

Paeonia (PAEONIACEAE) IN KOSOVO: A COMPREHENSIVE STUDY OF DIVERSITY, DISTRIBUTION, HABITATS AND THREATS

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Abstract

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This study provides a comprehensive analysis of the diversity, distribution, habitats and threats to *Paeonia* species in Kosovo. The research focused on three species: *Paeonia mascula*, *P. officinalis* and *P. peregrina*. Field surveys, herbarium data and literature research were used to investigate the distribution and ecological preferences of these species. *P. mascula* is classified as endangered due to habitat degradation and limited distribution. *P. peregrina*, although generally robust, is highly threatened by industrial activities, leading to habitat fragmentation. *P. officinalis*, which occurs at only one locality, is vulnerable to fires and collecting. The study highlights the urgent need for habitat monitoring, conservation measures and further research to ensure the survival of these species. These results provide important insights for national and regional conservation strategies.

Key words: vascular flora, *Paeonia*, Balkans, IUCN, conservation biology.

Introduction

The plants of the genus *Paeonia* (Paeoniaceae) are of significant botanical interest due to their unique ornamental and medicinal properties (Zhang et al., 2019). In Europe, the genus is represented by 23 species and 14 subspecies (Euro+Med 2006+), while globally it is known to have 38 species and four hybrids (World Flora Online, 2024), with distributions in the western North America, southern Europe and temperate regions of Asia. China is considered to be the centre of origin, evolution and diversity for the genus (Li et al., 2021).

The genus *Paeonia* encompasses a variety of taxa known for their ornamental value, holding a considerable global importance (Zhou et al., 2020; Li et al., 2021; Kamenetsky-Goldstein, Yu, 2022; Sun et al., 2022). This genus exhibits significant morphological diversity and occupies a wide range of habitats, contributing to the ecological richness of these areas (Zhou, 2006). *Paeonia* species play crucial ecological roles such as supporting pollinators and maintaining habitat integrity (Bernhardt et al., 2013; Tian et al., 2023). They are also of cultural and historical significance and often featured in traditional medicine (Sgadari et al., 2025) and horticulture (Kamenetsky-Goldstein, Yu, 2022). However, many *Paeonia* species face threats from habitat destruction, overharvesting and climate change, highlighting the urgent need for comprehensive conservation strategies to ensure their survival and preservation of their ecological and cultural

contributions (Neëman, 2003; Kim et al., 2016; Wang, 2020).

Protecting *Paeonia* species is essential not only for maintaining biodiversity, but also for safeguarding the ecological functions they support and the cultural heritage they represent (Kumar et al., 2022). Conservation efforts can help mitigate the impacts of environmental changes and human activities, ensuring that these valuable plant species continue to thrive in their natural habitats and contribute to the ecological health of the regions they inhabit (Wang, 2019; Ji et al., 2012; Berisha et al., 2020; Manela et al., 2021).

In the Balkan Peninsula, studies on the taxonomic diversity and distribution of *Paeonia* taxa are relatively limited. However, based on local floras (Table 1), a diverse range of species is documented. In Greece, seven species are reported: *Paeonia clusii* Stern, *P. corsica* Tausch, *P. daurica* Andrews, *P. mascula* (L.) Mill., *P. parnassica* Tzanoud., *P. peregrina* Mill. and *P. saueri* D. Y. Hong & al. (Dimopoulos et al., 2016). Bulgaria hosts three wild species: *P. mascula* (L.) Mill., *P. peregrina* Mill. and *P. tenuifolia* L. (Jordanov, 1970). From Serbia, four species are reported: *P. mascula* (L.) Mill. (syn. *P. corallina* Retz.), *P. officinalis* L., *P. peregrina* Mill. (syn. *P. decora* G. Anderson) and *P. tenuifolia* L. (Blečić, 1972). From Albania, five species are reported: *P. albiflora* Pall., *P. mascula* (L.) Mill., *P. officinalis* L., *P. peregrina* Mill. and *P. saueri* D. Y. Hong & al. (Barina et al., 2018). From Croatia, only two species are reported: *P. mascula* (L.) Mill. and *P. officinalis* L. (Nikolić, 2004). In North Macedonia, there are records

of the presence of the following two *Paeonia* species: *P. mascula* (L.) Mill. and *P. peregrina* Mill. (Micevski, 1995). Kosovo, despite its small territory of 10,887 km² compared to the other countries of the peninsula, is home to three wild species of *Paeonia*: *P. mascula* (L.) Mill., *P. officinalis* L. and *P. peregrina* Mill. (Blečić, 1972; Millaku et al., 2013).

