
**ENDEMIC FLORA OF THE CARPATHIANS: THE IMPORTANCE
OF DIGITALLY INTEGRATING SCIENTIFIC INFORMATION
OF MAJOR CARPATHIAN REGION HERBARIA**

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The Carpathian Region is recognised as one of the most biodiverse regions of Europe, encompassing both a high global plant species richness and a high number of endemics. However, distribution data residing from old herbarium collections is often hard to access, although the information is relevant for a wider audience of researchers going beyond the single-country level. Here we aim to review the major role of herbarium collections in holding relevant information for the distribution of CR endemic plant taxa and the importance of herbarium digitization as both a more straightforward and non-invasive method of herbarium data visualization, investigation and data sharing within the CR and a tool for increasing the scientific knowledge in plant conservation strategies. We present an overview of the endemic taxa type specimen distribution among few selected major herbaria and the country-level spatial structure of endemic taxa specimens preserved in several of these herbaria in order to highlight the relevance of herbarium collections for researchers from other countries.

Keywords: herbarium, historical collections, distribution, digital information, database, biodiversity, endemism

Extended summary

Generally recognized as being among the major European biodiversity hotspots, the Carpathian Region (CR), including here the Carpathian Mountains and the Transylvanian Plateau, is characterized by both high global plant species richness and a high level of endemism of angiosperms. Crossing eight different countries (Austria, Czechia, Slovakia, Poland, Ukraine, Hungary, Romania and Serbia, with varying coverage), the Carpathian Region's natural habitats are included in a network of nature reserves across all these countries.

Rarely, such protected areas are being shared by two countries that co-manage trans-border Natural or National parks. In such rare cases, information exchange among neighbouring countries effectively increase the efficiency of protected areas' management. However, the majority of protected areas within our region are confined to the national borders of a single country.

In all cases, their establishment and management require accurate information on general distribution, global population assessments and extinction threat evaluation of species. Among the elements especially prone to be affected by various disturbance factors and extinction threats are the endemic taxa, elements with usually narrower distribution compared to other taxa. Moreover, such elements represent the most authentic biological inheritance of a region and they are unique indicators of biodiversity.

In order to obtain a realistic overview on the value and effectiveness of conservation strategies, one prerequisite is to assess all available distribution information on endemic species, an important focus of the conservation efforts. However, such information is spread over a multitude of sources within the CR, including local literature and herbarium collections, resources that are not always easily accessible for researchers from other CR countries. Here, we will discuss the role of the herbarium collections in preserving and making available knowledge on the distribution of endemic plant taxa. We focus on the relevance of collected data for researchers from other countries other than the collection is currently established and the importance of enhanced and efficient data sharing among researchers at the Pan-Carpathian scale (thus going beyond the single-country perspective).

Following a period of rich botanical explorations in the 19th and the first half of the 20th century, herbarium data were preserved in several major herbaria across the CR, not necessarily corresponding to the current configuration of national borders. This period was essential for the discovery of most Carpathian endemics and for building the knowledge on their distribution across the region. However, notwithstanding the herbarium collection exchanges through national flora exsiccates or individual specimen duplicates, many herbaria hold important and unique distributional data that are relevant for researchers in other countries. Specimens found recently in the BP collection (Hungarian Natural History Museum Herbarium, Budapest) can serve as pertinent examples of such numerous data. They uncover a new locality for *Pedicularis baumgartennii*, a very rare South-Eastern Carpathian endemic with only five previously known populations, collected in the Buila-Vânturarița Massif, or a specimen of *Silene zawadzki* recorded from the Bucegi Mts. (both mountain ranges protected and managed as National or Natural Parks). Herbarium explorations provide important biodiversity-relevant data that were previously unknown (following the abovementioned examples, to the Romanian researchers) although such specimens were often collected more than 50 years ago.

