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Macromycetes in alpine snow-bed communities—mycocoenological investigations

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SUMMARY

For a period of 3 or 5 years, six plots in the alpine zone of Switzerland, mainly in the Bernese Oberland, have been observed for macromycetes. In snow-bed communities, 88 species could be found, 25 on siliceous ground and 63 on calcareous ground. Fungi with a wide ecological range and a large distribution area dominate in acidic snow-bed communities (Salicetum herbaceae (SAH)) and fungi with distinctly specified ecological claims dominate in calciphilous snow-bed communities (Salicetum retuso-reticulate (SAR)). In both vegetation types mycorrhizae-formers play a most important role. The differences in the flora between the two snow-bed communities are greater for the macromycetes than for the phanerogams. Both vegetation types are characterized by macromycetes.

Key-words: agaricales, alpine zone, discomycetes, mycocoenology, snow-bed communities.

INTRODUCTION

Snow-bed vegetation often passes for a paragon of a high alpine vegetation type, yet this vegetation type takes up only a small surface of the entire alpine plant cover. In fact, grass heaths dominate the alpine zone of the central European Alps. Snow-bed communities occur in habitats with extreme ecological conditions, normally at the bottom of a northern exposed slope with a thick snow cover during winter, or at higher altitude in regions with relatively high precipitation. The very short vegetation period, the main feature of snow-bed communities, lasts 3 months in favourable years and 8 weeks in unfavourable ones (Walter & Breckle 1986). Among the very few plants found that can develop under these rough climatic conditions are the dwarf willows. The rest of the species are tiny, nestled to the soil. Liverworts and mosses play an important role in such vegetation types.

Macromycetes are a very substantial part of these alpine communities. It was Favre (1955) who first focused attention on the mycoflora of such extreme habitats. Moreover, he discovered a high diversity of mycorrhizae-forming fungi of dwarf shrubs. The aim of this investigation was to assess snow-bed communities of siliceous and limestone areas both quantitatively and qualitatively. This paper is part of a more comprehensive study on the ecology, sociology and taxonomy of alpine macromycetes (Senn-Irlet 1986).

Fig. 1. Map of Switzerland showing the investigation areas.

MATERIALS AND METHODS

The investigations were carried out in four areas of the alpine mountains of Switzerland (Fig. 1). At each site, plots of at least 30 m^2 were selected in vegetations considered to be of homogeneous composition. Vegetation was described with Braun-Blanquet relevés and symbols. Mosses and lichens were collected and identified in the laboratory.

Mycocoenological analyses

In accordance with the proposals of Barkman (1976) and Arnolds (1982), permanent plots of 30–100 m^2 were established and observed for a period of 3 (four plots) or 5 years (two plots) to achieve detailed qualitative and quantitative information about macromycete abundance, frequency and biomass. The carpophores were counted and removed from the plot then dry weight was measured by weighing some mature carpophores. The following parameters were calculated:

(1) Density (D) of carpophores per year:

$$DC_y = \frac{\sum_{A}^{x} C \times 100}{s},$$

where x = number of visits, C = number of carpophores, s = surface of the plot, y = number of observation years.

(2) Total number of carpophores per plot:

$$tDC = \sum DC_y.$$

(3) Average density (aD) of carpophores per year:

$$aDC_y = \frac{tDC}{y}.$$

(4) Maximum density (*mD*) of carpophores per visit:

$$mDCv(3y) = \frac{cm100}{s},$$

where *cm* = maximum number of carpophores established on one visit during the observation period.

RESULTS

Vegetation

Snow-bed vegetation on limestone differs strikingly from that on siliceous ground. Based on the composition of the phanerogams, all relevés can be ascribed to already well-known plant communities (Braun-Blanquet 1949). Yet, plot 33 shows an interesting species composition. The unusual occurrence of *Arabis coerulea* and *Salix reticulata* in plot 33, in an area with predominantly acidophilous flora, is caused by glacially transported dolomitic material in a moraine. However, the community is still interpreted as a SAH.

The three plots of SAR show several species typical of dwarf shrubs and of calcareous heaths. These vegetation types can be found in the neighbourhood, thus they form contact communities. Above plot 41 the *Rhododendro-Vaccinietum,* another type of dwarf shrub heath, is present. Adjacent to plots 42 and 43 *Caricetum ferrugineae* has developed a moist grass heath community. These neighbouring vegetation types influence the floristic composition of the SAR plots.

