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Short research contribution

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INDIVIDUAL AND POPULATION PARAMETERS OF *CAREX PILOSA* SCOP. (CYPERACEAE) IN FOUR FOREST SITES IN WESTERN CARPATHIANS (SLOVAKIA)

ABSTRACT: The sedge *Carex pilosa* Scop. was studied in beech forest sites situated on 470 m a.s.l. (Kremnické Vrchy Mts), 1290 m a.s.l. (Poľana Mts), 1275 m a.s.l. (Vtáčnik Mts) and 1170 m a.s.l. (Veľká Fatra Mts) in the Western Carpathians (Central Slovakia). The degree of leaf necrotisation was considerably lower in site Kremnické Vrchy Mts. The shortest mean length of shoots was observed in the Poľana Mts (27.3 cm) and the Kremnické Vrchy Mts (36.6 cm), i.e. in forest sites with lack of light in herb layer, the longest in the Veľká Fatra Mts (43.1 cm) and the Vtáčnik Mts (48.8 cm) with looser canopy of forest stands. The mean density of shoots (222> 211> 181> 26 per 1m^2), aboveground weight of a one shoot (0.386> 0.345> 0.303> 0.166 g), phytomass (85.7> 72.8> 54.8> 6.2 g m^{-2}) and energy storage (1669.4> 1326.5> 1052.8> 119.1 kJm^{-2}) of *Carex pilosa* populations decreased in the following order according the sites: Vtáčnik Mts> Kremnické Vrchy Mts> Veľká Fatra Mts> Poľana Mts. Different sequence was in case of the mean energy content: Vtáčnik Mts> Poľana Mts> Veľká Fatra Mts> Kremnické Vrchy Mts. Significant differences in mean shoot length were found between *Carex pilosa* population growing in lowest site (Kremnické Vrchy Mts) and populations growing in highest sites (Vtáčnik Mts, Veľká Fatra Mts) with different climatic conditions. The energy content was distinctively higher in the case of the highest situated plots (19.21–19.48 kJ g^{-1}) in comparison with the lowest situated site at the Kremnické Vrchy Mts (18.22 kJ g^{-1}). The insignificant differences were found only between the Poľana Mts and Veľká Fatra Mts plots. Differences in the mean shoot weight were insignificant.

KEY WORDS: C*arex pilosa*, biometric parameters, beech ecosystems, Western Carpathians

Carex pilosa Scop. is a perennial evergreen sedge belonging to the family *Cyperaceae* (Dostál 1989). This hemicryptophyte has usually a 15–30 cm long subterranean rhizome and overwintering leaves. The stalks are triangular on the crosscut, smooth, up to 50 cm in length. The leaves in rosette are 4–7 mm in width, flat, with fine hairs. This plant with clonal growth propagates mainly vegetatively by extrasheat offshoots (tillers) and creeping rhizomes. The growth of offshoots representing a new growing cycle begins in autumn. In this period, it is possible to determine the future generative organs. A steep rise of temperature in spring (by 5°C and more) is the stimulus for the intensive growth of assimilatory organs. The plant flowers from the end of April to the beginning of May. All the life cycle of the plant takes less than two years (Schieber and Kováčová 2000). According to Ellenberg (1974) the species is

Table 1. Climatic characteristics of study sites in Western Carpathians.

Locality	Altitude (m)	Climatic		Range of precipitation (mm)		Range of temperatures (°C)		
		region	subregion	annual	Apr.–Sept.	annual	Jan.	July
Kremnické Vrchy Mts	470	mildly warm	mildly warm, mildly humid, hilly land or highlands	700–800	350–450	6–7	-3–-4	17–18
Poľana Mts	1290	cool	very humid	1000–1100	550–650	3–4	-5–-6	13–14
Vtáčnik Mts Veľká Fatra Mts	1275 1170	cool	mildly cool, very humid	1100–1200	550–650	3–4	-5–-6	14–15

Table 2. Some properties of studied soils.

