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Retreat of *Dentaria enneaphyllos* in Rychlebské hory Mts (Czech Republic), in perspective of habitat preferences

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Dentaria enneaphyllos L. is a characteristic herb of species-rich temperate forests of Central Europe. Because the mountain forest ecosystems in the North of the Czech Republic were profoundly changed during the last decades, decline of this sensitive species was expected. Historical (before 1980) and recent distribution and habitat types of *Dentaria enneaphyllos* in Rychlebské hory Mts, a typical Central-European mountainous area are compared. Ecological preferences of the species within the Czech Republic are viewed using information from main phytosociological overviews, and calibrating ELLENBERG indicator values for 646 phytosociological relevés with *Dentaria enneaphyllos* from the years 1930–2000. Historical distribution in Rychlebské hory Mts covered a greater part of the study area, with common bedrocks as granites and gneiss. Recent populations occur almost exclusively in the southernmost part, which is marked by a specific bedrock, phyllite and crystalline limestone. Recent localities are leeward valleys and foothills, whereas historical localities often were wind-exposed slopes. Ecological preferences within the Czech Republic did not change during 1930–2000; the species is quite strictly confined to specific conditions. Interestingly, ELLENBERG's indicator values for the species *Dentraria enneaphyllos* differ from the calibrated values for relevés in five of six parameters. The pprobable cause of the species retreat in Rychlebské hory Mts is soil acidification and nutrient leaching induced with acid industrial deposits. The only acceptable habitats remained the sites with both accumulation of nutrients (along water courses) and capacity to buffer the acid deposits (calcareous bedrock).

Key words: *Dentaria enneaphyllos*, habitat preferences, long-term changes, population dynamics, Czech Republic.

Introduction

Changes in species distribution are commonly caused by changes in environments, which are often induced by human activities. Many species require a narrow range of life conditions, hence are sensitive to such changes. Herbs and grasses characteristic for temperate forests are typical examples. In temperate forests of Europe and NE-America the human influence has been lasting for hundreds of years. Several main directions of the environmental changes can be briefly summed up (compare PUHE & ULRICH, 2001): Forestry management (logging, reforestation practices, liming), non-forestry use (litter and other biomass removal, forest grazing), game breeding, industrial pollution (airborne depositions of sulfur and nitrogen in particular). Different territories experienced different kind and intensity of human influence. For example, forest fragmentation and non-forestry use played the strongest role in densely inhabited areas (PETERKEN & GAME, 1984; WULF & SCHMIDT, 1996) while sulfur deposits, for example, have had a deep impact on forest ecosystems along the mountain belt on the Czech-Polish-German border (KANDLER & INNES, 1995; BOCHENEK et al., 1997).

Processes induced by airborne deposits have profoundly influenced soils and vegetation of temperate forests. Acids from sulfur and nitrogen oxides, and ammonia, caused leaching of base cations (Ca, Mg, K, and others), which consequently led to acidification of soils (FEDERER et al., 1989; LIKENS et al., 1996; BOBBINK et al., 1998). Peak values of sulfur dioxide deposits were recorded in Central Europe in the 1980s (BERGE et al., 1999). Effect of increased nitrogen, the key nutrient element, can be observed in the most of European ecosystems (BOBBINK et al., 1998). Soil changes combined with influence of forestry management have led to vegetation changes in forest understorey. This is documented e.g. by FALKENGREN-GRERUP & TYLER (1991), MEIER et al. (1995), DIEKMANN et al. (1999). Distribution of forest herbs is significantly linked with soil acidity and soil base cations concentration, at low and high pH-intervals especially (FALKENGREN-GRERUP et al., 1995). In European forests exposed to acid depositions and nitrification, acid-tolerant and nitrophilous species are therefore on increase.

To trace the vegetation changes of beech (*Fagus sylvatica*) forests in one mountainous area in the Czech Republic, I resampled phytosociological relevés recorded in Rychlebské hory Mts sixty years ago (source: HARTMANN & JAHN, 1967). Decrease of many species characteristic for forests with a good nutrient supply, moderately acidic and moist soils, was observed (HÉDL, 2001, 2004). Assessment of environmental changes, using ELLENBERG indicator values (ELLENBERG et al., 1992), showed a decline in soil calcium and lost of productivity (interpretation according to SCHAFFERS & SÝKORA, 2000), drying of substrate and opening the canopy. The compared plots covered, however, only a negligible part of the whole territory. A research focused to a particular species therefore seems to be a sound support of the results.

