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# Plant species composition and potential feed value of permanent grasslands in the central part of Drahanská vrchovina Upland

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**Abstract:** Nerušil P., Komárek P., Menšík L. 2016: Plant species composition and potential feed value of permanent grasslands in the central part of Drahanská vrchovina Upland – *Beskydy*, 9 (1–2): 9–20

In multifunctional agriculture, permanent grasslands (PG) present an important culture which keeps the soil in the continuous production status while helping to shape the landscape and protecting biodiversity, plus it has a number of other non-productive functions. The aim of the study was to evaluate, using the "Inventory and Classification of PG" method, species composition and the feed value of fodder in permanent grasslands in a specific farming company (ZEMSPOL Sloup a.s.) located in the area of the Drahanská vrchovina Upland. Multivariate analysis of PCA identified four categories of sites in the area: meadows/pastures with a higher proportion of legumes and grass species and potentially higher quality of fodder; meadows/pastures with a low proportion of grass species, a high proportion of other herbs and a very low potential feed value of fodder, etc. Most of PG are completely lacking legumes which supply nitrogen to the vegetation and are a major improvement for fodder production and its quality. Infestation with broad-leaf sorrels (*Rumex acetosa* /L./ and *Rumex obtusifolius* /L./) may be potential risk in the future. Additional seeding of grass-clover mixtures seems to be a useful way to improve the botanical composition of meadows and pastures in the area of interest, whether it would involve applying a strip or harrow seeder.

**Key words:** grassland; plant species composition; feed value; PCA analysis; Drahanská vrchovina Upland; Czech Republic

## Introduction

From the perspective of multifunctional agriculture grasslands present an especially significant culture, which involves land use, co-shaping the landscape and preserving biodiversity; grasslands also support crop systems including the use of manure and wastewater from farm structures (Harvieu 2002). Hrabě (2003) points out that permanent grasslands (PG) are the only cultures capable of temporarily replacing the irreplaceable function of forest, in terms of permanent stability of the landscape and living conditions, as they have a number of characteristics consistent with forest ecosystems.

In the Czech Republic, PG occupy an area of about 997 thousand ha, which is 24% of the total agricultural land, i.e., 4,215,000 ha (MoA 2015). The major portion of the PG area is found in less-favoured areas (LFA). In the context of the promotion of agriculture, the area of PG in the Czech Republic has increased in the most recent ten to fifteen years. Considering the major decline in the stock of cattle (46% in 2000 compared with 1990) and sheep (19.5%) (Hejduk, Hrabě 2001) and the growing area of PG there is an excess of fodder produced in PG with a portion of the surfaces remaining unharvested. Non-harvested areas, however, cannot fully perform the non-productive functions and can become a source of weed for the surrounding land (Fiala, Gaisler 1999).

In PG, the botanical composition is determined by a natural occurrence of grasses and legumes. The basic agrobotanical groups of mixed grass communities (phytocoenoses) involve grasses, clovers (legumes) and other herbs (dicotyledonous species) (Novák 2008). Clovers add an important protein component to the fodder, thus contributing mainly to increased milk production in dairy cows. Compared with pure grass cover the proportion of clovers in green fodder increases feed intake (Steinwidder, Wurm 2003). In terms of protein, clovers greatly exceed grasses while featuring a favourable content of fibre, essential amino acids, minerals (Ca, Mg, K and P), and vitamins & pro-vitamins, high digestibility of organic matter (60% to 80%) and, finally, a high concentration of energy (Givens et al. 2000) Botanical composition is crucial for ensuring productive and non-productive functions of PG (Michaud et al. 2012), including the quality parameters of produced fodder; fodder quality is based on high digestibility, nutrient concentration and nutrient ratio (Gaujour et al. 2012; da Silveira Pontes et al. 2015). In the long term, botanical composition/fodder quality can be influenced by fertilising and crop utilisation systems, i.e., the intensity and frequency of grazing, alternating mowing and grazing or numbers of cuts during the year (Komárek et al. 2005; Hejcman et al. 2007, 2010; Nerušil et al. 2012).

The productive importance of PG lies in the fact that they present an important source of bulky, carbohydrate-protein feedstuff for livestock, especially in LFA (Rychnovská et al. 1985; Štýbnarová 2011), as well as a substrate for biogas plants (BGP) as a substitute for maize (Nerušil et al. 2016). Based on site conditions and the management system, yields range from 1.6 and 8.0 t of hay per ha; in renewed grasslands or those where additional seeding was applied, the yield can reach 10-12 t of quality hay per hectare (Pozdíšek et al. 2004).

The aim of the study was to evaluate, using the "Inventory and Classification of PG" method, species composition and the feed value of fodder in permanent grasslands in a specific farming company located in the area of the Drahanská vrchovina Upland.

## Material and methods

### *Site description:*

Permanent grasslands (PG) found on the land of ZEMSPOL Sloup a.s., a farming company, were subjected to the studies in 2001–2002 (Fig 1); the plots were found in the territory of the Drahanská vrchovina Upland (representing about 2.7% of the Czech Republic), approximately 30 km north of the city of Brno, Czech Republic. It refers to a significantly forested region (668 km$^2$ = over 40% of its total area) covering mainly the Culm Drahanská and Konická Highlands as well as the Moravian Karst of Devonian origin and part of principally Brno granitic eruptive rock. A more comprehensive description of grassland vegetation is given in Table 1.