Mosses play an important role in the structure of snow-beds. In SAH there are nearly exclusively acrocarpeous mosses beside some tiny hepatics, whereas in SAR pleurocarpeous mosses dominate. Moreover, the richness of lichens is striking in SAR. In relation to their cryptogam composition the two snow-bed communities differ greatly; there are only a few species in common. For the mycological study it is interesting that only five species of higher plants may form ectomycorrhizas, i.e. *Salix herbacea, S. retusa, S. reticulata, Dryas octopetala* and *Polygonum viviparum.*

Mycoflora

Two examples of the original mycocoenological data are shown in Tables 1 and 2. The great differences between these two plots, one on siliceous ground the other on calcareous ground, are significant.

The plot in the SAH is very poor in fungal species; however, some compensate by their abundance. Many of the SAH macrofungi have a wide ecological range, a large distribution area, and are found in a wide altitudinal range. The mycoflora is considered to be rather trivial. *Psilocybe chionophila,* a species close to *P. montana,* and *Galerina chionophila* are exceptions. They are known only from arctic–alpine snow-beds.

The productivity of macrofungi in plot 11 is minimal: 1 g dried substance per 100 m^2 $year^{-1}$. An often singular production of small fruiting bodies very late in the season, due to harsh climatic conditions, explains the typical low macrofungi productivity of SAH communities. Indeed, carpophores with a cap size between 0·5 cm and 2 cm are standard, rarely some medium-sized carpophores (e.g. *Cortinarius favrei*) occur.

The plot in SAR reveals quite a different picture. Overall 37 species have been found in 5 years. Apart from some fungi with a wider ecological range, several species have to be considered as endemic found exclusively in the alpine zone of Central Europe and Scandinavia. Obviously they are bound to special plant species. For instance, *Marasmius epidryas* only occurs on dead lignified parts of *Dryas octopetala* (Rosaceae). Other fungi as *Inocybe*

Table 1. The mycocoenosis of an acidic snow-bed community *Salicetum herbaceae*

	1981		1982		1983				1984		1985			DC (100 m²)						
	4/8	16/9	21/7	17/9	27/7	11/8	24/8	23/9	3/8	20/8	25/7	22/8	9/9	1983	1984	1985	*aDC*	*tDC*	*mDC*	d.w. mg (3y)
Total no. species	0	2	0	3	0	0	1	4	0	0	0	0	3	5	0	3	2·6			
Total no. carpophores	0	9	0	6	0	0	15	66	0	0	0	0	30	253	0	94	116			2944
Psilocybe chionophila	—	6	—	1	—	—	15	27	—	—	—	—	1	131	—	3	45	134	84	804
Galerina vittaeformis	—		—	3	—	—	—	2	—	—	—	—	—	6	—	—	2	6·2	6	60
Laccaria tetraspora	—	3	—	2	—	—	—	17	—	—	—	—	17	53	—	53	35	106	53	1298
Entoloma conferendum	—	—	—	—	—	—	1	—	—	—	—	—	—	3	—	—	1	3·1	3·1	258
Dermocybe cinnamomeolutea	—	+	—	+	—	—	—	19	—	—	—	—	12	59	—	38	32	97	59	524

Plot no. 11: Grimsel–Oberaar, slope of Zinggenstock, 2315 m.ü.M., N exp.; 32 m².

egenula, *I. luteipes* and *Cortinarius favrei* form mycorrhizae with dwarf willows (*Salix* sect. *Glaciales*), *Dryas octopetala* and presumably with some other alpine phanerogams. Saprophytic fungi may also be bound to special substrates. Debaud (1983) showed that litter extracts of *Dryas octopetala* stimulated the growth of several calciphilous *Clitocybe* species while an extract of *Salix herbacea* had the opposite effect at least on *Clitocybe lateritia*. Among the remaining species of SAR we have found many that are very rare in Europe, such as *Arrhenia acerosa*, *Galerina pseudocerina* and *Gerronema albidum*. In plot 42 *Marasmius androsaceus* must be regarded as an alien species; it grows on the needles of *Picea abies* that have been blown by wind into the plot. In fact the presence of *Marasmius androsaceus* indicates the proximity of subalpine spruce forest.

