


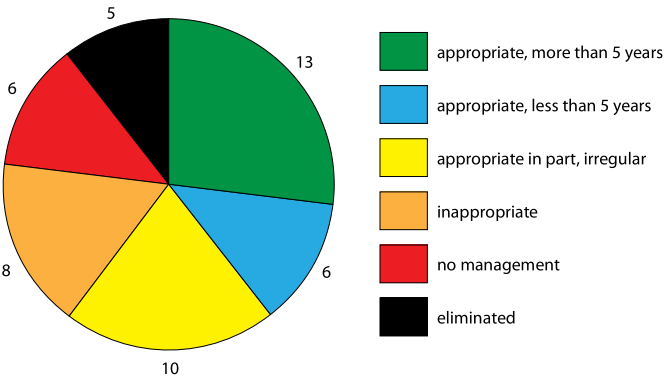
|                   |   |
|-------------------|---|
| Location          |  Southwest and south Czech Republic<br>48°49'–49°24' N, 13°22'–14°51' E; elevation 414–870 m   |
| Protection status | PLA (Blanský les – 1 site), NP (Šumava – 1 site), NR (9 sites), SCI (all 13 sites)  |
| Ecosystem types   | Broad spectrum of grassland types classified as Subatlantic broad-leaved dry grasslands ( <i>Bromion erecti</i> ), Extensive hay meadows ( <i>Arrhenatherion elatioris</i> ), Species-rich <i>Nardus</i> grasslands ( <i>Violion caninae</i> ), locally also dry grasslands on acidic soils ( <i>Koelerio-Phleion phleoidis</i> ) |
| Restored area     | 6.8 ha in total (13 sites)  |
| Financial support | Regional Authority of the South Bohemian Region, Regional Authority of the Plzeň Region, landscape management programmes, Operational Programme Environment   |
| Costs             | Initially €40,000 (elimination of shrubs and trees, site levelling, mowing or grazing, and turf disturbance); annually €10,000 (mowing once to twice or rotational grazing, turf disturbance)   |

### Initial conditions

*Gentianella praecox* subsp. *bohemica* is an endemic to the Bohemian massif and a Czech subendemic. Its historic distribution area includes the Czech Republic (most of the territory except W and NW Bohemia and SE and E Moravia), north Austria, the W part of Lower Bavaria and southernmost Poland. It is a strict biennial, which has been observed to decline radically in site number and population size (Königer et al. 2012). These changes are particularly connected with an overall decrease in pasture area and area of grassland enclaves, changes in agricultural practice, and habitat fragmentation. Since 2000 the taxon has been recorded at only 113 sites in its entire distribution area (70 of them in the Czech Republic). At 23 of them, however, not a single flowering plant has been recorded in the past five years.

Our study focuses on SW and S Bohemia, including 50 recent localities (Fig. 1), where population abundance and site management have been monitored for more than 10 years. Assessment of the recovery of the populations was nevertheless carried out at only 13 sites, where high-quality cleanups were realized and suitable management was maintained at an optimal level for at least four years.

The monitored sites had various starting conditions, not only in terms of the condition of the habitat, but also of the *Gentianella praecox* subsp. *bohemica* populations. Three sites were more or less regularly mown without turf disturbance; four were farmed very irregularly, which had led to a strong accumulation of living and dead biomass; six sites were overgrown by shrubs and trees or by planted pines (see Fig. 5). The average number of flowering plants three years



**Fig. 1.** Type, time length and quality of farming at 50 sites in S and SW Bohemia where *Gentianella praecox* subsp. *bohemica* was recorded at least once in 2000–2010.



**Fig. 2.** Flowering *Gentianella praecox* subsp. *bohemica* originating from the seedbank after restoration of the site. (R. Ouředník)

before restoration was zero at three sites, up to 20 at three, 20 to 100 at four, and more than 100 at three sites. Based on studies of population-biological features (summarised by Brabec et al. 2011, Brabec & Zmeškalová 2011, Bucharová et al. 2012), it was considered useful to add more or less regular turf disturbance to the traditionally recommended regular farming of the sites by means of mowing or grazing.