One of the most decreased species was *Dentaria enneaphyllos*. Its frequency has lowered by 97% between the two compared datasets. In this study, changes in the species distribution in the whole territory of Rychlebské hory Mts are inquired. Objectives are: (1) To compare historical (before 1980) and recent distribution of the species in Rychlebské hory Mts., (2) to compare the species habitat types there both historical and recent, (3) to determine the preferred ecological conditions, as described in main phytosociological studies, and calibrating ELLENBERG indicator values for phytosociological relevés from the Czech Republic, (4) to see if there was a change of these preferences during the 20th century.

Material and methods

Study area

Rychlebské hory Mountains represent a typical Central European mountainous region with elevations from 350 to 1125 m a.s.l.; its area is about 280 km^2. Typical habitats are moderate slopes, flat ranges, and 200–500 m deep river valleys (DEMEK, 1987).

Silicates, mainly gneiss, mica schist, granite and granodiorite, amphibolite etc., are the prevailing bedrock. The southernmost area is dominated with phyllite and crystalline limestone, which is only rarely scattered elsewhere. Considering the Czech Republic, Rychlebské hory Mts received low to intermediate amounts of airborne deposits of sulfur and nitrogen (http://www.chmi.cz/uoco/isko/hodkva/hodkvae.html); this has not resulted in a vast forest die-off as in the north-western parts of the country. Vegetation is constituted mostly of forests, which are partly Norway spruce (*Picea abies* KARST.) stands, partly spruce mixed with European beech (*Fagus sylvatica* L.), or the pure beech stands. In the district of Jeseník where the study area is situated, the spruce forms 67%, and the beech 18% of the forest composition (http://www.uhul.cz/slhp3).

Methods

Comparison of historical and recent species distribution in Rychlebské hory Mts is based on floristic and phytosociological data from literature, and mapping the recent populations, respectively. The sources of floristic data covering the period before 1980 are CHRTEK et al. (1959) and JANÁČKOVÁ (1968, map 29); both also compiled older records from the 19th and early 20th centuries (e.g., by FIEK, 1881; SCHUBE, 1903; DUDA, 1949). HARTMANN & JAHN (1967) published the only set of historical phytosociological relevés, recorded in the 1940s. Field mapping of the recent species populations was carried out in Aprils 1999 and 2000. Several records from 1993–2000, including occurrence in phytosociological relevés from

