# IMPACT OF WIND DISASTER IN HIGH TATRAS IN NOVEMBER 2004 ON CARABID COMMUNITIES

**ŠUSTEK ZBYŠEK**

**Abstract.** At the night of 14 November 2004, a major part of Norway spruce forests in the southern slopes of High Tatras, at the altitudes of about 850 to 1200 m, were destroyed by wind exceeding 200 $km.h^{-1}$. During next two years, the timber was harvested in the major part of the area affected. In a minor part, the timber has been let in situ in order to allow study of succession of biota without any human intervention. In addition a considerable part of the harvested area was burned in 2005, possibly from speculative reasons. Study of the disaster impacts on the Carabid communities was possible as late as after finishing of harvesting. It started in 2007 in six study plots: intact mature Norway spruce forest as a reference plot, one plot with timber let in situ for study reasons and in four plots with harvested timber, among which two were also burned. The first results show that the less affected plot was that with preserved timber. It has completely preserved the original species composition and any penetration of the xenocoenous, xero- and heliophilous species has not been observed. Only abundance of species decreased to about 30% of abundance in the intact forest. In all plots with removed timber, the original species composition was affected. Except of *Carabus violaceus* and *C. glabratus*, which were tolerant to deforestation or even profited from it, the original species occurred here only occasionally and invasion of xenocoenous species (mostly *Amara* spp., *Notiophilus biguttatus*, *Bembidion lampros*, *Poecilus cupreus*) stared here. Its intensity was much higher in the burned plots and was still enhanced by mowing the secondary vegetation in one re-afforested plot. In contrast to expectations, there were not observed invasion od *Pseudoophonus rufipes*, an extremely expansive and abundant species, and of other heliophilous species.

**Key words:** Carabidae, wind disaster, High Tatras, ecology

**Rezumat Consecinţele catastrofei de vânt din Tatra Înaltă din noiembrie 2004 asupra cenozelor de carabide.** În noaptea de 14 noiembrie 2004 o mare parte a molidişurilor în valea Popradska kotlina în Tatra Înaltă au fost distruse de un vânt cu viteza de peste 200 km pe oră. În cursul urmatorilor doi ani, triunchiurile căzute au fost îndepărtate din majoritatea suprafeţei afectate. O mică parte a fost lăsată pe loc pentru a se putea studia succesiunea Biotei pe suprafeţele cu şi fără intervenţie umană. În cursul lucrărilor de exploatare a lemnului o mare parte a suprafeţei afectate a fost incendiată, probabil din motive speculative. Studiul consecinţelor catastrofei asupra faunei de pe suprafaţa solului a fost posibil abia după terminarea lucrărilor. Colectarea carabidelor a început abia în anul 2007, în şase staţionare: molidişul seminatural intact ca staţionar de referinţă, un staţionar cu lemnul lăsat in situ şi patru staţionare cu lemn colectat, din care două au fost ulterior afectate de foc. Primele rezultate arată că cel mai puţin afectată a fost cenoza de pe suprafaţa cu lemnul lasat in situ păstrând, toate speciile din staţionarul de referinţă, dar cu număr scăzut de indivizi (la 30% de numărul din staţionarul de referinţă), însă fără invazia speciilor xenocene heliofile. În celelalte staţionare, numărul speciilor tipice pentru păduri a fost redus, cu excepţia speciilor *Carabus violaceus* şi *C. gabratus*, care se întâlnesc numai ocazional. În aceste staţionare au apărut un număr ridicat de specii heliofile, mai ales din genul *Amara* precum şi *Notiophilus biguttatus*, *Bembidion lampros* şi *Poecilus cupreus*. Contrar aşteptărilor, nu s-a constatat invazia speciei *Pseudophonus rufipes* - specie extrem de expansivă şi abundentă, precum şi a celorlalte specii heliofile .

**Cuvânte cheie:** carabide, vânt catastrofal, Tatra Înaltă, ecologie

## INTRODUCTION

At the night of 14 November 2004, a major part of Norway spruce forests in the southern slopes of High Tatras, at the altitudes from about 850 to 1200 m, was destroyed in an about 16 km long and 4 km wide strip by wind reaching a velocity of up to 200 km per hour. In two subsequent years the fallen timber was removed from the major part of the area affected. There were let only sparse individuals of pines and larches, which have survived the catastrophe. Such a catastrophe occurred there in a similar extent already in early 20th century as a consequence of planting unsuitable ecotypes of Norway spruce in mid 19th century. In spite of the fact that the forests destroyed were of the artificial origin, they have already reached an advanced succession stage, could not be considered as pure monocultures and were protected in the framework of the Tatra National Park. Beside this their species composition as such was not in any discordance with the potential composition of vegetation, because of the rain shadow caused by extensive Carpathian mountain ranges situated westerly of High Tatras, as well as by the High Tatras themselves. The resulting deficiency in humidity does not allowed the beech-fir forests, which would represent the natural potential vegetation at these altitudes, to develop here (Michalko 1985) and existence of extensive Norway spruce stands is to be considered natural in such conditions. The same phenomenon also occurs in the eastern slopes of Carpathians in Romania (CĂLINESCU 1944).

