



EGF 2010
Kiel Germany

Grassland in a changing world

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**VOLUME 15
GRASSLAND SCIENCE IN EUROPE**

Regulation of meadow saffron (*Colchicum autumnale* L.) in extensively managed grasslands

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Abstract

During the last years, the toxic grassland species *Colchicum autumnale* has reached critical population densities in extensively managed grasslands of Austria and Germany. As farmers have problems to feed or sell their hay, there is a risk of intensification or abandonment. Extensive management is essential for conserving species-rich grasslands and their ecosystem services. Our objective was to develop management strategies to regulate *C. autumnale* without affecting species richness. In 2008 we established permanent plots (1 m²) in seven Austrian and eight German *C. autumnale* populations. In each country, we conducted one of four (five) different mowing treatments per plot and recorded every individual of *C. autumnale*. For data analysis via a matrix population model, plants were categorized into five life stages. First results show that an early cut in April/May had the strongest effect on population growth rate (λ). The population growth rate of the control treatment was about 1, i.e. population equilibrium, whereas the other treatments reduced λ significantly below 1, indicating population decline. Differences in λ between control and other treatments were mainly the result of growth reduction and increased regression.

Keywords: *Colchicum autumnale*, extensive management, matrix population models, lifetable response experiment (LTRE)

Introduction

During the last years, the toxic grassland species *Colchicum autumnale* has reached critical population densities in extensively managed grasslands of Austria and Germany. As farmers have problems to feed or sell their hay, there is a risk of intensification or abandonment. However, extensive management is essential for the conservation of species-rich grasslands and their important ecosystem services (Dierschke and Briemle, 2002). Therefore, our objective was to develop suitable measures to reduce the size of *C. autumnale* populations without significantly affecting species diversity. In this study, we compared the effect of seven different mowing regimes on population dynamics of *C. autumnale* in Austria and Germany. We hypothesized that the earlier the mowing date and the more intensive the mowing regime, the more negative is its effect on the *C. autumnale* population. To evaluate treatment effects on population dynamics and population growth rate, matrix population models (Caswell, 2001) were applied.

Material and methods

In 2008 we established 16–20 permanent plots (1 m² each plus a buffer zone of at least 0.5 m) in seven Austrian and eight German *C. autumnale* populations (in three regions of each country). Investigated grasslands were extensively managed, i.e. not fertilised and mown once

or twice a year. *C. autumnale* density per plot without seedlings ranged from 11 to 63 (average: 34) and 6 to 147 (average: 49) plants per m² in Germany and Austria, respectively. In each country, every plot (including the buffer zone) was subject to one of four different mowing treatments (Table 1). Treatments were replicated four times in Germany and five times in Austria. In one region in Germany, a fifth treatment was applied.

Table 1. Overview of mowing treatments in Austria and Germany

Treatment no.	Mowing treatment	Austria (A)	Germany (G)
1A, 1G	June, September (Control)	x	x
2G	Mid-May		x
3A, 3G	Mid-May, June	x	x
4G	Mid-May, June, September		x
5G	April, Mid-May		x (in one region only)
6A	Beginning of May, June	x	
7A	June, repeated flower-removal in autumn	x	

We recorded every individual of *C. autumnale* per plot and assigned it to one of five life stages (Fig. 1). Transition matrices and population growth rates (λ) were calculated for each treatment and country. Fecundity was determined by dividing the number of generative plants by the number of seedlings in the following year. We established a 95% confidence interval for λ of each matrix by bootstrapping the data (10000 iterations). The contribution of different demographic processes to the difference in λ between each treatment and the control (Caswell, 2001) was quantified by a life-table response experiment (LTRE).

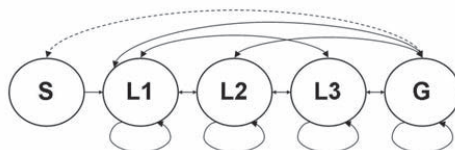


Figure 1. Life cycle graph of *Colchicum autumnale* (S seedling, L1-L3 vegetative plant with one, two and three or more leaves, G generative plant with capsules). Arrows indicate possible transitions between stages, the dashed line represents fecundity.

