Journal of Plant Development
Vol. **31**, Dec **2024**: 207-214
DOI: 10.47743/jpd.2024.31.1.963

ISSN 2065-3158 print / e-ISSN 2066-9917
Available online: www.plant-journal.uaic.ro

Research Article

MAIN THREATS AFFECTING *ARNICA MONTANA* L. IN THE NORTHEASTERN REGION OF ROMANIAN CARPATHIANS

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Abstract: The current paper is focused on an emblematic medicinal species, *Arnica montana*, and on identification of the main threats it faces in the northeastern region of Romanian Carpathians. The species was investigated in 30 localities, in various habitats, characterized by different land management types, and different floristic composition of plant communities. The most important threat for *A. montana* in NE Carpathians was the habitat loss, mainly caused by abandonment of the traditional meadows management and natural succession of vegetation. Accumulated data underline the importance of management measures for *A. montana*, measures that have controlled and maintained the habitats of montane grasslands over time. The most suitable method of maintaining habitats in a favorable state of conservation could be represented by a combination of mowing and moderate intensity grazing while maintaining a level of fertilization as low as possible. Collection of flower heads for medicinal purposes must be avoided in small size populations.

Keywords: *Arnica montana*, conservation, grasslands, management, threats.

Introduction

The extinction rate of numerous plant species has accelerated [HUMPHREYS & al. 2019] in the last decades as a result of degradation of natural habitats due to (among others) their inadequate management, overexploitation, urbanization or climate change. Detailed knowledge about threats to plant species is mandatory in elaborating and implementing conservation strategies [HERNÁNDEZ-YÁÑEZ & al. 2016]. Comprehensive assessment of threats to a certain plant species will enable specific approaches in development and implementation of conservation actions [GALLAGHER & al. 2023]. While conservation efforts are mainly focused on endemic species or those with narrow distributions, conservation of medicinal plants is essential because of their role in human health [SHUKLA, 2023].

Arnica montana L. is one of the approximately 30 species of the *Arnica* spp. genus, distributed in Europe, Asia and North America [SCHMIDT, 2023]. It is a medicinal, perennial forb, with European areal. It grows in nutrient-poor pastures and hayfields, forest glades, or heathlands from lowlands up to the mountain or subalpine vegetation belts [CIOCÂRLAN, 2000; MAURICE & al. 2012; DUWE & al. 2017; PĂCURAR & al. 2023], up to 3000 m a.s.l. [DUWE & al. 2017]. From an ecological point of view, it is a heliophilous species, but it can tolerate a certain degree of shading, preferring moderately moist, acidic and nutrient-poor soils

Received: 29 October 2024 / ***Revised***: 4 December 2024 / ***Accepted***: 9 December 2024

[ELLENBERG & al. 1992; SÂRBU & al. 2013]. It is a diagnostic species for secondary grasslands on nutrient poor soils classified in class *Nardetea strictae* Rivas Goday et Borja Carbonell in Rivas Goday et Mayor López 1966 (more frequent in plant communities within *Nardetalia strictae* Preising 1950 order), but significant populations can be identified in class *Calluno-Ulicetea* Br.-Bl. et Tx. ex Klika et Hadač 1944 (in vegetation of *Vaccinio myrtilli-Genistetalia pilosae* Schubert ex Passarge 1964 order) or *Molinio-Arrhenatheretea* Tx. 1937 (in particular in plant communities classified in order *Arrhenatheretalia elatioris* Tx. 1931) [CHIFU & al. 2015; MUCINA & al. 2016]. The species has both the capacity for vegetative propagation by the long-living rhizomes as well as for sexual reproduction, but it is fully self-incompatible [LUIJTEN & al. 1996; BEGEMANN, 2022]. Despite pappus presence, the fruits have a limited dispersal ability [STRYKSTRA & al. 1998], while the seeds generally germinates in the autumn and do not form a bank in the soil [BEGEMANN, 2022].

