KOINCIDENCIA REAKCIÍ MÄKKÝŠOV (MOLLUSCA) A BYSTRUŠKOVITÝCH (COLEOPTERA, CARABIDAE) NA VETERNÚ KATASTROFU VO VYSOKÝCH TATRÁCH V ROKU 2004

COINCIDENCE OF RESPONSE OF MOLLUSCS (MOLLUSCA) AND GROUND BEETLES (COLEOPTERA, CARABIDAE) ON WIND DISASTER IN HIGH TATRA IN 2004

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Abstrakt

Dopad veternej katastrófy vo Vysokých Tatrách 19. novembra 2004 na mäkkýše a bystruškovité sa študoval na šiestich plochách zahŕňajúcich neporušený vyspelý smrekový les, plochu s ponechanou drevnou hmotou a plochy s odstránenou drevnou hmotou, z ktorých dve plochy boli dodatočne zasiahnuté požiarom. Mäkkýše reagovali na rastúce poškodenie biotopu iba poklesom počtu druhov a jedincov alebo úplnou absenciou. Na poškodených plochách nebol pozorovaný sklon ku kolonizácii mäkkýšmi charakteristickými pre otvorenú kultúrnu krajinu. Stenotopné lesné druhy bystruškovitých reagovali podobne ako mäkkýše, no v obmedzenej miere prežívali aj na plochách poškodených dodatočne požiarom. Niektoré tolerantnejšie lesné druhy boli na jednej z plôch s odstránenou drevnou hmotou dokonca zvýhodnené. Na rozdiel od mäkkýšov na plochách s odstránenou drevnou hmotou nastala invázia bystruškovitých charakteristických pre otvorenú krajinu. Ich invázia prebiehala diferencovane podľa stavu bylinnej vegetácie prežívajúcej na plochách s odstránenou hmotou alebo spontánne vznikajúcej na plochách poškodených dodatočne požiarom.

Abstract

Impact of the wind disaster in High Tatras on 19 November 2004 on molluscs and Carabids was studied in six plots ranging from an intact mature spruce forest, through damaged forests with timber let *in situ*, to four plots with extracted timber, among which two plots were additionally affected by fire. The molluscs reacted on the increasing damaging of the habitat uniformly by decline of number of species and individuals or by their total absence. There was not observed any tendency to colonization of the damaged areas by molluscs characteristic for cultural open landscape. The stenotopic forests Carabids reacted in a similar ways as the molluscs, but they survived to a limited degree even in the most damaged burned plots or the more tolerant species were even favored in one of the plots with extracted timber. Unlike the molluscs, there started an invasion of open landscape species in the plots with extracted timber. This invasion differed in dependence on the character of herbage stratum surviving in the unburned plots or spontaneously appearing in the burned plots.

Introduction

The wind disaster in High Tatras on 19 November 2004 destroyed mature spruce stands on an enormous, in Central European scale, area. The damaged area represents a unique experiment area to study reactions of different groups of living organisms on the disaster impacts and an unique occasion to study different succession on flora and fauna on the plots let experimentally to spontaneous development and on areas subjected to different modes of management. The molluscs and Carabids represent two invertebrate groups with considerably limited dispersal power and close relationships to the respective habitats. The dispersal power of molluscs is much more limited than in most Carabids.
The aim of this study is to show differences in reaction of these invertebrates on the wind disaster and on impact of different regimen in individual part of the damaged area.

Methods

The beetles and molluscs were collected by pitfall traps filled with formalin. Plastic jars of 0.5 liter, with mouth diameter of 90 mm served as traps. The traps were emptied once a month. In each plot, six traps were installed in a line in mutual distances of about 5 m. Additionally, the molluscs were collected individually. The material of molluscs from pitfall traps and individual sampling was pooled because of a very low number of molluscs collected.

The ecological characteristics of molluscs are taken from LOŽEK (1974), LISICKÝ (1991) and KERNEY (1983), while those of Carabids from BURMEISTER (1939), HŮRKA (1996), LARSON (1949), ŠUSTEK (2000) and THIELE (1977).

