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Morphological variation of *Jovibarba heuffelii* (Crassulaceae) in the central Balkan Peninsula—The impact of geological, orographical and bioclimatic factors on the differentiation of populations

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Abstract

The aim of this study was to quantify and compare morphological variation between 14 populations of *J. heuffelii* distributed in Serbia, Romania, Bulgaria and Macedonia and to correlate their morphological characteristics with the geomorphologic and bioclimatic parameters of their habitats. For these purposes, several multivariate analyses (PCA, CDA, clustering UPGMA analysis based on Mahalanobis distances, MCA, and Spearman's correlation) of the vegetative and generative plant organs were performed. Analyses showed that apart from the overall morphological variability, which is related to environmental conditions, there are four groups of populations that are morphologically distinct. Although the results clearly indicate the significant influence of environmental factors (elevation, aspect and slope) on the morphology of the species, we found that recent bioclimatic conditions, geological substratum and geographical position are only of secondary importance in the pattern of morphological variation in *J. heuffelii* in the area investigated.

Key words: characters, Diopogon, ecological differentiation, morphometrics, taxonomy

Introduction

The genus *Jovibarba* Opiz (1852: 54) (Crassulaceae) is endemic to Europe (Jalas *et al.* 1999). It is distributed in the Alps, the Carpathians and the Balkans (Meusel *et al.* 1965). The main morphological characteristics that separate the representatives of the genus *Jovibarba* from genus *Sempervivum* Linnaeus (1753: 464) are flowers with 6 (sometimes 7) petals in contrast to 8–16 petals in *Sempervivum*. Microscopic observations also indicate differences in pollen morphology (Parnell 1991) and ornamentation of the seed coat (testa) (Knapp 1994). The results of recent molecular research have shown that *Jovibarba* and *Sempervivum* s. str. are monophyletic sister-groups / sister-clades (Mort *et al.* 2002, 2010; Zonneveld 2005; Topalov *et al*. 2006; Šinko *et al*. 2013). Phytochemical research by Stevens *et al*. (1996) has supported the classification of *Jovibarba* and *Sempervivum* s. str. in subordinate ranks (subgenus, section) within a broadly circumscribed *Sempervivum* s. l. which also includes *Jovibarba* (De Candolle 1828; Berger 1930; Hart *et al.* 2003).

According to the last edition of Flora Europea (Parnell & Favarger 1993), *Jovibarba* includes only two species: *J. globifera* (Linnaeus 1753: 464) J. Parnell (1990: 219) and *J. heuffelii* (Schott 1852: 18) A. & D. Löve (1961: 39). Originally both species were described as taxa within the genus *Sempervivum* (Schott 1852). *J. globifera* has a wide range of distribution including the Alps, central Europe and the Carpathian mountains, compared to *J. heuffelii* which is distributed in the central part of the Balkan Peninsula and central and southern parts of the Carpathians (Meusel 1965; Jalas *et al*. 1999). Nearly all authors have recognized different numbers of subspecies within *J. globifera*. Lack of stolons, vegetative reproduction by symmetrical splitting up of the parent rosette into two or more equal rosettes and campaniform corolla with nonfimbriated petals are the main characteristics which separate taxa in the *J. heuffelii* group from the *Jovibarba globifera* group. Another conspicuous character is the dimension of mature rosettes of the *J. heuffelii* taxa, which have larger diameters than the rosettes in the *J. globifera* group (Praeger 1932).

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