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IMPACT OF COMBINED MANAGEMENT ON THE NEWLY ESTABLISHED PASTURE SWARD

P. Hakrová, K. Novotná, Z. Sýkorová, M. Šlachta, J. Frelich

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Abstract

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The effect of the combined grazing and cutting management on the phytocenological characteristics was examined at the submountain paddock in the South Bohemia. The botanical scans were sampled during the five-years study (2006–2010) starting after the sowing the pasture sward in the originally arable field and 0–2 years after the beginning of the grazing (paddock A and paddock B, respectively). The paddock A was grazed all year round, whereas the paddock B was grazed in spring and autumn and cut in summer for hay. At both paddocks, *Lolium perenne, Trifolium repens* and *Taraxacum* sect. *Ruderalia* dominated the community of total 43 and 47 species (paddock A and B, respectively). Among the sowing species, *Lolium perenne*, *Festuca pratensis, Poa pratensis, Festuca rubra* and *Trifolium repens* increased its cover on both paddocks, while *Phleum pratense* increased its cover only at paddock B. *Lolium multiflorum* decreased it cover at both paddocks. Most of arable field weeds disappeared (paddock A) or decreased its cover (paddock B). The cover of herb layer was higher at paddock A than at paddock B, whereas the number of species (N), the diversity (H) and the equitability (J) was higher at paddock B than at paddock A. The cover of herb layer increased during the study at both the paddocks, while the number of species declined at paddock A and increased at paddock B.

grazing management, cutting, sowing the pasture sward, vegetation development, plant diversity, sheep and cattle

Permanent grasslands form one quarter to total agricultural land in the Czech Republic. For the most part they are located in sub-mountain and mountain areas, which are considered as LFA with a lower production capacity than agricultural land at lower altitudes (Frelich *et al*., 2006). The traditional management of the permanent grasslands, in addition to mowing, is cattle and sheep grazing and the production of forage (Kvapilík, 2004). The grazing spread mainly in the border areas in last two decades due to the development of beef husbandry in mountain areas and due to the subsidies for the grassland management (Kvapilík, 2004; Kohoutek *et al*., 2009). The positive effects of grazing was found regarding the production and the health in cattle (Frelich *et al*., 2009; Frelich *et al*., 2011; Frelich and Šlachta, 2011).

The transition of arable land to a permanent grassland use to be applied by farmers in order to provide their animals a sufficient grazing area. Although a choice of a convenient seed mixture is a base of succesful development of the sward, grazing magement and the environmental conditions affect the species composition substantially (Humphrey and Patterson 2000; Hejcman *et al.,* 2002; Pavlů *et al.,* 2003; Sanderson *et al.*, 2004; Edwards *et al.*, 2005; Ambruz and Hejduk, 2011).

The aim of the study was to examine the development of the pasture sward newly established in the arable field extensively grazed by sheeps and cattle (permanently and grazed in spring and autumn with cut in summer). We assume that the different management can affect species composition and coverage of established permanent grassland.

MATERIAL AND METHODS

The experiment was carried out at the private farm of Ing. Jan Vejčík in the Dlouhá Stropnice village (580 meters a.s.l.) in the South Bohemia in the Czech Republic. The original arable field (aimed on production of rape or cereals) was gradually transformed to the pasture by sowing the seed mixture (Tab. I) in order to feed a newly established herd of the livestock (sheep and cattle). The experimental area was formed by two paddocks with different management given in detail in Tab. I. The paddock A (Strop-old, 18 ha) was sown in spring 2004 and cut in summer and grazed since subsequent year (2005–2010). The paddock B (Strop-young, 9 ha) was sown in spring 2006 and cut in summer. In the next three years (2007–2009) was grazed in spring and autumn and cut in summer. In the last year (2010) was only grazed. The paddocks were grazed by a mixed herd of 130–150 sheep (mainly Valachian breed) and about 20 animals of Aberdeen Angus cattle. Grazing started in paddock A. No chemical treatment nor fertilisation was applied at paddocks. The sward was dragged and rolled early in the spring and the ungrazed rests of sward were cut in late summer.

The line of five permanent plots (one in area 16 m^2) in fifty-meters distance was established in both the paddocks. A phytosociological vegetation relevé, cover of herb layer (E1) and total number of species (N) was recorded at each plot three-times a year (in May, July and September) (Moravec, 1994; Prach, 1994) in years 2006–2010 (it is 15 phytosociological relevés on each permanent plot). The Shannon index of diversity (H), the Shannon index of equitability (J) (Magurran, 1988) and the species persistence according to Moravec (1994) were calculated.