The hierarchical classification was carried out by the unweighted average linkage method (ORLÓCI 1978). As similarity function the chord distance was used in the case of carabids, while the Euclidean distance in the case of molluscs. The Euclidean distance was chosen due to a very low number of molluscs and their absence in one of the study plots. In this way, all samples could be included in the dendrogram. The detrended correspondence analysis (DCA) was used as indirect ordination method. The calculations were carried out by the program CAP. The direct ordination of Carabid communities (POOLE 1974) was made according to preference of individual species for vegetation cover and humidity. A four-degree semiquantitative scale of the vegetation cover preference and an eight-degree semiquantitative scale of the humidity preference (ŠUSTEK 2004) was used for this purpose. The ordination scores were calculated as arithmetical mean of preferences of individual species weighted by their abundance.

Sampling sites

The study plot in the area damaged by the wind disaster were selected by the staff of Research branch of the Management of State Forests of the High Tatra National Park and are also used by other specialists. Their brief review is given in the table 1.

Table 1. Survey of study plots in the area affected by the wind disaster in High Tatra on 19 November 2004

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	J	D	ZD	ZL	V
Geographical coordinates	49°07′17.5″N 20°06′15.0″E	49°09'33.7" N, 20°15'07.9" E	49°07′15.3″N 20°09′46.0″E	49°07′49.3″N 20°11′49.1″E	49°08′02.7″N 20°11′30.1″E	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	timber *in situ*	timber extracted, unburned	timber extracted, burned	timber extracted, burned	timber extracted unburned

Results

Molluscs

In all six plots, only 8 mollusc species were recorded (Tab. 2). In the individual plots, number of mollusc species ranged from 0 (upper burned plot at Tatranské Zruby) to 6 (Vodný les). The quantitative representation of molluscs was also extremely low, reaching a maximum of 9 individuals in the plot Vodný les (Tab. 2). Any of the species recorded did not occur simultaneously in all study plots.

Table 2. Survey of molluscs in individual study plots in the area affected by the wind disaster

	Study plot						
	Vyšné Hágy	**Jamy**	**Danielov dom**	**Tatr. Zruby lower**	**Tatr. Zruby upper**	**Vodný *Les***	**Positive plots**
Arianta arbustorum (Linnaeus, 1758)	1					1	2
Arion fuscus (Müller, 1774)	1	3				1	3
Isognomostoma isognomostomos (Schröter, 1784)						2	1
Limax cinereoniger Wolf, 1803		1					1
Lehmannia marginata (O. F. Müller, 1774)	2		1				2
Semilimax kotulae (Westerlund, 1883)	2	2				1	3
Euconulus fulvus (O. F. Müller, 1774)				1		3	2
Perpolita hammonis (Ström, 1756)			1			1	2
Number of species	4	3	2	1	0	6	
Number of individuals	6	6	2	1	0	9	

The low qualitative and quantitative representation of molluscs resulted in all plots from a very low content of carbonates in the whole area studied (trophic series AB). In spite of a very small number of species and individuals, there is evident a clear tendency to differentiation of the samples into three groups indicated by hierarchical classification (Fig. 1):

III. the reference plot and the plot with the timber *in situ* with 3 and 4 species recorded and with 6 individuals collected.
IV. the plot Vodný les, where the timber was extracted, but an intact growth of shrubs and little trees (*Alnus, Salix, Sorbu, Rubus* and *Picea abies*) was preserved in the center of the plot with a creek and its alluvium. In this plot the maximum of 6 species a 9 individuals was collected.
V. other plots with extracted timber, with 0 – 2 species and 0 – 2 individuals. Within these plots, a tendency to a further differentiation between the unburned plot at Danielov dom and both burned plots at Tatranské Zruby was indicated.

