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IMPACT OF DEFORESTATION ON RIPARIAN COMMUNITIES OF CARABIDS (INSECTA, COLEOPTERA) ALONG BROOKS IN HIGH TATRAS

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Abstract

The Carabid communities on banks of eight brooks in High Tatras were investigated in 2009 and 2010. The communities at the brooks running through the intact forests stands or subalpine meadows at altitudes above 1500 m have mostly an identical fauna with the neighboring habitats, consisting of stenotopic forests species. Only on wider gravely shores, some mountain ripicolous species contributed to the species diversity of communities. In these brooks the average water temperature in the growing season ranged from 5.81°C to 7.84°C, except of the Tomanov potok brook, with the surprisingly high temperature of the 8.59°C, contrasting with the low temperature (4.73°C) in the Javorový potok, running parallel in the distance of about 150 m. In the area deforested by the wind disaster of November 2004, the average water temperature in the brooks ranged in the growing season from 8.81°C to 8.97°C. The brook bank fauna consisted of a mixture of the most tolerant forest species and invasion species characteristic for open landscape or arable land. The changes in the composition of the Carabid communities on brook banks and in water temperature were a common consequence of deforestation caused by the wind disaster and are closely correlated.

Introduction

The extensive deforestation caused in High Tatras by the windstorm on 14 November 2004 has essentially changed the climatic character of the damaged area and affected the both abiotic and biotic components of the aquatic and terrestrial ecosystem. These impacts can be also strengthened by the human activities connected with the management of the damaged areas (ILLYOVÁ et al. 2011, KRNO et al. 2006). The Carabid communities in the damaged forests differentiated into three major groups: (1) the almost intact communities in sites with calamite timber let *in situ*, (2) the communities in the sites with extracted timber characterized by a strong decline of stenotopic forests species and by a considerable favoring of the tolerant species and (3) the communities on the areas with extracted timber damaged additionally by fire, in which invasions of species typical of arable land also occur (ŠUSTEK 2007, 2008). This differentiation has, up to present, a stable character, with minor changes resulting from the between-year changes in the climate. The rainier and colder years positively influenced the community structure of the carabids in the next growing season. There arise however questions, (1) what is the deforestation impact on the fauna of brook banks, where specific ripicolous species can occur (BURMEISTER 1939, HŮRKA 1995, LARSON 1949, THIELE 1977) or (2) to what degree the deforestation impact on the Carabids could be moderated in damaged habitats by higher humidity (ŠKVARENINA et al. 2002, ŠUSTEK 2007). The aim of this contribution is to show, how composition of the Carabid ripicolous communities changes along the altitudinal gradient and between the intact and damaged areas.

Methods

The beetles were pitfall-trapped. The plastic jars of 0.5 l and opening diameter of 9 cm, filled with 4% formalin and protected against rain by a plastic disc served as traps. The traps were located closely to the brook bank. According to accessibility of the banks, 3 – 6 traps were installed in each site. The traps were exposed from May to November and empted at two month intervals.

The preference of species for humidity and vegetation cover was evaluated using two semiquantitative scales (ŠUSTEK 2004), in which 1 means xerophilous species and 8 polyhydrophilous species or 1 means the open landscapes (heliophilous) species while 4 means the forest species requiring shadowing by tree vegetation and 5 the species bound to permanently moist soil (Tab. 1). Each community is than characterized by a number calculated as an average of preference of recorded species weighed by number of individuals of each species (Fig. 4). The data for this classification were mostly taken from BURMEISTER (1939), HŮRKA (1995), LARSON (1949) and THIELE (1977).

The hierarchical classification of the Carabid communities was carried out by the unweighted pair group method using the Horn´s index as a measure of proportional similarity of the communities. This similarity index was used in order to compensate the different number of traps and chatche size in some localities. The non-hierarchic classification of the communities was made by the detrended correspondence analysis (DCA) and principal component analysis. The calculations were carried out by the Programs Past and CAP.

The water temperature in individual brooks was measured by automatic thermistores (8-TR Minilogs, Vemco Ltd., Shad Ba, Nova Scotia, Canada) fixed in the selected profiles of the brooks and exposed the whole year over. The data were downloaded once a year. The average temperatures were calculated for the equally long periods of the growing season, from May to September.