Locality	Soil subtype[1)]	Horizon	Layer (cm)	Soil reaction pH_{H2O}	Soil reaction pH_{KCl}	Ekv. $CaCO_3$ (%)	C_{ox}[2)] (%)	Humus (%)
Kremnické	Andic	Aoq	0–5	5.9	4.7	–	2.3	4.0
vrchy Mts	Cambisol	Bvn_1	25–35	6.0	4.7	–	0.7	1.2
		Bvn_1	45–55	6.2	4.7	–	0.3	0.5
		Bvn_2	60–70	6.3	4.7	–	0.3	0.5
		C	80–90	6.3	4.7	–	0.2	0.3
Poľana Mts	Cambi-Vitric	Aa	0–5	4.3	3.7	–	14.5	25.0
	Andosol	Aa	10–20	4.5	4.1	–	11.3	19.5
		Ba	30–40	4.5	4.1	–	8.1	14.0
		B/C	50–70	4.6	4.2	–	2.9	5.0
Vtáčnik Mts	Cambi-Vitric	Aa	0–5	4.2	3.7	–	16.6	28.6
	Andosol	Aa	10–20	4.8	4.3	–	13.1	22.6
		Ba_1	30–40	4.8	4.6	–	9.0	15.5
		Ba_2	50–70	4.7	4.2	–	5.2	9.0
Veľká Fatra	Cambi-Rendzic	Amc	0–5	7.6	6.7	33	15.6	26.9
Mts	Leptosol	Bvc_1	10–20	7.5	7.0	44	8.6	14.8
		Bvc_2	20–40	7.6	6.6	56	6.8	11.7

[1] according to Collective (2000).
[2] C_{ox} – content of soil organic carbon determined by Turin (Šály and Ciesarik 1991).

hemisciophyte close to moderate sciophyte, thermophilic – close to partially thermophilic, suboceanic and/or weakly subcontinental, fresh hydrophilous, weakly acidophilic, with moderate demands on nutrients. The nitrogen requirement is low to moderate.

In Slovakia, *Carex pilosa* is abundant beginning with the Malé and Biele Karpaty Mts on the West, ending with the Vihorlat and Bukovské Vrchy Mts, on the East. Exceptionally, it descends to altitudes 150–210 m (Kubíček and Hindák 1977), and as-

cends to 1300 m a.s.l. (Križo and Kmeť 1996). The cover of the species in lower parts of the Malé Karpaty Mts slopes (about 300 m a.s.l.) reaches about 25 % (Kubíček and Šimonovič 1980). The species forms very dense stands on the plains of Slovenský Kras Mts. Its ecological optimum occurs at the 300–700 m a.s.l. where it forms closed stands particularly in the oak-beech ecosystems. The species penetrates into the driest floodplain ecosystems (Kukla, personal observations). At present, it frequently occurs also in secondary oak and hornbeam ecosystems.

Ecological research of *Carex pilosa* communities was performed in Western Carpathians in last years (Kováčová *et al.* 1999a, b, Kukla *et al.* 1998). The goal of this investigation was to find out how the site conditions on the upper boundary of the *Carex pilosa* occurrence are reflected in values of selected biometric parameters of its populations in comparison with the values observed in more favourable environment.

The *Carex pilosa* communities were studied in beech forests situated on 470 m a.s.l. (Kremnické Vrchy Mts), 1290 m a.s.l. (Poľana Mts), 1275 m a.s.l. (Vtáčnik Mts) and 1170 m a.s.l. (Veľká Fatra Mts) in the Western Carpathians (Fig. 1).

The climatic characteristics of studied sites according to Miklós *et al.* (2002) are briefly presented in Table 1.

The soils in the Poľana, Vtáčnik and Kremnické Vrchy Mts forest ecosystems were formed from andesitic tuffaceous agglomerates, from dolomites – in the Veľká Fatra Mts. Some properties of studied soils are presented in Table 2.

Basic characteristics of studied forest ecosystems including geographical coordinates are described in Table 3. The names of the plant taxa were given according to

Table 3. Basic characteristics of studied sites.

