Morphological differentiation within the *Ranunculus cassubicus* group compared to variation of isozymes, ploidy levels, and reproductive systems: implications for taxonomy

E. Hörandl

Institute of Botany, University of Vienna, Austria

Received November 20, 2001; accepted May 10, 2002
Published online: September 13, 2002
© Springer-Verlag 2002

Abstract. In the partly apomictic *Ranunculus cassubicus* group, a subgroup of the *R. auricomus* complex, two species were studied by morphometric analyses: *R. cassubicifolius* W. Koch (with three diploid and two autotetraploid sexual populations), and *R. carpaticola* Soó (with three diploid sexual populations and a hexaploid apomictic one). Multidimensional scaling analyses (MDS) of individuals, boxplots and cluster analyses of populations revealed a differentiation of *R. cassubicifolius* and *R. carpaticola*, whereby in MDS the hexaploid apomorphic individuals are partly intermediate between *R. cassubicifolius* and *R. carpaticola*. The cytodemes of *R. cassubicifolius* showed no morphological and only a weak genetic differentiation. A comparison of morphology, isozymes, reproductive system and ploidy levels showed only partly congruence of data sets in respect of grouping populations, thus illustrating the problem to find criteria for a taxonomic concept. A treatment of the apomictic population as a separate group is indicated by all data sets, afterwards *R. cassubicifolius* and diploid *R. carpaticola* represent two other well-defined groups. Canonical variate analysis including all characters confirmed the three suggested groups as significantly different and showed that a total of 89.3% of individuals are correctly classified; number of teeth of stem leaf segments and number of petals are the most discriminating characters. Herbarium studies confirm the morphological differentiation yielded from population samples. The three population groups are even better separated in a canonical variate analysis of isozyme data (presence/absence of 25 alleles) of the same material, here 92.6% of individuals are correctly classified. Morphology and isozyme data suggest that the hexaploid apomict originated from hybrids of *R. cassubicifolius* and diploid *R. carpaticola* and must be excluded from the sexual taxa; the final classification and naming of the apomicts must be left for further studies on a larger material. The sexual taxa should be classified as separate species. Herbarium studies indicate that *R. carpaticola* s.str. is widespread over the Carpathians and might include other populations hitherto ascribed to other microspecies as well.

Key words: Apomixis, morphometrics, isozymes, multivariate statistics, polyploidy, *Ranunculus auricomus* complex, taxonomy.

Introduction

The *Ranunculus cassubicus* group is a Central and Eastern European group of apomictic and sexual taxa. Some authors summarize all under *R. cassubicus* L. s.l. (e.g., Tamura 1995), others
treat them as a subgroup within the large *R. auricomus* complex (Borchers-Kolb 1985, Jalas and Suominen 1989, Hörandl and Guter- mann 1998a). The group is morphologically rather well characterized by basal sheets (leaves without blade), large undivided basal leaves, palmate lower stem leaves with dentate-crenate or pinnatifid segments, and large flowers. About 28 microspecies have been described from Central Europe, that differ mainly in the shape of lower stem leaves, in the size of flowers, and in the shape and indumentum of the torus. Several cytodemes occur in this group (2x, 3x, 4x, 5x, 8x; see literature survey in Jalas and Suominen 1989), whereby polyploids usually have apomictic (pseudogamous) mode of reproduction (Häfliger 1943, Jankun and Izmailow 1965, Izmailow 1973).

Recent isozyme studies have revealed that at least two sexual, rather widespread taxa occur in this group: one is *R. cassubicifolius* W. Koch, which comprises diploids from the Swiss Jura to the middle Austrian prealpine foreland, and tetraploids in the Praelps of Lower Austria (Hörandl and Greilhuber, 2002; see map in Fig. 1). Embryological studies (Rutishauser 1954a,b; Nogler 1984; Svoma and Hörandl, unpubl.) and isozyme variation (Hörandl and Greilhuber, 2002) have shown a sexual mode of reproduction for both cytodemes. Allozymes indicate only a weak genetic differentiation of cytodemes and autopoloid origin of the tetraploids (Hörandl and Greilhuber, 2002). Both cytodemes occur in swampy forests, in gorges and along prealpine rivulets (e.g., with *Alnus glutinosa* or *A. incana*).

The second species is *R. carpaticola* Soó, a rather widespread species described from NE. Carpathians (Ucrania) and reported from Slovakia, Hungary and Romania (Soó 1964, Májovský and Murin 1987, map in Jalas and Suominen 1989). It grows mainly in oak (*Quercus cerris*, *Q. petraea*) and hornbeech forests (Soó 1964), in Romania also in beech forests (Hörandl, pers. obs.). Populations from two localities around the small town Revúca in Central Slovakia (Slovenské rudorohoje) and from Romania (South Carpathians, Mt. Buceces) are diploid and sexual according to isozyme studies of Hörandl and Greilhuber (2002). One hexaploid population from Central Slovakia (Ivachnová) had a clonal population structure that is typical for apomictic goldilocks, allelic composition of this population is more similar to *R. cassubicifolius* than to *R. carpaticola*.

**Fig. 1.** Locations of the material examined in this study (see Table 1 for populations and appendix for herbarium material), and distribution of *R. cassubicifolius* (after Hörandl et al. 1997, Hörandl and Guter- mann 1998c, Hörandl 2000)