Characteristics of study sites

The Carabids were collected on the banks of following eight brooks in High Tatras seleceted so to they reflect the altitudinal gradient of the aquatic ecosystems and the differences between the intact and damaged areas. The sites can be briefly characterized as follows:

Zelený potok - upper site – E 20° 12' 49.86", N 49° 12' 18.79", 1743 m a.s.l., average water temperature 5.82°C, a southeasterly oriented grassy plot between two talus cones, individually dispersed small dwarf pines in vicinity. 6 traps installed about 2 m from the water, the site was completely open,

Zelený potok - lower site – E 20° 13' 4.15", N 49° 12' 32.35", 1548 m a.s.l., average water temperature 6.31°C, a flat stony alluvium on the bottom of the valley, near the Zelené pleso lake, a discontinuous cover of willows, bilberries and high herbs. 6 traps installed about 1 - 2 m from the water, the site was partially shadowed,

Tomanov potok– E 19° 56' 1.03", N 49° 13' 16.92", 1294 m a. s. l., average water temperature 8.59°C, an *Alnetum* at the brook left side, on a flat alluvium with deep humic soil, 6 traps were installed in a flat moist alluvium, the site was completely shadowed,

Tichý potok – E 19° 54' 49.04", N 49° 8' 49.36", 1058 m a.s.l., average water temperature 7.89°C, an open stony area at the brook left side bank, with low discontinuous trees and shrubs, six traps installed about 3 m from the water, the site was partially shadowed,

Poprad – E 20° 4' 41.93", N 49° 7' 12.49", 1232 m a.s.l., average water temperature 8.81°C ,brook bank on a small clearing on a southern slope, 2 traps were installed on a steep easterly oriented bank, about 2 m from the water, the site was almost open,

Veľký Šum – E 20° 6' 26.83, N 49° 7' 44.95. 1253 m a.s.l., average water temperature 7.24°C, a partly opened mature Norway spruce stand, 6 traps were installed in the grassy stand with dispersed low spruces and willows, about 1 m from the bank, the site was partially shadowed,

Hromadná Voda – E 20° 10' 18.95", N 49° 7' 20.88", 1021 m a.s.l., average water temperature 8.82°C, damaged area of the former Norway spruce forests, 3 the traps were installed in the secondary vegetation of willows and aspens, about 0,5 - 1 m from the bank, the site was completely open,

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Slavkovský potok– E 20° 11' 42.4752", N 49° 7' 58.77", 1047 m a.s.l., average water temperature 8.97°C, lower part of the stretch passing the burden area of the former Norway spruce forest. near the Tatranské Zruby, about 100 m above the water plant, the sampling site was situated in a deep glen, 3 traps were installed about 1 m from the brook bank, the site was completely open.

Results

The whole material studied consists of 205 individuals belonging to 28 species. The number of species in individual sites varied from 6 to 14 (Table 1) and number of individuals per site ranged from 9 to 48. The species belonged to four major ecological groups. The first one includes three cryophilous species, *Deltomerus tatricus*, *Pterostichus morio* and *Pterostichus blandulus* characteristic for the alpine meadows. The second group represented a complex of 14 species (*Carabus auronitens, Carabus fabricii, Carabus glabratus, Carabus linnei, Carabus violaceus, Cychrus attenuatus, Cycrus caraboides, Pterostichus burmeisteri, Pterostichus foveolatus Pterostichus pillosus, Pterostichus pumilio, Pterostichus unctulatus* and *Trechus* striatulus) regularly constituting fauna of the closed mountain forests. Among them, occurrence of *Carabus fabricii* is of a great faunistic significance. *Carabus violaceus* has wide amplitude of vertical distribution with the optimum in the beech to spruce vegetation tier (in the sense of RAUŠER & ZLATNÍK 1966) and shows a remarkable tolerance to deforestation. The third group included five species ripicolous (*Nebria rufescens, Nebria Jockischi, Chlaenius nitidulus, Bembidion glaciale)* and one hygrophilous species (*Pterostichus niger*). The fourth group included six open landscape species (*Amara erratica, Amara aenea, Bembidion kampros, Harpalus quadripunctatus, Poecilus cupreus* and *Microlestes maurus*). Among them *Amara aenea, Bembidion kampros* and *Poecilus cupreus* are typical of arable land and *Microlestes maurus* is an expressively xeophilous species preffering even strongly insolated habitats with discontinuous herbage or grassy vegetation. In the area studied all these species represented a strongly xenocoenous element.