The productivity of fungal biomass in SAR is 10 g year^{-1}, so it is 10 times higher than in SAH. Beside many tiny fruiting bodies some single big carpophores occur, such as *Russula delica* (plot 42), which reached normal cap size. Due to the lower altitude the vegetation period of the investigated SAR plots lasts longer than that in the SAH plots. This may be the main reason for such great differences in the productivity. In the SAH plots the snow melts only during July; in 1981 and 1984 there was thick snow cover even in the first week of August, while the SAR plots were free of snow from mid-July. In SAH the fructification period starts in the second half of August (Table 1) and is often interrupted by snowfalls in September. Only in years with exceptionally high September temperatures can the mycoflora of SAH develop fully. This was the case in autumn 1985. On 30 September 1985 plot 33 had eight species, with a total of 33 fruiting bodies; this is the best record of all visits to a SAH plot.

Fungi with a wide ecological range and a large distribution area dominate in SAH, while fungi with specified ecological demands dominate in SAR. This is true not only in the case of plot 11 versus 42 but also when comparing all plots (Table 3). Comparing the values given for the maximum number of carpophores established on one visit (*mDCy* (3*y*)) it is obvious that in SAH only few species occur but with rather high densities, while in SAR many species occur but always with low densities (Table 4).

The annual frequency of carpophores

While species pattern and seasonality in SAH are more or less regular, the fungi in SAR appear very irregular over the years (see Table 2): two-thirds of all species occurred only once in 5 years. That means that either the plot size was too small or a much longer observation period is needed to obtain a more consistent picture of the species composition. The size of the sample plot is a very great problem. Barkman (1968) clearly demonstrated a minimum area for macrofungi but as alpine plant communities often form small patches one location seems to be far below the minimum area for fungi. The three plots within SAR cover almost the entire surface of SAR vegetation type in all localities studied so a larger plot size could not have been chosen. So for calciphilous snow-bed communities a much longer observation period is needed and the number of plots must be enlarged, however, for acidic snow-beds a 3-year investigation period seems to be sufficient for a representative inventory of the mycoflora.

Mycocoenology, a preliminary list of characteristic species

A list including the abundance of all fungi observed in snow-bed communities is given in Table 3. After an observation period of 3 or 5 years (e.g. in plot 42) the number of fungal species exceeds that of mosses and lichens, and in SAR communities even that of higher plants.

Table 2. The mycocoenosis of a calciphilous snow-bed community *Salicetum retuso-reticulatae*

	1981						1982	1983				1984		1985			DC (100 m²)						
	6/8	12/8	18/8	26/8	3/9	10/9	26/7	21/7	6/8	18/8	8/9	1/8	24/8	27/7	3/9	26/9	1983	1984	1985	*aDC*	*tDC*	*mDC*	d.w. mg (3y)
Total no. species	3	6	7	15	3	6	8	0	0	3	2	0	6	1	10	4	5	6	13	7			
Total no. carpophores	0	0	0	0	0	0	20	0	0	17	2	0	12	8	20	11	63	40	130	78			28924
Entoloma cyanulum	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cortinarius sp.	+	+	—	+	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3·3	1·1	3·3	3·3	166
Inocybe luteipes	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Marasmius epidryas	—	—	—	—	+	—	5	—	—	—	—	—	3	—	—	—	—	10	—	3·3	10	10	190
Clitocybe concava	—	+	—	—	—	—	—	—	—	3	—	—	—	—	—	—	10	—	—	3·3	10	10	510
Marasmius androsaceus	—	+	—	—	—	—	4	—	—	13	—	—	—	—	—	—	43	—	—	14	43	43	216
Mycena galopus	—	+	—	—	—	+	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gerronema albidum	—	—	+	—	+	3	—	—	—	—	—	—	—	—	2	—	—	—	7	2·3	6·6	6·6	91
Entoloma sarcitulum	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cortinarius cf *rusticellus*	—	—	+	—	—	—	—	—	—	1	—	—	—	—	—	—	3	—	—	1·0	3·3	3·3	33
Inocybe petiginosa	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Galerina unicolor	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Galerina pseudocerina	—	—	+	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arrhenia acerosa	—	—	+	+	—	—	—	—	—	—	1	—	—	—	6	—	3	—	20	7·7	20	23	391
Hebeloma marginatulum	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	3	1·0	3·3	3·3	136

