Federal Ministry Sustainability and Tourism
AREC Raumberg-Gumpenstein Agriculture

Erich M. Pötsch
Agricultural Research and Education Centre
Raumberg-Gumpenstein, Austria

University of Natural Resources and Applied Life Sciences, Vienna

Response of plant functional traits to temperature along an alpine gradient of altitude

27th General Meeting of the European Grassland Federation

Cork, Ireland
Juni 2018

Background

- **Alpine landscapes are characterized by extreme topographic conditions (steepness, shallow soils …) and by a strong gradient of altitude**
- **Alpine grasslands are occurring at sites even higher than 2,000 m a.s.l. and are faced with extreme weather conditions (temperature, frost periods, snow cover …)**
- **Climate change predictions for the European Alps augur badly in terms of warming, seasonal distribution of rainfall, radiation and weather extremes (Gobiet et al., 2014)**

Science of the Total Environment 493 (2014) 1138–1151

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

21st century climate change in the European Alps—A review☆

Andreas Gobiet [a,*], Sven Kotlarski [b], Martin Beniston [c], Georg Heinrich [a], Jan Rajczak [b], Markus Stoffel [c]

[a] Wegener Center for Climate and Global Change, University of Graz, Brandhofgasse 5, 8010 Graz, Austria
[b] Institute for Atmospheric and Climate Science, ETH Zurich, Universitätstrasse 16, 8092 Zurich, Switzerland
[c] Institute for Environmental Sciences, University of Geneva, Site de Battelle – Bâtiment D, 7, route de Drize – 1227 Carouge, Geneva, Switzerland

- **Alpine grassland & grassland species have to (be) adapt(ed) to changing environmental conditions**

Objectives and research questions

- **Are plant functional traits affected by different environmental conditions along a gradient of altitude?**
- **Is the available observation period long enough for significant changes/adaptations?**
- **How are functional traits correlated with each other?**
- **Are there any differences between plant species?**

Material & methods (I)

- **Transplantation experiment with two common and wide spread grassland species – Golden oat grass (*Trisetum flavescens L.*) and Ribwort plantain (*Plantago lanceolata*)**
- **Both species were sown and cultivated in flower pots under greenhouse conditions at AREC**

Golden oat grass

Ribwort

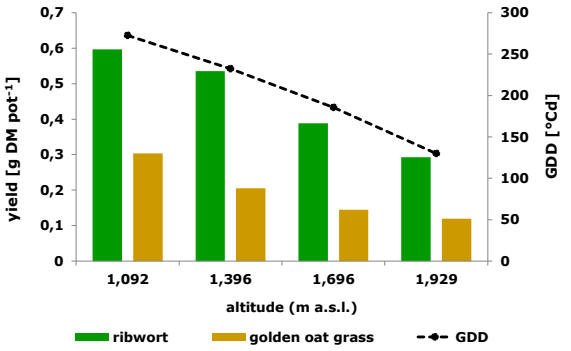
- **In June 2016 the pots were positioned outdoor at four different altitudes (1,092 m, 1,396 m, 1,696 m , 1,929 m a.s.l.) in Filzmoos/Slbg. and observed for a period of five weeks**

Material & methods (II)

- **Flower pots enclosed in metal cages to avoid damage and losses both by grazing activities and curious wanderer & mountaineers**

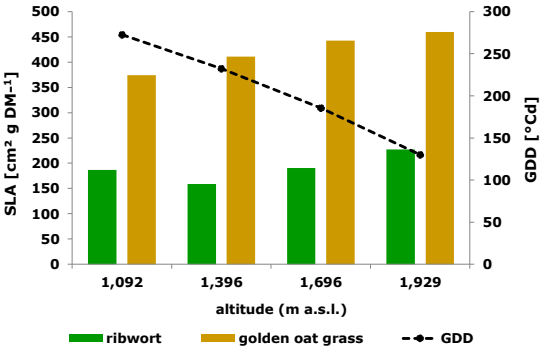
- **South-facing sites, equipped with mobile weather stations to monitor air- and soil temperature and precipitation**
- **Leaf length and plant height were measured six times during the observation period, leaf area was recorded twice**
- **Above ground biomass yield and specific leaf area were measured at the end of the experiment after removing the flower pots from the sites**

Biomass yield of two grassland species in relation to different levels of altitude & sum of temperature



