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Špeciálne rubriky: Terminológia, Tribúna, Kronika.

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THE ALCON BLUE *Maculinea alcon* (Lepidoptera: Lycaenidae) IN EASTERN AUSTRIA: STATUS AND CONSERVATION MEASURES

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Abstract

Höttinger H., Schlick-Steiner B.C., Steiner F.M.: The Alcon blue *Maculinea alcon* (Lepidoptera: Lycaenidae) in eastern Austria: status and conservation measures. Ekológia (Bratislava), Vol. 22, No. 2, 107–118, 2003.

In eastern Austria (Lower Austria, Burgenland), three populations of the obligatory parasitic Alcon blue butterfly *Maculinea alcon* were investigated. The finding of prepupal larvae in nests of the ant *Myrmica scabrinodis* is the first host ant record in Austria. Based on egg counts, the *Maculinea alcon* population sizes were estimated and the metapopulation structure assessed. Based on the data from the ant assemblages, the estimated population sizes of the larval foodplant *Gentiana pneumonanthe* and the known threats, the viability of the metapopulations was assessed. Accordingly, each of the five recent metapopulations of *Maculinea alcon* in eastern Austria has less than 50 individuals and must be regarded as critically endangered.

We propose a protection plan including (1) safeguarding of the open and nutrient-poor character of the habitats, (2) stopping drainages, ploughing and intensification of the habitats, (3) safeguarding of the minimal area, (4) special protective measures for *Gentiana pneumonanthe*, (5) connecting habitat fragments, (6) reducing high grazing pressure due to row deer in small-sized habitats, and (7) establishing the ideal nest density of host ants.

The extinction of *Maculinea alcon* in eastern Austria can be prevented only if protective measures are realised immediately.

Introduction

The Alcon blue *Maculinea alcon* Denis & Schiffermüller 1775 is one of Europe's most endangered butterflies (Munguira, Martin, 1999). It is classified as vulnerable in Europe and has decreased by 20–50 % over the last 25 years (Van Swaay, Warren, 1999). In Austria it is classified as endangered in the national red data book (Huemer et al., 1994). In eastern Austria, its status was insufficiently known for the pro-

vince Lower Austria (Höttinger, Pennerstorfer, 1999); in the province Burgenland it is critically endangered (Höttinger, 1998). *M. alcon* and its main larval foodplant *Gentiana pneumonanthe* may serve as excellent indicator and umbrella species for habitat management and conservation.

The taxonomic situation of *Maculinea alcon* and the closely related taxon *M. rebeli* Hirschke 1904 has yet to be resolved. They are treated as biospecies, subspecies, semispecies or ecological races of one species, respectively (Schlick-Steiner et al., 2002). The distinction is usually based on ecological aspects such as habitat, host ant species and larval foodplants.

M. alcon is restricted to moorland and wet grassland (Settele et al., 1999). Known larval foodplants of *M. alcon* include *Gentiana pneumonanthe*, *G. asclepiadea* and *G. germanica*, whereas known host ant species are *Myrmica ruginodis, M. scabrinodis* and *M. rubra* (SBN, 1987; Weidemann, 1985; Munguira, Martín, 1999). To date, in Burgenland and Lower Austria only *G. pneumonanthe* has been confirmed as a host plant. The host ant species may differ geographically, which could hint at different ecological subspecies or even cryptic species of *Maculinea alcon* (Elmes et al., 1994).

After eclosion, the *M. alcon* caterpillars feed for 3–4 weeks inside the gentian pods, moult three times during this period, but remain very small. In the fourth larval stage they leave the plants and wait to be adopted by foraging *Myrmica* workers. The caterpillars secrete allomones mimicking the ant larvae and thus are taken to the ant nests. There they are directly fed by the ant workers and eat ant larvae. They hibernate and pupate in the ant nests, from which the butterflies usually emerge in the summer of the following year (Liebig, 1989; Munguira, Martín, 1999, Nash et al., 2002).

