



Biogeography of the Carpathians: towards a better understanding of biodiversity patterns

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The Carpathians are one of the most extensive mountain ranges of the European Alpine System (Ozenda 1985) and a widely recognised mountain biodiversity hotspot in Europe (Schmitt 2009; Bálint et al. 2011; Mráz and Ronikier 2016). Additionally, although well-delimited from geomorphological point of view, the Carpathian Region (with its subunits, i.e. the Western, Eastern and Southern Carpathians, the Apuseni Mountains and the Transylvanian Basin) is closely linked through its shared biotic components with the neighbouring mountainous regions of the Alps, the Hercynian Massif, and the Balkan Peninsula (Stevanović 1996; Coldea 2003; Aeschmann et al. 2004; Puşcaş and Choler 2012; Jablonski et al. 2016). Evolution and spatial distribution of taxa and genetic lineages, and assembly of biotic communities in this region, were largely shaped by an interplay of geomorphology, habitat distribution, and past climatic oscillations during the Tertiary and Quaternary, which alternated periods of biotic interchange among regions with periods of increased isolation. The consequences of lineage divergence, as well as the role of both ecological and historical factors in driving evolutionary processes and shaping biogeographical patterns, have become the focal point of burgeoning research

initiatives over the last decade (reviewed by Ronikier 2011; Mráz and Ronikier 2016), further pursued with numerous recent studies (Šrámková-Fuxová et al. 2017; Wielstra et al. 2017; Jarčuška et al. 2019; Juříčková et al. 2019; Melichárková et al. 2019; Pârvulescu et al. 2019; Tkach et al. 2019; Zajac et al. 2020). The ever-increasing scientific interest for the biogeography of the Carpathian Region required a dedicated framework for sharing ideas and results in order to provide a clearer and thorough overview. This led to the establishment of the Biogeography of the Carpathians series of conferences.

The present topical collection of Plant Systematics and Evolution arose from The Second Interdisciplinary Symposium *Biogeography of the Carpathians—ecological and evolutionary facets of biodiversity*, held on 28–30 September 2017, Cluj-Napoca, Romania. This edition of the symposium was organised within the framework of a long-term international collaboration and continued the idea of the first edition of this meeting initiated and organised in 2013, in Kraków (Poland), which proved successful and timely as an information exchange platform for the scientific community interested in the Carpathian biodiversity (Mráz and Ronikier 2016; abstracts available at https://abcbot.pl/pdf/suppl55_1/sup_55_s1.pdf). The central theme and aim of the Cluj-Napoca symposium was to further present and discuss the most recent advances on the biodiversity, biogeography and evolution in the Carpathian region, focused on several topics such as: the historical and ecological biogeography and the drivers of evolution and species assemblages, the Carpathians in a larger biogeographical context, and finally the diversity of Carpathians (from genes to ecosystems) and its conservation. The symposium brought together about 130 scientists from 11 countries (Austria, Czechia, France, Germany, Hungary, Poland, Romania, Serbia, Slovakia, UK and Ukraine), who covered various disciplines, ranging from systematics (plants, animals, algae, fungi, lichens) to ecology, biogeography, palynology or conservation biology.

Contribution to “Biogeography of the Carpathians”.

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Abstracts of all contributions have been published in a special issue of *Studia Universitatis Babeş-Bolyai, series Biologia*, Volume 62, Special Issue, 2017 (available online at <http://studia.ubbcluj.ro/download/pdf/1106.pdf>).

The papers published in the Biogeography of the Carpathians topical collection are mostly derived from the presentations given at the meeting. Consequently, they provide a good overview of the latest research carried out in the Carpathian Region, related to the above-mentioned topics. The largest set of papers concerns spatial patterns of diversity including their taxonomical resonance. Skokanová et al. (2019) and Šrámková et al. (2019) focus on phylogeographic patterns and the taxonomy of two intricate groups: *Tephrosieris longifolia* agg. and *Arabidopsis halleri*, respectively. Using a wide range of molecular markers and multivariate morphometric analysis, the authors provide taxonomic and biogeographic treatment of the infraspecific variation of both groups in the Carpathians and adjacent regions (the Alps, the Balkans and the Hercynian Massif). In a similar spatial context, the role of the Carpathians as an important glacial refugium and their connections with neighbouring areas are highlighted by a study on *Doronicum austriacum* (Stachurska-Swakoń et al. 2020). These results, presented in a comparative framework, offer new insights into the phylogeographic patterns of species building subalpine tall-herb communities. The phylogeographic break between the Western and the South-Eastern Carpathians and the close affinity between the Western Carpathian and Sudetes populations appeared as the most significant features shared by all of the so far studied species belonging to the tall-herb plant communities.

Macková et al. (2020) and Mered'a et al. (2019) contribute to the better understanding of a rather complex cytogeography of the Western Carpathians (see Mráz and Ronikier 2016) and present comprehensive cytogeographical surveys in *Cotoneaster* and *Sesleria*, two morphologically variable and taxonomically intricate genera. Spatial patterns of ploidy and genome size variation found in both groups challenge previous taxonomic concepts and clarify the geographical distribution of taxa. These papers demonstrate the usefulness of flow cytometric approach for rapid and accurate ploidy level and genome size assessment thus providing an important tool for discrimination of closely related taxa.

Recent studies on ecological drivers of the Carpathian biodiversity are pictured by a case study of peculiar, isolated habitats, namely 19 saline lakes in the Transylvanian Basin. Spatial structure and taxonomic diversity of the phototrophic primary producer communities that inhabit these extreme saline environments are explored by Şuteu et al. (2021). The authors highlight that, contrary to their initial hypothesis, not salinity but habitat heterogeneity, together with nutrient availability, constitute the main drivers of taxonomic diversity in the investigated lakes. In addition, their results

show that local phototrophic communities are characterised by the presence of rare taxa in more than 60% of cases, challenging the expectation that these algal communities are entirely composed of widespread ecological specialists.

Finally, one paper featured in this special issue does not provide original data but rather an important research perspective. Breman et al. (2020) outline a new, international project launched by the Carpathian Research Network (CRN), an international consortium (involving researchers from Czechia, Slovakia, Poland, Ukraine, Hungary, Romania and France) that endeavours to overcome previous drawbacks of country-specific research and conservation activities that limited data sharing and maintained contrasting chorological and taxonomic knowledge among neighbouring Carpathian countries. In the present time, when climate change poses a higher than ever need of understanding the larger picture of biodiversity patterns by accessing big datasets (Franklin et al. 2017), this initiative appears highly needed to provide an adequate framework for effective assessment of the Carpathian biodiversity. Among the main goals, the CRN aims to produce the first comprehensive taxonomical and biogeographical synthesis of the Carpathian endemic vascular flora, to better understand the underlying processes involved in its evolution and distribution, and to improve its conservation.

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