The aims of the current study were to (i) provide an overview of the taxonomic diversity of the genus *Paeonia* in Kosovo, (ii) analyse the natural distribution of the present species and identify their main natural habitats and (iii) review the current trends in populations and their threats, and consequently, assess the conservation status and propose potential measures needed to adequately protect these important plant species.

Material and methods

The studied species

According to available literature sources, herbarium specimens and our own field data, three native *Paeonia* species occur in Kosovo. Thus, this study deals with: *P. mascula* (L.) Mill., *P. officinalis* L. and *P. peregrina* Mill. (Fig. 1). For species taxonomy, we have entirely relied on the EuroMed Checklist (Euro+Med 2006+) and have updated our taxonomy accordingly.

Data collection and analysis

This study represents an extensive investigation encompassing all 11 known localities of *Paeonia* species in Kosovo. These sites were identified through field surveys, a thorough review of the existing literature and a critical examination of the herbarium specimens housed at the University of Prishtina Herbarium (UPH) – Herbarium Faculty of Mathematics and Natural Sciences, University of Prishtina. The distribution of these localities is presented in Fig. 2. Notably, some herbarium specimens were collected between 2002 and 2006, while a significant portion of the vouchers was collected more actively by our team during compilation of the *Red Book of the Vascular Flora of the Republic of Kosovo* (Millaku et al., 2013) between 2009 and 2013. Subsequently, from 2014 to 2024, we conducted numerous field surveys at all known localities of the genus. We carefully monitored population trends, changes in extent of occurrence (EOO) and area of occupancy (AOO), as well as the threats posed to the populations of these species. Population sizes were measured during field surveys for each habitat/site, ensuring detailed assessments through systematic counting of mature individuals, complemented by herbarium voucher data where applicable. To determine the habitat types where each species thrives, we care-

Table 1. Presence of wild *Paeonia* species across countries of the Balkan Peninsula based on literature data.

Species	Greece	Bulgaria	Serbia	Albania	Croatia	North Macedonia	Kosovo
<i>Paeonia albiflora</i> Pall.				•			
<i>Paeonia clusii</i> Stern	•						
<i>Paeonia corsica</i> Tausch	•						
<i>Paeonia daurica</i> Andrews	•						
<i>Paeonia mascula</i> (L.) Mill.	•	•	•	•	•	•	•
<i>Paeonia officinalis</i> L.			•	•	•		•
<i>Paeonia parnassica</i> Tzanoud.	•						
<i>Paeonia peregrina</i> Mill.	•	•	•	•		•	•
<i>Paeonia saueri</i> D.Y. Hong & al.	•			•			
<i>Paeonia tenuifolia</i> L.		•	•				

Fig. 1. The *Paeonia* species of Kosovo. A – *Paeonia mascula* (Pashtrik Mt.), B – *Paeonia officinalis* (Pashtrik Mt.), C – *Paeonia peregrina* (Gl-larevë) (photos: E. Krasniqi).



