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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 a permanent source of environmental heterogeneity in forest habitats (Valverde, Silvertown, 1998). Many woodland herbs, including *V. officinalis*, colonize the clearings after the opening of canopy gaps. Although natural conditions in plant populations may differ in many respects, the level of shading seems to be the most important factor determining differences between populations in terms of plant survival and demography (Mook et al., 1989; Muraoka et al., 1997; Bergstedt, Milberg, 2001; Reader, Bricker, 1992; Liira, 2002). The shading of the herb layer by the woody species has a considerable influence not only on the biomass, energy, abundance and length of the herbs (Brewer, 1980; Hinsberg, Tienderen, 1997; Viglaský et al., 1998) but also on their fertility. Although a considerable attention has been paid to the structure, dynamics, production, spatial structure and population biology of some herb species (Tumidajowicz, 1995; Kubíček, Hindák, 1977; Kubíček, 1977a; Laska, 1996; Kubíček, Šimonovič, 1975; Križová, 1993; Faliński, 1998; Hinsberg, Tienderen, 1997), only a little is known, in particular, about their response to the forest secondary succession. We focused our research for the adaptation abilities of this species in terms of their production, morphometric variables and phenology in the changed environment (according to varying canopy density). We evaluated the variables expressing the vitality (number, weight, length, production, energy) and life activity of vegetative and generative shoots of the species during the research conducted in years 1994 and 1995. This paper proceeds with the former works performed in the location EES Kremnické vrchy (Kodrík, 1993; Kováčová et al., 1999; Schieber, Kováčová, 2002; Barna, Kodrík, 2002) and contributes to the production-ecological synthetic concept of the herb synusia in submountain beech forest ecosystems.

Methods

The species

Veronica officinalis forms small, isolated colonies and represents about 1-5% of the total herb cover in conditions at the EES. The species is a perennial chamephyte belonging to *Scrophulariaceae*. It´s spread practically throughout entire Europe, from the lowlands to higher situated sites up to the subalpine vegetation zone. The stalk is creeping, with regenerating buds on shoots. The leaves are opposite, evergreen around whole year (Jurko, 1990). The seeds are lens-shaped. The diaspores are dispersed through polychoria. Species grows on fresh moist, moderate acid soils. In experimental conditions nitrate and exchangeable phosphate considerably influence growth of the species (Tyler, 1996). *V. officinalis* is a well-known species thanks to its healing effects (Scarlat et al., 1985; Rusu, Bucur, 1996; De, Mancini, 1997).

Study sites

The research was realized at the Ecological Experimental Station (EES) Kremnické vrchy Mts. The EES is situated on the SE slopes of the Kremnické vrchy Mts (48° 38´ N, 19° 04´ E, 450–510 m asl). The parent rocks of soils on the studied localities are andesite tuffaceous agglomerates.

The Station consists of an eco-series of monitoring plots (MP) with different stand densities: control MP K (stand density 0.9) and parallel MPs: H (clear-cut area), I (density 0.3), S (density 0.5), M (density 0.7). The whole-area shelterwood cutting accomplished in the winter 1988/1989 resulted in the following stand composition: MP I - intensive cutting (93% *Fagus sylvatica*, 5% *Quercus dalechampii*, 2% *Carpinus betulus*), MP S – medium cutting (90% *Fagus sylvatica*, 4% *Quercus dalechampii*, 4% *Abies alba*, 2% *Carpinus betulus*), MP M – mild cutting (79% *Fagus sylvatica*, 4% *Quercus dalechampii*, 17% *Abies alba*, 1% *Carpinus betulus*), MP K (92% *Fagus sylvatica*, 2% *Quercus dalechampii*, 4% *Abies alba*, 2% *Carpinus betulus*).

