THE ANALYSIS OF THE INFLUENCE OF GRAZING INTENSITY ON THE DIVERSITY AND ABUNDANCE OF PLANTS AND SPIDERS (ARACHNIDA: ARANEAE)

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ABSTRACT

In restoration projects, low stock grazing has become a popular means of management. However, an accurate understanding of the effects of grazing on plants and spiders is often lacking. Although spiders and plants are not closely related evolutionarily or genetically, the relationship between them can be complex and diverse. Many species of spider build their webs or nests on plants, using the leaves, stems, or flowers as anchoring points. This provides them with protection from predators, access to prey and a stable habitat. On the other hand, spiders can provide a number of benefits to grassland ecosystems, such as helping to control populations of insects and other arthropods that can damage or consume grassland plants.This study addresses the effects of different grazing regimes on plant and spider diversity in siliceous grasslands. Plant and spider diversity was studied for four months in the Sharri Mountains (Kosovo) in order to determine the biodiversity in ungrazed, moderately grazed and overgrazed siliceuous grasslands. The responses of plant height, plant biomass, plant species diversity and spider species diversity to three grazing intensities at 12 sites were recorded. Vegetation structure (plant height and plant biomass) was significantly higher in ungrazed grasslands compared to grazed and overgrazed grasslands. This was not the case, however, for spider species richness and diversity, as these were higher in moderately grazed than ungrazed grassland. On overgrazed grasslands, spider diversity was extremely low, as only one species of spider (*Pardosa saltuaria*) was recorded. Plant and spider diversity increased in the following order: overgrazed grasslands < ungrazed grasslands < moderately grazed grasslands, in all the habitats studied. Different grazing intensities significantly affected the abundance of particular plants on siliceous grasslands, for example, *Deschampsia cespitosa*, one of the most dominant plants on siliceous grasslands had an abundance of 4.77% in ungrazed grasslands., but only 4.94% in moderately grazed grasslands and was absent in overgrazed grasslands. There were other species of plants that were most abundant in intensively grazed silicate grasslands. One of them was *Nardus stricta*, whose percentage in ungrazed, moderately grazed and overgrazed grasslands was characterized by a multiple exponential increase in % (s1 – ungrazed grasslands = 0.99%, s2 – moderately grazed grasslands = 1.25% and s3 – overgrazed grasslands = 10.50%). It is concluded that the intensity of grazing of natural grasslands directly affects biodiversity and that this information may be valuable for long-term management and conservation programs in similar habitats in SE Europe and beyond.

Keywords: biodiversity; plant ecology; siliceous grasslands; spider species composition

Introduction

Due to human activities that directly threaten biodiversity, the need for conservation measures and actions is becoming increasingly urgent (Galli et al. 2014; Hoban et al. 2021). This is particularly evident in natural habitats and within national parks, where the negative effects of human activities are already visible (Reimann et al. 2011). One of the natural habitats under such negative influence and known for their high plant diversity are silicate grasslands, which are classified as habitats of priority interest due to their high biodiversity (Anonymous 1992). Particularly important in this context are the so-called "species-rich *Nardus* grasslands", which are widely distributed on siliceous substrates in the alpine and mountainous habitats in Europe (Galvánek and Janák 2008; Wilson et al. 2012; Pittarello et al. 2017). Due to the high level of negative effects on a continental scale, these habitats were classified as vulnerable (VU) in Europe in 2017 (Janssen et al. 2017). It is known that extensive and continuous grazing of these grasslands can result in large-scale destruction and gradual conversion of them into semi-natural habitats (Tscharntke et al. 2002; Steffan-Dewenter and Leschke 2003). Indeed, most European grasslands are now considered to be semi-natural due to prolonged grazing, burning and other detrimental factors (EEA 2016). Given these negative factors, which are permanent and of varying intensity, efforts to conserve biodiversity in semi-natural grasslands in Europe remain a real challenge (Mills et al. 2007; Dumont et al. 2009). One of the most common practices used to enhance the biodiversity of grazed grasslands is to reduce the stocking rates of such grasslands. In general, there are few studies on how grazing intensity simultaneously affects insect and plant communities (Scohier and Dumont 2012; Zhu et al. 2015; Ravetto Enri et al. 2017). However, there are many more that separately address the effects of grazing on plant diversity (Porensky et al. 2017; Zhang et al. 2018; González-Hernández et al. 2020) or insect diversity (Williams et al. 2012; Davidson et al. 2020).

