Lichenologist **28**(3): 245–256 (1996)

THE IMPORTANCE OF SOREDIATE CRUSTOSE LICHENS IN THE EPIPHYTIC LICHEN FLORA OF THE SWISS PLATEAU AND THE PRE-ALPS

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Abstract: Standardized lichen surveys were conducted on 849 trees in 132 ecological long-term observation plots in the Swiss Plateau and Pre-Alps: 262 lichen taxa were identified, 64 (24%) of them sorediate crustose species. Their mean percentage of the flora on individual trees and in individual plots was even higher. The mean percentage of crustose lichen species with vegetative propagules, such as soredia, was per plot significantly higher in the Pre-Alps than in the Plateau, higher in forest than in non-forest areas, and, according to the vegetation belts, lowest in the colline-submontane zone. It was found that the biodiversity of lichens could not be determined without considering the sorediate crustose lichens. Furthermore, by performing standardized surveys of all taxa, the occurrence of the following species in Switzerland was confirmed for the first time: *Cliostomum leprosum*, *Fuscidea arboricola*, *Fuscidea pusilla*, *Hypocenomyce leucococca*, *Hypocenomyce sorophora*, *Lecanora norvegica*, *Lepraria eburnea*, *Lepraria elobata*, *Lepraria jackii*, *Lepraria obtusatica*, *Lepraria rigidula*, *Pertusaria borealis* and *Rinodina griseosoralifera*. Seven taxa that displayed distinctive chemistry, could not yet be identified.

Introduction

The development of vegetative, symbiotic propagules is considered an evolutionary innovation of lichenized fungi (Honegger 1991; Poelt 1995; Büdel & Scheidegger 1996). In general it is more frequent among lichens than generative dispersal (Henssen & Jahns 1973). Evolutionary radiation of lichenized fungi often led to morphologically similar species that mainly differ in their types of diaspores (Hale 1965). Poelt (1970) compiled the numerous groups of forms in the concept of species pairs, where the fertile taxa are usually regarded as phylogenetically older. However, in addition to the known species pairs, there are many species without generative reproductive organs that could not be taxonomically allocated and thus so far are only tentatively identified or not at all. This is especially true of sorediate crustose lichens.

As a result of the difficulty in identification and the completely insufficient taxonomic classification within this circle of forms, floristic surveys have often paid too little attention to sorediate crustose lichens and their percentage of the total number of species could scarcely be estimated. In recent years numerous taxonomic studies have dealt with epiphytic sorediate crustose lichens (e.g. Tønsberg 1992; Diederich 1989; Laundon 1992; Leuckert & Knoph 1992; Purvis *et al.*, 1992; Schreiner & Hafellner 1992) and have proved perfectly valid for other regions. Within the framework of the development of

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0024–2829/96/030245+12 $18.00/0

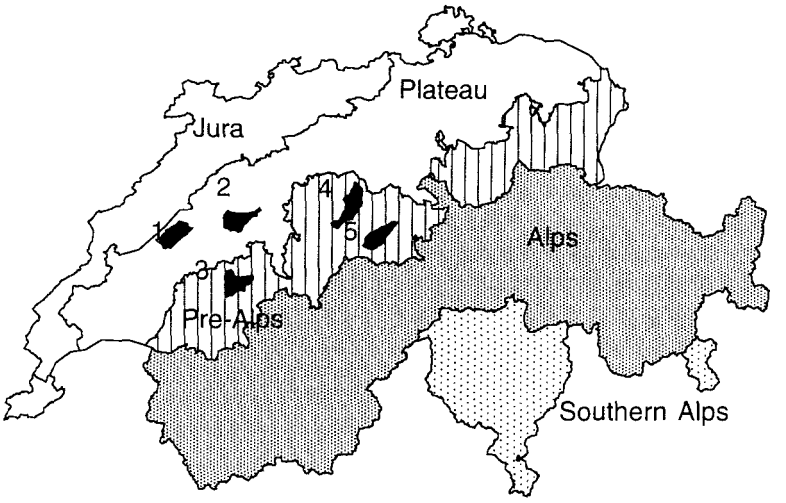

FIG. 1. The five areas of study on the Swiss Plateau and the Pre-Alps. 1: Payerne; 2: Bern West; 3: Schwarzsee; 4: Entlebuch; 5: Glaubenberg.

a representative survey of diversity, distribution and dynamics of the epiphytic lichens occurring in Switzerland, we attempted to identify all lichen species growing on the trunk of 849 randomly selected trees in order to determine the frequencies and percentages of sorediate crustose lichens.

Materials and Methods

The Plateau and Pre-Alps regions were chosen as the study area, comprising, respectively, 22·8% and 16·0% of the total area of Switzerland (41 291 km^2; Bundesamt für Statistik 1980). Within these regions data sampling was concentrated in the five areas Bern West, Entlebuch, Glaubenberg, Payerne and Schwarzsee (Welten & Sutter 1982) (Fig. 1). The study area was stratified horizontally in terms of region, forest/non-forest, and vertically according to four vegetation belts (EAFV 1988). The criteria for stratification were combined, resulting in 12 large-scale habitats.

The entire epiphytic lichen flora of 849 trees from a stem height of 0 to 170 cm (sampling unit) was recorded as an assessment of the percentage of the stem covered (Dietrich 1993). The sampling units were situated in 132 ecological long-term observation plots located from the intersection points of the 1 × 1 km grid of the Swiss co-ordinate system, which are taken as survey centres. In selecting the study plots, care was taken to ensure that at least ten were chosen for each of the 12 large-scale habitats. This resulted in the selection of 44 sampling plots in the Plateau and 88 in the Pre-Alps, 63 non-forest and 69 forest samples and 44 study sites in the colline-submontane zone, 44 in the lower montane zone, 24 in the upper montane zone, and 20 in the subalpine zone.

