Selective livestock grazing and its consequences for functional vegetation properties and agronomic services of species-rich grasslands
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References to chapters (in bold in parentheses) within section ‘3 Methods’ as well as within section ‘4 Results’ are references to author’s publications or manuscripts listed in section ‘7 Publications or manuscripts’.
1 Introduction

In the early 1990s, large-scale land-use changes took place in many countries of Central and Eastern Europe as a result of political transformation (Miklas 2008; Metera et al. 2010). In the Czech Republic, cattle numbers decreased to half and the number of sheep to a quarter in comparison to the 1980s (Hejcman 2005a). In consequence, vast areas of low-productive grasslands were abandoned, especially in the hilly borderlands. Cessation of grassland management led to encroachment of shrubs and expansion of highly competitive grasses (e.g. *Arrhenatherum elatius*, *Brachypodium pinnatum*, *Calamagrostis epigejos*, *Molinia arundinacea*, *M. caerulea*) and forbs (e.g. *Hypericum maculatum*, *Polygonum bistorta*), which caused subsequent severe reduction of species richness (Lepš 1999; Klimeš et al. 2000; Klimeš et al. 2001; Mládek et al. 2006; Pecháčková et al. 2010). In 1999 came a turning point in Czech agricultural and nature conservation policy. Several subsidy programmes were introduced. Particularly extensive grazing received considerable support and so became the most profitable tool for grassland maintenance (Miklas 2008). Instead of cutting and haymaking or rotational grazing of dairy cows performed in the past fifty years, farmers increasingly began to apply grazing of large herds of beef cattle and sheep for the entire vegetation season due to its higher profitability. However, at that time there was only little evidence of the effect of grazing regimes on the vegetation structure and occurrence of endangered plant and animal species in various grassland types of the Czech Republic (see Krahulec et al. 2001; Pavlů et al. 2003; Háková et al. 2004).

![Fig. 1](image-url)

**Fig. 1** Location of study area: the White Carpathians Protected Landscape area is situated in Central Europe in the borderland between the Czech Republic and Slovakia (in Czech Republic: Bílé Karpaty, in Slovakia: Biele Karpaty)

As transferability of results of abundant grazing studies from Western Europe is limited due to different species compositions and also due to a discrepancy in effects under variable
climatic conditions (e.g. de Bello et al. 2005), in 2000 the Ministry of the Environment started to support monitoring of the influence of grazing regimes on vegetation in Protected Landscape Areas (PLA). Several projects were initiated in the Bílé Karpaty PLA (Fig. 1), which can boast on possessing extremely species-rich grasslands in the European context (Jongepier and Jongepierová 2009). I was fortunate to take part in the first project (VaV 610/10/00), under which I compiled my master thesis focused on the classification of grassland communities with respect to grazing management and its history (published later: Mládek 2008). In 2003, I was approached by I. Jongepierová (Czech Union for Nature Conservation & Administration of the Bílé Karpaty PLA) to conduct a multidisciplinary project as a principal investigator (VaV 620/11/03). This project was aimed at bringing evidence from a wide spectrum of semi-natural grassland communities regarding effects of grazing on plants, insects and soil biota, and simultaneously report on forage quantity and quality, subsequent livestock performance and farming economy in order to facilitate the preparation of Czech agri-environmental measures and nature conservation subsidy programmes. An important output of the project was a complex methodology for management of grasslands with grazing in PLAs (Mládek et al. 2006). As a consequence of all the research issues solved during both previous projects and during the current project, which is dealing with effects of management on plant community functioning (RPV SP/2D3/179/07), I decided to conceive my PhD thesis in a complex manner.

