SHIFTS IN REPREZENTATION OF ALTITUDE PREFERENCE GROUPS OF CARABID BEETLES (COLEOPTERA, CARABIDAE) IN THE ZONE OF WINDSTORM CALAMITE IN HIGH TATRA IN NOVEMBER 2004

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Abstract

The Carabid communities in High Tatra in the zone damaged by windstorm of 2004 showed visible structural changes in 2007-2014 that are also indicated by shifts in representation of species with different vertical distribution. In all plots there increased representation of species having lower limit of distribution in the oak vegetation tier and optimum of distribution in oak-beech and beech-oak vegetation tier, as well as of the species that have wider amplitude of vertical distribution. This might be interpreted as reflection warming of the climate, but the more detailed analysis shows that more probable cause is climatic drought, as well as a higher competitiveness of some species. Irrespectively of the real causes, some lowland forests species (*Carabus coriaceus, Carabus nemoralis, Carabus hortensis*) spread in the localities studied. Among the parameters of vertical distribution od species these changes are best indicated by the average lower limit of vertical distribution and its average amplitude

Introduction

The carabid communities in High Tatra Mts. in the area damaged by the windstorm of 14 November 2004 were subjected to deep transformations resulting from the extensive deforestation, disturbance of soil surface during timber extraction, fire of a large portion of the damaged area, repeated cutting of herbage and spontaneous pioneer woody vegetation in some study plots, as well as from short term climatic fluctuation, especially temperature and humidity. These changes were described, on increasingly long time series and from different aspects, in several earlier papers (ŠUSTEK 2007 a 2008, ŠUSTEK & ČEJKA 2009, ŠUSTEK & VIDO 2012 a 2013).

These papers have shown that the deforestation combined with the additional anthropogenic interventions had approximately similarly strong influence on post-catastrophic succession of the Carabid communities as the natural fluctuations in temperature and humidity that were reflected with an approximately one year delay after their incidence. Influence of deforestation and connected anthropogenic inherencies were plot-specific, whereas the climatic factors had the same impact on the Carabid communities in all plots. This impact was reflected especially by cumulative abundance and biomass of Carabids and number of recorded species (ŠUSTEK & VIDO 2013). Simultaneously with these changes there was observed another, no to striking process, the slight spreading of species with optimum altitudinal distribution in lower altitudes. These species formed two groups – the first one consisted of open landscape (field) species immigrating into the damaged plots from fields in the Popradská kotlina basin, the second consisted of the typical species of lowland forests. Spreading of the first group species could be easily explained by the deforestation. The spreading of more thermophilous forest species can have different reasons. One of them is warming of the local climate in the study area. However, neither the sub-mountain and mountain forest Carabid species are not a homogenous stenotopic group, with the same altitudinal preference and distribution amplitude. Thus there appears the question, whether the shifts in representation of species with different altitudinal preference represent a more general trend. Clarifying of this question is the main aim of this paper.

Methods

The beetles were pitfall-trapped in six plots during eight growing seasons from 2007 to 2014. In each plot six traps were exposed from late May to early November. The traps were installed in distances of about 5-6 m in a line crossing each plot. The plots are characterized in details in ŠUSTEK & VIDO (2013). The basic characteristics are given table 1.

Table 1. Geographical and principal ecological characteristics of six study plots in High Tatra

Locality	Vyšné Hágy reference plot	Tatranská Lomnica Jamy,	Tatranská Polianka, Danielov dom	Tatranské Zruby lower plot	Tatranské Zruby upper plot	Nový Smokovec, Vodný les
Locality abbreviations	VH	**JA**	**DD**	**ZL**	**ZU**	**VL**
Geographical coordinates	49°07´17.5N 20°06´15.0E	49°09'33.7"N, 20°15'07.9"E	49°07´15.3N 20°09´46.0E	49°07´49.3N 20°11´49.1E	49°08´02.7N 20°11´30.1E	49°08'07.6"N 20°12'24.8" E
Altitude [m]	1233	1062	1060	1015	1095	1022
Vegetation tier	Spruce.	Spruce	Spruce	Spruce	Spruce	Spruce
Trophic series	AB	AB	AB	AB	AB	AB
Group of geobiocoens	*Sorbi Piceeta*	*Sorbi Piceeta*	*Sorbi Piceeta*	*Sorbi Piceeta*	*Sorbi Piceeta*	*Sorbi Piceeta*
Degree of damaging	Intact mature spruce forest	Fallen timber *in situ*	Timber extracted unburned	Timber extracted, burned	Timber extracted, burned	Timber extracted unburned