For floristic assessment the lichenological data on each plot were compiled for one to 16 sampling units, depending on the density of the tree vegetation, in terms of presence or absence. If not otherwise noted, the results are based on this kind of plot data. On the basis of a subdivision of the study area according to the three stratification criteria, the dependence of the mean percentage of sorediate crustose lichens on region, forest/non-forest, and vegetation belt was examined. The given percentages per stratum were computed and the differences between them checked for significance by means of the z-test ($\alpha = 1\%$; Riedwyl 1978). We also checked the dependence between the percentage of sorediate crustose lichens and the total number of species.

All species were classified as 'sorediate crustose lichens' that, as a rule, produced soredia, independent of whether or not they also had organs for generative propagation. In accordance

with Tønsberg (1992) we also considered *Candelariella xanthostigma*, *Chaenotheca furfuracea* and the species belonging to the genus *Lepraria*.

The identification of lichen substances was conducted within the standardized method after Culberson & Ammann (1979). The material was not tested for chloroatranorin and isousnic acid. Several critical species were compared with the material identified by Tønsberg from the Herbarium Bergen (BG). The collections are presently stored in the herbarium of M. Dietrich. The nomenclature follows Santesson (1993).

Results

Frequency of sorediate crustose lichens and their percentage of the lichen flora

According to the stratification applied, the 132 sample sites investigated displayed differences in their ecology, as various types of vegetation with, for example differing exposures, inclinations and types of management occurred within each stratum. Within the entire study area 262 lichen taxa were found, 64 of them sorediate crustose lichens. In absolute terms their frequencies on 132 sample sites differed greatly (Table 1). Only 45% of the sorediate species (29) occurred on more than 5% of all the sample sites. The most frequent were *Lepraria lobificans* (found on 90 sites), *Phlyctis argena* (83), *Micarea prasina* (68), *Candelariella xanthostigma* (66), *Lepraria rigidula* (64) and *Chaenotheca furfuracea* (54). On the other hand, the species *Biatora epixanthoides*, *Cliostomum leprosum*, *Fuscidea arboricola*, *Hypocenomyce scalaris*, *Lecidella scabra*, *Megalospora tuberculosa*, *Micarea* sp. 1, *Mycoblastus alpinus*, *Ochrolechia microstictoides*, *Pertusaria borealis*, *Pertusaria hemisphaerica* and *s.K. 3* were found only once.

Comparison of the mean percentage of sorediate crustose lichens between the strata (Table 2) reveals significant differences ($\alpha = 1\%$). In the Pre-Alps the percentage of 34% is significantly higher than that of 27% in the Plateau. The same is true for the forest sites, the average of 37% being significantly higher than the 26% of the non-forest sites. Regarding the vegetation belts, the percentage in the colline-submontane zone, with only 25%, is significantly lower than elsewhere. Within the sorediate crustose lichens, species of the genus *Lepraria* play an important role. They represent an average of 12% of the flora of the forest plots. This is significantly greater than the 5% they represent in the non-forest sites. Comparison of the mean percentage of *Lepraria* species per plot between the Plateau and Pre-Alps regions and between the vegetation belts reveals a higher value for the Pre-Alps and the lowest for the colline-submontane zone, but the differences are not significant. However, the significant differences between the mean percentages of sorediate crustose lichens in forest and non-forest, Plateau and Pre-Alps, colline-submontane and higher zones were not only due to the contribution of *Lepraria* alone. Also if *Lepraria* is excluded from the calculation, the differences are statistically significant: in forest sites the mean is 25%, in non-forest 21%; in the Pre-Alps 25%, in the Plateau 19%; and in the colline-submontane zone 19% (Table 2).

The number of lichen species exerts little negative effect on the percentage of sorediate crustose lichens. With a correlation coefficient of $r = -0{\cdot}27$ the relationship is very low. The correlation between the total number of species

TABLE 1. *Sorediate crustose lichens in order of the number of sampling sites at which they were found*

Taxon	No. of sites	Taxon	No. of sites
Lepraria lobificans	90	*Haematomma ochroleucum*	5
Phlyctis argena	83	*Lecanora allophana* f. *sorediata**	5
Micarea prasina	68	*Trapelia corticola*	5
Candelariella xanthostigma	66	*Lecidea porphyrospoda**	4
*Lepraria rigidula**	64	*Biatora efflorescens*	3
Candelariella reflexa	54	*Trapeliopsis flexuosa*	3
Chaenotheca furfuracea	36	*Caloplaca citrina*	2
Lecidella sp. 1**	30	*Caloplaca obscurella*	2
Loxospora elatina	29	*Megalaria pulverea*	2
Lecidella flavosorediata	29	*Fuscidea praeruptorum**	2
Ochrolechia androgyna	27	*Fuscidea pusilla**	2
Pertusaria amara	26	*Hypocenomyce leucococca**	2
*Lepraria eburnea**	26	*Lecanora conizaeoides*	2
Mycoblastus fucatus	23	*Lecanora* sp. 1**	2
Buellia griseovirens	22	*Lecanora impudens*	2
Pertusaria albescens	22	*Lecanora norvegica**	2
Lecanora expallens	21	*Ochrolechia alboflavescens*	2
Lecidella sp. 2**	21	*Ochrolechia arborea*	2
Lecanora aff. *flavoleprosa***	20	*Ochrolechia* sp. 1**	2
*Lepraria elobata**	20	*Rinodina griseosoralifera**	2
Chrysothrix candelaris	19	*Biatora epixanthoides*	1
*Hypocenomyce sorophora**	13	*Cliostomum leprosum**	1
Lepraria incana	13	*Fuscidea arboricola**	1
*Lepraria obtusatica**	13	*Hypocenomyce scalaris*	1
Caloplaca chlorina	10	*Lecidella scabra*	1
Biatora gyrophorica	9	*Megalospora tuberculosa*	1
*Leproloma vouauxii**	9	*Micarea* sp. 1**	1
Ropalospora viridis	8	*Mycoblastus alpinus**	1
*Lepraria jackii**	8	*Ochrolechia microstictoides*	1
*Lecidea nylanderi**	6	*Pertusaria borealis**	1
Lecidea pullata	6	*Pertusaria hemisphaerica*	1
Trapeliopsis gelatinosa	6	*s.K. 3***	1