As for the effects of grazing on spider diversity, they can be divided into short- and long-term effects. In the short term, the effects of grazing are associated with the oversimplification of general plant architecture, which directly affects the ability of spiders to forage for insects and reduces the diversity of primary sources in the com-

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plex food chain, thereby reducing the diversity of insects (Purvis and Curry 1981). A more direct long-term effect is caused by the obvious changes in the composition of plant communities and structure of the vegetation (Kruess and Tscharntke 2002). In these semi-natural grasslands, one of the most traditional management practices is low intensity grazing or mowing once a year, which in turn is often associated with a generally higher biodiversity (Barbaro et al. 2001; Plantureux et al. 2005; Dostálek and Frantík 2008; Török et al. 2018).

The aim of this study, which was carried out at Brezovicë, in the Sharri National Park, was to assess whether different grazing intensities will result in different levels of biodiversity in terms of plants and spiders. In the area studied, grazing occurs in three seasons (spring, summer and autumn), with sheep being the predominant grazing animal. The prediction was that less grazed grasslands will have a higher biodiversity than ungrazed and overgrazed grasslands. However, such an expectation is particularly difficult to predict when comparing plants and spiders (Dennis et al. 2015; Torma et al. 2023). There is an abundance of data on the diversity of spiders (Geci and Naumova 2021a, 2021b; Grapci-Kotori et al. 2022) in the area, which provides a good basis for further studies on this aspect. Based on this hypothesis, three grassland plots with different levels of grazing: ungrazed, moderately grazed and overgrazed, were selected for this study.

Material and Methods

Area studied

The area studied was in Sharri National Park, at Brezovicë, Shtërpce municipality, 54 km SW of Prishtina. The landscape structure was predominantly characterized by grasslands, gorges with springs and scattered forests consisting mainly of Balkan pine (*Pinus peuce* Griseb.) and dwarf juniper (*Juniperus communis* subsp. *nana* Syme). The average annual temperature is 7.6 °C, with August being the warmest month and January the coldest (Çavolli 1997; Ivanović et al. 2016). The annual precipitation ranges from 900 to 1100 mm, with the maximum in November and the minimum in August (Çavolli 1997). This study was carried out between May and August 2021 and included three types of grassland: *i.* ungrazed, *ii.* moderately grazed and *iii.* overgrazed. Grazing classification was based only on that year. In each of the three types of grassland four plots were sampled (= 12 plots sampled). Since the area is part of the Sharr National Park, it was agreed with the shepherds employed by the central management that the plots in the grasslands would not be grazed. In addition, a 4,000 m^2 mountain meadow was grazed at a low intensity (only one short period of grazing per month by 10 sheep). This was done under supervision and only during the 4-month survey period. The grasslands in the overgrazed group were constantly grazed and were on that part of the hillside that was somewhat flatter and more accessible for the sheep.

Vegetation characteristics, survey design and sampling protocol

Vascular plant taxa were recorded throughout the four-month season, with the aim of obtaining the total number of plant taxa per site. All three types of grassland studied belonged to the same type of vegetation, had the same geological base and similar ecological conditions. This enabled a comparative analysis of silicate grasslands exposed to different grazing pressures. For each plant taxon, the percentage total cover per sampling unit was recorded in the field. Vegetation characteristics of the same subalpine to alpine silicicolous grasslands (*Poion violaceae* Horvat et al. 1937) differed in their general composition of plant taxa and abundance depending on the intensity of grazing.

To minimize other effects in the selection of the plots, care was taken to ensure that each plot in each grazing group (s1 – ungrazed, s2 – moderately grazed and s3 – overgrazed grasslands) was similar in its general ecology (including moisture and soil conditions). The distance between plots was 500 meters. In this way, erroneous comparisons and discrepancies in data were avoided. A total of 12 plots were analysed.