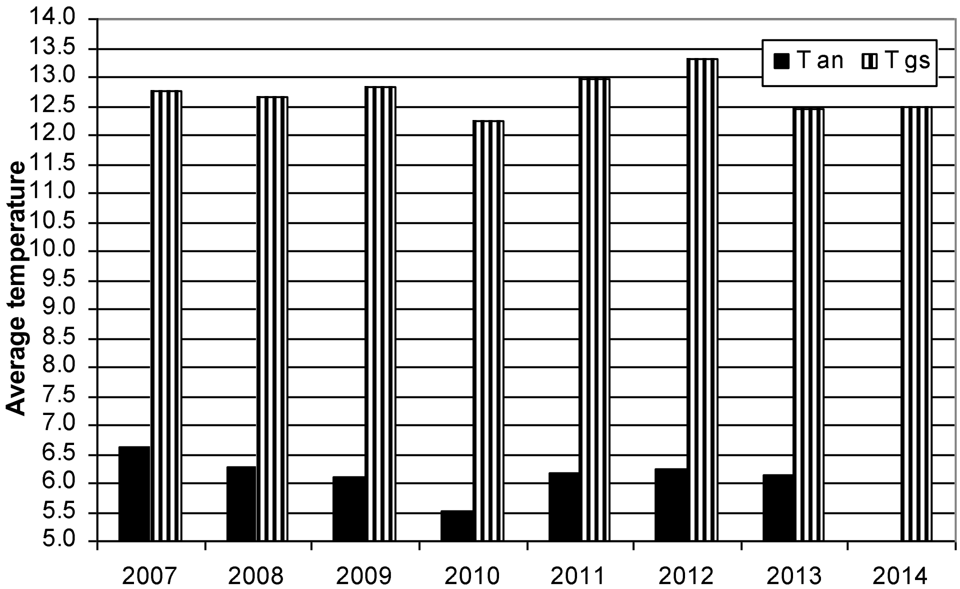

Fig. 1. Annual and growing season average temperatures in the 2007-2014 at the meteorological station Tatranská Lomnica. (for 20014 the annual average still not available)

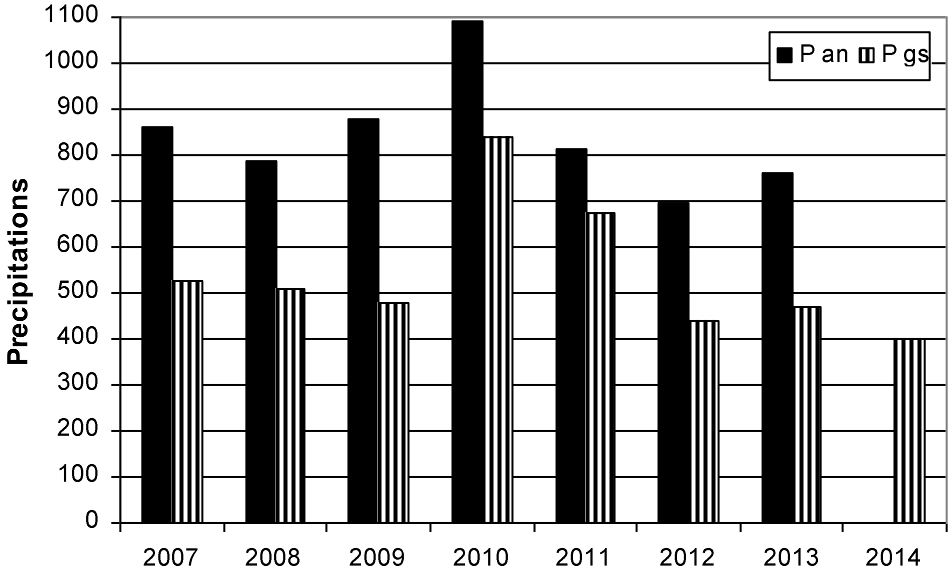

Fig. 2. Annual (P an) and growing season precipitation sums (P gs) in the 2007-2014 at the meteorological station Tatranská Lomnica (for 20014 the annual sum still not available)

Position of the traps did not change during the whole study period. Only in the reference plot in Vyšné Hágy the trap line was to be shifted about 150 m easterly, in results of damaging the stand by the windstorm in April 2014 and following extraction of the fallen timber. The character of the new plot in the mature spruce stand is identical and the shift has not influenced the results.

The climatic changes were characterized by average annual temperature, average temperature during vegetation period (Fig. 1), annual precipitation sums and precipitation sums during the growing season (Fig. 2), (VIDO, personal communication).

The characteristics of altitudinal preference of Carabid species according vegetation tiers (RAUŠER & ZLATNÍK, 1966) was taken from ŠUSTEK (2000), who graphically characterized the amplitude of vertical distribution of species and optimum of their occurrence within this amplitude. The optimum was characterized according to usual dominance position of a species taken in communities in different natural or seminatural ecosystems. In this study, the lower and upper limits of distribution was expressed by number of the respective vegetation tier (1 – oak veg. t., 2 – beech-oak veg. t., 3 –oak beech veg. t.„ 4 – beech veg. t.„ 5 – fire-beech veg. t.„ 6 – fire-beech-spruce veg. t.„ 7 – spruce veg. t.„ 8 – dwarf pine veg. t.„ 9 – alpine meadows veg. t.„ RAUŠER & ZLATNÍK 1966). The optimum was characterized in the same way, but in case of species having their optimum in more vegetation tiers it was expressed as the middle of the optimum interval. Some species (*Carabus violaceus*) can have a polymodal vertical distribution, but in this case the optimum in lowlands results from anthropogenic transformations of lowland forests and drift by flood waters (ŠUSTEK 1994, 1997). The vertical distribution of species and their habitat preference are characterized in table 2.