As patent from the table 1, in no habitat studied a community consisting of the characteristic riparian species (BURMEISTER, 1939, HŮRKA 1995, LARSON 1949) was found. Such species co-occur only in both sites along the Zelený potok brook (*Nebria rufescens, Nebria jockischi, Bembidion glaciale*) and at the Tichý potok and Slavkovský potok brooks (*Chlaenius nitidulus* or *Pterostichus niger*). The major part of the communities consisted of mezohygrophiilous forests species or in the deforested site also by invading heliophilous species of open landscape. The fact that in the narrow riparian zone or even alluvia of brook or around springs the carabid communities are strongly influenced by the species inhabiting the adjacent habitats is known also from other localities in High Tatras (ŠUSTEK 2006) or in other West Carpatian mountains (ŠUSTEK & ŽUFFA 1986).

Table 1. Survey of Carabid species recorded on banks of eight brooks in High Tatras, their preference for humidity and vegetation cover, number of individuals and of species in each study site

Species			Brook							
	Humidity	Vegetation cover	Zelený potok hore	Zelený potok dole	Tomanov potok	Tichý potok	Poprad	Veľký šum	Hromadná voda	Slavkovský potok
Amara aenea (DE GEER, 1774)	3	1					1		1	3
Amara erratica (DUFTSCHMIDT, 1812)	3	1								1
Bembidion glaciale JEANNEL, 1941	8	5		8						
Bembidion lampros (HERBST, 1784)	3	1					1		2	3
Calathus metallicus DEJEAN, 1828	5	2	9	5		2				
Carabus auronitens FABRICIUS, 1792	4	4	4		2	1		1		
Carabus fabricii PANZER, 1796	5	3	4							
Carabus glabratus PAYKULL, 1790	4	4					1	2		1

Carabus linnei PANZER, 1812	5	4			3	1		1		
Carabus violaceus LINNAEUS, 1758	5	5			5	1	1	3	2	6
Cycrus caraboides (LINNAEUS, 1758)	5	4	3		1					
Cychrus attenuatus FABRICIUS, 1792	5	4			5			1		
Deltomerus tatricus (MILLER, 1859)	5	1	2							
Harpalus quadripuncatus DEJEAN, 1829	4	2							2	3
Chlaenius nititidulus (SCHRANK, 1781)	8	5				1				
Microlestes maurus (STURM, 1827)	2	1								1
Nebria jockischi DEJEAN, 1826	8	5	1							
Nebria rufescens (STROEM, 1768)	8	5	1	6	1	1				
Poecilus cupreus (LINNAEUS, 1758)	4	1					3		7	9
Pterostichus blandulus MILLER, 1859	5	1	2							
Pterostichus burmeisteri HEER, 1838	5	4			5			3		
Pterostichus foveolatus (DUFTSCHMIDT, 1812)	5	4	2		9	1	2	9		
Pterostichus morio (DUFTSCHMIDT, 1812)	5	1	8	1						
Pterostichus niger (SCHALLER, 1783)	6	4				1				1
Pterostichus pillosus (HOST, 1789)	5	4	5	2						
Pterostichus pumilio (DEJEAN, 1828)	5	4	1		9			1		
Pterostichus unctulatus (DUFTSCHMIDT,1812)	5	4	1		3	1		1		
Trechus striatulus PUTZEYS, 1847	5	4	5	3				5	1	
Number of species			14	6	10	9	6	10	6	9
Number of individuals			48	25	43	10	9	27	15	28