		Kremnické vrchy Mts	Poľana Mts	Vtáčnik Mts	Veľká Fatra Mts
Geographical coordinates		48°38'10"N 19°04'10"E	48°37'50"N 19°28'30"E	48°37'14"N 18°38'07"E	48°52'50"N 19°10'50"E
Altitude (m)		470	1290	1275	1170
Exposure		WSW	SW	S	NW
Slope (°)		15	10	5–10	5–10
Stand density[1)]	upper storey	0.9	0.3–0.4	0.5–0.6	0.1
	lower storey	–	0.7–0.8	–	0.1
Vegetation unit[2)]		*FAGETA PAUPERA*	*ABIETI-FAGETA*		*FAGETA TILIAE*
		INFERIORA	*SUPERIORA*		*SUBHUMILIA*
Canopy (%)		90–100	90–100	80	10–15
Stand age (in years)	upper storey	100	80–100	100–120	80–100
	lower storey	–	30–40	–	<20
Stand height (m)	upper storey	28	16–18	17	14
	lower storey	–	10–12	–	<5
			Cover of herb layer (%)		
Grasses, sedges (there from *Carex pilosa*)		5 (±5)	10–15 (5–15)	30–70 (30–70)	70 (65–70)
Other herbs		20	10	10–20	50–60
Total		25	10–20	50–75	90–100

[1)] according to Assmann (1968)
[2)] according to Zlatník (1976)

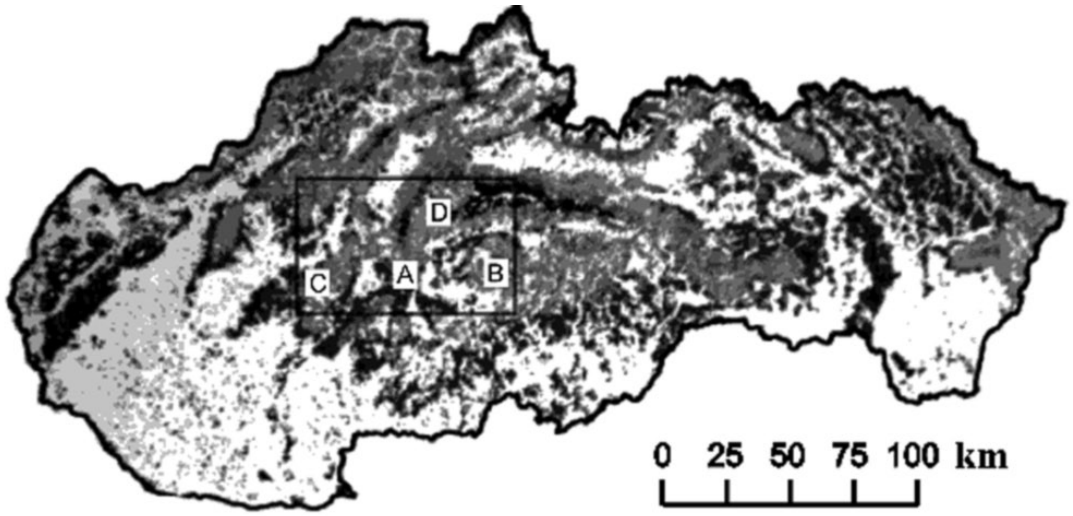

Fig. 1. The localisation of study sites in Western Carpathians (Central Slovakia):
A – Kremnické Vrchy Mts, B – Poľana Mts, C – Vtáčnik Mts, D – Veľká Fatra Mts

Dostál (1989). The main stand-forming species in the Kremnické Vrchy Mts is 80-year old beech (*Fagus sylvatica* L.).

The other tree species as linden (*Tilia cordata* Mill.), fir (*Abies alba* Mill.) and maple (*Acer pseudoplatanus* L.) occur only in undergrowth. The *Carex pilosa* Scop. species is accompanied by mesotrophic species mainly *Dentaria bulbifera* L. and *Galium odoratum* (L.) Scop. The other studied beech ecosystems are developed in fragments. The small admixture of spruce (*Picea abies* (L.) Karst.) occurs in the beech stand in the Poľana Mts and of maple (*Acer pseudoplatanus* L.) in the beech stand in the Vtáčnik Mts. Lower stand storeys contain, in addition to above mentioned woody plants, only ash (*Sorbus aucuparia* L.) and several shrubs. The site conditions of studied ecosystems indicate mountain species as *Adenostyles alliariae* Gouan)A. J. Kerner, *Cicerbita alpina* (L.)Wallr., *Hieracium prenanthoides* Will., *Luzula sylvatica* (Huds.) Gaud. and *Thalictrum aquilegifolium* L.

