

Using phenological progression and phenological complementarity to reveal potential for late grassland harvest

Mládek J. and Juráková J.

Department of Botany, Faculty of Science, Palacký University, Šlechtitelů 11, 783 71 Olomouc, Czech Republic

Corresponding author: jan.mladek@upol.cz, mladekjan@seznam.cz

Abstract

Farmers often face the problem of which grasslands enable harvest later in the season without a substantial decline in fodder quality. As decline is particularly driven by plant phenology, there arises a question which long-term management produces vegetation with a slower phenological progression and/or supports occurrence of later developing species (i.e. phenological complementarity). We used an experiment in dry broad-leaved grassland in the White Carpathian Mountains (Czech Republic) with three treatments: sheep grazing, mowing in mid-July and fallow. Species cover and phenophase were recorded in permanent plots at the beginning of May, June and July during two seasons. Phenological complementarity appeared only in the grazed plots. Community-weighted means of plant traits revealed that grazed and mown plots were characterised by earlier flowering and lower leaf dry matter content than fallow plots. Consistently, community phenological progression was the fastest in the mown plots and the slowest in the fallow plots. Mown plots accelerated the development earlier than grazed plots which was apparent from a significantly higher cover proportion of non-sterile species in June. We concluded that long-term grazed swards offer a greater potential for a single late harvest than mown grasslands, as fodder quality is expected to decline more slowly.

Keywords: asynchrony of growth, fallow, grazing, late harvest, mowing, phenophase

Introduction

Especially in mountainous and less-favoured areas, farmers' timing of grassland use has to accommodate new agri-environmental scheme rules and also weather conditions. Thus, farmers often face the problem of which grasslands allow for harvest later in the season without a substantial decline in fodder quality (Martin *et al.*, 2009). Decline of fodder quality is particularly driven by the speed of species phenological progression (PP) (Duru *et al.*, 2008). Therefore, which factors control the overall community PP is a challenging question. Grassland communities with higher community-weighted means (CWM) of leaf dry matter content (LDMC) flower later (Ansquer *et al.*, 2009). However, no study has explicitly answered the question of how community PP is modified by long-term management. The aim of our study was to test experimentally which long-term management supports a vegetation composition that produces slower community PP and/or enables later developing species to coexist within a community. Both these processes may retard fodder quality decline and widen the 'time window' for harvesting (Martin *et al.*, 2009; Mládek *et al.*, 2011).

Materials and methods

During the 2009 and 2010, community PP and complementarity were investigated in plots of a long-term management experiment which was set up in 2004 in dry broad-leaved grassland. The site is located near the town of Brumov-Bylnice (49°05'58"N, 18°01'59"E; 370 m above sea level; mean annual temperature 7.9°C, mean annual precipitation 760 mm) in the White Carpathians Mountains, Czech Republic. Three management treatments (rotational sheep

grazing from April with two cycles per year, mowing in mid-July, and fallow) were applied, each treatment in five 5×5 m experimental plots arranged in blocks (scheme in Mládek *et al.*, 2011). We monitored a permanent subplot 1 m² in size within each experimental plot. The subplots in the grazed treatments were protected each year from grazing until all observations were completed and were then only grazed in autumn. In each plot, cover (in %) and phenophase of all species were recorded at the beginning of May, June and July. We distinguished five phenophases (*sensu* Martínková *et al.*, 2005): sterile plant (1), plant with flower buds (2), flowering plant (3), plant with immature fruits (4), and plant with mature fruits (5). The phenophase for a species was assigned the highest of values attained by at least 30% of individuals in a subplot. Index of phenological complementarity (Stevens and Carson, 2001) was used to describe the asynchrony of growth: if peak cover of all species occurs at the same time, then the index value is << 0; if some dominant species display their peak cover in spring and others reach their peak cover in summer, then the value is > 0.

Results and discussion

Comparison of phenological complementarity (Figure 1A) showed that in both years mown plots had the lowest index values, indicating the most synchronous community development. Indeed, the seven most abundant species in the mown plots reached their peak cover in May or June, whereas four out of seven species in the grazed plots peaked in May (grasses) and three species in July (dicotyledons) (data not shown). Later developing species may substantially improve overall fodder digestibility due to positive effects of high nitrogen concentration tissues on the digestion process (Niderkorn and Baumont, 2009). Remarkably, vegetation under the influence of long-term grazing displayed complementarity only in the first year of observation. This might be attributed to the protection of the monitored permanent plots from early spring grazing, enabling early developing species to gain competitive advantage and possibly suppressing the occurrence of later developing species the next year. Further, analyses of variance for the CWM of functional traits according to database values (Bioflor database: onset of flowering, $P = 0.04$; LEDA traitbase: LDMC, $P = 0.04$) and post-hoc Fisher's LSD test revealed that grazed and mown plots were similar, but in contrast to the fallow plots they were associated with communities with earlier flowering and lower LDMC. Therefore, according

