FOLIA OECOLOGICA – vol. 35, no. 2 (2008). ISSN 1336-5266

Woodland strawberry (*Fragaria vesca* L.) – growth parameters in the Chočské vrchy Mts

Ján Kukla[1], Margita Kuklová[1], Erika Maliníková[2]
[1]Institute of Forest Ecology of the Slovak Academy of Sciences, Štúrova 2, 960 53 Zvolen, Slovak Republic, E-mail: kukla@savzv.sk, E-mail: kuklova@savzv.sk
[2]The Catholic University, Faculty of Pedagogy, Andreja Hlinku 60, 034 01 Ružomberok, Slovak Republic, E-mail: malinikova@fedu.ku.sk

Abstract
Kukla, J., Kuklová, M., Maliníková, E. 2008. Woodland strawberry (*Fragaria vesca* L.) – growth parameters in the Chočské vrchy Mts. *Folia oecol*., 35: 33–38.

The research was oriented on study of variability of selected growth parameters (length, weight, energy content, number of leaves in rosette and content of plant ash) of woodland strawberry in ecologically different geobiocoenoses in the Chočské vrchy Mts. The studied geobiocoenoses belong to the follo-wing forest vegetation tiers: the 4th – beech (geobiocoenosis 8), the 5th – fir-beech (geobiocoenoses 1, 5 and 6) and the 6th – spruce-beech-fir (geobiocoenosis 2). The highest differences in weight and energy storage of the *Fragaria vesca* rosettes (58%) were found between the geobiocoenoses of the 5th and the 6th forest vegetation tiers. The differences in energy density [kJ g^{-1} of dry matter] were small (3.2%), and significantly lower values were observed in the geobiocoenosis of the beech vegetation tier, similarly as in case of rosette length. The differences in the length and number of leaves in rosettes reached 33–34%. The highest average number of leaves per one rosette was ascertained in geobiocoenosis of the beech vegetation tier, the lowest in spruce-beech-fir vegetation tier. Significantly higher growth parameters (the mean length, weight, ash and energy content) of woodland strawberry observed in forest geobiocoenoses of 5th vegetation tier were connected with lower total herb cover.

Key words
Fragaria vesca L., growth parameters, forest ecosystems, the Chočské vrchy Mts

Introduction

The Chočské vrchy Mts are characterised by a considerable diversity of forest ecosystems represented by geobiocoenoses from the 4th (beech) to the 8th (dwarf pine) forest vegetation tiers (fvt). The current altitudinal gradation of vegetation is a result of long-term interrelations between the climatic conditions and ecological requirements of the plant species. The differences in ecological conditions are caused especially by mesoclimate and altitudinal climate, which is primarily reflected in composition of woody species and secondary also in herb layer of the biocoenoses (Hančinský, 1972). The high diversity of the plant species results from the specific properties of soils formed from carbonate parent rocks and variable geomorphological and climatic conditions. Growth and development of plants are influenced very significantly also by abiotic stress factors, eg by occurrence of extreme temperature, drought, environment pollution, etc (Bláha and Hnilička, 2004). The rate of energy flow, nutrient cycling, primary production and decomposition of organic matter are controlled by climatic, primarily temperature- and moisture-related environmental conditions. Therefore knowledge of developmental state of forest ecosystems is not possible without systematic study of their ecological conditions as well as of succession processes and changes in growth parameters of the species populations forming the plant communities (Kukla et al., 2003, 2004; Kuklová et al., 2005; Barna, 2000, 2004; Kodrík, 2004). In this paper we present results of research primarily oriented on assessment of growth

parameters of the woodland strawberry (*Fragaria vesca* L.) currently growing in ecologically different ecosystems of the 4th and 6th forest vegetation tiers in the Chočské vrchy Mts.

Material and methods

The Chočské vrchy Mts belong to the territory of West-Carpathian flora, district Central Carpathians, region Fatra and sub-region Chočské vrchy. The vegetation cover has mountain to high-mountain character. The geological substrate consists of mesozoic rocks as carbonates, dolomites and clay-rich limestones (Michal, 1977; Bozalková, 1981). In general, the Chočské vrchy Mts belong to moderately cold and cold climatic regions (Šamaj and Valovič, 1981).