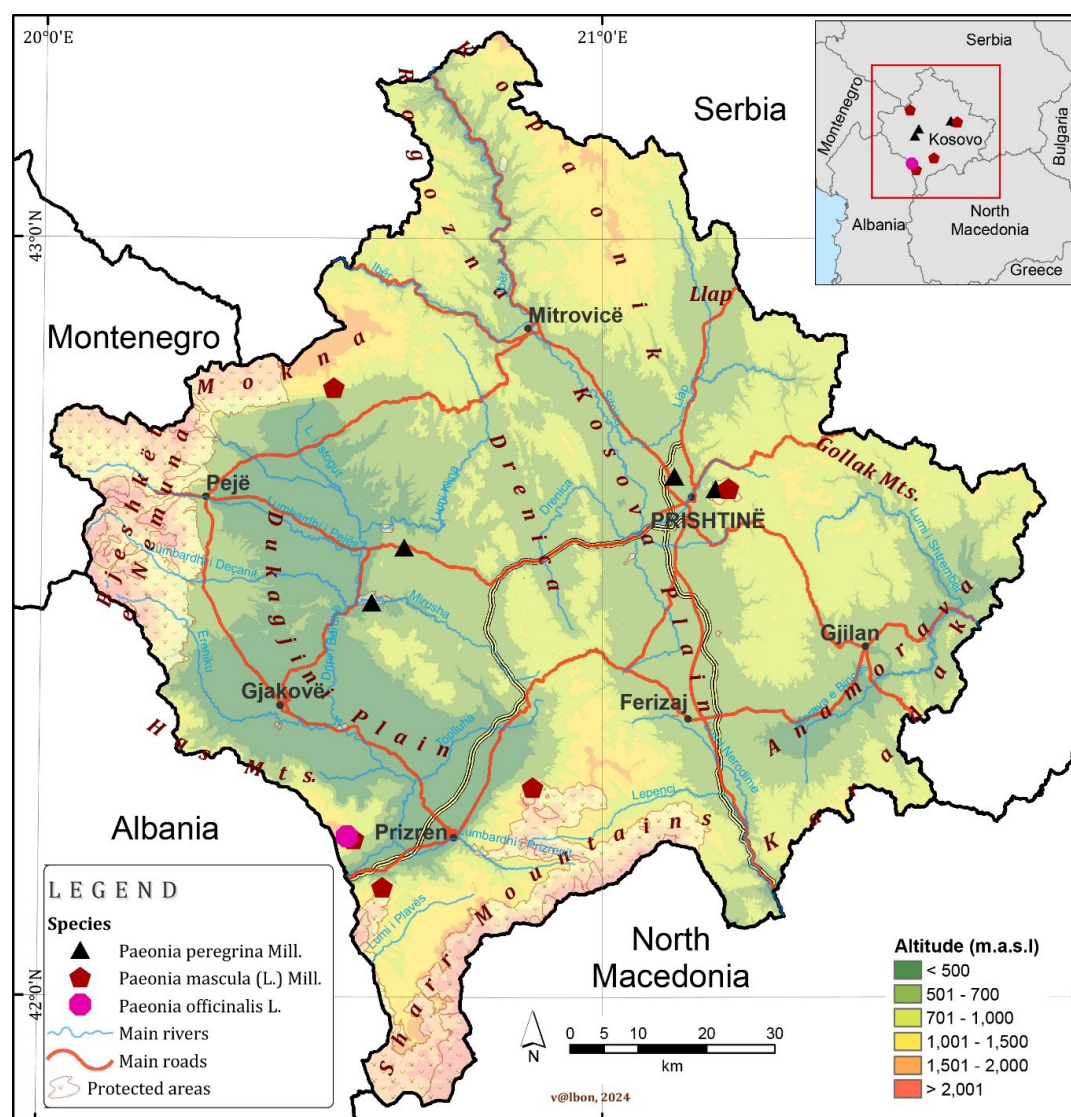


Fig. 2. The distribution map of recorded *Paeonia* L. species in Kosovo.

fully analysed habitat data from site surveys, herbarium vouchers and literature sources. Consequently, we assigned the appropriate European Nature Information System (EUNIS) habitat(s) to each *Paeonia* species (Davies et al., 2004; Chytrý et al., 2020) based on the dominant vegetation types of each habitat. The map included in this study was created using Geographic Information System software, while all graphs were generated using RStudio (version 2024.03.0+386; RStudio Team, 2024).

Results and discussion

Distribution and habitat types

Paeonia mascula (L.) Mill. (syn. = *P. corallina* Retz.) is a species native to northern Africa (Algeria and Morocco), Europe, the Middle East (Israel, Lebanon, Syria, Palestine) and Turkey, extending to Iran and Iraq (Lupo Osti, 2006). In Europe, it pre-

dominantly occurs in southern regions, including the Balkan Peninsula, Greece, Romania, Italy, France, Cyprus and Spain (GRIN, 2014; IUCN, 2024). In Kosovo, *P. mascula* has been recorded in five localities: above the village Syne (Istog Mt.), Pashtrik Mt., Koritnik Mt., Gërmia Regional Park (suburbs of Prishtina) and Mushtisht (Sharri Mts) (Fig. 2). In these areas, *P. mascula* thrives in forests and their associated forest clearings and fringes at altitudinal ranges from 830 m up to 1080 m a.s.l. (Fig. 3). The natural habitats of the species are associated with the following forest vegetation alliances: *Fagion sylvaticae* Luquet 1926, *Fraxino orni-Ostryion* Tomažič 1940 and *Quercion petraeo-cerridis* Lakušić et B. Jovanović in B. Jovanović & al. ex Čarni et Mucina 2015, as determined by the analysis of the corresponding vegetation constitution of its populations (Rexhepi, 1986, 1994; Millaku et al., 2013). Based on its observed locations and associated vegetation types (Table 2), *P. mascula* is best assigned to the following EUNIS habitats:

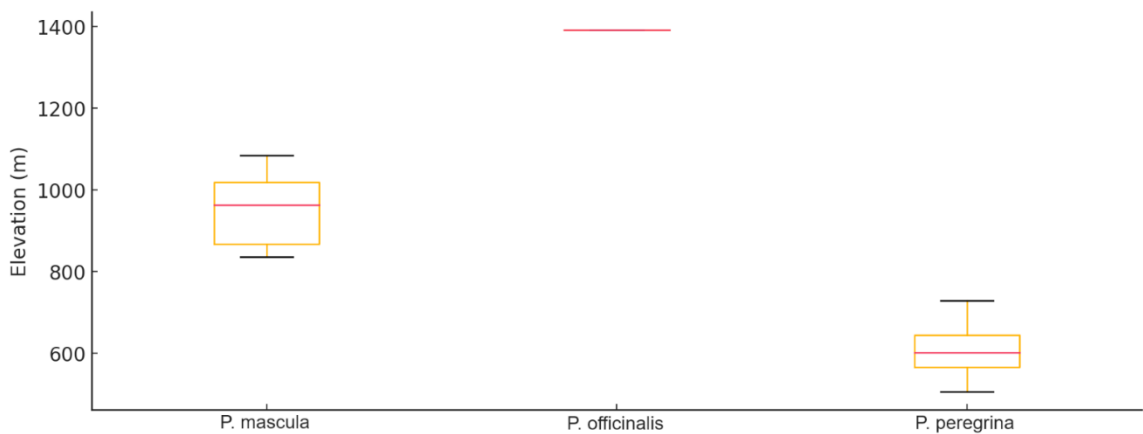


Fig. 3. Elevation range distribution for *Paeonia* species in all recorded habitats in Kosovo.

Table 2. Summary of distribution, habitat characteristics and conservation status of *Paeonia* species in Kosovo.

Species	Localities	Altitude (m a.s.l.)	Substrate	Rainfall (mm/year)	Vegetation type (EUNIS habitat)	Number of individuals	Threats	Population trend
<i>Paeonia mascula</i>	Syne, Pashtrik Mt., Koritnik Mt., Gërmia Regional Park, Mushtisht	830–1080	Calcareous	900–1100	G1.6 beech forests, G1.7 thermophilous deciduous forests, G1.8 lowland thermophilous forests	~200–300/site	Habitat degradation, fires, deforestation	Declining (EN)
<i>Paeonia officinalis</i>	Pashtrik Mt.	1390–1400	Calcareous	800–1000	E4.4 calcareous subalpine grasslands, G1.6 beech forests	<100	Fires, collection for medicinal purposes	Critically low, highly threatened (EN)
<i>Paeonia peregrina</i>	Gllarevë, Llapçevë, Gërmi, Gazimestan	500–730	Calcareous, serpentine	600–800	G1.7 thermophilous deciduous forests, G1.8 acidophilous <i>Quercus</i> -dominated forests, F3.1 shrublands	~300–500/site	Quarrying, habitat fragmentation, industrial development	Stable to declining (VU)

- Habitat code: G1.6 – Beech forests (*F. sylvatica*) – These habitats are characterised by the dominance of *F. sylvatica* L. and are typically found in cooler and more humid conditions, often in montane regions.
- Habitat code: G1.7 – Thermophilous deciduous forests (*Fraxino ornio-Ostryion*) – These forests are characterised by the presence of species such as *Fraxinus ornus* L. and *Ostrya carpinifolia* Scop. These habitats are typically found in warmer and drier areas compared to beech forests.
- Habitat code: G1.8 – Thermophilous deciduous forests of lowlands and hills (*Quercion petraeo-cerridis*) – These forests are dominated by *Quercus* L. species and are common in drier and warmer conditions, often found on rocky and nutrient-poor soils.