This catastrophe offers, however, an exceptional occasion for long termed observations of succession of biota in the area affected and its ability to restore its original composition. From this reason, a minor part of the stands destroyed have been let *in situ* in order to compare succession on the areas without any human intervention and in those, where the timber was almost completely removed and the area was let to further autonomous succession and those which have been artificially afforested, mostly with trees more resistant to wind (ashes, larches). The situation has also been complicated by the fact that during the timber removing a major part of the area affected was still damaged by fire, which arose perhaps unintentionally due to negligent tourists, but highly probably was founded intentionally, from

speculative reasons, by the lobbies interested in timber exploitation, massive investments and building activity around the existing sport and recreation resorts and in reduction of protection degree of the High Tatra National Park.

Such observations are of a high significance, because impacts of artificial or natural catastrophic deforestation of forest fauna were studied mostly at lower altitudes (MAGURA et al. 2003, ŠUSTEK 1984a, b) or on areas of a much lesser extent ŠUSTEK & ŽUFFA (1985, 1986). In adition the recent investigation of alpine carabid communities indicate, that strategy and habitat preference of some species can considerably change along the range of their altitudinal distribution (ŠUSTEK 2005). The aim of this contribution is to compare the present state of Carabid communities in the intact spruce forests and in the affected area in the sites with different management regime.

## METHODS

The beetles were pitfall-trapped using the half-liter plastic jars filled with 5% formol. Six traps were installed in a line in center of each study plot in distances of about five meters. They are emptied in one-month intervals. The study plots were selected by the staff of the Investigation Station of the State Silviculture Enterprise of the High Tatra National Park and serve for simultaneous investigations of abiotic factors and succession of biota. The plots were selected so that they include one intact mature Norway spruce stand westerly of the area affected, as a reference plot, one plot with timber let *in situ*, two plots with removed timber and two plots with removed timber and secondarily burned. In this study, two one-month samples from June-July and July-August 2007 are used.

The ecological data on species were taken from BURMEISTER (1939), HŮRKA (1996), ŠUSTEK (2000) and THIELE (1977).

The hierarchical classification of communities was carried out by the unweighted average linkage method using the indices of Jaccard and Ružička. The reciprocal ordering was used for non-hierarchic classification of the communities. All calculations were carried by means of the NUMCLAS program. The direct ordination was made on the basis of vegetation and humidity preferences of species. An original 4-degree semiquantitative scale was used for characterization of vegetation cover preference, while an 8-degree semiquantitative scale was used for humidity preference (ŠUSTEK 2004). The score of individual communities was calculated as arithmetic mean of preference of all species weighted by their abundance.

### Sampling Sites Specification

The sampling sites are situated in the center of the affected strip, five sites are in the affected area subjected to different management regime and, partly additionally affected by fire. One site, situated westerly of the affected strip in an intact spruce forests serves as reference plot. The plots were selected by the staff of the Research Station of the State Forest Management Office of the Tatra National Park and serve to simultaneous investigation of other organisms and abiotical processes.

Vyšné Hágy – 49° 07´ 25.6” N, 20° 07´ 12.5” E, altitude 1260 m, southern slope, declination about 20°, a mature continuous stand of 80-90 years, the ground covered mostly by raw humus and needles, locally by mooches and *Vaccinium myrtillus*, (coverage not higher than 20-30%) and individual young spruces. Reference plot.

Danielov dom - 49° 07´ 22.4” N, 20° 09´ 46.3” E, altitude 1080 m, southern slope, declination about 20°, originally a mature continuous stand of 80-90 years, the fallen timber completely removed, only about 1-1.5 m long trounces remained, in the plot individual mature larches and sparsely distributed young spruces also remained, the whole area covered by *Calamagrostis* spp. (coverage 80-90%) and individually by *Vaccinium myrtillus* or *Vaccinium vitis idea.* still not re-afforested.

Tatranské Zruby, lower plot – 49° 07´ 49.6” N, 20° 11´ 53.8” E, altitude 1005 m, almost flat, declination 2-3°, originally a mature continuous stand of 80-90 years, the fallen timber completely removed, only about 1-1.5 m long trounces let, individual mature larches also survived, the plot was completely burned, now is densely covered by about one meter high stand of *Chamaenerion angustifolium* (100%), recently re-afforested by ashes and larches (not higher than 40-50 cm), around which the spontaneous vegetation is cut.