The forest phytocoenoses are represented by the associations *Carici pilosae-Fagetum* O b e r d . 1958 and *Dentario bulbiferae-Fagetum* (Z l a t n i k 1935) H a r t m a n n 1953. From the geobiocoenological point of view, both phytocoenoses belong to the 3rd forest vegetation degree, mesotrophic order of geobiocens, group of forest types *Fagetum pauper inferiora* and types of geobiocens *Carex pilosa-nudum* and *Dentaria bulbifera-nudum* (Kukla et al., 1998).

Figure 1 gives the general thermopluviometric diagram for the EES (data extrapolated from the data measured at the meteorological station Sliač). Temperature and rainfall in the two years of the study are illustrated in Fig. 2.

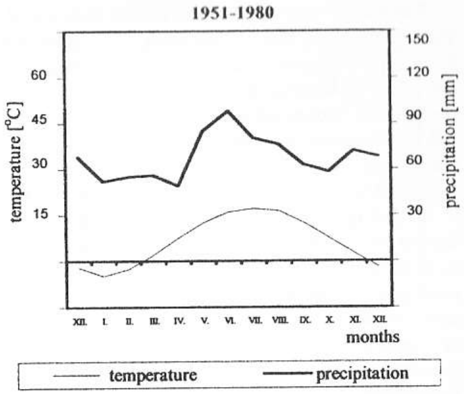

Fig. 1. Thermopluviometric diagram of EES Kremnické vrchy Mts.

Sampling

Research on the *Veronica officinalis* ran at years 1994–95 on experimental mini-plots, each 1x1 metre in size. The sampling was destructive (Kubíček, 1977b; Jakrlová, 1989). The experimental plots were designed and localised based on the results of a preliminary phytocoenological research performed by Kontriš et al. (1993) and Kontrišová et al. (1993). The total numbers of the mini-plots established on the individual experimental plots were as follows: 36-MP H, 30-MP I, 20-MP S, 18-MP M and 14-MP K. The herbaceous material was sampled in July 4–8 in 1994 and on the July 1 in 1995, in proximity of the studied mini-plots, from the same phytocoenoses and equally vital populations. The shoots growing from the creeping rhizomes (in the sense of Begon et al., 1997) were considered to be the aboveground parts of the individual herbs. The plants were divided into sterile (without generative organs) and fertile (with generative organs) ramets. Analysed plant material was dried at 85 °C up to the constant weight.

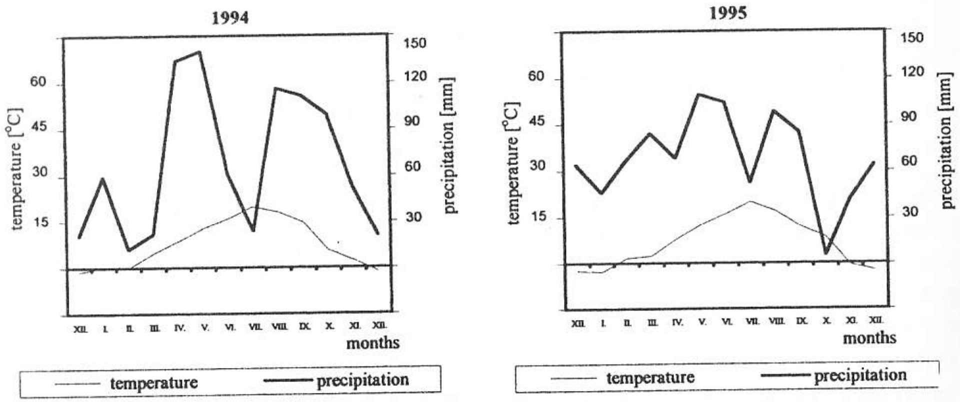

Fig. 2. Average months air temperature and precipitation of the years 1994–1995 on EES Kremnické vrchy Mts.

The energy value of the material was determined in an adiabatic calorimeter IKA C-4000 (software C-402). The homogenised samples weighing 0.7–1 gram were dried at 105 °C up to the constant weight, pressed and burnt in pure oxygen under a pressure of 30 atm. The final value of combustion heat was adjusted with regard to the values of binding and dissolution heat of sulphuric and nitric acids (DIN 51900). The percentage of ash content was determined gravimetrically after the burning of the samples in a muffle furnace at 500 °C (Javorský, 1987). The spatial and time-dependent differences in the parameters of the studied herb species (length of shoots and energy value of the aboveground phytomass) were examined using one-way ANOVA and Duncan´s test (Statgraphics, 1991). The homogenity of variances was evaluated through the Bartlett´s test.