P. officinalis L. is a species native to Europe and is found in Spain, northern Portugal, southern France, Italy, Switzerland, western Romania and the Balkan Peninsula (Lupo Osti,

2006; Aghababian, 2011; IUCN, 2024). Although it is widely cultivated in other regions, it is considered an endemic species of Europe (Andrieu et al., 2007). In Kosovo, *P. officinalis* has been recorded in one locality only, that is, Mt. Pashtrik (Fig. 2). There, it was observed growing in subalpine calcareous grasslands at altitudes ranging from 1390 to 1400 m a.s.l. (Fig. 3, Table 2). It typically appears as solitary individuals, sometimes forming scattered groups, and occasionally, it is found growing in proximity to Turkish hazel (*Corylus colurna* L.) trees. Based on its observed locations and associated vegetation types in Mt. Pashtrik, *P. officinalis* is best assigned to the following EUNIS habitats:

- habitat code: E4.4 (calcareous alpine and subalpine grasslands) and
- habitat code: G1.6 (beech forests): These habitats encompass the ecological range where it thrives, from nutrient-rich calcareous grasslands to transitional forested areas.

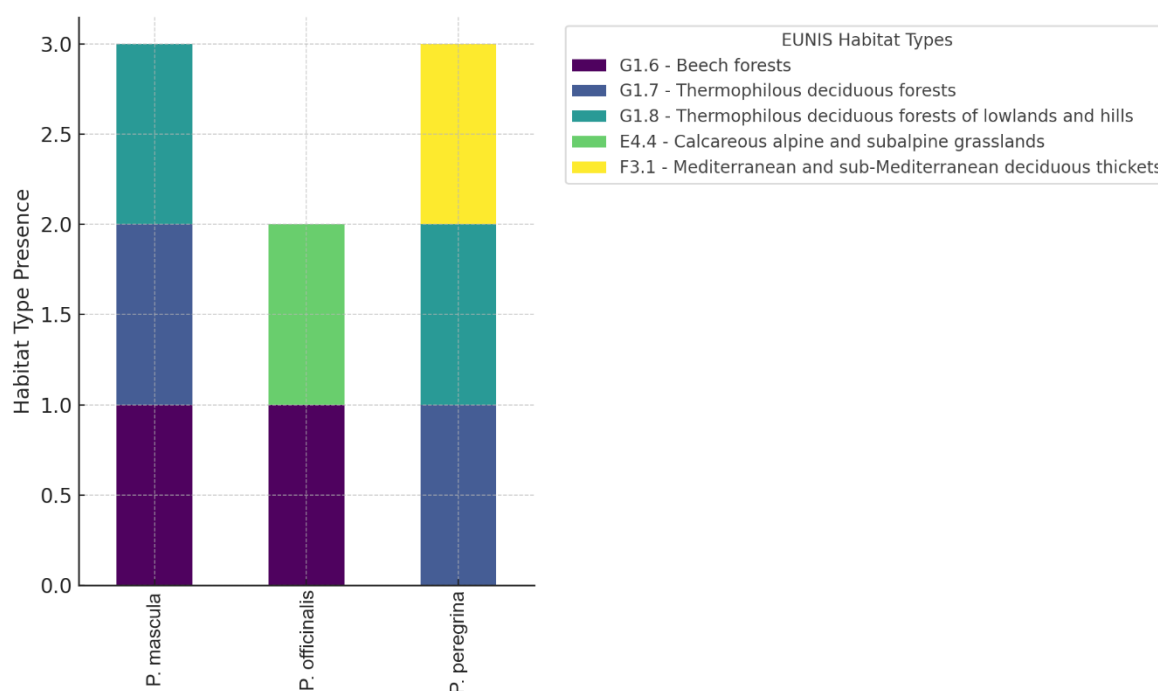


Fig. 4. The bar chart visualising the distribution of three *Paeonia* species across various EUNIS habitat types in Kosovo.

