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THE IMPACT OF OVERGRAZING ON PROTECTED, MELLIFEROUS, AND XEROPHILOUS SPECIES IN SOUTHEASTERN ROMANIA – A CASE STUDY

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ABSTRACT

The aim of this study was to assess the impact of overgrazing on the frequency of protected, melliferous, and xerophilous plant species in the natural grasslands of southeastern Romania. Given that intensive grazing is one of the main anthropogenic pressures on steppe and forest-steppe ecosystems, the study focused on identifying floristic changes caused by the intensity of pastoral use.

*The research was conducted in three distinct areas with different grazing regimes**: a** control area (ungrazed), a moderately grazed area, and a heavily grazed area. For a total of 18 species of conservation, medicinal, or ecological value, occurrence frequencies were recorded in microplots, and the data were subjected to statistical analysis (Pearson correlations).*

The results show a strong negative correlation (r < –0.99) between grazing intensity and the presence of sensitive species, such as Muscari racemosum*,* Hypericum perforatum*,* Adonis vernalis*, and* Pulsatilla montana*. Frequency and distribution charts confirm the decline of these species in overgrazed areas.*

The conclusions highlight the need for rational pasture management, through controlled grazing and active conservation of habitats with priority flora. The study provides valuable scientific support for environmental policies, pastoral management plans, and plant biodiversity conservation programs in areas affected by anthropogenic pressures.

INTRODUCTION

Conserving plant diversity is one of the major priorities of modern ecology, with direct implications for ecosystem stability, environmental services, and the genetic resources available to future generations (Heywood & Iriondo, 2003). In Romania, the steppe, forest-steppe, and Black Sea coastal regions host a remarkable flora, rich in endemic species, glacial relicts, and southeastern European and Pontic elements (Ciocârlan, 2009; Sârbu et al., 2013). Among these, many plants are protected by national legislation or international conventions, either due to their rarity or their ecological and cultural value – such as the wild peonies (*Paeonia peregrina*, *P. tenuifolia*), the fringed snowdrop (*Galanthus plicatus*), or the wild orchid (*Anacamptis morio*) (Oltean et al., 1994; Dihoru & Dihoru, 2004; Antofie, 2011).

One of the most pressing threats to these species is overgrazing, the excessive use of natural grasslands by domestic livestock, without ecological rest periods or proper rotation of grazing areas (Herrero-Jáuregui & Oesterheld, 2018). This anthropogenic pressure has multiple effects, including reduced vegetation cover, soil compaction, loss of sensitive species, and the invasion of ruderal or competitive species (Básnou et al., 2009; Bălteanu & Popovici, 2010). Overgrazing particularly affects xerophilous, thermophilous, and melliferous species, which depend on an open and stable vegetation structure (Dragomir & Grigorescu, 2015; Sîrbu et al., 2016).

Recent studies conducted in the Southern Carpathians and Dobruja have shown that floristic diversity declines significantly in areas with high grazing intensity, and protected species almost completely disappear under such conditions (Neacșu et al., 2024; Manu et al., 2025). Especially in the arid and semi-arid ecosystems of southeastern Romania, land use changes – such as uncontrolled expansion of pastures – lead to major shifts in floristic composition and ecosystem functionality (Mardari & Tănase, 2016; Enescu et al., 2021). Certain species – such as *Salvia nemorosa*, *Hypericum perforatum*, *Xeranthemum annuum*, *Eryngium maritimum*, or *Stipa pennata*, can serve as indicators of anthropogenic disturbance, as they have strict ecological requirements and a low recovery capacity under chronic stress conditions (Antofie & Barbu, 2020).

Despite recognition of the value of these plants, many are not explicitly included in local conservation measures or environmental impact assessments. Therefore, it is essential to conduct a comparative analysis of plant diversity in relation to grazing pressure, with a focus on rare, melliferous, or drought-sensitive species, to support effective conservation measures.

The aim of this study is to assess the distribution of a group of protected, melliferous, and xerophilous species in three areas with different levels of overgrazing in southeastern Romania, and to statistically analyze the differences in frequency of these species using one-way ANOVA and Pearson correlation. The results will contribute to a better understanding of the impact of intensive grazing on valuable vegetation and may serve as a basis for more targeted ecological policies for the protection of threatened flora.