Phenological observations were carried out at the beginning of vegetative period since the 1st March in regular time intervals of 2–3 days, later once a week in both years. With such frequent measurements we sought to determine the precise start and course of the individual phenophases. To evaluation of the individual phenophases (initiation of growth, green leaf, flower buds, flowering, unripe seeds, ripe seeds, seed dispersal) was made according to the scale of Zlatník (1978). The start of the phenophase was precised as a moment when 10% of shoots were in the phase or 50% of shoots for full development of the phase (Šuľc, 1981), respectively. Air temperature and precipitation were continually measured and analysed, using the data obtained with thermo-hygrographs and thermometers directly from the plots at the EES (Schieber, Kováčová, 2002).

Results

Phenology – vegetative and generative phenophases (Table 1)

The start of growth was observed at the end of the first decade of April (1994) or at the end of the 3rd pentade of April (1995). The phenophase "green leaf" started in the half of the last pentade of April (1994) or in the half of the first pentade of May (1995).

T a b l e 1. Phenophases of *Veronica officinalis* L. population (phenophase 1= initiation of growth, 2 = green leaf, 3 = flower buds, 4 = full flowering, 5 = unripe seeds, 6 = ripe seeds, 7 = seed dispersal)

Vegetative			Generative					Year
Phenophase	1	2	3	4	5	6	7	
Date	9.4	28.4.	15.5.	3.6.	14.6.	5.8.	18.8.	1994
	14.4	2.5.	19.5.	5.6.	18.6.	12.8.	26.8.	1995
Number of days since January 1th	99	118	135	154	165	217	230	1994
	104	122	139	156	169	224	238	1995
Mean soil temperature [°C]	5.6	9.8	10.1	13.1	13.9	15.2	15.3	1994
	4.7	9.2	9.3	14.2	14.4	14.2	14.4	1995

The first generative phenophase "flower buds" was observed in the half of May (1994) or at the end of the 2nd decade of May (1995). Flowering started in the half of the first pentade of June (1994), in the year 1995 two days later. Unripe seeds were observed in the middle of June (1994) or at the end of the 2nd decade of June. Ripe seeds were recorded at the end of the

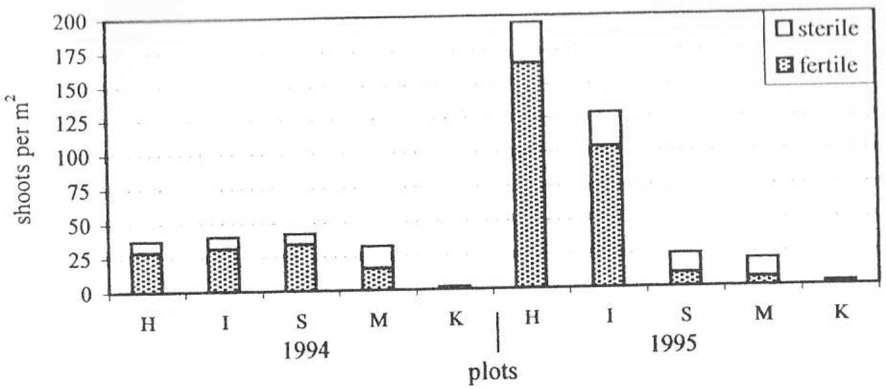

Fig. 3. Number of *Veronica officinalis* sterile and fertile shoots.

first pentade of August (1994) and one week later in 1995. Seed dispersal was observed since the half of the 4th pentade of August (1994), in 1995 since the last pentade of August.