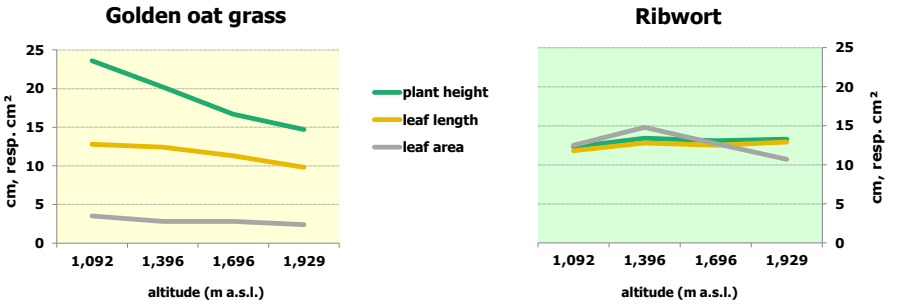
- **Growing degree-days significantly decrease with rising altitude (272°C to 130°C) ⇒ strong differences in growing conditions**
- **Dry matter yield of ribwort was twice as much as that of golden oat grass**
- **Clear response of aboveground biomass yield to altitudes (- 50% resp. – 60% for ribwort resp. golden oat grass)**

Specific leaf area of two grassland species in relation to different levels of altitude & sum of temperature



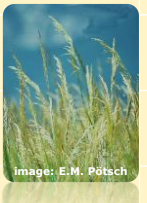
- **SLA** of ribwort was ~ half as much as that of golden oat grass ($p<0.001$)
- **SLA** of both species increased with rising altitude & decreasing GDD
- **F**indings are in contrast with some studies (e.g. Woodward 1979) but are confirmed by others (e.g. Wright et al., 2004)

Plant height, leaf length and leaf area of two alpine grassland species along an altitude/temperature gradient



- **G**olden oat grass – all functional trait values decreased with rising altitude
- **R**ibwort - slight increase of plant height and leaf length with rising altitude – indifferent development of leaf area along this gradient

Correlation matrix for functional traits of Golden oat grass along an altitude/temperature gradient

Plant species	Altitude (m a.s.l.)	functional traits	PH	LL
Golden oat grass (*Trisetum flavescens L.*) 	1,092	PH LL LA	1 0.58* 0.44	1 0.64*
	1,396	PH LL LA	1 0.62* -0.20	1 0.25
	1,696	PH LL LA	1 0.55* 0.45	1 0.56
	1,929	PH LL LA	1 0.32 -0.30	1 0.45

PH = plant height; LL = leaf length; LA = leaf area

- Both plant height and leaf area were positively correlated to leaf length along all tested altitudes
- Plant height and leaf area exhibited (non significant) positive and negative correlations

Correlation matrix for functional traits of Ribwort along an altitude/temperature gradient

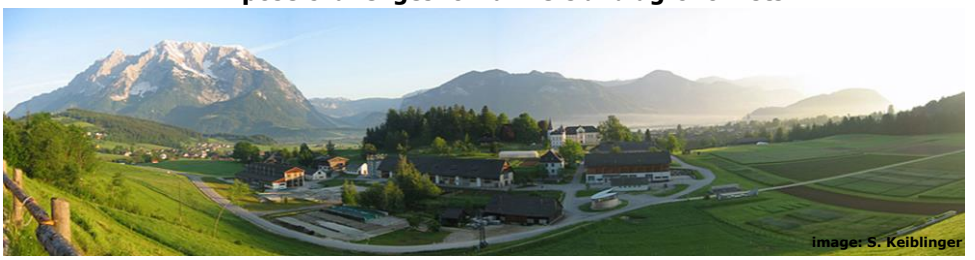
Plant species	Altitude (m a.s.l.)	functional traits	PH	LL
Ribwort (*Plantago lanceolata*) 	1,092	PH LL LA	1 0.99*** -0.31	1 -0.29
	1,396	PH LL LA	1 0.99*** 0.03	1 0.03
	1,696	PH LL LA	1 0.99*** -0.35	1 -0.30
	1,929	PH LL LA	1 0.98*** -0.30	1 -0.29

PH = plant height; LL = leaf length; LA = leaf area

- Plant height and leaf length were strongly positively correlated along the full gradient of altitudes (P<0.001)
- Weak relationship between plant height : leaf area and leaf area : leaf length

Conclusions

- **Functional traits of two selected alpine plant species were significantly affected by a strong gradient of altitude**
- **Plants of the same genotype were able to adapt quickly to different environmental conditions ⇒ high potential of phenotypic plasticity**
- **Our findings are of increasing relevance in the context of climate change, which may:**
  - **alter metabolism, growth rates and phenology and therefore modify functional trait expression**
  - **influence grazing behaviour of ruminants**
  - **pose challenges for farmers and agronomists**



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MANY THANKS TO YOU FOR LISTENING

AND TO J. SCHELLBERG, D. LENZEN AND B. KRAUTZER

FOR THEIR CONTRIBUTION & SUPPORT!

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