In addition to the composition of plant taxa and the percentage cover of each plant taxa, plant height and biomass were measured in each sampling unit. Plant height and biomass were measured in 25 m^2 quadrants, along transects set 10 meters apart. Plant height was measured as the height of the plant cover at five different points within the transect, four near the corners (1.2 m) of the square plot and one exactly in the middle of the plot. The protocol for height measurements was repeated in the same manner in all plots. Vegetation biomass was determined using a direct destruction technique. Samples of plants (all aboveground parts of grasses were cut off) were collected at the same sampling points, including the dry biomass and litter on the ground, where plant height was measured at five points within plots. The quadrants used were 50 × 50 cm. Samples were placed in marked bags and then oven dried (24 hours at 80 °C) and their weight recorded.

Spiders (*Araneae*) were collected using an aspirator and sweeping an entomological net (42 cm diameter) 22 times over vegetation while traversing random transects at each site sampled. In addition, spiders were collected using pitfall traps. Two pitfalls per plot were set 10 m apart from each other. All spiders collected were preserved in 75% ethanol, sorted and identified to species level using the identification key Araneae-Spiders of Europe (Nentwig et al. 2022).

Statistical analysis

To better understand the effects of grazing on grasslands of the same composition (subalpine grasslands on acidic soils), the abundance (number of individuals per plot) and number of species (number of species per plot) record in the three types of grasslands: not grazed, moderately grazed, and overgrazed by sheep, were compared. Data collected from May to August included vascular plants and spiders. Because the number of spiders recorded at each site was particularly low, the plant and spider diversity data were combined for further analysis. The combined data collected from May to August were analysed using linear mixed-effects models calibrated with a Poisson distribution using the R package Ime4 (Bates et al. 2015). For carrying out a range of numerical analyses and operations, PAST statistical software was used (Hammer et al. 2001). To measure the similarity of the different types of habitats, Czekanowski coefficient (Czekanowski 1909) was used.

Results

Vegetation and plant species diversiy

Mean plant species richness (per 25 m^2 plots) differed slightly (0.75) between the ungrazed and moderately grazed grasslands, whereas the differences between the moderately grazed and over-grazed grasslands (0.27) and between ungrazed and over-grazed grasslands (0.31) were much greater according to the Czekanowski Coefficient of Similarity (Table 1). The total number of plant taxa recorded per site (as a sum of all plots) was also noticeably different between the two first sites (s1 = 95 plant taxa, s2 = 99 plant taxa) and the 3rd one (over-grazed site), where only 55 plant taxa were recorded (Table 1). A list of all taxa in terms of presence/absence is presented in the supplementary material (Annex Table 1).

Table 1 Similarity in terms of % composition of the three types of grasslands (s1 – ungrazed, s2 – moderately grazed and s3 – overgrazed grasslands) based on the intensity of grazing, according to the Czekanowski Coefficient of Similarity and the the total number of plant taxa recorded per grassland site.

Czekanowski Coefficient			Plant taxa richness per site		
s1 – s2	**s2 – s3**	**s1 – s3**	**s1**	**s2**	**s3**
0.75	0.27	0.31	95 *taxa*	99 *taxa*	55 *taxa*

A direct comparison of plant diversity revealed that there are three species of plants unique to the ungrazed grasslands: *Primula minima* L., *Scleranthus perennis* subsp. *marginatus* (Guss.) Nyman and *Cirsium heterophyllum* (L.) Hill. Moderately grazed grasslands, on the other hand, are characterized by a greater number of species only occurring there, with a total of seven plant species: *Carduus acanthoides* L., *Veratrum album* L., *Potentilla aurea* L., *Pedicularis verticillata* L., *Knautia midzorensis* Formánek, *Crepis aurea* (L.) Cass. and *Antennaria dioica* (L.) Gaertn. A total of ninety-two species were recorded in these two types of grassland. It is interesting to note that of the fifty-five species of plants in the overgrazed grassland sites, not one is characteristic and only occurring there.