The farming company manages a farm land of 1,647 hectares found at an elevation of 490 to 590 m. The mean annual air temperature is 6.3 °C and multi-annual average yearly rainfall is 638 mm (Pivec 1992). The company cultivates

cereals (783 ha), rape seed (284 ha), maize for silage (192 ha), other annual fodder crops (76 ha), alfalfa (37 ha), red clover, and clover-grass mixtures (261 ha). Permanent grasslands (473 ha) represent 22.3 % of the farm land. The company is focused on raising cattle (1,312 individuals, of which 450 are dairy cows) and pigs (2,088); it also keeps 16 draft horses. Farm land load by herbivores equals 0,475 livestock units per hectare. Soil types beneath PG involve Cambisols, Gleysols, rendzic Leptosols and haplic Luvisols in the area (Němeček et al. 2011; WRB 2014).

### *Methods:*

The representation of individual plant species primary agrobotanical groups and gaps of the PG observed was carried out by the method of reduced projective dominance - visual assessment of the stand (Horký et al. 2013). The phytocoenological picture of each of the plant species, primary agrobotanical groups and gaps were recorded as % of coverage (D %) and using the Braun-Blanquet scale (+ = coverage of 0.33 %, r - individual plants in the stand). The nomenclature of plants follows the botanical dictionary by Kubát et al. 2002). The potential value of the fodder was evaluated y a number of quality (WZ-Wertzahl) according to Klapp (1956), where 8 = the highest-quality fodder, -1 = toxic species; the total calculated value was increased by gaps. The overall evaluation of each PG was carried out by the "PG Inventory and Classification" method according to Koníček et al. 1966).

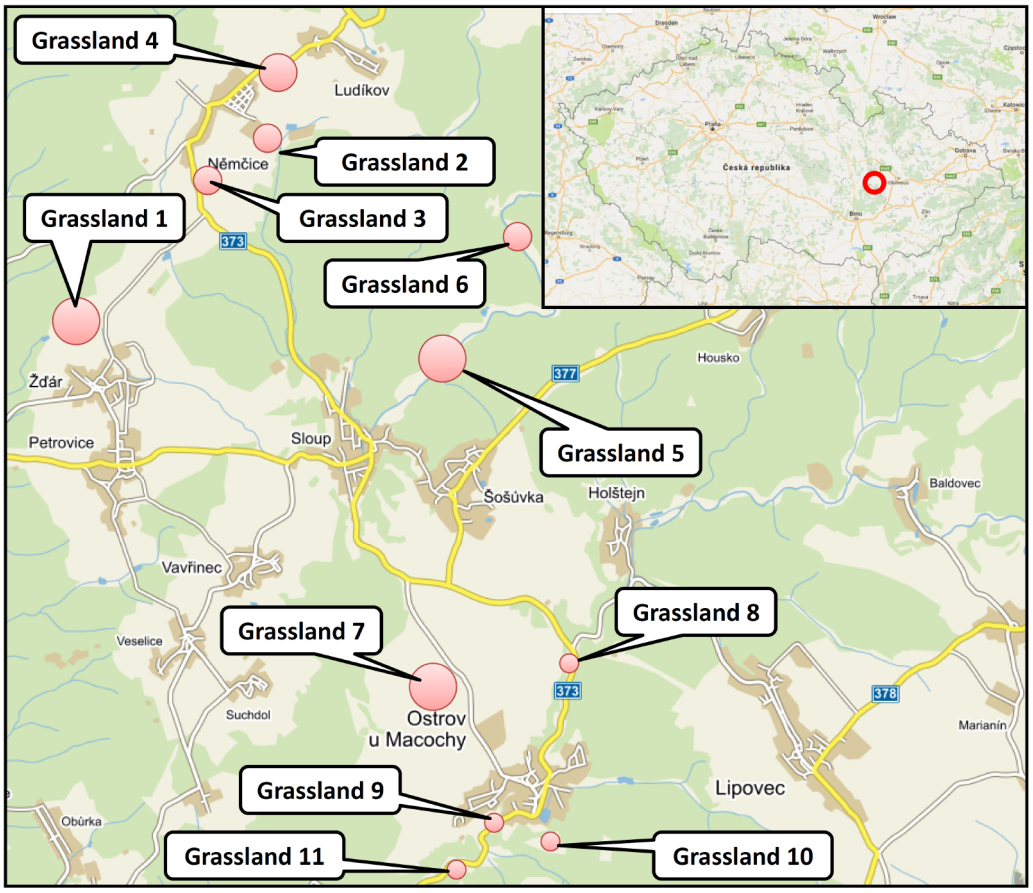


*Fig. 1: A map giving an overview of the area indicating the monitored PG (base data sourced from www.seznam.cz).*