Tatranské Zruby, upper plot – 49° 08´ 4.0” N, 20° 11´ 31.2” E, altitude 1100 m, southeastern splote, declination 20-30°, originally a mature continuous stand of 80-90 years, the fallen timber completely removed, only about 1-1.5 m long trounces let, individual mature larches rarely survived, the plot was completely burned, now is densely covered by about one meter high stand of *Chamaenerion angustifolium* (100%), still not re-afforested.

Nový Smokovec – Vodný les – 49° 08´ 8.1” N, 20° 12´ 27.5” E, altitude 1015 m, a little southerly opened valley of a creek on southern slope, originally a mature continuous stand of spruces of 80-120 years, locally with young spruces up to 3 m, with admixed willows and alders along the creek, the fallen timber completely removed, only about 1-1.5 m long trounces let, the whole area covered by *Calamagrostis* spp. (coverage 80-90%), locally *Rubus* spp. and *Vaccinium myrtilus.* The plot lies on margin of the burned area. Still not re-afforested.

Tatranská Lomnica – Jamy - 49° 09´ 18.4” N, 20° 14´ 51.3” E, altitude 1060 m, a strongly undulated, mostly southerly and southeasterly oriented terrain, declination varying from 5-25°, originally a mature continuous stand of 80-90 years, individual pines and young spruces survived, the timber let *in situ*, only a narrow corridor cut along a former little path to allow to entry the area interior. The traps were situated along this path. The herbaceous vegetation consists of little patches of grasses or the soil surface covered by needles.

## RESULTS

*General Characteristic of Species Composition*

In all six sites 34 species were recorded (Tab. 1). They split in two groups – the first includes stenotopic forests species distributed in highlands, at elevations of about 300-1200 m, but some of them reaching also the subalpine zone (*Carabus violaceus, Pterostichus foveolatus, Cychrus caraboides*) or occurring also in lowland forests (*Carabus hortensis, Carabus violaceus, Cychrus caraboides*). All of them are unable to fly, except of *Trichotichnus laevicollis*).

**Table 1.** Survey of species, their ecological parameters and activity abundance in six sampling plots in Norway spruce forest in High Tatras affected by gale disaster in November 2004

**Tabelul 1.** Lista speciilor, paramertre ecologice ale lor şi activitatea abundeşei la şase staţionare în molidişurile din Tatra Înaltă distruse de vânt la Noiembrie 2004

