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Terricolous Lichens in the Glacier Forefield of the Gaisbergferner (Eastern Alps, Tyrol, Austria)

Mag. Dr. Peter O. Bilovitz[*)], **Anja Wallner**[*)], **Veronika Tutzer**[*)], **Dr. Juri Nascimbene**[**)], and **Ao. Univ.-Prof. Mag. Dr. Helmut Mayrhofer**[*)]

[*)]Institute of Plant Sciences, University of Graz, Holteigasse 6, 8010 Graz, Austria, Europe

[**)]Department of Life Sciences, University of Trieste, Via Giorgieri 10, 34100 Trieste, Italy

Summary

The investigation of lichens on soil, plant debris and terricolous mosses in the glacier forefield of the Gaisbergferner yielded 41 lichen taxa (39 species and 2 varieties) and one lichenicolous fungus. Three sampling sites were established at increasing distance from the glacier, in order to compare species diversity, abundance and composition.

Keywords

Lichenized *Ascomycetes*; *Lichenes*. – Biodiversity; ecology; flora; floristics. – Alps; alpine belt; glacier forefield; glacier retreat

1. Introduction

With 620 glaciers, 3% of Tyrol (Austria, Cental Europe) is covered by ice. After the end of the Little Ice Age (about 1850), these glaciers retreated by about 50% of their initial area providing open ground for succession of biota (Fischer & Hartl 2013). In very recent years (i.e. between 1997 and 2006) an accelerated retreat is observed, which is mainly attributed to temperature anomalies (Abermann & al. 2013). For example, since the beginning of the climate measurements in Obergurgl in 1953, the mean annual temperature increased by 1.2°C (Fischer 2010). These changes are expected to influence the dynamics of the most sensitive components of the biota, for instance terricolous lichens. These organisms are suitable indicators of various environmental disturbances of alpine regions, because of their direct contact with the soil, their competition with other ground vegetation and their sensitivity to anthropogenic influences (St. Clair & al. 2007, Rai & al. 2012).

In the framework of a project on the impact of changing local conditions on lichen occurrence in glacier retreat regions, we investigated the terricolous lichen biota of five

corresponding author: pe.bilovitz@uni-graz.at.
anja.wallner@edu.uni-graz.at,veronika.tutzer@edu.uni-graz.at, helmut.mayrhofer@uni-graz.at
junasc@libero.it

Dedicated to Univ.-Prof. Dr. Irmtraud Thaler (Graz) on the Occasion of her 90th Birthday

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glacier forefields in the Eastern Alps (see also Bilovitz & al. 2014). The floristic data from the forefield of the Gaisbergferner (Fig. 1) in Tyrol are presented in this paper.

2. Investigation Area

The Gaisbergferner is a valley glacier situated in the Gaisbergtal, which is an alpine side valley of the Gurgler Tal in the Ötztal Alps of Tyrol, Austria.

Climate is continental with an average annual precipitation of 849 mm (weather station of Obergurgl, 1938 m, period 1953–2011, Kuhn & al. 2013).

Basement rocks of the Ötztal-Stubai Complex and Schneeberg Complex are exposed. Both units are part of the Austroalpine Nappe System. The Ötztal-Stubai Complex is mainly composed of paragneiss and mica schists. The Schneeberg Complex consists of coarse mica schists with centimeter-large phenocrysts of garnet and hornblende, of amphibolite and marble (Krainer 2010).

Besides climate and bedrock, the activity around the human settlements strongly influenced and still influences today's vegetation around Obergurgl (Meixner & Siegl 2010, Patzelt 2010, Ortner & al. 2012, Zanesco 2012). Subalpine vegetation around Obergurgl is dominated by pastures and meadows (Mayer & al. 2012). Cembran pine forests and dwarf shrub heaths are further important plant communities in the subalpine belt (Mayer & Erschbamer 2012).

The glacier forefield of the Rotmoosferner is one of the long-term ecological research sites in Obergurgl, where different aspects of the development of an ecosystem on barren ground have been investigated: soil succession (Schwienbacher & Koch 2010), primary succession on alpine virgin soil under the aspect of plant sociology and population biology (Nagl & Erschbamer 2010), bryophytes (Gärtner 2010a, 2010b), lichens (Türk & Erschbamer 2010a, 2010b), invertebrate animals (Koch & Kaufmann 2010), and fungi (Peintner & Kuhnert 2010). The vegetation history of the Rotmoostal and the influence of plant immigration, climate, altitude and human activities were outlined by Bortenschlager 2010.