*Table 1: Basic description of permanent grasslands.*

| **Plot serial number** | PG1 | PG2 | PG3 | PG4 | PG5 | PG6 | PG7 | PG8 | PG9 | PG10; PG11 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Elevation (m)** | 575 | 610 | 610 | 620 | 485 | 510 | 500 | 465 | 460 | 490; 445 |
| **Total plot area (ha)** | 8.00 | 26.0 | 8.00 | 13.0 | 17.5 | 17.5 | 20.0 | 8.0 | 1.0 | 10.0; 8.0 |
| **Estate name** | Rozsochy-Žďár | Pod kravínem | U mlýna | U MNV | Sloupská luka - I | Sloupská luka - II | Úžlebí | Žleb (U kaštanu) | Žleb (U léčebny) | Žleb (U Balcarky) (Vilémovský žleb) |
| **Intensity of use of vegetation** | M | P | P | P | M | M | M | M | M | M |
| **Slope and exposure** | >3, E | - to > 3, W | - to > 3, W | -, W | - to > 3, S | - to > 3, S | > 3, S | - to > 3, E | -, E | -, E |
| **Plot surface** | F | | | | | | | | | |
| **Soil class** | LS | | | | | | | | | |
| **Soil type** | Cambisol | Cambisol | Cambisol | Cambisol | fluvic Gleysol | fluvic Gleysol | rendzic Leptosols | haplic Luvisols | rendzic Leptosols | haplic Luvisols |
| **Water conditions (degree)** | III | III | III | III | II in to III | II in to III | IV | IV | IV | IV |
| **Vegetation composition (group)** | B | A-B | C | B | B | B | B | B | B | B |
| **The main species present** | Cock's-foot, smooth meadow-grass, red fescue | Cock's-foot, red fescue, smooth meadow-grass | Cock's-foot, smooth meadow-grass, yellow oat-grass | Smooth meadow-grass, cock's foot | Meadow foxtail, cock's foot, yellow oat-grass | Smooth meadow-grass, meadow foxtail, cock's foot | Smooth meadow-grass, cock's foot | Smooth meadow-grass, meadow foxtail, red fescue | Meadow foxtail, yellow oat-grass, smooth meadow-grass | Smooth meadow-grass, yellow oat-grass |
| **The economic standing** | ⊙ | | | | | | | | | |
| **The yield per hectare (t.ha$^{-1}$)** | 4.0 | 3.5 | 3.5 | 3.5 | 4.0 | 4.0 | 4.0 | 3.5 | 3.5 | 3.5 |
| **Arability** | AR | | | | | | | | | |
| **A method for improving the stand (type)** | M, AS | | | | | | | | | |

Explanatory notes:
PG – permanent grassland
Description made according to the "PG Inventory and Classification" method (Koníček et al. 1966)
M – meadow, P – pasture, – plane; > 3 – sloping 3 to 7,9°; E, W, S – slope exposure; F – flat surface; LS – loamy–sandy; II – occasionally waterlogged site, in II – occasionally waterlogged site, inundation area, III – optimal site, IV – drying site; A – fully closed cultural stand, B – stand with predominance of valuable species occupying more than 40% to 50% of the area, C – stand with a small proportion of valuable species occupying less than 40% to 50% of the area; ⊙ plot near a settlement (municipality); AR – immediately arable plot; M – fertilisation (organic, mineral), AS – additional seeding

### *Statistical analysis:*

Statistical analysis, including graphical outputs, was carried out using STATISTICA 12.0 (Stat-Soft Inc., Tulsa USA, StatSoft ČR s.r.o. 2014). Principal Component Analysis (PCA) was used for interpreting the agrobotanical groups (Graminoids, Legumes, Forbs) and the gaps. Selected measured characteristics were used as predictors (factors); they were chosen on the basis of an eigenvalue graph. Variables with impaired assumption of normality were converted using logarithmic transformation. As part of step 1, PCA was carried out with all the variables to compute the most important variables. Step 2 involved selecting active and supplementary variables for better interpretation. This stepwise analysis significantly improves the outcome of the PCA analysis in case of a smaller number of samples. PCA was used for calculating a component weight for the investigated variables (Meloun, Militký 2011). Based on correlations and contributions in convincing factors each of the characteristics was subsequently judged for relevance to explain the multidimensional dependencies (correlations) in the factorial plane. Statistical significance was assessed at a significance level of P = 0.05 (Meloun, Militký 2012).

## Results

The representation of plant species in permanent grasslands (PG) is very diverse. The number of species was identified to be 4 to 19 at individual sites (PG) with *Dactylis glomerata* (L.), *Alopecurus pratensis* (L.) and *Poa pratensis* (L.) being the grasses represented to the greatest extent. Of legumes, this involved only *Trifolium repens* (L.); of herbs, *Taraxacum sect. ruderalia, Anthriscus sylvestris* (L.), *Galium verum* (L)., *Rumex acetosa* (L.) and *Rumex obtusifolius* (L.) featured the highest percentage; for other species, refer to Appendix A. Supplementary data. For the summary characteristic of primary agrobotanical groups and gaps see Table 2. In each of the PG, grass presence is 46% to 94%. At five sites (PG4, 5, 6, 9, and 10) there was 1% to 5% legumes. At one site (PG3) herbs prevailed over grasses and legumes. Gaps were evaluated to range from 1% to 10%.

