The influence of snow cover duration on alpine plant phenology

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Background

Climate change affects snow cover duration in alpine ecosystems. Snow insulates soil and vegetation during winter months and allows soil processes to continue. Too early snowmelt may put plants at risk of lethal freezing events in spring. The development of many alpine plant species is photoperiodically controlled, thus, these plants will not profit from earlier snowmelt. Delayed snowmelt shortens the growing season of alpine plants. Less time for flowering and seed formation may reduce the reproductive fitness. In a snow manipulation experiment at 2500 m a.s.l., we examine the influence of variable snowmelt dates on alpine plant phenology.

Objectives

1) Testing the feasibility of manual snow cover manipulation at high elevation
2) Identify phenology strategies in alpine plant species

Field site with the snow cover manipulation at 2500 m a.s.l.

A snow removal (top) and a snow addition (bottom) plot on July 8th, 2016

Conclusions

1) Manual snow removal is feasible and efficient for advancing snowmelt dates
2) We observed different phenology shifts related to snowmelt:
   - Opportunistic flowering soon after snowmelt (e.g. *Carex curvula*)
   - Flowering induced by thermal sums (degree hour thresholds, e.g. *Potentilla aurea*)
   - Flowering induced by photoperiod (*Poa alpina*)

Results & Discussion

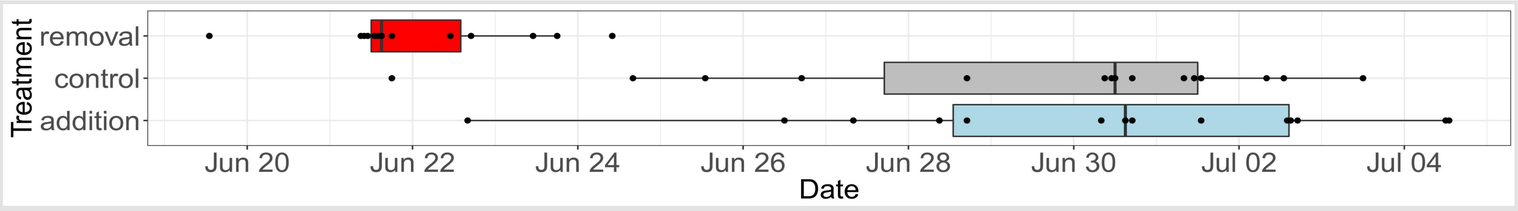

Figure 1: Exact snowmelt dates in 45 plots (15 snow removal plots (red) - earlier snowmelt, 15 snow addition plots (blue)- later snowmelt, 15 control plots (grey). On July 5th, 2016, all plots were snow free.