Species persistence is the percentage share of phytosociological relevés in which the species occurs in the total number of observed phytosociological releves. Plant species were grouped into three classes of permanent species (51–100%), additive species (26–50%) and random species (up to 25%) (Brockmann-Jerosch in Moravec, 1994).

The difference between the years and between the paddocks were evaluated by ANOVA for repeated measurements (StatSoft CR, s r. o., 2008) for N, E1, H and J characteristics. The values of E1 were ArcSin transformed before calculation.

The effect of the year and of the paddock on the species composition was evaluated by CANOCO software (ter Braak and Šmilauer, 1998) using the RDA analysis. The significance of the axes was tested by Monte Carlo permutation test with 499 permutations. The analysis was visualized by CanoDraw software (ter Braak and Šmilauer, 2002).

RESULTS

The list of species, their mean cover in the first and in the last observed year and their persistence is given in Tab. II. In total 43 species at paddock A and 47 species at paddock B was found.

Nine species (paddock A) and twelve species (paddock B) were included in the category of permanent species (21% and 25.5% of total species, respectively). They formed 96% and 93% of E1 at paddock A and at paddock B, respectively. Eight species was included in the category of additive species at both the paddocks. They formed 18.6% of all species and only 2.9% of E1 at paddock A and 17% of all species and 5.9% of E1 at paddock B. Twenty-six species and 27 species (at paddock A and at paddock B, respectively) was involved in category of random species, which was 60.5% and 57.5% of all species (at paddock A and at paddock B, respectively) and 1.1% of E1 at both the paddocks.

I: *The management history of experimental site*

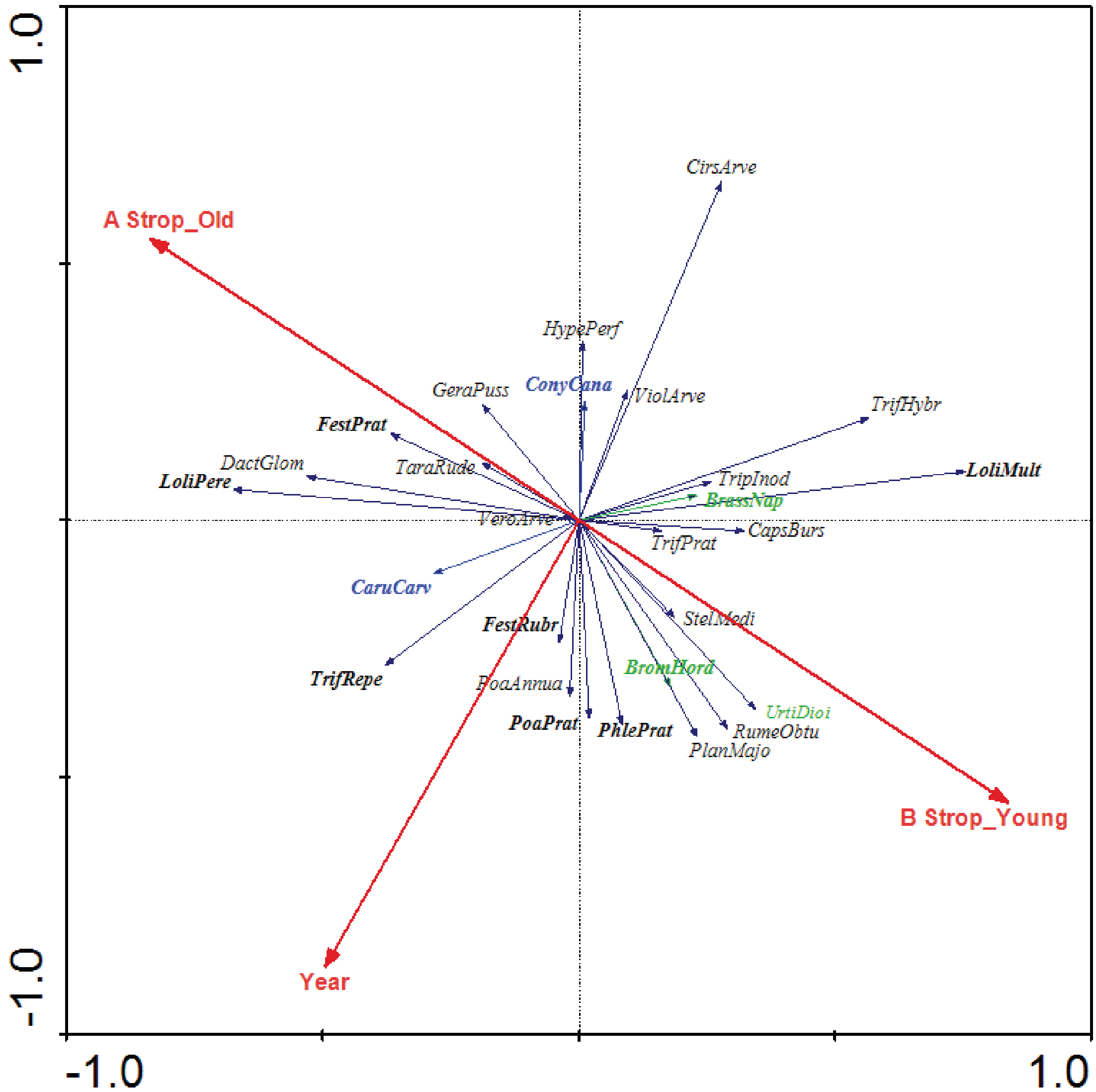
Site	Paddock A (Strop_Old)	Paddock B (Strop_Young)
Altitude	580 meters a.s.l.	580 meters a.s.l.
Exposure	southwest	southwest
Slope	3.8°	3.8°
GPS	48°44´53; 14°44´41	48°44´53; 14°44´41
Date of sowing	2004 – spring	2006 – spring
Sowing of mixture	*Festuca pratensis* (26%) *Lolium perenne* (23%) *Phleum pratense* (20%) *Festuca rubra* (10%) *Lolium multiflorum* (10%) *Trifolium repens* (8%) *Poa pratensis* (3%)	*Festuca pratensis* (15%) *Lolium perenne* (25%) *Phleum pratense* (25%) *Festuca rubra* (15%) *Lolium multiflorum* (10%) *Trifolium repens* (7%) *Poa pratensis* (3%)
Further treatment	2004 – cutting in summer 2005–2010 – grazing all the year	2006 – cutting in summer 2007–2009 – grazing in spring and autumn, cutting in summer 2010 – grazing all the year

