.	7	.	.	.	.	.	.	.	3
Lepraria eburnea J.R.Laundon	48	.	.	.	.	.	.	1	122	7	.	.
Lepraria elobata Tønsberg	.	.	.	16	17	20	17	18	.	4	.	.
Lepraria incana (L.) Ach.	.	.	.	.	.	.	3	70	2	.	.	.
Lepraria jackii Tønsberg	28	.	.	27	19	.	12	15	.	5	.	.
Lepraria leuckertiana (Zedda) L. Saag.	.	.	.	.	.	.	.	.	42	13	.	.
Lepraria lobificans Nyl.	.	8	.	.	.	.	34	20	71	.	2	2
Lepraria rigidula (de Lesd.) Tønsberg	.	.	.	3	1	.	.	.	1	10	.	.
Leptogium saturninum (Dicks.) Nyl.	.	.	.	.	.	.	.	.	.	.	.	1
Letharia vulpina (L.) Hue	.	.	183	.	23	.	31	2	.	.	.	.
Loxospora elatina (Ach.) A.Massal.	22	.	.	1	3	.	6	26	10	.	.	.
Melanelixia glabratula (Lamy) Sandler & Arup	61	.	.	1	.	.	25	204	143	1	30	47
Melanelixia subargentifera (Nyl.) O. Blanco et al.	.	.	.	.	.	2	.	.	.	.	.	.
Melanelixia subaurifera (Nyl.) O. Blanco et al.	.	.	.	.	.	.	.	.	14	.	51	57
Melanohalea exasperatula (Nyl.) O. Blanco et al.	.	.	.	8	3	55	.	24	.	.	.	.
Micarea botryoides (Nyl.) Coppins	.	.	1	.	.	.	.	.	.	.	.	.
Micarea melaena (Nyl.) Hedl.	.	.	2	.	.	.	.	.	.	.	.	.
Micarea prasina sl	48	.	.	38	.	3	15	16	40	3	.	.
Mycobilimbia epixanthoides (Nyl.) Vitik. et al.	.	35	.	.	.	.	.	.	.	.	.	.
Mycoblastus affinis (Schaer.) T.Schauer	.	.	.	.	.	.	.	.	.	.	.	2
Normandina pulchella (Borrer) Nyl.	.	.	.	.	.	.	.	.	.	.	9	9
Ochrolechia alboflavescens (Wulfen) Zahlbr.	.	.	12	2	17	2	190	5	.	.	.	.
Ochrolechia arborea (Kreyer) Almb.	.	.	.	.	.	.	43	17	.	.	.	.
Ochrolechia microstictoides Räsänen	8	.	4	6	8	.	74	50	3	.	.	.