### Abiotic conditions

Chemical analyses of the soils showed a wide range of abiotic conditions at the monitored 13 sites. At a depth of ca. 5 cm the soil reaction varied from acidic (pH 4.7) to slightly basic (pH 7.7), which

is correlated with the contents of Ca (661–7898 mg.kg<sup>-1</sup>) and Mg (52–1204 mg.kg<sup>-1</sup>) ions. The sites are poor to moderately rich in nutrients: total carbon content varied from 0.9 to 11.9%, nitrogen from 0.1 to 0.8%, exchangeable phosphorus from 2.8 to 19.3 mg.kg<sup>-1</sup>.

## Objectives

Recovery and stabilisation of present *Gentianella praecox* subsp. *bohemica* populations.

## Restoration measures

|           |  |
|-----------|--|
| 2000–2005 | First experimental study of the impact of various types of management (no management, mowing, mowing and disturbance) and timing (June, October–November). Recommendations to nature conservation authorities included in action plan documents (Brabec 2003).   |
| 2005–2008 | Large-scale cleanup (9 cases) or optimisation (3 cases) measures at various sites. In one case, a site had already been cleaned up in 1995 (0.1 ha). The cleanup included cutting of most shrubs and trees, whereby stumps were partly or completely pulled out; complete mowing and cleaning of the site, turf disturbance by harrowing or raking (see Fig. 5–8), in one case also levelling with light machines.   |
| 2006–2011 | Yearly repeated, optimised farming of the sites. Mesic grasslands: first cut May–June, second one October/November, turf disturbance by harrowing or raking up litter, or by performing a vertical cut at the end of October, in November or in early spring (not later than mid-April). Dry grasslands: one to three years after the cleanup mowing twice a year (May–June, October/November) and annual turf disturbance; following, a transition to one cut a year either in May–June or October/November and every other year turf disturbance by harrowing or raking up litter, or by performing a vertical cut at the end of October, in November or in early spring (not later than mid-April). |
| 1999–2011 | Yearly monitoring of all known recent populations of <i>Gentianella praecox</i> subsp. <i>bohemica</i> .   |
| 2011      | Endorsement of <i>Gentianella praecox</i> subsp. <i>bohemica</i> Action Plan (see <a href="http://www.zachranneprogramy.cz">www.zachranneprogramy.cz</a> ), compilation of management principles (Brabec & Zmeškalová 2011) – emphasis on the importance of turf disturbance and regularity of management.   |



Fig. 3. Gentianellas are pollinated by Hymenoptera. (J. Brabec)

## Results

Population recovery was assessed at 13 sites. As shown in Fig. 4, site restoration and introduction of optimal management including turf disturbance led to a rapid (mostly several fold) increase in the number of flowering plants in the first three years in 10 cases. At two sites, where not more than one flowering plant per year appeared in a five-year period before the intervention, the populations could not be recovered. In one case the number of flowering plants first decreased slightly, after which the population began to increase slightly.

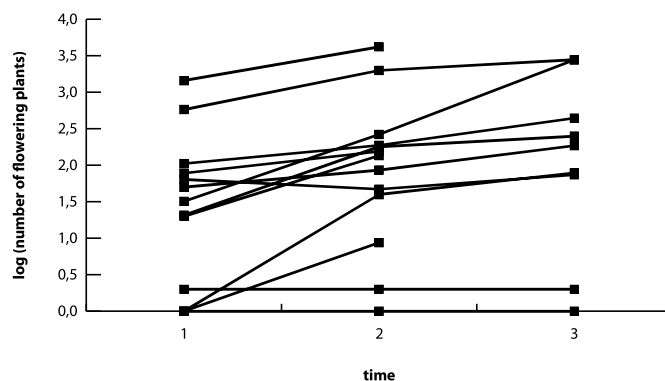


Fig. 4. Numbers of flowering plants before site restoration (Time 1 = three-year average, i.e. two years before restoration plus the year of restoration), three years after site restoration (Time 2 = three-year average), and in the past three years (Time 3 = average of the years 2009–2011). The last number is not indicated if management started later than 2007 (and Time 3 would thus equal Time 2).