The aim of the present study was to assess the status of *Maculinea alcon* in Lower Austria and Burgenland and to develop a protection plan. This included (1) localising populations of the larval foodplant *Gentiana pneumonanthe*, (2) searching for the host ant species, so far unknown in Austria, (3) recording the ant assemblages at the studied sites, (4) assessing the actual and potential threats to the *Maculinea alcon* populations, (5) estimating (meta-) population sizes, and (6) estimating viability of the metapopulations.

Study area

From early May to late July 2001, populations of *Maculinea alcon* were investigated at three sites in eastern Austria (Fig. 1): two in Lower Austria in the Waldviertel (mown moist meadow and a partly afforested lowland moor, 0.15 ha each, 580 m a.s.l.), and one in Burgenland in the Northern Stremtal (partly mown moist meadow, 15 ha, 210 m a.s.l.).

Records after 1980 are available from three additional sites: one in the Feuchte Ebene in a nature reserve (mown moist meadow, 180 m a.s.l.), one in the national park Neusiedler See-Seewinkel (mown lowland moor, 120 m a.s.l.) and one in the Southern Stremtal (moist fallow, 210 m a.s.l.) (own. obs., Eis, pers. comm., Rachinger, pers. comm.; exact site names and positions not presented for conservation reasons).

Mean temperature was significantly higher in the study year than in the previous years (all calculations based on data of the Central Institute of Meteorology and Geodynamics, Vienna): At Japons, the nearest climate station to the two populations in the Waldviertel, it was 8.25 °C from August 2000 to July 2001, while it had been 7.58 °C from 1991 to 2000 and 6.77 °C from 1961 to 2000. At Fürstenfeld, the nearest climate station to the Northern Stremtal, it was 10.98 °C from August 2000 to July 2001, while it had been 9.60 °C from 1991 to 2000 and 9.00 °C from 1961 to 2000. The amount of precipitation in the study year was similar to the average (Japons: 575 mm from August 2000 to July 2001, 568 mm from 1991 to 2000, 590 mm from 1961 to 2000; Fürstenfeld: 767 mm from August 2000 to July 2001, 742 mm from 1991 to 2000, 750 mm from 1961 to 2000).

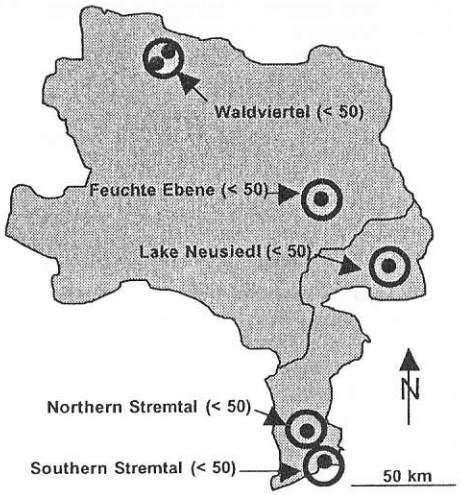

Fig. 1. Current populations (dots) and metapopulations (circles) of *Maculinea alcon* in eastern Austria (Lower Austria, Burgenland). Estimated sizes of the metapopulations are indicated in parentheses.

Material and methods

Gentians were counted at the three sites. At each site, *M. alcon* eggs were counted on five plots of 12.5 m^2 each. The total number of eggs of a site was estimated by multiplying the mean number of eggs per gentian with the total number of gentians per site.

The ant assemblages were investigated with five pitfall traps per site (Majer, 1978; 22 mm diameter, ethanol:glycerin = 5:1). They were exposed 4–6 weeks. Additional nest searches and honey baits completed the list of recorded ant species per site. When a *Myrmica* nest was found, we searched it for larvae and pupae of *M. alcon*. When larvae or pupae were found, their number, size and colour and the behaviour of host ants were recorded. Ants were determined according to Seifert (1996), caterpillars according to SBN (1987). Peak numbers of *M. alcon* butterflies at a site were recorded, avoiding double counts. No special method (e.g. transect count) was used, as the number of butterflies per site was too low to use them for the estimation of population sizes.

Actual and potential threats at the sites were recorded and classified according to their impact.