| | Fly ability | Veg. cov. | Humidity | Vyšné Hágy | Jamy | Danielov dom | Tatranské zruby upper | Tatranské zruby lower | Vodný les |
|---|---|---|---|---|---|---|---|---|---|
| *Agonum sexpunctatum* (LINNAEUS, 1758) | F | 1 | 5 | | | | 1 | 1 | |
| *Amara aenea* (DE GEER, 1774) | F | 1 | 3 | | | 2 | 6 | 1 | |
| *Amara eurynota* (PANZER, 1797) | F | 1 | 3 | | | 1 | 2 | 21 | 1 |
| *Amara familiaris* (DUFTSCHMIDT, 1812) | F | 1 | 3 | | | 3 | | 1 | 1 |
| *Amara nitida* STURM, 1825 | F | 1 | 3 | | | | | | 1 |
| *Anisodactylus binotatus* (FABRICIUS, 1792) | F | 1 | 6 | | | | 1 | 2 | |
| *Amara erratica* (DUFTSCHMIDT, 1812) | F | 1 | 3 | | | 102 | 8 | 6 | 14 |
| *Bembidion lampros* (HERBST, 1784( | F | 1 | 3 | | | | 4 | 26 | |
| *Calathus micropterus* DUFTSCHMIDT, 1812 | N | 4 | 3 | 9 | | | | | |
| *Carabus auronitens* FABRICIUS, 1792 | N | 4 | 4 | 18 | 1 | 1 | 3 | | |
| *Carabus glabratus* PAYKULL, 1790 | N | 4 | 5 | 7 | 15 | 47 | 4 | 8 | 5 |
| *Carabus hortensis* LINNAEUS, 1758 | N | 4 | 4 | | | | | 1 | |
| *Carabus linnei* DEJEAN, 1826 | N | 4 | 5 | 17 | 25 | 1 | | 7 | |
| *Carabus violaceus* LINNAEUS, 1758 | N | 4 | 5 | 29 | 10 | 40 | 1 | 2 | 3 |
| *Cychrus carabaoides* (LINNAEUS, 1758( | N | 4 | 5 | 8 | | | | | |
| *Harpalus affinis* (SCHRANK, 1784) | F | 1 | 3 | | | | | | 1 |
| *Harpalus quadripunctatus* (DEJEAN, 1829) | F | 1 | 4 | | | | | 2 | |
| *Loricera caerulescens* (LINNAEUS, 1758) | F | 2 | 4 | | | | | | 5 |
| *Microlestes maurus* (STURM, 1827) | F | 1 | 2 | | | | | 1 | |
| *Molops piceus* (PANZER, 1793) | N | 4 | 4 | 7 | | | 1 | 2 | 1 |
| *Notiophilus biguttatus* (FABRICIUS, 1779) | F | 1 | 4 | 4 | | | 1 | 4 | 5 |
| *Poecilus cupreus* (LINNAEUS, 1758) | F | 1 | 4 | | | 1 | 5 | 17 | |
| *Pseudoophonus rufipes* (DE GEER, 1774) | F | 1 | 4 | | | 1 | 2 | | |
| *Pterostichus aethiops* (PANZER, 1797) | N | 4 | 5 | 3 | 9 | 1 | 1 | | 2 |
| *Pterostichus burmeisteri* (HEER, 1801) | N | 4 | 5 | 17 | 16 | 2 | 1 | | 5 |
| *Pterostichus foveolatus* DUFTSCHMIDT, 1812 | N | 4 | 5 | 44 | 4 | | | 1 | 1 |
| *Pterostichus niger* (SCHALLER, 1783) | F | 4 | 6 | | | | | | 1 |
| *Pterostichus nigrita* (FABRICIUS, 1792( | F | 2 | 8 | | | | | | 2 |
| *Pterostichus oblongopunctatus* (FABRICIUS, 1787) | F | 4 | 5 | | | 1 | 1 | 3 | |
| *Pterostichus strenuus* (PANZER, 1797) | F | 2 | 7 | | | | | | 1 |
| *Pterostichus unctulatus* DUFTSCHMIDT, 1812 | N | 4 | 5 | 208 | 25 | 28 | 8 | 1 | 2 |
| *Trechus amplicollis* FAIRMAIR, 1859 | N | 4 | 5 | | | | | | 4 |
| *Trechus latus* Puzeys, 1847 | N | 4 | 5 | | | | | | 1 |
| *Trichotichnus laevicollis* DUFTSCHMIDT, 1812 | F | 4 | 5 | 1 | 1 | | | | 1 |
| Number of individuals | | | | 372 | 106 | 231 | 50 | 107 | 57 |
| Number of species | | | | 13 | 9 | 14 | 17 | 19 | 20 |
| Diversity index H´ | | | | 2.35 | 2.72 | 2.00 | 3.65 | 3.34 | 3.75 |
| Dominance concentration index D | | | | 0.34 | 0.17 | 0.28 | 0.10 | 0.14 | 0.11 |

Explanations:
Flying ability: N – non-flying species, F – flying species.

Gradient of preference of vegetation cover: 1 – heliophilous open landscape species, 2 – eurytopic species, 4 – stenotopic forest species.
Gradient of humidity preference: 1 – extremely xerophilous species, 8 – extremely hygrophilous species.
Explicații:
Abilitate de zbor: N – specii nu zburatoare, F – specii zburatoare
Gradientul preferinței acoperișului vegetal: 1 – specii heliofile a peisajului deschis, 2 specii euritopice, 4 specii stenotope de pădure.
Gradientul preferinței umedității: 1 – specii extreme de xerofile, 8 specii extreme de higrofile

The second group includes species having their optimum occurrence in open landscape in lowlands and reaching to the highlands up to ca. 1000-1200 m. Only one of them, *Amara erratica*, is a rather montane species, and three (*Pterostichus nigrita, Pterostichus strenuus, Loricera caerulescens*) are eurytopic species indifferent to vegetation cover. All of these species are able to fly. Most of species of both groups are more or less mesohygrophilous. Only four species (*Pterostichus niger, Pterostichus nigrita, Pterostichus strenuous and Anisodactylus binottatus*) are hygrophilous or polyhygrophilous), whereas only one species (*Microlestes maurus*) is strongly xerophilous.

There have not been found any alpine species known to occur abundantly in High Tatra in the zone of dwarf pine stands, subalpine and alpine meadows (*Carabus sylvestris* PANZER, 1793, *Calathus metallicus* DEJEAN, 1828, *Trechus striatulus* PUTZEYS 1847, *Pterostichus morio carpathicus* KULT, 1947),

**Presence and Abundance Changes between the Reference Site**

The community in the reference site consists of 12 species, among 12 are stenotopic forests species and one (*Notiophilus biguttatus*) is eurytopic. There was not recorded any xenocoenous species. Except of *Calathus micropterus* and *Trichotichnus laevicollis* all species occurring in the intact stand occurred in the sites damaged, but their abundance strongly decreased in most of them (Tab. 1). Only two species, *Carabus glabratus* and *Carabus violaceus* were not visibly affected by damaging or removing of the tree cover, or in the site Danielov dom (not affected by fire) they were even favored by elimination of competition of similarly sized congeners.