Forest type	SF	B	LSP	Larch pasture			Spruce			SP	O	R
Sub-type				A	E	I	H	In	L			
Ochrolechia szatalaensis Verseghy	5	.	.	.	.	.	.	.	.	.	.	.
Opegrapha atra Pers.	14	17	.	.	.	.	.	.	.	.	.	12
Opegrapha niveoatra (Borrer) J.R.Laundon	73	.	.	.	.	.	.	6	90	.	.	.
Opegrapha varia Pers.	5	3	.	.	.	.	.	.	.	.	.	.
Opegrapha viridis (Ach.) Behlen & Desberger	12	.	.	.	.	.	.	.	.	.	.	.
Opegrapha vulgata Ach.	35	.	.	.	.	.	.	11	104	.	.	.
Opegrapha zonata Körb.	38	.	.	.	.	.	.	.	.	.	.	.
Pachyphiale fagicola (Hepp) Zwackh	.	.	.	.	.	.	.	.	.	.	.	12
Parmelia saxatilis (L.) Ach.	41	.	6	6	22	.	179	309	2	17	.	.
Parmelia sulcata Taylor	.	.	1	44	45	60	78	107	9	8	19	122
Parmelina tiliacea (Hoffm.) Hale	.	.	.	.	.	.	.	.	.	.	3	3
Parmeliopsis ambigua (Wulfen) Nyl.	1	.	195	225	241	125	998	591	13	146	.	.
Parmeliopsis hyperopta (Ach.) Arnold	.	.	6	51	91	20	262	153	7	1	.	.
Pertusaria albescens (Huds.) M.Choisy & Werner	27	.	.	.	.	.	.	1	.	.	.	3
Pertusaria amara (Ach.) Nyl.	22	.	.	.	.	.	4	35	.	.	.	.
Pertusaria hemisphaerica (Flörke) Erichsen	2	.	.	.	.	.	.	4	.	.	.	.
Pertusaria leioplaca DC.	.	12	.	.	.	.	.	.	.	.	.	.
Pertusaria ophthalmiza (Nyl.) Nyl.	1	.	.	.	.	.	.	1	.	.	.	.
Pertusaria pupillaris (Nyl.) Th.Fr.	.	.	.	.	.	.	3	11	6	.	.	.
Phaeophyscia chloantha (Ach.) Moberg	.	47	.	.	.	.	.	.	.	.	74	117
Phaeophyscia hirsuta (Mereschk.) Essl.	.	.	.	.	.	.	.	.	.	.	13	13
Phaeophyscia orbicularis (Neck.) Moberg	.	.	.	.	.	2	.	.	.	.	27	67
Phlyctis argena (Spreng.) Flot.	189	85	.	.	.	.	.	2	92	.	.	46
Physcia adscendens (Fr.) H.Olivier	.	.	.	.	.	3	.	.	1	.	70	155
Physcia dubia (Hoffm.) Lettau	.	.	.	.	.	11	.	.	.	.	.	.
Physcia tenella (Scop.) DC.	.	.	.	.	.	25	.	.	.	.	.	5
Physconia distorta (With.) J.R.Laundon	.	.	.	.	.	.	.	.	.	.	.	1
Physconia perisidiosa (Erichsen) Moberg	.	.	.	.	.	.	.	.	.	.	.	2
Placynthiella icmalea (Ach.) Coppins & P.James	.	.	.	.	17	1	4	.	3	.	.	.
Platismatia glauca (L.) W. L. Culb. & C. F. Culb.	24	.	6	.	3	.	64	19	.	.	.	.
Porina aenea (Wallr.) Zahlbr.	2	3	.	.	.	.	.	3	45	.	.	.
Pseudevernia furfuracea (L.) Zopf var. furfuracea	4	.	.	7	39	11	111	108	.	1	.	.
Pseudevernia furfuracea var. ceratea (Ach.) D.Hawksw.	.	.	260	38	167	56	621	193	.	.	.	.
Punctelia subrudecta (Nyl.) Krog	.	.	.	.	.	.	.	.	.	.	10	10
Pycnora sorophora (Vain.) Hafellner	.	.	31	.	.	.	.	.	.	192	.	.
Ramalina farinacea (L.) Ach.	3	.	.	.	.	.	2	8	.	.	1	5
Ramalina obtusata (Arnold) Bitter	17	.	.	.	.	.	55	101	5	.	.	.
Ramalina pollinaria (Westr.) Ach.	.	.	.	.	.	.	.	.	10	.	.	.
Ramalina thrausta (Ach.) Nyl.	.	.	.	.	.	.	24	2	.	.	.	.
Rinodina albana (A.Massal.) A.Massal.	.	1	.	.	.	.	.	.	.	.	.	.
Rinodina capensis Hampe	.	.	.	.	.	.	.	3	.	.	.	.
Rinodina degeliana Coppins	.	.	.	.	.	.	.	10	2	.	.	.
Rinodina exigua (Ach.) Gray	.	.	.	.	.	.	.	.	9	.	.	.
Rinodina papillata H. Magn.	.	.	.	.	.	.	.	.	.	.	71	71
Rinodina poeltiana Giralt & Obermayer	.	.	.	.	.	.	.	.	.	.	40	40