Density of shoots (Fig. 3)

The numbers of sterile shoots per 1m2 ranged from 2 on MP K to 16 on MP M in 1994. The mean numbers observed on plots H, I and S were practically equal (8-9). In the case of the fertile shoots, the corresponding values ranged from 16 (MP M) to 34 (MP S). The values determined in the managed phytocoenoses (H, I a S) were very similar (with only a 10% difference).

The numbers of sterile shoots determined in 1995 ranged from 3 (MP K) to 30 (MP H) per 1 m2. For the fertile shoots the corresponding values ranged from 6 (MP M) to 165 (MP H). On MP S and M the numbers of the sterile shoots were equal. The numbers of both fertile and sterile shoots observed on plot H in 1995 were 5.3 times higher compared to 1994. On MP I the increase was 220 %. The trend on MPs S and M was opposite: in average only 65 % of sterile and fertile shoots compared to 1994. No fertile shoots were found in the years of study on the mini-plots situated on the control plot K.

Shoot length (Fig. 4)

The herb length is a very important biometric variable, reflecting the vitality of the herbs growing at the given locality. For this reason, we separately analysed the individual shoots growing from creeping rhizomes. The average shoot length on the monitoring plots ranged from 16.8 (MP K) to 22.8 cm (MP M) in 1994. So the difference between maximum and minimum was 6 cm (36 %). Based on the results obtained with ANOVA (Fig. 4) we can conclude that the differences between the average values of the herb length on the individual plots measured in 1994 were not statistically significant. The corresponding values ranged much more: from 9.3 (MP K) to 29.7 cm (MP H) in 1995. So the difference was

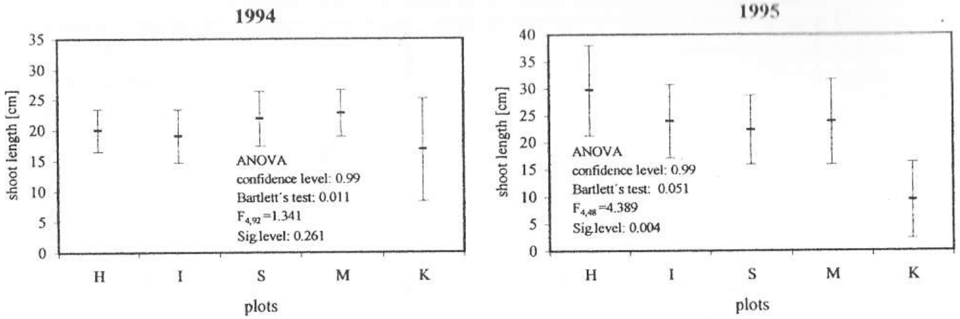

Fig. 4. ANOVA for mean shoot length of *Veronica officinalis* species.

considerable: 20.4 cm (220 % compared to the minimum). The results of the one-way ANOVA (Fig. 4) in this year confirmed the significant differences between the average values of herb length on the monitoring plots. The Duncan´s test also revealed the significant difference between the control plot and the managed plots H, I, S and M.

We observed longer shoots on the managed MPs (MP H by 48 %, MP I by 25 %, MP S by 2 %, MP M by 4.5 %) in 1995 compared to 1994. On the other hand, the mean shoot length on control plot was remarkably lower (in average by 7.5 cm, that means 80 %) compared to the value observed in 1994.

Shoot weight (Fig. 5)

The phytomass values of *Veronica officinalis* in 1994 were in the case of sterile shoots from 0.105 g (MP S) to 0.175 g (MP M). Higher values of the average weight of sterile shoots were determined on the control plot (0.168 g) and on the plot M (0.175 g). In the case of the fertile shoots the tendency was opposite: the higher weight values were observed on the mini-plots situated in the managed stands (MP H-S). The weights of the individuals growing on these plots ranged from 0.310 g to 0.422 g (36 % difference).