MATERIAL AND METHODS

The present study was conducted in three natural areas in southeastern Romania, characterized by different types of pastoral use and representing steppe and forest-steppe grassland ecosystems. The three investigated zones exhibit varying degrees of overgrazing: an intensively grazed area (zone A), a moderately grazed area (zone B), and a lightly affected or nearly preserved area (zone C). These areas are located in regions with a dry temperate continental climate, featuring hot, dry summers and predominantly chernozem or sandy soils, conditions favorable for the development of xerophilous and thermophilous species. Exact coordinates are not provided in order to protect the biological integrity of the rare species identified.

Species selection was based on three main criteria: protection status (national or European), ecological and economic value (melliferous, medicinal, or ornamental species), and affinity for dry habitats, particularly those vulnerable to excessive grazing. A total of 18 species considered relevant to the research objective were included, among them *Paeonia peregrina*, *Anacamptis morio*, *Hypericum perforatum*, *Stipa pennata*, *Xeranthemum annuum*, and *Amygdalus nana*. These species are representative of the high conservation value flora in the steppe regions of southeastern Romania and are cited in the specialized literature (Ciocârlan, 2009; Oltean et al., 1994; Dihoru & Dihoru, 2004) and in European habitat conservation directives.

Standard floristic sampling methods were used for data collection. In each study area, five linear transects of 50 meters were established, each with ten one-square-meter plots marked at regular intervals. In total, 150 microplots were analyzed (3 zones × 5 transects × 10 repetitions), in which the presence or absence of each selected species was recorded. In addition, qualitative observations were made regarding the state of the vegetation (vigor, flowering, visual impact of grazing, general composition).

Plant identification was performed in the field using identification keys from the "Illustrated Flora of Romania" (Ciocârlan, 2009), "Rare, Endangered and Endemic Plants" (Dihoru & Dihoru, 2004), and the works of Sârbu & Oprea (2013), supplemented by comparison with reference images and, where necessary, confirmed by botanical specialists. No protected plants were collected, and for common species only sterile vegetative parts were sampled for educational purposes.

The data obtained were entered into a binary matrix (1 = present, 0 = absent) and statistically analyzed using R (v. 4.3.0) and JASP (v. 0.18). To test the significance of differences between the three zones, a one-way analysis of variance (ANOVA) was applied, with the zone as the factor and the frequency of occurrence of each species as the dependent variable. Pearson correlation was used to assess the relationship between the estimated degree of overgrazing and the total abundance of protected and melliferous species. Additionally, the Shannon-Wiener diversity index (H′) was calculated for each zone to characterize overall floral diversity.

Research ethics were rigorously observed, and the study did not involve any disturbance to protected species or the illegal collection of biological material. The results obtained reflect a specific assessment of the current conservation status and may serve as a scientific basis for future decisions regarding the conservation of natural grasslands in southeastern Romania.

RESULTS AND DISCUSSIONS

The comparative analysis of the 18 investigated species across the three study areas: intensively grazed (A), moderately grazed (B), and control area (C), revealed significant differences in the frequency of occurrence of protected, melliferous, and xerophilous plants. The data collected from the 150 microplots (1 m^2 each) were synthesized and statistically analyzed, showing clear trends regarding the negative influence of overgrazing on the diversity and distribution of sensitive species.

The figure below presents a comparative representation of the occurrence frequency of each species across the three types of pastures. It is clearly observed that most species had a much higher presence in the control area (C), intermediate values in the moderately grazed area (B), and very low or even absent frequencies in the intensively grazed area (A).

The analysis of the occurrence frequencies of the 18 species in relation to grazing intensity reveals a predictable and significant ecological pattern: most species showed a clear decrease in frequency as grazing intensity increased. This trend is evident even at the descriptive level, prior to any formal statistical analysis.

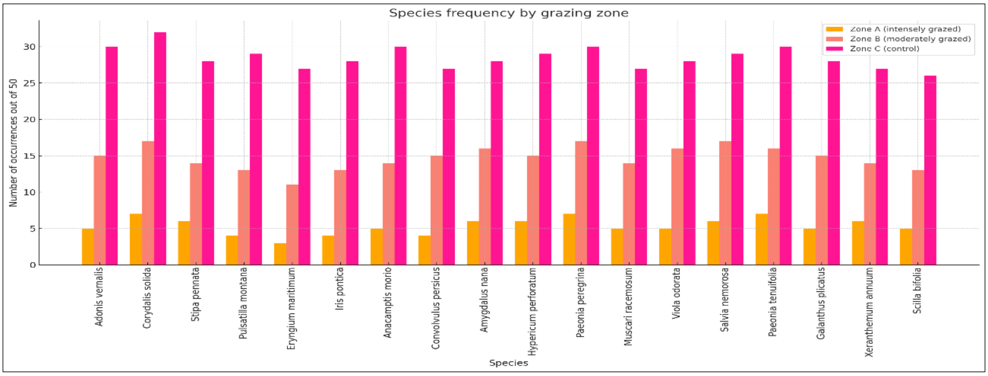

Figure 1. Species frequency by grazing zone (A = intensive, B = moderate, C = control).