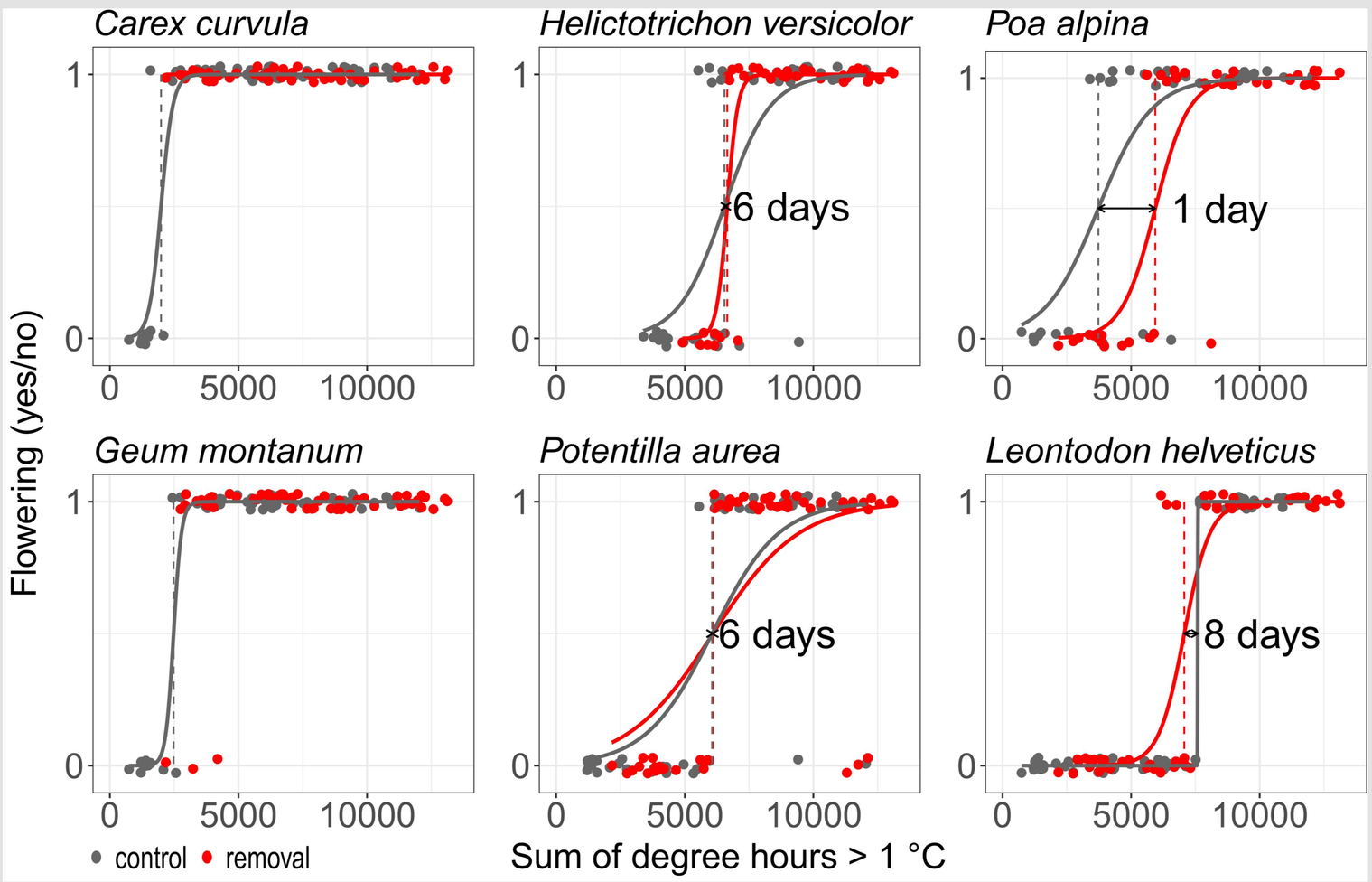

Figure 2: Probabilities for flowering for six alpine plant species in relation to cumulative degree hours >1ºC and snow removal (red: earlier snowmelt, grey: control). The number of days indicates the advanced flowering dates per species, induced by earlier snowmelt.

Snow manipulation

Snow reduction led to significantly earlier snowmelt ($P<0.01$). On average, these plots were snow free 7 days before the control, matching recent results of Klein *et al.* (2016) who found a decline in snow cover duration by 5.8 days per decade since 1970.

Plant phenology

The selected alpine plant species adopt different strategies for their phenological shift between vegetative and flowering stages (Figure 2). The dominant sedge *Carex curvula* as well as herb *Geum montanum* flowered shortly after snowmelt. The grass *Helictotrichon versicolor* and the herb *Potentilla aurea* showed a distinct temperature sum threshold at which they start flowering (ca. 6000 degree hours >1ºC, corresponding to ca. 21 bright days). The grass *Poa alpina* seems to be at least partly controlled by photoperiod, confirming results of Keller & Körner (2003). *Leontodon helveticus* did not show a clear response and its strategy might depend on the timing of snowmelt, possibly by releasing several flowering cohorts which are not all controlled by the same mechanism.

Methods & References

Snow manipulation was manually achieved in Apr/Jun 2016. Snow depth was de- or increased (down to 0.5m or up to 2.2-2.5m) to advance or delay snowmelt. Snowmelt dates were identified by a clear soil temperature increase, measured by temperature loggers (middle of each 2m x 2.5m plot) in 3-4 cm soil depth. Plant phenology was assessed six times during the growing season. For each plot, each species was allocated to its phenology stage, based on the majority of the individuals. Phenological shift between vegetative and flowering stage is assessed here (logit functions of sum of degree hours > 1ºC after snowmelt).

Keller, F., Körner, C. (2003). Arctic, Antarctic, and Alpine Research 35: 361–368; Klein, G., Vitasse, Y., Rixen, C., Marty, C., & Rebetez, M. (2016). Climatic Change 139: 637-649.
Klein, G., Vitasse, Y., Rixen, C., Marty, C., Rebetez, M. (2016). Shorter snow cover duration since 1970 in the Swiss Alps due to earlier snowmelt more than later snow onset. Climate Change.

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