The research was carried out in ecologically different geobiocoenoses selected on the background of forest typological maps and terrain recognition. The selecting criterion was phytocenological uniformity and sufficient size of geobiocoenological plots. The research of the *Fragaria vesca* population was carried out on five monitoring plots situated at altitudes 710–800 m. The studied geobiocoenoses belong to the 4th – beech (geobiocoenosis 8), 5th – fir-beech (geobiocoenoses 1, 5 and 6) and 6th – spruce-beech-fir fvt (geobiocoenosis 2). More detailed characteristic of the geobiocoenoses is presented in Table 1. The soils were classified according to Collective (2000), the geobiocoenoses in sense of Zlatník (1976a, b) and the plant taxa were determined and named according to Dostál (1989).

The plant material was obtained by means of random sampling from an area of 400 m^2 of the phytocoenological relevé. The *Fragaria vesca* species as a typical rosette plant is characterised by the clonal growth form (Klimeš et al., 1997). As a plant individual was considered rosette of leaves. The following phytoparameters were measured: the number of leaves in rosette, length of the longest shoot, and after drying at 80 °C for 48 hours, the weight of rosette with a precision of 0.002 g. The samples were homogenised in a planetary micro mill (<0.001 mm) and amounts weighing 0.7–1 g were pressed into a form of briquette, dried at 105 °C, to a constant weight and burnt in pure oxygen under a pressure of 3.04 MPa. The energy value of shoots was determined using an adiabatic calorimeter IKA C 4000 (C-402 software). The content of ash was determined gravimetrically, after burning the plant sample in a muffle furnace at 500 °C (Javorský et al., 1987).

The influence of ecological conditions on the growth parameters of the strawberry was evaluated by using the method ANOVA and the Mann-Whitney U test.

Table 1. Basic characteristics of the studied geobiocoenoses

Geobiocoenosis		G5	G1	G6	G2	G8
Altitude [m]		800	730	780	780	710
Exposition		ENE	NW	NNW	NW	S
Slope [°]		25	10–15	30	30–35	35–40
Rock		clay-rich limestone	dolomitic limestone			
Soil		Eutric	Calcaric		Cambi-Rendzic	Rendzic
		Cambisol			Leptosol	
Forest vegetation tier		5. fir-beech			6. spruce-beech--fir	4. beech
Edaphic-hydric	order	leading			a little restricted	restricted
	suborder	normal	on shallow or skeletal eluvium			dwarfish
Edaphic-trophic order/interord.		B mesotrophic	B/D mesotrophic/calc.		C/D nitrophilous/calc.	D calciphilous
Group of types of geobiocoens (Zlatník, 1976a, b)		*Abieti-Fageta typica*	*Abieti-Fageta ulmi inferiora*		*Fagi-Acereta superiora*	*Pineta dealpina*
Stand age [year]		80–100	80–100	80–100	50–70	40–80
Stand density		0.7–0.8	0.7–0.8	0.6	0.5–0.6	0–0.6
Canopy [%]		80	80	70	60[40]	0–60
Total herb cover [%]		70–90	60–90	60–80	80–100	80–90
Grasses and grassy species [%]		10[30]	20–40	5–10[70]	10–20[40]	20–70
The other species [%]		60–80	40–70	40–60	70–90	30–60
Mosses [%]		5–10	15–20	10[30]	80	–

Results and discussion

Number of leaves in a rosette

The average number of leaves found in strawberry rosettes (Table 2) ranged from 3 to 4.5 (minimum – 2 leaves, maximum – 7 leaves in a rosette). According to the decreasing mean number of leaves in a rosette, the studied geobiocoenoses (G) can be arranged into the following order: G8 (4.5) > G6 (4.4) > G1 (4.1) > G5 (3.9) > G2 (3.0). The maximal number of leaves in a rosette (4.5) was observed in the 4th – beech fvt, the lowest (3) in the 6th – spruce-beech-fir fvt (geobiocoenosis G2). The number of leaves in a rosette showed differences between the plots. There were found significant differences among strawberry population growing in geobiocoenosis G2 in comparison with populations growing in other geobiocoenoses (Table 3; $P < 0.01$; Mann-Whitney U test).