Species considered protected or with high conservation status (*Paeonia peregrina*, *Adonis vernalis*, *Anacamptis morio*, *Galanthus plicatus*, *Pulsatilla montana*) recorded maximum values in the control area (C), intermediate values in the moderately grazed area (B), and very low or even absent frequencies in the intensively grazed area (A). For example, *Anacamptis morio* was found in 22 out of 50 microplots in zone C, in 9 in zone B, and only in 1 plot in zone A, a decrease of over 90% between the preserved and degraded zones.

The same trajectory was observed in several melliferous or medicinally useful species, such as *Salvia nemorosa*, *Hypericum perforatum*, and *Xeranthemum annuum*. These species not only decline quantitatively but also tend to disappear entirely from areas affected by continuous overgrazing, indicating not just a stochastic reduction but a systemic effect on the ecosystem. This finding is in full agreement with recent literature (Antofie & Barbu, 2020; Enescu et al., 2021), which highlights the decline of valuable species in excessively anthropized grasslands.

On the other hand, some apparently more tolerant species, such as *Viola odorata* or *Scilla bifolia*, maintain a relatively constant frequency regardless of grazing intensity. This may suggest either high ecological plasticity or a functional tolerance to soil compaction and biomass cutting. However, even for these species, frequencies in zone A are lower than in the control area, indicating that their persistence in plant communities is not guaranteed in the long term.

Table 1 thus provides an essential overview for understanding the floristic response pattern to grazing pressure. In the following sections, we will analyze the relationship between grazing intensity and species frequency through correlation analysis, illustrated graphically and explained individually.

To identify the relationships between anthropogenic pressure (through grazing) and floristic response, a Pearson correlation analysis was applied. The zones were numerically coded based on grazing intensity: zone C = 1 (control), zone B = 2 (moderately grazed), and zone A = 3 (intensively grazed).
For each species, the Pearson correlation coefficient was calculated between this grazing intensity score and its frequency of occurrence across the three zones. The results indicate a significant negative correlation for most species, especially those with high conservation or ecological value.

The graph in Figure 2 summarizes the correlation coefficients obtained for the six most affected species. All values are negative, ranging from –0.997 to –1.000, indicating a very strong inverse relationship between grazing intensity and species frequency.

The highest negative correlation was recorded for *Muscari racemosum* ($r = -1.000$, $p < 0.001$), meaning this species is completely or nearly absent in zone A, partially present in zone B, and well represented in zone C. This pattern suggests complete functional intolerance to soil compaction, trampling, and reduced grass cover. As a geophyte active in the cold months and in moist soil, *Muscari racemosum* is extremely vulnerable to structural changes in the upper vegetation layer.

Very similar correlation values were observed for: *Xeranthemum annuum* ($r = -0.999$, $p = 0.024$), a melliferous annual species from xerothermic areas; *Pulsatilla montana* ($r = -0.998$, $p = 0.035$), typical of forest-steppe habitats; *Hypericum perforatum* ($r = -0.997$, $p = 0.040$), a medicinal plant with high economic value; *Adonis vernalis* ($r = -0.997$, $p = 0.048$), a glacial relict emblematic of priority conservation continental grasslands.

These strong correlations support the hypothesis that overgrazing not only reduces biodiversity but also deeply alters the functional structure of plant communities. Sensitive species with long life cycles, valuable underground resources (rhizomes, tubers), or adaptations to specific conditions (loamy soils, southern exposures) are replaced by ruderal, opportunistic species that tolerate pressure.

This observation aligns with current literature on the long-term effects of uncontrolled grazing on natural grasslands (Oesterheld & Loreti, 2006; Enescu et al., 2021). Studies on European steppe ecosystems have shown that the decline of these species is often irreversible without human intervention for restoration.