Cortinarius rufostriatus	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	6	—	—	20	6·6	20	20	1680
Melanoleuca brevipes	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mycenella favreana	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Inocybe egenula	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Entoloma subgen. *Nolanea*	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Clavaria sp.	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Entoloma favrei	—	—	—	—	—	+	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Inocybe nitidiuscula	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Entoloma tenellum	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mycena citrinomarginata	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Clitocybe gibba	—	—	—	—	—	—	+	—	—	—	—	—	1	—	2	—	—	3	7	3·3	6·6	10	2310
Mycena pura	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	3	—	1·0	3·3	3·3	627
Inocybe geophylla	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	3·3	—	—	1·0	3·3	3·3	198
Cortinarius rigidus	—	—	—	—	—	—	—	—	—	—	—	—	3	—	2	—	—	10	7	5·5	10	17	863
Cortinarius favrei	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	13	—	4·3	13	13	9659
Inocybe sp.	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3	—	1·0	3·3	3·3	150
Inocybe sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	17	5·6	17	17	1020
Geopora arenosa	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	—	—	—	20	6·6	20	20	120
Mycena urania	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	13	4·3	6·6	13	143
Galerina vittaeformis 2 sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	7	2·3	6·6	6·6	70
Russula delica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3	1·0	3·3	3·3	9900
Clitocybe sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3	1·0	3·3	3·3	600

Plot no. 42: Schynige Platte—Daube, 2060 m.ü.M., N exp.; 30 m^2.

Table 3. List of macromycetes and their average annual carpophore densities from snow-bed communities in Switzerland

Vegetation type	SAH			SAR				mDCv	
Plot no.	11	22	33	41	42	43			
Total no. observations	13	12	10	11	16	13			
Total no. taxa	5	16	11	28	36	23	er*	SAH	SAR
Entoloma conferendum (Britz.) Noord.	1	—	—	—	—	—	THh	1	—
Psilocybe chionophila Lam.	45	13	2	—	—	—	TPbp	38	—
Laccaria tetraspora Sing.	35	52	13	—	—	—	TPhm	73	—
Galerina chionophila Senn-Irl.	—	47	—	—	—	—	TPbp	30	—
Omphalina velutipes Orton	—	7	—	—	—	—	THh	7·3	—
Hebeloma minus Bruchet	—	1	—	—	—	—	TPhm	1	—
Cortinarius hinnuleus f. gracilis	—	0·5	—	—	—	—	TPhm	0·6	—
Entoloma sericeum (Bull. ex Mér.) Quél.	—	4	—	—	—	—	TPhm	4	—
Inocybe rhacodes Favre	—	4	—	—	—	—	TPhm	4·3	—
Inocybe giacomi Favre	—	5	—	—	—	—	TPhm	3·3	—
Anellaria semiovata	—	3	—	—	—	—	VC	3·3	—
Conocybe tetraspora Sing.	—	2	—	—	—	—	VC	2·3	—
Russula norvegica Reid	—	0·5	—	—	—	—	TPhm	0·6	—
Inocybe calamistrata (Fr.) Gill.	—	—	16	—	—	—	TPhm	15·6	—
Lactarius uvidus Fr.	—	—	3	—	—	—	TPhm	2·6	—
Entoloma cf *occultopigmentatum*	—	—	1	—	—	—	THh	1	—
Entoloma sp.	—	—	2	—	1	5	THh	1	4
Cortinarius sp.	—	4	2	6	1	+	TPhm	18	4
Cortinarius favrei Mos. ex Hend.	—	4	2	5	4	3	TPhm	4·3	9·3
Clitocybe lateritia Favre	—	—	4	5	—	—	THl	1·6	2
Entoloma favrei Noord.	—	—	1	—	0·4	—	THh	1	1
Inocybe sp.	—	—	4	—	7	—	TPhm	3·6	5·6
Discomycetes	—	—	+	1	—	—	THl	2·6	1
Galerina vittaeformis (Fr.) Sing.	2	—	—	—	2	—	TPbs	2	2·3
Dermocybe cinnamomeolutea (Ort.) Mos.	32	3	—	1	—	—	TPhm	22	1

Table 3. (Continued)