The production of *Carex pilosa* Scop. populations was determined according to Jakrlová (in Dykyjová 1989). The study was accomplished in July 2002. Each aboveground shoot (rosette of leaves) was considered as an „individual" (Slavíková 1986, Begon *et al.* 1997). The growth and vitality of sedge grass populations were evaluated by means of the following parameters: length of living and necrotised parts of leaves, density of shoots, weight of mean shoot, aboveground phytomass, energy content (kJ g^{-1}) and energy storage (kJ m^{-2}). The density of *Carex pilosa* Scop. shoots was assessed on representative miniplots 1 m^2. The sampling of 30–60 shoots from an area of 400 m^2 was randomized.

Sample material was dried for 48 hours at a temperature of 80°C and then weighted with a precision of 0.002 g. The energy content of phytomass (J g^{-1} of dry matter) was determined using an adiabatic calorimeter IKA C-4000 (software C-402). The samples weighing 0.7–1 g and homogenised were pressed into a form of briquette, dried up to a constant weight at 105°C and burnt in pure oxygen under a pressure of 3.04 MPa. The final value of combustion heat was corrected with regard to the heat values of sulphuric and nitric acid. The effects of site ecological conditions on individual (shoot length, weight, energy content) of *Carex pilosa* was analysed with ANOVA and Kruskal-Wallis´test. The significance of differences between sites was determined using the multiple range analysis (Duncan). Homogeneity of variances was evaluated by means of Bartlett´s test (Statgraphics, Chajdiak *et al.* 1994).

The values of selected parameters of *Carex pilosa* populations are presented in Table 4. The mean weight of shoot (0.386> 0.345> 0.303> 0.166 g), density of shoots

(222> 211> 181> 26 per 1 m^2), aboveground phytomass (85.7> 72.8> 54.8> 6.2 g m^{-2}) and energy storage (1669.4> 1326.5> 1052.8> 119.1 kJ m^{-2}) of *Carex pilosa* populations decreased, following the same sequence of the studied sites: Vtáčnik Mts> Kremnické Vrchy Mts> Veľká Fatra Mts> Poľana Mts. The shoot density in all studied sites was similar, with exception of the Poľana Mts (due possibly to the lack of light in the vertically differentiated forest stand). The mean number of leaves in shoots was somewhat lower in highest located sites, while the share of leaf necrotisation was considerably lower in the Kremnické Vrchy Mts with more favourable environmental conditions. The maximum aboveground phytomass (85.7 g m^{-2}) was found in the Vtáčnik Mts, minimum one (6.2 g m^{-2}) in the Poľana Mts where also the lowest values of shoot density and of mean shoot weight were observed. Differences (according to Kruskal-Wallis analysis, d.f. = 3.8, P = 0.0703) in the mean shoot weight values between study sites were insignificant. The highest energy storage was found in the Vtáčnik Mts site (1669.4 kJ m^{-2}). In comparison with this value the energy storage in the Kremnické Vrchy, Veľká Fatra and Poľana Mts sites was only 80%, 63% and 7%, respectively.

Kubíček and Jurko (1975) and Kubíček and Šimonovič (1980) have found 27–49 per m^2 of *Carex pilosa* shoots in different sites of *Carici pilosae-Carpinetum* association in the Malé Karpaty Mts . The shoot weight values ranged from 0.322 to 0.410 g and from 11.0 to 15.8 g m^{-2} for aboveground phytomass. Similar phytomass of this species (14.1 g m^{-2}) was found by Kubíček and Šimonovič (1975) also in the same association in other mountainous site in Carpathian region (Báb, Nitrianska Pahorkatina Mts). These values were as a rule lower in comparison with our results. The exception was only the mean shoot weight, value of which was similar to our value found in the Vtáčnik Mts. Schieber and Kováčová (2000) found the maximum density of *Carex pilosa* shoots in the Kremnické Vrchy Mts in May, the highest phytomass in September. There were no substantially differences in comparison with data of previously mentioned authors.