2 Aims of the Thesis

As indicated in the title the Thesis deals with selective livestock grazing and its consequences for functional vegetation properties and agronomic services of species-rich grasslands. To understand the causes and consequences of selective grazing we aimed to following issues:

- review studies dealing with diet selection of herbivores in species-rich grasslands
- recognise the underlying mechanisms of diet selection of sheep in productive mesic and low-productive dry species-rich grasslands
- understand the feedbacks of sheep grazing selectivity on functional vegetation properties
- reveal the relationship between community-weighted plant functional traits and forage quantity and quality and their seasonal development
- on the basis of long-term management experiments identify management-induced effects on the agronomic value of broad-leaved dry grasslands
- examine which long-term management produces vegetation with the slowest phenological progression and supports phenological complementarity
- elucidate seasonal development of organic matter digestibility and nutrient concentrations in biomass in species-rich grasslands and compare their absolute values with characteristics of agriculturally improved grasslands and with requirements for optimal cattle nutrition
- identify grassland types in which postponing of the first harvest until summer does not substantially reduce forage quality
recognise long-term management regime which supports functional vegetation properties providing a potential for late harvest

3 Methods

Large herbivores such as cattle and sheep graze selectively responding to many abiotic and biotic factors. Hence, contrary to mowing machines, sward defoliation by grazing is usually not uniform but highly heterogeneous. Especially in species-rich grasslands, the diversity of forage supply enables large herbivores to express their feeding preferences. To understand the causes and consequences of selective grazing I made a survey of all relevant literature sources and compiled a review on diet selection of herbivores in species-rich pastures together with P. Hejcmanová, specialist in large herbivore grazing behaviour (Chapter III). Diet selection, in other words foraging strategy, substantially differs between sheep and cattle; and their feeding preferences are modified by availability and spatial distribution of preferred forage as well as by overall grazing intensity. Hence, in order to recognise the underlying mechanisms of diet selection in our species-rich grasslands and regional grazing systems, two separate studies were performed (sheep selectivity in Chapter IV; preliminary results of cattle grazing selectivity in: Pavelčík and Mládek 2008). Several researchers tried to find a mechanistic understanding between sheep selectivity and plant response to grazing (e.g. Cingolani et al. 2005; Evju et al. 2009). However, they did not find clear links. This might be attributed to the fact that positive response to a grazing regime is not only exhibit by less defoliated species (avoidance strategy) but also by light-demanding species compensating frequent defoliation by fast regrowth (tolerance strategy). Furthermore, response to grazing is dependent not only on defoliation rate but also on nutrient impoverishment or enrichment (see Rusch et al. 2009). Consequently, selective defoliation together with soil disturbance by trampling and nutrient enrichment with faeces and urine produce a feedback on structure and species composition of the sward.

Recent grassland studies have documented that the effects of grazing (or any other management regime) on community structure and composition can be better understood using ecological knowledge of plant functional traits (e.g. de Bello et al. 2005; Cruz et al. 2010). Particularly community-weighted means of traits have proved to be suitable for an identification of functional vegetation properties (see e.g. Doležal et al. 2011). Community-weighted means are based on the ‘biomass ratio hypothesis’ (Grime 1998), which postulates that functional vegetation properties depend on the traits of the most abundant species of the community. Especially leaf traits (specific leaf area, leaf dry matter content – henceforth LDMC) related to fundamental plant resource acquisition – conservation trade-offs are useful to capture the response of a community to factors applied such as management regime (Duru et al. 2010a) as well as to predict community feedback on ecosystem processes such as litter decomposition (Garnier et al. 2004). These are called ‘response traits’ and ‘effect traits’, respectively (Lavorel and Garnier 2002). Thus, community-weighted leaf traits are suitable to assess ecosystem services of semi-natural grasslands (Diaz et al. 2007; de Bello et al. 2010). Land-use (i.e. in our case long-term grassland management regime) substantially modifies delivery of ecosystem services by affecting ecosystem properties either directly or indirectly via functional traits (Lavorel et al. 2011); the conceptual framework of all relevant links is presented in Fig. 2.
Fig. 2 Ecosystem services of grasslands (including agronomic value – forage quantity and quality) are derived from ecosystem properties. This conceptual framework identifies the direct effects of land use on ecosystem properties; the combined direct effects of land use and abiotic variables on ecosystem properties, and the combination of abiotic effects with indirect effects via plant functional traits (CWM: community-weighted means of functional traits; FD: trait functional divergence) (Lavorel et al. 2011)

Huge areas of grasslands throughout Europe are currently maintained for their biodiversity (pollination, aesthetic and cultural values), but financial resources for biodiversity-targeted management are limited, therefore knowledge of management-induced effects on the agronomic value are of high importance. In consequence, understanding of the relationship between functional traits and seasonal development of forage quantity and quality is crucial for assessing agronomic services of species-rich grasslands. The first steps to reaching this have been made. High LDMC was identified as a suitable marker of low herbage digestibility and productivity (Pontes et al. 2007; Duru et al. 2008; Andueza et al. 2010). Further, diversity of LDMC within a community was acknowledged to identify a seasonal growth pattern (Duru et al. 2010b, c): high diversity was shown to be connected with less variation of herbage mass around the growth peak, thus providing greater flexibility in grassland harvest (Martin et al. 2009).