## Other lessons learned and future prospects

The previous recommended management of *Gentianella praecox* subsp. *bohemica* sites most often included regular mowing (leaving a relatively tall stand was often recommended in order not to damage young plants) or extensive grazing. However, when restoring, stabilising and maintaining sites, cutting as low as possible combined with raking up and removing all hay carefully, or intensive rotational grazing is necessary. The aim is to disturb the turf and create small gaps before the time of seed germination, which is each year at the turn of April and May. The management must not be carried out at the time of growth, flowering and seed ripening of the gentians, i.e. roughly from July to mid-October. Conversely, intensive farming (mowing twice a year, rotational grazing) from mid-October to the end of June in the following year is ideal. Although management in autumn and spring partly leads to disturbance of plant development (cutting off followed by compensational branching) and to direct destruction of rosette seedlings, at the same time it lowers competition and enables germination of seed from the short-term or long-term seedbank, which compensates for these losses by up to tenfold. As demonstrated in experimental studies (Brabec et al. 2011, Bucharová et al. 2012), germination of seed from the seedbank is the most important factor in the life cycle phase of this biennial taxon and at the same time the one best to be influenced by farming.

## Public support

The management of the 13 sites is organised by five different nature conservation bodies. As of 2011 all activities are coordinated by the Nature Conservation Agency of the Czech Republic as part of the species action plan for this gentian. The actual cleanup and management is carried out by various actors – landowners (2 cases), tenants (1), private farmers (4), specialised firms (4), and NGOs (2). Espe-



cially when starting regular management or optimising management, also work by volunteers at the sites was very important. This mostly included additional turf disturbance, but in two cases volunteers carried out the whole cleanup on their own and managed the site (with consent of the landowner) for three years.

## Acknowledgements

This work was supported by the grants GA UK 268/1999/B BIO/PřF, MŠMT VaV 2B06178 and Nature Conservation Agency of the Czech Republic.

## References

Brabec J. (2003): Studie hořečku mnohotvarého českého (*Gentianella praecox* ssp. *bohemica*) jako podklad pro záchranný program taxonů rodu *Gentianella* v ČR (Study of *Gentianella praecox* ssp. *bohemica* as a basis for an action plan of *Gentianella* taxa in the Czech Republic). – Ms.; final report, Ministerstvo životního prostředí ČR, Praha.

Brabec J., Bucharová A. & Štefánek M. (2011): Vliv obhospodařování na životní cyklus hořečku mnohotvarého českého (*Gentianella praecox* subsp. *bohemica*) (Impact of management on the lifecycle of *Gentianella praecox* subsp. *bohemica*). – *Příroda* 31: 85–109.

Brabec J. & Zmeškalová J. (eds) (2011): Zásady péče o lokality hořečku mnohotvarého českého (Principles of management of *Gentianella praecox* subsp. *bohemica* sites). – Agentura ochrany přírody a krajiny ČR and Muzeum Cheb, p. o. Karlovarského kraje, Praha.

Bucharová A., Brabec J. & Münzbergová Z. (2012): Effect of land use and climate change on future fate of populations of an endemic species of central Europe. – *Biological Conservation* 145: 39–47.

Königer J., Rebernig C.A., Brabec J., Kiehl K. & Greimler J. (2012): Spatial and temporal determinants of genetic structure in *Gentianella bohemica*. – *Ecology and Evolution* 2: 636–648.



Fig. 5. View of Kozlovská stráň, 18 September 2004. In 2003–2007 not any *Gentianella praecox* subsp. *bohemica* plant flowered at this site, which was gradually colonised by pine trees. (J. Brabec)



Fig. 6. Cleanup at Kozlovská stráň, March 2007. (R. Ouředník)



Fig. 7. Cleanup at Kozlovská stráň, March 2007. (R. Ouředník)



Fig. 8. Kozlovská stráň, denuded plots after autumn cut and spring raking incl. turf disturbance, May 2009. (R. Ouředník)