Length of a rosette

The length of rosettes (of the longest leaf) of woodland strawberry is presented in Fig 1. The average length of rosettes ranged from 9.9 cm to 14.9 cm. According to the descending length of rosettes (mean ± standard deviation), the studied geobiocoenoses create the following sequence: G1 (14.9 ± 2.6 cm) > G5 (14 ± 2.2 cm) > G2 (13.4 ± 2.1 cm) > G6 (10.7 ± 1.8 cm) > G8 (9.9 ± 2.4 cm). Higher values of this parameter were observed in geobiocoenoses of the 5th and 6th fvt (G1, G2 and G5). The maximum difference in length of rosettes reached 5 cm and the minimum length represented 66% from the maximum one. Significant differences (Tables 4, 5) were found among average rosette lengths of strawberry population growing in geobiocoenosis of beech fvt and the populations growing in the geobiocoenoses situated in the fir-beech and spruce-beech-fir fvt ($P < 0.01$; LSD multiple range test). The mean lengths of strawberry rosettes found in the Chočské vrchy Mts are comparable with the mean rosette lengths of this species (7.4–15.2 cm) found in phytocoenoses of managed beech stands in the Kremnické vrchy Mts by Schieber and Kováčová (2002a). Longest strawberry rosettes (17.4 cm) observed these authors in a closed beech stand with the lowest intensity of penetrating light (Schieber and Kováčová, 2002a).

Weight of a rosette

The average dry weight of strawberry rosettes growing in the phytocoenoses of the studied geobiocoenoses ranged from 0.200 to 0.345 g (Fig 1). The minimum weight represents 42% from the maximum one. According to decreased weight of rosettes (mean ± standard deviation), the studied geobiocoenoses create the following sequence: G1 (0.345 ± 0.068 g) > G5 (0.301 ± 0.069 g) > G8 (0.297 ± 0.022 g) > G6 (0.214 ± 0.036 g) > G2 (0.200 ± 0.067 g). Significantly higher weight of rosettes was observed in geobiocoenosis G1 (5th fvt) in comparison with populations growing in geobiocoenoses G2 (6th fvt) and G6 (5th fvt; $P < 0.05$; LSD multiple range test; Table 4, 5). The mean weight of strawberry rosettes found in the Chočské vrchy Mts is comparable with the mean weights of this species (0.134 to 0.338 g) found in the phytocoenosis of a closed managed beech stand in the Kremnické vrchy Mts (Schieber and Kováčová, 2002a). Somewhat higher values (by 19–51 %) observed these authors in case of fertile strawberry individuals (Schieber and Kováčová, 2002b).

Table 2. Mean number of leaves in *Fragaria vesca* rosettes

Geobiocoenosis	Sample size	Average	Minimum	Maximum	Standard deviation	Coefficient of variation
G1 (5th fvt)	21	4.1	2	6	±0.99	24.3
G2 (6th fvt)	20	3.0	2	4	±0.73	24.2
G5 (5th fvt)	21	3.9	2	5	±0.72	18.8
G6 (5th fvt)	35	4.4	2	7	±1.15	25.6
G8 (4th fvt)	18	4.5	3	6	±0.70	15.9

Table 3. Statistically significant differences in number of rosette leaves of *Fragaria vesca* species (* $P < 0.01$; Mann – Whitney U test)

Geobiocoenosis	G1 (5th fvt)	G5 (5th fvt)	G6 (5th fvt)	G8 (4th fvt)
G2 (6th fvt)	0.00070*	0.00085*	0.00001*	0.000009*