Population sizes of *M. alcon* females were estimated by dividing the total number of eggs per site by the number of eggs per female according to literature data (50, 70, 120 and 200 eggs per female; Kockelke et al., 1994; Settele et al., 1999; Vanreusel et al., 2000). For estimating total population sizes, the numbers of females were doubled, assuming a 1:1 ratio of males to females. Although in some cases the sex ratio was found to be shifted in favour of males (Wynhoff et al., 1996; Vanreusel et al., 2000), this ratio was chosen in order to prevent overestimations.

If the population size estimated by egg counts was lower than the population size estimated by counts of individuals (also assuming a ratio of 1:1), the latter was used to estimate population size (Table 1).

Table 1. Results of the egg counts in the year 2001, estimated sizes of the populations based on egg counts (50–200 eggs assumed per female, ? = not controlled in 2001, 0 = no findings in 2001, but in previous years) and final estimations of metapopulation sizes

Study sites	Gentians	Eggs per gentian	Total number of eggs	Estimated population size based on egg counts	Estimated population size based on observed adults	Final estimation of metapopulation size
Partly afforested lowland moor, Waldviertel	10	3	30	2	14	< 50
Mown moist meadow, Waldviertel	15	3	45	2	4	
Partly mown moist meadow, Northern Stremtal	500	4	2000	20-80	2	< 50
Mown moist meadow, Feuchte Ebene				?	?	< 50
Mown lowland moor, Lake Neusiedl				?	4	< 50
Moist fallow, Southern Stremtal				0	0	< 50

A metapopulation structure of *M. alcon* populations was assumed if the distance between sites was larger than the known maximum migration distance of 900–1700 m (Settele et al., 1996; Wynhoff et al., 1996; Vanreusel et al., 2000).

We assessed the viability of the metapopulations taking into account the following parameters: life history, autecology, minimal viable population size, minimal area, migration distance, actual number and size of populations, isolation and fragmentation, and actual threats (Settele et al., 1995; Wynhoff et al., 1996; Brinkmann et al., 1998; Amler et al., 1999; Settele et al., 1999; Vanreusel et al., 2000).

Results

Gentiana pneumonanthe

The number of gentians per site varied from 10 (lowland moor, Waldviertel), to 15 (moist meadow, Waldviertel), to 500 (moist meadow, Northern Stremtal, Table 1).

Ants

A total of ten ant species was found (Table 2), species richness varying from four (moist meadow, Waldviertel) to seven species (moist meadow, Northern Stremtal) per site. A total of four *Myrmica* species (*M. scabrinodis, ruginodis, vandeli, rubra*) was found, but only *M. scabrinodis* occurred at all sites. It was numerically dominant at the lowland moor and at the moist meadow in the Waldviertel, followed by *Formica transkaucasica* and *Myrmica vandeli*, respectively. At the moist meadow, Northern Stremtal, *Myrmica rubra* and *Lasius niger* were most abundant.

Table 2. Ant assemblages at the studied sites

Species	Partly afforested lowland moor, Waldviertel	Mown moist meadow, Waldviertel	Partly mown moist meadow, Northern Stremtal
Myrmica scabrinodis Nylander 1846	x	x	x
Myrmica rubra Linnaeus 1758			x
Myrmica vandeli Bondroit 1920	x	x	
Myrmica ruginodis Nylander 1846	x		x
Lasius alienus (Förster 1850)			x
Lasius niger (Linnaeus 1758)	x	x	x
Lasius flavus (Fabricius 1781)		x	x
Formica transkaucasica Nassonov 1889	x		
Formica cunicularia Latreille 1798	x		
Formica pratensis Retzius 1783			x

Maculinea alcon

The numbers of observed adults were very low at each site. On 16. 7. 2001 in the lowland moor, Waldviertel, seven males and two females were recorded, at the moist meadow, Waldviertel, two males. At the moist meadow, Northern Stremtal, only one female could be observed on 6. 7. 2001.

The numbers of eggs per site are shown in Table 1. At the two sites in the Waldviertel, only 30 respectively 50 eggs were found, at the moist meadow, Northern Stremtal, the value exceeded 2000.