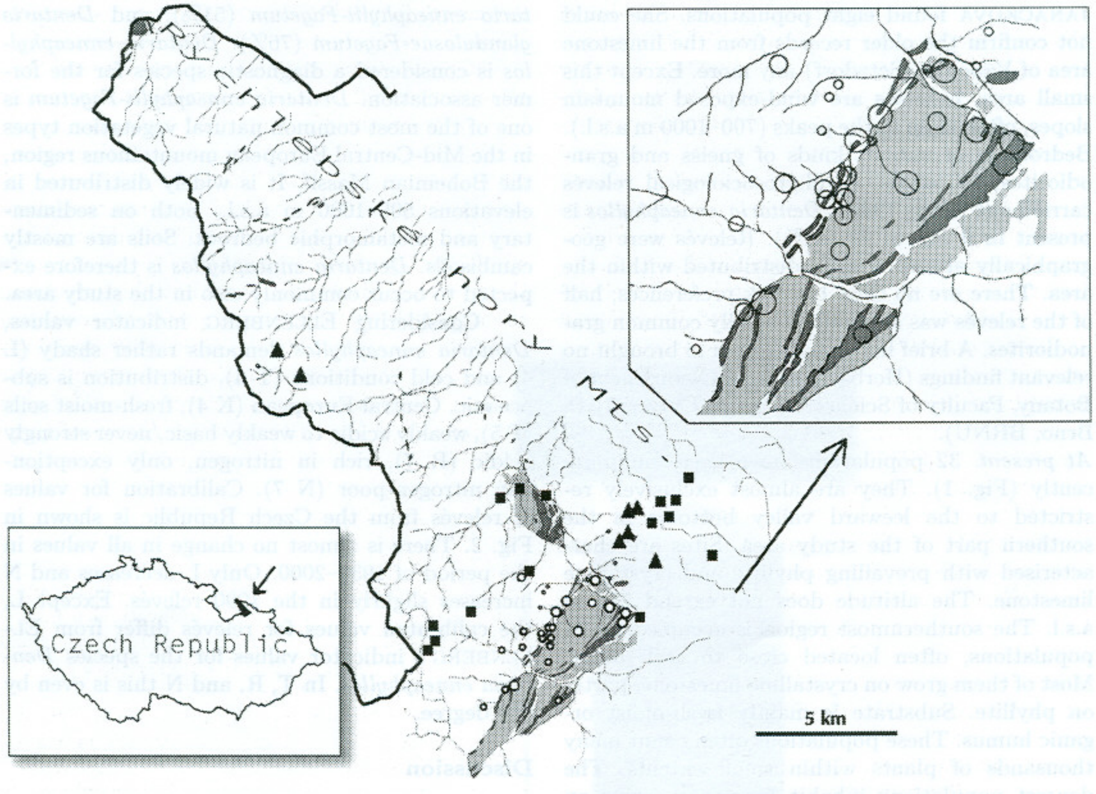

Fig. 1. Historical and recent distribution of *Dentaria enneaphyllos* L. in Rychlebské hory Mts. Historical (full squares – floristic data, and full triangles – phytosociological data) and recent (open circles, size corresponding with population size) occurrences do not overlap; recent populations are restricted to valleys with specific bedrock, phyllite (shaded light gray) and crystalline limestone (dark gray). Upper right box is a detailed view to the southernmost area where 30 of 32 recent populations occur.

the same period (see HEDL, 2001), were added. In literature, the recent distribution is documented only in a floristic study of only one locality by SEDLÁČKOVÁ & LUSTYK (1999). Habitat preferences within the study area concern site geology and geomorphology. No other direct information can be obtained for historical localities. Sources of information are Geological maps of the Czech Republic, scale 1:50 000, available at http://nts4.cgu.cz/website/GEOCR50

Phytosociological overviews concerning forest vegetation of the Czech Republic are MORAVEC et al. (1982 and 2000) and NEUHÄUSLOVÁ (1998). Habitat preferences within the Czech Republic are assessed calibrating ELLENBERG indicator values for 646 phytosociological relevés from the whole country, containing *Dentaria enneaphyllos*. Relevés are stored in the Czech National Phytosociological Database (http://www.sci.muni.cz/botany/vegsci_c.htm). Calibration for relevés (TER BRAAK, 1995) is computed as averages of ELLENBERG indicator values for species present (ELLENBERG et al., 1992). Six parameters are considered: undestorey light (L), temperature (T), continentality (K), soil moisture (F), soil reaction (R), and soil nitrogen (N). The latter two can be considered as soil calcium and site productivity, respectively (SCHAFFERS & SÝKORA, 2000). Temporal change of the six parameters between 1930 and 2000 is shown with distance weighed least-squares curves fitted in scatterplots, using STATISTICA 6.0 software (STATSOFT 2001).

Nomenclature of taxa follows KUBÁT (2002), syntaxa MORAVEC et al. (2000).

Results

Distribution in Rychlebské hory Mts

History. Occurrence excerpted from literature published in 1881–1968 is mapped in Fig. 1. Surprisingly, no records are dated back to the 19th century. The first records are by BUCHS from 1907 and 1909 (CHRTEK et al., 1959). CHRTEK with his colleagues noted five broader localities, giving information on common occurrence elsewhere.

JANÁČKOVÁ found eight populations. She could not confirm the older records from the limestone area of Vápenná (Setzdorf) any more. Except this small area, habitats are wind-exposed mountain slopes, often close to the peaks (700–1000 m a.s.l.). Bedrock is of various kinds of gneiss and granodiorites, i.e. acidic. In phytosociological relevés carried out in the 1940s, *Dentaria enneaphyllos* is present in 9 out of 22 (41%). Relevés were geographically almost equally distributed within the area. There are no clear bedrock preferences; half of the relevés was situated on locally common granodiorites. A brief herbarium search in brought no relevant findings (Herbarium of the Department of Botany, Faculty of Science, Masaryk University in Brno, BRNU).