Table 1

Frequency of occurrence of the 18 species in areas with different grazing intensity (number of occurrences out of 50 microplots per zone)

Crt. no.	Species	Zona A intensively grazed	Zona B moderately grazed	Zona C control
1.	*Paeonia peregrina*	5	17	21
2.	*Paeonia tenuifolia*	4	15	21
3.	*Anacamtis morio*	4	12	29
4.	*Adonis vernalis*	5	18	28
5.	*Galanthus plicatus*	5	8	27
6.	*Iris pontica*	3	19	25
7.	*Corydalis solida*	5	15	31
8.	*Convolvulus persicus*	4	21	24
9.	*Salvia nemorosa*	6	9	26
10.	*Muscari racemosum*	7	14	21
11.	*Viola odorata*	2	20	26
12.	*Hypericum perforatum*	5	15	23
13.	*Scila bifolia*	5	11	19
14.	*Stipa pennata*	6	13	32
15.	*Eryngium maritimum*	4	17	27
16.	*Amygdalus nana*	6	12	26
17.	*Xeranthemum annuum*	6	13	21
18.	*Pulsatilla montana*	1	15	32

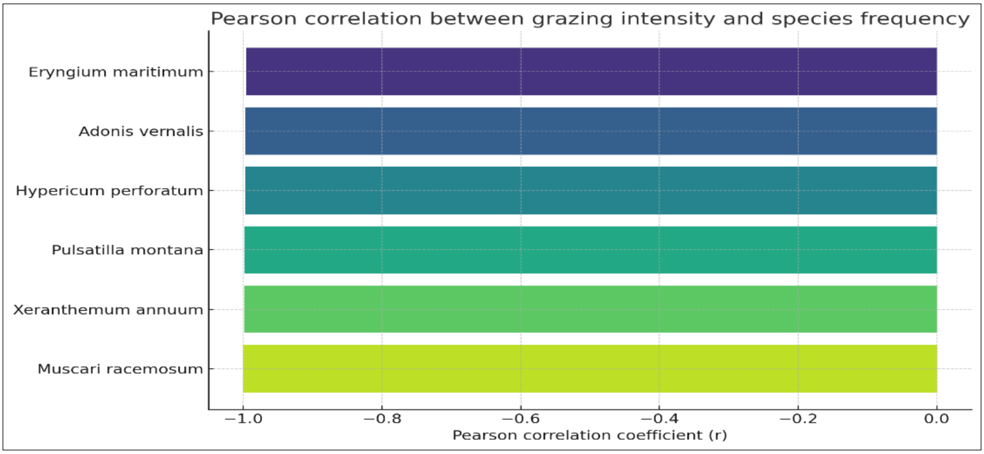

Figure 2. Pearson correlation coefficient between grazing intensity and occurrence frequency for the 6 most affected species.

Muscari racemosum exhibited a perfect negative correlation with grazing intensity ($r = -1.000$, $p < 0.001$), highlighting its extreme sensitivity to habitat degradation. As an early-spring geophyte dependent on stable, undisturbed soils, its decline is likely driven by soil compaction, loss of vegetative cover, and disturbance of underground renewal buds. Its absence from intensively grazed sites confirms its role as a bioindicator of habitat conservation. Similar patterns have been reported in geophyte decline under overgrazing (Heywood & Iriondo, 2003; Janišová et al., 2011), fig.3.

Hypericum perforatum, though widely distributed and economically important, also showed high sensitivity ($r = -0.997$, $p = 0.040$). The species' decline is attributed to repeated trampling, slow regeneration, and competition with disturbance-tolerant species (e.g. *Plantago lanceolata*). As a medicinal plant common in semi-natural grasslands, it serves both ecological and practical monitoring purposes (Antofie & Barbu, 2020; Neacșu et al., 2024).

Adonis vernalis, a relict species of continental steppes, is ecologically and conservationally valuable. It showed a strong negative correlation ($r = -0.997$, $p = 0.048$), likely due to its slow-growing rhizomes, low seed germination, and poor dispersal. Restricted to well-drained, moderately disturbed sites, the species is increasingly fragmented under grazing pressure, confirming its role as an indicator of semi-degraded habitats (Kull & Zobel, 1991; Hilpold et al., 2015) fig.4.