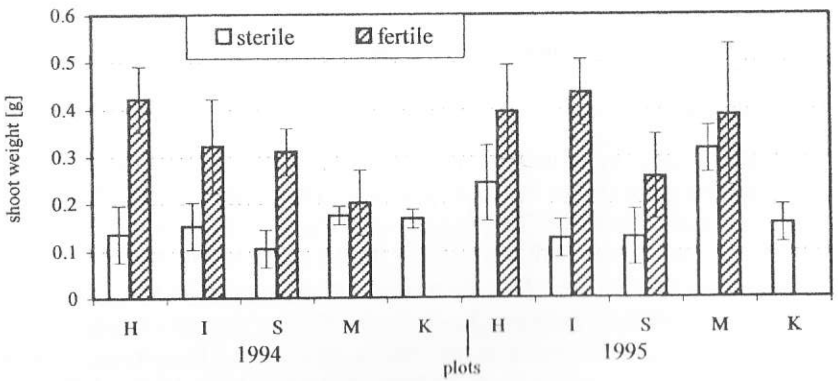

Fig. 5. Mean weight (bars) and standard deviations of *Veronica officinalis* shoots.

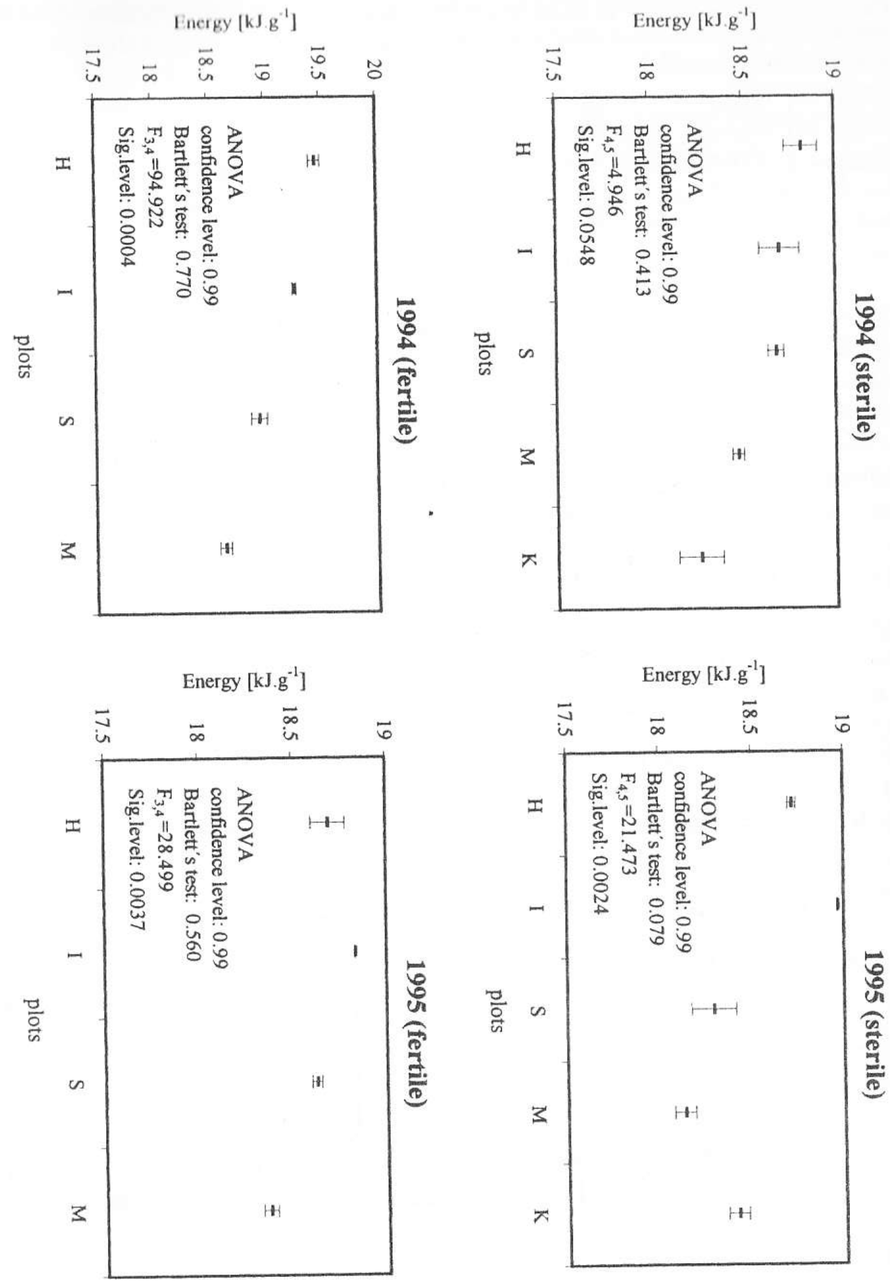

Fig. 6. ANOVA for energy biomass of *Veronica officinalis* species.

T a b l e 2. Differences in energy values [kJ.g^{-1}] of *Veronica officinalis* biomass between years 1994-1995 obtained through data processing with ANOVA

Plot	Shoot	F-ratio	P (sig.level)	
H	sterile	2.266	0.2712	n.s.
	fertile	103.253	0.0095	*
I	sterile	12.811	0.0700	n.s.
	fertile	999.9	0.0008	**
S	sterile	6.254	0.1295	n.s.
	fertile	35.846	0.0268	*
M	sterile	57.255	0.0170	*
	fertile	34.547	0.0277	*
K	sterile	0.556	0.541	n.s.

Note: n.s. - no significant difference
* - P< 0.05, ** - P< 0.01
d.f. = 1, 3 (in all cases)

The decreasing trend in shoot weight with increasing cutting intensity observed in 1994 did not continue in 1995.The average weight of the fertile shoots was the highest on the clear-cut (0.394 g) and on the plot I (0.435 g). A remarkably high weight was found on plot M (0.387 g). In the case of the sterile shoots, the values ranged from 0.125 g (MP I) to 0.315 g (MP M). The difference was 150 %.