The community in the site with fallen timber let *in situ* was poorer in number of species (9) and exhibited a lower cumulative abundance (106 ind.). However, most species occurred in similar numbers of individuals (Tab. 1) Only abundance of *Pterostichu unctulatus* and *Pterostichus foveolatus* dropped suddenly to about 10% of their abundance in the reference site. On the contrary this community has not still been penetrated by any xenocoenous species.

The community in the site with removed timber but not affected by fire consisted of 14 species with cumulative abundance of 231 individuals. Seven among them were common with the reference site, but except *Carabus glabratus* and *C. violaceus*, they survived here in much lower numbers of individuals (Tab. 1). These species together represented 61% of individuals. The species not found in the reference site was *Pterostichus oblongopunctatus*, a frequent forests species of lowlands and middle altitudes. These species together represented 61% of individuals. Six species were open landscape species. Most abundant of them was *Amara erratica* representing 44% of all individuals. Its presence is obviously a consequence of deforestation, but as it is a montane species. Therefore its occurrence can not be interpreted negatively from the so zoological viewpoint. Only the remaining five species (*Amara aenea, Amara eurynota, Amara familiaris, Poecilus cupreus, Pseudoophonus rufipes*) can be considered as expressively xenocoenous.

The next three sites (both in Tatranské Zruby, Vodný Les) consisted of a relatively large number of species (17; 19 and 20, respectively), but cumulative abundance of all species was much lower (50; 107 and 57 ind., respectively) than in the reference plot. The species occurring in the reference site nine species survived there little, representing about one quarter of species (6; 5 and 6, respectively) but they occurred here always individually only. Besides this there were recorded two forest species (*Carabus hortensis* and *Pterostichus oblongopunctatus*) not occurring in the reference plot or in the moderately affected plot with laying timber. Major part of the community consisted of open landscape, xenocoenous species (7, 9 and 5 species, respectively). Their cumulative abundance represented 56%, 70% and 31.6% of all individuals. Beside it, in the site Vodný les three polyhygrophilous species (*Pterostichus niger. Pterostichus nigrita, Pterostichus strenuus*), also occurred in small number of individuals, due to a narrow alluvium of a creek running through this site.

**Hierarchical Classification and Ordination of the Communities**

The hierarchical classification based on presence/absence data (Jaccard´s coefficient) forms two clusters (Fig. 1). The first cluster, at dissimilarity level of 0.3, joins the communities from the reference site and site with laying timber. The second cluster, at dissimilarity level of 0.55, joins three communities from deforested sites. The community from Vodný Les takes an isolated position in the dendrogram, joing to the cluster at dissimilarity level of 0.65. This structure of dendrogram reflects absence of xenocoenous species in the reference site and in the site with laying timber, a high proportion of xenocoenous species in the affected sites and occurrence of some hygrophilous species in the site Vodný les.

The hierarchical classification based on non standardized quantitative data (Ružička´s index) (Fig. 2) forms two clusters at dissimilarity level of 0.9. The core of the first cluster consists of the community from the reference site and from the site with laying timber. Presence of community from the deforested site Danielom Dom in this cluster

results from a high abundance of *Carabus glabratus* and *Carabus violaceus* as a common feature with the first two communities and from a high abundance of *Amara erratica* as a feature different from other affected sites. The core of the second cluster includes communities from both burnt sites, to which the community from Vodný les joins. It reflects high proportion of xenocoenous species, a low abundance of *Amara erratica* in all three communities and presence of hygrophilous species and a slightly increased level of surviving of some forest species.