The average plant biomass differed in the three types of grassland; in ungrazed grasslands the average biomass was 234.2 g, in moderately grazed grasslands 54.5 g and in overgrazed grasslands it was 33.6 g (Fig. 1), although these differences are not statistically significant, with the probability of difference between the first and the second being $p = 0.08$, first to the third $p = 0.06$ and second to the third ($p = 0.26$). The average height of the vegetation was significantly lower in overgrazed grasslands (23.6 cm), 47.7 cm in the moderately grazed grasslands, while in the ungrazed grasslands the average height was 144 cm (Fig. 1). On the other hand, total vegetation cover ranged from 91% to 100% at the sites sampled in the three types of grassland and were significantly different.

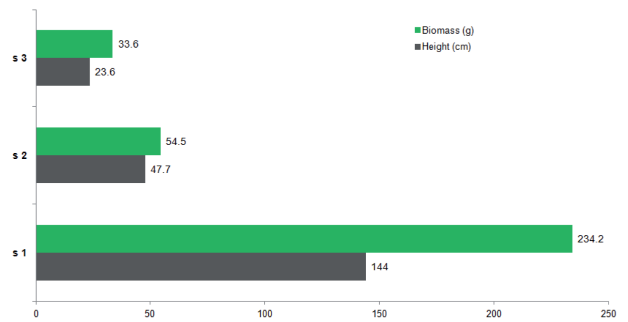

Fig. 1 The biomass (g) and the average height (cm) of plants in the three types of grasslands: s1 – ungrazed , s2 – moderately grazed and s3 – overgrazed grasslands.

The syntaxonomic affiliation of the grasslands studied based on the presence of dominant plant taxa, general ecological characteristics and indicator species, was that they all belong to the alliance: *Poion violaceae* Horvat et al. 1937 [Order: *Seslerietalia comosae* Simon 1958 and Class: *Juncetea trifidi* Hadač in Klika et Hadač 1944]. This vegetation alliance includes alpine and subalpine siliceous grasslands on deep acid soils in wind-protected habitats in the Balkan Peninsula. At all 12 sites sampled, vegetation was dominated by the following ten plant taxa: *Deschampsia caespitosa* (L.) P. Beauv., *Bellardiochloa variegata* (Lam.) Kerguélen, *Calamagrostis arundinacea* (L.) Roth., *Phleum phleoides* (L.) H. Karst., *Galium anisophyllon* Vill., *Festuca adamovicii* (St.-Yves) Markgr.-Dann., *Vaccinium myrtillus* L., *Pimpinella saxifraga* L., *Nardus stricta* L. and *Jasione orbiculata* Velen.

It is worth noting that grazing intensity significantly affected the abundance of individual plant taxa at many of the sites sampled. Of the plant taxa mentioned above: *D. caespitosa* (s1 = 4.77%, s2 = 4.94% and s3 = 0.00%), *Ph. phleoides* (s1 = 3.69%, s2 = 1.62% and s3 = 0.00%), *C. arundinacea* (s1 = 2.97%, s2 = 0.81%, and s3 = 0.00%), *P. saxifraga* (s1 = 2.16%, s2 = 2.43%, and s3 = 0.00%) and *G. anisophyllon* (s1 = 3.24%, s2 = 2.43%, and s3 = 0.84%), which occurred mainly in ungrazed (s1) and moderately grazed (s2) grasslands, but were almost completely absent in overgrazed grasslands (s3). This clearly indicates that these plants, among others at somewhat lower percentages, occur at a lower abundance in intensively grazed grasslands. *J. orbiculata* had particularly inconsistent responses to grazing intensity (s1 = 1.17%, s2 = 0.96%, and s3 = 4.20%). On the other hand, *N. stricta* (s1 = 0.99%, s2 = 1.25% and s3 = 10.50%), *Geum montanum* (s1 = 0.27%, s2 = 0.52% and s3 = 4.62%) and *F. adamovicii* (s1 = 2.97%, s2 = 2.58% and s3 = 7.14%), belong to the second group of plants that benefited from intensive grazing. Their percentage cover was > 4.5% in the overgrazed grasslands. In addition, there was a group of plants that were consistently present regardless of grazing intensity, such as *V. myrtillus* (s1 = 3.33%, s2 = 3.10%, s3 = 3.78%).