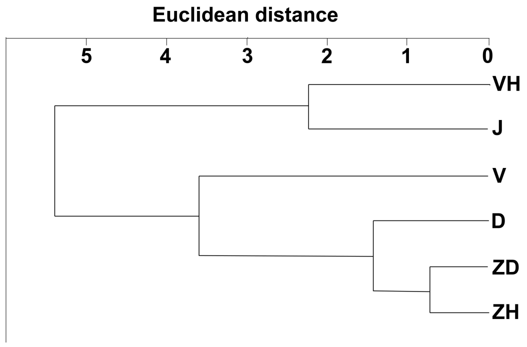


Fig. 1. Hierarchical classification of samples of molluscs based on Euclidean distance, abbreviations of localities as in Table 1

The reference plot and the less affected plots in Jamy and Vodný les were characterized by common occurrence of *Semilimax kotulae*, a species indicating relatively well preserved forest stands, as well as by the forests species *Arion fuscus, Arianta arbustorum* and *Lehmania marginata*, among which, however, the two former species were not found in all three plots. In addition, the plot Vodný les was characterized by two other relatively sensitive forests species - *Isognomostomos isognomostomos* and *Euconulus fulvus*. In the next three plots, all with extracted timber and two having been also burned, only the eurytopic forest species *Euconulus fulvus, Lehmania marginata* and *Perpolita hammonis* sporadically survived. There were not recorded any species preferring cultural open landscape.

According to LOŽEK (1974), the most frequent species of the forests in the trophical series A and AB in High Tatras and in the spruce vegetation tier are *Lehmania marginata, Semilimax kotulae Arianta arbustorum* and *Pseudofusulus varians* (C. Pfeiffer, 1828). Occurrence of the first three species was also confirmed by us, while occurrence of the former species, however, was not recorded during our investigation.

Carabids

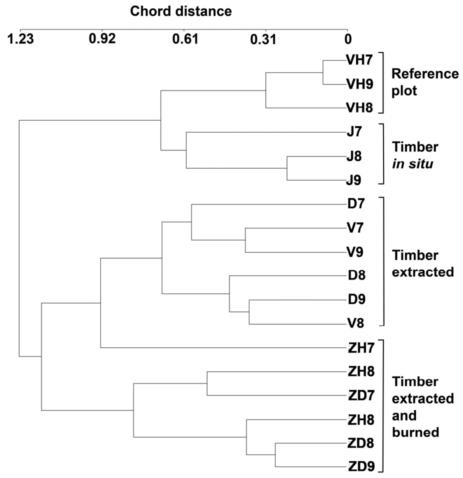
Altogether 35 species were recorded on the study plots in 2007-2009 (Tab. 3). Among them only *Carabus violaceus* occurred in all study plots and in all years. Other 21 species occurred at least in half of the plots and only five species were found just in one plot.

The species recorded form two principal ecological groups. The first group includes stenotopic forest species with wide amplitude of vertical distribution at elevations of 300 – 1400 m a. s. l. Some of them (*Carabus violaceus*, *Pterostichus foveolatus* and *Cychrus caraboides*) ascend to the dwarf pine vegetation tier or also occur in lowlands (*Carabus violaceus;* in acidic trophic series or rarely in floodplain forests also *Cychrus caraboides*). Two species, *Carabus coriaceus and Carabus hortensis,* have occurrence optimum in oak and beech-oak vegetation tier and in the spruce vegetation tier have the upper limit of their vertical distribution. Except of *Trichotichnus laevicollis* these species are unable to fly. Except for the Carpathic endemic species *Pterostichus foveolatus,* all submontane forest species are distributed in all Central European mountain ranges, while the species with wide amplitude of vertical distribution occur in a major part of Europe.

The second group includes eurytopic species characteristic of the open landscape ecosystems. They are distributed from lowlands to altitudes of about 1000 – 1200 m. Only *Amara erratica* is a typical mountain species. Some of these species, especially the representatives of the genus *Amara,* are phytophagous or panthophagous. *Microlestes maurus* is xerophilous and heliophilous, while *Bembidion lampros* is heliophilous. Both these species prefer open habitats with discontinuous vegetation cover and patches of naked soil surface.

The species *Pterostichus niger, Pterostichus nigrita, Pterostichus strenuus* and *Anisodactylus binottatus* are hydrophilous and occurred only in Vodný les, at banks of the creek crossing this study site.

