Workshop: Ecology of Glacier Forelands

SEPTEMBER
17-21, 2014

OBERGURGL, AUSTRIA

Edited by Brigitta Erschbamer, Mauro Gobbi,
Rüdiger Kaufmann, Valeria Lencioni and Nikolaus Schallhart

Museo delle Scienze

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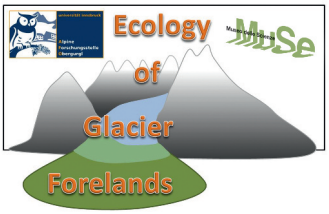

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Workshop: Ecology of Glacier Forelands

September 17-21, 2014; Obergurgl, Austria

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Edited by: Brigitta Erschbamer, Mauro Gobbi, Rüdiger Kaufmann,
Valeria Lencioni and Nikolaus Schallhart

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Contents

Foreword

Over the last years people working on glacier forelands and on pro- or periglacial environments have brought forward highly interesting new aspects from a variety of geographic regions.

Among them are really astonishing and unexpected results which raise the question what are local specifics and what are common traits and mechanisms in such environments.

This calls for common approaches and joint actions on a super-regional scale. In a follow-up of our 2008 workshop we therefore want to bring together people working on any organisms with their interactions and their abiotic environment in the terrestrial and aquatic habitats of deglaciated terrain of any kind including debris covered glaciers, rock glaciers, and nunataks.

There are two major aims of this workshop:

1. Planning joint actions and harmonizing approaches
2. Outlining a review paper on this topic

The workgroups will be:

1. Interactions: Organismic, Environmental, Trophic
2. Periglacial Environments & Permafrost across the Regions of the World
3. Community Ecology of Colonization & Succession (including Theory)

September 2014, Obergurgl, Austria

The Organizing Committee

The Venue

ALPINE RESEARCH CENTRE OBERGURGL

It is located in the immediate vicinity of the central divide of the Austrian Alps featuring many beautiful glacier forelands, rock glaciers and whatever periglacial phenomena you want to see.

The history of the University Center goes back to 1951, when three former customs buildings were converted for use by the Obergurgl Federal Sports Center and Innsbruck University's Alpine Research Centre.

The Alpine Research Centre Obergurgl connects interdisciplinary research tradition with current dynamic research activity. The focus concentrates on environmental and climatologic sciences, cultural, economical and historical research as well as studies about sociological aspects in the high mountain regions for scenario modeling.

It is an important field station of the Innsbruck University (research focus: Alpine Space - Man and Environment) and furthermore an important site within the national and international platform LTER/LTSER (Long-term Ecosystem Research, Long-term Socio-economic and Ecosystem Research), as part of the LTER region Tyrolean Alps.

For further Information on the University Center or the Alpine Research Centre Obergurgl please visit the following homepages:

http://www.uz-obergurgl.at/english/ (University Center)
http://www.uibk.ac.at/afo/index.html.en (Alpine Research Centre)

Program Overview

Wednesday 17.09.2014	Thursday 18.09.2014	Friday 19.09.2014	Saturday 20.09.2014
	09:00 Opening	**09:00-10:15** Talks (Session 4)	**09:00-11:00** Workgroups
	09:30-10:30 Talks (Session 1)	Break	Break
	Break	**11:00-12:00** Talks (Session 5)	11:30-12:30 Workgroup Results
	11:00-12:30 Talks (Session 2)	Lunch	Lunch
	Lunch	13:30-18:00 Excursion Glacier Foreland	**14:00-16:15** Synthesis Session
Arrival and gathering in Innsbruck	**14:00-15:30** Talks (Session 3)		Break
	Break		**17:00-19:00** Review Paper Session
	16:15-18:15 Poster Session		
18:00 Bus transfer Innsbruck-Obergurgl			
19:30 Dinner	**19:00** Dinner	Conference Dinner	**19:00** Dinner
Meet & Greet	Informal Meeting		Informal Meeting

Sunday, 21.09.2014: Optional full-day excursion (Details will depend on weather)

Monday, 22.09.2014: Departure

Excursion

EXCURSION TO A LOCAL GLACIER FORELAND (FRIDAY AFTERNOON):

We will go by cable car up to a ridge called “Hohe Mut” (2650 m a.s.l.). From there we have a spectacular view at the glaciers and at the central divide of the Alps.

We will than hike down into Rotmoos valley, the outdoor lab of the Innsbruck glacier foreland group, where we will visit the investigation sites. There is a nice mountain hut nearby for refreshments.

FULL-DAY EXCURSION (SUNDAY):

We will give you a guided tour in the area to show you points of scientific interest. We will see the high alpine landscape, both in its pristine form, and with the influence of human land use over millennia.

This includes the rather dramatic effects of the recent intensive use for winter tourism. Be prepared for some hiking on this day.

Detailed Program

THURSDAY 18.09.2014

09:30-10:30 Session 1

09:30 Brigitta Erschbamer
How fast does glacier foreland colonisation proceed?

09:45 Thomas Fickert & Friederike Grüninger
Klebelsberg revisited - Did primary succession in glacier forelands a century ago differ from today?

10:00 Mauro Gobbi, Mattia Brambilla & Simone Tenan
Suggesting analytical approaches for a better understanding of arthropod ecology along glacier forelands

10:15 Rüdiger Kaufmann
Connell & Slatyer revisited: What we really know about mechanisms driving succession of glacier forelands

11:00-12:30 Session 2

11:00 Andrea Danler & Brigitta Erschbamer
Colonization pattern in three glacier forelands in the Ötztal Alps

11:15 Silvia Marcante, Brigitta Erschbamer, Othmar Buchner & Gilbert Neuner
Impact of heat on survival of early developmental stages of glacier foreland species

11:30 Monika Stawska & Agata Buchwal
Radial growth of dwarf shrubs and perennial plants in Ebbadalen (Central Spitsbergen)

11:45 Peter O. Bilovitz, Helmut Mayrhofer & Juri Nascimbene
Terricolous lichens in glacier forelands of the Eastern Alps - diversity, abundance and composition

12:00 Marc Oliva & Jesús Ruiz-Fernández
Geoecological dynamics in an ice-free area in the Maritime Antarctica: a study case from Elephant Point (Livingston Island, South Shetland)

12:15 María Ingimarsdóttir, Tancredi Caruso, Jörgen Ripa, Ólöf Birna Magnúsdóttir, Anders Michelsen & Katarina Hedlund
Soil community assembly on nunataks, Iceland

14:00-15:30 Session 3

14:00 Sigmund Hågvar & Mikael Ohlson
Three invisible carbon sources feed pioneer invertebrates in a Norwegian glacier foreland

14:15 Michael Engel, Giacomo Bertoldi, Daniele Penna, Luca Mao, Andrea Dell'Agnese, Francesco Comiti & Stefan Zerbe
The Matsch Glacier forefield (South Tyrol): an integrated analysis of snow cover dynamics, runoff generation and sediment transport (additional poster)

14:30 Laurent Moya, Hannes Peter, Thorsten Dittmar, & Ruben Sommaruga
Ultrahigh-resolution molecular characterization of DOM in glacier-fed and clear alpine lakes

14:45 Ulrike Nickus, Hansjörg Thies, Karl Krainer & Richard Tessadri
Active rock glaciers and their impact on stream water quality (additional poster)

15:00 Marco Caccianiga & Mauro Gobbi
Plant-arthropod communities on glacial and periglacial landforms of the Italian Alps: state of the art and future perspectives

15:15 Jeffrey H. Frederick, Sanjay Pyare, Kevin S. White, Todd J. Brinkman & Kris J. Hundertmark
*Terrestrial thermal dynamics and associated constraints on the behavior of Mountain Goats (*Oreamnos americanus*) in southeast Alaska (additional poster)*

16:15-18:15 Poster Session

Mauro Gobbi, Alessandra Franceschini, Luca Toldo & Valeria Lencioni
Comparative study on terrestrial and aquatic invertebrate assemblages along a glacier foreland

Sanda Iepure & Javier Lillo Ramos
State of the art of hyporheic invertebrates from glacial-feed streams in two contrasted scenarios

Gianalberto Losapio, Mauro Gobbi, Giuseppe Marano, Chiara Compostella, Patrizia Boracchi & Marco Caccianiga
Plants and flower-visiting insects along a debris-covered glacier foreland

Chiara Maffioletti, Mauro Gobbi & Marco Caccianiga
Distribution patterns in plants and ground beetles along a debris-covered glacier foreland

Georg Rainer, Georg Walch, Maria Knapp, Andreas Gruber & Ursula Peintner
Detection of soil fungal communities from in-growth mesh bags: A comparison of cultivation-based and molecular methods

Duccio Tampucci, Maddalena Raphaela Althea Angeleri, Erika Cabrini, Clara Citterio, Chiara Maffioletti, Federico Mangili, Ilaria Alice Muzzolon, Chiara Compostella, Mauro Gobbi & Marco Caccianiga
Refugia landforms for alpine flora and fauna: ecological and biogeographical significance of a habitat system

Georg Walch, Regina Kuhnert, Maria Knapp, Georg Rainer, Andreas Gruber & Ursula Peintner
Peeking into the black box of biodiversity: Culturing and identifying soil fungi from in-growth mesh bags

Plus eight posters supplementary to talks (indicated there).