At present. 32 populations have been found recently (Fig. 1). They are almost exclusively restricted to the leeward valley bottoms in the southern part of the study area. Sites are characterised with prevailing phyllite and crystalline limestone. The altitude does not extend 700 m a.s.l. The southernmost region is occupied by 21 populations, often located close to each other. Most of them grow on crystalline limestone, partly on phyllite. Substrate is mainly fresh-moist organic humus. These populations often count many thousands of plants within small extents. The densest populations inhabit limestone screes on quite steep slopes and alluvial habitats with high soil moisture and nutrient content. The largest population covers several hectares on crystalline limestone in a pure mature Norway spruce stand. Adjacent to the southernmost region ten populations were found. Bedrock is mainly amphibolites, i.e. basic, although no carbonates occur there. Populations count small to medium number of plants, sometimes counting only one to few individuals. Just two small populations occur on acidic granodiorites, western slopes of Jasanový vrch near Vápenná. In contrast, four phytosociological relevés from this locality contained *Dentaria enneaphyllos* in the 1940s. Only one plant was found elsewhere in Rychlebské hory Mts. Historically, several records come from there. In 1998–1999, *Dentaria enneaphyllos* occurred just in 5 out of 57 relevés (9%) done on the sites of HARTMANN's relevés.

Ecological requirements in the Czech Republic

Dentaria enneaphyllos is a characteristic herb of Central-European beech (*Fagus sylvatica*) forests. It occurs with lower to intermediate frequency in alliances *Tilio-Acerion* and *Fagion.* The highest frequencies were accounted for associations *Dentario enneaphylli-Fagetum* (51%), and *Dentario glandulosae-Fagetum* (76%). *Dentaria enneaphyllos* is considered a diagnostic species for the former association. *Dentario enneaphylli-Fagetum* is one of the most common natural vegetation types in the Mid-Central European mountainous region, the Bohemian Massif. It is widely distributed in elevations 500–1000 m a.s.l., both on sedimentary and metamorphic bedrock. Soils are mostly cambisoils. *Dentaria enneaphyllos* is therefore expected to occur commonly also in the study area.

Considering ELLENBERG indicator values, *Dentaria enneaphyllos* demands rather shady (L 4) and cold conditions (T 4), distribution is suboceanic, Central-European (K 4), fresh-moist soils (F 5), weakly acidic to weakly basic, never strongly acidic (R 7), rich in nitrogen, only exceptionally nitrogen-poor (N 7). Calibration for values of relevés from the Czech Republic is shown in Fig. 2. There is almost no change in all values in the period of 1930–2000. Only L decreases and N increases slightly in the 1990 relevés. Except L, the calibrated values for relevés differ from ELLENBERG's indicator values for the species *Dentaria enneaphyllos.* In T, R, and N this is even by one degree.

Discussion

Discontinuity in distributions of *Dentaria enneaphyllos* in the study area before 1980 and recently is apparent. The most notable is that the both distributions almost do not overlap. Recently, *Dentaria enneaphyllos* is limited to a small area in the south. Considering the fact that the documentation of historical distribution is very leaky (because the botanical research was only occasional), we have to conclude that the species decreased strongly. Similar trend was recorded in Saxony (HARDTKE & IHL, 2000); also in the Red List of the Czech flora *Dentaria enneaphyllos* is treated as a rare species – category C4 (HOLUB & PROCHÁZKA, 2000).

Conspicuous changes are in habitat preferences. Typical habitats of the past were windward (N, NW, and W-exposed) slopes and bedrock of acid silicates (gneiss and granodiorite). The most numerous recent populations occur on calcareous substrate of leeward valleys and foothills. It is probable that several or many populations occurred also on limestones in the past. Some of them were recorded near Vápenná (Setzdorf); they most probably do not exist today, which might be due to the management of the sites. Vernal geophytes (*Dentaria enneaphyllos* is a typical ex-