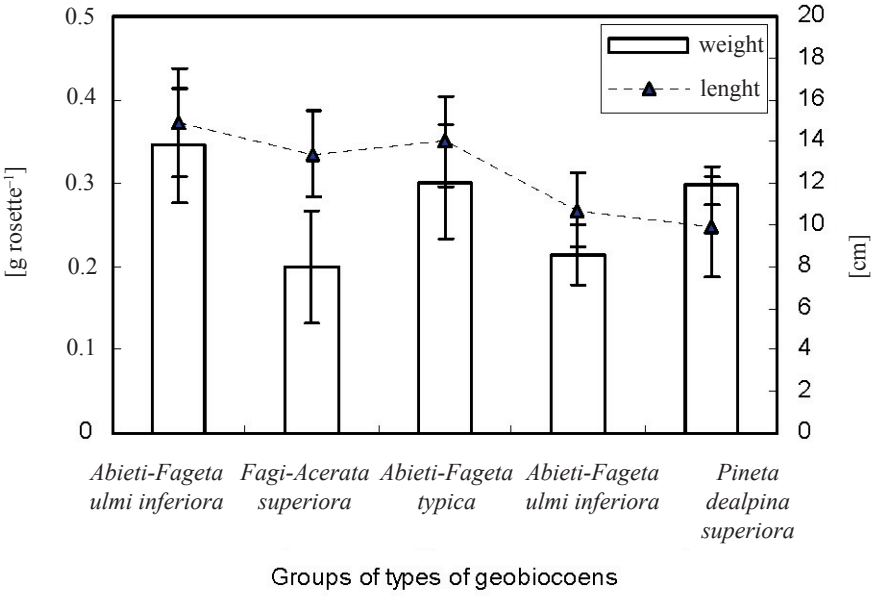

Fig 1. Dry weight and length of long leaf in *Fragaria vesca* rosettes (mean ± standard deviation)

Table 4. Results from one way ANOVA of Fragaria vesca growth parameters (* P < 0.05; ** P < 0.01)

Growth parameter	ANOVA			Bartlett´s test
	Degrees of freedom	F-ratio	P-value	
Rosette length	4; 114	21.050	0.0000**	0.4808
Rosette weight	4; 19	4.864	0.0102*	0.3781
Energy content	4; 19	8.668	0.0008**	0.1226

Table 5. Statistically significant differences in growth parameters of *Fragaria vesca* rosettes (*P < 0.05, **P < 0.01, LSD multiple range test)

Geobiocoenosis	G1 (5th fvt)	G2 (6th fvt)	G5 (5th fvt)	G6 (5th fvt)	G8 (4th fvt)
			Length		
G6 (5th fvt)	**	**	**	–	ns
G8 (4th fvt)	**	**	**	ns	–
			Dry weight		
G1 (5th fvt)	–	*	ns	*	ns
			Energy density		
G8 (4th fvt)	**	**	**	**	–

Energy and ash content in a rosette

The energy content (Joul g^{-1} d.m.) and energy storage (Joul $rosette^{-1}$) in strawberry rosettes are illustrated in Fig 2. According to the descending energy content (mean ± standard deviation) the studied geobiocoenoses create the following order: G1 (18,533 ± 42.5 J g^{-1}) > G2 (18,469 ± 102 J g^{-1}) > G6 (18,407 ± 126 J g^{-1}) > G5 (18,357 ± 204 J g^{-1}) > G8 (17,934 ± 244 J g^{-1}). Density of energy in 1 g of dry matter was different (Tables 4, 5). Maximum difference among the studied geobiocoenoses made 599 J. Significantly higher density of energy was observed in geobiocoenoses of the 5th and 6th fvt (G1, G2, G5 a G6) in comparison with geobiocoenosis G8 situated in the 4th fvt (P < 0.01; LSD multiple range test). The results are comparable with the data (18,220–21,352 J g^{-1} d.m.) obtained in other regions of the West Carpathians (Kováčová and Schieber, 2003; Kukla et al., 2003; Kuklová et al., 2005; Konôpková and Tokár, 2000; Konôpková, 2006).

The ash content found in the strawberry rosettes growing in the Chočské vrchy Mts fluctuated from

8.2% to 10.8%. The maximum value of the ash content in this species was found in the geobiocoenosis G1 (5th fvt).

Conclusions

The obtained results show that growth parameters of the *Fragaria vesca* species growing in the geobiocoenoses situated from the 4th to the 6th fvt are considerably variable. The highest differences among the studied strawberry populations (about 58%) were found in the values of dry weight and energy storage of rosettes. However, the significant differences were found only between the geobiocoenoses of the 5th and 6th fvt. The differences in density of energy were not big (3.2%). Significantly higher density of energy was observed in the ecosystems situated in the 5th and 6th fvt in comparison with the 4th fvt. The differences in length of rosettes and number of leaves in strawberry rosettes represented 33–34%. Significantly higher length of rosettes was ascertained in geobiocoenoses situated in the 5th and 6th fvt in comparison with the geobiocoenosis of 4th fvt. The highest average number of leaves in rosette was found in the geobiocoenosis of beech vegetation tier, the lowest in geobiocoenoses of spruce-beech-fir vegetation tier. Significant differences in number of rosette leaves were found among strawberry populations growing in the 6th fvt and populations growing in other studied geobiocoenoses. Significantly higher growth parameters (the mean length, weight, ash content and content of energy) of woodland strawberry observed in geobiocoenoses of 5th fvt were associated with lower total herb cover of plant communities.