Vegetation type	SAH			SAR				mDCv	
Plot no.	11	22	33	41	42	43			
Total no. observations	13	12	10	11	16	13			
Total no. taxa	5	16	11	28	36	23	er*	SAH	SAR
Thelephora caryophyllea Fr.	—	—	—	17	—	—	TPhm	—	11
Inocybe monochroa Favre	—	—	—	1	—	—	TPhm	—	1
Hydropus scabripes (Murr.) Sing.	—	—	—	1	—	—	THh	—	1
Inocybe dulcamara s.l.	—	—	—	0·3	—	—	TPhm	—	0·3
Cortinarius oreobius Favre	—	—	—	0·3	—	—	TPhm	—	0·3
Cortinarius tenebricus Favre	—	—	—	0·3	—	—	TPhm	—	0·3
Cortinarius anomalus (Fr. ex Fr.) Fr.	—	—	—	0·6	—	—	TPhm	—	0·3
Hygrocybe conica	—	—	—	0·3	—	—	THh	—	0·3
Entoloma cf poliopus	—	—	—	0·6	—	—	THh	—	0·3
Inocybe fastigiata	—	—	—	0·3	—	—	TPhm	—	0·3
Entoloma linkii (Fr.)	—	—	—	0·3	—	—	THh	—	0·3
Bovista sp.	—	—	—	0·3	—	—	THh	—	0·3
Gerronema aff. reclinis	—	—	—	0·6	—	—	THh	—	0·3
Inocybe geraniodora Favre.	—	—	—	+	—	—	TPhm	—	—
Marasmius epidryas Kühn.	—	—	—	12	3	—	LR	—	13
Inocybe lutescens Vel.	—	—	—	1	—	1	TPhm	—	2
Laccaria pumila Fayod	—	—	—	2	—	+	TPhm	—	1·3
Hygrocybe mucronella (Fr.) Karst.	—	—	—	0·8	—	4	THh	—	3·6
Collybia dryophila (Bull: Fr.) Kum.	—	—	—	1	—	5	THl	—	4·6
Russula nana Kill.	—	—	—	2	—	2	TPhm	—	3·3
Arrhenia acerosa (Fr.) Kühn.	—	—	—	0·3	8	+	TPbs	—	7
Galerina pseudocerina Smith & Sing.	—	—	—	0·6	1	6	TPbs	—	7·3
Hebeloma marginatulum (Favre) Bruch.	—	—	—	1	1	—	TPhm	—	2
Gerronema albidum (Fr.) Sing.	—	—	—	—	2	+	THl	—	2·3
Inocybe geophylla (Sow.:Fr.) Kum.	—	—	—	—	1	1	TPhm	—	2
Clitocybe concava sensu Lam.	—	—	—	—	3	+	THh	—	3·3
Mycena urania (Fr.:Fr.) Quél.	—	—	—	—	4	1	THl	—	5·3

Table 3. (Continued)

Vegetation type	SAH			SAR				mDCv	
Plot no.	11	22	33	41	42	43			
Total no. observations	13	12	10	11	16	13			
Total no. taxa	5	16	11	28	36	23	er*	SAH	SAR
Entoloma tenellum (Favre) Noord.	—	—	—	—	0·2	10	THh	—	10
Entoloma sarcitulum (Kühn. & Rom.) Arn.	—	—	—	—	+	7	THh	—	5·6
Mycenella favreana Hk.	—	—	—	—	+	1	TPhm	—	1
Inocybe egenula Favre	—	—	—	—	+	+	TPhm	—	—
Marasmius androsaceus (L.:Fr.) Fr.	—	—	—	—	14	—	TPhs	—	14
Geopora arenosa (Fuck.) Korf	—	—	—	—	7	—	THh	—	6·6
Cortinarius rigidus Fr.	—	—	—	—	5	—	TPhm	—	3·3
Cortinarius rufostriatus Favre	—	—	—	—	7	—	TPhm	—	6·6
Clitocybe sp.	—	—	—	—	1	—	THh	—	1
Entoloma cyanulum (Lasch ex Fr.)	—	—	—	—	+	—	THh	—	—
Russula delica Fr.	—	—	—	—	1	—	TPhm	—	1
Clavaria sp. (yellow)	—	—	—	—	+	—	TPbs	—	1
Mycena pura (Pers.:Fr.) Kum.	—	—	—	—	1	—	THh	—	1
Galerina unicolor (Fr.) Sing.	—	—	—	—	+	—	TPbs	—	—
Clitocybe gibba (Pers.: Fr.) Kum.	—	—	—	—	3	—	THh	—	—
Inocybe nitidiuscula (Britz.) Sacc.	—	—	—	—	+	—	TPhm	—	2·3
Mycena citrinomargiata Gill.	—	—	—	—	+	—	TH1	—	5
Inocybe luteipes Favre	—	—	—	—	+	—	TPhm	—	—
Inocybe petiginosa (Fr.:Fr.) Gill.	—	—	—	—	+	—	TPhm	—	—
Melanoleuca brevipes	—	—	—	—	+	—	THh	—	—
Mycena galopus	—	—	—	—	+	—	TH1	—	1
Cortinarius rusticellus Favre	—	—	—	—	1	—	TPhm	—	1
Entoloma sericellum	—	—	—	—	—	11	THh	—	11
Conocybe sp.	—	—	—	—	—	1	THh	—	—
Melanoleuca stridula	—	—	—	—	—	+	THh	—	1·8
Russula nauseosa	—	—	—	—	—	+	TPhm	—	—
Helvella corium	—	—	—	—	—	+	THh	—	—