II: *The species at paddocks A and B listed according their stability, with their mean value of E1(%) in the first (2006) and in the last year (2010) of the examination ns = > 0.05, * < 0.05, ** < 0.01, *** < 0.001*

stability	Paddock A (Strop_Old)					Paddock B (Strop_Young)				
class	**stability**	**species**	**cover 2006**	**cover 2010**	**P level**	**stability**	**species**	**cover 2006**	**cover 2010**	**P level**
permanent species (51–100%)	100	Lolium perenne	45.40	52.00	*	100	Lolium perenne	4.80	28.93	***
	100	Trifolium repens	4.10	25.80	***	100	Trifolium repens	3.35	10.47	**
	100	Festuca pratensis	2.65	3.37	ns	94	Lolium multiflorum	39.70	0.80	***
	99	*Taraxacum* sect. *Ruderalia*	6.25	7.00	**	94	*Taraxacum* sect. *Ruderalia*	0.60	6.33	***
	90	Phleum pratense	3.65	1.17	***	94	Rumex obtusifolius	0.50	6.73	*
	73	Rumex obtusifolius	0.55	0.60	ns	78	Festuca pratensis	0.40	3.30	*
	67	Trifolium hybridum	4.30	0.27	***	78	Trifolium hybridum	14.20	0.20	***
	59	Lolium multiflorum	0.95	0.10	**	71	Poa annua	0.20	2.03	*
	57	Dactylis glomerata	0.20	0.50	ns	69	Phleum pratense	0.00	10.33	***
						57	Plantago major	0.00	0.53	**
						57	Urtica dioica	0.30	1.63	ns
						52	Trifolium pratense	0.15	0.43	ns
		9 species					12 species			
additives species (26–50%)	50	Poa annua	0.00	1.97	*	45	Bromus hordeaceus	0.00	2.00	*
	49	Cirsium arvense	0.50	0.01	***	42	Stellaria media	0.20	0.33	ns
	41	Trifolium pratense	0.30	0.07	ns	40	Capsella bursa-pastoris	0.00	0.18	ns
	33	Geranium pusillum	0.03	0.04	***	35	Poa pratensis	0.00	7.67	***
	31	Cerastium arvense	0.00	0.17	ns	35	Cirsium arvense	0.35	0.01	***
	29	Veronica arvensis	0.11	0.10	ns	32	Festuca rubra	0.00	2.33	***
	29	Festuca rubra	0.00	0.07	*	29	Veronica serpyllifolia	0.00	0.10	ns
	26	Poa pratensis	0.00	0.13	ns	29	Tripleurospermum inodorum	0.10	0.10	ns
		8 species					8 species			
random species (0–25%)	17	Capsella bursa-pastoris	0.16	0.00	*	23	Veronica arvensis	0.00	0.17	ns
	17	Agrostis stolonifera	0.00	0.27	ns	23	Cerastium arvense	0.00	0.13	ns
	17	Vicia cracca	0.00	0.04	ns	17	Vicia cracca	0.00	0.04	ns
	16	Tripleurospermum inodorum	0.16	0.00	*	14	Equisetum arvense	0.00	0.07	ns
	13	Stellaria media	0.20	0.03	*	6	Achillea millefolium	0.00	0.07	ns
	11	Hypericum perforatum	0.15	0.00	**	5	Brassica napus	0.01	0.00	*
	10	Carum carvi	0.00	0.11	*	5	Chenopodium album	0.00	0.04	ns
	9	Viola arvensis	0.16	0.00	**					
	3	Conyza canadensis	0.10	0.00	*					
		Other 17 species					Other 20 species			
		26 species					27 species			
total species		43 species					47 species			