Although several current studies highlighted the importance of intraspecific trait variability for inspection of community-weighted trait response to environment (e.g. Lepš et al. 2011), for most traits positive covariation between species turnover and intraspecific trait variability was reported. Thus, neglecting intraspecific trait variability results usually only in underestimation of community response to environmental changes, in other words patterns
found on the basis of field measurements should be more pronounced than patterns on the basis of ‘fixed’ database values. Therefore, we utilised freely accessible trait values of most European grassland species in databases (BiolFlor – Klotz et al. 2002; LEDA – Kleyer et al. 2008), and elucidated herbivores’ diet selection strategies, effects of grazing regimes on community functioning and agronomic services of species-rich grasslands with the help of community-weighted functional traits.

In order to investigate the effects of grazing regimes on plant species composition and community functioning, long-term experiments were established in several grassland communities (associations as defined in Chytrý (2007)): Carlino acaulis-Brometum erecti Oberdorfer 1957 (alliance Bromion erecti Koch 1926), Festuco capillatae-Nardetum strictae Klika et Šmarda 1944 (alliance Violion caninae Schwickerath 1944), Poo-Trisetetum flavescentis Knapp ex Oberdorfer 1957 (alliance Arrhenatherion elatioris Luquet 1926) and Anthoxantho odorati-Agrostietum tenuis Sillinger 1933 (originally included in Cynosurion cristati Tüxen 1947, but according to Rozbrojová et al. 2010 rather belonging to Arrhenatherion elatioris). In 2004 we selected three sites in the Bílé Karpaty (White Carpathian) Mts. (Bromion, Cynosurion, Violion) and in 2006 three sites in the Javorníky Mts. (Arrhenatherion, Bromion, Bromion), in which the same experimental design was used. The design included four treatments: (1) mowing in mid-July, (2) extensive rotational sheep grazing starting in June combined with burning of litter every third year in March (traditional management in the region), (3) extensive rotational sheep grazing, and (4) abandonment (lying fallow). Each treatment was 10 times replicated within each site; one replication comprised of a 5 m × 5 m experimental plot. Treatments were arranged in blocks situated within two ‘exclosures’ per site, i.e. one exclosure contained five blocks (Fig. 2).

Six (five) years of vegetation monitoring in permanent subplots 1 m² in size (located in the centre of each experimental plot) in broad-leaved dry grasslands (all three Bromion sites) were sufficient to reveal marked differences in effects of management treatments on community-weighted functional traits (Chapter V). The design of the experiments encompassed factors with random effects so that performing data analysis with traditional repeated measures ANOVA was not eligible. Therefore, all analyses were carried out with linear mixed-effect models using restricted maximum likelihood methods (Crawley 2007; Zuur et al. 2009), in which management and its interaction with year were treated as fixed effects while site, exclosure, block, subplot code and year as random effects.

Grassland managers advising farmers on utilisation of semi-natural grasslands need some simple diagnostic tools to assess grassland agronomic services, i.e. forage quantity and quality. As mentioned above, methods based on functional vegetation properties seem to be very promising (see Ansquer et al. 2009a; Duru et al. 2010c). We decided to test if patterns found for community-weighted LDMC on a large scale of grasslands are valid when differently managed swards are taken into consideration. Low LDMC at the community scale was acknowledged to be connected to high herbage productivity and high nutrient concentrations in biomass (Garnier et al. 2004; Gaucherand and Lavorel 2007). Therefore, considering vegetation in three long-term experiments in the Bílé Karpaty (White Carpathian) Mts. (Bromion, Cynosurion, Violion), we asked whether management supporting the lowest community LDMC also provides the highest amount of standing biomass and highest total amounts of nitrogen (N), phosphorus (P) and potassium (K) (Chapter VI).
Fig. 3 Experimental design used in 12 grasslands. Management treatments were allocated into five blocks; treatments within blocks were not arranged randomly for reasons of building of an exclosure around the mown and abandoned plots (similarly as in Hejcman et al. 2005b), i.e. the vicinity of burned and abandoned plots was excluded with regard to fire risk.

