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ECOLOGICAL EVALUATION OF GRASSLAND VEGETATION IN HODRUŠSKÁ HORNATINA HIGHLAND

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Abstract

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In the submitted paper, we have analysed the results of a systematic survey of grassland communities, performed in Hodrušská hornatina highland, in Štiavnické vrchy mountains. The main aims of the research were: i) syntaxonomical classification of grassland vegetation; ii) analysis of the main ecological gradients in species composition; iii) evaluation of the influence of environmental factors on species composition of grasslands. The dataset included 153 phytosociological relevés recorded on grasslands. Grassland communities were classified within five associations: *Holcetum lanati, Pastinaco sativae-Arrhenatheretum elatioris, Alchemillo-Arrhenatheretum elatioris, Anthoxantho odorati-Agrostietum tenuis, Onobrychido viciifoliae-Brometum erecti; and the successional and transitional stages belonging to alliances Arrhenatherion elatioris and Bromion erecti.* The results of the Detrended Correspondence Analysis support our assumption that the main environmental gradient in species composition on grassland is related to moisture. The results of the Redundancy Analysis show that all used environmental variables explained 3.4% of the variability of the species data. The most important factors affecting the species composition were altitude, slope, distance from settlements, and management.

Key words: biodiversity, Ellenberg indication values, grasslands, Hodrušská hornatina highland, management, Štiavnické vrchy mountains.

Introduction

The study presents the results of the research realised in Hodrušská hornatina highland, situated in the western part of Štiavnické vrchy mountains. The majority of the area is included in Štiavnické vrchy Protected Landscape Area established in 1979 in order to protect natural elements as well as monuments associated with historic mining activities. The larger part of Hodrušská hornatina highland is also included among the sites of European importance within the NATURA 2000 network. The vast majority of grasslands in this area were created by human activities. After grubbing up forests for mining purposes, man began to manage and cultivate these bare places. As a result of grazing and mowing, reverse succession was prevented and often large areas of flowery grasslands were formed. Some of them are characterized by relatively high species diversity. On area of 25 m^2, we can find more than 60 species (Klimantová, 2017). Such a high number of species is the result of long-term grassland management (mowing and grazing) and different microclimatic conditions. In pre-industrial agriculture, semi-natural grasslands constituted the nutrient base for production, as they supplied fodder for the livestock, which in turn provided manure necessary for crop production (Lennartsson et al., 2016). During socialism, meadows were mainly of economic interest in agriculture. In the period of collectivization, there was a trend of meadow intensification due to higher yields. This approach resulted in great deprivation of species diversity in meadows. Unfortunately, this extreme was followed by another one. The insufficient financial remuneration caused that they were neglected or abandoned and overgrown with seedlings. This caused a rapid decline in area of semi-natural grassland, which has caused a severe decline in abundance and diversity of plants (Johansen et al., 2019). The area of meadows with high species diversity is getting smaller and smaller every year. However, thanks to nature conservation and activity of people living in the area, at least part of these unique plant communities have been preserved.

The flora and vegetation of the area have attracted the attention of many botanists since the 18th century (Ján Anton Scopoli, Pál Kitaibel) (Hrabovec, 1990; Oťaheľová et al., 2011). An outstanding botanist of the first half of the 19th century was also Rudolf Feistmantel, who contributed to the establishment of a botanical and dendrological garden in Kysihýbel. In that time, Feichtinger Sándor and Fekete Lajos also botanized in the surroundings of Banská Štiavnica (Vozárová, Šípošová, 2010). The research of Mikyška between 1929 and 1939 (Ciriaková, Hegedüšová, 2003) ca ne considered the oldest phytosociological research in the area of the Štiavnické vrchy mountains. During the second half of the 19th century, Andrej Kmeť concerned himself with further research of the area. However, the most comprehensive publication about flora in Štiavnické vrchy mountains dates back to 1985, when Aladar Hlavaček summarized the knowledge and herbarium collections into a publication Flora of Štiavnické vrchy PLA. The vegetation of the southern foothills of Štiavnické vrchy mountains were summarized by Neuhäusl and Neuhäuslová-Novotná during the years 1964–1965 (Ciriaková, Hegedüšová, 2003). In their publications, Ružičková (1986), Ružičková, Halada (2005), Hegedüšová, Ružičková (2007), and Klimantová (2017) investigated the meadow and pasture vegetation of the Štiavnické vrchy mountains.

The main objectives of our research were the syntaxonomical classification of grassland vegetation in the area of Hodrušská hornatina highland, subsequent analysis of the main ecological gradient in their species composition, and the evaluation of the influence of environmental factors on species composition of grasslands.