Prepupal larvae (n = 10) of *M. alcon* were exclusively found in nests of *Myrmica scabrinodis* (n = 5) at the partly afforested lowland moor, Waldviertel. Numbers of *Maculinea alcon* larvae per nest varied from one to three. At the other sites, no larvae or pupae could be found in *Myrmica* ant nests.

Further searches for eggs and adults of *Maculinea alcon* at 15 sites of *Gentiana pneumonanthe* in eastern Austria (most of them in Burgenland) remained unsuccessful.

Threats

The threats to the studied populations of *Maculinea alcon* are listed in Table 3. In eastern Austria, certain threats may lead to local extinctions (afforestation, ploughing of grassland, land drainage, mowing of the gentians before seeding), to potential extinction (critical area, critical population size of gentians, eutrophication) or to weakening of populations (grazing of gentians by deer, import of biocides, critical population size of the host ants, shrubbing).

Table 3. Threats to *Maculinea alcon* in eastern Austria, listed according to their impact

Impact	Threats	Direct effects of threats
Extinction	afforestation	from shading of the gentians to total loss of the habitat
	drainage, intensification, ploughing of grassland	drying, eutrophication or total loss of the habitat
	mowing of the gentians before seeding	loss of eggs and caterpillars
Potential extinction	critical habitat area	too low relative nest densities of host ants
	critical size of gentian populations	reduced opportunity of egglaying and feeding of caterpillars
	eutrophication	gentians at a disadvantage versus nitrophilous plants
Endangering	losses of gentians and eggs due to grazing by deer	loss of eggs and caterpillars
	import of biocides	increased mortality of butterflies and host ants
	critical size of host ant populations	reduced chance of adoption of caterpillars by host ants
	shrubbing	shading of gentians and host ant nests

Discussion

With respect to the fact, that the field investigations were performed in one season only, any calculations based on our set of data could be biased by the exceptionally high mean temperature between August 2000 and July 2001. Further investigations over a longer period of time are necessary to elucidate the impact of climatic variations on the populations of *Maculinea alcon*, *Gentiana pneumonanthe* and their *Myrmica* host ants.

Host ants

Our finding of prepupal *Maculinea alcon* larvae in *Myrmica scabrinodis* nests is the first host ant record in Austria. This agrees with preliminary results from the Czech Republic, where *M. scabrinodis* is also used as a host (Krenova, pers. comm.). *Maculinea alcon* uses different host ants in different parts of Europe: in Spain and France it was found to use *Myrmica scabrinodis* exclusively, in the Netherlands and Denmark *M. ruginodis* and *M. rubra* (Elmes et al., 1998; Als et al., 2002), in Belgium *M. ruginodis*, *M. rubra* and *M. scabrinodis* (Vanreusel et al., 2000). These host ant differences are taken as indications of different subspecies or cryptic species of *Maculinea alcon* by some authors (e.g. Elmes et al., 1994). Further investigations will reveal whether other *Myrmica* species are used as host ants in central Europe, as is the case with *Maculinea rebeli* (Steiner et al., 2003).

Populations and metapopulations of Maculinea alcon

Six current populations (records after 1980) of *Maculinea alcon* are known in eastern Austria (Fig. 1). We estimate all of them to be very small, forming five small-sized metapopulations, each containing less than 50 individuals (Table 1): While the calculation of the size of the biggest population (Northern Stremtal) yields 20–80 individuals, we postulate a population size of < 50 to remain on the safe side. The population Feuchte Ebene could not be controlled in 2001 because we were only informed about its existence after the flight season (Eis, pers. comm.), which was too late for egg counting. Nonetheless, we estimate its size at < 50 due to observations of adults during the last years (Eis, pers. comm.). At the population Southern Stremtal, no eggs and adults were detected in 2001. As in the past, at this population years without records of *M. alcon* were followed by years with "refindings" of the species; we, however, estimate its size at < 50. At any rate, potential extinction must be taken into consideration here.