FRIDAY 19.09.2014

09:00-10:15 Session 4

09:00 Ursula Peintner, Irmgard Oberkofler, Gretl Fleisch, Maria Knapp, Georg Rainer, Georg Walch & Regina Kuhnert
Knowns and unknowns: winter soil fungal communities and their possible interactions

09:15 Maria Knapp, Georg Rainer, Georg Walch & Ursula Peintner
Soil fungal communities from in-growth mesh bags in snow covered alpine soil (additional poster)

09:30 Regina Kuhnert, Irmgard Oberkofler, Gretl Fleisch & Ursula Peintner
What happens with the fungal biomass under the snow cover in alpine soils? (additional poster)

09:45 Alfonso Esposito, Engy Ahmed, Sonia Ciccazzo, Johannes Sikorski, Jörg Overmann, Sara J. M. Holmström & Lorenzo Brusetti
Bioprospecting of the microbial diversity in varnish and non-varnish rock surfaces (additional poster)

10:00 Lorenzo Brusetti, Sonia Ciccazzo, Alfonso Esposito, Elisa Varolo & Stefan Zerbe
Bacterial communities associated to the nitrogen cycle in proto-soils of the Matsch Valley glacier forefield (South Tyrol, Northern Italy)

11:00-12:00 Session 5

11:00 Michael Traugott, Rüdiger Kaufmann, Daniela Sint, & Corinna Wallinger
Trophic ecology - functional perspectives on species communities in glacier forelands (additional poster)

11:15 Daniela Sint, Lorna Raso, Corinna Wallinger, Rüdiger Kaufmann & Michael Traugott
What DNA can do for you - molecular methods to investigate trophic interactions in glacier forelands (additional poster)

11:30 Corinna Wallinger, Mauro Gobbi & Michael Traugott
Primary succession of plant-herbivore interactions on Alpine glacier forelands

11:45 Andrea Fischer
Time series of glacier fluctuation data as precondition and result of glacier forefield evidence in the Austrian Alps: Status quo and open questions

13:30-18:30 Excursion to Rotmoos Glacier Foreland

SATURDAY 20.09.2014

09:00-11:00 Workgroup Sessions (parallel with options to move between groups)
Interactions: Organismic, Environmental, Trophic

Periglacial Environments & Permafrost across the Regions of the World

Community Ecology of Colonization & Succession (including Theory)

11:30-12:30 Workgroup Results (plenary)
11:30 Interactions: Organismic, Environmental, Trophic

11:50 Periglacial Environments & Permafrost across the Regions of the World

12:10 Community Ecology of Colonization & Succession (including Theory)

14:00-16:15 Synthesis Session
Pinpointing knowledge gaps

Planning joint actions and harmonizing approaches

17:00-19:00 Review Paper Session
Planning a comprehensive review paper on current knowledge about ecology of glacier forelands and periglacial environments

ABSTRACTS
Oral communications

How fast does glacier foreland colonisation proceed?

Brigitta Erschbamer

Institute of Botany, University of Innsbruck, Sternwartestraße 15, A-6020 Innsbruck, Austria (*Brigitta.Erschbamer@uibk.ac.at*)

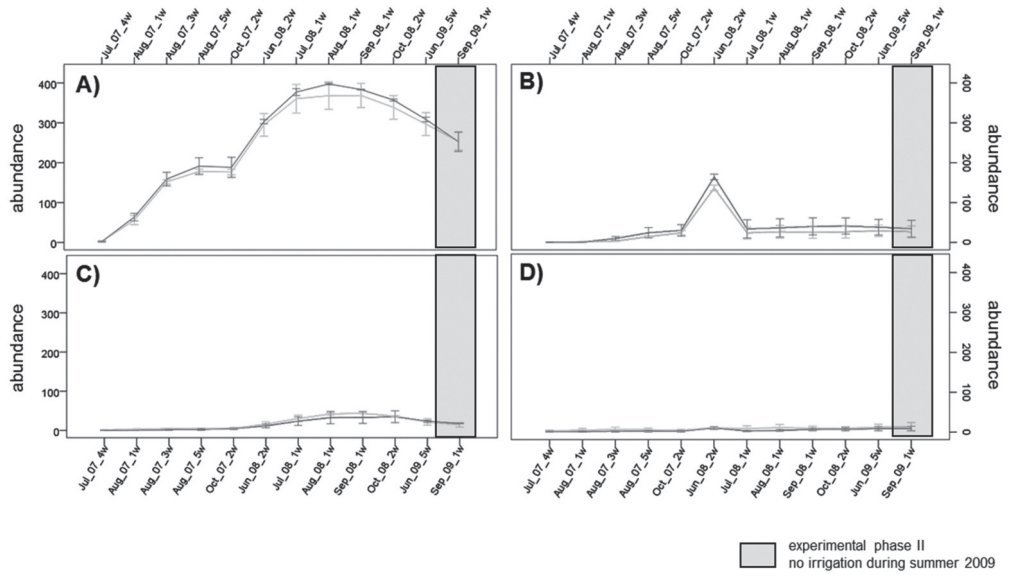
Abiotic and biotic factors governing colonisation were analysed in the glacier foreland of the Rotmoosferner (Obergurgl, Ötztal, Austria) at 2,300-2,450 m a.s.l, using plots of 25 × 25 cm on moraines of the glacier stages 1971 and 1956. Vegetated and bare ground sites were compared. In addition, experiments were carried out in bare ground plots of the moraine 1971, providing seed addition (10 glacier foreland species), automatic irrigation, and artificially created safe sites. Colonisation was also studied in experimentally created gaps along the succession gradient.

Drought and seed limitation were identified as most restricting factors for germination on bare ground plots. Safe sites were less important for germination. However, they were essential for community development. After 12 years of observation, the cover in bare ground plots was still found to be rather low whereas species numbers increased continuously year by year.

Thus, natural seedling recruitment occurred but establishment and growth failed due to the harsh conditions at the bare ground. Within vegetated plots saturation of species numbers was observed. In contrast, total cover per plot increased slowly from the first to the last monitoring year. Along the successional gradient, only the local colonisers accounted for the regeneration of the artificially created gaps.

Key words:
germination, irrigation, safe sites, seed limitation, seedling recruitment.

SEEDLING ABUNDANCE FROM 2007 TILL 2009



Abundance of the seedlings on plots with (dark grey) and without (light grey) artificially created safe sites during 12 censuses from July 2007 till September 2009. A) and B): plots with seed addition carried out on 18th July 2007; A) and C): plots with irrigation in 2007 and 2008; D) control plots without seed addition and without irrigation (FWF project P19090-B16).

Klebelsberg revisited - Did primary succession of vegetation in glacier forelands a century ago differ from today?

Thomas Fickert* & Friederike Grüninger

Physical Geography, University of Passau, Innstraße. 40, 94032 Passau, Germany

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Since the Little Ice Age (LIA) maximum extent around 1850 the glaciers of the Alps lost more than half of their respective area. The bare ground exposed is subsequently available for colonization by plants. Due to the specific site conditions (e.g. katabatic winds, soil frost activity, meltwater discharge, long lasting snow cover, rocky and coarse grained substrate prone to desiccations, etc.) glacier forelands are particularly challenging environments to become colonized by organisms. In addition, as many high altitude plant species exhibit limited dispersal ability and high mortality during establishment, colonization and vegetation dynamics in glacier forelands are considered slow and retarded. Recent research, however, assumes that primary succession of vegetation in glacier forelands is accelerated by climate warming, speeding up the colonization process itself as well as changing the colonization strategy of the plant species involved.

Using a virtually complete plant species list sampled by Raimund v. Klebelsberg in 1911 and recent data collected along a chronosequence within the glacier foreland of the Lenksteinferner (South Tyrol) we address the following questions:

- Do plants colonize the glacier foreland faster today compared to the date when Klebelsberg visited roughly a century ago?
- Do species involved in the early colonization of bare ground differ between the two sampling dates? As the glacier terminus was closer to alpine heath vegetation and treeline at the beginning of the last century, a different species pool may have been available back then.
- How persistent are the species involved in primary succession? Are any of the taxa reported by Klebelsberg (1913)[1] for the area between the LIA moraines and the glacier terminus in 1911 still present today?
- Do biological traits of the species involved in primary succession differ between the two sampling dates?

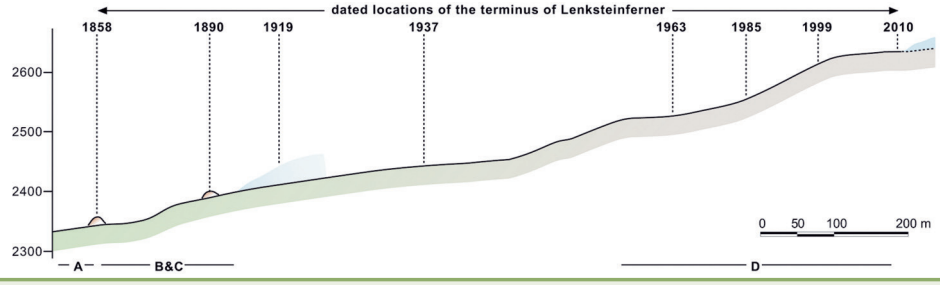
Key words:
colonization strategies, Lenksteinferner, Little Ice Age, vegetation dynamics.

[1] Klebelsberg, R. von (1913): Das Vordringen der Hochgebirgsvegetation in den Tiroler Alpen – Eine alpin-pflanzengeographische Studie. In: Österreichische Botanische Zeitschrift, Bd. 63, H. 5, 177-186 and H. 6, 241-254.