For each one-year sample from each study the average lower and upper limit and optimum was calculated These values were calculated as mean of all species weighted by abundance of each species (POOLE 1974).. The obtained values were plotted in diagram. In the same way the average amplitude width (difference between upper and lower limit) and distance of upper limit from the optimum (difference between upper limit and optimum) was calculated. This analysis was done separately for all species and only for the typical forest species.

Results and discussion

The results are based of a material consisting of 5,329 individuals that belong to 50 species. Number of species and individuals in one-year samples ranged from 7 to 20 and from 28 to 378 respectively (Tab. 3 – 5). These differences result from the state of the community and climatic character of the year (see ŠUSTEK & VIDO 2013). Principally, number of individuals and species strongly declined after the drought of 2007 and later on both parameters recuperated, with some delay, until 2011-2012 due to a series the colder and more humid years (Fig. 2 – 5). Then the number of species and individuals declined again in correlation with the warmer and drier years and growing seasons of 2013 and 2014. Beside it, the communities in the damaged plots were richer in species due to invasions of xenocoenous open landscape species. They were also sometimes richer in individuals, owing to two factors: (1) temporal invasions of xenocoenous species (*Poecilus cupreus. Poecilus versicolor, Amara* spp. *Harpalus* spp., *Peudoophonus rufipes, Microlestes maurus, Bembidion lampros*) and (2) successful survival of two tolerant forest species (*Carabus violaceus* and *Carabus glabratus*). In general, there also run a gradual convergence of the communities from the damaged plots with extracted timber and additionally affected by fire to those affected just by deforestation and timber extraction. All these communities eventually formed a common group (ŠUSTEK & VIDO 2013). This convergence was caused by growth of pioneer wood vegetation and regular cutting of dense stands of *Chamerion angustifolium* and their replacement by growths of *Calamagrostis* sp.

The parameters of vertical distribution of individual species (Fig. 5 – 9) changes in the period 2007-2014 as follows. The average lower limit (Fig. 5) continuously declined in all the study plots from the range of about 1.8-3.2 to values bellow 2. Hence the there increased representation of species have in the lower limit in the oak vegetation tier. The average optimum of vertical distribution (Fig. 6) was very stable in the intact reference plot in Vyšné Hágy and in the plot with timber *in situ* in Jamy, *b*ut in spite of it it showed a moderate decline from 5,9 in 2007 to 5,6 in 2012-2014, At the same time, the average optimum strongly varied in other damaged plots, with a strong drops in both burned plots in 2007-2009 and a continuous declining trend in Vodný les, where it decreased from the initial values of 4.8 in 2007 to 1,6 and 2,7 in 2013 and 2014, respectively. In the case of the communities from the burned plots it was due to predominance of *Poecilus cupreus*, a typical species of the arable land in lowlands, while in Vodný les to spreading and increasing dominance of three species of lowland forests, *Carabus coriaceus*, *Carabus nemortalis* and *Carabus hortensis.*

The average upper limit of the upper distribution (Fig. 7) was very stable in all plots. In the intact plot in Vyšné Hágy and in the plot with timber *in situ* in Jamy it moderately fluctuated around the level 7.8, while around 6,5 in the burned lots and moderately increased in these plots in 2014. A visible decline from 7.5 to 6.3 occurred in Vodný les especially due to *Carabus coriaceus*, *Carabus nemortalis* and *Carabus hortensis*. The stability of values the average upper limit results from the fact that all recorded species occurred here at their upper limit of distribution amplitude or close to it (Table 2).

The average amplitude of vertical distribution (Fig. 8) showed a stable level around the values 4,5 in all plots in the period 2007- 2009, but later on there started a slight increasing trend to the values ranging from 5.1 to 6.2 in 2014. This increase represents other expression of the increasing representation of the species having their lower limit of vertical distribution in the oak vegetation tier (Table 2).

The average difference between upper limit of vertical distribution and its optimum also shows a stability in all plots, but in the burned plots the difference decreased from the initial values ranging from 3.8 to 4.0 to the values close to 2.0. This is also just other expression of strong changes in representation of *Poecilus cupreus*, as shown above in the case of average optimum.

In general, the shift in representation of species with different amplitude of vertical distribution is best shown by the lower limit (Fig. 5) and width of the distribution amplitude (Fig. 8).

The described changes might indicate a trend to warming in all, intact and damaged plots. However, in the studied period it is in contradiction to the average annual temperatures (Fig. 1), which culminated in 2007, then declined to 2010 and again culminated in 2012 and then slightly decreased. At the same time, there was a culmination of humidity in 2010, which was followed by a decline (Fig. 2) that reached even lower values than in 2007, which caused dramatic changes in the Carabid communities in 2008-2009 (Fig. 3 and 4). Thus it seems that the humidity or durst have a stronger effect of structure of Carabid communities than the temperature. Of cause, the species having its optimum in lower vegetation tiers live in drier conditions as shown by ŠKVARENINA

Table 2. Scientific names of Carabid species recorded in six study plots in High Tatra in 2007-2004 and characteristics of their vertical distribution according to vegetation tiers (L - lower limit, O – optimum. U – upper limit, amplitude width, U-O – distance between upper limit and optimum, numbers means vegetation tiers: 1 – oak, 2 – beech-oak, 3 –oak beech, 4 – beech, 5 – fire-beech, 6 – fire-beech-spruce, 7 – spruce, 8 – dwarf pine, 9 – alpine meadows),