On the chart of component weights PC1 and PC2 there are only the first two axes significant, which together explain about 93% of the variability (Fig 2). Axis PC1 clearly characterises the representation of grasses, other herbs and empty spaces that go straight along that axis and are correlated with it over 0.9. Axis PC3 shows no strong correlation; the direction is however discerned based on the representation of legumes in PG. Multivariate analysis PCA (axes PC1 and PC2) significantly discerned, in the evaluated

*Table 2: Overall characteristics of agrobotanical groups (Graminoids, Legumes, Forbs), the gaps and potential feed value (WZ) of permanent grasslands.*

| PG | Name of field | Graminoids (%) | Legumes (%) | Forbs (%) | Gaps (%) | WZ |
|---|---|---|---|---|---|---|
| PG1 | Rozsochy-Žďár | 79 | 0 | 19 | 2 | 635 |
| PG2 | Pod Kravínem | 94 | 0 | 5 | 1 | 619 |
| PG3 | U mlýna | 40 | 0 | 50 | 10 | 550 |
| PG4 | U MNV | 70 | 5 | 20 | 5 | 695 |
| PG5 | Sloupská luka - I | 72 | 2 | 25 | 1 | 601 |
| PG6 | Sloupská luka - II | 76 | 1 | 22 | 1 | 656 |
| PG7 | Úžlebí | 46 | 0 | 44 | 10 | 577 |
| PG8 | Žleb (U kaštanu) | 91 | 0 | 6 | 3 | 678 |
| PG9 | Žleb (U léčebny) | 73 | 1 | 25 | 1 | 563 |
| PG10 | Žleb (U Balcarky) | 67 | 5 | 25 | 3 | 642 |
| PG11 | Vilémovský žleb | 60 | 0 | 30 | 10 | 586 |

Explanatory notes: PG - permanent grassland; WZ - Wertzahl according to Klapp (1956)

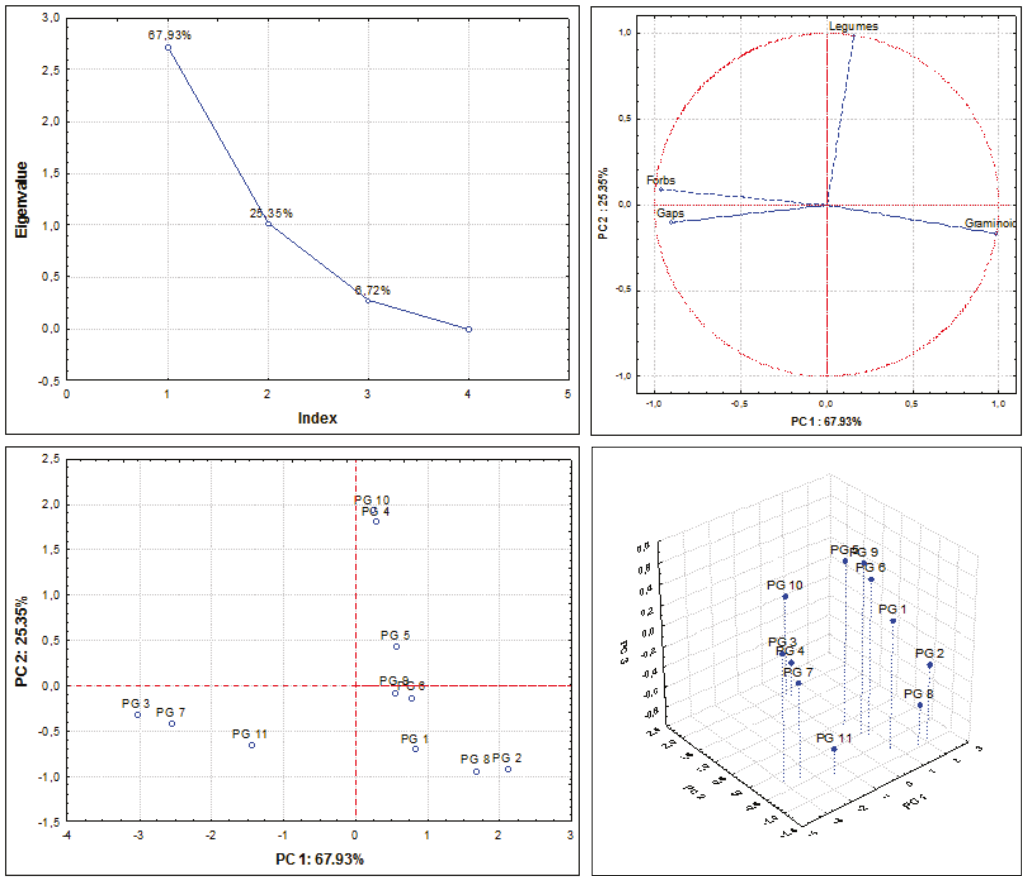


*Fig 2. PCA of agrobotanical groups (Graminoids, Legumes, Forbs), the gaps of permanent grasslands*

parameters – see Graminoids, Legumes, Forbs, and Gaps – four categories of PG sites: (1) PG 3, 7, 11 – low representation of grass species (40% to 60%), high representation of other herbs; (2) PG 1, 2, 8 – high representation of grass species (over 80%), very low representation of other herbs; (3) PG 5, 6, 9 – medium-high representation of grass species (60% to 80%), low representation of other herbs (22% to 25%) and legumes (1%); and (4) PG 4, 10 – medium-high representation of grass species (60% to 80%), representation of legumes (5%) and other herbs (20% to 25%).