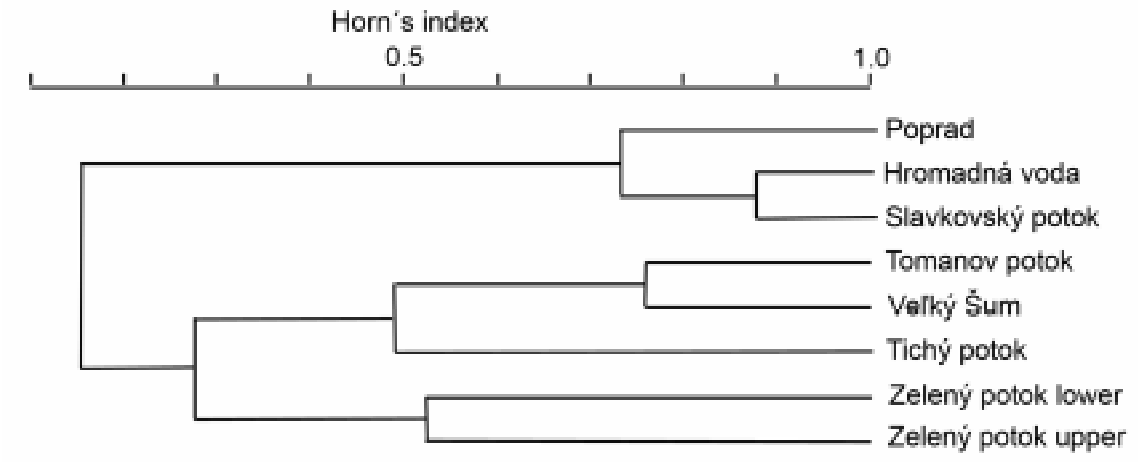

Fig. 1. Hierarchical classification of the Carabid communities living on the banks of eight brooks in High Tatras.

The communities form two clusters at similarity level of 0.15 (Fig. 1). The first cluster includes communities from the brooks Poprad, Hromadná voda and Slavkovský potok characterized by occurrence of the heliophilous species *Poecilus cupreus, Harpalus quadripunctatus, Amara aeanea, Amara erratica, Bembidion lampros*, and relatively tolerant forest species *Carabus violaceus* and *Carabus glabratus*. The only hydropholous element in this sites was Pterostichus niger, a species with wide amplitude of vertical distribution and a characteristic species of floodplain ecosystems in lowlands.

The second cluster consists of two subclusters at similarity level 0.3. The first subcluster includes communities from more or less shadowed bank of Tomanov potok, Veľký Šum and Tichý potok at the altitudes of about 1,000 – 1,300 m Characterized by absence of the heliophilous species and by

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occurrence of typical species of mountain forests like *Prerostichus foveolatus, Pterostichus burmeister, Cycrus attenuatus and Cychrus caraboides, Pterostichus unctulatus* and *Pterostichus pumilio*. The second subcluster includes two communities, from open or partly shadowed sites from altitudes of 1,500 – 1,750 m at the Zelený potok brook. These communities are characterized by the common occurrence of *Calathus metallicus*. The higher situated site consists of typical forests species, which tolerate, at higher altitudes, absence of closed tree vegetation. In addition there occurred the rare and highly localized species *Carabus fabricii*. The lower site was characterized by the typical ripicolous species *Bembidion glaciale, Nebria rufescens* and *Nebria jockischi*.

The pattern described by the hierarchical classification (Fig. 1) is confirmed by the DCA ordination (Fig. 2), where the communities from the Zelený potok brook are situated in the left lower corner of the ordination diagram. The communities from the more or less shadowed banks of the Tomanov potok, Veľký Šum and Tichý potok in the upper central part, while the communities from the open banks of Poprad, Hromadná voda and Slavkovský potok are in the right lower part of the ordination spas. Thus the first axis can be interpreted as gradient of temperature increasing from left to right or as gradient of altitude decreasing from right to left. The second axis can be interpreted as gradient of shadowing of the banks, increasing upwards, from Zelený potok and Hromadná voda to the completely shadowed banks of the Tomanov potok brook.