*Species discussed in Appendix 1.
**Taxa discussed in Appendix 2.

and the percentage of *Lepraria* species is given by $r = -0{\cdot}37$, that between the number of species and the percentage of sorediate crustose lichens excluding *Lepraria* by $r = -0{\cdot}10$. The highest percentage of sorediate crustose lichens in the 12 large-scale habitats was found in the forest areas of the lower montane zone of the Plateau with 43% (not significant; $n = 10$); the lowest, with 17% (not significant, $n = 13$), in the non-forest areas of the colline-submontane zone of the Plateau.

Sorediate crustose lichens constituted 24% of the lichen flora within the study area (Table 3). An average of 24 lichen species were found on each sampling plot ($n = 132$). The computed percentage of sorediate crustose lichens per plot was 32%. In relation to the sampling unit ($n = 849$), with an average of ten lichen species, the computed percentage amounts to as much as 40% per individual tree.

TABLE 2. *Absolute and mean number of species per stratum and percentage of sorediate crustose lichens including (incl.) or excluding (excl.) Lepraria*

	Lichens		Sorediate crustose lichens		
			incl. *Lepraria*	excl. *Lepraria*	
Stratum	Total	∅	∅%	∅%	*n*
Non-forest	195	25 ± 9	26 ± 10	21 ± 7	63
Forest	202	23 ± 11	37 ± 12	25 ± 9	69
Colline-submontane zone	141	22 ± 8	25 ± 12	19 ± 9	44
Lower montane zone	145	20 ± 9	35 ± 14	24 ± 9	44
Upper montane zone	160	30 ± 12	37 ± 9	27 ± 6	24
Subalpine zone	114	30 ± 9	32 ± 7	24 ± 5	20
Plateau	134	20 ± 10	27 ± 13	19 ± 9	44
Pre-Alps	243	26 ± 10	34 ± 12	25 ± 8	88

TABLE 3. *Number of species and percentage of sorediate crustose lichens per study area, sampling plot and sampling unit**

	Lichens	Sorediate crustose lichens		
Interpretation unit	∅	∅	∅%	*n*
Study area	262	64	24	1
Sampling plot	24 ± 10	8 ± 3	32 ± 13	132
Sampling unit	10 ± 6	4 ± 2	40 ± 23	849

*∅=mean number of species ± standard deviation; ∅%=mean percentage ± standard deviation; *n*=sample size.

Discussion

Thanks to better knowledge of sorediate crustose lichens achieved through numerous new descriptions and revisions over the past few years, it was possible to identify 64 sorediate crustose lichens in the Swiss Plateau and Pre-Alps. This number constitutes 24% of the total 262 species distinguished. A systematic survey of 849 sample units as tree trunks on 132 study plots revealed the high percentage of sorediate crustose lichens among the flora, and allowed the discovery of new or otherwise interesting species to Switzerland (Appendix 1 and 2). Furthermore, sampling from plots distributed over diverse habitats, according to the vertical and horizontal stratification of the whole study area, permitted probable conjectures on the distribution and frequency of species of which little is known so far. For instance, *Lepraria lobificans* and *Lepraria rigidula* were found to be just as common and widely distributed within the study area as such well-known sorediate crustose species as *Phlyctis argena* or *Micarea prasina*. In contrast, *Lepraria obtusatica* seems to be a stenoecious species favouring fir-beech and fir-spruce forests in the

montane and subalpine zones. Also, just because a particular species has not been identified in an area does not necessarily imply that it is uncommon. For instance, *Lecidella* sp. 1 was found only in the Pre-Alps, yet on 30 sampling sites at all altitudes; *Lecidella* sp. 2, on the other hand occurred throughout the entire study area, except in the subalpine zone.

The distribution of frequency indicates that there are few common species such as *Lepraria lobificans* and numerous rare ones, occurring at a percentage of only one or a few per thousand host trees. Thus it is comparable to the overall frequency distribution of lichens as described by Kuusinen (1994), Roth (1995) and Dietrich (1996). From this it is clear that there are rare species amongst sorediate crustose lichens but they can be investigated by means of an efficient survey method.