Potential feed value of fodder was found to range from 550 WZ to 695 WZ. The lowest potential quality was found at PG 3, 7, 9, and 11, while the highest quality was seen at PG 4, 8, and 10 (Table 2).

## Discussion

The farmed PG provide agronomic as well as ecological benefits. Both of the above are based on (i) simple botanical composition, i.e. the presence and predominance of species, and (ii) functional assessment of the vegetation (e.g. percentage of entomophilous species, numbers of oligotrophic species, dry matter content of leaves and flowering time, etc.). Both of the benefits are influenced by farming and soil & climatic factors (Michaud et al. 2012). In the study area, PG represent a source of a bulky, carbohydrate-protein feedstuff for milk production; it conforms to the prevailing intensity of use of the grasslands (three PG classified as P – pastures, eight PG ranked as PG M – meadows) (Table 1). On most studied sites there were species of grass (*Poa pratensis* /L./; *Dactylis glomerata* /L./) with a high feed value of fodder

(Klapp 1956). The rated PG also comprise a low (1% to 5%) representation of legumes (*Trifolium repens* /L./) that significantly increase fodder quality (Givens et al. 2000; Steinwidder, Wurm 2003; Nerušil et al. 2012) as well as species diversity (Pozdíšek et al. 2004; Štýbnarová 2011). The prevailing portion of farm land of ZEMSPOL Sloup a.s. belongs to Moravian Karst PLA; over 75% of the company's land is classified a vulnerable area under Act 262/2012 Coll., where the management of grasslands and arable land is subject to mandatory limits (the year-round dose of nitrogen fertilisers applied to grassland is limited to 80 kg N per ha and the use of mineral fertilisers is restricted to 40 kg N per ha /Klír, Kozlovská 2012/). As a result, the representation of legumes (Hejduk 2012) has a very important role in the study area with the limited levels of fertilisation. Some sites (PG 3, 7) are at varying stages of degradation (the representation of legumes being 0% and that of other herbs, i.e. *Taraxacum sect. ruderalia, Galium verum* (L)., and even *Rumex acetosa* /L./ and *Rumex obtusifolius* /L./ etc., being high – see Appendix A. Supplementary data); prospectively, the quality of stands will need to be enhanced by additional seeding (using clover-grass mixtures sown by a strip or harrow seeder) (Kohoutek et al. 2007). In this direction, using a wide range of fodder crops will be critical in future (Carter, Blair 2013; Walden, Lindborg 2016) that would be capable of reaching the required changes in quality over a short period (Gaujour et al. 2012; da Silveira Pontes et al. 2015).

## Conclusion

In the Czech Republic, PG represent nearly 25% of farm land and are now seen more as a means to perform a range of non-productive functions and, less frequently, as a source of cheap and natural fodder for livestock. Based on the research and a comprehensive review of PG on the land of ZEMSPOL Sloup a.s., a farming company, in the region of the Drahanská vrchovina Upland, conclusions can be drawn as follows:

- Mostly represented grass species comprised *Dactylis glomerata* L., *Alopecurus pratensis* L., and *Poa pratensis* L.; of legumes, *Trifolium repens* L was only present. Of other herbs, the there was the highest percentage of *Taraxacum sect. ruderalia.*
- Weeding by broad-leaf sorrels (*Rumex acetosa*/L./ and *Rumex obtusifolius* /L./) is the issue in several PG in the study area. The solution may lie in continuous control by herbicides, mowing the plants before they develop seeds, and other measures (Hejduk, Macháč 2002; Pavlů et al. 2011).
- Multivariate analysis PCA significantly discerned four categories of sites (PG) in the territory - meadows (pastures) with a higher proportion of legumes and potentially higher feed value of the fodder; meadows (pastures) with a low proportion of grass species (40% to 60%), a high proportion of other herbs and a very low potential feed value of the fodder.
- Legumes that provide nitrogen supply to vegetation and significantly improve the fodder quality and production are completely missing in most PG. At such sites, additional seeding by clover-grass mixtures, whether by means of a strip seeder or a harrow seeder, seems to be an appropriate way for improvement.
- Alternate grazing and mowing which would be used to reach an optimal botanical composition, especially representation of clovers at the level of 20% to 30%, would be the best way of making use of PG in the territory.

Useful pratotechnology measures can be applied to enhance the quality of grasslands for farming purposes; they include plant nutrition and fertilisation, additional seeding by sowing legumes into the initial grassland, timely cuts, as well as grazing by polygastric herbivores.

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## Appendix A. Supplementary data

The summary of botanical composition and potential feed value of individual plant species in monitored permanent grassland.

## References


Carter, D.L., Blair, J.M. 2013: Seed source has variable effects on species, communities, and ecosystem properties in grassland restorations. *Ecosphere*, 4: 1–16.

da Silveira Pontes, L., Maire, V., Schellberg, J., Louault, F. 2015: Grass strategies and grassland community responses to environmental drivers: a review. *Agronomy for Sustainable Development*, 35: 1297–1318.