P. peregrina Mill. (syn. = *P. decora* G. Anderson) is a species native to Europe and Turkey. In Europe, it is distributed in its southern and southeastern parts, from Greece, Albania, Bulgaria, North Macedonia, Montenegro and Serbia to Romania, European Turkey and Moldova (Aghababian, 2011; Hong, 2010; Dane, Olgun, 1997). In Kosovo, *P. peregrina* has been recorded in four localities: Gllarevë (along with some surrounding areas), Llapçevë, Gërmi and Gazimestan (Fig. 2). In these localities, it was thriving in oak forests and shrubs at altitudes ranging from 500 to 730 m a.s.l. (Fig. 3, Table 2). Given the natural vegetation types where the species thrives and the accompanying plant species it has, *P. peregrina* populations fall into the following EUNIS habitat types:

- habitat code: G1.7: thermophilous deciduous forests (including *Quercus frainetto* and *Quercus pubescens* forests),
- habitat code: G1.8: acidophilous *Quercus*-dominated forests (for the *Quercetum frainetto-cerris* association) and
- habitat code: F3.1: mediterranean and sub-mediterranean deciduous thickets (to account for the *Cratogeomys-Prunetum spinosae* community).

As for the habitat preferences and adaptability of each *Paeonia* species, the EUNIS habitat types highlight their ecological insights as shown on Fig. 4. *P. mascula* is present in three distinct habitat types: G1.6 (beech forests), G1.7 (thermophilous deciduous forests) and G1.8 (thermophilous deciduous forests of lowlands and hills). This indicates a broad adaptability to different forest environments, suggesting that *P. mascula* can thrive in a variety of deciduous forest types, from cooler beech forests to warmer, lowland thermophilous forests. *P. officinalis*, on the other hand, is found in two specific habitat types: E4.4 (calcareous alpine and subalpine grasslands) and in

a narrowly limited site on G1.6 (beech forests). This limited range suggests a preference for higher altitude and calcareous environments, indicating that *P. officinalis* is more specialised in its habitat requirements. *P. peregrina* demonstrates a high degree of ecological flexibility, occupying three habitat types: G1.7 (thermophilous deciduous forests), G1.8 (acidophilous *Quercus*-dominated forests) and F3.1 (mediterranean and sub-mediterranean deciduous thickets). The presence of this species in both deciduous forests and mediterranean thickets, especially those dominated by *Quercus* species, shows its adaptability to a variety of forest and shrubland environments. The habitat diversity of *Paeonia mascula* and *P. peregrina* (Fig. 4) is broader compared to that of *P. officinalis*, which is more specialised in high-altitude, calcareous habitats.

Population trends and conservation status

The populations of *P. mascula* are characterised by very limited areas of natural distribution and a small number of recorded mature individuals. Specifically, the populations in Pashtrik Mt., Istog Mt. and Mushtisht Mt. have particularly restricted distribution areas. These populations are under significant threat due to habitat degradation, fires and deforestation. Considering all populations of the species within the country, EOO is <5,000 km² and AOO is <400 km². Based on these factors and the current surveyed situation, the species is nationally classified under the IUCN (International Union for Conservation of Nature) category as Endangered (EN): EN-B2ab (i, ii) (Millaku et al., 2013). The status of *P. mascula*, which was assessed as EN in 2013 (Millaku et al., 2013), remains fully valid even after 10 years. This is because the popula-

tions of the species and the risks it faces have remained unchanged. This classification reflects the ongoing threats to the habitat and populations of *P. mascula*, emphasising the urgent need for conservation efforts to prevent further decline. The legal and conservation status of *P. mascula* indicates regional variations in protection, with some Balkan countries, for instance, listing it as an EN species, for example, in Bulgaria (Peev et al., 2011) due to habitat threats, while it remains of lesser concern at a broader European level (Bilz et al., 2011).

P. peregrina populations in Kosovo are generally robust and healthy, particularly when compared to the other two *Paeonia* species in the country. However, the four known populations of *P. peregrina* in Kosovo exhibit significant differences in terms of their overall status, threats and population trends. The *P. peregrina* populations in Gllarevë and Mirushë are especially under pressure from quarrying activities, which have increased and expanded at the expense of the natural populations of *P. peregrina*. In contrast to other regions where the species typically grows on limestone substrates, several individuals in the Mirusha region (Llapçevë-Volljakë) have been observed on serpentine substrates (Krasniqi, 2003). Furthermore, a new highway is currently being constructed across the species' population in Gllarevë, and this area is also subjected to pressures from stone slate extraction and processing. These combined factors exert substantial pressure and cause considerable damage to the sensitive habitats of the species in this area, leading to habitat fragmentation and population isolation. The other three *P. peregrina* populations are more stable and protected from negative factors, despite the fact that the largest population of the species is located in the already threatened locality of Gllarevë. *P. peregrina* in Kosovo has been evaluated as Vulnerable (VU B1B2 ab (iii, iv)) due to its restricted geographical range and the continuing decline in the quality of its habitat and population size (Millaku et al., 2013). We consider that this threat status remains valid; however, more thorough monitoring and habitat restoration in Gllarevë are highly needed. In Europe, the species is classified as Least Concern (LC), indicating that its populations are widespread and stable, facing no significant threats across the continent (Chadburn, 2014).