Species	Familiy	Lifeform	Klebelsberg data A	Klebelsberg data B	recent data C	recent data D
Leucanthemopsis alpina [1]	Asteraceae	H herb		x	x	x
Cirsium spinosissimum	Asteraceae	H herb			x	
Doronicum clusii ssp. *villosum*	Asteraceae	H herb			x	
Erigeron uniflorus	Asteraceae	H herb			x	
Gnaphalium supinum	Asteraceae	H herb		x	x	x
Hieracium c.f. *alpinum*	Asteraceae	H herb			x	
Homogyne alpina	Asteraceae	H herb	x		x	
Leontodon hispidus	Asteraceae	H herb			x	x
Senecio incanus ssp. *carniolicus*	Asteraceae	H herb	x		x	
Solidago virgaurea ssp. *minuta*	Asteraceae	H herb			x	
Taraxacum alpinum agg.	Asteraceae	H herb	x		x	x
Arabis alpina	Brassicaceae	Ch		x		x
Cardamine resedifolia	Brassicaceae	H herb				x
Campanula barbata	Campanulaceae	H herb			x	
Campanula scheuchzeri	Campanulaceae	H herb			x	
Phyteuma hemisphaericum	Campanulaceae	H herb	x		x	
Arenaria biflora	Caryophyllaceae	Ch		x		x
Cerastium cerastoides	Caryophyllaceae	Ch				x
Cerastium uniflorum	Caryophyllaceae	Ch		x		x
Moehringia ciliata [2]	Caryophyllaceae	H herb		x		
Sagina saginoides	Caryophyllaceae	H herb				x
Silene acaulis ssp. exscapa [3]	Caryophyllaceae	Ch		x	x	x
Sedum alpestre	Crassulaceae	Ch		x	x	x
Sempervivum montanum ssp. *montanum*	Crassulaceae	Ch			x	
Juniperus communis ssp. *nana*	Cupressaceae	NaPh			x	
Carex atrata	Cyperaceae	H gram			x	
Carex curvula ssp. *curvula*	Cyperaceae	H gram	x		x	
Carex frigida	Cyperaceae	H gram			x	
Eriophorum scheuchzeri	Cyperaceae	H gram	x			
Polystichum lonchitis	Dryopteridaceae	H herb			x	
Loiseleuria procumbens	Ericaceae	Ch	x		x	
Rhododendron ferrugineum	Ericaceae	NaPh	x		x	x
Vaccinium gaultherioides [4]	Ericaceae	Ch	x		x	
Lotus corniculatus ssp. *alpestris*	Fabaceae	H herb			x	
Trifolium pallescens	Fabaceae	H herb			x	
Gentiana nivalis	Gentianaceae	Th			x	
Juncus trifidus	Juncaceae	H gram	x		x	
Luzula alpinopilosa	Juncaceae	H gram			x	x
Luzula spicata	Juncaceae	H gram			x	
Pinguicula leptoceras	Lentibulariaceae	H herb			x	
Huperzia selago	Lycopodiaceae	Ch	x		x	
Lycopodium alpinum	Lycopodiaceae	Ch			x	
Euphrasia minima	Orobanchaceae	Th	x		x	
Pedicularis kerneri [5]	Orobanchaceae	H herb	x		x	
Larix decidua	Pinaceae	MacPh			x	
Picea abies	Pinaceae	MacPh			x	
Agrostis rupestris	Poaceae	H gram		x	x	x
Deschampsia cespitosa ssp. *gaudinii*	Poaceae	H gram	x		x	x
Nardus stricta	Poaceae	H gram	x		x	
Poa alpina	Poaceae	H gram		x	x	x
Poa laxa	Poaceae	H gram			x	x
Trisetum spicatum	Poaceae	H gram			x	x
Oxyria digyna	Polygonaceae	H herb		x	x	x
Persicaria vivipara [6]	Polygonaceae	H herb		x	x	
Primula minima	Primulaceae	H herb	x		x	
Soldanella pusilla	Primulaceae	H herb	x			
Pulsatilla alpina ssp. *alba*	Ranunculaceae	H herb			x	
Ranunculus glacialis	Ranunculaceae	H herb		x		x
Geum reptans	Rosaceae	H herb		x	x	x
Potentilla aurea	Rosaceae	H herb			x	
Sibbaldia procumbens	Rosaceae	H herb	x		x	
Salix herbacea	Salicaceae	Ch		x	x	x
Salix retusa	Salicaceae	Ch			x	x
Saxifraga aizoides	Saxifragaceae	Ch		x		
Saxifraga biflora	Saxifragaceae	Ch		x		
Saxifraga bryoides	Saxifragaceae	Ch		x	x	x
Saxifraga exarata [7]	Saxifragaceae	Ch		x		x
Saxifraga oppositifolia	Saxifragaceae	Ch		x		x
Saxifraga paniculata [8]	Saxifragaceae	Ch		x	x	
Selaginella selaginoides	Selaginellaceae	Ch	x		x	
Linaria alpina ssp. *alpina*	Veronicaceae	H herb				x
Veronica alpina	Veronicaceae	H herb		x	x	x
Viola c.f. *biflora*	Violaceae	H herb			x	

taxonomy of species at Klebelsberg 1913:
1) *Chrysanthemum alpinum*
2) *Moehringia polygonoides*
3) *Silene acaulis*
4) *Vaccinium uliginosum*
5) *Pedicularis asplenifolia*
6) *Polygonum viviparum*
7) *Saxifraga muscoides*
8) *Saxifraga aizoon var. brevifolia*

notes on sites:
A) species listed by Klebelsberg 1913 growing close to the glacier foreland outside the 1858 terminal moraine, but not inside
B) species listed by Klebelsberg 1913, growing within the glacier foreland deglaciated between 1858 and 1911
C) species recently sampled on test sites within area B
D) species recently sampled on test sites in the glacier foreland covering approximately the same timespan since deglaciation like area A of Klebelsberg (i.e. ~ 50 years)



Species encountered in front of the LIA terminal moraine (A) and at different locations and different dates within the glacier foreland of Lenksteinferner (South Tyrol).

Suggesting analytical approaches for a better understanding of arthropod ecology along glacier forelands

Mauro Gobbi[1]*, Mattia Brambilla[2,3] & Simone Tenan[3]

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[2] Division Biodiversity and Protected Areas, Lombardy Foundation for the Environment, Largo 10 luglio 1976 1, I-20822 Seveso (MB), Italy

[3] Department of Vertebrate Zoology, MUSE - Museo delle Scienze, Corso del Lavoro e della Scienza 3, I-38123 Trento, Italy

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We discuss how the increasing availability of powerful statistical tools results in analytical approaches that facilitate solving problems tied to the intrinsic nature of research on glacier forelands, and improve our understanding of animal ecology in this peculiar habitat.

Pitfall trapping data, frequently available for arthropods, can be affected by spatial autocorrelation which in turn leads to the following question: Are the observed patterns (community composition, species occurrence, etc.) driven by environmental factors (e.g. time since deglaciation, habitat features), or simply by spatial pattern, with nearest sites mostly sharing species and communities? Explicitly testing for spatial autocorrelation is recommended in order to answer this question, whereas *ad-hoc* sampling design can be planned, e.g. by placing sample sites with wide differences in time since deglaciation close to each other.

Imperfect detection probability is an additional issue when we want to infer on species richness and population size by means of pitfall trap data. In this case, recently developed hierarchical models, such as multinomial mixture models, represent flexible tools that easily allow the inclusion of spatial covariates of abundance with full accounting for imperfect detection as well as any imbalance in the data set.

Another tricky point is that we often deal with scarcely represented species and relatively low sample sizes, yet we want to evaluate what environmental factors are more likely to drive the spatial and temporal processes we observe. A possible way to overcome limited sample size is represented by multi-species models, e.g. using multivariate adaptive regression splines. This statistical method allows multi-response models, which are particularly meaningful in determining what factors are more likely to be important across all species.

Key words:
imperfect detection, MARS, spatial autocorrelations, population size.

Species	Acronym	Wing m.	No. sites	Int.	B	100 yr lag
Amara (*Celia*) *erratica* (Duftschmid 1812)	Ama_err	W	8	0.287	0.361	no
Amara (*Celia*) *praetermissa* (C.R. Sahlberg 1827)	Ama_pra	W	6	0.144	0.433	no
Amara (*Paracelia*) *quenseli* (Schönherr 1806)	Ama_que	W	6	0.428	−0.217	no
Cymindis (*Tarulus*) *vaporariorum* (Linnaeus 1758)	Cym_vap	W	9	0.358	0.325	no
Nebria (*Eunebria*) *jockischii* Sturm 1815	Neb_joc	W	3	0.214	−0.108	no
Nebria (*Eunebria*) *picicornis* (Fabricius 1792)	Neb_pic	W	5	0.073	0.469	no
Nebria (*Boreonebria*) *rufescens* (Stroem 1768)	Neb_ruf	W	1	−0.001	0.129	partly
Ocydromus (*Peryphus*) *incognitus* (G. Müller 1931)	Ocy_inc	W	3	0.145	0.049	no
Princidium (*Testedium*) *bipunctatum* (Linnaeus 1761)	Pri_bip	W	2	0.078	0.075	no
Sinechostictus doderoi (Ganglbauer 1891)	Sin_dod	W	2	0.143	−0.072	no
Bradycellus (*Bradycellus*) *caucasicus* (Chaudoir 1846)	Bra_cau	L	1	−0.007	0.144	yes
Calathus (*Neocalathus*) *melanocephalus* (Linnaeus 1758)	Cal_mel	L	3	−0.005	0.394	yes
Calathus (*Neocalathus*) *micropterus* (Duftschmid 1812)	Cal_mic	L	3	−0.005	0.394	yes
Carabus (*Platycarabus*) *depressus* Bonelli 1810	Car_dep	L	7	0.284	0.240	no
Carabus (*Orinocarabus*) *sylvestris* Panzer 1793	Car_syl	L	13	0.712	0.023	no
Cychrus caraboides (Linnaeus 1758)	Cyc_car	L	1	−0.007	0.144	yes
Leistus (*Leistus*) *nitidus* (Duftschmid 1812)	Lei_nit	L	2	−0.008	0.273	yes
Notiophilus aquaticus (Linnaeus 1758)	Not_aqu	L	4	0.217	0.013	no
Oreonebria (*Oreonebria*) *castanea* (Bonelli 1810)	Ore_cas	L	8	0.571	−0.289	no
Pterostichus (*Oreophilus*) *multipunctatus* (Dejean 1828)	Pte_mul	L	2	−0.008	0.273	yes
Pterostichus (*Haptoderus*) *unctulatus* (Duftschmid 1812)	Pte_unc	L	1	0.003	0.121	partly
Synuchus vivalis (Illiger 1798)	Syn_viv	L	2	−0.008	0.273	yes

Coefficients of the multi-response model for occurrence “B” of carabid beetles in relation to time since deglaciation.

Connell & Slatyer revisited: What we really know about mechanisms driving succession of glacier forelands

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In a seminal paper on mechanisms of succession, Connell and Slatyer (1977)[1] proposed three alternative models: (1) facilitation model, (2) tolerance model, and (3) inhibition model. They considered the facilitation model as the most likely to apply in primary successions such as glacier forelands. It implies that early species prepare the ground and thus facilitate the establishment of later successional species.

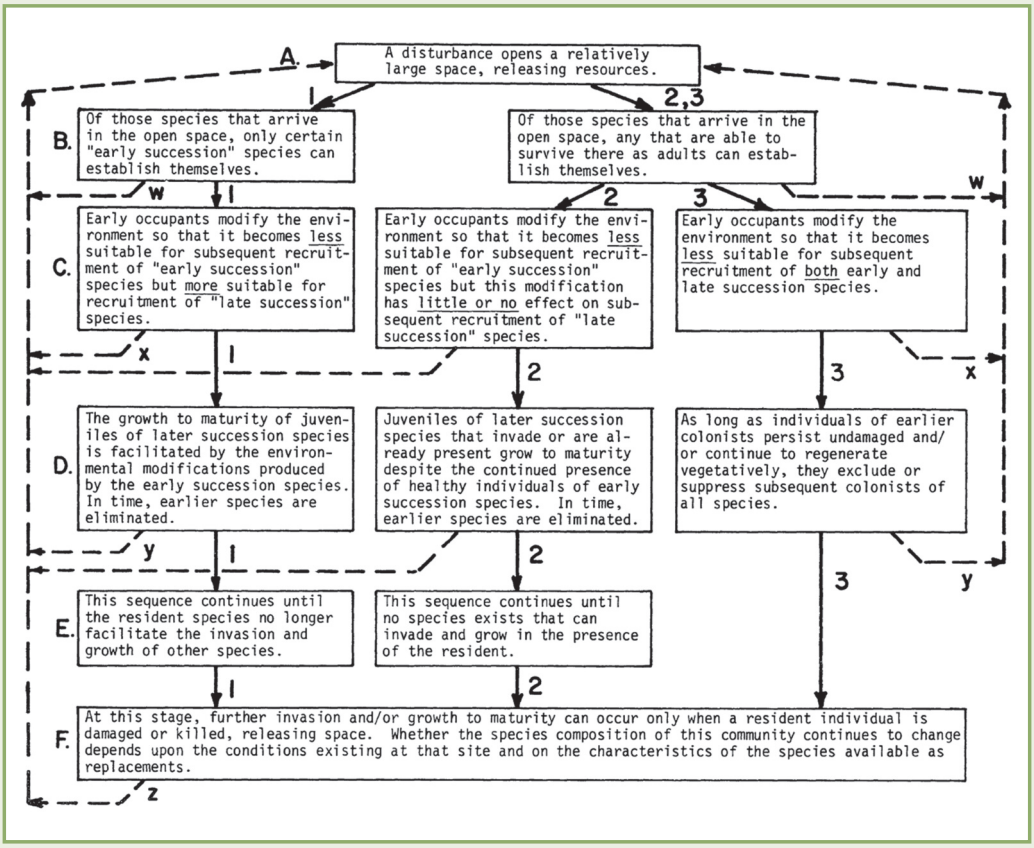
But they also recognised that other interactions may be important too when the focus is not on plants but on all organism groups involved. Competition has traditionally received much attention, but also the decomposition capacity of microorganisms, herbivory and predation by animals, as well as pathogens may play an important role. Generally, experimental approaches are required for the assessment of organismic interactions, observation alone can only give an indication.