The species composition differed between paddocks as well as between the years (F = 66.743, p = 0.006). The first axes explained 37% of variability – 24% was explained by the effect of the paddock and 13% by the effect of the year. The species with significant change of cover (Tab. II) are vizualised at Fig. 1. The arrows indicate a higher cover of species at a given paddock than on the other one (except the species occurring only at one paddock: *Bromus hordeaceus, Urtica dioica* and *Brassica napus* at paddock B (Strop_Young) and *Conyza canadensis* and *Carum carvi* at paddock A (Strop_Old). The species with arrows in the opposite direction than the effect of the year decreased their cover in run of the examination. The decrease of the cover of weed and ruderal species (*Cirsium arvense*, *Capsella bursa-pastoris, Tripleurospermum inodorum, Brassica napus* and *Conyza canadensis*) was thus evident.

Among the sowing species, *Lolium perenne*, *Festuca pratensis, Poa pratensis, Festuca rubra* and *Trifolium repens* increased its cover on both paddocks, while *Phleum pratense* increased its cover only at paddock B (Tab. II). *Lolium multiflorum* decreased its cover at both paddocks, but especially at paddock B, where

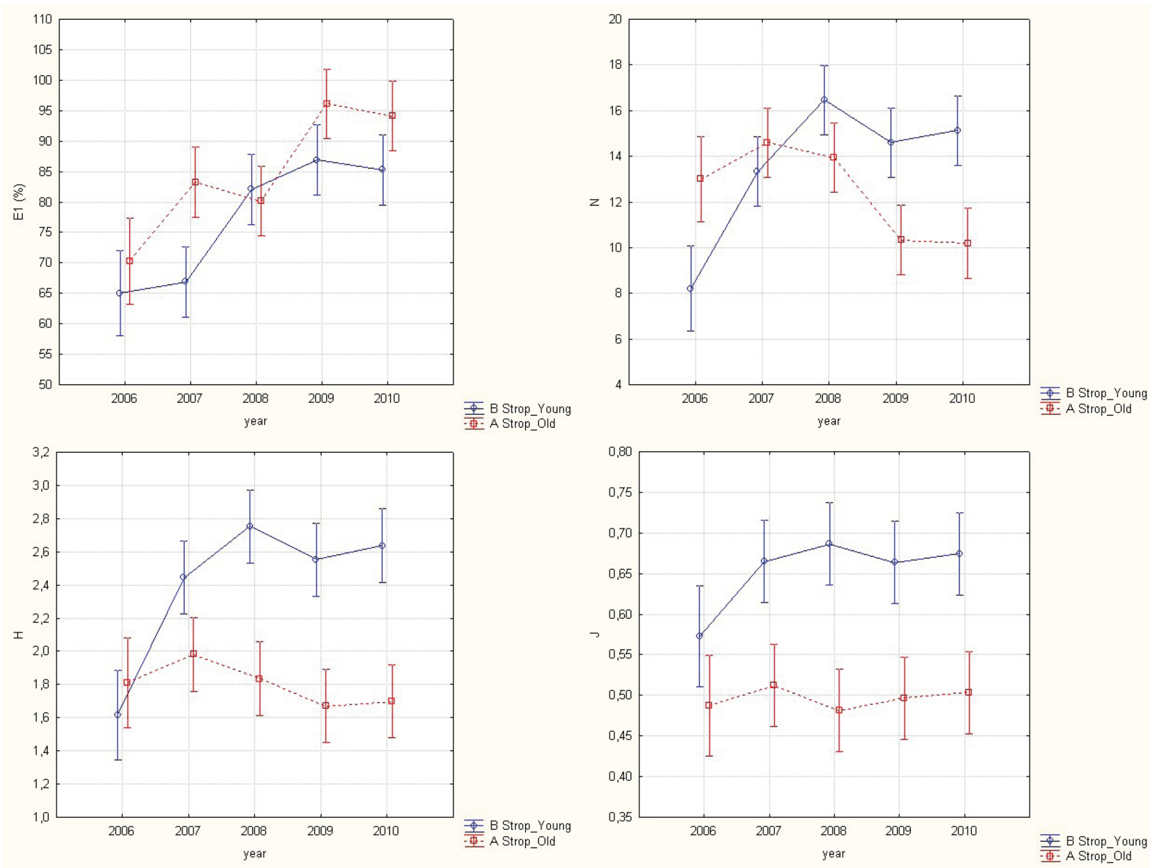


1: *Results of RDA analysis of the effect of site and year on the species composition of the sward. The species with statistically significant change in cover are visualized. The sown species are depicted in bold, the species occurring only at paddock A are depicted in blue and those occurring only at paddock B are depicted in green. Used abbreviations of species names: BrassNap (Brassica napus), BromHord (Bromus hordeaceus), CapsBurs (Capsella bursa-partoris), CaruCarv (Carum carvi), Cirsarve (Cirsium arvense), ConyCana (Conyza canadensis), DactGlom (Dactylis glomerata), FestPrat (Festuca pratensis), FestRubr (Festuca rubra), GeraPusi (Geranium pusillum), HypePerfu (Hypericum perforatum), LoliMult (Lolium multiflorum), LoliPere (Lolium