The species composition is characteristic of the altitude of all plots affected and of their appartenance to the spruce vegetation tier. Therefore there were missing the species *Carabus sylvestris* and *Pterostichus morio carpathicus* are characteristic, at least in High Tatras, for the dwarf pine or alpine vegetation tier. There were also missing some species like *Trechus striatulus, Leistus piceus* and *Calathus metallicus,* which use to descent even to middle altitudes, as well as several species characteristic of mountain and submountain forest geobiocoenoses in the Carpathians, first of all *Pterostichus pilosus* and some species of the genus *Trechus* (ŠUSTEK, 2006, 2008; ŠUSTEK & ŽUFFA 1986, 1988). The year 2008 was characterized in all study sites by a strong drop of number species and individuals (Tab. 3). The decline of number of species was moderate in the reference plot and in less affected plots (to 70 – 80% of the values from 2007), while number of individuals decreased even to 20 –25 %. In the more affected plots (Vodný les and both plots in Tatranské Zruby) the values of both parameters decreased almost equally to 30 – 50% of the values from 2007. On the contrary, in 2009 the values of these parameters recuperated to a considerable degree, but in any plot they did not reach the values observed in 2007.



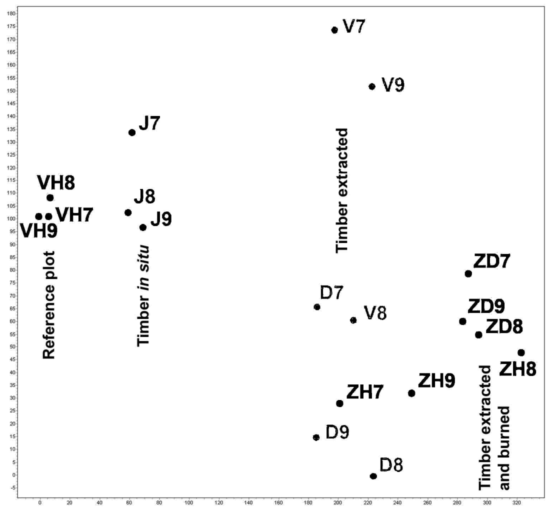


Fig. 2. Hierarchical classification of Carabid communities based on proportional similarity of one-year samples from 2007 – 2009. Locality abbreviations as in table 1; 7 – year 2007, 8 – year 2008, 9 – year 2009

Fig. 3. DCA of one-year samples from 2007 – 2009

Hierarchical classification based on proportional similarity expressed by chord distance form at dissimilarity level of 1.23 two clusters of communities (Fig. 2). One includes one-year samples from the reference plot and from the plot with fallen timber let *in situ*. Within this cluster, at dissimilarity level of 0.7 appear two sub-clusters: one including the samples from the reference plot and the second including the samples from the plot with timber *in situ*. The second cluster includes samples from all plots with extracted timber. This cluster includes two subclusters (at dissimilarity level 1.1). The first one includes the samples from plots, which were not affected by fire and the sample from the upper burned plot at Tatranské Zruby from 2007. The second one only the samples from plots affected additionally in 2005 by fire. Within both subclusters the richer samples from 2007 and 2009 tend to agglomerate.

The same interpretation also results from DCA ordination (Fig. 3), there the 1. axis represents gradient reaching from reference plot, through the plot with timber *in situ* until the burned plots. The 2. axis represent a less clear gradient of humidity. The samples from drier places concentrate in the lower part of the scatter diagram, while those from more humid, especially the samples from Vodný les, are situated in the upper part of the diagram.

Both classifications reflect presence of all stenotopic forest species in the reference plot and inn the plot with timber *in situ*, competition favoring of the more tolerant *Carabus violaceus* and *Carabus glabratus* in all plots with extracted timber. Within these plots the classification reflects higher representation of *Amara* spp. in the unburned plots dominated by *Calamagrostis villosa* or an increased abundance of *Poecilus cupreus* and *Bembidion lampros* on the burned plot overgrown by *Epilobium angustifolium*.

The results of classification show the existing differentiation of communities in the affected plots to be highly stable. It seems, however, that in regard to a faster colonization of the burned plots by the pioneer wooden plants (*Sambucus racemosa*, *Salix* spp., *Sorbus* sp.) a break in the succession course might come earlier than in the unburned plots, where the spontaneous restoration of the wooden vegetation is slower.