Species	Altitudinal distribution				
	L	O	U	A	U-O
Agonum micans (Nicolai, 1822)	1	2	6	5	4
Agonum sexpunctatum (Linnaeus, 1758)	1	3	7	6	4
Amara aenea (De Geer, 1774)	1	2	6	5	4
Amara erratica (Duftschmidt, 1812)	5	7	9	4	2
Amara eurynota (Panzer, 1797)	2	4	6	4	2
Amara familiaris (Duftschmidt, 1812)	1	2	6	5	4
Amara lunicollis Schiodte, 1837	2	4	6	4	2
Amara nitida Sturm, 1825	1	2	5	4	3
*Amara ovata (*Fabricius, 1792)	1	2	6	5	4
Anisodactylus binotatus (Fabricius, 1792)	1	2	6	5	4
Bembidion lampros (Herbst, 1784)	1	1.5	6	5	4.5
Calathus metalicus Dejean, 1828	5	7	9	4	2
Calathus micropterus Duftschmidt, 1812	3	5	7	4	2
Carabus arvensis Herbst, 1784	3	5	7	4	2
Carabus auronitens Fabricius, 1792	3	5.5	8	5	2.5
Carabus coriaceus Linnaeus 1758	1	2	6	5	4
Carabus glabratus Paykull, 1790	1	5.5	7	6	1.5
Carabus hortensis Linnaeus, 1758	1	2	6	5	4
Carabus linnei Dejean, 1826	3	5.5	8	5	2.5
Carabus nemoralis O. F. Müller, 1764	1	2.5	6	5	3.5
Carabus violaceus Linnaeus, 1758	1	5.5	8	7	2.5
Cychrus caraboides (Linnaeus, 1758(	1	5.5	8	7	2.5
Europhilus gracilipes Duftschmidt, 1812	1	3	7	6	4
Harpalus affinis (Schrank, 1784)	1	1.5	6	5	4.5
Harpalus distinguendus Duftschmidt, 1812	1	2	7	6	5
Harpalus latus (Linnaeus, 1758)	1	1.5	6	5	4.5
Harpalus quadripunctatus (Dejean, 1829)	4	6	7	3	1
Leistus piceus Frölich, 1799	4	6	8	4	2
Leistus terminatus (Hellwig in Panzer, 1793)	3	6.5	8	5	1.5
Loricera caerulescens (Linnaeus, 1758)	1	3	8	7	5
Microlestes maurus (Sturm, 1827)	1	1	6	5	5
Molops piceus (Panzer, 1793)	2	3	6	4	3
Notiophilus biguttatus (Fabricius, 1779)	1	2	7	6	5
Notiophilus palustris (Duftschmidt, 1812)	1	3	8	7	5
Poecilus cupreus (Linnaeus, 1758)	1	1.5	6	5	4.5
Poecilus versicolor (Sturm, 1824)	2	4.5	6	4	1.5
Pseudoophonus rufipes (De Geer, 1774)	1	1.5	6	5	4.5
Pterostichus aethiops (Panzer, 1797)	5	6	8	3	2
Pterostichus angustatus (Duftschmidt, 1812)	5	6	8	3	2
Pterostichus burmeisteri (Heer, 1801)	3	4.5	7	4	2.5
Pterostichus foveolatus Duftschmidt, 1812	3	5.5	8	5	2.5
Pterostichus niger (Schaller, 1783)	1	1.5	6	5	4.5
Pterostichus nigrita (Fabricius, 1792(	1	1.5	6	5	4.5
Pterostichus oblongopunctatus (Fabricius, 1787)	1	3	6	5	3
Pterostichus strenuus (Panzer, 1797)	1	2	6	5	4
Pterostichus unctulatus Duftschmidt, 1812	4	6.5	8	4	1.5
Trechus amplicollis Fairmair, 1859	4	5	7	3	2
Trechus latus Puzeys, 1847	3	6.5	8	5	1.5
Trechus striatulus Putzeys, 1847	3	6.5	9	6	2.5
Trichotichnus laevicollis Duftschmidt, 1812	3	5.5	7	4	1.5

Table 3. Survey of species and number of individuals recorded in the reference plot in Vyšné Hágy and in the plot with fallen timber in situ in Jamy near Tatranská Lomnica in 2007-2007 (for individual years only the last digit given)