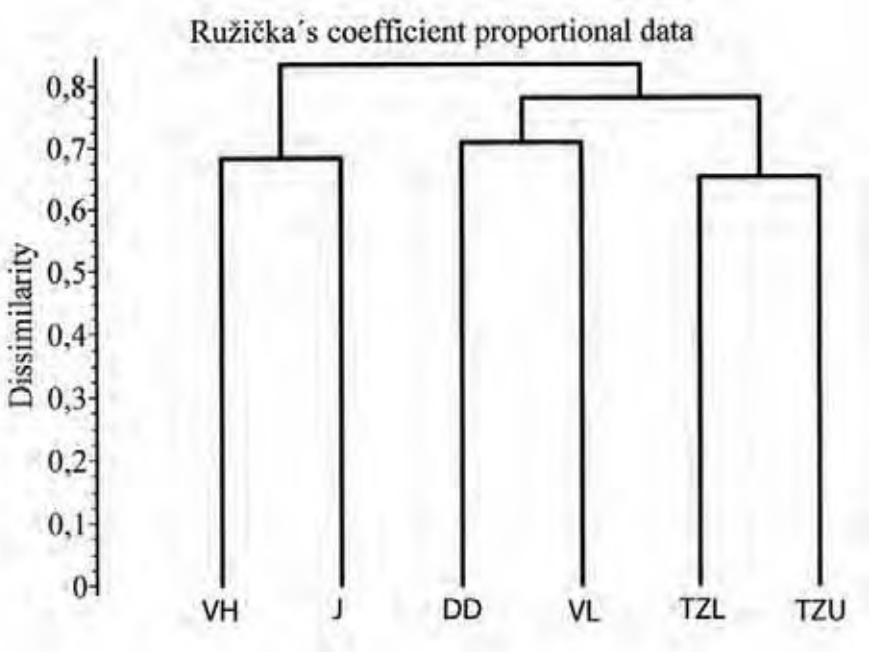


**Figure 1.** Hierarchical classification of the communities according to presence absence data (Jaccard´s coefficient).
**Figura 1.** Clasificarea ierarhică a cenozelor după prezenţă şi absenţă a lor (coeficientul lui Jaccard)

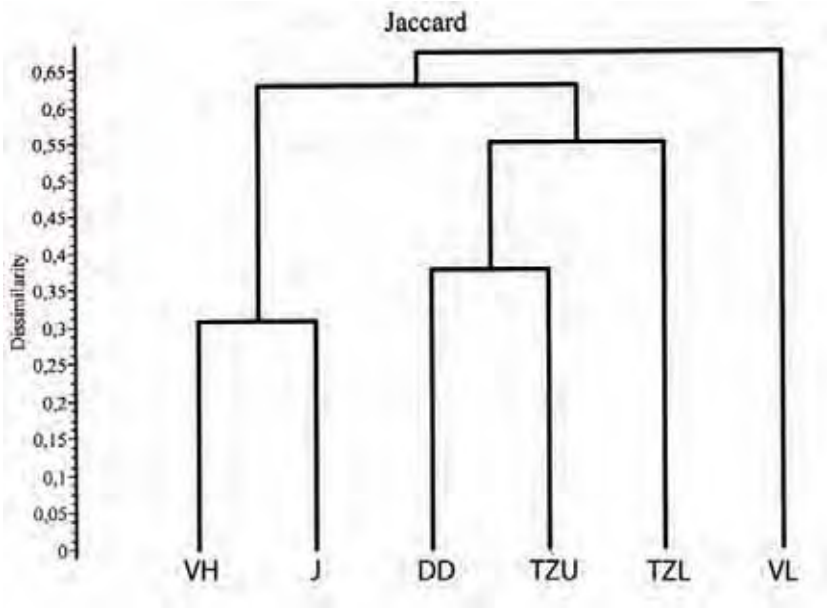


**Figure 2.** Hierarchical classification of the communities according to non-standardized abundance data (Ružička´s coefficient).
**Figura 2.** Clasificarea ierarhică a cenozelor după abundenţă nestandartizată (coeficientul lui Ružička)

The hierarchical classification using standardized quantitative data (relative abundance, Ružička´s index) (Fig. 3) form three separate clusters at dissimilarity level of 0.68-0.70. The first includes the communities from the reference site, the second from the deforested and burnt site in Tatranské Zruby, the third the sites from Danielov Dom and Vodný les. The two former. The second cluster reflects mainly the increased representation of *Amara erratica, Poecilus cupreus, Bembidion lampros* and, while the third increased representation of *Poecilus cupreus, Bembidion lampros* a slightly higher degree of surviving of *Carabus violaceus, Carabus glabratus and Pterostichus burmeisteri*.