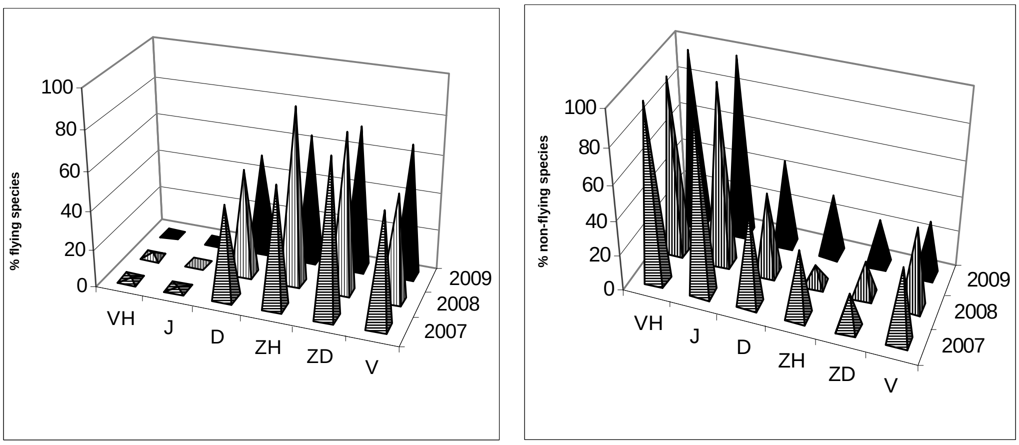


Fig. 4. Changes in proportion of flying and non-flying Carabids in the years 2007 - 2009, abbreviation of study plots as in table 1

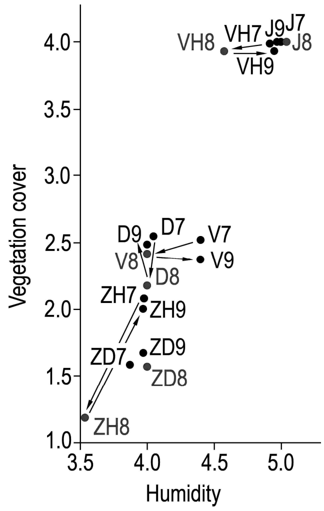


Fig. 5. Direct ordination of Carabid communities based of preference for vegetation cover and humidity in 2007 – 2009, abbreviation of study plots as in table 1.

The communities in the reference plot and in the plot with the fallen timber *in situ* consisted in all three years exclusively from stenotopic wingless species. In other plots proportion of these species declined considerably (Fig. 4) in favor of flying xenocoenous species, especially in the upper burned plot in Tatranské Zruby in 2008.

The between-year changes in representation of the forests and open landscape species, as well as of the species with different requirements for humidity are shown by the direct ordination of the one-year samples (Fig. 5). In the upper right corner, the samples from the reference lot and plot with the fallen timber *in situ* are concentrated in all three years. Their position is very stable, especially in the case of samples from the plot with timber *in situ*. In both plots the open landscape species were missing, while the eurytopic species were represented only negligibly. Most species were mesohydrophilous, with slightly increased requirements to humidity. Their position was very stable during the whole investigation period. In the left lower part of the diagram, the samples from the plots with extracted timber are situated. The upper part of their cluster includes the samples from unburned plots, showing lower proportion of xerophilous and heliophilous species. On the contrary, in the lower part of the cluster includes samples from the burned plots. The higher representation of open landscape species or even of expressively heliophilous and xerophilous species (*Microlestes minutus* and *Bembidion lampros*) is, however, just an indirect consequence of the extensive fire in 2005. Directly it results from intentional mowing of growths of *Epilobium angustifolium* in artificially afforested places. In 2008 proportion of open landscape species and xerophilous increased in all plots with extracted timber, but in 2009 their proportion returned almost in the original state of 2007.