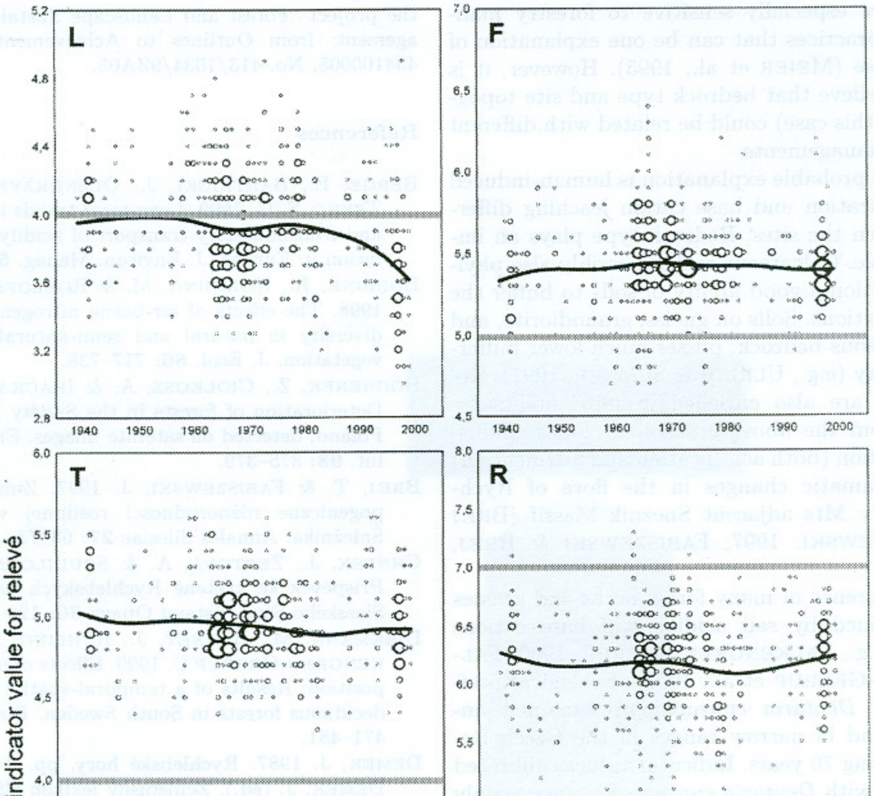

Fig. 2. Frequency scatterplot of ELLENBERG indicator values for 646 relevés from the territory of the Czech Republic, 1930–2000, with *Dentaria enneaphyllos*. Parameters are understorey light (L), temperature (T), continentality (K), soil moisture (F), soil acidity (R) and nitrogen (N). Circle size denotes number of relevés (1 to 17). Curves are distance-weighed least squares fits showing almost unchanged temporal trends in species' requirements. Bold gray lines show the ELLENBERG's indicator value for species *Dentaria enneaphyllos* L. Both values differ even by 1 degree (T, R, N).

ample) are especially sensitive to forestry management practices that can be one explanation of its decrease (MEIER et al., 1995). However, it is hard to believe that bedrock type and site topography (in this case) could be related with different forestry managements.

More probable explanation is human-induced soil acidification and base cation leaching differing between the sites. Bedrock type plays an important role. Calcareous rocks (possibly also phyllite) condition a good ability of soils to buffer the acid depositions. Soils on gneiss, granodiorite, and other siliceous bedrock, posses much lower buffering capacity (e.g., ULRICH & SUMNER, 1991). Recent sites are also enriched in nutrients transported from the above-positioned slopes. Industrial pollution (both acidification and nitrification) caused dramatic changes in the flora of Rychlebské hory Mts adjacent Sneznik Massif (BREJ & FABISZEWSKI, 1997; FABISZEWSKI & BREJ, 2000).

Occurrence of many forest herbs and grasses is determined by soil acidity and base cations content (e.g., FALKENGREN-GRERUP, 1990; FALKENGREN-GRERUP et al., 1995). Ecological preferences of *Dentaria enneaphyllos* remained unchanged and in narrow ranges in the Czech Republic during 70 years. Indicator values calibrated for relevés with *Dentaria enneaphyllos* vary mainly within one degree for each indicator parameter (with some outliers). The species has therefore been excluded from habitats with conditions beyond these limits. It is probable that acidification processes in soils exceeded the critical limits for *Dentaria enneaphyllos* in the study area.

Marked differences between species indicator value and the average of relevé values have two possible explanations. Either, ELLENBERG's indicator values for *Dentaria enneaphyllos* cannot be used in the Czech Republic or, and perhaps more probably, the species constantly inhabits specific microhabitats within the sites (i.e., relevés). The average for the sites is lower (K – less continental, R – less soil calcium and lower pH, N – less soil nitrogen and lower productivity), or higher (T – warmer, F – moister) than the species requires according to ELLENBERG.

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