The estimated total number of *M. alcon* in eastern Austria (Lower Austria and Burgenland) is less than 200 individuals. No data on the minimal population size of *M. alcon* are available from the literature. Assuming the known minimal population sizes of *M. rebeli* between 50 and 300 individuals (Brinkmann et al., 1998; Amler et al., 1999), all *M. alcon* populations in eastern Austria are below minimal size. Other studies revealed metapopulation sizes of 20 to more than 1000 (Belgium; Vanreusel et al., 2000), 500 to 700 (The Netherlands; Wynhoff et al., 1996) and 2000 individuals (France; Munguira, Martín, 1999).

Viability assessment of Maculinea alcon in eastern Austria

All causes of decline of *M. alcon* in eastern Austria are discussed separately and summarised in a final classification (Table 4).

Moist meadows and lowland moors, the exclusive habitats of *M. alcon* in central Europe, are generally endangered (Munguira, Martín, 1999). In eastern Austria, the most critical threats to the habitats are drainage, afforestation and ploughing of moist grassland. Another great problem is fertilising of the remaining habitats, high mowing intensity and unfavourable mowing regimes, especially too early cutting, even in nature reserves and national parks.

Gentiana pneumonanthe, a character species of extensively managed grassland, is vulnerable in Austria (Niklfeld, 1999). At the two Waldviertel sites, the small population sizes of *G. pneumonanthe* are probably the limiting factors for *Maculinea alcon*. Additionally, at the afforested lowland moor in the Waldviertel and at the partly mown moist meadow of the Northern Stremtal, the gentian plants are overgrown by vegetation. This is known to reduce the accessibility for egglaying females (Krismann, 2000).

The three potential host ants *Myrmica scabrinodis, M. ruginodis* and *M. rubra* are not endangered (Schlick-Steiner et al., in prep.). The recorded host species *M. scabrinodis* inhabits dry to wet habitats and reaches its highest nest densities in lowland moors (Seifert, 1996). The availability and density of host ant nests is known to be one of the limiting factors for *Maculinea alcon* (Elmes, Thomas, 1992), and this might help explain the small population sizes of *M. alcon* despite high gentian densities in the Northern Stremtal.

Table 4. Viability assessment of the *Maculinea alcon* metapopulations in eastern Austria

	Parameters	*Maculinea alcon*	Source
General	life cycle	egglaying on *Gentiana pneumonanthe*, first 4 larval stages in the ovaries of *G. pneumonanthe*, 11-23 months including pupation in nests of *Myrmica scabrinodis, M. ruginodis, M. rubra*	own findings; SBN (1987) Ebert, Rennwald (1991)
	autecology	hygrophilous species of nutrient-poor lowland moors and moist meadows	own findings; Ebert, Rennwald (1991)
	minimal population size	50 to 300 (*M. rebeli*)	Brinkman et al. (1998) Amler et al. (1999)
	minimal area	ca 1 ha	Wynhoff et al. (1996) Munguira, Martín (1999) Settele et al. (1999)
	maximal migration distance	low mobility, 900 - 1700 m	Settele et al. (1996) Vanreusel et al. (2000)
	general causes of decline	abandonment of rural management, intensification of rural management, afforestation, built development, pollution, overcollecting, lack of studies	Munguira, Martín (1999)
Local	number and size of populations	6 known populations (all < 50 individuals)	own findings
	belonging of the populations to metapopulations	5 metapopulations (Waldviertel, Feuchte Ebene, Lake Neusiedl, Northern Stremtal, Southern Stremtal)	own findings
	isolation of the populations of a metapopulation	high fragmentation of habitat patches: distances (with the exception of Waldviertel) > maximum migration distance	own findings
	estimated size of metapopulations	all metapopulations < 50 individuals	own findings
	actual threats	habitat loss due to ploughing, drainage, afforestation, shrubbing; critical population sizes of gentians and host ants, eutrophication, mowing of gentians before seeding, import of biocides, grazing by deer	own findings
	impact of loss of single populations on the metapopulation	due to the small number of populations and the small populations sizes the loss of every single population can lead to instability, genetic bottleneck situation and furthermore to the loss of the metapopulations	own findings; Brookes et al. (1997) Saccheri et al. (1998) Amler et al. (1999)
Final classification	endangering of metapopulations	all metapopulations and therefore *M. alcon* are critically endangered in eastern Austria	

Table 4 presents the final classification of the conservation status of *M. alcon* in eastern Austria. This first attempt, partly based on rough estimates, is timely considering the underlying urgency. Based on present knowledge, all five metapopulations in eastern Austria must be regarded as critically endangered. This is justified due to the small number of

individuals within the metapopulations, the consistently low number of populations within the metapopulations (maximum two) and the severe ongoing threats. Therefore, *M. alcon* must be classified as critically endangered in Lower Austria and Burgenland.