Material and methods

Study area

Štiavnické vrchy mountains, with its geological origin and specific biogeographical location, represents a unique area (Kollár, Lacika, 2004). It is situated in the boundary of two climatic types, which allows permeation of Pannonian and Carpathian flora. The study was conducted in the Hodrušská hornatina highland, in the western part of the Štiavnické vrchy mountains (Central Slovakia). Its area is more than 35,136 ha. The vertical dissection of the area is 707 m, from the lowest point 232 m a.s.l. to the highest 939 m a.s.l. The geology of the area is formed by andesite, granite, and limestone in some parts. The prevailing soil types in the territory of Hodrušská hornatina highland are fluvisol, rendzinas (Miklós, Hrnčiarová, 2002) and cambisol (Kunca et al., 2005). The climate in Hodrušská hornatina highland is moderately warm, with the average annual temperature between 6 and 10 °C. Summers are relatively short and dry, with average temperature of the hottest month between 15 and 19 °C. On the other side, the average temperature of the coldest month range from -1 to -5 °C. The total annual precipitation range between 700 and 900 mm (SHMÚ, 2015). The existing phytogeographic division of Slovakia (Futák, 1966) places the area of Hodrušská hornatina highland in the West Carpathian phytogeographical region (*Carpaticum occidentale*), namely in the Praecarpathian district. The vegetation is a mosaic of mixed oak-hornbeam forests (*Carpinion betuli*) and beech forests (*Fagion sylvaticae*) with meadows, pastures, and arable fields.

Field sampling

The bases for selection study sites were to obtain sampling plots representing the diversity of grasslands in Hodrušská hornatina highland. They included meadows with intensive and extensive management, pastures, orchards, and abandoned grasslands. During three vegetation periods (2013–2015), vegetation data was collected from 153 study sites (Fig. 1), according to the Zürich-Montpellier methodological approach (Braun-Blanquet, 1964). The sampling plots were squares of size 5×5 m, which is recommended for grasslands (Chytrý, Otýpková, 2003). The nine-element ordination scale was used for the estimation of species abundance (van der Maarel, 1979). For the nomenclature of vascular plants, the list of Marhold, Hindák (1998) was used.

Vegetation analysis

The collected phytosociological records were converted to database using Turboveg management program (Hennekens, Schaminée, 2001). The numerical classification was performed by TWINSPAN classification (Hill, 1979), carried out using the software JUICE 7.0 (Tichý, 2002). According to Botta-Dukát et al. (2005), we have used the crispness of classification to determine the optimal number of clusters. Based on the highest Average Crispness Value, the data were divided into eight groups. Diagnostic species for the individual clusters in the data set were determined by calculation of species fidelity, using the phi coefficient (Chytrý et al., 2002). The threshold fidelity value for diagnostic species

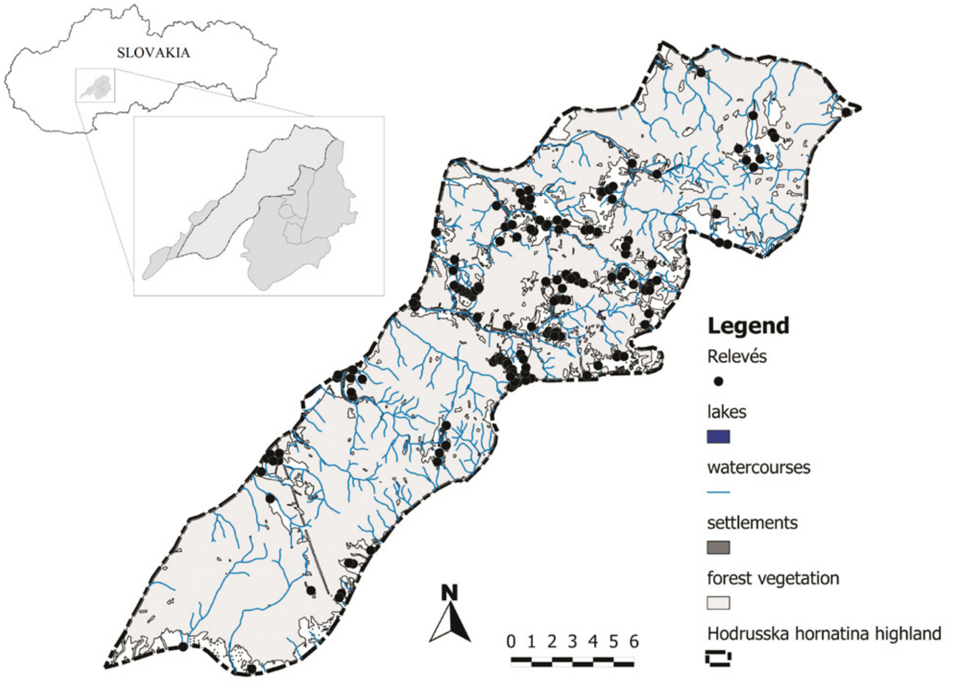

Fig. 1. Location of the study area in the Slovak Republic. The small picture in the left corner shows the position of Štiavnické vrchy mountains in the Slovak Republic. Black points show the location of sampling plots.

was set to phi = 0.20. The statistical significance of the fidelity values was tested using Fisher's exact test ($p < 0.001$). Diagnostic species are of local validity. For the syntaxonomical analysis, we used the Expert system for the identification of grasslands in Slovakia (Janišová et al., 2010), created for the territory of Slovak Republic. A list of vegetation units of Slovakia (Hegedüšová Vantarová, Škodová, 2014) was used for the nomenclature of grassland communities.