Acknowledgement

This work was granted by the Slovak Research and Development Agency under the contract No. APVV-0102-06 and by the Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences (Project No. 2/7161/27).

References

Barna, M. 2000. Impact of shelterwood cutting on twig growth in predominant beech trees (Fagus sylvatica L.). *Ekológia (Bratislava),* 19 (4): 341–353.

Barna, M. 2004. Adaptation of European beech (Fagus sylvatica L.) to different ecological conditions: leaf size variation. *Pol. J. Ecol.*, 52 (1): 35–45.

Bláha, L., Hnilička, F. 2004. Influence of abiotic stresses on the basic traits of root system. *Biológia (Bratislava),* 59, Suppl. 13: 145–150.

Bozalková, I. 1981. Geografická stavba ŠPR Choč [Geographical structure of the National Nature Reserve Choč]. *Vlastiv. Zbor.*, 6: 177–183.

Collective, 2000. *Morfogenetický klasifikačný systém pôd Slovenska. Bazálna referenčná taxonómia* [Morphogenetic soil classification system of Slovakia. Basic reference taxonomy]. Bratislava: VÚPOP, Societas pedologica Slovaka. 76 p.

Dostál, J. 1989. *Nová květena ČSSR 2* [New flora of the Czechoslovak Socialistic Republic 2]. Praha: Academia. 1548 p.

Hančinský, L. 1972. *Lesné typy Slovenska* [Forest types of Slovakia]. Bratislava: Príroda. 307 p.

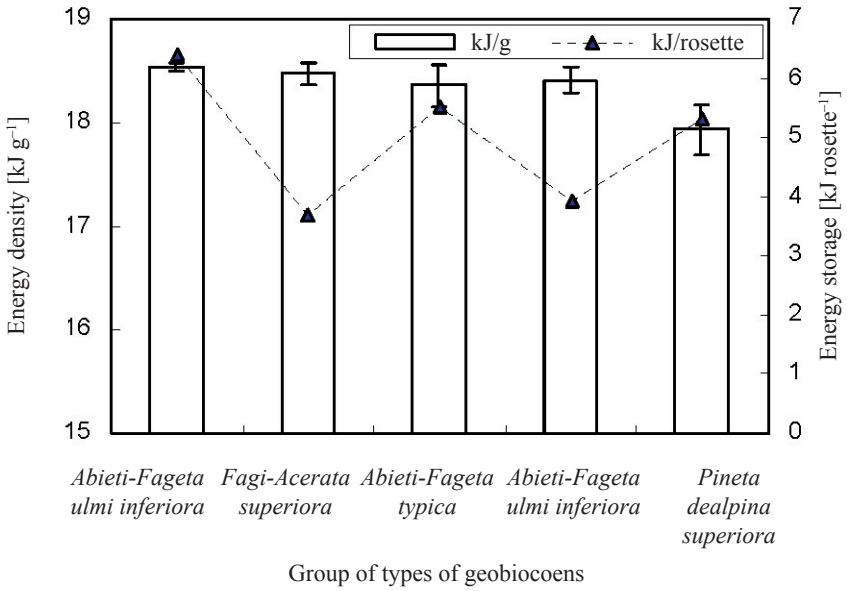

Fig 2. Content of energy in dry mass of *Fragaria vesca* species (mean ± standard deviation)

Javorský, P., Fojtíková, D., Kalaš, V., Schwarz, M. 1987. *Chemické rozbory v zemědělských laboratořích* [Chemical analyses in an agricultural laboratory]. České Budějovice: MZVž. 397 p.

Klimeš, L., Klimešová, J., Hendriks, R., Groenendael, J. van 1997. Clonal plant architecture: a comparative analysis of form and function. In Kroon, H. de, Groenendael, J. van (eds). *The ecology and evolution of clonal plants*. Leiden: Backhuys publishers, p. 1–29.

Kodrík, M. 2004. Human-induced environmental loading in the National Park Malá Fatra Mts indicated through fine roots of the main forest stand. *Ekológia (Bratislava),* 23 (4): 408–413.

Konôpková, J. 2006. Contents of bioelements and energy equivalent in assimilatory organs of European chestnut (Castanea sativa Mill.) *Folia oecol.*, 33: 94–101.