Protection plan

The poor status of this species calls for urgent conservation measurements targeted at the larval foodplants, host ants and butterflies (Munguira, Martín, 1999). As *M. alcon* is an umbrella species for its habitats, measurements for its protection are of great value for many associated and mostly endangered species.

Based on experience with other European populations (SBN, 1987; Elmes, Thomas, 1992; Wynhoff et al., 1996; Munguira, Martín, 1999; Vanreusel et al., 2000; Van Dyck, pers. comm.) and the current threats, we suggest the following measurements (listed according to priority):

(1) The open and nutrient-poor character of the habitats must be safeguarded by a site-specific management. The import of nutrients and biocides must be reduced. Afforestations and shrubbings must cease. Creation of open ground in small parts of the habitat (e.g. every 5 years) promotes the germination of *Gentiana pneumonanthe* (Oostermeijer et al., 1994; Vanreusel et al., 2000). If mowing of the habitat or parts of it is necessary, this should not be done before late September, when the larvae have already left the gentians. Mowing with less heavy machines and at least 10 cm above the ground is favourable to the host ant nests. The establishment of "controlled fallow grassland" in some parts of the habitats (especially those with high densities of host ants) should be considered. Grazing of the habitat creates bare soil and therefore can be conducive to germination of *G. pneumonanthe* and positive for *Myrmica* host ants. On the other hand, cattle, sheep and horses (especially at high grazing densities) feed on *G. pneumonanthe* (own obs.; Vanreusel et al., 2000). Grazing can therefore be very harmful in small gentian populations and even lead to local extinction (Maes, van Dyck, 2001). It should be taken into consideration only for larger habitats (e.g. Northern Stremtal) and only in a rotational system. Grazing during and 4 weeks after the flight period of *Maculinea alcon* should be avoided because of trampling of gentians. It should take place in early May when gentians are still small or in late September, although this schedule can be modified regionally. Coupling of grazing animals causes eutrophication and is therefore harmful to gentians and host ants.

(2) Drainage and subsequent lowering of the water table level, ploughing or intensification of grassland in current and potential habitats must be stopped or prevented.

(3) The minimal area of habitats of 1 ha must be ensured or established.

(4) Special protective measures for the gentians must be undertaken, e.g. establishment of small patches of open soil in the vicinity of gentian plants, conducive to germination. More experience with this approach remains to be gathered (Vanreusel et al., 2000).

(5) Habitat fragments must be connected, e.g. by establishing grassland corridors with a minimal width of 200–500 m (Wynhoff et al., 1996). Stepping stones between local populations must be preserved or created (maximum distance ca 1 km). For the long-term sur-

vival of a *M. alcon* metapopulation, at least 10 habitat patches each measuring 0.5 to 1 ha are necessary (Vanreusel et al., 2000).

(6) Egg losses due to grazing by high densities of row deer must be reduced, especially in small-sized habitats, by removing feeding places or in some cases even by fencing.

(7) The nest densities of host ants, which ensure the long-term survival of *M. alcon* populations, have to be guaranteed or established. The best method to achieve this is to create – in other parts of the habitat – the habitat conditions of those parts of the habitat with the highest densities of host ant species.

The following aspects should be considered during implementation of the protection plan:

(1) Discretion regarding the exact position of the sites in order to prevent overcollecting.

(2) Coordination of protection and habitat managment in a national and international context.

(3) Efforts to include *M. alcon* into the annexes of the habitats directive of the European Union.

(4) Due to the urgency and severeness of the problem, protection cannot exclusively be based on volunteer management-contracts, but on a combination of legal protection as nature reserves and contracts.