Data processing and analysis

For ecological characterization of vegetation units, the cover-weighted average Ellenberg indication values (EIV) for soil reaction, moisture, nutrient content, temperature, and continentality were used (Ellenberg et al., 1992). Also, a database from sampling plots containing the following environmental factors was prepared: altitude, slope, aspect, heat index, geological bedrock, distance to nearest settlement, applied management. The heat index was calculated according to the formula: Heat index = cos (aspect – 225°) × tg (slope); where cos = cosine and tg = tangent (Parker, 1988). Information on geological bedrock was acquired from a map in 1:100,000 scale (State Geological Institute of Dionýz Štúr; see also https://apl.geology.sk/gm50js/). A free multiplatform geographic information system GRASS GIS (Grass Development Team, 2016) was used to calculate the distance between our sampling plots and nearest settlements. The applied management was encoded as intensively managed, extensively managed, and abandoned. Statistical analyses were performed by STATISTICA 8 (StatSoft, 2001). Ordination analysis of ecological gradients was done by CANOCO 4.5 software (Ter Braak, Šmilauer, 2002). Detrended Correspondence Analysis (DCA) was used to determine the gradient length and select suitable ordination model. The EIV were plotted onto the DCA diagram only as supplementary environmental variables. The linear model of the Redundancy Analysis (RDA) was selected because of the highest value of gradient length (3.030) (Lepš, Šmilauer, 2003, p. 51). The significance of the impact of environmental factors on species composition was tested by the Monte Carlo permutation test (499 permutation; $p < 0.05$).

Results

Syntaxonomical classification

Using the expert system, we classified all 153 phytosociological relevés made in Hodrušská hornatina highland.

The hierarchical system of syntaxa:

Molinio-Arrhenatheretea R. Tx. 1937
  Molinia caeruleae Koch 1926
    Deschampsion cespitosae Horvatić 1930
      ***Holcetum lanati* Issler 1936**
  Arrhenatheretalia R. Tx. 1931
    Arrhenatherion elatioris Luquet 1926
      ***Pastinaco sativae-Arrhenatheretum ealtioris* Passarge 1964**
      ***Alchemillo-Arrhenatheretum elatioris* Sougnez et Limbourg 1963**
      ***Anthoxantho odorati-Agrostietum tenuis* Sillinger 1933**
Festuco-Brometea Br.-Bl. et R. Tx. ex Soó 1947
  Brometalia erecti Br.-Bl. 1936
    Bromion erecti Koch 1926
    ***Onobrychido viciifoliae-Brometum erecti* T.Müller 1966**

Nine relevés were assigned to the association *Holcetum lanati* Issler 1936, 37 relevés were classified as *Pastinaco sativae-Arrhenatheretum ealtioris* Passarge 1964, 33 relevés as *Alchemillo-Arrhenatheretum elatioris* Sougnez et Limbourg 1963, 30 relevés *Anthoxantho odorati-Agrostietum* *tenuis* Sillinger 1933, and five relevés as *Onobrychido viciifoliae-Brometum erecti* T. Müller 1966. Relevés that could not be assigned directly to associations due their transitional character were classified only to higher syntaxonomical groups – alliances *Arrhenatherion elatioris* Luquet 1926 and *Bromion erecti* Koch 1926. A detailed description of all grassland communities occurring in the Hodrušská hornatina highland was published by Klimantová (2017).

Ecological analysis

The ecological requirements of identified syntaxa were evaluated on the basis of cover-weighted average Ellenberg indicator values (EIV). The comparison of EIV showed significant differences between ecological requirements of each syntaxonomical group, especially in requirements for moisture (Fig. 2). The soil moisture reflected the species composition of individual communities. The syntaxonomical groups basically copied the humidity gradient. We could significantly distinguish three different groups of communities. The first group contained associations (*Holcetum lanati*, intensively managed grasslands of *Pastinaco sativae-Arrhenatheretum ealtioris*) with the prevalence of hygrophilous species (*Cardamine pratensis*, *Ranunculus acris*, *Lychnis flos-cuculi*, *Crepis biennis*), the second group contained mesophilous meadows (*Pastinaco sativae-Arrhenatheretum ealtioris*, *Alchemillo-Arrhenatheretum elatioris*, *Anthoxantho odorati-Agrostietum tenuis*, transitional stages within the alliance *Arrhenatherion elatioris*), and the third group contained subxerophilous and xerophilous associations (*Bromion erecti*, *Onobrychido viciifoliae-Brometum erecti*) with the prevalence of xerophytic species (*Dianthus carthusianorum*, *Geranium sanguineum*, *Hieracium pilosella*). As for light requirements, the associations *Onobrychido viciifoliae-Brometum erecti* and *Anthoxantho odorati-Agrostietum tenuis* reached the highest values. These communities were characterized by higher prevalence of heliophilous species as *Arabis hirsuta*, *Dianthus carthusianorum*, *Plantago media*, *Sanguisorba minor*, *Trifolium montanum*. On the other hand, in communities of the association *Holcetum lanati*, and in intensively managed grasslands of *Pastinaco sativae-Arrhenatheretum ealtioris* dominated species of high grasses and herbs. Therefore, the occurrence of shade-tolerant species was significantly higher than in other communities (*Cruciata laevipes*, *Trifolium repens*, *T. pratense*, *Veronica chamaedrys*). The EIV for temperature ranged between values four and five, what pertained to the indicators of cold and mild climate. As for continentality, the majority of determined synatxonomical groups belonged to the transition between oceanic and suboceanic communities. Communities belonging to the association of *Onobrychido viciifoliae-Brometum erecti* had neutral and alkaline reaction. Other communities grew on neutral or moderately acid soil. The species composition of plant communities was mainly affected by nutrient content in the soil. Communities belonging to the association of intensively managed grasslands of *Pastinaco sativae-Arrhenatheretum ealtioris* had the highest nutrient demands. Lower nutrient content was characteristic to grassland communities of *Bromion erecti*, *Onobrychido viciifoliae-Brometum erecti*, *Anthoxantho odorati-Agrostietum tenuis*.