Forest type	SF	B	LSP	Larch pasture			Spruce			SP	O	R
Sub-type				A	E	I	H	In	L			
Rinodina septentrionalis Malme	.	.	.	.	.	2	.	.	.	.	.	.
Schismatomma pericleum (Ach.) Branth & Rostr.	71	.	.	.	.	.	163	21	46	.	.	.
Scoliciosporum chlorococcum (Stenh.) Vězda	.	.	.	.	.	.	.	.	.	.	11	11
Scoliciosporum umbrinum (Ach.) Arnold	.	.	.	.	.	2	.	.	.	.	.	.
Strangospora moriformis (Ach.) Stein	.	.	13	.	.	.	.	.	.	.	.	.
Thelomma ocellatum (Körb.) Tibell	.	.	2	.	.	1	.	.	.	.	.	.
Trapeliopsis flexuosa (Fr.) Coppins & P.James	.	.	2	2	54	26	.	5	.	13	.	.
Tuckermannopsis chlorophylla (Willd.) Hale	3	.	13	5	49	9	527	82	4	.	.	.
Tuckneraria laureri (Kremp.) Randlane & Thell	.	.	5	39	106	5	120	67	1	.	.	.
Usnea barbata (L.) Weber ex F.H. Wigg.	.	.	4	.	8	1	46	12	.	.	.	.
Usnea diplotypus Vain.	.	.	.	.	.	.	46	.	.	.	.	.
Usnea filipendula Stirt.	.	.	.	.	.	.	5	7	.	.	.	.
Usnea florida (L.) F.H.Wigg.	.	.	.	.	.	.	16	.	.	.	.	.
Usnea hirta (L.) F.H.Wigg.	5	.	120	154	283	72	528	634	.	.	.	.
Usnea intermedia (A. Massal.) Jatta	.	.	.	.	.	.	.	2	.	.	.	.
Usnea subfloridana Stirt.	.	.	.	28	68	29	11	.	.	.	.	.
Usnea substerilis Motyka	.	.	.	.	.	.	.	17	.	.	.	.
Vulpicida pinastri (Scop.) J.E.Mattsson & M.J.Lai	1	.	23	116	189	71	294	424	73	1	.	.
Xanthoria candelaria (L.) Th.Fr.	.	.	.	9	.	135	.	2	.	.	.	.
Xanthoria fallax (Hepp) Arnold	.	.	.	.	.	.	.	.	.	.	30	56
Xanthoria fulva (Hoffm.) Poelt & Petutschnig	.	.	.	.	.	.	.	.	.	.	7	7
Xanthoria parietina (L.) Th.Fr.	.	.	.	.	.	.	.	.	.	.	3	57
Xanthoria polycarpa (Hoffm.) Rieber	.	.	.	.	.	4	.	.	.	.	.	.
Non Lichenized species												
Chaenothecopsis pusilla (Ach.) A. F. W. Schmidt	.	.	.	.	.	.	125	2	6	.	.	.
Microcalicium disseminatum (Ach.) Vain.	.	.	.	1	7	.	98	11	.	.	.	.
Mycocalicium subtile (Pers.) Szatala	.	.	.	.	.	.	24	.	1	.	.	.
Naetrocymbe punctiformis (Pers.) R.C.Harris	.	5	.	.	.	.	.	.	.	.	.	61
Sarea difformis (Fr.) Fr.	2	.	.	.	.	.	.	.	2	.	.	.
Stenocybe major Körb.	12	.	.	.	.	.	.	.	.	.	.	.
Tromera resinae (Fr.) Körb.	.	.	.	.	.	.	.	1	2	.	.	.

2.3 Species identification, nomenclature, and species traits

When possible, lichens were identified in the field. However, in most cases species identification was based on the study of specimens (c. 1200) collected and stored both in the personal herbarium of JN and in the herbarium of the Nature Museum of South Tyrol (Bolzano). Especially crustose lichens were identified in the laboratory using a dissecting and a biological microscope. Routine chemical spot tests were performed for most specimens. The identification of sterile crustose lichens (including all *Lepraria* species; c. 150 specimens) was based on standardized thin-layer chromatography (TLC), following the protocols of White & James (1985) and Orange et al. (2001). Nomenclature of lichens mainly follows Wirth et al. (2013).

The species ecological traits were evaluated using the ecological indicator values retrieved from Nimis & Martellos (2008). 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) 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); (c) 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); (d) eutrophication (1 = no eutrophication; 2 = very weak eutrophication; 3 = weak eutrophication; 4 = rather high eutrophication; 5 = very high eutrophication).

Also biological traits of the species (growth forms, photobiont type, and reproductive strategies) were retrieved from Nimis & Martellos (2008). 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, leprose 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.

3 Results and discussion

One-hundred-ninety-three lichenized and seven non lichenized species were found (Table 2). Among lichenized species, 118 are crustose, 46 are foliose, and 29 are fruticose and the two main reproduction strategies are by ascospores (sexual reproduction, 90 species) and asexually by soredia (90 species) and the photobiont is mainly a coccoid green alga (174 species), while species with cyanobacteria or Trentepholia are rare (1 and 18 species respectively). All the non-lichenized species are crustose and reproduce by ascospores.