Results and discussion

All treatments except the control resulted in a reduced λ (Fig. 2A). While the results of the treatments 2G, 3A, 3G, 4G, 6A and 7A (Table 1) were similar in spite of their different mowing regime, treatment 5G resulted in a markedly lower λ . Treatment 5G had also the largest effect on λ when compared to the other treatments within the same single region. In general, controls had population growth rates of around 1, indicating population equilibrium. LTRE analyses revealed that differences in population growth rate between controls and treatments were mainly due to growth reduction, but also to an increase in regression (Fig. 2B). Of all treatments, regression was highest in treatment 5G, which was also the only treatment where stasis was strongly affected. Effects on growth and on regression increased within the Austrian treatments in the order 7A, 3A, 6A. Stasis was positive in the early mown treatment 6A due to the strong contribution of L1 plants staying in their stage. They were possibly less affected by mowing than the other stages due to their smaller size. Differences in λ between the treatments can be explained with the life cycle of the species. Each year, the plant's corm is replaced by a new corm, which starts storing nutrients with leaf emergence in late April. Until then, the old corm provides nutrients and gradually becomes depleted (Frankova *et al.*, 2003). Thus, an early leaf removal in mid-April or early May reduces the nutrient reserves of *C. autumnale* more dramatically than a later cut. Accordingly, the smallest λ in our study resulted from the earliest mowing treatments, i.e. 5G and 6A.

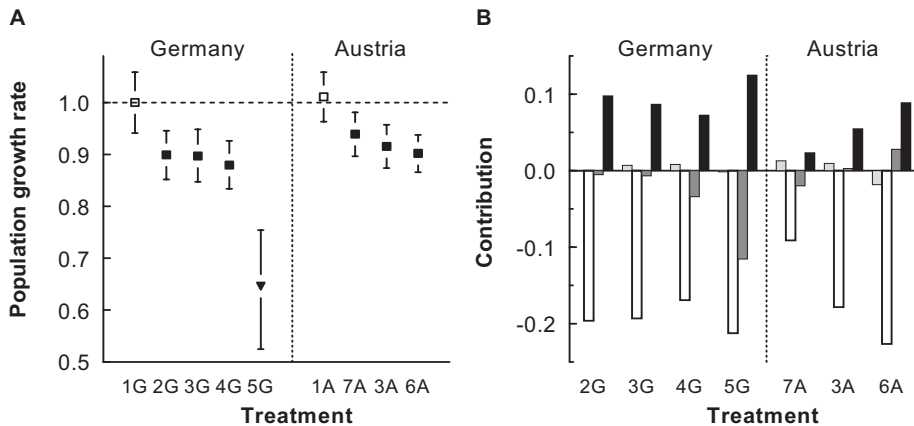


Figure 2: (A) Mean population growth rates (λ) with their confidence intervals of *Colchicum* populations under different treatments (cf. Table 1). Treatment 5G (triangle) was only carried out within one region (three populations), open squares denote controls, broken horizontal line indicates stable population growth ($\lambda = 1$). (B) Contribution of different demographic processes to λ from a life table response experiment. Light gray bars denote fecundity, open bars growth, dark gray bars stasis, and black bars regression.

The much stronger effect of treatment 5G on λ compared to 6A may have two reasons: (1) the second cut in May in treatment 5G resulted in a suppression of photosynthesis and nutrient storage, as regrown plant tissue was removed. (2) Leaf removal in April could have a larger effect on plant performance than in May, when the plant has possibly already stored nutrients in the corm. The similar results of the treatments 2G-4G despite different mowing intensity are due to the fact that leaves did not regrow after the cut in May, and thus plants were not additionally affected by the cut in June. In summary, the early cut treatments showed the best results (cf. Wehsarg, 1929). The next years will show which treatments exert consistent effects on *Colchicum* and result in sufficiently reduced population densities without affecting total plant diversity.

Acknowledgements

We thank the Deutsche Bundesstiftung Umwelt (Ref. no. 25073-33/0), the Federal Ministry of Agriculture, Forestry, Environment and Water Management, Jubiläumssfonds der Österreichischen Nationalbank, and Österreichische Bundesforste for financial support, the farmers, and all people who helped during the project.

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