Crustose lichens reproducing by soredia do not comprise the same percentage in all habitats. They occur significantly more frequently in forested areas than in non-forested areas. Also the percentage of *Lepraria* species, as sorediate crustose lichens (Tønsberg 1992), is significantly higher in forests. This is easily understandable, as the leprose growth form, with its hydrophobic thallus surface (Henssen & Jahns 1973), can be regarded as an adaptation to the absorption of water vapour, and is commonly found on sheltered sites with high humidity and little illumination (Tønsberg 1992). In the other sorediate lichens, the formation of soredia is regarded as an advantageous propagation strategy of *k*-selected species (Rogers 1990). Since the mean percentage of sorediate crustose lichens, even if *Lepraria* is excluded, is significantly higher in forest stands than on solitary trees, this strategy seems to be more important in forests.

Just how the significantly higher percentage in the Pre-Alps as opposed to the Plateau is to be interpreted needs further studies, as it could be assumed that the more intensive land-use in the Plateau on the whole promotes *k*-selected species. The same is true for the colline-submontane zone, which, within the study area, bears the lowest percentage of sorediate crustose lichens, but the probable highest in terms of intensity of land use.

Sites with few lichens are often colonized only by sorediate crustose species, such as *Lepraria lobificans*, *L. rigidula* and *Micarea prasina*. Therefore, it may be expected that the percentage of sorediate crustose species is negatively affected by the total number of species. In fact, however, the correlation, with $r = -0{\cdot}27$, is very low. Furthermore, on the basis of the low correlation coefficient of $r = -0{\cdot}37$ between number of species and percentage of *Lepraria* species, the hypothesis that sampling sites with few species display a high percentage of ubiquitous *Lepraria* species can be dismissed. The negative correlation of the number of species to the percentage of sorediate crustose lichens excluding *Lepraria* is only $r = -0{\cdot}10$.

The recognition of sorediate lichens in the field and the essential analysis by thin-layer chromatography (TLC) in the laboratory consume much time and material. Furthermore, the risk of faulty identification is undoubtedly higher if sorediate crustose lichens are considered in a survey. However, the percentage of species in the study area as a whole (24%), the mean value for the sampling sites (32%) and the trees (40%) justify the expenditure for the determination of all taxa. In terms of biodiversity, floristic lichen surveys that do not include

sorediate crustose lichens are incomplete. Consequently the aims of any given survey should be examined to determine whether these taxa can justifiably be omitted. Possibly their inclusion could be of use for gaining further knowledge on the diversity, pattern and dynamics of epiphytic lichen vegetation.

The authors wish to express their thanks to M. Sieber (Birmensdorf) for translating the manuscript. Our sincerest thanks go to Dr T. Tønsberg for giving us access to material for comparison from Herbar BG and to Dr B. Coppins (Edinburgh) for the comments on a sterile species of *Micarea* and several fertile crustose lichens; also to Prof. C. Leuckert (Berlin) for analysing the compounds contained in two unidentified species, and Dr P. Diederich for giving us access to his species lists from excursions in Switzerland. Stimulating discussions with Dr P. Brassel, Prof. R. Schlaepfer and R. Ghosh (Birmensdorf), Dr K. Ammann and B. Fischer (Berne) are gratefully acknowledged. We are also grateful to the Swiss National Science Foundation for financial support (Project No. 31–32567.91).

Appendix 1: New and interesting species to Switzerland

The data are restricted to specimens investigated by means of TLC. The associated species include the lichens found on the corresponding tree trunks from 0–170 cm. The data on distribution are based on the literature by Tønsberg (1992), Purvis *et al.* (1992), Diederich (1989), Santesson (1993), Clauzade & Roux (1985), Nimis (1993), Schreiner & Hafellner (1992), Poelt & Vězda (1977, 1981), and Wirth (1994).

Cliostomum leprosum (Räsänen) Holien & Tønsberg
Pre-Alps: Canton of Obwalden, Sarnen, Trogenwald, *Pinus mugo*, 1516 m, *Dietrich* 2016.
Chemistry: Atranorin, caperatic acid.
Associated species: 13 species including *Hypogymnia bitteri*, *H. farinacea*, *Parmeliopsis ambigua*, *P. hyperopta*.
Distribution recorded in the literature: Finland, Norway, Sweden, North America; new to Switzerland.

Fuscidea arboricola Coppins & Tønsberg
Pre-Alps: Canton of Lucerne, Escholzmatt, Schriberschwändili, *Fagus sylvatica*, 1058 m, *Dietrich* 1698.
Chemistry: Fumarprotocetraric acid, protocetraric acid, confumarprotocetraric acid.
Associated species: 8 species including *Arthonia radiata*, *Buellia griseovirens*, *Graphis scripta*, *Melanelia fuliginosa*.
Distribution recorded in the literature: Norway, Scotland, Sweden; new to Switzerland.

Fuscidea praeruptorum (Du Rietz & H. Magn.) V. Wirth & Vězda
Pre-Alps: Canton of Fribourg, Plaffeien, Eggersloch, *Picea abies*, 1210 m, *Dietrich* 2165; Canton of Lucerne, Schüpfheim, Eggli, *Acer pseudoplatanus*, 756 m, *Dietrich* 1684.
Chemistry: Alectorialic acid with satellites.
Associated species: 10 and 27 species; common to both localities: *Melanelia exasperatula*, *Parmelia sulcata*.
Distribution (as epiphytes) recorded in the literature: Norway, Sweden. This species has primarily been found on saxicolous sites. Its distribution ranges from the British Isles over Scandinavia and western Europe to eastern Central Europe and southern Italy.