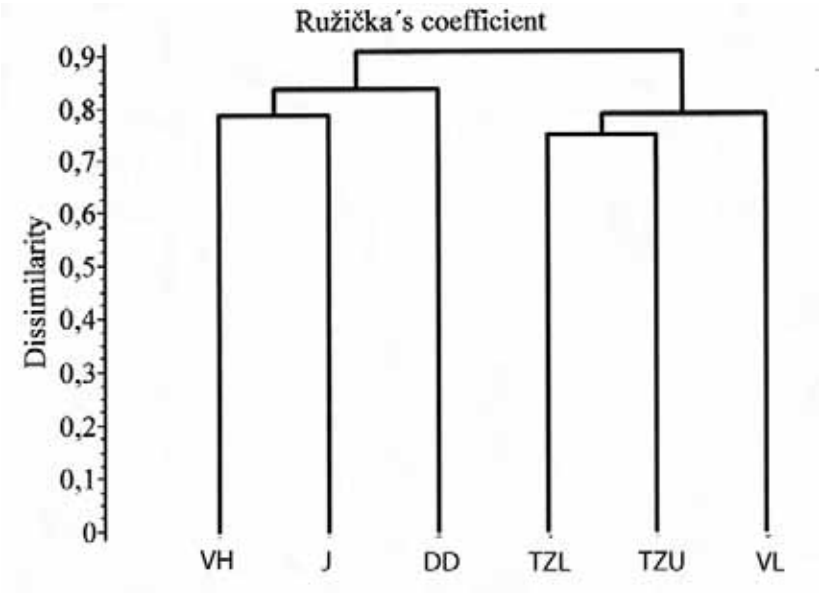


**Figure 3.** Hierarchical classification of the communities according to standardized (relative abundance) data (Ružička´s coefficient).
**Figura 3.** Clasificarea ierarhică a cenozelor după abundență estandartizată (abundență relativă, coeficientul lui Ružička)

The diagram of reciprocal ordering (Fig. 4) has the same interpretation. There arise three clear groups of communities: 1 and 2 – reference site and site with laying timber, 4 and 5 – both burn sites from Tatranské Zruby and 3 and 6 – Danielov Dom and Vodný les. Thus along the first ordination axis are clearly separated the communities from sites with removed timber, while along the second axis the communities from the deforested sites affected secondarily by fire and exposed to a slightly stronger invasion of the heliophilous, open landscapes species are separated the not burnt ones.

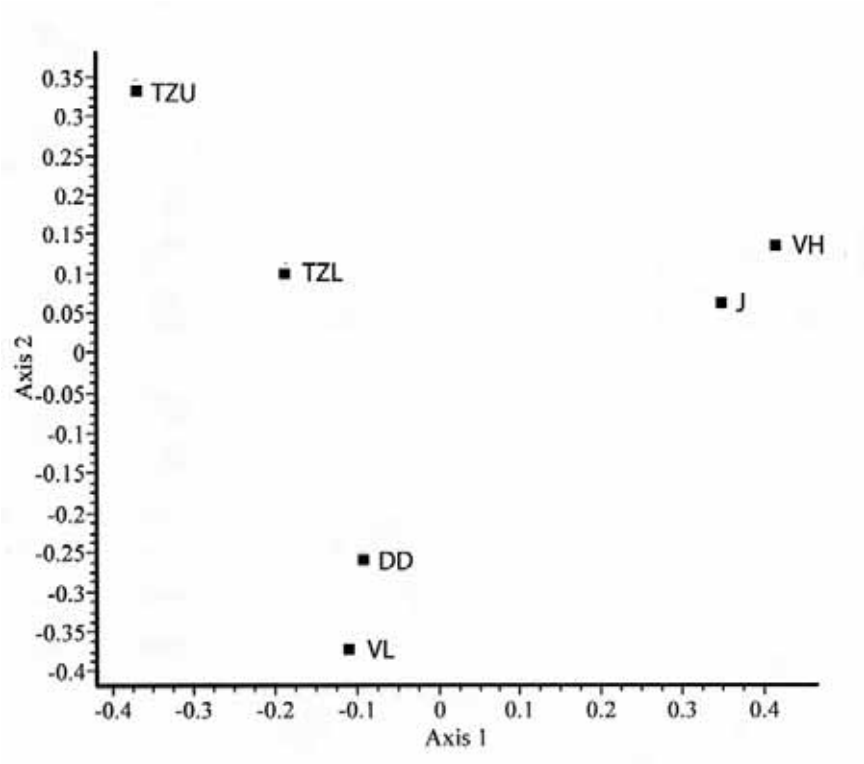


**Figure 4.** Diagram of reciprocal ordering (VH – Vyšné Hágy, J – Jamy, D – Danielov Dom, TZL – Tatranské Zruby lower, TZU – Tatranské Zruby upper, VL – Vodný les).
**Figura 4.** Diagram de ordinație după algoritmul "reciprocal ordering (VH – Vyšné Hágy, J – Jamy, D – Danielov Dom, TZL – Tatranské Zruby staționarul de jos, TZU – Tatranské Zruby staționarul de sus VL – Vodný les).