perenne), PhlePrat (Phleum pratense), PlanMajo (Plantago major), PoaAnnua (Poa annua), PoaPrat (Poa pratensis), RumeObtu (Rumex obtusifolius), StelMedi (Stellaria media), TaraRude (Taraxacum sect. Ruderalia), TrifPrat (Trifolium pratense), TrifRepe (Trifolium repens), TrifHybr (Trifolium hybridum), TripInod (Tripleurospermum inodorum), UrtiDioi (Urtica dioica), VeroArve (Veronica arvensis), ViolArve (Viola arvensis).*

its cover was much higher in the first year than later (Tab. II).

Concerning the newly introduced (unsown) species, the persistence higher than 50% at both paddocks was found by *Rumex obtusifolius* (which increased cover particularly at paddock B), *Poa annua* (which increased abundance particularly at paddock B), *Plantago major* (increased cover particularly at paddock B), *Dactylis glomerata* (which increased cover particularly at paddock A). *Taraxacum* sect. *Ruderalia* increased its cover at paddock B as to 6.7%, while at paddock A reached the cover more than 6% already in the first year (and 7% at the end of the examination). *Trifolium hybridum* decreased cover at both paddocks, particularly at paddock B, where it reached the highest value of 14.2% in the first year.

The E1 was higher at paddock A than at paddock B, whereas the number of species (N), the diversity (H) and the equitability (J) was higher at paddock B than at paddock A (Fig. 2). The E1 increased at both paddocks during the examination, from 70.3% to 94.1% at paddock A and from 65% to 85.2% at paddock B (Fig. 2, Tab. III). The number of species decreased from 13 to 10.2 at paddock A, while it increased in the first and second year at paddock B from 8.2 to 16.5 and it rested about 15 in the next years (Fig. 2, Tab. III). The diversity (H) changed in similar way to the number of species at particular paddocks, while the equitability (J) did not change significantly between years (Tab. III). Significant interactions between paddock and year were found by E1, number of species (N) and the diversity (H) (Tab. III).