Environmental factors

The Detrended Correspondence Analysis (DCA) in Fig. 3 shows the distribution of individual syntaxonomical groups in the ordination space in relation to environmental factors. Total inertia in the DCA was 5.71; eigenvalues were 0.249 (axis 1) and 0.167 (axis 2). The first axis explained

4.4% of the species variance; the second axis explained 2.9%. The first axis was positively correlated with light (correlation coefficient: 0.420) and negatively correlated with moisture and nutrient content (-0.813 and -0.898). The second axis was positively correlated with continentality (0.396), temperature (0.478) and soil reaction (0.652).

Based on gradient length (1. DCA axis: 3.030 and 2. DCA axis: 2.482) determined by DCA anal-

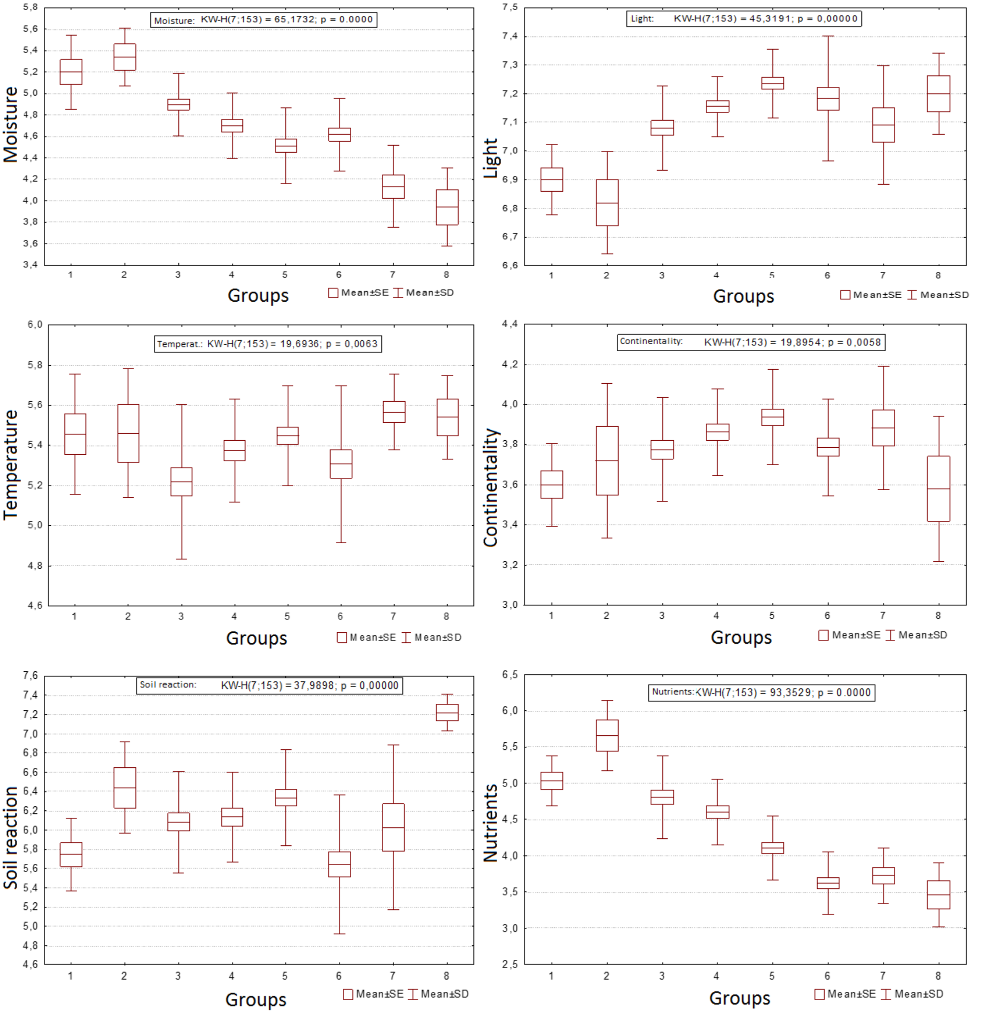

Fig. 2. Comparison of cover-weighted average Ellenberg indicator values. The syntaxonomical groups are numbered as follows: 1 – *Holcetum lanati,* 2 – *Pastinaco sativae-Arrhenatheretum elatioris – intensive meadows,* 3 – *Pastinaco sativae-Arrhenatheretum elatioris,* 4 – *Alchemillo-Arrhenatheretum elatioris,* 5 – *Arrhenatherion elatioris,* 6 – *Anthoxantho odorati-Agrostietum tenuis,* 7 – *Bromion erecti,* 8 – *Onobrychido viciifoliae-Brometum erecti.*

ysis, linear ordination methods were used. The relationship between species composition and selected environmental factors was analysed using redundancy analysis. The first RDA axis explained 3.4% variance of the species data and 27.2% of the species-environment relationship, which means that 27.2% of the variability of our data set caused by the selected environmental factors was reflected by the first axis. The second RDA axis explained 1.9% variance of the species data and 15.7% of the species-environment relationship. The factors heat index, slope, altitude, distance from nearest settlements, management, limestone and slate bedrock were significant at $p = 0.05$ (Table 1) in the Monte Carlo permutation test. Of all significant environmental factors, the management, altitude, distance from nearest settlements and slope had the strongest effect on the variability of our data set.