A first comprehensive survey of the lichen flora of the area of "Gurgl" was presented by Arnold 1877 (additions in Arnold 1879, 1880, 1881, 1886, 1893, 1897). Tobolewski 1976 recorded 170 lichen species from the Ötztal Alps, most of them from the Gurgler Tal and the Venter Tal, but also from some smaller valleys as the Gaisbergtal with 38 species. The lichen flora of the area of Obergurgl has been studied in detail by Hofmann & al. 1988, who presented a list of 420 taxa, including some lichenicolous fungi. They listed 60 lichen species from the Gaisbergtal and 30 from the parallel Rotmoostal with its glacier, the Rotmoosferner (also cited in Gärtner 2010b: 277). A survey of the lichen biota in the glacier forefield of the Rotmoosferner has been provided by Türk & Erschbamer 2010a, 2010b, recording 75 lichen taxa. Data on cryptogams (bryophytes, lichens, algae) from the Rotmoostal were presented by Gärtner 2010a, 2010b, while Gärtner & Hofbauer 2012 studied lichens and bryophytes of the coniferous belt and the subalpine dwarf shrub zone around Obergurgl.

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3. Material and Methods

Sampling location: Austria, Tyrol, Ötztal Alps, Ötztal Nature Park, SE of Obergurgl, Gaisbergtal, 46°50’N/11°02’–03’E, 2350–2460 m, glacier forefield of the Gaisbergferner, 30. & 31.VIII.2013, leg. P. Bilovitz, V. Tutzer & A. Wallner.

Three sampling sites were established at increasing distance from the glacier, corresponding to a gradient of moraine age: site 1 = c. 600 m, site 2 = c. 1000 m, site 3 = c. 1500 m. In each site, lichens were surveyed within five 1 × 1 m randomly placed plots, both on soil (ter) and on plant debris or decaying terricolous mosses (deb). Spots with larger stones were avoided. Phanerogams were present in all three sites, but, with increasing distance from the glacier, diversity rose and vegetation cover became denser. Each plot was divided into 10 × 10 cm quadrats (Bilovitz & al. 2014: Fig. 2), in order to obtain data on species frequency (max. frequency/plot = 100). For each species, specimens were collected for a more accurate identification in the laboratory.

The specimens have been identified mainly with the aid of Wirth & al. 2013, using routine light microscopy techniques. Some of the identifications required verification by using standardized thin-layer chromatography (TLC), following the protocols of White & James 1985 and Orange & al. 2001. The specimens are preserved in the herbarium of the Institute of Plant Sciences, University of Graz (GZU). The nomenclature mainly follows Wirth & al. 2013, or other modern treatments.

4. Results and Discussion

Forty-one lichen taxa (39 species and 2 varieties) and the lichenicolous fungus *Arthonia stereocaulina* (Ohlert) R. Sant. on *Stereocaulon alpinum* were found in the three sampling sites.

The diversity of terricolous lichens near the front of the glacier was very low. The first lichens occurred at a distance of about 600 m from the front (site 1), and only 9 species were found in this sampling site. The fruticose lichen *Stereocaulon alpinum* was not only the most noticable, but also the most frequent species, followed by *Cladonia cariosa* s. l., *Peltigera rufescens* and *Cladonia symphycarpia*. The rest of the species only occurred with low frequency.

At a distance of about 1000 m to the glacier (site 2), we found a similar species assemblage with twice the number of species. This increase of species richness was mainly due to the contribution of crustose lichens growing on plant debris and/or decaying terricolous mosses. The dominance of *Stereocaulon alpinum* was even more evident than in site 1.

The number of species rose significantly at a distance of about 1500 m from the glacier in the area of the end moraine of 1850 (site 3), where we found 32 lichens. The fruticose lichens *Thamnolia vermicularis*, *Stereocaulon alpinum* and *Flavocetraria nivalis* reached the highest frequency values.

In comparison with the glacier forefield of the Rötkees in South Tyrol, with 29 species (Bilovitz & al. 2014), the total diversity of the Gaisbergferner glacier forefield was higher. One third of the species occurred in both forefields. In both sites increasing lichen diversity and abundance directly correlate with the increasing age of the moraine. Interestingly, this pattern of lichen diversity was related with a change in species traits composition, supporting the hypothesis that the response of lichen communities to environmental factors is likely to be mediated by the selection of functional traits that determine the performance of the species (Webb & al. 2010). Recently, Giordani & al. 2012 demonstrated that lichen functional traits are correlated with the main climatic and anthropogenic gradients, while Rapai & al. 2012 demonstrated that lichen traits explain a huge amount of variation in community assemblage along a high elevation gradient.