2: *The development of the examined parameters in particular years. The means and the 0.95 intervals of significance (vertical lines) are given in the figure.*

III: *The significance level (P) of the effects of the paddock, year, and their interaction on the phytocenological sward characteristics: cover of herb layer (arcsinus transformed) (E1), number of species (N), Shannon index of diversity (H), Shannon index of equitability (J)*

	E1	N	H	J
paddock	*0,000137*	*0,027967*	*0,000000*	*0,000000*
year	*0,000000*	*0,000005*	*0,000176*	0,247940
paddock*year	*0,038871*	*0,000000*	*0,000029*	0,339006

DISCUSSION

The observed swards are very young and with small mean number of species (10, resp. 15 species). The dominance of the *Lolium perenne* and *Trifolium repens* was established in the pasture sward 2–3 years after its sowing. From seven sown species (including six grass species and one legume), particularly these two species adapted best to the climatic and soil conditions at the locality and kept their dominance (or enhanced it) during next years of the experiment.

Concerning the other sown species, *Festuca pratensis* was the other dominant species, mainly at paddock A, as well as *Festuca rubra, Poa pratensis, Phleum pratense* and *Lolium multiflorum* (all at paddock B). *Lolium multiflorum* declined in its abundance between 2006 and 2010. Low abundance and persistence was found in most of the herbs, except for *Taraxacum* sect. *Ruderalia* (dominant at both paddocks) and for *Rumex obtusifolius* (dominant at paddock B).

Regarding the species composition, the dominant *Lolium perenne* and the permanent species *Poa annua, Trifolium repens* and *Plantago major* the examined swards fit best to pasture swards of *Cynosurion* association (Chytrý *et al.*, 2007). The arable field weed species disappered from swards during the examination (*Conyza canadensis, Viola arvensis, Cirsium arvense, Capsella bursa-pastoris, Tripleurospermum inodorum, Stellaria media, Polygonum aviculare*) and the species of permanent pasture swards occurred in small cover (f.e. *Carum carvi, Vicia cracca* and *Agrostis stolonifera*) at paddock A. In contrary, at paddock B the weed species decline cover less readily (only *Brassica napus, Polygonum aviculare* disappeared) and very rarely with a small cover occured meadow species, like *Achillea millefolium* and *Vicia cracca* for example.

The low number of species at paddock A can be explained by a high cover of *Trifolium repens*, which increased as to 25% while three species disappeared in one year. Strong decrease in the number of colonizing species caused by fast spred of *Trifolium repens* was observed also by Lepš *et al.* (2007).

Besides the initial species composition of the swards, the presence of the species in the surroundings plays an important role when concerns the future species composition by the change or revitalisation of the swards (Dzwonko and Loster, 1998; Hulme *et al.*, 1999), as well as their size (Lencová and Prach, 2011). The examined pastures were initially the arable land and thus the seed bank of the meadow and pasture species cannot be expected at the locality and the development of the swards thus will take longer time.

The major effect on the sward structure and the cover may have been expected by the grazing, which became an important management factor already 1–2 years after the sward sowing. The grazing supports the development of the low-stem grasses and prostrate forbs, mainly of their cover rather than the number of species (Pavlů *et al.*, 2007). This may explain the low number of species and high cover of low-stem grass *Lolium perenne* and prostrate forb *Trifolium repens* at paddock A. The sward was nearly completely covered and did not allow much the introduction of new species.

The shorter grazing season at paddock B (because grazing started in paddock A) was probably the reason for the dominance of more species. Loosely turfed grasses and grass with creeping rootstalks rapid spring growth, like *Phleum pratense, Poa pratensis* and *Festuca rubra* (Skládanka *et al.*, 2009) can develop sufficiently before the cutting later in the season. These species contribute substantially to the total cover at paddock B. Also the species with short vegetation cycle, mainly the arable field weeds, have sufficient time to create the seeds at paddock B and thus do not so readily disappear at this paddock.

The stability of the swards is strongly influenced by the intensity of the sward management and by the intensity of the grazing (Grant *et al.*, 1996; Hulme *et al.*, 1999; Hejcman *et al.*, 2002). The sward management was extensive at examined paddocks according to evaluation of Hejcman *et al.* (2002), i.e. the pastures were not fertilised, resowing or chemically treated in some other way. As concerns the sward height during the pasture period, kept between 5 and 10 cm, the grazing may be evaluated as intensive at examined paddock A. Paddock B was grazed as the second one and few years was cut in summer. We can consider that was grazed extensively against paddock A.