(5) Control the success of the conservation measures and habitat management as well as monitor the gentians, ants and butterflies (through egg counts) at selected sites.

(6) Further detailed mapping of *Gentiana pneumonanthe* and verification whether the habitats are inhabited by *Maculinea alcon* by searching for their eggs.

If implementation is started immediately, the protection plan might still ensure the long-term survival of the species in eastern Austria; otherwise, *M. alcon* may go extinct in the near future.

Translated by the authors

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Höttinger H., Schlick-Steiner B.C., Steiner F.M.: *Maculinea alcon* (Lepidoptera: Lycaenidae) **vo východnom Rakúsku: stav a ochranné opatrenia.**

Vo východnom Rakúsku (Dolné Rakúsko, Burgenland) sme skúmali tri populácie parazitickej *Maculinea alcon.* Objavenie prepupálnych lariev v mravenisku *Myrmica scabrinodis* je prvým záznamom o mravcovi ako hostiteľovi. Na základe počtu vajíčok sme určili veľkosť populácie *Maculinea alcon* a vyhodnotili sme štruktúru metapopulácie. Na základe údajov o početnosti mravcov sme vyhodnotili odhadnutú veľkosť populácie *Gentiana pneumonanthe,* ako aj ich známe ohrozenia a schopnosť rastu metapopulácií. Každý z posledných piatich metapopulácií *Maculinea alcon* vo východnom Rakúsku má menej ako 50 jedincov a musí sa považovať za kriticky ohrozené. Navrhujeme, aby plán ochrany obsahoval 1. zabezpečenie otvorených a na potravu chudobných habitátov, 2. pozastavenie drenážovania, orby a intenzifikácie habitátov, 3. zabezpečenie minimálneho územia, 4. zvláštne ochranné opatrenia pre *Gentiana pneumonanthe*, 5. spojovacie fragmenty stanovíšť, 6. zredukovanie tlaku pasenia jeleňov na maloplošných stanovištiach a 7. založenie ideálnej hustoty mravenísk hostiteľských mravcov.

Vyhynutiu *Maculinea alcon* vo východnom Rakúsku možno zabrániť iba okamžitými ochrannými opatreniami.

ABOVEGROUND BIOMASS, ENERGY CONTENT AND PHENOLOGY OF *Veronica officinalis* L. *(Scrophulariaceae)* POPULATION UNDER DIFFERENT CANOPY DENSITY OF BEECH STAND

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Abstract

Kováčová M., Schieber B.: Aboveground biomass, energy content and phenology of *Veronica officinalis* L. *(Scrophulariaceae)* population under different canopy density of beech stand. Ekológia (Bratislava), Vol. 22, No. 2, 119–131, 2003.

We studied the biomass, density and length variability of shoots, energy content and phenology of *Veronica officinalis* L. populations growing in beech forest with different canopy density. The average values of shoot density, length, weight and energy contents of the studied species recorded in 1994–1995 considerably varied according to the tree canopy: 2–195 shoots per m^2, 9.3-29.7 cm, 0.105–0.435 gram and 6.14–1,351.7 $kJ.m^{-2}$, 18.372–19.453 $kJ.g^{-1}$ (fertile shoots), 18.135–18.970 $kJ.g^{-1}$ of dry matter (sterile shoots), respectively. Statistical analysis performed on the energy values between years 1994-1995 confirmed significant differences in the case of fertile shoots. In accordance with the current climatic conditions, in 1994 all phenophases were shifted earlier compared to 1995. Full flowering date was recorded during the first pentade of June in both years.

Key words: Veronica officinalis, biomass, energy content, population structure, phenology, beech forest

Introduction

The present forest stands at the Ecological Experimental Station Kremnické vrchy Mts consist of associations *Carici pilosae-Fagetum* and *Dentario bulbiferae-Fagetum* with local occurrence of beech-hornbeam stands. The basic and the most spread association is *Dentario bulbiferae-Fagetum*. We focused attention on the model species *Veronica officinalis* and its response to the environmental changes induced by the human activities (shelterwood cutting) in beech ecosystem. The opening of canopy gaps caused by natural disturbances is