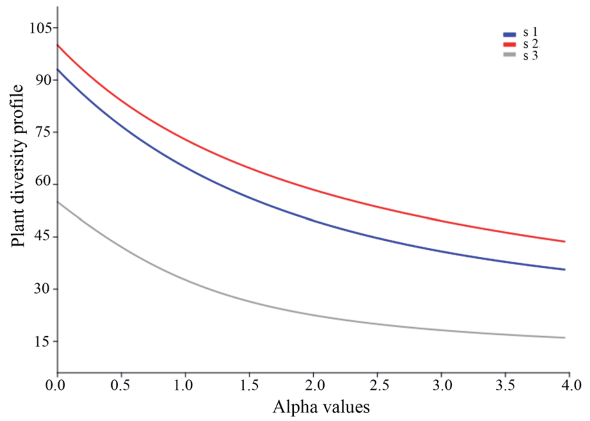

Fig. 2 The overall plant diversity profiles for the three types of grassland, based on grazing intensity. s1 – ungrazed, s2 – moderately grazed and s3 – overgrazed grasslands.

As this study was of an ecologically uniform grassland ecosystem that was subjected to different degrees of grazing, the total number of plant taxa at each site sampled was analysed. When analyzing the α-diversity of plant taxa at the sampling sites (s1, s2, and s3), it was found that the highest α-diversity was recorded in s2 – moderately grazed, followed by s1 – ungrazed and the lowest in s3 – overgrazed grasslands (Fig. 2).

Spiders

A total of 10 species of spiders (Annex – Table 2) were collected by sweepnetting and using an apirator, from May to August. The most abundant genus was *Araneus* with three species (*A. diadematus*, *A. quadratus* and *A. opisthographa*). *Pardosa saltuaria* was the most abundant in terms of the number of individuals, with a total of 20 individuals (18 individuals, or 100% of spider taxa in s3, and 2 individuals in s2 or 14.2%, consisting of 4 males and 16 females). A total of six individuals was recorded for *Tibellus oblongus,* of which five were recorded in s1 (or 35.7%) and one in s2 or 7.14%), consisting of 2 males and 4 females. For *Aculepeira ceropegia* it was six individuals, three in s1 (21.4%) and three in s2 (21.4%), 1 male and 5 females. For *Araneus diadematus* it was six individuals, four in s1 (28.5%) and two in s2 (14.2%), 2 males and 4 females. For *Araneus quadratus* it was three individuals, 1 in s1 (7.1%) and two in s2 (14.2%), all female. In addition in s1 one female of the species *Microlinyphia pusilla* was recorded and in s2 four species (each by one individual): *Xysticus audax* (female), *Platnickina tincta* (female), *Araniella opisthographa* (male) and *Linyphia triangularis* (female).

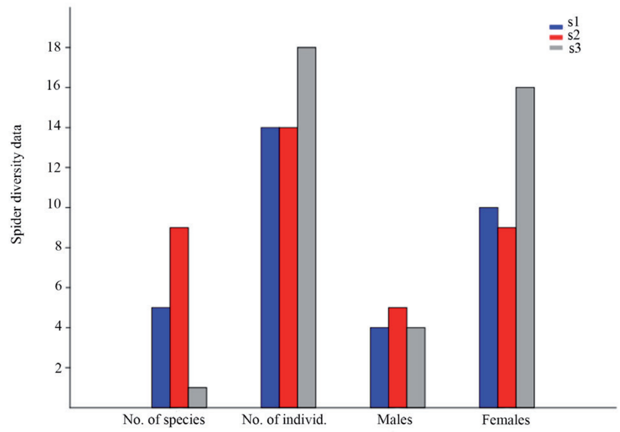

Fig. 3 The total number of species and numbers of spiders, and males and females recorded in s1 – ungrazed , s2 – moderately grazed and s3 – overgrazed grasslands.

The diversity of spiders in all three type of grassland types was very low. The largest number of species (Fig. 3) was recorded at site 2 (s2 grasslands) with a total of 9 species, followed by site 1 (s1 – ungrazed grasslands) with a total of 5 spider species, while at site 3 (s3 – overgrazed grasslands) only one species of spider (*Pardosa saltuaria*) was recorded. At site 3 (overgrazed grasslands) the highest number of spiders was recorded, but they were individuals of the same species (*Pardosa saltuaria*). In terms of the sex ratio, as can be seen in Fig. 3, females dominate with 72.9% being female and 27.1% male.