Especially in mountainous and less-favoured areas, farmers have to accommodate timing of grassland management to weather conditions or new agri-environmental schemes. Recently applied schemes usually postpone defoliation activities to June–July in order to assure diasporic production of endangered plant species and reproduction of insects and ground-nesting birds (Kleijn and Sutherland 2003). Thus, farmers often face the problem which grasslands enable a harvest later in the season without a substantial decline in forage quality (Martin et al. 2009). As forage quality decline is particularly driven by the speed of phenological progression of species (Duru et al. 2008); it is a challenging question which factors control this progression. It was found that grassland communities with higher community-weighted LDMC flower later (Ansquer et al. 2009b), however, hitherto no study has answered the question how phenological progression is modified by long-term management (Chapter VII). In another study we explicitly asked how postponed defoliation affects biomass production and forage quality in different vegetation types and, therefore, profitability of livestock production systems. In agriculturally improved grasslands summer harvest provides forage of lower digestibility for livestock and lower N, P and K concentrations than spring harvest (Bruinenberg et al. 2002; Gibson 2009). However, semi-natural grasslands occur on a wide range of soils with distinct levels of nutrient availability and their dominant plant species substantially differ in resource economy strategies (Eckstein et al. 1999). Leaf lifespan vs. nutrient resorption strategies may produce distinct seasonal nutrient concentration patterns. The paper in Chapter VIII is focused on seasonal changes in crude fibre concentration and organic matter digestibility while manuscript in Chapter IX primarily deals with the development of nutrient concentrations in biomass and provides a comparison of these with requirements for optimal cattle nutrition. Furthermore, the presented ratios of nutrient concentrations in biomass help to reveal which nutrients limit biomass production and thus preserve the unique species-richness of grassland communities in the Bílé
Karpaty Mts., where flysch bedrock with alternating claystone and sandstone layers (usually rich in Ca and K) predominates. This question is particularly important under increasing levels of atmospheric N deposition and has not received much attention in the Western Carpathians to date (but see Rozbrojová and Hájek 2008).

Understanding of interactions between plants, nutrient flows and large herbivore grazing is of high importance for designing proper agri-environmental schemes and farm plans. The complexity of effects of grassland management on structure and functioning of semi-natural grasslands (including agronomic services) has thoroughly been presented in the Czech Republic by prof. Rychnovská (Rychnovská 1993) and a group led by prof. Hejcman and Dr. Pavlů (Pavlů et al. 2003; Hejcman 2005a; Pavlů et al. 2006), who showed me all the processes in grasslands in a wide context. However, effects of grazing regimes on extraordinarily species-rich grasslands in the Bílé Karpaty Mts. have received almost no attention (but see a short-term study by Lanta et al. 2009), and therefore this thesis provides first complex picture of how these unique grasslands function under grazing regimes.

4 Results

In order to encourage farmers and their advisors to promote using species-rich grasslands, the agronomic services they can provide should be demonstrated. Reviewing literature on diet selection of livestock (Chapter III), we may conclude that domesticated ruminants perform better for having available a variety of food types. Species-rich grasslands offer a wide variety of food types, in which livestock can meet their demands for energy and intake of nutrients, and regulate their intake of toxins better than when constrained to a single food, even if the food is nutritionally balanced. In this way livestock also experience the benefits of ingesting small amounts of compounds with medicinal effects and they learn to prefer plant species containing such compounds. This is the case for sheep preferentially grazing highly toxic White hellebore (*Veratrum album*) or even Meadow saffron (*Colchicum autumnale*) in species-rich pastures in the Czech Republic. Grazing herbivores seldom consume enough toxins to result in poisoning because they regulate their intake through post-ingestive feedback and quickly learn to eat mixtures of plants that mitigate toxicity. For instance, tannins contained in many wild plants may interact in rumen with highly toxic alkaloids from other plants, thus neutralising their negative effects. Such experiences enable animals to adapt to local diets and stressors. Particularly low grazing intensity allowing animals to manifest their feeding preferences increases animal welfare and also production per animal. This agronomic service of species-rich grasslands, i.e. welfare of grazing livestock, has not yet been sufficiently highlighted.