*er: The ecological function of each fungus is indicated in the list according to Arnolds (1982): TPHm = mycorrhizal fungus, THh = fungus of humus, TH1 = fungus on decomposing litter, TPhs = saprophytic fungus on stems and leaves, TPHp = parasitic fungus on bryophytes, TPhs = saprophytic fungus on bryophytes, LR = lignicolous fungus on roots, VC = fungus on dung.

Table 4. Species composition of snow-bed communities

	SAH*	In common	SAR*	Sum (SAH+SAR)
Phanerogams	37	11	41	78
Mosses and lichens	17	3	52	69
Macromycetes	25	9	63	88

*SAH = Salicetum herbaceae, SAR = Salicetum retuso-reticulatae.

Table 5. Species in each category of diagnostic taxa

Salicetum herbaceae	*Salicetum retuso-reticulatae*
Characteristic species	
Psilocybe chionophila	*Laccaria pumila*
Laccaria tetraspora	*Galerina pseudocerina*
	Clitocybe concava
	Entoloma tenellum
Constant species	
Galerina chionophila	*Russula nana*
Inocybe calamistrata	*Arrhenia acerosa*
	Marasmius epidryas
	Mycenella favreana
	Inocybe egenula
	Entoloma sarcitulum
	Hebeloma marginatulum
	Collybia dryophila
Dermocybe cinnamomeolutea	*Dermocybe cinnamomeolutea*
Cortinarius favrei	*Cortinarius favrei*
Dominant species (weight dominance)	
Psilocybe chionophila	*Russula delica*
Cortinarius favrei	*Cortinarius favrei*
	Entoloma sarcitulum
	Thelephora caryophyllea

Despite the lack of similar investigations in other regions of the Alps, and despite the low number of test plots, an attempt is made to characterize the two snow-bed communities with macromycetes. Due to methodological problems mentioned above, the results are preliminary. Based on Arnold's (1982) report, three categories of diagnostic taxa can be formed (Table 5). (1) Taxa with a high frequency in only one plant community are considered to be characteristic species. They are defined with a higher frequency or a considerably higher carpophore density than in other vegetation types studied. Note that this concept is not identical to the character species in the sense of Braun-Blanquet (1949). (2) Constant taxa are those occurring in almost all plots of a certain syntaxon. (3) Dominant are those species with the highest carpophore density or productivity. They determine to a large extent the appearance of mycocoenoses.