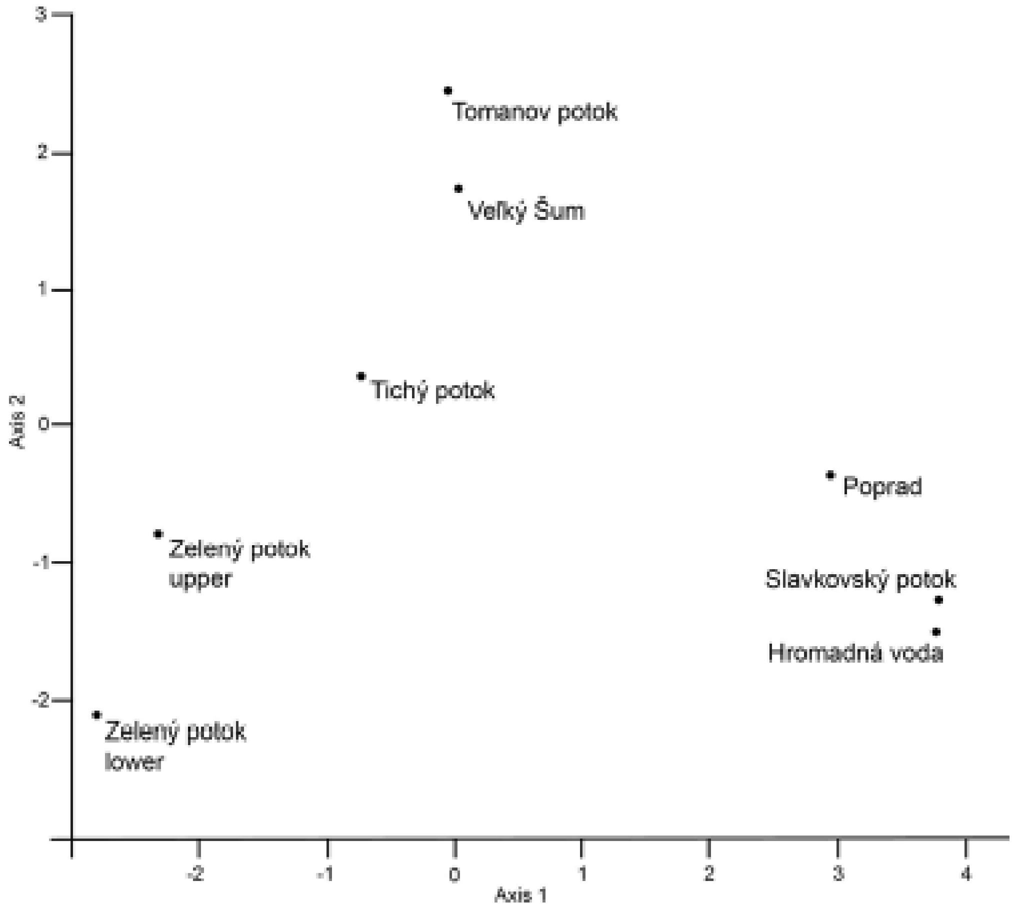

Fig. 2. DCA Ordination of Carabid communities on the banks of eight brooks in High Tatras.