Therefore it is explored what evidence for interactions and mechanisms in the succession of glacier forelands has been gathered since the 1970ies, in which respects the picture is sufficiently clear, and where knowledge gaps remain. Connell and Slatyer also dealt extensively with the stability of successional communities (apart from the change inherent in succession), an important point, as glacier forelands are often considered to be ecosystems susceptible to disturbance.

Therefore the state of knowledge on resistance and resilience of glacier foreland communities will be discussed. Finally, new methodological approaches for these questions will be addressed.

Key words:
community assembly, competition, facilitation, stability, succession models, theory.

[1] Connell, J. H., and R. O. Slatyer. 1977. Mechanisms of succession in natural communities and their role in community stability and organization. American Naturalist 111: 1119-1144.



The original figure of Connell and Slatyer (1977) with the description of the mechanisms underlying the facilitation (1), tolerance (2) and inhibition (3) models and the pathways after disturbances (w, x, y, z,; in order of declining frequency).

Colonization pattern in three glacier forelands in the Ötztal Alps

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Glacier retreat is well documented in the Ötztal Alps and also primary succession was investigated in several glacier forelands. The aim of my master thesis was to study primary succession along adjacent glacier forelands with similar bedrock (calcareous and siliceous) and to compare it to one on siliceous bedrock.

Three glacier forelands of similar sizes and extents were chosen: Gaisbergtal, Rotmoostal and Langtal. Relevées of 3 × 3 m were performed along the chronosequences in two glacier forelands (the third one will be sampled in summer 2014).

Data were analyzed by means of TWINSPAN. In both glacier forelands four major communities were identified: a pioneer stage, a species-rich pioneer stage, an early successional stage and a *Kobresia myosuroides* grassland. Species composition was highly similar, however, spatial distribution varied between the two glacier forelands.

This can be explained by the asymmetric retreat of the glacier and the specific topography in the Gaisbergtal. Moreover, each glacier foreland has its own dynamic.

Key words:
early successional stage, *Kobresia myosuroides* grassland, pioneer stage, primary succession.

Investigation area: Gaisbergtal (left) and Rotmoostal (right). Pictures from August 2013

Impact of heat on survival of early developmental stages of glacier foreland species

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In the Rotmoos glacier foreland, seeds readily germinate but high seedling mortality retards establishment. We hypothesised that heat on the ground surface is lethal to seedlings. The heat strain in different ground strata was assessed from 2007-2010. For heat risk assessment differences in heat tolerance (LT_{50}) between imbibed (G1), germinated seeds (G2) and seedlings (G3) of eleven alpine species from different successional stages and the heat hardening capacity of seedlings was determined.

Across all species, LT_{50} decreased significantly by 9K from G1 (55 °C) to G3 (46 °C). Intraspecifically, LT_{50} of seedlings varied between 40.6 °C and 52.5 °C. Along the chronosequence LT_{50} in G1 was similar, but was higher in G2 and G3 of early successional species. Field grown seedlings had mostly an increased LT_{50} (2K).

The highest heat load occurred at 0 - 0.5 cm at the soil surface (mean/absolute maximum: 42.6 °C/54.1 °C) posing a significant heat injury risk for seedlings. Below small stones (diameter 0 - 0.5 cm) maxima were 4K lower, indicating heat safer microsites. Inter-annually, 2010 was the hottest year with heat exceeding LT_{50} at all microsites. Temperature maxima on sandy surfaces were lower than on microsites with gravel (diameter <5 to 10 mm).

The hot summer of 2010 may be a small foretaste of in future more severe and frequent heat waves. Ground surface temperature maxima at the pioneer stage are already now critical for heat survival and may partly explain the high seedling mortality recognized on recently deglaciated terrain.

Key words:
alpine plants, germination, risk assessment, seeds, temperature stress.

Radial growth of dwarf shrubs and perennial plants in Ebbadalen (central Spitsbergen)

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Global warming observed nowadays causes an increase in geomorphic activity in polar regions. Habitat conditions, in particular water availability and stability of the deposits, have a significant influence on tundra expansion and the rate of shrub succession within newly deglaciated areas.

Dwarf shrubs and perennial plants growing within an alluvial fan and upper marine terraces in Ebbadalen, located in central Spitsbergen have been selected to assess their dendrochronological potential. The goal of the study was to determine how geomorphic activity affects the lifespan and wood anatomy of most dominant shrub and herb species.

Within the investigated area microforms differentiated by origin, age and stability were selected to analyse the influence of different habitat conditions on longevity of dwarf shrubs of *Salix polaris* and perennial plants such as *Cerastium arcticum*, *Draba corymbosa*, *Pedicularis hirsuta, Erigeron humilis*. Traditional dendrochronological methods were used, including measurements of tree-ring widths. Additionally, observations of changes in wood anatomy and morphology of annual growth rings of dwarf shrubs indicating mechanical stress caused by geomorphic activity were conducted.

The oldest individual of *Salix polaris* was found within upper marine terraces and was 65 years old. The oldest perennial plant found in the study was *Draba corymbosa* growing within unstable habitat of an alluvial fan and represented the age of more than 30 years. Dwarf shrubs collected from the microsites located within the alluvial fan showed severe changes in wood anatomy such as tension wood, irregular and partially missing rings, multiple scars and partially injured roots.

Key words:
dendrochronology, habitat conditions, lifespan, wood anatomy.

Terricolous lichens in glacier forelands of the Eastern Alps - diversity, abundance and composition

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Terricolous lichens in glacier forelands are almost unexplored. However, 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. 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 glacier forefields in the Eastern Alps (Gaisbergferner and Pasterze in Austria, Rötkees and Matscherferner in Italy as well as the Morteratsch glacier foreland in Switzerland). Three sampling sites were established at increasing distance from each glacier that correspond to a gradient of moraine age. In each site, lichens were surveyed within five 1 × 1 m randomly placed plots (devided in 10 × 10 cm quadrats), both on soil and on plant debris or decaying terricolous mosses. The gradient of species richness, composition and biological traits seems to reflect the gradient of moraine age, lichen communities being more diverse as much as the substrate is more stable. We draw a comparison of diversity, abundance and composition of terricolous lichens in these young ecosystems on barren ground.

Key words:
alpine belt, ecology, glacier retreat, lichenized Ascomycetes.

Geoecological dynamics in an ice-free area in the Maritime Antarctica: a study case from Elephant Point (Livingston Island, South Shetland)

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Elephant Point is a small ice-free area of ca. 1 km² in the southwestern corner of Livingston Island (South Shetland Islands, Antarctica). The land surface in this peninsula is exposed thanks to the recent retreat of the Rotch dome glacier. Nowadays, this peninsula constitutes a maritime permafrost environment where periglacial processes are dominant. It is an area with a large biodiversity of plants and animals, especially in the area close to the sea.

Geomorphological units were used as the basis for mapping the distribution of the different ecological areas. Five main geoecological units were identified:

- Glacier: Birds and Weddell seals are distributed in the margins of the glacier, near the coast.
- Proglacial environment: Small areas recently deglaciated affected by thermokarst processes. Very little biological activity.
- Moraine complex: The moraine is 20 - 50 m height and 1 km length. It is composed by a sequence of arches running from the W to the E along the peninsula. The sediments of the moraine are intensely reworked by periglacial slope processes (mudflows, solifluction), more active on the north facing slope.
- Bedrock plateaus with patterned ground forms in areas where cryosoils are present: Several colonies of birds were identified, with thick ornithogenic soils and earth hummocks developed in these environments.
- Marine terraces: Up to 5 different raised beaches were identified (2, 3, 5, 7, 10 m a.s.l.). Biological activity is very intense in these areas (seals, penguins, birds, etc). Interestingly, minor geomorphological units near the shoreline were created by the biological activity of penguin colonies (penguin mounds) and others landforms were affected by the erosion generated by elephant seals (haul scars).

Key words: deglaciation, geomorphological processes, periglacial processes.

This research was funded by the Portuguese Science Foundation through the projects HOLOANTAR (Holocene environmental change in the Maritime Antarctic. Interactions between permafrost and the lacustrine environment, reference PTDC/CTE-GIX/119582/2010) and PROPOLAR (Portuguese Polar Program).

Soil community assembly on nunataks, Iceland

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Nunataks are ice-free areas in glacier surroundings. They have both the chronological sequence of a glacier foreland and the restrict boundaries of an island. Thus, they offer a unique opportunity to study community assembly and how dispersal constraints, or abilities, may affect the assembly process.

Dispersal abilities determine what species reach the habitat but environmental constraints and species interactions determine what species actually establish. Random dispersal and strong environmental control may result in the same pattern of community structures because sites that are close to each other tend to have more similar environment than sites that are far apart. To get an idea on the role of each of those factors, we sampled collembolans and oribatid mites, and measured environmental factors along transects within four nunataks in Vatnajökull Iceland, extending from the youngest part of the nunatak to the older parts.

The community assembly on the nunataks was similar to ones on glacier forelands, indicating that glaciers do not act as barriers for dispersal of soil arthropods despite the notion that dispersal to nunataks should be counteracted by katabatic winds. Age of terrain and plant richness had significant effects on the community assembly.

However, a substantial part of the variation in the community structure could not be explained by the environment but only by spatial distances. When all the results were linked together they indicated that the local environment was important in structuring the soil communities but that we were probably also looking at a large influx of soil arthropods, especially of collembolans.