P. officinalis, on the other hand, is present in Kosovo at only one locality, with a relatively low number of mature individuals in Pashtrik Mt. It has a very limited distribution in part of the mountain and is particularly threatened by fires, which are likely to occur in the dry calcareous grasslands where the plant grows. In addition, it is threatened by collection due to its medicinal properties. Given that its EOO is less than 300 km² and AOO is less than 200 km², the species' threat status in Kosovo is classified as EN (EN – B1ab(i, ii, iii, iv) + 2ab(i, ii, iii, iv)) (Millaku et al., 2013). In Europe, the species is classified as LC, indicating that its populations are widespread and stable, facing no significant threats across the continent (Chadburn, 2016). However, in the European Red List of Plants (Bilz et al., 2011), a particular subspecies of this species (*P. officinalis* subsp. *banatica* (Rochel) Soó) is classified as Data Deficient (DD) for Europe, meaning that there is insufficient information available to make a direct or indirect assessment of its risk of extinction.

The different conservation statuses of *Paeonia* species in Kosovo highlight the importance of local conservation efforts and the need for tailored management strategies. The fact that *P. mascula* is classified as EN in Kosovo, while in the wider European context it is considered to be of less concern highlights the importance of

regional threats such as habitat destruction and deforestation that are specific to the local environment (Peev et al., 2011). Similarly, *P. peregrina*, although generally robust, is under strong pressure from industrial activities such as quarrying and infrastructure development, particularly in Gllarevë. Increasing industrial activity poses a significant threat to the species' habitat, leading to fragmentation and isolation, which could drastically affect the genetic diversity and viability of populations over time (Millaku et al., 2013).

Furthermore, the situation of *P. officinalis* in Kosovo, which is restricted to a single site with specific ecological requirements, underlines the vulnerability of species with limited distribution ranges. The threat of fires and collection for medicinal purposes exacerbates the risks and calls for urgent conservation measures. Despite being classified as LC at the European level, the local threats in Kosovo require immediate action to prevent further decline (Chadburn, 2016).

In Kosovo, only *P. officinalis* is present; however, since its subspecies *P. officinalis* subsp. *banatica* is included in the European Red List as DD (Bilz et al., 2011), we have chosen to highlight this classification to emphasise the need for additional attention and research on the species within Kosovo.

The conservation challenges faced by *Paeonia* species in Kosovo are reflective of broader trends observed in the Balkans, where habitat fragmentation and anthropogenic pressures remain key threats (Dajić et al., 2012; Chirilă, Vassilev, 2024). Comparing these findings with neighbouring countries could provide a regional perspective and identify shared conservation priorities.

This knowledge of the habitat preferences and threats facing *Paeonia* species in Kosovo can not only inform conservation strategies at the national level, but also contribute to broader regional conservation efforts in the Balkans and Europe.

Conclusion

This comprehensive study of *Paeonia* species in Kosovo provides important insights into their diversity, distribution, habitats and threats. The three species studied, *P. mascula*, *P. officinalis* and *P. peregrina*, have different ecological preferences and face different conservation challenges. *P. mascula*, which is classified as endangered, continues to suffer from habitat destruction and limited distribution, highlighting the need for targeted conservation measures. *P. peregrina*, while generally robust, is under significant pressure from industrial activities, particularly in Gllarevë, necessitating immediate habitat restoration and monitoring. *P. officinalis*, with its limited distribution and vulnerability to fires and collection, also requires urgent conservation action.

The local conservation status of these species underlines the importance of regional assessments and tailored management strategies. This study provides valuable baseline data that can inform future conservation efforts and policy decisions in Kosovo. Continued monitoring and detailed ecological studies are essential to protect these species from further decline. The results of this study not only contribute to national conservation efforts, but also provide valuable insights for broader regional initiatives in the Balkans and Europe.

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