Species	Vyšné Hágy - REF								Jamy - NEXT							
	7	8	9	0	1	2	3	4	7	8	9	0	1	2	3	4
A. micans																
A. sexpunctatum																
A. aenea																
A. erratica					1								1			
A. eurynota																
A. familiaris																
A. lunicollis																
A. nitida																
A. ovata																
A. binotatus																
B. lampros																
C. metalicus													1			
C. micropterus	9	12	10	13	1						2	4				
C. arvensis				1												
C. auronitens	18	1	6	10	16			2	1		1	3	9	3		
C. coriaceus																
C. glabratus	7	1	3	3	9	8	8	21	15	1	6	11	8	3	6	24
C. hortensis																
C. linnei	17	2	8	14	15	2	1	11	25	2	3	8	2	1	1	
C. nemoralis																
C. violaceus	29	9	18	53	89	67	47	49	10	6	14	30	31	24	31	8
C. caraboides	8		2	3	4	4					1	3	3		3	3
E. gracilipes																
H. affinis																
H. distinguendus																
H. latus																
H. quadripunctatus.												3	1		3	4
L. piceus							1									
L. terminatus																
L. caerulescens																
M. maurus																
M. piceus	7		3	4	4	1	1				1	1				
N. biguttatus	4	2	2	1	1	1						1				
N. palustris					1											
P. cupreus																
P. versicolor																
P. rufipes																
P. aethiops	3	1	1	3	9	4	1	1	9	1		4	11	5	1	2
P. angustatus																
P. burmeisteri	17	5	13	25	25	17	14		16	5	10	14		5		
P. foveolatus	44	9	25	57	94	12	6	4	4	1	2	9	2	2	2	
P. niger																
P. nigrita																
P. oblongopuncatust.			1	1	1										1	
P. strenuus																
P. unctulatus	208	35	159	186	47	27	13	8	25	8	16	29	8	7		1
T. amplicollis																
T. latus																
T. striatulus					8							2	1			
T. laevicollis	1			2	3		1		1			3	2	1	6	4
Number of individuals	372	77	251	376	328	143	93	96	106	24	56	125	80	51	54	46
Number of species	13	10	13	15	17	10	10	7	9	7	10	15	13	9	9	7

Table 4. Survey of species and number of individuals recorded in two plots with extracted in 2007-2007 (for individual years only the last digit given)

Species	Danielov dom EXT								Tatranské Zruby lower FIRa							
	7	8	9	0	1	2	3	4	7	8	9	0	1	2	3	4
A. micans														1		
A. sexpunctatum									1							
A. aenea	2	2	5	2					1			2				
A. erratica	102	12	26	18	7	5			6	4	3	5	1		4	1
A. eurynota	1	6	2	2					21	1	6	1				
A. familiaris	3		1	1					1	1		1				
A. lunicollis						1								1		
A. nitida				23	22								112	5		
A. ovata																
A. binotatus									2							
B. lampros									26	1	4			1		
C. metalicus																
C. micropterus																
C. arvensis																
C. auronitens	1	1	1	2	1							1	1		2	
C. coriaceus																
C. glabratus	47	1		11	35	5	54	34	8	2	5	3	9	16	11	47
C. hortensis									1							
C. linnei	4			1					7							
C. nemoralis																
C. violaceus	40	18	23	36	78	62	23	23	2	6	10	21	79	33	19	82
C. caraboides	2			2									1			
E. gracilipes															2	
H. affinis																
H. distinguendus								1								
H. latus															1	
H. quadripunct.					3		1		2				2	1	1	2
L. piceus																
L. terminatus																
L. caerulescens				1	1				1			1				
M. maurus									1	2	4					
M. piceus			1		1	1	3	1	2				12	34	61	13
N. biguttatus						1			4	3	6	2				
N. palustris				1									1			
P. cupreus	1	3	2	6	3		2		17	21	25	9	4	1	1	
P. versicolor				7	4	5	1	3					117	19	28	2
P. rufipes	1	2	1	1								1				
P. aethiops	1			4	11	2	1	1					7			
P. angustatus					3											
P. burmeisteri	2		1	2	1	2						1		1		
P. foveolatus				1					1				1		2	
P. niger													3	16		8
P. nigrita																
P. oblongopunct.	1						1		3							
P. strenuus																
P. unctulatus	28	1	9	15	3		1		1		2	7				
T. amplicollis																
T. latus																
T. striatulus																
T. laevicollis			1	1	2		1						2	1		1
Number of individuals	236	46	73	137	175	84	88	63	108	41	65	55	352	130	132	156
Number of species	15	9	12	20	15	9	10	6	20	9	9	13	15	13	11	8

Table 5. Survey of species and number of individuals recorded in two plots with extracted in 2007-2007 (for individual years only the last digit given)