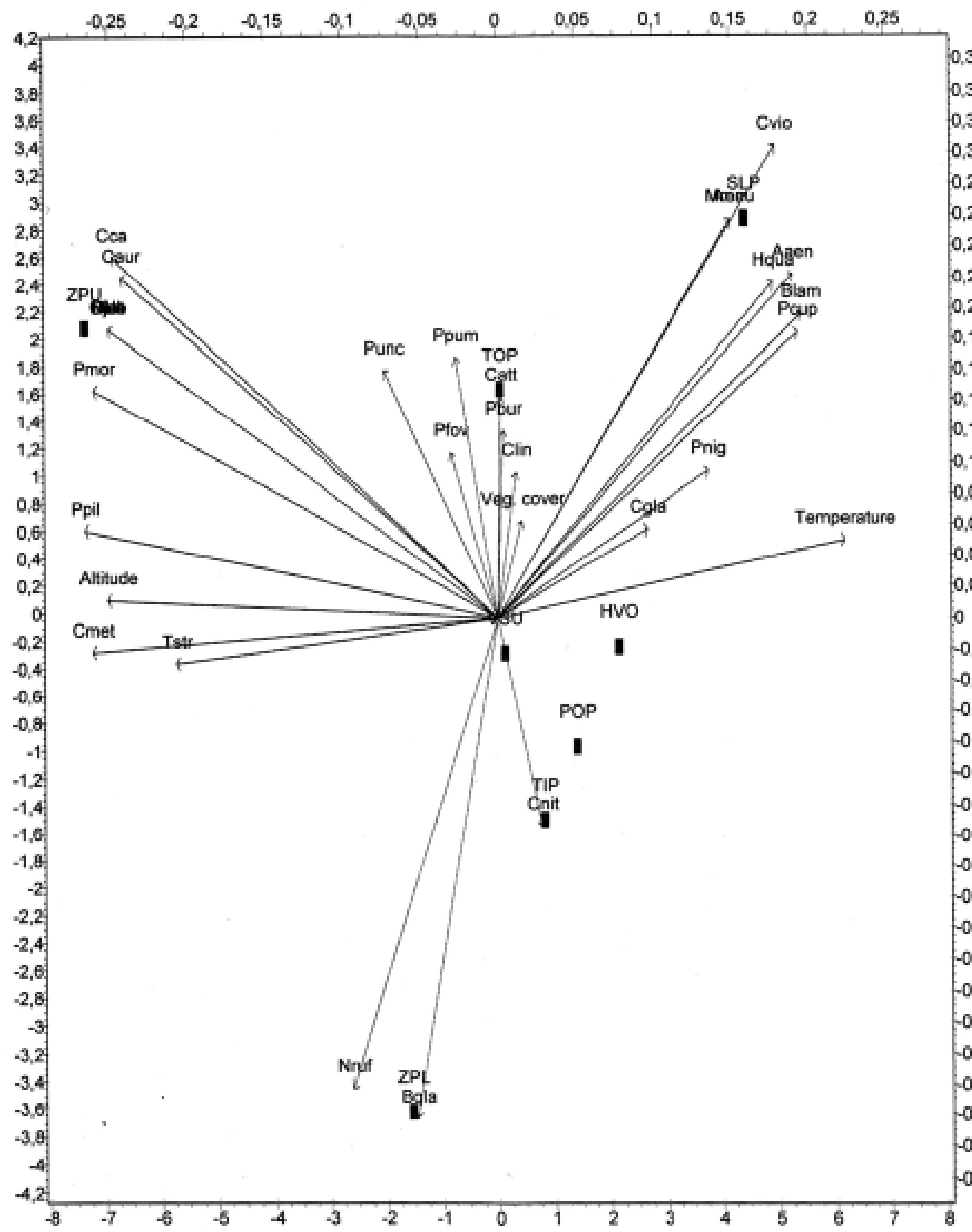

Fig. 3. PCA Ordination of the Carabid communities on banks of eight brooks in High Tatras and of three environmental variables (water temperature during growing season, altitude and vegetation cover), (abbreviations of sites – ZPU – Zelený potok upper, ZPL Zelený potok lower, TOP – Tomanov potok, TIP –Tichý potok, POP – Poprad, HVO – Hromadná voda,, VŠU – Veľký Šum, SLP – Slavkovský potok, abbreviations of species consist of first letter of the generic name and of three first letters of the specific name give in Tab. 1).

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The PCA ordination (Fig. 3) gives still more detailed classification of the localities and their association with individual species and their correlation with three environmental factors (altitude, vegetation cover and average water temperature. The communities at the Zelený Potok brook are clearly correlated by the higher altitude, but they are separated each from other by presence of the cryophilous species *Prerostichus morio* and *Pterostichus blandulus* in the upper site and by the ripicolous species *Nebria rufescens* and *Bembidion glaciale* in the gravely bank in the lower study site. The community at the Tomanov potok brook is correlated by the closed vegetation cover and common occurrence of *Cychrus attenuatus, Cychrus caraboides, Carabus linei, Pterostichus burmeisteri, Pterostichus unctulatus, Pterostichus pumilio, Pterostichus foveloatus* and *Trechus striatulus*. The semi-shadowed community from the Veľký Šum brook takes a central position, while that from the almost open banks of the Tichý potok brook is separated due to occurrence of the typical ripicolous species *Chlaenius nitidulus*. The communities from the deforested banks of the brooks Hromadná voda, Slavkovský potok and Poprad are clearly associated with the increased water temperature and penetration of the open landscape species *Amara aenea, Bembidion lampros, Harpalus quadrupunctatus, Poecilus cupreus* and *Microlestes maurus*.