The position of obtained relevés in relation to environmental factors is shown in Fig. 4. Intensively managed grasslands of the association *Pastinaco sativae-Arrhenatheretum elatioris* are distributed in the right side of the ordination graph. On the other hand, abandoned grassland of

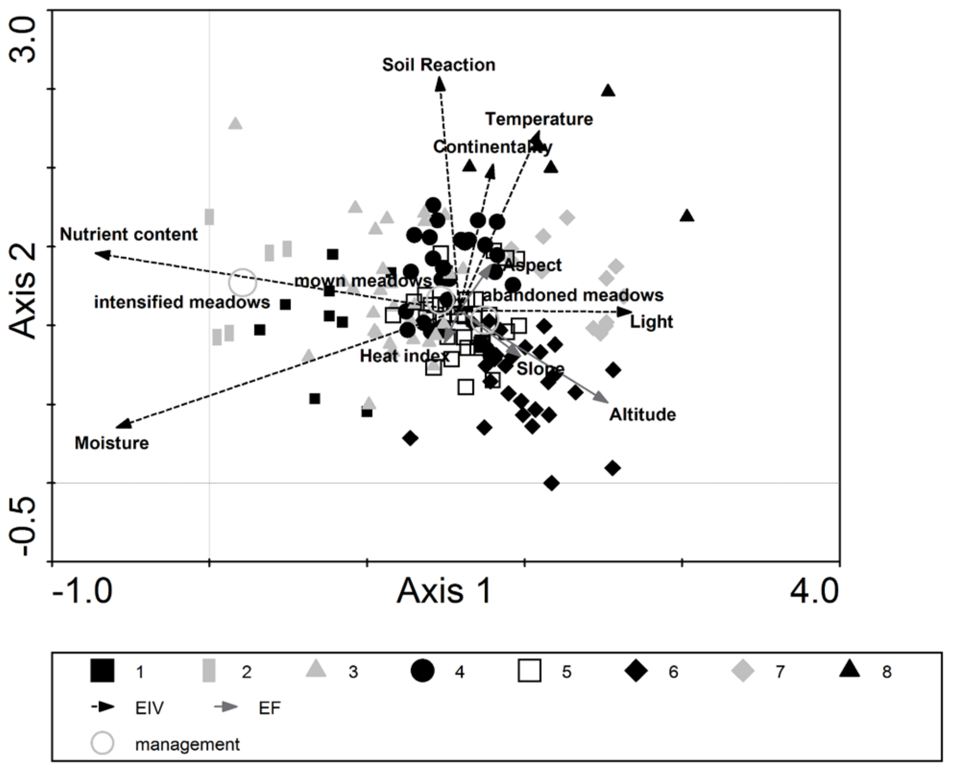

Fig. 3. Detrended correspondence analysis of phytosociological relevés. The cover-weighted average EIV for the relevés were plotted onto the ordination diagram as supplementary environmental data. The syntaxonomical groups are marked as follows: 1 – *Holcetum lanati,* 2 – *Pastinaco sativae-Arrhenatheretum elatioris – intensive meadows,* 3 – *Pastinaco sativae-Arrhenatheretum elatioris,* 4 – *Alchemillo-Arrhenatheretum elatioris,* 5 – *Arrhenatherion elatioris,* 6 – *Anthoxantho odorati-Agrostietum tenuis,* 7 – *Bromion erecti,* 8 – *Onobrychido viciifoliae-Brometum erecti.*

the association *Alchemillo-Arrhenatheretum elatioris* were situated in the left part of the figure. Subxerophilous grasslands of the association *Onobrychido viciifoliae-Brometum erecti* are concentrated in the lower part of the ordination area, where the heat index and the limestone bedrock have a considerable influence. Communities of *Anthoxantho odorati-Agrostietum tenuis* are distributed in the left part, correlated with increasing altitude. Most of the relevés of associations *Pastinaco sativae-Arrhenatheretum elatioris* and *Arrhenatherion elatioris* are distributed almost over the whole ordination area. It indicates that these types of vegetation are rather indifferent to the selected environmental factors.

T a b l e 1. Results of significance testing for environmental factors influence on plant community composition (Monte-Carlo permutation test)

Environmental variables	p-value	F-ratio
Heat index	**0.0440**	1.36
Slope	**0.0020**	1.71
Altitude	**0.0020**	3.48
Distance from nearest settlements	**0.0020**	1.76
Management	**0.0020**	4.07
Basalt	0.4300	1.01
Limestone	**0.0040**	2.03
Granite	0.4300	1.01
Slate	**0.0100**	1.71
Andesite	0.0920	1.24
Ryolit	0.0780	1.25

Notes: p-value – value of significance; F-ratio – results of Fisher's test; parameters significant at p = 0.05 are in bold.