Species	Tatranské Zruby upper FIRb								Vodný les							
	7	8	9	0	1	2	3	4	7	8	9	0	1	2	3	4
A. micans																
A. sexpunctatum	1					1						1	1			
A. aenea	6		2	3	4		1	1			1					
A. erratica	8	2	2	4	1	1	2		14	9	12	8	2			
A. eurynota	2	3	1	2					1			1				
A. familiaris				2					1		1					
A. lunicollis																
A. nitida				1	103	3			1				1	2		
A. ovata					2											
A. binotatus	1										1	1				
B. lampros	4	9	3							1	1					
C. metalicus																
C. micropterus							1	1								
C. arvensis																
C. auronitens	3		1	1	3		1	1								
C. coriaceus						1					1	2	4	5	6	2
C. glabratus	4		1	4	9	9	7	24	5	1	3	2	13	18	35	23
C. hortensis												1	3	3		2
C. linnei																
C. nemoralis													5	5	3	2
C. violaceus	1	3	5	17	38	31	33	29	3	7	4	15	34	12	19	32
C.caraboides												1	1	1		
E. gracilipes							1	3								
H. affinis									1		2					
H. distinguendus																
H. latus													1		2	
H. quadripunctus					1			1				1				1
L. piceus																
L. terminatus													1			
L. caerulescens					1				5	1	2	1				
M. maurus		2	2									1				
M. piceus	1		2	1	11	10	20	2	1			2	11	6	4	2
N. biguttatus	1			1					5		2					
N. palustris						1										
P. cupreus	5	8	13	8	3					1		2	3			
P. versicolor					74	5	7	3					4	1	1	
P. rufipes	2	1	2	1							1					
P. aethiops	1				1				2			1	3	5	8	7
P. angustatus													2			
P. burmeisteri	1		1	1					5	2	4	3	3			
P. foveolatus			1	1					1			2				4
P. niger									1		2	1				
P. nigrita									2		3	1				
P. oblongopunctus	1											1	2			
P. strenuus									1		1					
P. unctulatus	8		2	6	1			1	2			4				
T. amplicollis									4		2					
T. latus									1							
T. striatulus															1	3
T. laevicollis					2			1	1		1		1	1		
Number of individuals	50	28	38	53	254	62	73	67	57	22	44	52	95	58	79	78
Number of species	17	7	14	15	15	9	9	11	20	7	18	21	19	11	9	10

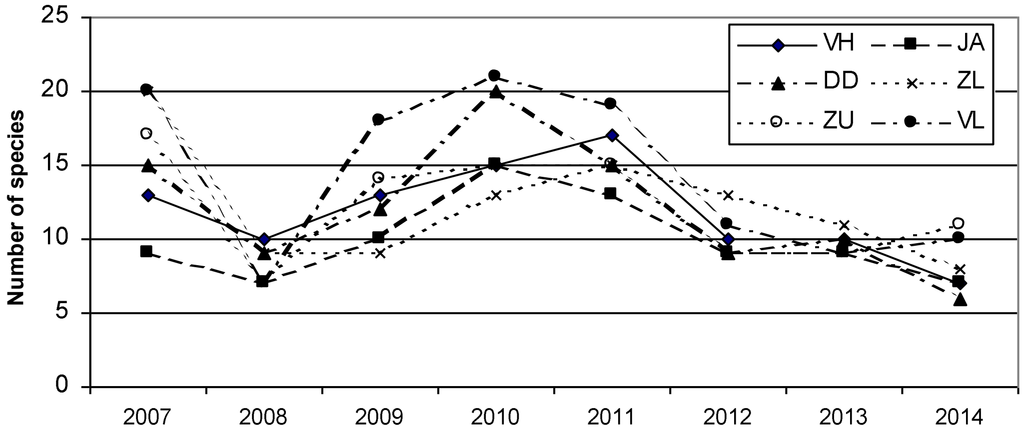

Fig. 3. Changes in number of species in six study plots in Hogh Tatra in 2007-2014 (VH – Vyšné Hágy, JA jamy, DD – Danilov dom, ZL – Tatranské Zruby lower, ZU Tatranské Zruby upper, VL – Vodný les).

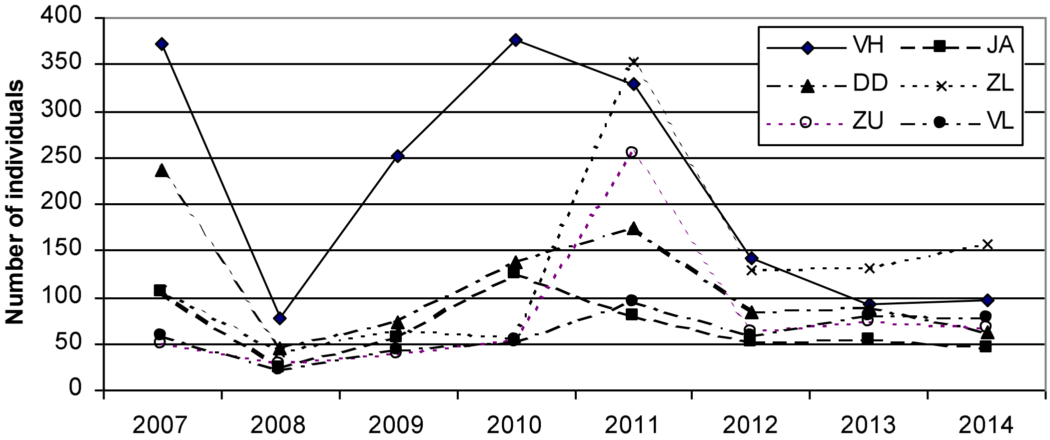

Fig. 4. Changes in number of species in six study plots in Hogh Tatra in 2007-2014 (VH – Vyšné Hágy, JA jamy, DD – Danilov dom, ZL – Tatranské Zruby lower, ZU Tatranské Zruby upper, VL – Vodný les).