Stable isotope studies on their food sources supports our conclusions, because they indicated that part of the collembolans had just arrived and had thus probably not yet established.

Key words:
collembolans, dispersal, local environment, oribatid mites.

Three invisible carbon sources feed pioneer invertebrates in a Norwegian glacier foreland

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The Hardangerjøkulen glacier in central South Norway has receded since year 2000. Studies of the gut content of pioneer invertebrates have revealed that they feed on very cryptic carbon sources:

1. Ancient carbon released by the glacier: Sand and silt close to the ice edge contained small amounts of 21,000 year old organic material, and this fine-grained material was accumulated in the bottom of small dams. Here, ancient carbon was assimilated by larvae of chironomid midges. Adult midges with a radiocarbon age of 1,040 years transported ancient carbon to terrestrial habitats. These locally produced midges were preyed upon by beetles, spiders and harvestmen, which achieved a radiocarbon age between 340 and 1,100 years.
2. Biofilm: Certain springtails had diatoms in their gut, indicating that they had eaten terrestrial biofilm with photosynthetic algae.
3. Pioneer mosses: Three beetle species and one springtail species grazed on tiny pioneer mosses or their dispersal units.

The study illustrates that chlorophyll-based food chains start almost immediately, and that predators are not always first.

General suggestions for further research in glacier forelands:

- Gut content studies, both directly and via DNA primers, are the key to reveal pioneer food webs.
- More studies of biodiversity and succession in pioneer dams, and transport of carbon from aquatic to terrestrial habitats.
- Awareness of early chlorophyll via algae or mosses.
- Dispersal ability of pioneer invertebrates.

Key words:
ancient carbon, biofilm, gut contents, pioneer food chains, pioneer mosses.

View towards the ice front in 2010, taken from the 2005-moraine. Photo: Daniel Flø.

The Matsch Glacier foreland (South Tyrol): an integrated analysis of snow cover dynamics, runoff generation and sediment transport

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Retreating glaciers lead to new emerging ecosystems in the glacier forelands. While these forelands become less connected to the glacier, the river network remains continuously affected by the glacier and melt dynamics at higher elevations. Understanding the physical drivers behind these dynamics and the fluviomorphological evolution of the river network requires an integrated analysis of different hydrological, geochemical and geomorphological processes.

Here we present the interdisciplinary research carried out between 2011 and 2013 at the Saldur River, which drains the Matsch Glacier foreland (Eastern Italian Alps). To estimate snow cover dynamics at the catchment scale, we used satellite imagery derived from MODIS and Landsat while *in-situ* data at the plot scale were derived from snow profiles.

These data were employed for hydrological model calibration to provide snow water equivalent estimates in the whole catchment and to understand the seasonal level of glacier ablation. Continuously measured water stages at two cross sections revealed seasonal runoff dynamics governed by snowmelt, glacier melt and rainfall events. To identify the daily contribution of snowmelt, glacier melt and groundwater in the river during single melting events, tracer data such as electrical conductivity and stable water isotopes (d^2H and $d^{18}O$) were analysed. Additionally, spring water was sampled to obtain the groundwater signature.

To continuously monitor the bedload transport, a Japanese acoustic pipe was installed and its response was calibrated against *in-situ* measurements performed by means of portable "Bunte" traps. Additional data on bedload were derived from the use of RFID tracers, monitored by means of 4 stationary antennas. Further research in the Matsch Glacier foreland will focus on monitoring different sub-catchments, bedload sampling at the glacier snout and extended water sampling at different water springs.

Key words:
bedload, hydrological modelling, hydrology, interdisciplinary approach, tracer analysis.

Ultrahigh-resolution molecular characterization of DOM in glacier-fed and clear alpine lakes

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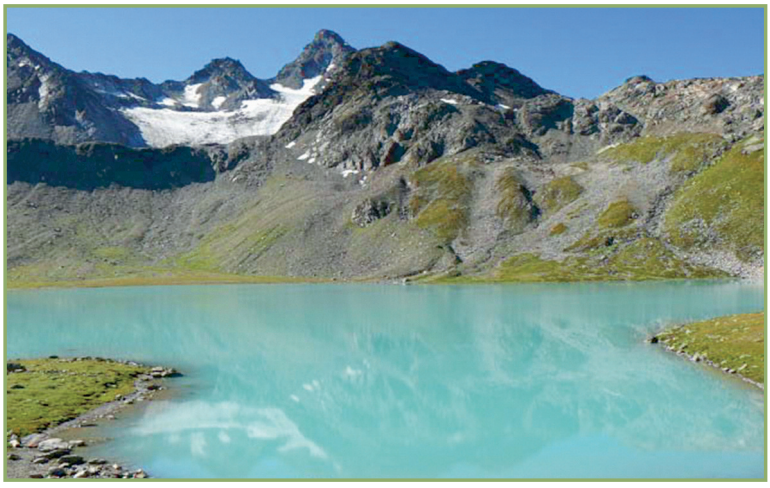
Key words: glacial flour, glacier retreat, turbid lakes.

A remarkable characteristic of glacier-fed lakes is their high content of suspended minerogenic particles, so-called 'glacial flour'. The current rapid glacier retreat is expected to increase turbidity in glacier-fed lakes with consequences for the primary production and UV penetration.

At the same time, the rapid glacier retreat may lead to the loss of connectivity to lakes that then became clear. In combination, these processes may have consequences for the composition of Dissolved Organic Matter (DOM) and its diversity. We hypothesized that diversity of dissolved organic molecules increases with decreasing turbidity due to the change in contribution of phytoplankton-derived carbon.

We used Fourier-Transform Ion Cyclotron Mass Spectrometry to assess the molecular composition and diversity of DOM in four interconnected lakes in the Austrian Alps over the ice-free season. This analysis was complemented with spectrophotometric and fluorometric measurements. Three of the lakes receive water from a glacier and exhibited a turbidity gradient, whereas one lake lost contact to the glacier and it is clear. Our results showed that DOM composition differed between all lakes and showed substantial seasonal variation.

In terms of diversity, the clear lake had not only 16 % to 20 % more organic molecules than the turbid lakes, but also 12-fold more unique ones. These results suggest that the increase in DOM diversity with decreasing turbidity will sustain a higher prokaryotic diversity in clear lakes.



One of the Faselfad turbid lakes and the glacier of the study.

Active rock glaciers and their impact on stream water quality

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Active rock glaciers are a fascinating form of mountain permafrost. Out of the ~ 500 active rock glaciers, which have been reported from the Tyrolean Alps, some 30 % are found in the Ötztal and Stubai Alps. Hochebenkar rock glacier is one of the most intensively investigated active rock glaciers in the Austrian Alps with flow measurements starting in 1938.

Since 2007, the chemical composition of the rock glacier outflows has been investigated. Runoff of an active rock glacier reveals a high seasonal and diurnal variability with varying relative contributions of snowmelt, precipitation events, groundwater and melting of internal ice. Peak discharge generally occurs in late spring caused by the melting of the seasonal snow pack, and secondary peaks are linked to heavy summer precipitation.

Solute concentrations of rock glacier streams tend to increase from the onset of snowmelt in spring (or early summer) until autumn with values of electrical conductivity rising from ~ 100 up to ~ 500 µS/cm in September or October. The dominating ions calcium, magnesium and sulfate comprise up to 98 % of the total ion balance. Rock glacier streams may also contain high concentrations of heavy metals which exceed limits of drinking water by one order of magnitude. Here, we report on the seasonality of rock glacier streams and their varying chemical composition. We focus on Hochebenkar outflows and we compare the results with data of rock glacier streams in North and South Tyrol.

Key words:
alpine headwater, runoff seasonality, solute concentration.

Plant-arthropod communities on glacial and periglacial landforms of the Italian Alps: state of the art and future perspectives

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Investigation on the effects of climate change on ecosystems has focused on temperature-limited habitats, where they are expected to have the strongest impact. Ice-related landforms are particularly affected in terms of habitat loss but also of triggering of primary succession.

In spite of the long tradition of ecological investigation in high-altitude ecosystems, few studies have been addressed to the integrated analysis of plant and animal communities and even less to their comparison through a functional approach.

We aim to present an ongoing, long-term investigation of plants and ground-dwelling arthropods (spiders and carabid beetles) on different ice-related landforms of the Italian Alps.

Relationships of plant and arthropod communities with the physical environment have been investigated on a debris-covered glacier emphasizing its role for the survival of cold adapted species at low altitude. The study of the successional pathway of plant and arthropod communities on a glacier foreland showed a consistent gradient of plant and carabid functional traits throughout the succession following a resource availability and disturbance/stability gradient. Preliminary data from three rock glaciers on different substrata indicate the occurrence of distinct plant and arthropod assemblage with respect to the surrounding environments, and the capability of these landforms to support large populations of cold-adapted arthropod species.

The overall picture of plant and arthropod life on these demanding habitats shows an important role of abiotic factors (soil grain size distribution, stability, microclimate), which select for specific functional responses of plants and arthropods. The possible role of ice-related landforms as refugia for cold adapted species during warm climatic stages seems to be supported at least for some landforms and some taxa, and deserves further investigations being a crucial topic in the field of climate change.

Key words:
cold adapted species, debris-covered glacier, functional traits, rock glacier.

Terrestrial thermal dynamics and associated constraints on the behavior of mountain goats (*Oreamnos americanus*) in southeast Alaska

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Increasing temperatures and climate variability are of current global concern and may be more pronounced at higher latitudes. As such, wildlife that occurs in northern habitats may be especially susceptible to changes in climate conditions, ecosystem structure, and phenology.

There is a marked need to better understand thermoregulatory constraints on faunal behavior and the effect of changing landscapes on wildlife populations. Alpine Caprinae including mountain goats (*Oreamnos americanus*) have been described to be sensitive to temperature changes within their summer range.

Consequently, mountain goats may be forced to select habitats which allow for the maintenance of a stable core temperature on warm days. Mountain goats must spend a substantial portion of their time actively foraging in summer. Additionally, the low abundance of high quality food at high elevation sites coupled with the energetic cost of accessing these areas could have adverse effects on survival if too much time is spent on thermoregulatory habitat selection. This study aims to elucidate mountain goat behavioral activity budgets across alpine temperature gradients in southeast Alaska.

A current problem in modeling climatic data and using them in context with ecological study is that it remains difficult to make assumptions for a species or landscape based on broad spatial models. Downscaling to achieve high resolution climate data that also takes diverse terrain features into account is essential. Thus, downscaled alpine thermal dynamics will be monitored (and modeled) using an array of meteorological stations and passive temperature loggers. This research demonstrates an interdisciplinary, novel approach to understanding environmental dynamics by incorporating wildlife behavior, climate science, ecology, and geospatial modeling to index environmental change.