Konôpková, J. Tokár, F. 2000. Energy content of the aboveground biomass of Quercus rubra L. and Juglans nigra L. *Ekológia (Bratislava*), 19 (1): 10–22.

Kováčová, M., Schieber, B. 2003. Aboveground biomass, energy content and phenology of Veronica officinalis L. (Scrophulariaceae) population under different canopy density of beech stand. *Ekológia (Bratislava)*, 22 (2): 119–131.

Kukla, J., Kováčová, M., Schieber, B. 2003. Bioparameters of selected herb species in the High Tatra Mts. spruce ecosystems. *Pol. J. Ecol.*, 51 (3): 369–376.

Kukla, J., Kuklová, M., Schieber, B. 2004. Responses of some herbs to different ecological conditions in spruce ecosystems of the Bielovodská dolina valley. *Ekológia (Bratislava),* 23 (3): 252–269.

Kuklová, M., Kukla, J., Schieber, B. 2005. Individual and population parameters of Carex pilosa Scop. (Cyperaceae) in four forest sites in the Western Carpathians (Slovakia). *Pol. J. Ecol.*, 53 (3): 427–434.

Michal, P. 1977. Prosiecka a Kvačianska dolina [The mountain valleys Prosiecka and Kvačianska]. *Pamiat. a Prír.*, 2: 40–41.

Schieber, B., Kováčová, M. 2002a. Fenológia a produkčné parametre druhu Fragaria vesca (L.) v Kremnických vrchoch [Phenology and production parameters of the species Fragaria vesca (L.) in the Kremnické vrchy Mts.]. In Kubíček et al. (eds). *Ekológia a produktivita bylinnej vrstvy lesných ekosystémov.* Bratislava: ÚKE SAV, SES SAV, p. 69–74.

Schieber, B., Kováčová, M. 2002b. Production and growth processes of the species Fragaria vesca (L.) (Rosaceae) in a submountain beech forest. *Ekológia (Bratislava),* 21 (3): 264–274.

Šamaj, F., Valovič, Š. 1981. Klimatické pomery Liptova [Climatic conditions of the region Liptov]. *Vlastiv. Zbor.*, 6: 11–52.

Zlatník, A. 1976a. Přehled skupin typů geobiocénů původne lesních a křovinových v ČSSR [Survey of groups of types of geobiocoens primarily forest and shrubby in the C.S.S.R]. *Zprávy Geogr. Úst. ČSAV*, 13: 55–64.

Zlatník, A. 1976b. *Lesnická fytocenologie* [Forest phytocenology]. Praha: Státní zemědelské nakladatelství. 495 p.

Rastové parametre jahody obyčajnej (*Fragaria vesca* L.) v Chočských vrchoch

Súhrn

Výskum bol zameraný na štúdium variability vybraných rastových parametrov (dĺžka, hmotnosť, obsah energie, počet listov v ružici a obsah popola) jahody obyčajnej v ekologicky rozdielnych geobiocenózach Chočských vrchov. Skúmané geobiocenózy patrili do nasledovných lesných vegetačných stupňov: 4. bukový (geobiocenóza 8), 5. jedľovo-bukový (geobiocenózy 1, 5 a 6) a 6. smrekovo-bukovo-jedľový (geobiocenóza 2). Najväčšie rozdiely v hmotnosti a zásobe energie v ružiciach druhu *Fragaria vesca* (58 %) sa zistili medzi geobiocenózami 5. a 6. lesného vegetačného stupňa. Rozdiely v hodnotách energie [kJ g^{-1} sušiny] boli malé (3,2 %) a významne nižšie hodnoty sa zistili v geobiocenózach bukového vegetačného stupňa, podobne ako v prípade dĺžky ružíc. Rozdiely v dĺžke a počte listov v ružiciach dosiahli 33–34 %. Najvyšší priemerný počet listov v ružici sa zistil v geobiocenóze bukového vegetačného stupňa, najnižší v smrekovo-bukovo-jedľovom vegetačnom stupni. Významne vyššie rastové parametre (priemerná dĺžka, hmotnosť, obsah popola a energia) jahody obyčajnej zistené v lesných geobiocenózach 5. vegetačného stupňa súviseli s nižším celkovým krytom bylín.

Received February 28, 2008
Accepted April 24, 2008