Discussion and conclusions

The results clearly show that the wind disaster strongly affected communities of molluscs and Carabids. But in all three years it was obvious that the disaster itself did not affected the original species composition of both animal groups as such. In spite of the scarce material, the mollucs community in the plot with timber *in situ* seems to be unaffected or little affected quantitatively. In contrast, the cumulative abundance of Carabids communities decreased here to about on third of presumed original level.

A much stronger damaging resulted from processing and extraction of timber from the major part of the area, which disturbed the litter by heavy mechanisms. This effect was still enhanced by the fire on extensive area in 2005. In all these plots the Mollusc and Carabids reacted in somewhat different ways. In both cases, number of the stenotopic forests species and their abundance was considerably reduced, but they survived there to a limited scale. Only in one burned plot the molluscs were not recorded at all. Unlike the molluscs, two forest Carabid species, *Carabus violaceus* and *C. glabratus*, were even favored by elimination of competition pressure of the stenotopic species and thus their abundance increased in one of the unburned plots with extracted timber.

Unlike the molluscs, all plots with extracted timber started to be colonized by open landscape Carabids, which are able to fly. In addition, the colonization strongly differed in the unburned and burned plots. In the unburned the herbage stratum with predominant growth of *Calamagrostis villosa* served as a food basis for the phytophagous Carabids od the genus *Amara*, while in the burned plots overgrown with *Epilobium angustifolium* these species were replaced by carnicoous *Poecilus cupreus*. Beside it, the cutting of *Epilobium angustifolium* resulted in denuding of soil surface and its direct exposing Sun. It attracted some xero- and heliophilous Carabids, but at the same time it worsened conditions of the mollusks. Possibly just from this reason, they absented in on of the burned plots. Due to invasion of the open landscape Carabids the species number in some plot with extracted timber was even higher than in the reference plot or in the plot with timber *in situ*.

The colonization of the plots with extracted timber by open landscape Carabids is obviously a transitory state, which will last until a continuous cover of shrubs and trees will have been restored. Until that time the molluscs will survive in the damaged plots only in a very limited number of tolerant species and individuals.

Somewhat different was the reaction of both invertebrate groups on increased moisture in alluvium of the nameless creek crossing center of the plot Vodný les. In Carabids, the extensive moisture resulted in presence of several individuals of four expressively hydrophilous species *Pterostichus niger*, *Pterostichus nigrita*, *Trechus amplicollis* and *Anisodactylus binotatus*, but they did not essentially affected the overall character of the community. On the contrary, in the molluscs the increased moisture made possible occurrence of several more or less eurytopic forests species. Due to it, the highest species diversity of the molluscs was recorded just in this plot, in spite of disturbance of its major part.

Although reaction of both groups on the wind disaster differ in the plots with extracted timber, the principal pattern of differentiation of these plots according to degree of the community damaging is similar and represents the same sequence: (1) reference plot, (2) plot with timber *in situ*, (3) plots with extracted timber and (4) the additionally burned plots.

Differences in reactions of molluscs and Carabids on impact of the wind disaster result mainly from the fact that the Carabids include a large group of adaptable and moveable species of open landscape, predominantly the s.c. field species, which quickly invaded the damaged plots. If only the stenotopic forest Carabids would be considered, the reaction of both invertebrate group would be almost identical.

Although the final synthesis of reactions of individual groups of living organisms on the wind disaster must consider many contradictory results and viewpoints, especially in regard to gradations of bark beetles and their attacks on the intact stands, the reactions of molluscs and Carabids conformingly show, that the preserving of the fallen timber *in situ* was the best solution for the soil surface fauna.

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Tab. 3. Survey of carabids in individual study plots on the years 2007 – 2009 in the area affected by the wind disaster.