This study will assist wildlife-, land- and conservation managers in making informed decisions with which they can assess appropriate actions to implement regarding the northern coastal temperate rainforest system in the face of a warming climate.

Key words:
animal behavior, Caprinae, lapse rates, temperature modeling, thermoregulation

American Mountain Goat (*Oreamnos americanus*) in southeast Alaska

Knowns and unknowns: winter soil fungal communities and their possible interactions

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Soil microbial communities follow distinct seasonal cycles, which result in drastic changes in processes involving soil nutrient availability and have large ecological consequences due to shifts of dominating functional groups of soil fungi.

Fungal biomass is highest during winter, because fungi are extensively growing during winter in snow-covered soil, as shown based on in-growth mesh bag approaches. But who are these winter-active fungi, and what is their function and possible interactions? To answer these questions, we monitored microbial biomass, N, ergosterol, and the amount of fungal hyphae during summer and winter.

The soil fungal communities (SFC) were identified based on both, rDNA ITS clone libraries and cultivation approaches from in-growth mesh bags. Winter soil temperatures ranged between –0.6 °C and –0.1 °C in snow-covered soil of the Rotmoos glacier foreland (Ötztaler Alpen, Austria). We found distinct seasonal patterns for fungal biomass, with highest biomass concentrations during winter in snow-covered soil, and a mean hyphal ingrowth of 5.6 m g^{-1} soil during winter. Species composition of winter SFC was clearly different from summer SFC: saprobial fungi were clearly dominating during winter, while mycorrhizal fungi were the dominant groups during summer. Winter also appeared to be an important period for the development for plant- and animal pathogenic fungi, or for fungal endophytes.

The consequences and possible interactions will be briefly discussed based on selected fungal species.

Key words:
alpine soil mycobiota, Ascomycota, glacier foreland, psychrotolerant yeasts and fungi, rDNA ITS clone libraries.

Soil fungal communities from in-growth mesh bags in snow covered alpine soil

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Fungi are very adaptive microorganisms and have the ability to grow at a wide range of temperatures. Fungal activity was also detected in snow-covered soil of alpine habitats like the glacier foreland of the Rotmoosferner (Ötz valley / Ötztaler Alpen / Austrian Central Alps).

Our main aim was to identify fungi growing actively during the snow-covered period and to address the problem of species recognition in environmental sampling. We investigated soil fungal communities in alpine soil with *Salix herbacea* as dominating vegetation type. In-growth mesh bags filled with sterile quartz sand were buried for detection and identification of fungal species actively growing during the snow-covered period. Quartz sand cornels were plated on three different media (PDA, SNA and MMN) and incubated at 10 °C for 1-3 weeks. Fungi were transferred to MEA to obtain pure cultures, which were further incubated at 10 °C. Morphological characteristics and rDNA-ITS sequences were used for identification of pure cultures. Clone libraries for the molecular identification of soil fungal communities were based on pooled DNA-extracts from in-growth mesh bags (n = 6). We will discuss species richness and diversity from alpine snow covered soil and the differences in results from cultivation-based and molecular approaches.

Key words:
rDNA-ITS sequences, *Salix herbacea*, sterile quartz sand.

What happens with the fungal biomass under the snow cover in alpine soils?

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Recent studies changed the traditional view of seasonal dynamics in soil microbial communities: winter is no longer regarded as dormancy period, but as a time of high fungal activities and nutrient turnover. In winter, the dominance of fungi is promoted by the occurrence of complex organic polymers and by phenolic compounds.

We investigated the mycobiota of a primary successional glacier foreland at 2,350 m (Rotmoosferner, Ötz valley, Austria) as a model for alpine soil fungal communities. Fungal communities associated with three alpine plants (*Kobresia myosuroides*, *Salix herbacea* and *Persicaria vivipara*) were investigated, and soils without plant cover were used as control. Fungal biomass (evaluated by ergosterol content) was subjected to a distinct seasonal dynamics: fungal biomass increased during winter under the snow cover.

The presence of plant cover had a significant positive effect on the amount of fungal biomass in the soil. Organic matter appears to be a critical factor for the development of soil fungal communities. Approaches with in-growth mesh bags (MB) buried during winter allowed the detection of fungi actively growing under the snow-cover at temperatures between -0.6 °C and -0.1 °C. The effect of native soil or acid-washed quartz sand as MB substrate was compared based on microscopic measurements of hyphal length and on rDNA ITS clone libraries. MB filled with native soil yielded four- to ten-fold higher values of fungal biomass (m hyphae / g substrate) than MB filled with sand, and supported relatively higher rates of saprobial fungi. Most of them were psychrotolerant Ascomycota or basidiomycete yeasts.

Native soil as MB substrate consistently facilitates assessment of external mycelial production, and is especially suitable for a reliable detection of more integral (including otherwise neglected saprobial) fungal communities in habitats with low biomass productivity.

Key words:
Ascomycota, basidiomycete yeasts, ergosterol, fungal biomass, glacier foreland, rDNA ITS clone libraries.

Bioprospecting of the microbial diversity in varnish and non-varnish rock surfaces

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Rock varnish is a deposition of iron and manganese oxides that glues together different clay minerals; it has been studied by geologists for many years, but has only recently raised interest from a microbiological perspective.

We looked for the main bacterial and archaeal communities colonizing rock varnish and compared the results with those from neighbouring rock surfaces without varnish, using elemental composition analysis of the rocks, SEM imaging of the rock-microbial interactions, 16S rRNA gene high-throughput (HTP) sequencing by Illumina run (V4 region), and classical culturing methods. We sampled 15 varnish and 15 non-varnish samples of rock surface in Matsch valley (South Tyrol, Italy), a south-east oriented valley with a metamorphic lithology at about 2,500 m a.s.l., from microsites where varnish rocks were found in close proximity with non-varnish rocks.

There was little variation in the rock elemental composition between varnish and non-varnish samples, probably the changes in the chemical composition of rock varnish do not regard the element itself but rather its oxidation state. The SEM micrographs revealed different microbial morphotypes existing on the rock surfaces. HTP sequencing gave an average of 473,026 reads per sample.

The bacterial communities on the studied rock surfaces are dominated by Proteobacteria and various photosynthetic taxa, however, Acidobacteria, Actinobacteria, Chloroflexi and Armatimonadetes were present at a lower percentage. In comparison, there were significantly less autotrophic taxa on non-varnish rocks. The enrichment experiments are currently ongoing, and the results regarding the physiological features of the isolated strains will be presented at the conference. To our knowledge this is the first study performed on the microbial diversity of rock varnish using intensive cultivation, in combination with molecular and geochemical analysis. We showed that rock varnish has a different microbial community with respect to its neighbouring non-varnish rock surface, with more chemolithotrophic taxa.

Key words:
bacterial communities, bioweathering, rock varnish, glacier forefields, Alps.

Bacterial communities associated to the nitrogen cycle in proto-soils of the Matsch Valley glacier forefield (South Tyrol, northern Italy)

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Moraines represent ideal sites to study the microbial contribution to plant community establishment. Study aim was to characterize bacterial communities involved in soil neo-genesis and pioneer plant growth. The study site was the Weisskugel glacier forefield in the Matsch Valley (South Tyrol) at an altitude of 2,400 m a.s.l.

The first plant colonization started around 1840 when the glacier began to retreat. We firstly investigated the effect of plant species on the rhizobacteria of 33 plant individuals belonging to 13 different pioneer species. In early primary succession, pioneer plant species could select distinct rhizobacterial communities.

Then, we studied the rhizosphere effect on the bacterial communities associated to "safe sites", little sites surrounded by big stones and filled up of stone debris or mud. We found significant differences among the bacterial profiles of the sites. The biodiversity, structure, and role of both the overall and the active rhizobacterial communities of the most common floristic associations in the valley (Cetrario-Loiseleurenion, *Nardion strictae*, *Festucetum halleri*) were studied during the early and late growing season at two different periods of glacier retreat characterized by different environmental parameters. We used techniques such as ARISA, 16S rRNA gene pyrosequencing on DNA and RNA, and *nifH* gene pyrosequencing.

The overall rhizobacterial community structure of the two transects in the early and late growing seasons were significantly different from the correspondent active rhizobacterial communities. Within the overall bacterial communities, each plot differed significantly according to 1) the sampling season and 2) to soil age, whereas within the active bacterial communities plots clustered mainly according to the season.

A marked shift in active Proteobacteria, Acidobacteria, Planctomycetes highlighted the difference between the vegetation plots, growing seasons, and soil ages. We found a great importance of *Bradyrhizobium* as main bacterial genus in N fixation in such kind of environment.

Key words:
active bacterial communities, nihH gene, RNA, chronosequence, pioneer plants, Alps.

Trophic ecology - functional perspectives on species communities in glacier forelands

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All organisms in an ecosystem interact with each other – either directly or indirectly. These connections between species are represented by interaction networks which govern the dynamics and changes within species assemblages.

An understanding of the species' interplay among each other and with their resources thus provides a functional approach to assess links across different trophic levels at varying spatial and temporal scales. Trophic interactions are one of the driving forces within these networks but the examination of their development and functioning in a changing environment, such as glacier forelands, has been rather neglected in ecology so far.

New methodologies provide exciting opportunities to measure how species interact in food webs and how these connections evolve during primary succession. Here, we will briefly outline how the analysis of stable isotopes and fatty acids can be employed to unravel the trophic structure of glacier foreland communities and propose lines of future research addressing trophic aspects of glacier foreland communities.

Key words:
fatty acid analysis, food web development, stable isotope analysis, trophic level.

What DNA can do for you - molecular methods to investigate trophic interactions in glacier forelands

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As soon as it was found out that predatory arthropods are among the very first colonizers on recently deglaciated terrain, the question arose 'What are they feeding on?'. Several hypotheses regarding potential food sources were formulated, but they were difficult to test with conventional methodology.

So far stable isotope analysis (SIA) was the most reliable method to study the trophic position of invertebrate predators in glacier forelands, but this approach is limited in resolving specific feeding links. Over the last decade molecular methods developed to a highly sensitive and flexible tool to investigate trophic interactions in detail. Today they are widely applied to study food web interactions from the tropics to the arctic.

Molecular methods allow tracking consumption of food at different resolutions (from order down to species level) and detection of even a few prey molecules in the gut of a consumer is possible. We developed several molecular detection systems suitable to identify consumption of plant material as well as predatory arthropods and their prey in Alpine glacier forelands.

Thus, a suite of ready-to-use multiplex PCR detection systems is now available to track intraguild predation among predatory arthropods but also consumption of other potential food sources including plant material in general, Poaceae, Apiaceae, Collembola (indicated as main food source for predators by SIA) and various taxa of flying insects such as Lepidoptera, Hymenoptera and common dipteran families.