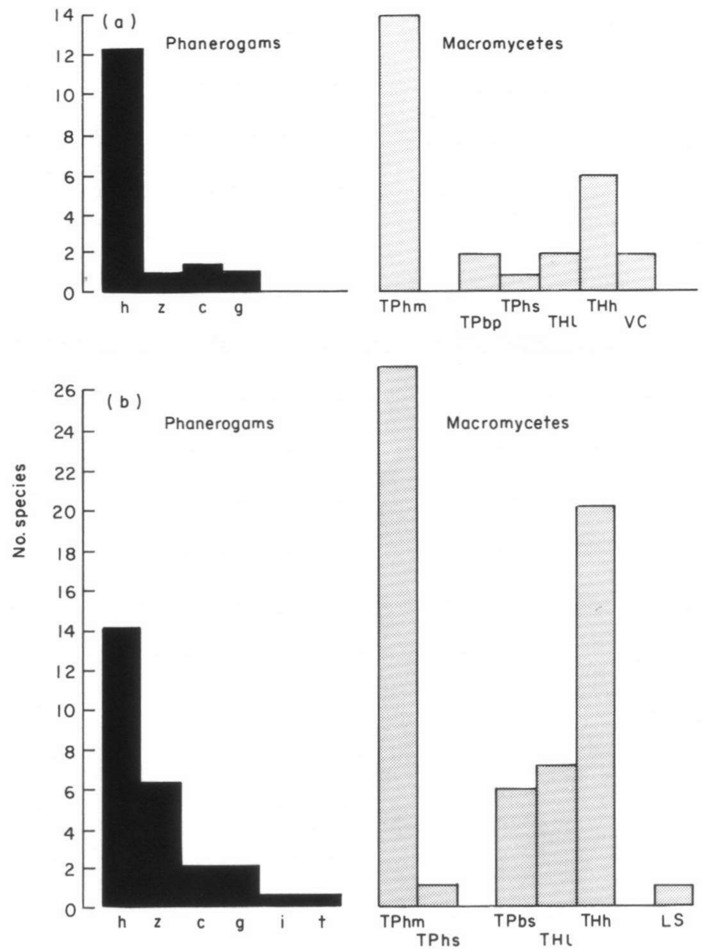

Fig. 2. Life forms of the higher plants and of the macromycetes in (a) *Salicetum herbaceae* and (b) *Salicetum retuso-reticulatae*. The life forms of the phanerogams are indicated according to Landolt (1977): h = hemicryptophytes, z = woody chamaephytes, c = herbaceous chamaephytes, g = geophytes, i = therophytes, t = evergreen nanophanerophytes. For the macromycetes see Table 3.

Life forms

The SAR and SAH differ considerably on the phanerogam species level and slightly less on the respective life form level. This counts even more for the cryptogams, especially the fungi studied. Hemicryptophytes and mycorrhizae-formers dominate (Fig. 2).

The higher diversity may be explained by slightly better climatic conditions and a greater variation in microrelief.

Humicolous fungi are very abundant and numerous in SAR: this is well explained by the high humus content of the uppermost soil of these plots. Despite the numerous species and the high coverage of bryophytes, parasitic macromycetes on mosses are lacking, and saprophytic macromycetes on distinguishable organic debris are scarce. Mosses and hepatics in SAR are more frequently attacked by bryophilous lichens such as *Lecidea hypnorum*, *Bacidia sabuletorum* and *Rinodina mniaraea* than by agarics, whereas in SAH agarics fill in this ecological niche. The fact that some lichenized fungi do attack mosses has recently been shown by Mayrhofer & Poelt (1985). The few coprophilous fungi in SAH plots reflect the grazing by cattle, whereas the SAR plots are too steep for that purpose.

DISCUSSION

Literature about alpine macromycetes is still scanty. Mainly through the articles of Kühner (1972) and Lamoure (1972) the 'combes à neige' became well known for alpine fungi. However, as Favre (1955) has pointed out, the snow-bed communities on siliceous grounds are rather poor in macromycetes. He observed a manifold mycoflora only in localities with a richer phanerogamic flora. So far Eynard (1977) has published the most detailed study about the ecology of agarics in acidic snow-bed communities. Altogether he counted in 12 plots double the species I found in four plots. In these SAH communities in Parc National de la Vanoise, constant species (i.e. species that occurred in most plots) are *Psilocybe chionophila, Dermocybe cinnamomeolutea, Laccaria laccata, Russula norvegica, Hebeloma marginatulum* and *Cortinarius favrei*; observations that agree with the present study.

Bon & Gehu (1973) mentioned 13 species for acidic snow-bed communities and 10 for calciphilous communities. Out of these species I observed only three species in each vegetation type. Kühner (1972) stated that *Galerina pseudocerina* is a very characteristic species of snow-bed communities on limestone; an observation confirmed in this paper.

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