Only a few species were extremely common (i.e. occurrence in >50 % of the plots), including Hypogymnia physodes, Parmeliopsis ambigua, Vulpicida pinastri and two caliciales (Chaenotheca trichialis, and Ch. chrysocephala); 25 species occurred between 49-20 % of the plots, including Ramalina obtusata and Tuckneraria laureri and several acidophytic lichens typical of coniferous forests (i.e. Evernia divaricata, Pseudevernia furfuracea s.l., Tuckermannopsis chlorophylla); 61 species occurred between 19-5 % of the plots, while

106 species occurred in less than 5% of the plots, 52 of them having being found in one plot only.
Rinodina papillata, found in two oak forests (plot 4, and 98), is newly reported for Europe and will be commented in detail in a forthcoming publication. Three species are new to Italy, 11 to Trentino-Alto Adige and 23 to South Tyrol (Table 3). Lecanora symmictiza was recently found in Italy near Obereggen (Nascimbene J. 2013), while Cetrelia monachorum was reported by Obermayer & Mayrhofer (2007) from Friuli-Venezia and South Tyrol.
Fourteen species (7% of the total flora) are included as threatened and 5 as near-threatened in the red list of the epiphytic lichens of Italy (Nascimbene et al., 2013) and are therefore of conservation concern (Table 3). In all forest types, except beech forests, some red listed species were found, with a relatively high incidence (≥7%) in spruce, silver-fir, and riparian forests. However, each forest type hosted a peculiar lichen assemblage with some species that were exclusively or more frequently found in one of them (Table 2).
The ecology of the species reflects the features of the main forest types (Figure 1), most of them being linked to acidic substrates (i.e. bark of conifers), preferring intermediate and well-lit conditions, humid-moderately humid habitats. The most part of the species are intolerant or scarcely tolerant to eutrophication. This warns against the potentially negative effects of increasing eutrophication that could be related with anthropic activities (Giordani et al. 2014).
The ecological and conservation-related issues based on this three-years research are being published in separated papers whose core messages are:
1) different forest types host peculiar lichen communities, suggesting that the conservation of lichen diversity is entrusted to the maintenance of forest landscape heterogeneity, including forest types of minor economic value and rural habitats;
2) the management intensity of larch grasslands strongly influences lichen diversity, with a general pattern indicating the best conditions in extensively managed stands. Both abandonment and management intensification were detrimental to biodiversity;
3) patterns of epiphytic lichen diversity along elevation gradients are associated with a mechanism of traits selection and corroborate the hypothesis that the species-elevation relationship reflects the physiological response of these organisms to the main climatic factors. Results warn for major shifts under climate change that could cause a severe extinction risk for many species.
The floristic results of this three-years project allowed to markedly improve the knowledge on the epiphytic lichens of South Tyrol, with several new records for the study area, Italy, and even one new record for Europe. Moreover, the huge amount of data and specimens retrieved from the 98 sampling plots also provided a first structured database on the distribution of the species, that was almost completely lacking.

Table 3: List of the noteworthy species including those that are newly reported for different geographic areas (Europe, Italy, Trentino-Alto Adige, South Tyrol) and the red-listed species according with Nascimbene et al. (2013).
Cr = critically endangered; En = endangered; Vu = vulnerable; Nt = near threatened.

Species	New_Europe	New_Italy	New_TAA	New_ST	Red List
Agonimia opuntiella				+	
Allocetraria oakesiana					Vu
Anisomeridium polypori				+	
Bacidia circumspecta				+	
Calicium pinastri		+			
Caloplaca herbidella					Nt
Candelariella efflorescens				+	
Candelariella lutella				+	
Catillaria alba			+		Cr
Cetrelia cetrarioides				+	
Chaenotheca chlorella			+		En
Chaenotheca gracilenta				+	Vu
Chaenotheca subroscida				+	
Cladonia borealis			+		
Cliostomum corrugatum					Nt
Cyphelium inquinans					Vu
Eopyrenula leucoplaca					Nt
Fellhanera bouteillei			+		Nt
Flavopunctelia soredica					En
Japewia tornoënsis				+	
Lecania hyalina				+	
Lecanora impudens				+	Vu
Lecanora salicicola				+	
Lecidea pullata				+	
Lecidella flavosorediata			+		
Lepraria eburnea				+	
Lepraria elobata				+	
Lepraria incana			+		
Lepraria jackii			+		
Lepraria leuckertiana			+		En
Lepraria lobificans				+	
Lepraria rigidula				+	
Loxospora elatina					En
Mycobilimbia epixanthoides			+		
Mycoblastus affinis					En
Opegrapha zonata				+	
Pachyphiale fagicola			+		