The decline of *A. montana* populations made it a species of European Community interest whose sampling from nature and exploitation should be carried out considering certain management measures according to the Habitat Directive (1992). It was also included in the Red List of cormophytes from Romania, as a vulnerable species [OLTEAN & al. 1994]. Cultivation of *A. montana* as a form of *ex-situ* conservation or as resource for pharmaceutical industry or reintroduction programs is challenging. A series of studies highlighted that it is a recalcitrant species in culture, the establishment and maintenance of plantations being relatively difficult and strongly dependent on climatic and edaphic conditions [SUGIER, 2007; SURMACZ-MAGDZIAK & SUGIER, 2012]. Also, differentiation and propagation potential of achenes depend on the morphological diversity of flowers and position of flower heads on the plant [SUGIER & al. 2022]. Similar studies carried out in Bulgaria [BALABANOVA & VITKOVA, 2016] showed that *A. montana* can only be successfully cultivated at altitudes above 1400 m, on acid soils, while in Serbia the species was cultivated at altitudes above 1000 m [PLJEVLJAKUŠIĆ & al. 2014], in contrast to northern Europe (Finland, Poland) where the species was cultivated at lower altitudes [SUGIER & al. 2013; SUGIER & al. 2022]. In addition, for some low altitude, and more isolated populations there was highlighted the genetic erosion phenomenon, a restricted gene flow among populations, and an increase of vegetative reproduction [DUWE & al. 2017; MAURICE & al. 2016]. Still, a large geographical distance and consequently increased genetic distance between populations can have negative effects generated by outbreeding depression, and the projects of reintroduction or restocking must be locally implemented [BEGEMANN, 2022].

Land management, abandonment of traditional practices, habitat loss and collection of flower heads for medicinal purposes are some of the various threats for persistence of this species [KATHE, 2006; PĂCURAR & al. 2007; ROTAR & al. 2010; MARDARI & al. 2019; HOLLMANN & al. 2020]. But, as HOLLMANN & al. (2020) emphasized, the threat types can be different depending on the location of *A. montana* populations and conservation actions may differ. Thus, the main objective of this article is to identify and characterize the major threats faced by *A. montana* in the northeastern region of Romanian Carpathians.

Material and methods

Identification and inventory of the natural populations of *Arnica montana* in the northeastern region of the Romanian Carpathians was carried out during 2014-2017 vegetation seasons. Most of locations were revisited in 2023-2024. Numerous transects were performed in different localities in several mountainous massifs, transects along which the populations of *A.*

montana were identified, counts were made in sample plots, and the main threats were registered and characterized. For all identified populations were registered floristical and phytosociological data, while the species' abundance and its population structure were also investigated.

Results and discussions

In the studied region, *Arnica montana* was identified in three types of habitats including six plant communities in 30 locations from Suceava, Neamț, and Bistrița-Năsăud counties: Sadova, Lucina, Tihuţa Pass, Valea Putnei, Cârlibaba, Piatra Fântânele, Călimanul Cerbului (three stations), Pietrosul Bistriței, Panaci, Șaru Dornei, Gura Haitii (two stations), Sabasa, Coverca, Drăgoiasa, Ortoaia (two stations), Chiril, Obcina Feredeului, Ceahlău, Dorna Arini (three stations), Rarău, Tarnița, Stulpicani, valleys of Farcașa și Neagra Broștenilor rivers (in Bistriței, Călimani, Stânișoarei, Rarău, Suhard, Bârgăului, Obcina Mestecănișului, Obcina Feredeului Mountains). *A. montana* was a part of the floristic compositions of some mesophilic secondary grasslands (pastures and meadows), acidophilous shrub communities (mainly in subalpine belt), grasslands - scrublands ecotones, abandoned pastures, etc. (Figure 1). More detailed information for each of these, aspects related to the location and characteristics of the populations, the floristic and phytosociological composition, the plant communities that define the type of habitat and references to the abundance of the species were presented in MARDARI & al. (2015, 2019).