As some of those systems target food at family and order level, they can be applied beneficially in different glacier forelands, allowing comparisons between studies, fostering the knowledge on general patterns in food web development following glacier retreat.

Key words:
molecular prey detection, molecular species identification, multiplex PCR.

Primary succession of plant-herbivore interactions on Alpine glacier forelands

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Glacier forelands are ideally suited to study the establishment of both plant- and animal communities along a chronosequence of successional stages. Vegetational succession has long been viewed as a plant- and soil-driven process within a single trophic level.

However, plant performance and the composition of plant communities during primary succession are also influenced by other organisms including herbivores. Plants, in turn, are defending themselves against herbivory. This defence is presumed to undergo significant changes along successional gradients.

However, little empirical information exists on how the patterns of herbivore-plant interactions change during primary succession. The proposed project directly addresses this knowledge gap by analysing the development of plant-herbivore trophic interactions. We aim to (i) investigate how herbivores impact upon plants and to (ii) assess how plants respond to herbivore feeding pressure along the successional gradient in three Alpine glacier forelands.

Apart from classical approaches, we will employ a suite of cutting-edge methods, comprising next generation sequencing and ultra-high-performance liquid chromatography-mass spectrometry, to determine changes in plant-herbivore interactions during primary succession. By combining direct feeding observations in the field and molecular data we will – for the first time in glacier forelands – generate insect herbivore-plant food webs to assess the temporal dynamics in plant-herbivore networks along the successional gradient.

The integrated approach applied will contribute essential knowledge of the mechanisms that drive the development and functioning of plant-herbivore interactions.

Key words:
diet analysis, herbivory, next generation sequencing, NGS, trophic interactions.

Time series of glacier fluctuation data as precondition and result of glacier forefield evidence in the Austrian Alps: Status quo and open questions

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Glacier fluctuations in the Eastern Alps are documented by descriptions, maps and measurements beginning in 1601, with regular monitoring since 1891. These relative length change data do not reflect the absolute changes which have taken place for various reasons.

For Holocene fluctuations information is available from dendrochronology and radiocarbon datings. The availability of these data vary from glacier to glacier, whereas the extent of all (today still existing) glaciers is recorded in the glacier inventories for the Little Ice Age (LIA) Maximum, 1969, 1998 and 2006.

In contrast to the length change records, the inventories reflect also the ice and snow cover at the higher elevation zones, with larger uncertainties for the LIA maximum. The compilation of all these available data (shape files and meta-data) is ongoing and will be available at the end of 2014 via the Pangaea.de data base as well as at the World Glacier Monitoring Service.

The archives of the Austrian Alpine Club contain also a large number of photographs and documents, showing the succession in the glacier forefields. As succession plays an important role for the future hydrological behaviour in terms of evaporation and water storage, as well as for the potential of other natural disasters as mass movements, studying past and current succession is not only an important task per se, but also for related fields of research.

From a glaciological perspective, a number of questions are open regarding the succession in periglacial areas:

- The growth of trees differs from glacier to glacier, and partly dendrochronological evidence is missing for glaciers where trees grow today. What triggers these differences?
- Vegetation develops on debris covered glaciers in Central Asia and Alaska, could this have been the case also in the Alps, and can we expect that as a future development?

Key words: climate change, glaciers, glacier forefields, hydrology, long term monitoring.

ABSTRACTS
Posters

Comparative study on terrestrial and aquatic invertebrate assemblages along a glacier foreland

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The spatio-temporal distribution of terrestrial invertebrates on glacier forelands and of macroinvertebrates in glacier-fed streams have been extensively investigated in relation to abiotic and biotic factors. There is a general consensus that terrestrial invertebrates along glacier forelands and macroinvertebrates in glacier-fed streams follow deterministic and directional colonisation patterns. However, the distribution of aquatic invertebrates in glacier-fed streams is strongly influenced by the presence of the glacier that affects its hydrological and thermal regime at daily, seasonal and annual scale. This influence decreases with increasing distance from the glacier snout and, theoretically, with the time since deglaciation. However, within the scenario of climate change, also stochastic changes in invertebrate assemblages (species composition, richness and diversity) are expected.

We propose a first study in a still glaciated catchment in which the colonisation patterns in relation to the time since deglaciation of terrestrial and aquatic invertebrates are compared. We considered as study model the glacier foreland of the Vedretta d'Amola (Central-Eastern Italian Alps). Data on terrestrial invertebrates were collected during the summers 2011 and 2012, while the aquatic fauna will be sampled during spring-autumn 2014. Aquatic macroinvertebrates will be sampled in sites selected at the same distance from the glacier as the terrestrial ones. The environmental variables recorded on the terrestrial sites were: vegetation cover, granulometry, organic matter; the variables recorded on aquatic sites will be: water temperature, discharge, current velocity, channel stability, conductivity, pH.

The two datasets will be analysed by comparing the patterns in taxa-traits turnover (e.g. feeding habits), richness and diversity in relation to the distance from the glacial snout as well age since deglaciation.

Key words:
assemblages turnover, glacier retreating, spatio-temporal patterns, species composition, species traits.

Vedretta d'Amola glacier foreland

State of the art of hyporheic invertebrates from glacial-feed streams in two contrasted scenarios

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The hydrological and chemical processes occurring in the hyporheic zone of glacial-feed streams have received an increasing attention in recent years, yet the studies of biotic assemblages and their response to cope with changing environmental conditions due to temperature increase and glaciers melting are still scarce.

The resilience and resistance of hyporheic biota in glacial-feed streams are highly controlled by long-lasting stress due to persistently low water temperatures, prolonged ice-cover, permafrost, strong freeze-thaw cycles, seasonal fluctuation of water discharge due to intense glacier melting, nutrient availability, and frequent disturbance of their physical habitats. The global warming strength the glacier-feed streams to swift the environmental conditions, and meiofauna is forced to cope with the new conditions or get extinct.

The structural pattern of hyporheic biota from glacial-feed streams is distinct in biodiversity, ecology, morphology, life-cycle and behaviour adaptations to cope with the adverse environmental conditions, and are moderately resilient to flow disturbances relative to availability of in-stream refugia and habitat hydrology. Here we present a general state-of-the art upon hyporheic biota from glacial-feed streams in terms of biodiversity, biogeography, ecology and dispersal constraints on communities structures with specific emphases on cold-adapted endemic groundwater species that are more vulnerable to shift in temperature regimes.

We specifically aim at documenting the current knowledge on hyporheic biota from two remote foreland regions, sub-Arctic in Swedish Lapland and Mediterranean in Spanish Pyrenees. The present contribution will offer an insight on hyporheic biota from glacial-feed streams as warning indicators for increasing temperature impact on high mountains stream ecosystems, and will also reinforce the predictive models on biodiversity and habitat loss due to climate changes at regional scales.

An intensive research is proposed in one the most ecologically critical region of southern Europe, the Monte Perdido foreland, where the southernmost continental glaciers still exist.

Key words:
biodiversity, Crustacea, foreland, glacial-feed rivers, hyporheic zone.

Pineta Valley (Spanish Pyrenees)

Tarfala Valley (Swedish Lapland)

Plants and flower-visiting insects along a debris-covered glacier foreland

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Knowledge about how plants and plant-related insects interact along a primary succession is still scarce. We aimed to assess how the changes in plant communities explain the variations in flower-visiting insects assemblages along a glacier foreland, focusing on insect ecological roles. We also investigated the importance of insects for the reproductive success of the plants *Leucanthemopsis alpina* and *Saxifraga bryoides,* considered as model species along the Vedretta d'Amola debris-covered glacier foreland (Central Italian Alps).

The sampling design consisted of five sites representing the main deglaciation stages. At each site flower-visiting insects were recorded over two flowering seasons (2012-2013); breeding experiments were carried out at each site during the second season through the exclusion of pollinators from some flowers and the successive analysis of the seed set.

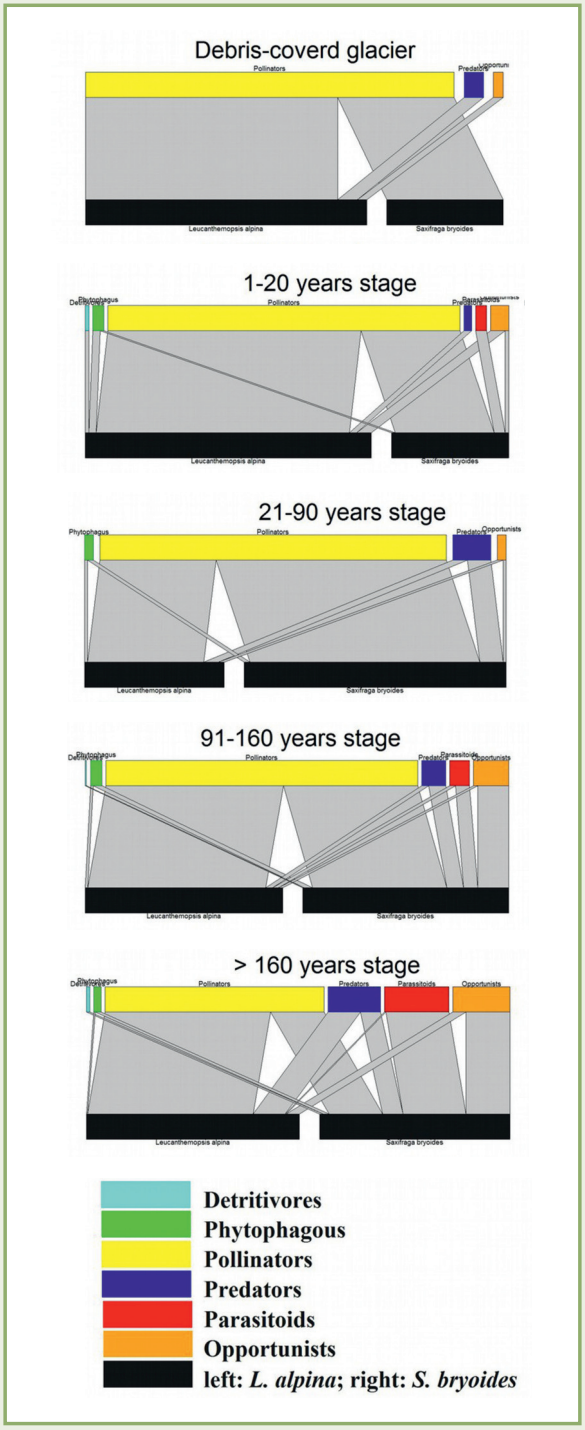
Insect community structure showed an increase in functional diversity along the chronosequence. Pollinators dominated the community on the debris-covered glacier and in the early successional stages, whereas parasitoids, predators and opportunists characterized the late successional stage.