The lower stocking rates of sheep at pastures resulted in the increase of the species richness (from 9 to 12) as well as the diversity (Shannon H from 0.55 to 0.8) by Marriot *et al.* (2009), which is in accordance with situation at paddock B in this study. By the rotational grazing, the high-stem grasses sensitive to the defoliation of continuous grazing, increase their cover (Pavlů *et al.*, 2003). On the other hand, other species (*Lolium perenne*, *Taraxacum* sect. *Ruderalia* and *Trifolium repens*) increase their cover by the continuous grazing, which was observed also in this study.

CONCLUSIONS

The composition of newly established pasture swards was influenced by the sowed seed mixture and subsequent management. The swards developed in well covered sward dominated by *Lolium perenne* and *Trifolium repens*. The only grazing resulted in low number of species and dominance only of three species (*L. perenne*, *T. repens* and *Taraxacum* sect. *Ruderalia*), while the shorter grazing season (with summer cut) resulted in dominance of more species of grasses (*Poa pratensis* and *Phleum pratense*) and increased number of species and cover.

SUMMARY

The aim of the study was to examine the development of newly sown sward grazed by sheep and cattle (only grazed or grazed with summer cut). The experiment was carried out at the farm of Ing. Jan Vejčík in the Dlouhá Stropnice village in the South Bohemia. Two paddocks were sown by the seed mixture

of six species of grasses and *Trifolium repens*. The grazing of mixed herds of 130–150 sheep (mainly Valachian breed) and about 20 animals of Aberdeen Angus cattle was subsequently performed there. The herd had access to the paddock A all the year through, whereas the paddock B was grazed in spring and autumn and cut in summer. The line of five permanent plots in fifty-meters distance was established in both the paddocks. A phytosociological vegetation relevé, cover of herb layer (E1) and total number of species (N) was recorded at each stand in area of 16 m^2 three-times a year (in May, July and September) (Moravec, 1994; Prach, 1994) in years 2006–2010. The Shannon index of diversity (H), the Shannon index of equitability (J) (Magurran, 1988) and the species persistence according to Moravec (1994) were calculated. The difference between the years and between the paddocks were evaluated by ANOVA for repeated measurements for N, E1, H and J characteristics. The values of E1 were ArcSin transformed before calculation. The effect of the year and of the paddock on the species composition was evaluated by CANOCO software (ter Braak and Šmilauer, 1998) using the RDA analysis.

In total 43 species at paddock A and 47 species at paddock B was found. Nine species (paddock A) and twelve species (paddock B) were included in the category of permanent species (21% and 25.5% of total species, respectively). They formed 96% and 93% of E1 at paddock A and at paddock B, respectively. Eight species was included in the category of additive species at both the paddocks. They formed 18.6% of all species and only 2.9% of E1 at paddock A and 17% of all species and 5.9% of E1 at paddock B. Twenty-six species and 27 species (at paddock A and at paddock B, respectively) was involved in category of random species, which was 60.5% and 57.5% of all species (at paddock A and at paddock B, respectively) and 1.1% of E1 at both the paddocks. Concerning the other sown species, *Festuca pratensis* was the other dominant species, mainly at paddock A, as well as *Festuca rubra, Poa pratensis, Phleum pratense* and *Lolium multiflorum* (all at paddock B). *L. multiflorum* declined in its cover between 2006 and 2010. Concerning the newly introduced (unsown) species, the persistence higher than 50% at both paddocks was found by *Rumex obtusifolius*, *Poa annua*, *Plantago major*, *Dactylis glomerata* and *Taraxacum* sect. *Ruderalia*. *Trifolium hybridum* decreased cover at both paddocks. The E1 was higher at paddock A than at paddock B ($P = 0.00014$), whereas the number of species (N), the diversity (H) and the equitability (J) was higher at paddock B than at paddock A ($P = 0.00000$). The E1 increased during the study at both the paddocks ($P = 0.00014$), while the number of species declined ($P = 0.00000$) at paddock A and increased at paddock B.

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Address

Ing. Pavlína Hakrová, Ph.D., Katedra krajinného managementu – Laboratoř aplikované ekologie, Zemědělská fakulta, Jihočeská univerzita v Českých Budějovicích, Studentská 13, 370 05 České Budějovice, Česká republika, e-mail: hakrova@zf.jcu.cz