Analyzing all of the data recorded in this study (Fig. 4) the ungrazed grasslands (s1) were characterized by a greater plant biomass and, consequently, by higher values for the height of the of vegetation (in cm) and the moderately grazed grasslands (s2) by a higher biodiversity than the other two. This is especially evident in the greater number of species of plants and spiders present. Thus, it is clear that the biodiversity recorded in overgrazed grasslands (s3) was very low, so intense grazing by sheep greatly negatively affected their overall diversity.

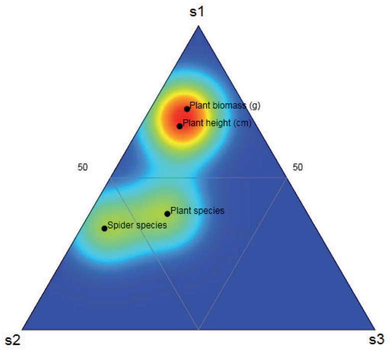

Fig. 4 A density map showing the distributions of the number of plant species, number of spider species, plant biomass (g), and plant height (cm) in three triangles corresponding to grassland types (s1, s2, and s3).

Discussion

The results indicate that increasing or decreasing grazing intensity in natural grasslands can have a direct effect on plant and spider diversity. It is a well-known ecological hypothesis that reduced grazing can directly affect grasslands and may result in the development of mosaic landscapes of heavily and lightly grazed grasslands (WallisDeVries and Raemakers 2001), which may be the basis for heterogeneous vegetation (Kruess and Tscharntke 2002). This hypothesis is supported by the diversity indices recorded in this study. Many species of plants responded to grazing intensity and differed significantly in abundance in the three types of grassland, such as: *Deschampsia caespitosa* (L.) P. Beauv., *Phleum phleoides* (L.) H. Karst., *Calamagrostis arundinacea* (L.) Roth, *Pimpinella saxifraga* L. and *Galium anisophyllon* Vill. In all these species, as well as in many others at a lower incidence, a reduction in abundance was recorded with increase in grazing intensity. There were other plant species like: *Geum montanum* L., *Nardus stricta* L., *Sesleria comosa* Velen. and *Festuca adamovicii* (St.-Yves) Markgr.-Dann. that were either highly tolerant of grazing or even favoured by intense grazing (Cole 1995). Most likely due to the low incidence of grazing and thus damage to plants, the ungrazed grasslands (s1) had the highest level of plant biomass and percentage cover of vegetation. In terms of the total number of species of plants, slightly higher numbers were recorded in the moderately grazed grasslands (s2), but did not differ significantly from that recorded in ungrazed grasslands (s1). The difference between s1 and s2 was more pronounced in the diversity of the few species of spiders recorded. This indicates that habitat composition structure either directly or indirectly determines spider diversity (Greenstone 1984; Dennis et al. 1998; Buchholz 2010; Ávila et al. 2017). That the moderately grazed grasslands (s2) had the highest spider populations reveals something about the natural habitat conditions that spiders prefer. Overgrazed grasslands (s3), on the other hand, are not only unfavourable for the development of plants, plant diversity and vegetation, but also for spiders.

The effects of grazing on plant and spider diversity became apparent when grasslands with three different grazing regimes were compared. A general trend towards higher diversity in moderately grazed and ungrazed, compared to overgrazed grasslands was evident. Although these results are based on a short-term analysis of grassland grazing intensity, the apparent differences in species diversity in the three types of grassland may prove valuable for habitat specialists, conservation efforts and heterogeneity analyses of the natural habitats in Sharri National Park. In ungrazed and moderately grazed grasslands, more spiders that rely on tall plants to hunt, such as building webs (Araneidae and Linyphiidae) or waiting for prey (Philodromidae and Thomisidae) were recorded, whereas in overgrazed grasslands where were nearly exclusively only active hunting spiders (Lycosidae).

It is well known that ungrazed grasslands are likely to be more heterogeneous than grazed (and especially overgrazed) grasslands. This is mainly due to the height of the vegetation in the former, which has a more complex architecture (Southwood et al. 1979; Southwood 1988; Pittarello et al. 2017).