Fiala, J., Gaisler, J. 1999: *Grassland management Foraging of unused*. Methodologies for agricultural practice, no. 5, ÚZPI, MZe ČR, Praha, 38 pp. (in Czech)

Gaujour, E., Amiaud, B., Mignolet, C., Plantureux, S. 2012: Factors and processes affecting plant biodiversity in permanent grasslands. A review. *Agronomy for Sustainable Development*, 32: 133–160.

Givens, D.I., Owen E., Axford, R.F.E., Omed, H.M. (Eds.) 2000: *Forage evaluation in ruminant nutrition*. CABI Publishing, Wallingford, UK, 2000, 496 pp. ISBN 0-85199-344-3.

Harvieu, B. 2002: Multi-functionality: a conceptual framework for a new organisation of research and development on grasslands and livestock systems. In Durand, J.L. *et al.* (Eds.). *Multi-function grassland: Quality Forage, Animal Products and Landscapes*. British Grassl. Soc., U.K., vol. 7, p. 1–2.

Hejcman, M., Klaudisová, M., Schellberg, J., Honsová, D. 2007: The Rengen Grassland Experiment: Plant species composition after 64 years of fertilizer application. *Agriculture, Ecosystems and Environment*, 122: 259–266.

Hejcman, M., Schellberg, J., Pavlů, V. 2010: Long-term effects of cutting frequency and liming on soil chemical properties, biomass production and plant species composition of Lolio-Cynosuretum grassland after the cessation of fertilizer application. *Applied Vegetation Science*, 13: 257–269.

Hejduk, S. 2012: Red clover Plant which changed an European agriculture. *Vesmír*, 91(11): 642–646. (in Czech)

Hejduk, S., Hrabě, F. 2001: Production and the need of forage in the Czech Republic. In: *Pasture and animal*. Brno: MZLU v Brně, p. 42. (in Czech)

Hejduk, S., Macháč, R. 2002: The possibilities of broad-leaved dock control. *Agromagazín*, 3 (4): 28–29. (in Czech)

Horký, P., Skládanka, J., Šeda, J. 2013: *Regeneration of grasslands and methods of studying grassland ecosystems*. Brno: Mendelova univerzita v Brně, 56 pp. ISBN 978-80-7375-889-9. (in Czech)

Hrabě, F. 2003: *Grass and lawns - what about them do not know*. Vydavatelství Ing. Petr Baštan, Olomouc, 2003, 158 pp. (in Czech)

Klapp, E. 1956: *Wiesen und Weiden. Behandlung*, Verbesserung und Nutzung von Grünlandflächen. Parey, Berlin, 519 pp.

Klír, J., Kozlovská, L. 2012: *Agricultural management in vulnerable zones*. Methodologies for agricultural practice. Crop Research Institute, Praha. 68 pp. ISBN 978-80-7427-123-6. (in Czech)

Komarek, P., Kohoutek, A., Fiala, J, Nerusil, P., Odstrcilova, V. 2005: Production and quality of grassland forage in relation to stocking rate and cutting frequency. In: Lillak, R., Viiralt, R., Linke, A., Geherman, V. (Ed.) Grassland Science In Europe. Integrating Efficient Grassland Farming and Biodiversity. Kreutzwaldi 56, Tartu, 51014, Estonia: Estonian Grassland Soc-Egs, 573–576.

Kohoutek, A., Odstrčilová, V., Nerušil, P., Komárek, P. 2007: *Estabilishment permanent grasslands in LFA*. Methodologies for agricultural practice. Crop Research Institute, Praha. 24 pp. ISBN 978-80-87011-29-4. (in Czech)

Koníček, B. 1966: *Inventarization and classification of grassland in the CSSR*. MZVH Praha. 64 pp. (in Czech)

Kubát, K., Hrouda, L, Chrtek, J. jun., Kaplan, Z., Kirschner, J., Štěpánek, J. [Eds.] 2002: *Key to the Flora of the Czech Republic. Academia*, Praha, 928 pp. (In Czech)

Meloun, M., Militký J. 2011: *Statistical Data Analysis*. A Practical Guide with 1250 Exercises and Answer key on CD, Woodhead Publishing India, 1600.

Meloun, M., Militký, J. 2012: *The interactive statistical analysis*. 4. Edition, Karolinum Praha, 955 pp. (in Czech)

Michaud, A., Plantureux, S., Amiaud, B., Carrère, P., Cruz, P., Duru, M., Dury, B., Farruggia, A., Fiorelli, J.L., Kerneis, E., Baumont,

R. 2012: Identification of the environmental factors which drive the botanical and functional composition of permanent grasslands. *The Journal of Agricultural Science,* 150(2): 219–236.

MZe 2015: *Situation prospective report: Soil*. Ministry of Agriculture of the Czech Republic, Praha. 134 pp. ISBN 978-80-7434-252-3. (in Czech)

Němeček, J., Macků, J., Vokoun, J., Vavříček, D., Novák, P. 2011: *The taxonomic soil classification system in the Czech Republic,* 2. Edition. Czech University of Life Sciences in Prague, 94 pp. (in Czech)

Nerusil, P., Kohoutek, A., Komarek, P., Odstrcilova, V., Nemcova, P. 2012. Evolution of forage quality of selected grass species during the first harvest regrowth. In: Golinski, P., Warda, M., Stypinski, P. (Ed.) Grassland Science in Europe. Grassland - A European Resource?. Dojazd 11, Poznan, 60-632, Poland: Polish Grassland Soc-Polskie Towarzystwo Lakarskie, 379–381.