The Fig. 5 indicates that the following species were linked to intensively managed meadows: *Poa pratensis*, *Plantago major*, *Cirsium arvense*, *Stellaria media*, *Tanacetum vulgare*, *Rumex acetosa*, *Taraxacum sec. Ruderalia*, *Symphytum officinale*, *Trifolium pratense*. Some of the abovementioned species are typical rather for synanthropic sites than for grasslands. However, they were able to infiltrate to the meadows with high nutrient content. Wet meadows species, as *Ranunculus acris*, *Alopecurus prtensis* and *Lychnis flos-cuculi* were positively correlated with moisture and negatively correlated with heat index. Mountain species as *Alchemilla xanthochlora*, *Avenella flexuosa*, *Hypericum maculatum*, *Rumex acetosella* were linked to higher altitude. Xerophilous plants as *Carlina acaulis*, *Pimpinella saxifrage*, *Hieracium pilosella*, *Viola arvensis*, *Dianthus carthusianorum*, *Thymus pulegioides* dominated on steep sunny slopes. On these steep slopes, nutrients are often leached out to lower levels, so species not demanding high nutrient content were also present: *Steris viscaria*, *Euphorbia cyparissias*. Other factors had either shorter gradient or the species were weakly correlated with them.

Using regression models, we further studied if the environmental factors have any influence on the species diversity. The regression analysis (Fig. 6) confirmed the relationship between species diversity and moisture, nutrient content and altitude as statistically significant. Regression analysis of main environmental factors indicated positive correlation between moisture and light; and nutrient content and moisture. These results confirmed the natural multiple dependence of the interaction of main environmental factors. The results of regression analysis of relationship between other factors did not confirm similar link.

Discussion

After the analysis of 153 phytosociological relevés, there were five associations of mesophilous and subxerophilous grasslands determined in Hodrušská hornatina highland. They were assigned

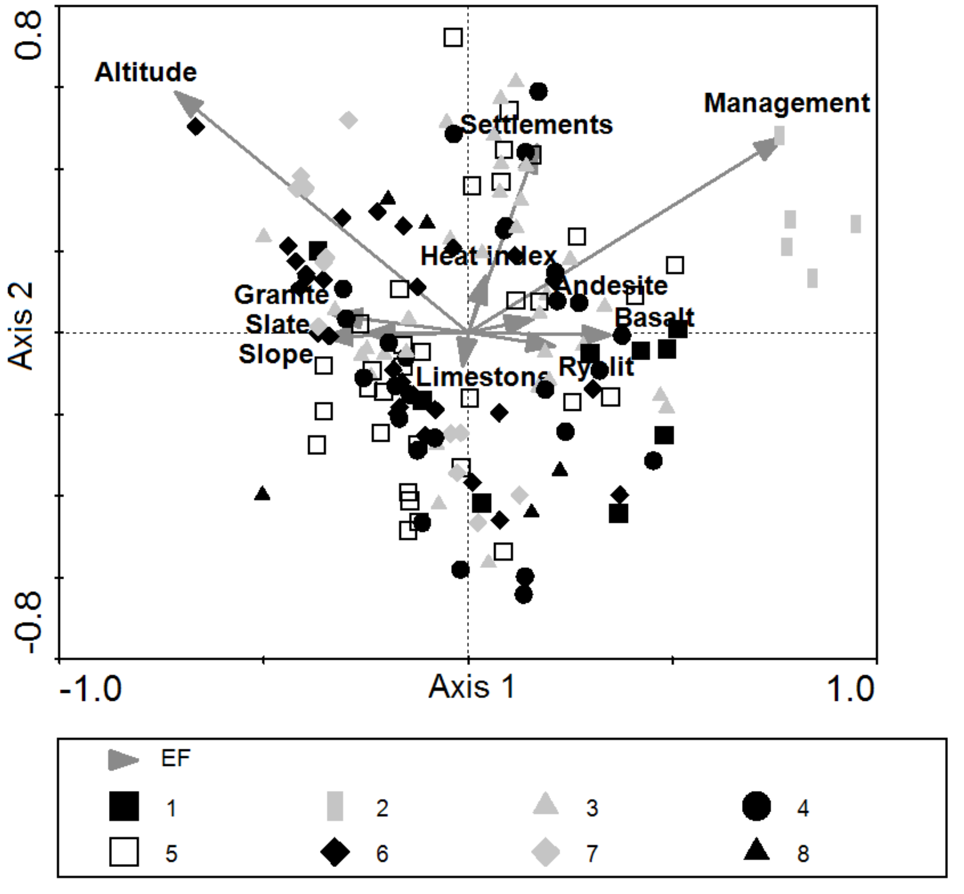

Fig. 4. Redundancy analysis of phytosociological relevés. The syntaxonomical groups are marked as follows: 1 – *Holcetum lanati,* 2 – *Pastinaco sativae-Arrhenatheretum elatioris – intensive meadows,* 3 – *Pastinaco sativae-Arrhenatheretum elatioris,* 4 – *Alchemillo-Arrhenatheretum elatioris,* 5 – *Arrhenatherion elatioris,* 6 – *Anthoxantho odorati-Agrostietum tenuis,* 7 – *Bromion erecti,* 8 – *Onobrychido viciifoliae-Brometum erecti.*

to the associations of *Holcetum lanati*, *Pastinaco sativae-Arrhenatheretum ealtioris*, *Alchemillo-Arrhenatheretum elatioris*, *Anthoxantho odorati-Agrostietum tenuis*, and *Onobrychido viciifoliae-Brometum erecti*. Relevés that could not be assigned directly to associations due their transitional character were classified only to higher syntaxonomical groups – alliances *Arrhenatherion elatioris* and *Bromion erecti*. The distribution of *Holcetum lanati* has not been very well documented yet, but the associations probably occur in the whole of temperate Europe (Stančić, 2008). In the Central Slovakia, its occurrence is stated on the alluvium of the Krupinica river (Kováčová, 1976). The majority of our relevés include communities from the alliance *Arrhenatherion elatioris*. These communities are very frequent in uplands and submountain regions (Janišová et al., 2007). In our