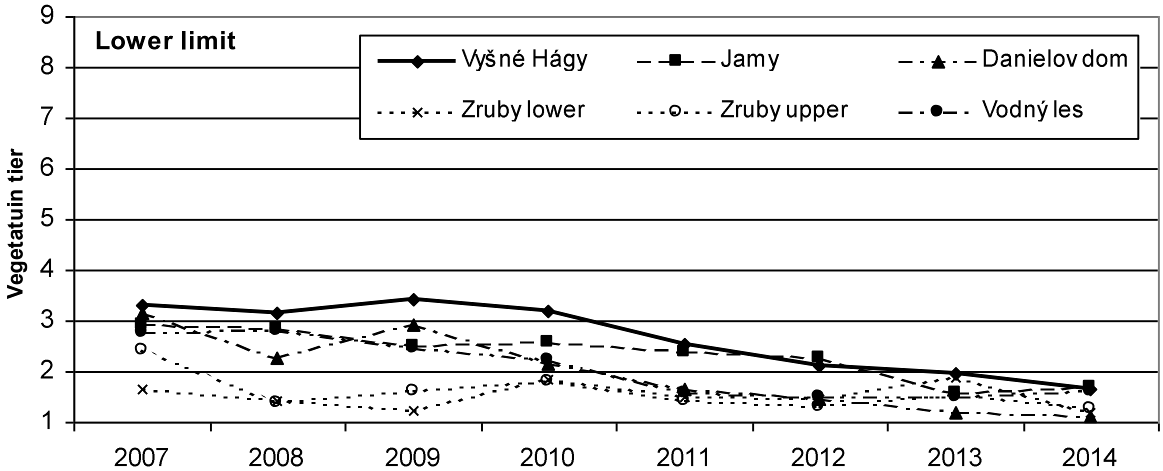

Fig. 5. Changes of average lower limit of vertical distributions of species in Carabid communities in six study plots in High Tatra in 2007-2014

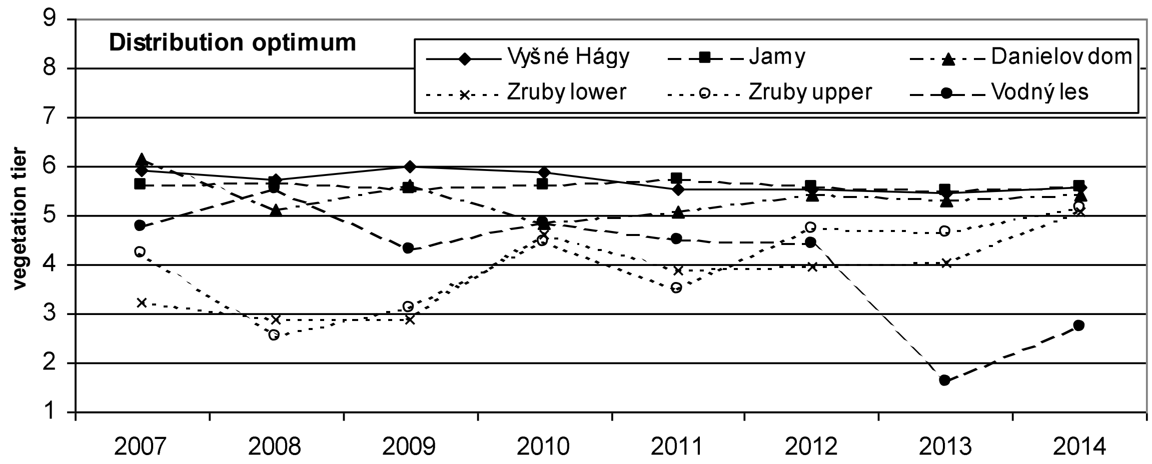

Fig. 6. Changes of average optimum of vertical distributions of species in Carabid communities in six study plots in High Tatra in 2007-2014

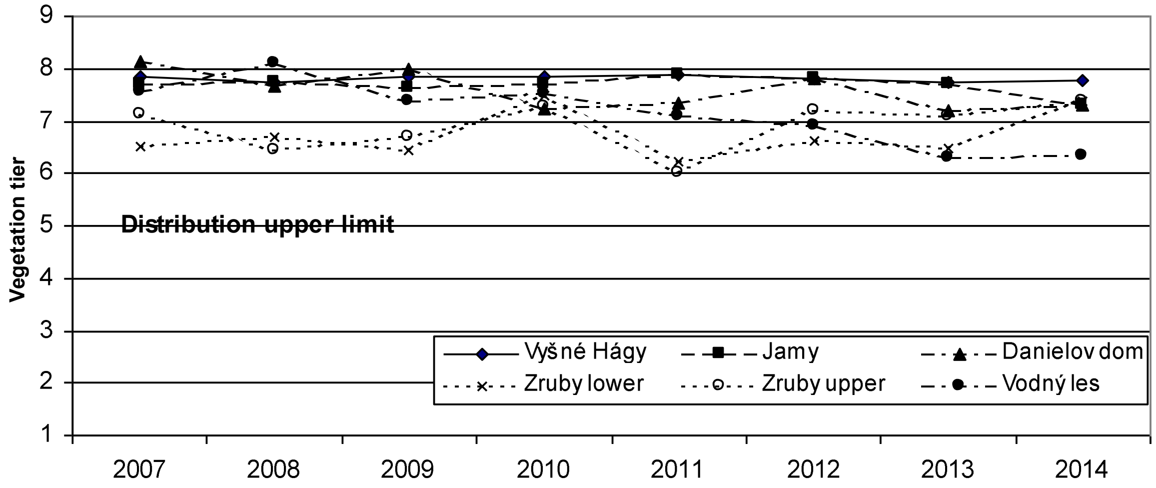

Fig. 7. Changes of average upper limit of vertical distributions of species in Carabid communities in six study plots in High Tatra in 2007-2014