Partial Canonical Correspondence Analysis showed that *L. alpina* is mainly visited by ubiquitous pollinators, whose abundance increased along the glacier foreland following vegetation development. Predators and opportunists were positively related to vegetation cover and entomophilous plants density. *S. bryoides* is strongly associated with pollinators only on the glacier foreland. In the late successional stage the presence of pollinators on *S. bryoides* decreased even if the insect community is more diversified. *S. bryoides* pollinators are positively related to entomophilous plant density and saxifrage cover, whereas parasitoids and opportunists were associated to high vegetation cover.

The reproductive success of plants varied among deglaciation stages. Surprisingly, *L. alpina* fitness was independent from pollinator abundance, unlike that of *S. bryoides*.

In summary, our results show that community features, such as vegetation cover and entomophilous species density, are important for variation in insects community composition.

Key words:
alpine plants, chronosequence, ecological network analysis, plant-insect interaction.



Plant-insect quantitative network along the primary succession of Amola debris-covered glacier.

Distribution patterns in plants and ground beetles along a debris-covered glacier foreland

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Main rationale of our research was to study ground beetle (Coleoptera: Carabidae) assemblages and vegetation along the receding Vedretta d'Amola debris-covered (DCG) glacier forefield (GF) (Central-Eastern Italian Alps). We addressed the hypothesis that shifts in carabid functional traits, as well in plant and carabid assemblage compositions, are associated with time since deglaciation of monitored sites along the GF. We also hypothesized that ecological features of plants and carabid assemblages on the DCG are linked to specific micro-habitat conditions.

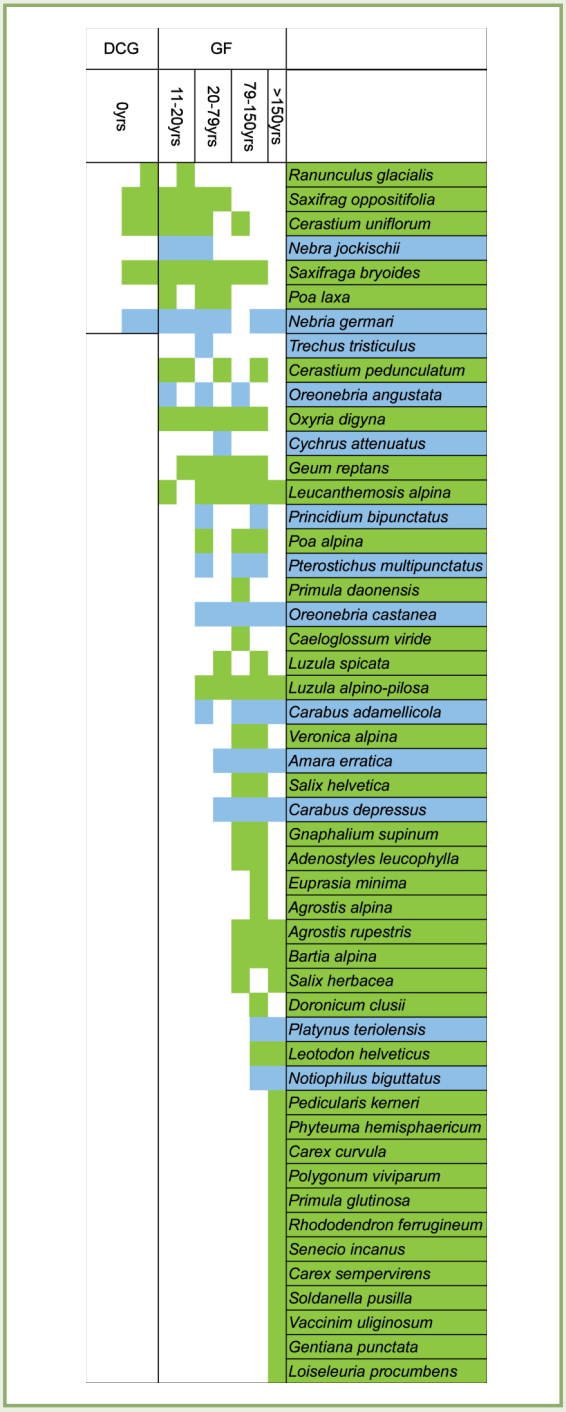
Ground beetles were pitfall-trapped and vegetation and soil were sampled around each trap. We investigated plant and carabid species diversity and abundance on the DCG and along the GF. In addition, we analyzed the following carabid functional traits: wing morphology, feeding strategies, breading season, and larval predatory strategies.

We found that DCG hosts four plant species; on the other hand just one species of carabid beetle was found: *Nebria germari*, which is a cold adapted species, unable to fly (wingless), olfactory and tactile nocturnal predator, with surface runner larvae and autumn breeding.

Accordingly to the literature we confirmed that time since deglaciation influences both plant species richness and cover along the GF as well as carabid species richness and assemblages composition. In addition, we observed that functional trait types increase from early to late successional stage probably due to higher habitat complexity and increased interspecific competition. Carabid assemblages in the GF are mainly characterized by wingless species, autumn breeders, surface runners, and olfactory and tactile predators. On the other hand, in the mid- and late successional stage spring breeders, surface walkers/soil explorers, zoospermophagous and eyes predator species appear.

The study of functional traits offers a new opportunity to increase the ecological knowledge of the glacier foreland landform, understanding the interactions along a primary succession.

Key words:
carabid beetles, functional traits, primary succession, species richness.



Plant (green) and carabid beetle (blue) succession on the debris covered glacier (DCG) and along the glacier foreland (GF) in relation to the time since deglaciation.

Detection of soil fungal communities from in-growth mesh bags: A comparison of cultivation-based and molecular methods

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Sand-filled, in-growth mesh bags (MB) were developed for quantifying the growth of fungal mycelia in forest soil during a defined period of time. In-growth MB were since then successfully used for the detection and identification of mycelia in forest soils, and for monitoring compositional changes in soil fungal communities (SFC) based on molecular methods. However, many of the obtained fungal sequences could not be assigned to known fungal groups, but remained "unnamed or unidentified".

We therefore decided to isolate fungi directly from MBs, and to use the obtained pure cultures for creating reference rDNA ITS sequences. The main aim of this study was to compare results from this cultivation-based approach with data from rDNA ITS clone libraries. The SFC were cultivated by direct plating of sand grains on PDA, SNA and MMN and incubation at 10 °C for 1-2 weeks as described by Walch et al. (this volume). Clone libraries were obtained based on pooled PCR products of 3 MBs, each. Fungal OTUs were defined with 99 % sequence homology. Data analysis was carried out with PcORD and Statistica.

This study was carried out in the *Pinus cembra* high altitude afforestation site Haggen situated at 1,980 m a.s.l. in the Tyrolean Central Alps (Austria). The method of detection significantly biased the composition of SFC: ectomycorrhizal fungi like *Rhizopogon* or *Suillus spp.* could not be detected with cultivation methods. In contrast, several soil fungi, e.g. *Umbelopsis spp.,* could not be detected with our clone libraries, probably due to PCR bias or DNA amplification problems. Unnamed or unidentified fungal species can only be named and formally described based on reference material such as cultures or vouchers.

Therefore a combination of both methods is not only valuable for identifying active SFCs, but also for a better knowledge of soil biodiversity.

Key words:
Ascomycota, barcoding of fungal isolates, *Pinus cembra* mycobiota, rDNA ITS clone libraries.

Refugia landforms for alpine flora and fauna: ecological and biogeographical significance of a habitat system

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Cold-adapted species are the first to be threatened by global warming, because of the progressive reduction and fragmentation of their habitat with glacier retreat and up-shift of altitudinal belts. The role of refugia, sites with local environmental conditions allowing the survival of such species, is thus more and more acknowledged.

We hypothesize that debris-covered glaciers and rock glaciers could act as refugium habitats for alpine flora and fauna during warm climatic stages, as a consequence of their microclimatic features and thermal inertia. The aim of our study is to analyze the ecological features of these landforms to infer their biogeographical significance in the climate change context.

Our project is set in range of a multidisciplinary PhD of University of Milan, in collaboration with Science Museum of Trento and Stelvio National Park. The sampling design considers microclimatic parameters, soil chemical and physical features and plant and arthropod communities (beetles and spiders as key taxa). We selected 2 glacier forelands, 2 debris-covered glaciers and 3 rock glaciers, located from Western (Monte Rosa) to Central Italian Alps (Adamello-Presanella and Ortles-Cevedale); a site on Southern Alps (Trobio Glacier, Orobic Alps) was also included as scenario of an almost deglaciated alpine landscape in a crucial biogeographical context.

We are going to compare these landforms with the surrounding environments in order to test this hypothesis: 1) debris-covered glaciers and rock glaciers differ from the neighboring iceless scree slopes for the presence of cold-adapted plant and arthropod species; 2) these landforms can host cold-adapted species, generally restricted to the nival belt, below their average altitudinal distribution (reputedly down to the elevation of alpine grasslands or subalpine woods).

The wide range of ecological and biogeographical contexts covered by our study could allow finding evidences in species distribution supporting the contingent historical role of these landforms in alpine biogeography.

Key words:
arthropods, climate change, debris-covered glaciers, rock glaciers, vegetation.

Peeking into the black box of biodiversity: Culturing and identifying soil fungi from in-growth mesh bags

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Environmental sampling is resulting in a huge number of unidentified sequences in public databases, as well as in the discovery of previously unknown fungal lineages in unexplored niches, such as winter soil or alpine habitats.

We buried in-growth mesh bags filled with sterile quartz sand during the snow-covered period and during the summer months in a subalpine *Pinus cembra* forest, and used them for isolation and cultivation of fungi (and also for estimation of fungal productivity through microscopic measurements of hyphal length). Cultures were obtained by plating quartz sand grains on three media (PDA, SNA and MNM). All cultures were first incubated at 10 °C.

Pure cultures were grown on MEA and identified based on morphology and rDNA ITS sequences. Species diversity obtained by culturing techniques was comparatively high, and fungal communities differed between summer and winter. We found this approach to be a promising technique for detection and isolation of soil fungi.

Using mesh bags for cultivation, we made sure that only fungi that were actively growing into the buried mesh bags were isolated. Among our isolates were also some possibly yet unknown or at least unnamed fungal taxa, so far only known from environmental sequencing.

We are thus confident that the method we described can provide valuable reference cultures for environmental sequencing and possibly also for future biotechnological applications.

Key words:
Ascomycetes, *Pinus cembra*, rDNA its sequences, Zygomycetes.

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