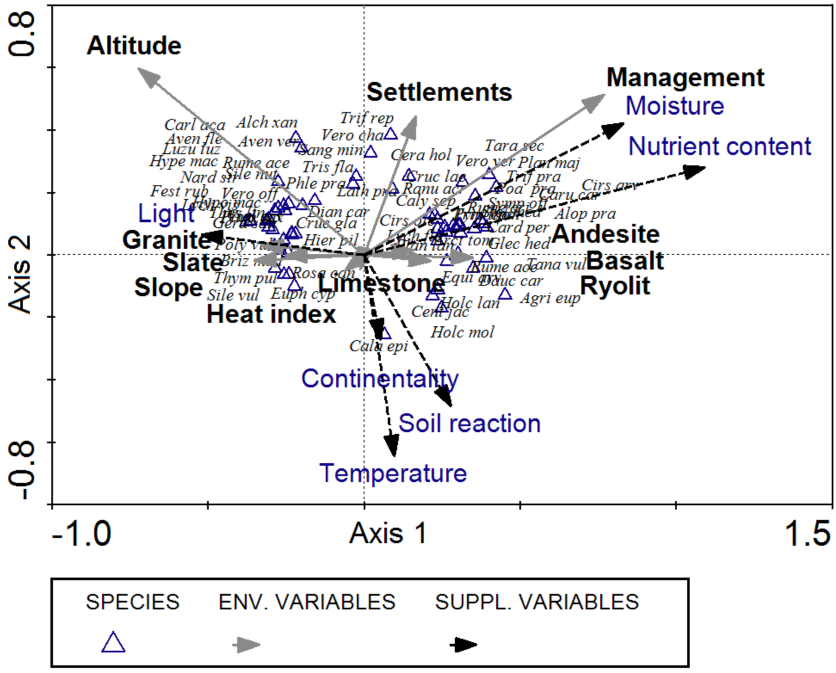

Fig. 5. RDA ordination of environmental factors and species.

research area, the association of *Pastinaco sativae-Arrhenatheretum ealtioris* was the most common. According to Hájková et al. (2014), it can be found almost in the whole area of Slovakia. Nowadays, they are mainly in uplands and inner basins of Slovak Carpathians because most of the lowland localities were ploughed up or intensified. The association of *Alchemillo-Arrhenatheretum elatioris* is mainly distributed on the volcanic or limestone bedrock of the central and western parts of Slovakia (Ružičková, Halada, 2005; Banásová et al., 2006). Either of the association *Anthoxantho odorati-Agrostietum tenuis* is not a rare community in the area. Its occurrence in the Štiavnické vrchy mountains was also confirmed by Ružičková (1986) and Ružičková, Halada (2005). According to Janišová et al. (2010), the associations of *Bromion erecti* alliance represent the most frequent semi-dry grasslands in Central Slovakia. The occurrence of the association of *Onobrychido viciifoliae-Brometum erecti* was confirmed in the area by Ružičková, Halada (2005).

The species diversity of each plant community depends on the set of conditions under which it has developed. These conditions differ by environmental factors, management regime and region (Melts et al., 2018). The ecological requirements of identified syntaxonomical groups were evaluated on the basis of cover-weighted average Ellenberg indicator values (EIV). The comparison of EIV showed significant differences between ecological requirements of each group, especially in the requirements for moisture and nutrient content. Therefore, we can distinguish mesophilous vegetation types from subxerophilous and xerophilous. Communities belonging to the association of intensively managed grasslands of *Pastinaco sativae-Arrhenatheretum ealtioris* had the highest nutrient demands. Lower nutrient content was characteristic to the grassland