Fuscidea pusilla Tønsberg
Pre-Alps: Canton of Obwalden, Sarnen, Herrenboden, *Abies alba*, 1299 m, *Dietrich* 2006; Fengmoo, *Picea abies*, 1127 m, *Dietrich* 2011.
Chemistry: Divaricatic acid.
Associated species: 13 species each; common to both localities: *Hypogymnia physodes*, *Lepraria lobificans*, *Micarea prasina*.
Distribution recorded in the literature: Denmark, Germany, Norway, Scotland, Sweden; new to Switzerland.

Hypocenomyce leucococca R. Sant.
Pre-Alps: Canton of Obwalden, Giswil, Rorwald, *Acer pseudoplatanus*, 1250 m, *Dietrich* 1602.

Chemistry: Alectorialic acid with satellites.

Associated species: 18 species including *Loxospora elatina*, *Parmelia saxatilis*, *Parmeliopsis ambigua*, *Pertusaria amara*, *Pertusaria borealis*.

Distribution recorded in the literature: Austria, Finland, Norway, Scotland, Sweden, North America; new to Switzerland.

Hypocenomyce sorophora (Vain.) P. James & Poelt
Pre-Alps: Canton of Obwalden, Giswil, four sites between 1322 and 1553 m, *Abies alba*, *Picea abies*, *Pinus mugo*, *Dietrich* 1614, 1635, 1645, 2035; Sarnen, 2 sites at 1409 and 1516 m, *Picea abies*, *Pinus mugo*, *Dietrich* 1953, 1968.

Chemistry: Alectorialic acid with satellites, ± traces of atranorin.

Associated species: 7 to 22 (13 on average); occurring more than four times: *Hypogymnia physodes*, *Imshaugia aleurites*, *Parmeliopsis ambigua*, *Platismatia glauca*, *Pseudevernia furfuracea*.

Distribution recorded in the literature: Austria, England, Germany, Italy, Norway, Sweden, North America; new to Switzerland.

Further observations on *Hypocenomyce sorophora* in thinned conifer stands and on solitary conifers in the subalpine zone indicate that this species is not uncommon, at least in the upper part of the Pre-Alps.

Lecanora allophana Nyl. f. sorediata Nyl. ex Vain.
Plateau: Canton of Fribourg, Rueyres-les-Prés, *Juglans regia*, 490 m, *Dietrich* 1494; Pre-Alps: Canton of Lucerne, Schüpfheim, Eggli, *Acer pseudoplatanus*, 756 m, *Dietrich* 1682.

Chemistry: Atranorin, allophana unknown 1 and 2 (Tønsberg 1992). Parallel chromatography of *Lecanora allophana* f. *sorediata* and *L. impudens* revealed the varying pattern of triterpenes (Tønsberg 1992).

Associated species: 20 and 27 species; common to both localities: *Candelaria concolor*, *Candelariella xanthostigma*, *Lecanora rugosella*, *Lecanora sambuci*, *Lecidella flavosorediata*, *Melanelia subargentifera*, *Phaeophyscia orbicularis*, *Physcia adscendens*, *P. tenella*, *Xanthoria parientina*; in Rueyres-les-Prés only, *Lecanora allophana* f. *allophana*.

Distribution recorded in the literature: Northern and Central Europe.

Lecanora norvegica Tønsberg
Pre-Alps: Canton of Lucerne, Entlebuch, Dieplischwand, *Abies alba*, 947 m, *Dietrich* 1677; Canton of Obwalden, Giswil, Glaubenbielental, *Acer pseudoplatanus*, 1322 m, Dietrich 1612.

Chemistry: Atranorin, fumarprotocetraric acid, protocetraric acid. Fumarprotocetraric acid was not reported from Norwegian specimens (Tønsberg 1992).

Associated species: 7 and 22 species; common to both localities: *Hypogymnia farinacea*, *H. physodes*, *Lepraria rigidula*, *Loxospora elatina*, *Micarea prasina*.

Distribution recorded in the literature: Norway, Sweden; new to Switzerland.

Lecidea nylanderi (Anzi) Th. Fr.
Pre-Alps: Canton of Obwalden, Sarnen, Siwellenbrunnenwald, *Picea abies*, 1333 m, *Dietrich* 1930.

Chemistry: Divaricatic acid, trace of atranorin.

Associated species: 25 species including *Buellia schaereri*, *Calicium viride*, *Evernia divaricata*, *Loxospora elatina*, *Mycoblastus affinis*, *M. fucatus*.

Distribution recorded in the literature: Europe, North America.

As with *Hypocenomyce sorophora*, *Lecidea nylanderi* was frequently observed in both the subalpine and the upper montane zones of the Pre-Alps, usually in clusters or loosened stands of conifers.

Lecidea porphyrospoda (Anzi) Th. Fr.
Pre-Alps: Canton of Lucerne, Entlebuch, Dieplischwand, *Abies alba*, 947 m, *Dietrich* 1676; Canton of Obwalden, Sarnen, Grund, *Alnus incana*, 1311 m, *Dietrich* 2005.

Chemistry: Lobaric acid.

Associated species: 7 and 32 species; common to both localities: *Hypogymnia physodes*, *Lepraria rigidula*.

Distribution recorded in the literature: Central Europe, Italy, Norway, Sweden.

Lepraria eburnea J. R. Laundon

Pre-Alps: Canton of Lucerne, Doppelschwand, Oberhüseren, *Picea abies*, 700 m, *Dietrich* 1829; Romoos, Chrummatt, *Acer pseudoplatanus*, 942 m, *Dietrich* 2091; Canton of Obwalden, Giswil, Hackerenboden, *Picea abies*, 950 m, *Dietrich* 1859; Sarnen, five sites between 598 and 1423 m, *Picea abies*, *Dietrich* 1813, 1959, 1961, 1979, 1996.