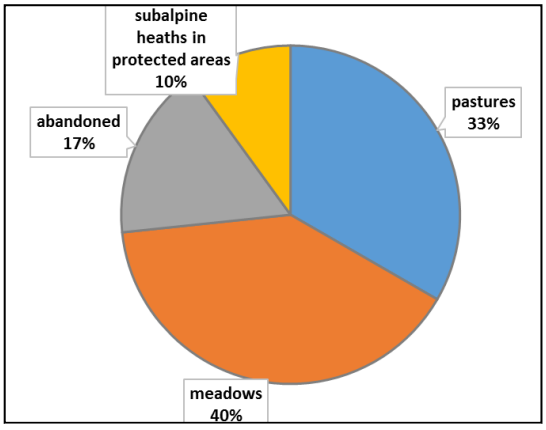

Figure 1. Distribution of *Arnica montana* sites depending on land management

The most important threats for *A. montana* in NE Carpathians are the habitat loss and fragmentation, mainly caused by abandonment of the traditional meadows management and secondarily caused by the expansion of human settlements (resulting in the destruction of the natural habitat and the extinction of local populations located on private properties, near or inside localities on lands suitable for various constructions). No threats from non-native invasive plant species were recorded in the studied habitats while the effect of tourism and recreation activities was negligible.

Land abandonment is perhaps the most significant threat for *A. montana* in the investigated areas because, through natural succession, it induces changes, in both the floristic composition of grasslands and on their functional and specific diversity. Abandoning mowing in grasslands (and even rational grazing) favors the establishment of some species of shrubs or trees (e.g. *Picea abies*) that, in turn, facilitates the colonization of meadows by other more competitive herbaceous species, changing their floristic composition (Figure 3). Maintaining the knowledge and practices of traditional use of meadows (mowing and grazing) represents the best solution for reducing the effect of abandonment in the studied region. Accumulated data underline the importance of management measures for *A. montana*, measures that have controlled and maintained montane grasslands over time. Mowing ensures the periodic

removal of dominant and competitive species and thus diminishes the competition relations, maintains the diversity of mountain meadows and favors species with leaves arranged in basal rosettes (Figure 2). Mowing also improves the light regime at ground level and prevents the accumulation of litter (which facilitates the establishment of juvenile *A. montana* individuals).

Figure 2. Mountain hay meadow with *Arnica montana* in Gura Haitii (Suceava county)

Figure 3. Abandoned grasslands and ecological succession in Călimani Mountains

In addition, a moderate grazing regime results in a decrease in the abundance of some dominant *Gramineae* species (animal selectivity) with an effect on the vertical structure of meadow communities, a positive effect that favors rosettes species. Grazing also reduces

competition in meadows and animals can represent vectors of seed and fruit dispersal of certain plant species, thus ensuring connectivity between populations and the recolonization of degraded habitats [ROSENTHAL & al. 2012]. The decrease in the density of *A. montana* individuals on unused or abandoned land can be interpreted as an effect of natural succession, whereby shrub species or young trees which facilitate the establishment of other grass species which through competition can eliminate the species typical of meadows developed on nutrients poor soils. In addition, in abandoned meadows there is a significant accumulation of litter, with an inhibitory effect on young plants mainly through physical obstruction and modification of the light regime.

Another effect of land abandonment is represented by the invasion of meadows by a series of native and highly competitive species that have the ability to build dense, compact communities, with rapid expansion, communities that in a short period of time modify the floristic composition of initial grasslands, and the diversity and abundance of species in mountain meadows.