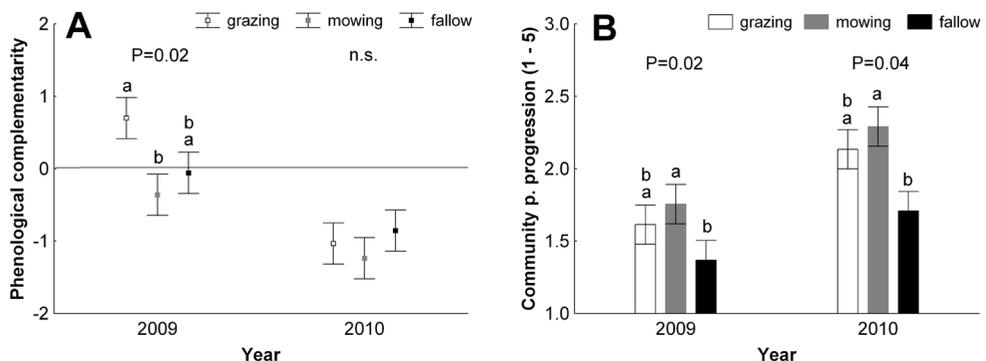


Figure 1. Index of phenological complementarity (A), above zero values indicate high seasonal asynchrony of species peak cover. In community phenological progression (B) the cover weighted mean of species phenophases is presented (values from 1 [sterile plant] to 5 [plant with mature fruits]) as averages over all three sampling dates. One-way ANOVA for each year separately; error bars represent SE; means with same letter are not significantly different (Fisher's LSD test, $P < 0.05$).

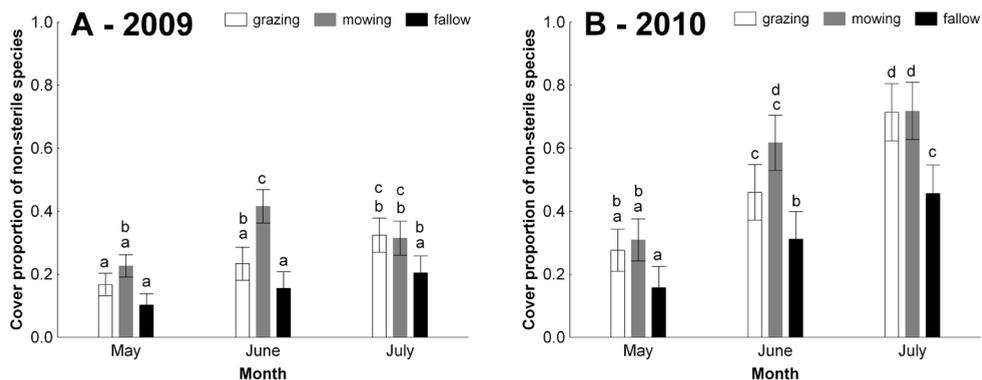


Figure 2. Seasonal development of cover proportions of non-sterile species (from 2 [plant with flower buds] to 5 [plant with mature fruits]). Repeated measures ANOVA; error bars represent SE; means with the same letter are not significantly different (Fisher's LSD test, $P < 0.05$).

to the results of Ansquer *et al.* (2009), in grazed and mown plots a parallel community PP may be expected, which should be faster than in fallow plots. In fact, community PP averaged over all three sampling dates was in both years the fastest in the mown plots and the slowest in the fallow plots (Figure 1B). Community PP of grazed plots was in both years slower than that of mown plots, but not significantly. In addition, we analysed the seasonal development of the cover proportions of non-sterile species (Figure 2A, 2B). Notably, the vegetation of the mown plots accelerated the development earlier (in June) than that of grazed plots (in July).

Conclusion

We showed, consistent with Ansquer *et al.* (2009), that community PP is slower in grassland with a higher LDMC (here fallow plots). However, in the case of a similar LDMC late harvest should be less unprofitable in long-term grazed than in mown grassland, because the former manifests a slower community PP and supports later developing species.

Acknowledgement

The research was funded by the Ministry of Environment of the Czech Republic under project RPV SP 2D3/179/07.

References

- Ansquer P., Haj Khaled R.A., Cruz P., Theau J.P., Therond O. and Duru M. (2009) Characterizing and predicting plant phenology in species-rich grasslands. *Grass and Forage Science* 64, 57-70.
- Duru M., Cruz P., Al Haj Khaled R., Ducourtieux C. and Theau J.P. (2008) Relevance of plant functional types based on leaf dry matter content for assessing digestibility of native grass species and species-rich grassland communities in spring. *Agronomy Journal* 100, 1622-1630.
- Martínková J., Šmilauer P. and Mihulka S. (2002) Phenological pattern of grassland species: relation to the ecological and morphological traits. *Flora* 197, 290-302.
- Martin G., Hossard L., Theau J.P., Therond O., Josien E., Cruz P., Rellier J.P., Martin-Clouaire R. and Duru M. (2009). Characterizing potential flexibility in grassland use. Application to the French Aubrac area. *Agronomy for Sustainable Development* 29, 381-389.
- Mládek J., Hejzman M., Hejduk S., Duchoslav M. and Pavlů V. (2011) Community seasonal development enables late defoliation without loss of forage quality in semi-natural grasslands. *Folia Geobotanica* 46, 17-34.
- Niderkorn V. and Baumont R. (2009) Associative effects between forages on feed intake and digestion in ruminants. *Animal* 3, 951-960.
- Stevens M.H.H. and Carson W.P. (2001) Phenological complementarity, species diversity and ecosystem function. *Oikos* 92, 291-296.