Chemistry: Alectorialic acid, barbatolic acid, protocetraric acid, ± atranorin.

Associated species: 4 to 22 (11 on average); occurring more than four times: *Chaenotheca furfuracea*, *C. trichialis*, *Dimerella pineti*, *Lepraria lobificans*, *Micarea prasina*.

Distribution recorded in the literature: British Isles, France, Germany, Norway, Sweden, North America; new to Switzerland.

Numerous other observations in the Pre-Alps indicate that this species is widespread and common, at least in this region.

Lepraria elobata Tønsberg

Pre-Alps: Canton of Lucerne, Escholzmatt, Schriberschwändili, *Picea abies*, 1058 m, *Dietrich* 1701; Schüpfheim, Chrachenwald, *Picea abies*, 1014 m, *Dietrich* 1681; Canton of Obwalden, Giswil, Seli, *Picea abies*, 1453 m, *Dietrich* 1947; Sachseln, Grossmattwald, 544 m, *Dietrich* 2063; Sarnen, 4 sites between 1311 and 1578 m, *Alnus incana*, *Picea abies*, *Dietrich* 1884, 1923, 1964, 1973.

Chemistry: Atranorin, stictic acid with satellites, zeorin.

Associated species: 3 to 25 (17 on average); occurring more than four times: *Chaenotheca chrysocephala*, *Cladonia coniocraea*, *Hypogymnia physodes*, *Imshaugia aleurites*, *Parmeliopsis ambigua*, *Pseudevernia furfuracea*.

Distribution recorded in the literature: British Isles, Germany, Norway, Sweden; new to Switzerland.

As in the case of *Lepraria eburnea*, this species was observed several times in other places, which indicates that it is widely distributed and relatively common.

Lepraria jackii Tønsberg

Plateau: Canton of Berne, Frauenkappelen, Ägerten, *Pseudotsuga menziesii*, 651 m, *Dietrich* 2110; Pre-Alps: Canton of Obwalden, Giswil, Glaubenbielen, *Picea abies*, 1553 m, *Dietrich* 2027; Sarnen, five sites between 1245 and 1316 m, *Abies alba*, *Picea abies*, *Pinus mugo*, *Dietrich* 1669, 1905, 1969, 1978, 1993.

Chemistry: Atranorin, roccellic acid, rangiformic acid.

Associated species: 6 to 34 (17 on average); occurring more than four times: *Chaenotheca chrysocephala*, *Cladonia digitata*, *Hypogymnia physodes*, *Imshaugia aleurites*, *Lepraria lobificans*, *Ochrolechia androgyna*, *Parmelia saxatilis*, *Parmeliopsis ambigua*, *Pseudevernia furfuracea*.

Distribution recorded in the literature: British Isles, Germany, Norway, Sweden; new to Switzerland. *Lepraria jackii* seems to be less widely distributed than *L. eburnea* or *L. elobata*. Observations in the upper montane and subalpine zones of the Pre-Alps, however, indicate that this species is not uncommon in these areas.

Lepraria obtusatica Tønsberg

Pre-Alps: Canton of Lucerne, Romoos, Alpetliweid, *Picea abies*, 785 m, *Dietrich* 1837.

Chemistry: Obtusatic acid, barbatic acid.

Associated species: Dimeralla pineti, *Lepraria lobificans*, *Micarea prasina*.

Distribution recorded in the literature: Norway; new to Switzerland.

Lepraria obtusatica has been observed exclusively in the Pre-Alps, where it mainly occurs in semi-natural fir-beech and fir-spruce forests on *Abies alba* and *Picea abies*.

Lepraria rigidula (de Lesd.) Tønsberg

Plateau and Pre-Alps in the cantons of Berne, Fribourg, Lucerne, Obwalden, Waadt, 15 sites between 433 and 1534 m, *Abies alba*, *Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*, *Juglans regia*, *Picea abies*, *Populus tremula*, *Prunus avium*, *Pyrus communis*, *Salix* sp., *Dietrich* 1438, 1462, 1474, 1478, 1584, 1657, 1680, 1702, 1747, 1795, 1868, 1940, 1945, 1975, 1982.

Chemistry: Atranorin, rigidula unknown (Tønsberg 1992).

Associated species: 2 to 26 (11 on average); occurring more than four times: *Candelariella reflexa*, *Hypogymnia physodes*, *Lepraria lobificans*, *Micarea prasina*, *Phlyctis argena*, *Physcia tenella*.

Distribution recorded in the literature: Andorra, Belgium, British Isles, Germany, Luxembourg, Norway, Spain, Sweden, new to Switzerland.

Apart from *Lepraria lobificans*, *L. rigidula* is the most common *Lepraria* species observed in both the Plateau and the Pre-Alps.

Leproloma vouauxii (Hue) J. R. Laundon

Plateau and Pre-Alps in the cantons of Berne, Fribourg, Lucerne, Waadt, eight sites between 463 and 767 m; *Acer pseudoplatanus*, *Crataegus* sp., *Fraxinus excelsior*, *Malus sylvestris*, *Prunus avium*, *Pyrus communis*, *Quercus robur*, *Dietrich* 1464, 1500, 1685, 2101, 2102, 2124, 2134, 2155.

Chemistry: Pannaric acid-6-methylester, vouauxii unknown 1 and 2 (Tønsberg 1992).

Associated species: 8 to 27 (17 on average); occurring more than four times: *Candelariella xanthostigma*, *Lecanora carpinea*, *L. sambuci*, *Phlyctis argena*, *Physcia tenella*, *Xanthoria parietina*.