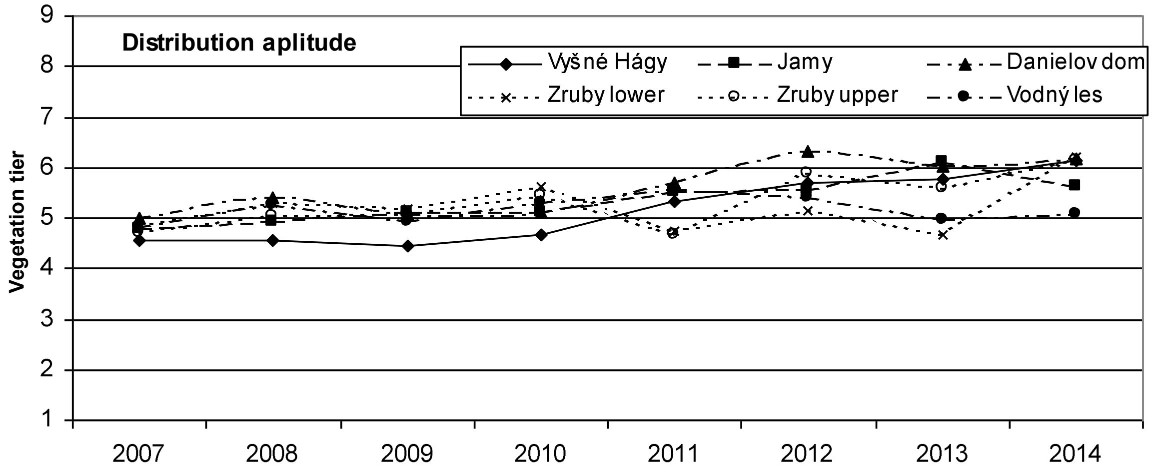

Fig. 8. Changes of average amplitude of vertical distributions of species in Carabid communities in six study plots in High Tatra in 2007-2014

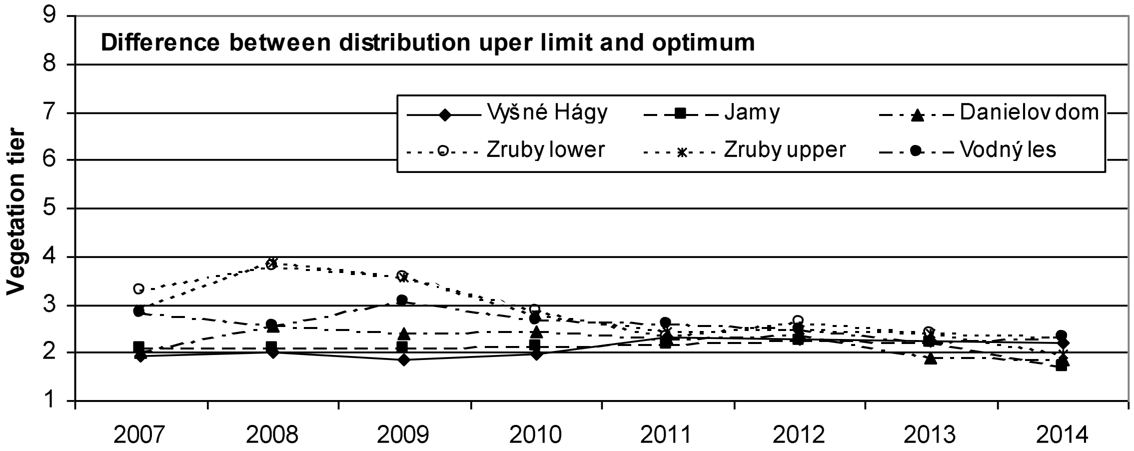

Fig. 9. Changes of average difference between upper limit and optimum of vertical distributions of species in Carabid communities in six study plots in High Tatra in 2007-2014

et all. (2002). The humidity, independent to momentary temperature, was also shown as a deciding factor for changes in diurnal activity of some mountain Carabids (ŠUSTEK, 2006). However, there can be also other cause of the observed changes – a higher competitiveness of some species, whose example can be *Carabus violaceus,* a species with wide amplitude of vertical distribution (Table 2), which really tends to occupy a dominant position in all plots. Thus the observed phenomena can not be explained in a simply way and a much longer series of observations is necessary for an adequate interpretation. There is possible a delay of Carabid reaction on changes in climatic factor as shown by ŠUSTEK & VIDO (2013). This delay can result from coincidence of such changes with reproduction cycle of Carabids. Thus the observed phenomena can not be explained in a simply way and a much longer series of observations is necessary for an adequate interpretation.

Acknowledgements
The author expresses his thanks to the Grant agency VEGA for financial support of this study by the grants 1/0281/11 a 2/0101/14, as well as to the Technical University at Zvolen for financial support by the project DoVP 432/2014

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