The natural habitats of acid grassland belong to a group of habitats whose conservation is a priority not only at regional and national levels, but also at the European level. The European Habitats Directive (Anonymous 1992) defines *Nardus stricta* communities on siliceous substrates as "species-rich" because they host a higher diversity of vascular plants compared to other siliceous habitats. Based on the results presented, as well as those of other studies (Millaku et al. 2013; Berisha et al. 2020), conservation efforts should focus primarily on siliceous grassland habitats with *Nardus stricta*, as they contain many important plant taxa and belong to a group of very high conservation importance.

Conclusions

In conclusion, in terms of maintaining habitats with high natural values and their proper management, efforts to reduce grazing intensity remain of crucial importance. This would have a direct effect on increasing plant and animal biodiversity, as revealed by this study of plants and spiders. There was correlation between plant and spider diversity in three types of differently grazed grasslands. The results indicate the importance of small-scale, moderate grazing of grasslands, as well as the conservation of longstanding, ungrazed grasslands. This would result in the conservation and restoration of plant and spider diversity. Because natural grasslands are one of the most important habitats in terms of biodiversity, proper management, extent and control of grazing, mowing, or general use of grasslands may be the key to the long-term conservation of these natural habitats.

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Annex – Table 1 Plant taxa presence/absence at each site.

No.	Plant taxa	s1	s2	s3	No.	Plant taxa	s1	s2	s3
1.	*Achillea multifida*	1	1	0	**2.**	*Patzkea paniculata*	1	1	1
3.	*Agrostis capillaris*	1	1	1	**4.**	*Luzula luzuloides*	1	1	0
5.	*Anthyllis vulneraria*	1	1	0	**6.**	*Geum montanum*	1	1	1
7.	*Festuca rubra*	1	1	1	**8.**	*Juncus trifidus*	1	1	0
9.	*Deschampsia cespitosa*	1	1	0	**10.**	*Vaccinium myrtillus*	1	1	1
11.	*Campanula rotundifolia*	1	1	1	**12.**	*Myosotis alpestris*	1	1	0
13.	*Filipendula vulgaris*	1	1	0	**14.**	*Jasione orbiculata.*	1	1	1
15.	*Geranium subcaulescens*	1	1	0	**16.**	*Campanula spatulata* subsp. *spatulata*	1	1	0
17.	*Poa alpina*	1	1	1	**18.**	*Pedicularis verticillata*	0	1	0
19.	*Plantago atrata*	1	1	1	**20.**	*Calamagrostis arundinacea*	1	1	0
21.	*Bellardiochloa variegata*	1	1	1	**22.**	*Knautia midzorensis*	0	1	0
23.	*Ochlopoa annua*	1	1	0	**24.**	*Bupleurum falcatum*	1	1	1
25.	*Stachys alopecuros*	1	1	0	**26.**	*Silene sendtneri*	1	1	1
27.	*Rumex acetosa*	1	1	1	**28.**	*Homogyne alpina*	1	1	0
29.	*Carex curvula*	1	1	1	**30.**	*Luzula spicata*	1	1	1
31.	*Arabis hirsuta*	1	1	0	**32.**	*Lotus corniculatus*	1	1	1
33.	*Hypericum richeri* subsp. *grisebachii*	1	1	0	**34.**	*Avenella flexuosa*	1	1	0
35.	*Dianthus deltoides*	1	1	0	**36.**	*Anthoxanthum odoratum*	1	1	1
37.	*Viola gracilis*	1	1	1	**38.**	*Poa media*	1	1	0
39.	*Silene vulgaris*	1	1	0	**40.**	*Thymus praecox* subsp. *zygiformis*	1	1	1
41.	*Primula veris*	1	1	1	**42.**	*Cerastium alpinum*	1	1	1
43.	*Carduus acanthoides*	0	1	1	**44.**	*Achillea lingulata*	1	1	1
45.	*Cirsium heterophyllum*	1	0	0	**46.**	*Viola elegantula*	1	1	1
47.	*Senecio squalidus* subsp. *rupestris*	1	1	0	**48.**	*Muscari botryoides*	1	1	1
49.	*Trifolium medium subsp. balcanicum*	1	1	1	**50.**	*Gentiana utriculosa*	1	1	1