We determined higher average values of the fertile shoots on MP I (35% difference) and MP M (90% difference) in 1995 compared with 1994. In the case of the sterile shoots the higher values were on plots H and M (80% differences).

Energy content (Fig. 6–7, Table 2)

The energy content of the studied species biomass varied according to site and stand conditions (Fig. 6). In 1994 the combustion heat of the sterile shoots moved between 18.271 kJ.g^{-1} (MP K) and 18.822 kJ.g^{-1} (MP H). The difference between the maximum and minimum was 551 J (i.e. 3 %). In the case of fertile shoots these values were from 18.639 kJ.g^{-1} (MP M) to 19.453 kJ.g^{-1} (MP H). The maximum value of the combustion heat was by 800 J (4.5 %) higher compared to the minimum. The fertile shoots reached higher values of combustion heat (in average by 3 %) compared to the sterile shoots on plots H-M. The results of

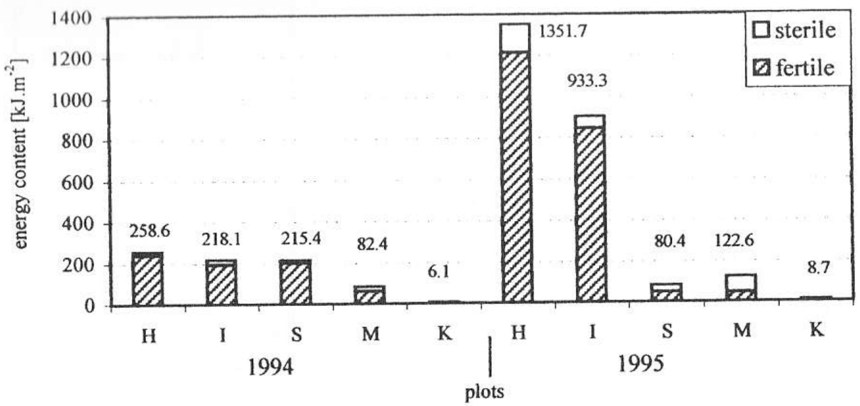

Fig. 7. Energy content of *Veronica officinalis* shoots.