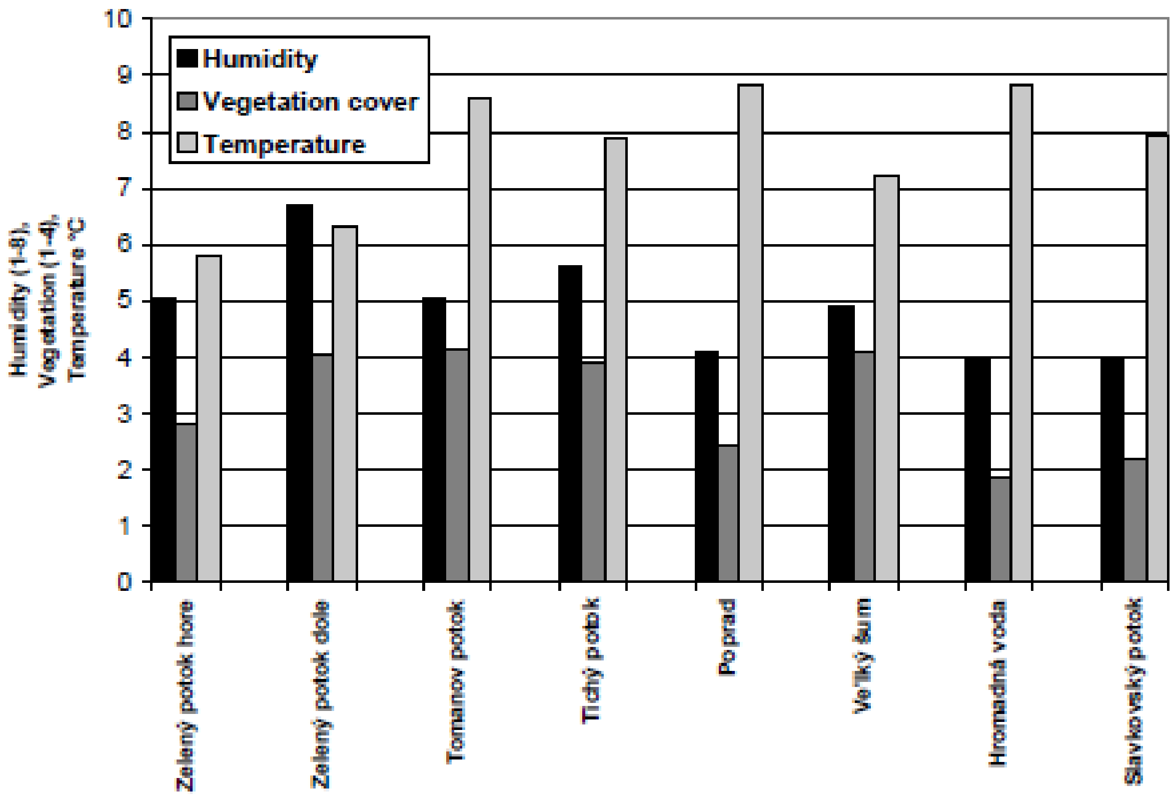

Fig. 4. Relationship between water temperature in the studied brooks and preference of carabid communities for humidity and vegetation cover.

The average preference of the Carabid community for humidity and vegetation cover (Fig. 4) shows that the preference for both factors is, in general, negatively correlated with the average water temperature. Water temperature was negatively correlated with the altitude ($r = -0.74$), but there were some sites, like the alluvium at the Tomanov potok brook, which laid at a considerable altitude of 1372 m, but temperature of its water as warm as water of brook stretches at lower altitudes (Hromadná voda, Slavkovský potok).