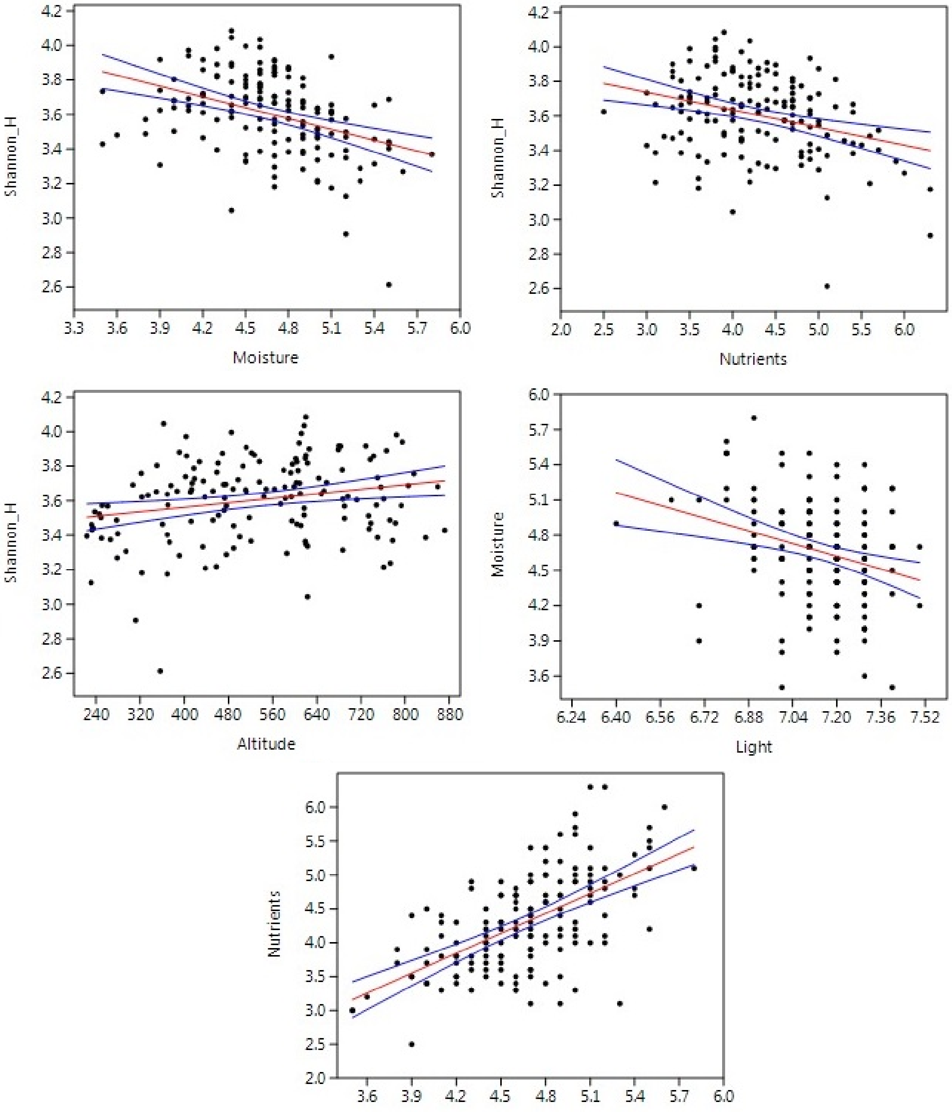

Fig. 6. Relationship between main environmental factors and species diversity: diversity and moisture ($p = 0.0001$), diversity and nutrient ($p = 0.0002$), diversity and altitude ($p = 0.004$); and between main environmental factors: moisture and light ($p = 0.00004$), nutrient and moisture ($p = 0.00000$).

communities of subxerophilous character, which could be caused by faster nutrient leaching on steep and mostly south-oriented slopes.

Based on the results of our research in Hodrušská hornatina highland, altitude, slope, distance from nearest settlements and management regime had the strongest effect of all significant environmental variables. This is in accordance with many other studies that identified altitude as one of the most important factors influencing species composition in grasslands (Cornwell, Grubb 2003; Halada et al., 2017). We can note that the distance from the nearest settlements is closely related to management regime. The abandonment of traditional agricultural landscape is higher in less favoured areas as mountain or outlying localities (Špulerová et al., 2016). Meadows are strongly human dependent, and they are not ecologically stable (Melts et al., 2018). According to Galvánek, Lepš (2008), even the temporary abandonment of management activities or incidental or irregular management of productivity can lead to long-term changes in the species composition. Rendeková et al. (2020) detected a significant decrease of species richness, diversity and evenness caused by abandonment of traditional land use in calcareous grasslands in Devínska Kobyla. On the other side, intensive management and associated fertilization also have negative effects on diversity (Kidd et al., 2017). Additionally, the nutrient strongly affects soil physico-chemical properties that determine species diversity (Pruchniewic, Zołnierz, 2014).

However, the effect of the selected environmental variables was much smaller than we had expected. In DCA, the first two axes explained 7.3% of the variability of the dataset. In RDA, the variability explained by the first two axes was even lower (5.3%). This is probably caused by the fact that species composition of grassland communities depends on the complex influence of a large number of environmental factors, and the chosen variables explained only a small part of the variability of the data. Also, the floristic composition in grasslands is shaped not only by current site condition and management, but also by the site age and history and ancient management practices (Halada et al., 2017). Janišová et al. (2010) mentioned that in grasslands with high species diversity, even a comprehensive set of environmental factors may explain only a small proportion of their variability.

We recorded increase of species richness with increased altitude. This may be due to intensive management provided on the meadows in lower altitude. Grasslands on moisture soils, on soils with enough nutrient content or in higher altitudes had, in our study area, generally higher species diversity.

Conclusion

In the submitted paper, we have summarised the results of a research realised on grassland vegetation in the area of Hodrušská hornatina highland. Although the area is mostly covered by forest vegetation, many valuable semi-natural grasslands can be found here. There are meadows, pastures, and also orchard meadows, typical for historical cultural landscape in Slovakia. The results of our research confirm that the structure and species composition of local vegetation types depend on the environmental conditions, particularly the altitude, slope, heat index, distance from the nearest settlements, geological ground followed by soil reaction and moisture. Therefore, mesophilous, subxerophilous and xerophilous submountain meadows occur in the area. Also, suitable management is an especially important factor in maintaining grassland communities.

Loss of interest in farming leads to progressive succession and afforestation, resulting in annual acreage losses. On the other side, intensive management reduces species richness of grassland vegetation. It is necessary to continue with proper management activities or find alternatives to traditional farming and utilization of meadows.

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