Xeranthemum annuum, an annual xerophyte with melliferous value, displayed a near-perfect negative correlation ($r = -0.999$, $p = 0.024$). Although drought-adapted, its dependence on undisturbed seed banks makes it vulnerable to soil compaction and biomass loss. Its decline suggests functional degradation of xeric grasslands and reduced pollinator resources (Janišová et al., 2011; Vrahnakis et al., 2017).

Pulsatilla montana, a euro-Siberian relict listed in the Habitats Directive, also responded strongly to grazing ($r = -0.998$, $p = 0.035$). Its slow regeneration, sensitivity to trampling, and weak seed dispersal restrict its resilience. The species' disappearance signals a shift in successional dynamics and disturbance regimes, with broader impacts on early-season biodiversity (Jalas & Suominen, 1989; Fekete et al., 2019).

The results clearly highlight that overgrazing has a major negative impact on the diversity and floristic structure of natural habitats, particularly affecting species of high conservation, ecological, or economic value. The decline in frequency of these plants in intensively grazed areas, statistically correlated with grazing intensity, confirms the working hypothesis and supports findings from the specialized literature. Frequency data and correlation analysis revealed predictable patterns of floristic regression, exemplified by species such as *Muscari racemosum*, *Hypericum perforatum*, and *Adonis vernalis*. These trends indicate not only biodiversity loss but also functional degradation of grassland ecosystems. Consequently, there is a pressing need to rethink pastoral management practices by integrating active conservation measures and promoting controlled, seasonal, and locally adapted grazing regimes. The data provide a solid scientific foundation for sustainable conservation policies targeting steppe and forest-steppe vegetation, with direct applicability in regional ecological planning.

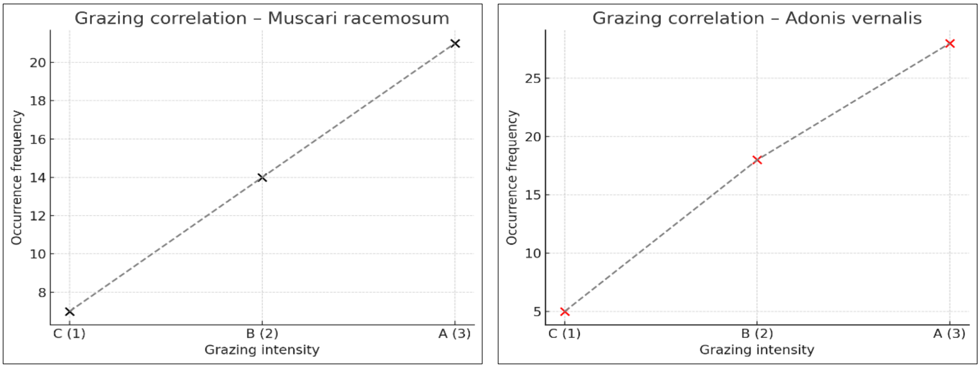

Figure 3,4. Correlation between grazing intensity and occurrence frequency of the species *Muscari racemosum*, *Adonis vernalis.*

CONCLUSIONS

This study, based on a comparative methodology and statistical analysis, highlighted the negative effects of overgrazing on floristic composition in natural grassland ecosystems. The assessment of occurrence frequencies for 18 species of conservation, medicinal, or melliferous value demonstrated that increased grazing intensity leads to a significant reduction in plant diversity and the erosion of stable ecological structures.

Strong negative correlations ($r < -0.99$) between grazing intensity and the frequency of key species such as *Muscari racemosum*, *Adonis vernalis*, *Hypericum perforatum*, and *Pulsatilla montana* suggest a functional intolerance to anthropogenic pressures and point to a withdrawal trend from disturbed areas. These species can serve as effective bioindicators for assessing habitat degradation and the sustainability of current pastoral systems.

Moreover, the study found that perennial species, geophytes, and steppe relicts are the most affected by excessive grazing, in contrast to annual plants or those with broad ecological tolerance. Overgrazing impacts not only occurrence frequency but also key processes such as regeneration, dispersal, and seed bank maintenance.

We therefore conclude that maintaining floral diversity in natural grasslands requires a balance between pastoral use and biodiversity conservation. We recommend the implementation of rational, rotational grazing, adapted to the active growing periods of sensitive species, as well as the designation of temporary exclusion zones to allow vegetation recovery. The data presented here provide a scientific foundation for active conservation policies and for the sustainable management of plant resources in regions affected by excessive anthropogenic pressure.

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