The mean shoot length (48.8> 43.1> 36.6> 27.3 cm) of *Carex pilosa* decreased in following order: Vtáčnik Mts> Veľká Fatra Mts> Kremnické Vrchy Mts> Poľana Mts. Significant differences in mean shoot length (according to ANOVA, F = 38.001, d.f. = 3.134, P = 0.000) were found between *Carex pilosa* population growing in lowest site (Kremnické Vrchy Mts) and populations growing in highest sites with different climatic conditions (Vtáčnik Mts, Veľká Fatra Mts) and also between these two populations of the highest situated sites. This was probably caused by different mean length and temperature of vegetation period, closer canopy and shortage of light in the herb layer of beech stands in the Kremnické Vrchy and Poľana Mts (Table 3). The mean *Carex pilosa* shoot length in the Kremnické Vrchy Mts is comparable with values found in this locality by Schieber and Kováčová (2000) in 1994–1996 (22.5–40.0 cm). In comparison with the data of Kontriš and Kontrišová (1992) from the Kremnické Vrchy Mts, the total lenght of *Carex pilosa* shoots in 2002 was higher aproximately about 17%, however, the share of the necrotised parts of leaves was higher up to 40%.

The mean energy content (19.48> 19.26> 19.21> 18.22 kJ g^{-1}) of *Carex pilosa* individuals decreased, following the sequence of the studied sites: Vtáčnik Mts> Poľana Mts> Veľká Fatra Mts> Kremnické Vrchy Mts. The values were clearly higher in the case of the highest situated sites in comparison with the lowest site. The significant differences (according to ANOVA, F = 336.996, d.f. = 3.20, P = 0.0000) in mean energy contents were found between the lowest site and each of the higher situated sites. Higher energy contents (in average by about 6%) were found in the highest located sites (Vtáčnik, Poľana and Veľká Fatra Mts).

The energy content values in grasses of oak-hornbeam ecosystems determined by Kubíček (1977) ranged from 18.172 to 19.266 kJ g^{-1}. Papp (after Jakucs 1985) found in an oak forest the sedge energy content between 18.171–18.502 kJ g^{-1}. Similar values we found also in the Kremnické Vrchy Mts. In the Vtáčnik Mts they were by about 5% higher. Energy content values in sedges growing in environmental conditions in Bulgaria varied from 17.881 to 19.964 kJ g^{-1} (Nikolov and Valčev 1995). Somewhat

Table 4. Selected parameters of *Carex pilosa* populations in four study sites in Western Carpathians (significantly differing values are marked with letters in brackets).

Locality	Density of shoots			Number of leaves in shoots			Shoot length necrotic parts		Shoot length living parts		Shoot length total	Weight of shoots	Phyto-mass	Energy storage	Energy content
	aver-age	min	max	average	min	max	average		average			average	average	average	average
	(individual.m^{-2})			(pieces)			(cm)	(%)	(cm)	(%)	(cm)	(g)	(g m^{-2})	(kJ m^{-2})	(kJ g^{-1})
A Kremnické Vrchy Mts (470 m a.s.l.)	211.3	41	431	3.2	2	5	4.0	10.9	32.6	89.1	36.6 ±8.3 (B, C, D)	0.345	72.8	1326.5	18.22 ±0.06 (B, C, D)
B Poľana Mts (1290 m a.s.l.)	26.3	13	36	2.6	2	4	4.0	14.7	23.3	85.3	27.3 ±7.7 (C, D)	0.166	6.2	119.1	19.26 ±0.09 (C)
C Vtáčnik Mts (1275 m a.s.l.)	221.7	126	296	2.8	2	4	6.4	13.1	42.4	86.9	48.8 ±4.5 (D)	0.386	85.7	1669.4	19.48 ±0.09 (D)
D Veľká Fatra Mts (1170 m a.s.l.)	181.0	93	269	2.7	2	4	6.3	14.6	36.7	85.4	43.1 ±7.3	0.303	54.8	1052.8	19.21 ±0.03

lower energy contents (16.426–17.477 kJ g^{-1}) were found in sedges growing in Southern Moravia floodplain forest (Vašíček, after Penka *et al*. 1985). It is evident that the energy content is increasing in herbs growing along altitudinal gradient. It was also recorded by Jolls (1984) and Usui *et al*. (1994).

The species growing on the upper boundary of their natural occurrence are a suitable object for ecological research. They enable to study to what extent the plant organism can adapt to extreme environmental conditions. The site conditions influence the structure, number, length and weight of shoots, value of biomass, energy storage and energy content of the local populations of plant communities. And the values of these parameters are reflected in the vitality of the relevant plant populations.

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