Distribution recorded in literature: Widespread over both hemispheres.

Mycoblastus alpinus (Fr.) Th. Fr. ex Hellb.

Pre-Alps: Canton of Obwalden, Giswil, Loomettlen, *Picea abies*, 1357 m, *Dietrich* 1650.

Chemistry: Atranorin, planaic acid, usnic acid.

Associated species: 16 species including *Chaenotheca chrysocephala*, *Hypogymnia bitteri*, *Micarea peliocarpa*, *Parmelia saxalitis*, *Usnea subfloridana.*

Distribution recorded in the literature: Northern Europe, England, Germany, Scotland, Switzerland.

Pertusaria borealis Erichsen

Pre-Alps: Canton of Obwalden, Giswil, Rorwald, *Acer pseudoplatanus*, 1250 m, *Dietrich* 1601.

Chemistry: Fumarprotocetraric acid.

Associated species: 18 species including *Hypocenomyce leucococca*, *Loxospora elatina*, *Parmelia saxatilis*, *Parmeliopsis ambigua*, *Pertusaria amara*.

Distribution recorded in the literature: Finland, Norway, Sweden, possibly Scotland, North America; new to Switzerland.

Rinodina griseosoralifera Coppins

Pre-Alps: Canton of Obwalden, Giswil, Brunegg, *Acer pseudoplatanus*, 992 m, *Dietrich* 1862.

Chemistry: Atranorin, zeorin.

Associated species: 32 species including *Leptogium saturninum*, *L. teretiusculum*, *Parmelina pastillifera*, *Peltigera praetextata*, *Phlyctis argena*, *Physcia tenella.*

Distribution recorded in the literature: Austria, British Isles, France, Germany, Luxembourg, Norway; new to Switzerland.

Appendix 2: Unidentified sorediate crustose lichens

Seven species with distinct chemistry could not be identified. They are briefly annotated with working names. Speciments analysed by TLC are cited. None of them exhibited generative organs of propagation.

Lecanora aff. flavoleprosa seems morphologically identical with *Lecanora flavoleprosa*, but contains only usnic acid and zeorin as secondary lichen substances.

Plateau and Pre-Alps: In the cantons of Berne, Fribourg, Lucerne, Obwalden, Waadt, eight sites between 430 and 1245 m, *Picea abies*, *Pinus sylvestris*, *Salix alba*, *Dietrich* 1660, 1712, 1730, 1737, 1836, 1850, 2018, 2138.

Lecanora sp. 1 exhibits an endo- to thin episubstratal whitish thallus, soon breaking down into whitish to sulphur-coloured irregular soralia. The compounds it contains are fumarprotocetraric acid, usnic acid and zeorin. Specimens for further identification are with P. James (London).

Pre-Alps: Canton of Obwalden, Sarnen, Münchenboden, *Abies alba*, 1299 m, *Dietrich* 2010.

Lecidella sp. 1 displays an endo- to episubstratal thallus, which is areolated in patches, and forms irregular grey-green to green soralia. C. Leuckert (Berlin) found the compounds atranorin, arthothelin (with a trace of dichlornorlichenxathone), thiophanic acid and a trace of another compound that he could not identify (written communication).

Pre-Alps: In the cantons of Berne, Fribourg, Lucerne, Obwalden, ten sites between 947 and 1398 m, *Abies alba*, *Picea abies*, *Dietrich* 1610, 1679, 1683, 1697, 1703, 2012, 2017, 2075, 2077, 2087.

Lecidella sp. 2 displays an endo- to thin episubstratal, whitish thallus, which is irregularly bursting to form grey-green soralia. C. Leuckert identified the compounds atranorin, capistratone, isoarthothelin, ± thiophanic acid, ± 3-O-methylthiophanic acid, ± aotearone (written communication). Specimens for the identification of *Lecidella* sp. 1 and *Lecidella* sp. 2 are with C. Leuckert.
Plateau and Pre-Alps: In the cantons of Berne, Lucerne, Obwalden, Waadt, eight sites between 433 and 980 m, *Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*, *Populus tremula*, *Prunus domestica*, *Dietrich* 1481, 1589, 1704, 1706, 1714, 1719, 2037, 2142.

Micarea sp. 1 displays a mostly endosubstratal to gelatinous, grey to blue-green irregularly sorediate thallus. It has been shown to contain gyrophoric acid. The only specimen was identified by B. Coppins (Edinburgh) as probably a new species of the genus *Micarea*.
Pre-Alps: Canton of Obwalden, Sarnen, Rischiwald, *Picea abies*, 1033 m, *Dietrich* 2015.

Ochrolechia sp. 1 is clearly episubstratal with a relatively thick, areolated, whitish thallus that displays pale green soralia, first punctiform, later becoming confluent. A brown prothallus can be clearly observed. The only compound found was an unidentified xanthone (Rf classes 7-7-7).
Plateau: Canton of Berne, Mühleberg, Buech, *Juglans regia*, 636 m, *Dietrich* 2107; Pre-Alps: Canton of Obwalden, Sarnen, Grund, *Alnus incana*, 1311 m, *Dietrich* 1891.

s.K. 3 is endo- to episubstratal, with a thin, pale green, finely sorediate thallus. It was found to contain two unidentified xanthones.
Pre-Alps: Canton of Obwalden, Sachseln, Eschlenwald, *Fraxinus excelsior*, 532 m, *Dietrich* 2055.