The results (especially the Zelený potok brook, upper site) confirm that the strongly positive climatic water balance (ŠKVARENINA et al. 2002) in higher vegetation tiers (dwarf pine vegetation tier in sense of RAUŠER & ZLATNÍK 1966) or in higher altitudes (above timber line) is able to compensate for the Carabids absence of the closed tree cover. However they show that still in the Norway spruce vegetation tier, the water balance is unable to compensate absence of closed tree cover and microclimatic condition required by the forest Carabids. At the same time, the results show that even the immediate vicinity of a water stream does not increase the humidity to such a degree, which would be able to compensate the impact of deforestation on the Carabid communities on the banks. Their composition in the deforested brook banks is identical as those on more remote parts of the damaged area of High Tatras (ŠUSTEK 2007, 2008).

The results also confirmed the fact that the riparian zones of mountain brooks have mostly almost identical carabid communities with the adjacent habitats and only in some place are also inhabited by highly specialized species.

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References

BURMEISTER, F., 1939: Biologie, Ökologie und Verbreitung der europäischen Käfer auf systematischer Grundlage. I. Band; Adephaga, I. Familiengruppe: Caraboidea. Edit. Hans Goecke Verlag. Krefeld: 307 pp.

HŮRKA, K., 1996:. Carabidae of the Czech and Slovak republics, Edit. Kabourek. Zlín: 565 pp.

ILLYOVÁ, M., BERACKO, P. & KRNO, I., 2011: Influence of land use on hyporheos in catchement streams of the Veľká Fatra Mts. Biologia, **66**: 320 – 327.

KRMO, I., ŠPORKA, F. ŠTEFKOVÁ., E., TIRJAKOVÁ, E., BITUŠÍK, H., BULÁNKOVÁ, E., LUKÁŠ, J., ILLÉŠOVÁ, D., DERKA, T., TOMAJKA, J. & ČERNÝ, J., 2006: Ecological study of a high.mountain stream ecosystem (Hincov potok, High Tatra Mountain, Slovakia). Acta Societatis zoologicae Behemicae. **69**: 299-316.

LARSON, K., 1949: Die fennoskandischen Carabidae, eine tiergeographische Studie I., Spezieller Teil, Elanders bocktryckerei Aktieboooklag, Göteborg, 711 s.

RAUŠER, J. & ZLATNÍK, A., 1966: Biogeografie I. Národní atlas CSSR, list 21, separát.

ŠKVARENINA, J., TOMLAIN, J. & KRIŽOVÁ, E., 2002: Klimatická vodní bilance vegetačních stupňů na Slovensku. Meteorologické zprávy, **55**: 103-109.

ŠUSTEK, Z. 2004: Characteristics of humidity requirements and relations to vegetation cover of selected Central-European Carabids (Col., Carabidae). Geobiocenologické spisy, Brno. **9**: 210 – 214.

ŠUSTEK, Z. 2006: Cenozele Carabidelor din ecosistemele alpine şi subalpine din Carpaţii occidentali. Oltenia, Studii şi comunpcări. Ştiinţele Naturii, 22: 138-147.

ŠUSTEK, Z. 2007: Reactions of carabid communities on wind disaster in High Tatras: a manifestation of species humidity preference. In: 15th International Poster Day, Transport of Water, Chemicals and Energy in the System Soil-Crop Canopy-Atmosphere. Bratislava, 15.11.2007, p. 635-643.

ŠUSTEK, Z. 2008: Veterná katastrofa vo Vysokých Tatrách a jej dopad na spoločenstvá bystruškovitých (Col. Carabidae) – výsledky z rokov 2007 a 2008, In: Fleischer, P. & Matejka, F. (eds.): Pokalamitný výskum v TANAP-e 2008, Tratranská Lomnica, p. 220-226.

ŠUSTEK, Z. & ŽUFFA, M. 1986. Orientačné výsledky inventarizačného výskumu spoločenstiev čeľadí Carabidae a Staphylinidae v CHKO Malá Fatra. Ochrana prírody, **7**: 347-374.

THIELE, H-U., 1977: Carabid beetles in their environments. Edit. Springer-Verlag. Berlin-Heidelberg-New York: 369 pp.