T a b l e 3. Energy values [kJ.g^{-1}] of *Veronica officinalis* ash free dry matter

Year	1994		1995	
Plot	sterile	fertile	sterile	fertile
H	20.252	20.892	20.127	20.076
I	20.122	20.694	20.392	20.228
S	20.102	20.349	19.668	20.003
M	19.858	20.018	19.495	19.731
K	19.660	-	19.798	-

ANOVA performed in this year confirmed significant differences in biomass energy values on the individual MPs only in the case of the fertile shoots (Fig. 6). The Duncan´s test identified significant differences only between plots H, I on one side and plots S, M on the other side. Another significant difference was also confirmed between plots S and M.

The combustion heat of the sterile shoots moved from 18.135 kJ.g^{-1} (MP M) to 18.970 kJ.g^{-1} (MP I) in the year 1995. The combustion heat value observed on control plot was higher in average by 1.5% compared to the values determined for the managed phytocoenoses S, M. The values for fertile shoots ranged in this year from 18.372 kJ.g^{-1} (MP M) to 18.834 kJ.g^{-1} (MP I). The ANOVA confirmed significant differences in the energy of phytomass of sterile and fertile shoots between the individual monitoring plots in 1995. In the case of the sterile shoots the differences were significant between plots H and M, and between I on one side and S, M, K on the other side. In the case of the fertile shoots, considering the managed plots, the differences were significant between plot M on one side and the plots H, I and S on the other side.

The mean energy values of sterile shoots determined for the individual plots in 1994 were not very different from the corresponding values obtained in 1995. A significant difference was only found in the case of plot M with the discussed value higher in year 1994. In the case of the fertile shoots, the energy values on plots H - M were significantly higher in 1994 (Table 2).

The energy content converted to the amount per one m^2 (Fig. 7) was 2 % on the control plot compared to the clear-cut (100 %) in 1994. The values determined for the other monitoring plots were as follows: 32 % MP M, 83 % MP S, 84 % MP I. In 1995 the energy content on the control plot was only 1 % compared to MP H (100 %). The values on the other plots were as follows: 9 % MP M, 6 % MP S, 67 % MP I.

Corrections required owing to heat loss by sulphuric acid moved from 2.3 J (fertile shoots) to 15.1 J (sterile shoots), and in the case of nitric acid from 6 J (sterile) to 6.6 J (fertile).

The average ash content in *V. officinalis* was about 7.5 % (sterile: 7.6 %, fertile 7.4 %). Energy values of ash free dry matter are summarised in Table 3.

Discussion and conclusions

Because the study years were rather different in terms of the climate, we supposed that this fact had also been responded by the course of the phenological phases of the populations of *Veronica officinalis*. The mean air temperature in January and February 1994 was above zero and the mean temperature in March, being 4.5 °C, was by 2.5 °C higher compared to the long-term average value. On the other hand, the temperature in March 1995 did not exceed the normal limits. The precipitation total in February and March 1994 was only 34 mm – a really value compared to 150 mm measured in 1995 (Fig. 2). These factors (higher air temperature – lower soil moisture content – higher soil temperature) promoted the earlier vegetative development of the species in 1994. The first phenophase "initiation of growth" was observed at the end of the first decade of April in year 1994, whereas five days later in 1995. The similar trend was also preserved in the case of the following two phenophases. The "full flowering" was observed within the first pentade of June in both years, in 1994 two days sooner. In the case of "unripe seed" the time shift between the years was again enhanced – to 4 days, in the case of "ripe seed" even to seven. The same was observed on "seed dispersal" which in 1994 was found to begin by eight days sooner compared to 1995. The cause was probably in drier weather conditions in 1994. For example: in this year the total precipitation amount in July was only 24 mm, in July 1995 it was 52 mm; in both cases under almost precisely the same air temperature. In such a way, these results have confirmed the promoting influence of higher air temperature in spring on initiation and course of the individual phenophases of the observed species (Fitter et al., 1995).

