Sexual and clonal reproduction in alpine plant life: persistence and dispersal as key processes to explain the maintenance of genetic diversity Tina Weppler, Andrea R. Pluess and Jürg Stöcklin

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Persistence by clonal growth is an obvious characteristic of most alpine plant life. Species from alpine communities are usually long-lived and rely strongly on the reproduction by vegetative growth. However, it remains unclear how the surprisingly high level of genetic variation in extremely long-lived clonal species with usually poor dispersal capacity is maintained. Current theories on the maintenance of genetic diversity have been developed for animal organisms and focus on the effects of spatial dispersal of mobile organisms with separate sexes, usually referred to as metapopulation theory. In an ongoing project we ask whether and how this dominant theoretical concept also applies to sessile plants which occur in the extreme patchy and fragmented alpine landscape and which possess complex reproductive systems. We use demographic field work, an experimental approach and molecular tools to answer the following questions: (1) How important is dispersal by seeds and the colonisation of new sites in the alpine landscape? (2) How effectively does it affect the balance between sexual and asexual reproduction? (3) How is the spatial genetic structure in alpine clonal species related to the dispersal of pollen and seeds? We will present preliminary results from a demographic study with the clonal *Geum reptans* in which we ask if the importance of establishment from seeds is sufficient to maintain a high genetic diversity within populations and if in newly created habitats traits favouring a high seed production and dispersal are favoured compared to later successional stages. Our results will be helpful to predict the resilience of alpine plants to global warming.

Phylogeographic analysis of *Pulsatilla alpina* (Ranunculaceae), including a relic population from the Harz Mountains (Northern Germany) Holger Zetzsche[1,2] and Frank R. Blattner[1]

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Pulsatilla alpina (L.) Delarbre subsumes up to nine subspecies with a complex distribution pattern in European alpine regions, ranging from Northern Spain through the Alps to the Carpathian Mountains. Populations also occur on mountain ranges in Corsica, Italy and the Balkan peninsula, as well as in some low mountain ranges north of the alpine arc. Though the species complex was morphologically extensively studied (Aichele & Schwegler 1957, Feddes Repertorium 60:1–230; Moser 1996, Dissertation, University Bern), the conspecific status of the subspecies and phylogenetic relationships between them remain unclear.

On the very top of the «Brocken» (1142 m, Harz Mountains, Germany) occurs the northern-most population of *P. alpina* (ssp. *alpicola*) in about 700 km distance to the nearest *P. alpina* habitat. This remote population is part of a small group of alpine plants growing just above the timberline (at 1110 m). It is hypothesised that these plants are relics of the last ice age. Equally likely seems recent long distance dispersal from one of the populations in the core area of distribution of *P. alpina*.

In the framework of a study on the origin of the alpine species of the Upper Harz Mountains we conduct a phylogeographic analysis of *P. alpina*. We use a nested analysis approach to clarify (sub)species boundaries within the *P. alpina* complex, and to analyse population genetic parameters for populations from the entire distribution range of the taxon. In a first step we sequenced the nrDNA ITS region in all subspecies recognised by Moser (1996), together with *P. occidentalis* and *P. vernalis* as outgroups. First results show that ITS sequences produce sufficient polymorphisms to analyse phylogenetic relationships within *P. alpina*. The deepest split within the *P. alpina*-clade separates an accession from northern Italy from all other individuals in the analysis. Accessions of the yellow-flowered ssp. *apiifolia* are dispersed in the cladogram and group together with white-flowered individuals from neighbouring regions. Accessions of ssp. *alpicola* are genetically similar, though geographically widely apart (Tatry

Mountains vs. Spain). An extended analysis of 347 individuals out of 42 populations covering the entire range of distribution of *P. alpina* will be conducted with microsatellite markers and RAPDs to get detailed insights in phylogeographic relationships of this species group.

The biogeography and origin of alpine taxa in the montane/alpine European endemic *Soldanella* (Primulaceae) Li-Bing Zhang, Hans Peter Comes and Joachim W. Kadereit

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Soldanella is well-characterised by its laciniate petal lobes. The 16 species of this genus are distributed across all major European high mountain ranges.

Based on morphological evidence, the genus can be subdivided into two sections: Sect. *Soldanella* contains 14 species and except for *S. villosa* from the Cordillera Cantabrica and the W Pyrenees is centred in SE Europe. In contrast to this the two species of sect. *Tubiflores* are found mainly in the Alps. The morphological subdivision of the genus is paralleled by the ecology of the two sections. Whereas most species of sect. *Soldanella* inhabit montane forest floor habitats, the species of sect. *Tubiflores* have an alpine ecology. The major exception to this is *S. alpina* which as a member of sect. *Soldanella* grows at alpine altitudes.

The phylogeny of *Soldanella* was analysed using ITS and AFLP variation. This analysis could not recover the two sections as monophyletic groups. Instead, *S. villosa* (sect. *Soldanella*) from the Cordillera Cantabrica and the W Pyrenees is sister to two major clades. The first of these contains *S. minima*, *S. pusilla* (both sect. *Tubiflores*) and *S. alpina* (sect. *Soldanella*), and the second the remaining 12 species of sect. *Soldanella*. This topology implies that (1) sect. *Soldanella* is paraphyletic in relation to the species of sect. *Tubiflores*, and (2) sect. *Tubiflores* is not monophyletic. Excluding *S. alpina* as a possible hybrid taxon from the phylogenetic analysis results in a weakly supported monophyletic sect. *Tubiflores* nested within a paraphyletic sect. *Soldanella*.

A phylogenetic analysis of Primulaceae by Källersjö et al. (2000) had identified *Omphalogramma* as the closest relatives of *Soldanella*, and the application of a molecular clock shows that *Soldanella* is < 1 mill. years old.

On this background it seems likely that *Soldanella* colonised Europe from Central Asia only in Quaternary times. The presence of *S. villosa* as the sister to the remainder of the genus at the western edge of the present range of *Soldanella* suggests that the genus expanded rapidly after its arrival. The alpine species of sect. *Tubiflores* originated from montane ancestors only in the Quaternary.

This hypothesis fully confirms the assumption of many authors that European alpine species originated from lowland ancestors, but in *Soldanella* this apparently happened more recently than generally believed.

The different amount of genetic differentiation among the alpine and montane species is believed to result from the differential effect of glacial periods on these two ecological groups.

Foto B. Hamperer

Abb. 13: *Soldanella alpina*

Molecular phylogeny and biogeography of the European high mountain endemic *Primula* sect. *Auricula* (Primulaceae) Li-Bing Zhang and Joachim W. Kadereit

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Primula sect. *Auricula* contains seven subsections and 24 species distributed from the Pyrenees to the Carpathians. It is one of only few endemics of the European Alpine system with a comparatively large number of species.

In the present study ITS sequence variation of 44 samples representing all 24 species of *Primula* sect. *Auricula* was investigated. This analysis was rooted with representatives of all six sections of *Primula* from Europe and America, two sections of *Primula* from Asia, and two species of *Douglasia*. The strict consensus tree of this analysis shows that sect. *Auricula* is a monophyletic group with 100% bootstrap support. Furthermore, the monophyly of subgen. *Auricula* containing sect. *Auricula*, sect. *Parryi* and sect. *Cuneifolia* is also supported with 100% bootstrap support. The distribution of sect. *Cuneifolia* in East Asia