By investigating causes and consequences of heterogeneous grazing we should detect livestock grazing preferences. However, absolute feeding preferences for plant species, which can be obtained from feeding trials, may not be applicable to species-rich pastures. On pastures, a herbivore’s diet selection is substantially modified by species availability, spatial distribution and neighbourhood effects. The pattern of selection is largely determined by the herbivore’s body-size; small herbivores as sheep and goats are generally more selective than large ones such as cattle. Larger herbivores are forced to select lower-quality forage in order to maintain a certain level of intake. However, both small and large animals adopt relatively selective strategies if available food resources exceed their needs. We tested whether sheep adopt different foraging strategies in productive mesic (*Arrhenatherion*) vs. low-productive dry (*Bromion*) species-rich grasslands dominated by resource-acquisitive vs. resource-conservative species, respectively (Chapter IV). Indeed, we found that in mesic grasslands, where forage was abundant and which offered a choice of highly nutritious species, the strategy of maximising forage quality was the most pronounced. On the contrary, in less productive dry grasslands, where the sward consisted mainly of species with low forage value,
the strategy of maximising forage quantity was preferred. This new result provided a better understanding of various effects of grazing under different environmental conditions. Maximisation of forage quantity in dry grasslands was detected consistently at several scales. Sheep selected plots with higher community-weighted canopy height as well as plant species with greater canopy height. This finding helped to elucidate the decrease in community-weighted canopy height and suppression of grasses under the grazing regime in the long-term management experiments within broad-leaved dry grasslands (Chapter V). This pattern might not be expected, because the dominant Tor-grass (*Brachypodium pinnatum*) belonging to the tallest species in the community is reported to be a highly unpalatable plant, having one of the lowest forage indicator values within the community. Presumably forage quality in early spring does not differ as much as is indicated in databases, therefore at the beginning of May *Brachypodium* biomass possessed a sufficient digestibility for sheep. Thus, sheep were not yet forced to select less productive dicotyledons (Chapter IV) exhibiting generally higher forage values throughout the season.

Semi-natural species-rich grasslands may be less productive than agriculturally improved ones, they could however have other advantages such as late-season or slower growth providing flexibility in grassland harvest. We examined which species-rich grasslands have a potential for late harvest without significant loss of forage quality, and how this agronomic service is related to functional vegetation properties. We revealed that for vegetation under long-time grazing pressure starting each year in early spring seasonal alterations in plant species proportions are typical. These can be uncovered in permanent plots with the help of the index of phenological complementarity or with the community seasonal development index, newly proposed by us for destructively sampled biomass data. Later-developing species seem to be partially accountable (together with a high proportion of species with persistent leaves — Chapter VIII and IX) for stabilisation of forage quality later in the season, which was demonstrated analysing the development of organic matter digestibility. In another study (Chapter VII), plots under long-time grazing comprised also more later-developing species and featured slower community-weighted phenological progression than vegetation in plots under mowing. Thus, within two independent studies we evidenced that in vegetation under long-time grazing pressure postponing of defoliation until summer produced the lowest decrease in forage quality. Therefore, permanent pastures render the greatest potential for flexibility in grassland harvest; this feature constitutes the agronomic service of species-rich grasslands, which may be utilised by farmers when the regular harvest (grazing) date has to be shifted due to bad weather conditions. Furthermore, one-year application of late harvest could be established as a low-cost agri-environmental measure. Nature conservation interest, i.e. reproduction of insects and ground-nesting birds, would be attained, while forage quality and subsequent profitability of livestock production would not be strongly diminished.