Nerušil, P., Menšík, L., Houdek, I., Jurka, M., Strašil, Z., Kohoutek, A. 2016: *Crop management, production and forage quality of selected grass varieties and grass mixtures as a maize substitute for biogas plants.* Methodologies for agricultural practice. Crop Research Institute, Praha. 27 pp. ISBN 978-80-7427-201-4. (in Czech)

Novák, J. 2008: *The pastures, meadows and lawns*. Patria I. spol. s r.o. Prievidza, 708 pp. ISBN 978-80-85674-23. (in Slovak)

Pavlů, V., Hejcman, M., Gaisler, J., Pavlů, L., Hujerová, R. 2011: *Possibilities of dock weeds control in grasslands under conditions of organic farming.* Methodologies for agricultural practice. Crop Research Institute, Praha. 32 pp. (in Czech)

Pivec, J. 1992: Air Temperature and Deficit of Precipitation. In: Klimo E, Maršálek J. (Ed.) *Manmade Spruce Ecosystem (Structure, Functions, Production, Processes).* Report from Project Rájec, Institute of Forest Ecology, Agriculture University Brno, 9–10.

Pozdíšek, J., Kohoutek, A., Bjelka, M., Nerušil, P. 2004: Utilization of grassland by suckler cow rearing. *Agricultural information, no. 2, ÚZPI, Praha*. 103 pp.

Rychnovská, M., Balátová-Tuláčková, E., Úlehlová, B. 1985: *Ecology of grasslands*. Praha: Academia, 291 pp.

StatSoft ČR s.r.o. 2014: *STATISTICA.Cz*, verze 12.0. www.statsoft.cz.

Steinwidder, A., Wurm, K. 2003: Weidemanagement für Milchkühe - Was kann und soll die Weide leisten? In: *„Der Fortschrittliche Landwirt"*, Heft 2/2003, 16 pp.

Štýbnarová, M. 2011: Changes in species diversity and organic matter digestibility at different intensity grassland management. *Dissertation thesis*. ČZU Praha. 147 pp. (in Czech)

Waldén, E, Lindborg, R. 2016: Long Term Positive Effect of Grassland Restoration on Plant Diversity - Success or Not? *Plos One,* 11: e0155836.

WRB 2014: IUSS Working Group WRB. World Reference Base for Soil Resources 2014. International soil classification system for naming soils and creating legends for soil maps. *World Soil Resources Reports,* No. 106. FAO, Rome.

## Appendix A. Supplementary data

*The summary of botanical composition and potential feed value of individual plant species in monitored permanent grassland.*

| | PG1 | | | PG2 | | | PG3 | | | PG4 | | | PG5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D |
| **Graminoids** | **79** | | | **94** | | | **40** | | | **70** | | | **72** | | |
| *Lolium perenne* (L.) | | | | | | | | | | | | | | | |
| *Festuca rubra* (L.) | 5 | 4 | 20 | 25 | 4 | 100 | | | | | | | | | |
| *Festuca pratensis* Huds. | | | | 5 | 8 | 40 | | | | | | | | | |
| *Poa pratensis* (L.) | 10 | 8 | 80 | 5 | 8 | 40 | 25 | 8 | 200 | 60 | 8 | 480 | 5 | 8 | 40 |
| *Poa annua* (L.) | | | | | | | | | | | | | | | |
| *Arrhenatherum elatius* (L.) | 5 | 7 | 35 | | | | | | | | | | 2 | 7 | 14 |
| *Alopecurus pratensis* (L.) | | | | | | | | | | | | | 55 | 7 | 385 |
| *Agrostis stolonifera* (L.) | | | | | | | | | | | | | | | |
| *Elytrigia repens* (L.) | | | | | | | | | | | | | | | |
| *Dactylis glomerata* (L.) | 59 | 7 | 413 | 59 | 7 | 413 | 10 | 7 | 70 | 10 | 7 | 70 | 7 | 7 | 49 |
| *Bromus inermis* Leyss. | | | | | | | | | | | | | 1 | 5 | 5 |
| *Trisetum flavescens* (L.) | | | | | | | 5 | 4 | 20 | | | | 2 | 4 | 8 |
| **Legumes** | **0** | | | **0** | | | **0** | | | **5** | | | **2** | | |
| *Trifolium repens* (L.) | | | | | | | | | | 5 | 8 | 40 | 2 | 8 | 16 |
| **Forbs** | **19** | | | **5** | | | **50** | | | **20** | | | **25** | | |
| *Lamium purpureum* (L.) | | | | | | | | | | | | | | | |
| *Plantago lanceolata* (L.) | | | | | | | | | | | | | 1 | 6 | 6 |
| *Geranium pratense* (L.) | | | | | | | | | | | | | | | |
| *Anthriscus sylvestris* (L.) | | | | | | | | | | | | | 1 | 4 | 4 |
| *Capsella bursa-pastoris* (L.) | | | | | | | | | | | | | | | |
| *Leucanthemum vulgare* (L.) | | | | | | | | | | | | | 5 | 2 | 10 |
| *Cirsium arvense* (L.) Scop. | 1 | 0 | 0 | | | | | | | | | | | | |
| *Myosotis sylvatica* Hoffm. | | | | | | | | | | | | | 1 | 2 | 2 |
| *Ranunculus repens* (L.) | | | | | | | | | | | | | 5 | 2 | 10 |
| *Ranunculus acris* (L.) | | | | | | | | | | | | | | | |
| *Bistorta major* S.F. Gray | | | | | | | | | | | | | 1 | 4 | 4 |
| *Bellis perennis* (L.) | | | | | | | | | | | | | 1 | 2 | 2 |
| *Malva sylvestris* (L.) | | | | | | | | | | | | | 1 | 4 | 4 |
| *Taraxacum sect. Ruderalia* | 16 | 5 | 80 | 5 | 5 | 25 | 50 | 5 | 250 | 20 | 5 | 100 | 5 | 5 | 25 |
| *Galium verum* (L.) | | | | | | | | | | | | | 1 | 3 | 3 |
| *Rumex acetosa* (L.) | 1 | 4 | 4 | | | | | | | | | | 2 | 4 | 8 |
| *Rumex obtusifolius* (L.) | 1 | 1 | 1 | | | | | | | | | | | | |
| *Achillea millefolium* (L.) | | | | | | | | | | | | | 1 | 5 | 5 |
| **Gaps** | **2** | | | **1** | | | **10** | | | **5** | | | **1** | | |
| **Total species** | **8** | | | **5** | | | **4** | | | **4** | | | **19** | | |
| **Total WZ** | **635** | | | **619** | | | **550** | | | **695** | | | **601** | | |