No.	Plant taxa	s1	s2	s3	No.	Plant taxa	s1	s2	s3
51.	*Alchemilla hybrida*	1	1	1	**52.**	*Pilosella hoppeana*	1	1	1
53.	*Pilosella officinarum*	1	1	1	**54.**	*Crepis aurea*	0	1	1
55.	*Verbascum longifolium subsp. pannosum*	1	1	1	**56.**	*Trifolium pratense*	1	1	1
57.	*Euphrasia rostkoviana* subsp. *montana*	1	1	0	**58.**	*Vaccinium uliginosum*	1	1	0
59.	*Ranunculus montanus*	1	1	1	**60.**	*Campanula scheuchzeri*	1	1	1
61.	*Leucanthemum vulgare*	1	1	0	**62.**	*Ligusticum mutellina*	1	1	1
63.	*Scabiosa columbaria*	1	1	0	**64.**	*Armeria canescens*	1	1	0
65.	*Veronica chamaedrys*	1	1	1	**66.**	*Centaurea nervosa*	1	1	0
67.	*Agrostis stolonifera*	1	1	1	**68.**	*Gentianella bulgarica*	1	1	0
69.	*Dianthus carthusianorum*	1	1	0	**70.**	*Gymnadenia conopsea*	1	1	0
71.	*Phleum phleoides*	1	1	0	**72.**	*Minuartia recurva*	1	1	0
73.	*Luzula sylvatica*	1	1	0	**74.**	*Scleranthus perennis* subsp. *marginatus*	1	0	0
75.	*Genista depressa*	1	1	0	**76.**	*Vaccinium vitis-idaea*	1	1	1
77.	*Galium anisophyllon*	1	1	1	**78.**	*Festuca adamovicii*	1	1	1
79.	*Veratrum album*	0	1	1	**80.**	*Sesleria comosa*	1	1	1
81.	*Silene viscaria*	1	1	0	**82.**	*Crocus veluchensis*	1	1	1
83.	*Asperula cynanchica*	1	1	0	**84.**	*Primula minima*	1	0	0
85.	*Bistorta vivipara*	1	1	0	**86.**	*Botrychium lunaria*	1	1	0
87.	*Nardus stricta*	1	1	1	**88.**	*Clinopodium alpinum*	1	1	0
89.	*Phyteuma pseudorbiculare*	1	1	1	**90.**	*Thesium alpinum*	1	1	1
91.	*Hieracium villosum*	1	1	1	**92.**	*Juniperus communis* subsp. *nana*	1	1	0
93.	*Poa badensis*	1	1	1	**94.**	*Antennaria dioica*	0	1	1
95.	*Pimpinella saxifraga*	1	1	0	**96.**	*Hieracium naegelianum*	1	1	1
97.	*Potentilla aurea*	0	1	1	**98.**	*Festuca halleri* subsp. *scardica*	1	1	0
99.	*Anemonastrum narcissiflorum*	1	1	1	**100.**	*Hypericum maculatum*	1	1	1
101.	*Linum capitatum*	1	1	1	**102.**	*Bruckenthalia spiculifolia*	1	1	0

Annex – Table 2 Spider species numbers and presence at each site.

No.	Spider taxa	s1	s2	s3
1.	*Tibellus oblongus* (Walckenaer, 1802)	**5**	**1**	0
2.	*Pardosa saltuaria* (L. Koch, 1870)	0	**2**	**18**
3.	*Xysticus audax* (Schrank, 1803)	0	**1**	0
4.	*Aculepeira ceropegia* (Walckenaer, 1802)	**3**	**3**	0
5.	*Platnickina tincta* (Walckenaer, 1802)	0	**1**	0
6.	*Araneus diadematus* Clerck, 1757	**4**	**2**	0
7.	*Araneus quadratus* Clerck, 1757	**1**	**2**	0
8.	*Araniella opisthographa* (Kulczyński, 1905)	0	**1**	0
9.	*Microlinyphia pusilla* (Sundevall, 1830)	**1**	0	0
10.	*Linyphia triangularis* (Clerck, 1757)	0	**1**	0