Since financial resources for biodiversity-targeted management are limited, effects of long-term grassland management on the agronomic value of semi-natural grasslands within large protected landscape areas should receive more attention. In this light finding optimal low-cost management is one of the major tasks in the European agri-environmental policy. We investigated effects of four management treatments in 120 permanent plots established in formerly abandoned dry grasslands (Chapter V). Although mowing in mid-July decreased the performance of grasses and enhanced forbs most of all treatments, we cannot recommend it as an optimal low-cost management type for maintenance of broad-leaved dry grasslands. Long-term mid-July mowing produced vegetation with a high proportion of rosettes, whose biomass is mostly not accessible to mowing machines or grazing livestock. Thus, sparse upright herbage provides forage of low quantity. In addition, the high proportion of species relying on generative reproduction and on early flowering indicates that vegetation under a long-term mowing regime, contrary to grazing, yields forage of lower quality.
Simple diagnostic tools for assessment of forage quantity and quality are needed. However, relationships found for community functional traits and ecosystem properties (e.g., biomass production – predictor of forage quantity) often originate from large ecological gradients and may not be applicable at other scales. On the large scale of grasslands, community-weighted LDMC was acknowledged to be connected to high herbage productivity and high nutrient concentrations in biomass. Hence, higher total amounts of nutrients in above-ground standing biomass should be linked to lower community LDMC. We tested this hypothesis using a dataset from management experiments (Chapter VI). Community LDMC appeared to be significantly the lowest under mowing, but in this light unexpectedly also the total amounts of N, P and K were significantly the lowest under mowing. We concluded, taking into account grasslands under different management regimes, that community-weighted LDMC cannot be used as a suitable indicator of agronomic value. This may be explained by high proportion of rosettes under mowing (Chapter V) which made a large part of the above-ground biomass inaccessible to harvesting. Furthermore, community-weighted LDMC long considered as a trait responding to fertility also responds to intensity of disturbance (Chapter V), which is in line with other current studies. Summing up, the relationships between community-weighted LDMC and forage quantity and quality are scale dependent and according to new results of Michel Duru’s research group (INRA, Toulouse) largely influenced by the proportion of dicotyledonous species. Hence they have newly proposed simple diagnostic tools based on LDMC of dominant grass species.

5 Conclusions

Our results indicate that maximising forage quality and maximising forage quantity are alternative diet selection strategies of sheep to exploit food resources in mesic and dry grasslands, respectively. This provided insight into the effects of early-spring grazing in broad-leaved dry grasslands, where sheep grazing unexpectedly eliminated productive but unpalatable grasses. Although mid-July mowing decreased the performance of grasses and enhanced forbs most of all management treatments, a pattern desired by nature conservationists, it cannot be recommended as the optimal low-cost management for broad-leaved dry grasslands due to its adverse effects on forage quantity and quality. Community-weighted mean of leaf dry matter content was a good indicator of seasonal growth pattern and forage quality, but not a suitable predictor of forage quantity when grasslands under different management regimes were taken into account. In two independent studies we evidenced that later-developing species were best supported under long-time grazing pressure, and postponing of defoliation until summer produced the smallest decrease in forage quality in grasslands managed in this way. We propose to establish a one-year late harvest application in permanent pastures as a low-cost agri-environmental measure. Nature conservation interest, i.e. reproduction of insects and ground-nesting birds, would be attained, while forage quality and subsequent profitability of livestock production would not be strongly reduced.

It can be concluded that community-weighted means of plant functional traits represent a powerful tool for analyses of causes and consequences of selective livestock grazing. Functional trait approach might also be helpful to assess forage quantity and quality obtained from species-rich grasslands and also for delimiting grassland types in which postponing of grassland harvest until summer at least diminishes the profitability of livestock production.

6 References

Hejcman M, Auf D, Gaaiser J (2005a) Year-round cattle grazing as an alternative management of hay meadows in the Giant Mts (Krkonoše, Karkonosze), the Czech Republic. Ekologia-Bratislava 24: 419–429


7 Publications or manuscripts
(numbering equals to chapters within whole PhD. Thesis)

Chapter III
**Review: Diet selection of herbivores on species-rich pastures**
Hejcmanová P, Mládek J (2011)
Chapter for the book Animal Husbandry, Nova Science Publishers
(accepted)

Chapter IV
**Sheep trade-off in diet selection: forage quality in mesic vs. forage quantity in dry species-rich grasslands**
Mládek J, Hejcmanová P, Dvorský M, Mládková P, Pavlů V, de Bello F, Hejcman M, Duchoslav M
(submitted)