Notes: PG – permanent grassland; D % – cover of the species in %, WZ – Wertzahl according to Klapp (1956)

| PG6 | | | PG7 | | | PG8 | | | PG9 | | | PG10 | | | PG11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D | % D | WZ | WZx%D |
| **76** | | | **46** | | | **91** | | | **73** | | | **67** | | | **60** | | |
| | | | | | | | | | | | | 1 | 8 | 8 | | | |
| | | | | | | 8 | 4 | 32 | | | | 5 | 4 | 20 | 5 | 4 | 20 |
| | | | | | | 1 | 8 | 8 | | | | 1 | 8 | 8 | | | |
| 39 | 8 | 312 | 34 | 8 | 272 | 50 | 8 | 400 | 12 | 8 | 96 | 48 | 8 | 384 | 43 | 8 | 344 |
| | | | | | | | | | | | | | | | 2 | 5 | 10 |
| 1 | 7 | 7 | 2 | 7 | 14 | | | 0 | | | 0 | 1 | 7 | 7 | 4 | 7 | 28 |
| 22 | 7 | 154 | | | 0 | 29 | 7 | 203 | 45 | 7 | 315 | | | | | | |
| | | | | | | 1 | 7 | 7 | | | | | | | | | |
| | | | | | | | | | | | | 5 | 4 | 20 | | | |
| 8 | 7 | 56 | 10 | 7 | 70 | | | | 1 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 |
| 1 | 5 | 5 | | | | 1 | 5 | 5 | | | | | | | | | |
| 5 | 4 | 20 | | | | 1 | 4 | 4 | 15 | 4 | 60 | 5 | 4 | 20 | 5 | 4 | 20 |
| **1** | | | **0** | | | **0** | | | **1** | | | **5** | | | **0** | | |
| 1 | 8 | 8 | | | | | | | 1 | 8 | 8 | 5 | 8 | 40 | | | |
| **22** | | | **44** | | | **6** | | | **25** | | **0** | **25** | | | **30** | | |
| | | | | | | 1 | 2 | 2 | 1 | 2 | 2 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | 1 | 1 | 1 | | | | | | |
| 2 | 4 | 8 | 1 | 4 | 4 | 1 | 4 | 4 | | | | | | | | | |
| | | | | | | 1 | 1 | 1 | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | 1 | 0 | 0 | | | | | | |
| 1 | 2 | 2 | | | | | | | | | | | | | 1 | 2 | 2 |
| 2 | 2 | 4 | | | | | | | 10 | 2 | 20 | | | | | | |
| | | | | | | | | | 1 | -1 | -1 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 1 | 4 | 4 | | | | | | | | | | | | | | | |
| 13 | 5 | 65 | 40 | 5 | 200 | 1 | 5 | 5 | 10 | 5 | 50 | 25 | 5 | 125 | 29 | 5 | 145 |
| 2 | 3 | 6 | 2 | 3 | 6 | 1 | 3 | 3 | | | | | | | | | |
| 1 | 4 | 4 | | | | | | | 1 | 4 | 4 | | | | | | |
| | | | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **1** | | | **10** | | | **3** | | | **1** | | | **3** | | | **10** | | |
| **14** | | | **7** | | | **13** | | | **12** | | | **10** | | | **8** | | |
| **656** | | | **577** | | | **678** | | | **563** | | | **642** | | | **586** | | |