Prehľad druhov	Ekologické vlastnosti				Vyšné Hágy			Jamy			Danielov dom			Tatranské Zruby hore			Tatranské Zruby dole			Vodný les		
	H	VC	F	W	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9
Agonum sexpunctatum (Linnaeus, 1758)	5	1	F	0.0350										1			1					
Amara aenea (De Geer, 1774)	3	1	F	0.0413							2	2	5	6		2	1					1
Amara erratica (Duftschmidt, 1812)	3	1	F	0.0457							102	12	26	8	2	2	6	4	3	14	9	12
Amara eurynota (Panzer, 1797)	3	1	F	0.0444							1	6	2	2	3	1	21	1	6	1		
Amara familiaris (Duftschmidt, 1812)	3	1	F	0.0413							3		1				1	1		1		1
Amara nitida Sturm, 1825	3	1	F	0.1561																1		
Anisodactylus binotatus (Fabricius, 1792)	6	4	F	0.0457										1			2					1
Bembidion lampros (Herbst, 1784(	3	1	F	0.0172										4	9	3	26	1	4		1	1
Bembidion properans (Stephens, 1828)	3	1	F	0.0172																		
Calathus micropterus Duftschmidt, 1812	3	1	N	0.0196	9	12	10			2												
Carabus auronitens Fabricius, 1792	4	4	N	1.3251	18	1	6	1		1	1	1	1	3		1						
Carabus coriaceus Linnaeus 1758	5	2	N	6.5950																		1
Carabus glabratus Paykull, 1790	5	1	N	1.7415	7	1	3	15	1	6	47	1		4		1	8	2	5	5	1	3
Carabus hortensis Linnaeus, 1758	4	4	N	1.7800													1					
Carabus linnei Dejean, 1826	5	4	N	1.0568	17	2	8	25	2	3	1						7					
Carabus violaceus Linnaeus, 1758	5	1	N	1.7457	29	9	18	10	6	14	40	18	23	1	3	5	2	6	10	3	7	4
Cychrus carabaoides (Linnaeus, 1758(	5	1	N	0.9256	8		2															
Harpalus affinis (Schrank, 1784)	3	4	F	0.1873																1		2
Harpalus quadripunctatus (Dejean, 1829)	4	4	F	0.0956													2					
Loricera caerulescens (Linnaeus, 1758)	4	4	F	0.0428													1			5	1	2
Microlestes maurus (Sturm, 1827)	2	1	F	0.0072											2	2	1	2	4			
Molops piceus (Panzer, 1793)	4	4	N	0.0443	7		3			1			1	1		2	2			1		
Notiophilus biguttatus (Fabricius, 1779)	4	4	F	0.0240	4	2	2							1			4	3	6	5		2
Poecilus cupreus (Linnaeus, 1758)	4	4	F	0.2710							1	3	2	5	8	13	17	21	25		1	
Pseudoophonus rufipes (De Geer, 1774)	4	1	F	0.4126							1	2	1	2	1	2						1
Pterostichus aethiops (Panzer, 1797)	5	1	N	0.0862	3	1	1	9	1		1			1						2		
Pterostichus burmeisteri (Heer, 1801)	5	4	N	0.1546	17	5	13	16	5	10	2		1	1		1				5	2	4
Pterostichus foveolatus Duftschmidt, 1812	5	4	N	0.2152	44	9	25	4	1	2						1	1			1		
Pterostichus niger (Schaller, 1783)	6	4	F	1.0600																1		2
Pterostichus nigrita (Fabricius, 1792(	8	4	F	0.0812																2		3
Pterostichus oblongopunctatus (Fabricius, 1787)	5	4	F	0.1941			1				1			1			3					
Pterostichus strenuus (Panzer, 1797)	7	4	F	0.0511																1		1
Pterostichus unctulatus Duftschmidt, 1812	5	4	N	0.0530	208	35	159	25	8	16	28	1	9	8		2	1		2	2		
Trechus amplicollis Fairmair, 1859	5	2	N	0.0159																4		2
Trechus latus Puzeys, 1847	5	4	N	0.0248																1		
Trichotichnus laevicollis Duftschmidt, 1812	5	2	F	0.1431	1			1					1							1		1
Počet jedincov					372	77	251	106	24	55	231	46	73	50	28	38	108	41	65	57	22	44
Počet druhov					13	10	13	9	7	9	14	9	12	17	7	14	20	9	9	20	7	18

Explanations: H – preference for humidity, VC – preference fo vegetation cover, F – ability to fly, flying species, N –non-flying species, W – average weight of one individual in grams.