Chapter V
**Reintroduction of management in broad-leaved dry grasslands: mowing enhances forbs but diminishes agronomic value**
Mládek J, Mládková P, Doležal J, Dančák M
(submitted)

Chapter VI
**Grassland response to long-term management and amounts of nutrients in standing biomass**
54th Symposium of the IAVS, 2011, Lyon
(accepted)

Chapter VII
**Using phenological progression and phenological complementarity to reveal a potential for late grassland harvest**
Mládek J, Juráková J (2011)
Grassland Science in Europe
(accepted)

Chapter VIII
**Community seasonal development enables late defoliation without loss of forage quality in semi-natural grasslands**
Folia Geobotanica 46: 17–34

Chapter IX
**Postponing of the first harvest in semi-natural grasslands: decline in nutrient concentrations?**
Mládek J, Hejcman M, Hejduk S, Pavlů V, Duchoslav M, Mládková P
(submitted)
8 Summary

Mládeč J (2011) Selective livestock grazing and its consequences for functional vegetation properties and agronomic services of species-rich grasslands

Planning of agri-environmental measures requires knowledge of the effects of management regimes on the occurrence of endangered plant and animal species as well as of the effects on grassland agronomic services, i.e. forage quantity and quality and their seasonal development. Effects of management on agronomic services of species-rich grasslands were seldom examined. In the face of the renascence of grazing at the end of the 1990s we particularly assessed the causes of selective grazing by livestock and evaluated its consequences for the agronomic value of the extraordinarily species-rich grasslands in the White Carpathian Mts., Czech Republic. In order to understand feedbacks of grazing on vegetation properties, studies of diet selection were reviewed and sheep grazing patterns in productive mesic and low-productive dry species-rich grasslands were analysed. The effects of four management regimes (sheep grazing, sheep grazing including spring burning of litter every third year, mowing in mid-July, abandonment) were investigated in long-term experiments using community-weighted means of plant functional traits. In addition, as nature conservation frequently requires postponing of grassland harvest until summer, we were interested to know in which grassland types this measure does not substantially reduce forage quality.

Our results indicate that maximising forage quality and maximising forage quantity are alternative diet selection strategies of sheep to exploit food resources in mesic and dry grasslands, respectively. This provided insight into the effects of early-spring grazing in broad-leaved dry grasslands, where sheep grazing unexpectedly eliminated productive but unpalatable grasses. Although mid-July mowing decreased the performance of grasses and enhanced forbs most of all management treatments, a pattern desired by nature conservationists, it cannot be recommended as the optimal low-cost management for broad-leaved dry grasslands due to its adverse effects on forage quantity and quality. Community-weighted mean of leaf dry matter content was a good indicator of seasonal growth pattern and forage quality, but not a suitable predictor of forage quantity when grasslands under different management regimes were taken into account. In two independent studies we evidenced that later-developing species were best supported under long-time grazing pressure, and postponing of defoliation until summer produced the smallest decrease in forage quality in grasslands managed in this way. We propose to establish a one-year late harvest application in permanent pastures as a low-cost agri-environmental measure. Nature conservation interest, i.e. reproduction of insects and ground-nesting birds, would be attained, while forage quality and subsequent profitability of livestock production would not be strongly reduced.

It can be concluded that community-weighted means of plant functional traits represent a powerful tool to analyse causes and consequences of selective livestock grazing as well to evaluate management-induced effects on agronomic services of species-rich grasslands.
9 Souhrn (Czech summary)

Mládek J (2011) Selektivní pastva dobytka a její důsledky na funkční vlastnosti a agronomické servisy druholiv bohatých travních porostů

Plánování agro-environmentálních opatření vyžaduje znalost vlivu managementu na výskyt ohrožených druhů rostlin a živočichů stejně jako vlivu na agronomické servisy travních porostů, tj. množství a kvalitu pice a jejich sezónní vývoj. Vliv různých typů managementu na agronomické servisy druholiv bohatých porostů byl zřídka zkoumán. Vzhledem k renesanci pastv v polovině 90. let 20. století v mimořádně druholiv bohatých travních porostech Bílých Karpat (Česká republika) bylo hlavním cílem této práce posoudit příčiny selektivní pastvy dobytka a vyhodnotit její dopady na funkční vlastnosti a agromonické servisy druhově bohatých travních porostů.

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