References

Büdel, B. & Scheidegger, C. (1996) Thallus morphology and anatomy. In *Lichen Biology* (T. H. Nash III, ed.): 37–64. Cambridge: Cambridge University Press.

Bundesamt für Statistik (ed.) (1980) Informationsraster Benützerhandbuch. *Arbeitsdokumente schweizerische Statistik* (Bern) H. 3.

Clauzade, G. & Roux, C. (1985) Likenoj de Okcidenta Europo. Ilustrita determinlibro. *Bulletin de la Société Botanique du Centre-Ouest.* Nouvelle série- Numéro Spécial **7:** 1–893.

Culberson, C. F. & Ammann, K. (1979) Standardmethode zur Dünnschichtchromatographie von Flechtensubstanzen. *Herzogia* **5:** 1–24.

Diederich, P. (1989) Les lichens épiphytiques et leurs champignons lichénicoles (macrolichens exceptés) du Luxembourg. *Travaux Scientifiques du Musée National d'Histoire Naturelle de Luxembourg* **14:** 1–268.

Dietrich, M. (1993) Methodenentwicklung für eine standardisierte Inventarisierung der epiphytischen Flechten im Schweizerischen Mittelland und den Voralpen. *Meylania* **4:** 19–20.

Dietrich, M. (1996) *Häufigkeit, Diversität, Verbreitung und Dynamik von epiphytischen Flechten im Schweizerischen Mittelland und den Voralpen. Methodische Ansätze zur Erstellung einer Roten Liste und zur standardisierten Durchführung von Dauerbeobachtungen.* Doctoral Thesis, University Bern.

EAFV (Eidgenössische Anstalt für das forstliche Versuchswesen) und BFL (Bundesamt für Forstwesen und Landschaftsschutz) (eds) (1988) Schweizerisches Landesforstinventar: Ergebnisse der Erstaufnahmen 1982–1986. *Berichte der Eidgenössischen Anstalt für das forstliche Versuchswesen* **305:** 1–375.

Hale, M. E. (1965) A monograph of *Parmelia* subgenus *Amphigymnia*. *Bulletin of the United States National Museum, Contributions from the United States National Herbarium* **36:** 193–357.

Henssen, A. & Jahns, H. M. (1973) ["1974"] *Lichenes*. Stuttgart: Georg Thieme Verlag.

Honegger, R. (1991) Fungal evolution: Symbiosis and morphogenesis. In *Symbiosis, a source of evolutionary innovation* (L. Margulis & R. Fester, eds): 319–340. Cambridge, MA: MIT Press.

Kuusinen, M. (1994) Epiphytic lichen diveristy on *Salix caprea* in old-growth southern and middle boreal forests of Finland. *Annales Botanici Fennici* **31:** 77–92.

Laundon, J. (1992) *Lepraria* in the British Isles. *Lichenologist* **24:** 315–350.
Leuckert, C. & Knoph, J. G. (1992) European taxa of saxicolous *Lecidella* containing chloroxanthones: identification of pattern using thin layer chromatography. *Lichenologist* **24:** 383–397.
Nimis, P. L. (1993) *The Lichens of Italy. An annotated catalogue.* Torino: Museo regionale di scienze naturali.
Poelt, J. (1970) Das Konzept der Artenpaare bei den Flechten. *Berichte der Deutschen Botanischen Gesellschaft.* **4:** 77–81.
Poelt, J. (1995) On lichenized asexual diaspores in foliose lichens—a contribution towards a more differentiated nomenclature (Lichens, Lecanorales). *Cryptogamic Botany* **5:** 159–162.
Poelt, J. & Vězda, A. (1977) *Bestimmungsschlüssel europäischer Flechten.* Ergänzungsheft I. Vaduz: J. Cramer.
Poelt, J. & Vězda, A. (1981) *Bestimmungsschlüssel europäischer Flechten.* Ergänzungsheft II. Vaduz: J. Cramer.
Purvis, O. W., Coppins, B. J., Hawksworth, D. L., James, P. W. & Moore, D. M. (eds) (1992) *The Lichen Flora of Great Britain and Ireland.* London: The Natural History Museum.
Riedwyl, H. (1978) *Angewandte mathematische Statistik in Wissenschaft, Administration und Technik.* Bern: Paul Haupt.
Rogers, R. W. (1990) Ecological strategies of lichens. *Lichenologist* **22:** 149–162.
Roth, I. (1995) Die Edelkastanie als Lebensraum für epiphytische Flechten. *Lizentiatsarbeit* Systematisch-Geobotanisches Institut, Universität Bern.
Santesson, R. (1993) *The Lichens and Lichenicolous Fungi of Sweden and Norway.* Lund.
Schreiner, E. & Hafellner, J. (1992) Sorediöse, corticole Krustenflechten im Ostalpenraum. I. Die Flechtenstoffe und die gesicherte Verbreitung der besser bekannten Arten. *Bibliotheca Lichenologica.* **45:** 1–291.
Tønsberg, T. (1992) The sorediate and isidiate, corticolous, crustose lichens in Norway. *Sommerfeltia* **14:** 1–331.
Welten, M. & Sutter, R. (1982) Verbreitungsatlas der Farn- und Blütenpflanzen der Schweiz. Basel: Birkhäuser.
Wirth, V. (1994) Checkliste der Flechten und flechtenbewohnenden Pilze Deutschlands—eine Arbeitshilfe. *Stuttgarter Beiträge zur Naturkunde.* Serie A **517:** 1–63.

Accepted for publication 1 *October* 1995