These results are similar to those of Türk & Erschbamer 2010a, 2010b, who listed 31 lichens growing on soil, plant debris and terricolous mosses from the nearby Rotmoosferner and found the same pattern of lichen diversity in relation to moraine age.

Ecological analyses on our dataset can be conducted in more depth when data will be available for all five glacier forefields covered by our project.

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Fig. 1.
Gaisbergferner and its forefield. – Phot. P. O. Bilovitz, 31.VIII.2013.

Table 1

List of lichenized taxa with their substrata and the frequency of each species in the three sampling sites (indeterminable material with low frequency not included).

		Frequency		
Taxon	**Substratum**	**Site 1**	**Site 2**	**Site 3**
Alectoria ochroleuca (Hoffm.) A. Massal.	ter	0	0	1
Arthrorhaphis spec.[1]	ter	0	0	15
Bacidia bagliettoana (A. Massal. & De Not.) Jatta	deb	0	1	1
Bryonora castanea (Hepp) Poelt	deb	1	0	0
Caloplaca sinapisperma (Lam. & DC.) Maheu & Gillet	deb	0	1	0
Caloplaca stillicidiorum s. l.	deb	0	11	19
Caloplaca tiroliensis Zahlbr.	deb	0	0	10
Catapyrenium cinereum (Pers.) Körb.	ter	0	7	9
Cetraria islandica (L.) Ach.	ter	0	7	33
Cetraria muricata (Ach.) Eckfeldt	ter	0	0	7
Cladonia cariosa s. l.[2]	ter	89	0	0
Cladonia cariosa s. l.[3]	ter	67	67	0
Cladonia macroceras (Delise) Hav.	ter	0	2	0
Cladonia pyxidata s. l.	ter	1	21	77
Cladonia symphycarpia (Flörke) Fr.	ter	45	84	12
Dactylina ramulosa (Hook.) Tuck.	ter	0	0	4
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell	ter	0	0	6
Flavocetraria nivalis (L.) Kärnefelt & Thell	ter	0	0	130
Fulgensia bracteata (Hoffm.) Räsänen subsp. *deformis* (Erichsen) Poelt	ter	0	0	27
Fuscopannaria praetermissa (Nyl.) P. M. Jørg.	ter	0	1	2
Lecanora bryopsora (Doppelb. & Poelt) Hafellner & Türk	deb	0	0	2
Lecanora hagenii (Ach.) Ach. var. *fallax* Hepp	deb	0	0	14
Lecidea berengeriana (A. Massal.) Th. Fr.	deb	0	0	1
Lecidella wulfenii (Hepp) Körb.	deb	0	1	69
Lepraria diffusa (J. R. Laundon) Kukwa	deb	0	0	2
Lepraria eburnea J. R. Laundon	deb	0	0	3
Megaspora verrucosa (Ach.) Hafellner & V. Wirth	deb	0	0	5
Ochrolechia inaequatula sensu auct.	deb	0	0	4
Peltigera lepidophora (Nyl. ex Vain.) Bitter	ter	5	2	0
Peltigera rufescens (Weiss) Humb.	ter	86	85	84
Phaeorrhiza nimbosa (Fr.) H. Mayrhofer & Poelt	deb, ter	0	0	2
Placynthiella icmalea (Ach.) Coppins & P. James	ter	0	1	0
Psoroma tenue Henssen var. *boreale* Henssen	ter	14	0	0
Rinodina mniaraea (Ach.) Körb. var. *mniaraea*	deb, ter	0	2	1

		Frequency		
Taxon	**Substratum**	**Site 1**	**Site 2**	**Site 3**
Rinodina mniaraea (Ach.) Körb. var. *cinnamomea* Th. Fr.	deb	0	0	2
Rinodina roscida (Sommerf.) Arnold	deb	0	1	2
Solorina bispora Nyl.	ter	0	0	16
Stereocaulon alpinum Laurer	ter	312	404	203
Thamnolia vermicularis (Sw.) Schaer. var. *vermicularis*[4]	ter	0	1	289
Thamnolia vermicularis var. *subuliformis* (Ehrh.) Schaer.[4]	ter	1	0	1
Toninia spec.[5]	ter	0	0	10
sterile, sorediate crustose lichen	deb	0	0	8

[1] no apothecia to distinguish between A. *alpina* and A. *vacillans.*

[2] with an affinity to Clade A according to Pino-Bodas & al. 2012.

[3] with an affinity to Clade D according to Pino-Bodas & al. 2012.

[4] doubtful frequency data of the two morphologically identical varieties of *T. vermicularis.*

[5] no apothecia.