Intensive grazing, especially by sheep, results in the invasion of meadows by some nitrophilous ruderal species that build dense communities (e.g. *Rumex alpinus*), sometimes over large areas, which gradually eliminate the semi-natural meadow communities. Because *A. montana* is a species with a rosette of basal leaves, it tolerates grazing well, but soil compaction by animals can have a negative effect on its populations. Respecting the grazing period, rotational grazing (because animal species are selective), correct determination of the pastoral value of meadows, and of maximal number of animals grazing per unit area of grassland are some ways to reduce the impact of this traditional activity on *A. montana* populations.

A usual practice in the investigated area is that of soil fertilization using natural manure. Increasing the amount of fertilizers also has negative effects, as the species prefers nutrient-poor soils. This effect can be explained by the fact that an increase in the amount of nutrients in the soil can determine the dominance of one-two-three species and the generation of an asymmetric competition, manifested against smaller (in size) and slower-growing species. Another possible explanation is related to the fact that ammonium ions are, in particular, toxic for this species because they prevent the formation of mycorrhizae and reduce the competitive abilities of the species [DUECK & ELDERSON, 1992; MAURICE & al. 2012]. This aspect could be important in the development of possible conservation strategies for the species, strategies that could suggest maintaining a low level of soil fertilization that is practiced in the studied region in order to increase the vegetal biomass production.

In most locations (e.g. Tihuţa Pass, Valea Putnei, Piatra Fântânele, Gura Haitii, Sabasa, Coverca, etc.) the habitat of mountain hay meadows presents a favorable state of conservation (because there are no major disturbances in terms of their surface, in structure and composition of plant communities). Their management – the lands are mowed – ensures the prospects of preserving these parameters in the future. For other populations (e.g. Sadova, Ortoaia, Obcina Feredeului, Dorna Arini, etc.), the habitat condition is inadequate (because of the abandonment of traditional management favoring the establishment of woody species, and of irrational grazing causing changes in the floristic composition of the meadows and their transition towards low-value *Nardus* grasslands). Also the species rich *Nardus* grasslands on siliceous substrates, in most locations (e.g. Chiril, Panaci, etc.) present a favorable state of conservation (the lands are mowed or moderately grazed). The threats to the habitat of subalpine heaths are minor as they are located in the perimeter of some protected areas (in strictly protected perimeters or inaccessible stations from Ceahlău National Park and Călimani National Park).

From another perspective, the main reason why the species is considered threatened is the excessive collection for medicinal use. The excessive collection of inflorescences, for an income source – as a type of disturbance, can significantly influence the populations of *A. montana*, in the long term, even in areas where the species was very abundant (e.g. Sabasa, Gura Haitii, Dorna Arini, Șaru Dornei, etc.). However, the effect of collecting inflorescences can be significant in the long term, by decreasing the genetic diversity and even causing the disappearance of smaller populations. Thus, the conservation strategy of this species must include a rational collection of flower heads only in areas where the species is abundant and only based on resource assessment and is strongly connected to habitat conservation. A project developed in central and northern regions of Apuseni Mountains (Romania) represent an excellent example of sustainable collection of *A. montana* and conservation of its habitat by maintaining the traditional management of grasslands, based on the participatory approach of both landowners and harvesters [PĂCURAR & al. 2023].

Conclusions

Overall, the results of this study are consistent with the hypothesis that the conservation of the species *A. montana* is dependent on the management measures applied to the habitat. The species requires that grassland mowing measures and low intensity grazing to be implemented after the achenes have matured. Mowing removes competitive species and prevents natural succession. Under these conditions, the most suitable method of maintaining habitats with *A. montana* in a favorable state of conservation could be represented by a combination of mowing and moderate intensity grazing and maintaining a level of fertilization as low as possible. Collection of flower heads for medicinal purposes must be avoided in small size populations.

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How to cite this article:

MARDARI C., BÎRSAN C. C., ȘTEFANACHE C. P. & TĂNASE C. 2024. Main threats affecting *Arnica montana* L. in the northeastern region of Romanian Carpathians. *J. Plant Develop*. **31**: 207-214. https://doi.org/10.47743/jpd.2024.31.1.963