Species	New_Europe	New_Italy	New_TAA	New_ST	Red List
Pertusaria pupillaris				+	
Pycnora sorophora					Vu
Ramalina obtusata					Vu
Rinodina degeliana		+			
Rinodina papillata	+				
Rinodina poeltiana		+			
Sarea difformis			+		
Schismatomma pericleum					Nt
Stenocybe major				+	
Tuckneraria laureri					Vu
Usnea barbata					
Usnea diplotypus				+	Cr
Usnea subfloridana				+	
Usnea substerilis				+	

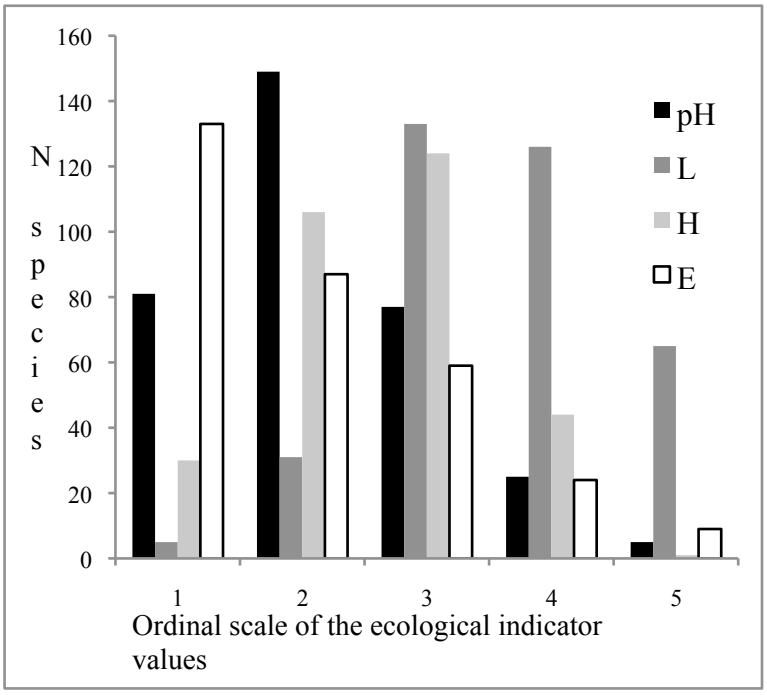

Figure 1: Ecological requirements of the lichenized species represented by 4 indicator values ranging on a five-level ordinal scale (pH = substrate pH; L = light; H = moisture; E = eutrophication). For more details see M & M section.

Riassunto

Questo studio riassume i risultati di un'indagine lichenologia condotta nell'ambito di un progetto triennale in 98 plot forestali distribuiti nell'intero territorio sudtirolese in diversi tipi di bosco. In totale sono stati censiti 193 licheni epifiti e 7 funghi non lichenizzati. Molte specie sono nuove per l'Alto Adige e per l'Italia. *Rinodina papillata*, rinvenuta in alcuni querceti della parte meridionale dell'area di studio, è nuova a livello Europeo. Molte specie sono incluse nella lista rossa nazionale ed hanno pertanto un marcato interesse conservazionistico. Nel complesso, la grande mole di dati e campioni ottenuti con questo progetto costituiscono un primo database informativo sulla distribuzione delle specie licheniche in Alto Adige.

Zusammenfassung

Diese Untersuchung umfasst die floristischen Ergebnisse einer Flechtenstudie, die an 98 Waldstandorten durchgeführt wurde. Diese repräsentieren die wichtigsten Waldtypen von Südtirol. Insgesamt wurden 200 Arten (193 Flechten und 7 Nicht-Flechtenpilze "non lichenized fungi") nachgewiesen, darunter etliche Neumeldungen für Südtirol und Italien. Die Art *Rinodina papillata* aus Eichenwäldern stellt eine Neumeldung für Europa dar. Mehrere Arten sind als gefährdet bekannt und stehen in der nationalen Roten Liste. Die im Rahmen dieses Forschungsprojektes große Menge an erfassten Individuen stellt die Grundlage für eine Datenbank zur Verbreitung von Flechtenarten dar, die bisher nahezu völlig gefehlt hat.

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Author's addresses:

Dr. Juri Nascimbene
Department of Life Sciences
University of Trieste
via Giorgieri 10
34100 Trieste, Italy

Nature Museum of South Tyrol
via Bottai 1
39100 Bolzano, Italy
junasc@libero.it

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