Major herbaria harbouring important collections for the endemic CR flora were established in several important academic institutions, including (herbarium acronyms [Thiers, continuously updated] and approximate number of recorded specimens of the collections in parentheses): the Herbarium of the Natural History Museum, Vienna, Austria (W, 5,500,000), the Herbarium of the University of Vienna, Austria (WU, 1,400,000), the Herbarium of the Charles University, Prague, Czechia (PRC, 2,200,000), the Herbarium of the National Museum in Prague, Czechia (PR, 2,000,000), the Herbarium Carpato-Pannonicum of the Hungarian Natural History Museum in Budapest, Hungary (BP, 2,097,424), the Herbarium of Debrecen University, Hungary (DE, 70,000), the Herbarium of the Polish Academy of Sciences, Kraków; Poland (KRAM, 1,227,500), the Herbarium of the Jagiellonian University, Kraków, Poland (KRA, 800,000), the Herbarium of the Wrocław University, Poland (WRSL, 500,000), the Herbarium of the University of Warsaw, Poland (WA, 450,000), the Herbarium of the Babeş-Bolyai University, Cluj-Napoca, Romania (CL, 660,000), the Herbarium of the Bruckenthal Natural History Museum, Sibiu, Romania (SIB, 180,000), the Herbarium of the "Dimitrie Brândză" Botanical Garden, Bucharest, Romania (BUC, 520,000), the Herbarium of the Institute of Biology of the Romanian

Academy, Bucharest, Romania (BUCA, 400,000), the Herbarium of the University of Craiova, Romania (CRAI, 400,000), the Herbarium of the Slovak Academy of Sciences, Bratislava, Slovakia (SAV, 322,495), the Herbarium of the Slovak National Museum, Bratislava, Slovakia (BRA, 467,394), the Herbarium of the Natural History Museum, Belgrade, Serbia (BEO, 490,000), the Herbarium of the Ivan Franco National University of Lviv, Ukraine (LW, 270,000), the Herbarium of the Museum of Natural History, Lviv, Ukraine (LWS, 115,000), the Herbarium of the "Yuriy Fedkovych" Chernivtsi State University, Ukraine (CHER, 150,000) or the Herbarium of the "M.G. Kholodny" Institute of Botany, National Academy of Sciences of Ukraine, Kiev, Ukraine (KW, 2,263,207) among others.

In this review we aim to present the major role of herbarium collections in holding relevant information for the distribution of CR endemic plant taxa and the importance of herbarium digitization as both a more straightforward and non-invasive method of herbarium data visualization, investigation and data sharing within the CR and a tool for increasing the knowledge in plant conservation strategies. Moreover, we focus on presenting an overview of the type specimen data distribution among several major herbaria and the country-level spatial structure of endemic taxa specimens preserved in these herbaria, in order to highlight the relevance of certain collections for endemic plant researchers from other countries.

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ЕНДЕМІЧНА ФЛОРА КАРПАТ: ВАЖЛИВІСТЬ ЦИФРОВОЇ НАУКОВОЇ ІНФОРМАЦІЇ З ГЕРБАРІЇВ КАРПАТСЬКОГО РЕГІОНУ

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Карпатський регіон належить до найбагатших на біотичне різноманіття регіонів Європи, що поєднує в собі водночас велике загальне видове багатство зі

значним числом ендеміків. Однак інформація щодо поширення рослин, представлених у давніх гербарних колекціях, часто є важкодоступною. Будучи важливим джерелом даних для міжнародної спільноти, часто такі колекції обмежені використанням на локальному рівні в межах однієї країни. Тому ми маємо на меті наголосити на важливій ролі гербарних колекцій у представленні даних про поширення ендемічних рослин Карпатського регіону, доцільності використання оцифрування як перспективного і неінвазивного методу візуалізації, опрацюванні та поширенні гербарного матеріалу серед наукової спільноти, а також у необхідності дослідження стратегій збереження цих рослин. Зокрема, щоби підкреслити важливість гербарних колекцій для дослідників з інших країн, ми представляємо огляд поширення окремих ендемічних таксонів у регіоні на підставі опрацювання типових зразків із кількох основних гербаріїв, а також результати просторового розподілу цих таксонів на рівні країн на підставі аналізу окремих гербарних колекцій.

Ключові слова: гербарій, історичні колекції, поширення, цифрова інформація, бази даних, біорізноманіття, ендемізм