Density is a function of site fertility, competition for mineral elements, light intensity and colonization abilities of a given species (Tumidajowicz, 1995). Our results show that the density of *V. officinalis* populations varied spatially – according to the density of tree canopy (light conditions) in the examined phytocoenoses. The numbers of the fertile shoots in phytocoenoses on monitoring plots H (clear-cut area) and I (density 0.3) in 1995 were several times higher compared to 1994. The opposite – decreasing trends in shoot numbers were observed in phytocoenoses on plots S (density 0.5) and M (density 0.7). Demography of the studied species changed with time, under the influence of environmental conditions (crown canopy). *V. officinalis* responded primarily to the changes in light supply determined by the secondary succession. After the cutting of intensity less or equal 50 % the crown canopy was being formed more quickly and the total length increment of the parent stand after the five years following the cutting treatment was in average 120 cm (Barna, 2000). This fact, had naturally resulted in worsening of light conditions in the studied phytocoenoses which was further reflected on the decreasing numbers of *V. officinalis* on plots S and M in 1995. Changes in light quantity primarily affected growth, production parameters and numbers of *Potentilla* species (Stuefer, Huber, 1998). Valverde, Silvertown (1998) in their study document smaller changes in the structure of survival of herbal populations under closed canopy compared to the populations growing on more opened (brighter) patches. Population growth and fecundity was more expressive in brighter conditions. The survival was more important for populations under closed canopy, where the growth is the slowest. The same holds also for other forest herbs (Chazdon, Pearcy, 1991).

Forest herbs are well-adapted to the ecology of the ground layer of the forest. Low light intensity is mainly reflected on longer shoots and larger values of specific leaf-area (Kubíček, Hindák, 1977; Schieber, Kováčová, 2002). Evidently longer shoots were only observed on plot M (with minimum reduced tree layer). The mean weight of an individual herb and the mean biomass energy value were higher on plots in the managed phytocoenoses H and I. The energy values of sterile and fertile shoots determined in 1994-1995 decreased with decreasing cutting intensity (from H to K), the values of the fertile shoots being higher. The relation between the phenological development and caloric values of the individual forest species is discussed in details in Kubíček (1977a). On the studied species the highest energy values were determined in the full-flowering phase and the lowest in the vegetative phase.

The results of our study allow us to obtain patterns of production and morphometric characteristics as well as of life activity of *V. officinalis* in natural and human-influenced beech stands. The variability in the studied parameters reflects the influences of various natural factors as well as of the cutting intensity. Our observations indicate that the demographic trends of *V. officinalis* populations observed in different environmental conditions are not uniform.

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Kováčová M., Schieber B.: **Nadzemná biomasa, energetický obsah a fenológia populácie *Veronica officinalis* L. v podmienkach rôzneho korunového zápoja bukového porastu.**

V podmienkach bukového lesa s rozdielnym korunovým zápojom sme študovali biomasu, denzitu a dĺžkovú variabilitu nadzemných výhonkov, energetický obsah a fenológiu populácie *Veronica officinalis* L. Priemerný počet výhonkov, dĺžka, hmotnosť a energetické obsahy študovaného druhu v rokoch 1994–1995 sa pohybovali v rozpäti: 2–195 výhonkov na m^2, 9,3–29,7 cm, 0,105–0,435 g, 6,14–1 351,7 $kJ.m^{-2}$ a 18,372–19,453 $kJ.g^{-1}$ (fertilné výhonky), 18,135–18,970 $kJ.g^{-1}$ sušiny (sterilné výhonky). Štatistická analýza energetického obsahu v porovnávaných rokoch 1994–1995 potvrdila významné rozdiely v prípade fertilných výhonkov. Vzhľadom na klimatické podmienky sme skorší nástup fenofáz pozorovali v roku 1994 v porovnaní s rokom 1995. Fenofázu kvitnutia sme v obidvoch rokoch zistili v priebehu prvej pentády júna.