**Structural Changes in the Communities**

The non-flying species highly predominate in the community in the reference site and on the site with laying timber (Fig. 5). The quantitative representation of flying species is even negligible (Fig. 6). In the communities if all deforested sites proportion of the non-flying and flying species is balanced (Danielov Dom) or the flying species represent even 2/3 of all species. The quantitative representation of both groups remains approximately balanced in Danielov dom and Vodný les, while in both communities in Tatranské Zruby proportion of individuals of flying species increases even to ¾.

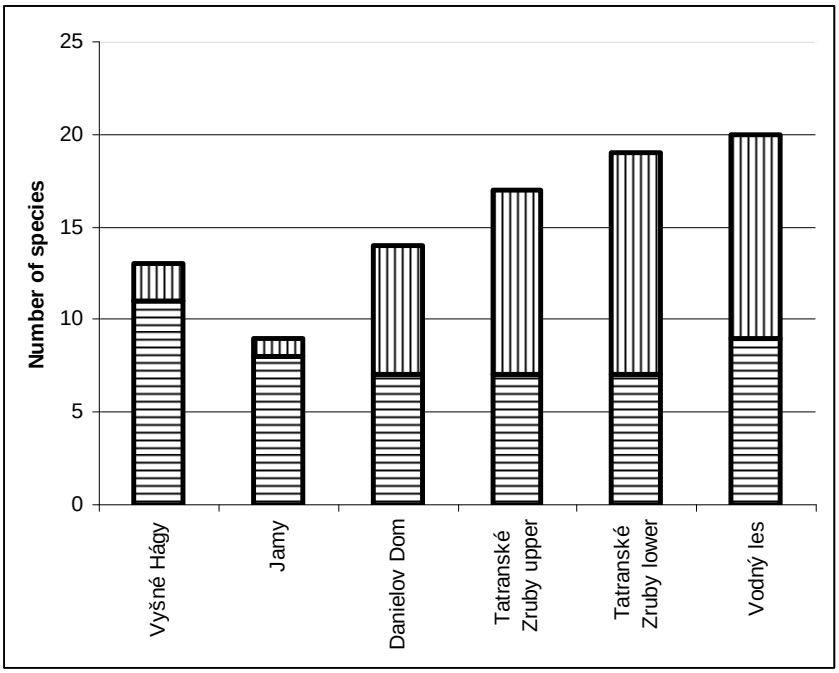


**Figure 5.** Number of flying (vertical hatching ) and non flying species (horizontal hatching) in individual localities.
**Figura 5.** Numărul speciilor zburătoare (rețea verticală) şi nezburătoare (rețea orizontală) in staționarele individuale

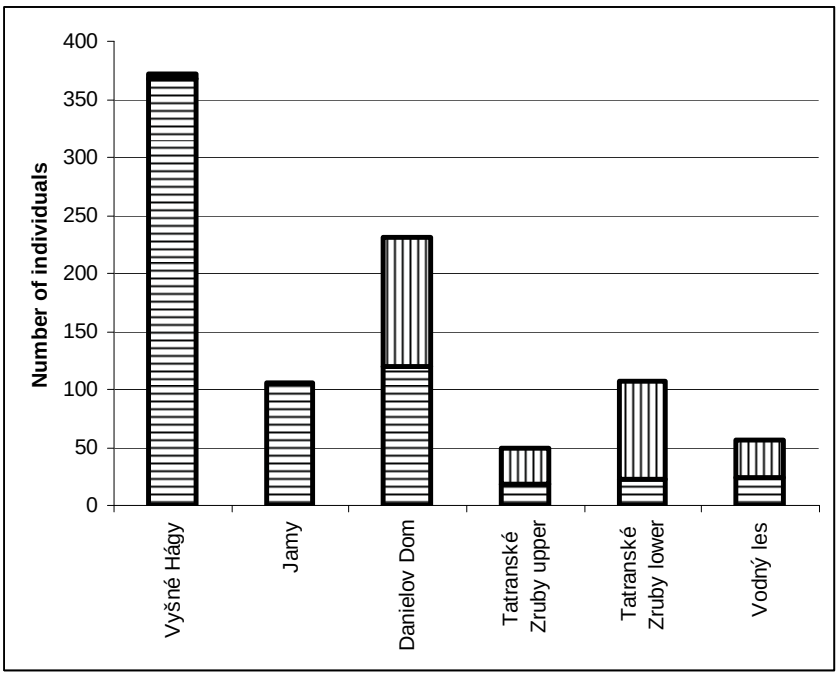


**Figure 6.** Number of individuals of flying (vertical hatching ) and non flying (horizontal hatching) species in individual localities.
**Figura 6.** Numărul indiviziilor zburatoare (rețea verticală) şi nu zburatoare (rețea orizontală) in staționarele individuale

The changes of proportion of forest and opened landscape species on one hand and of species with different preference of humidity is reflected in direct ordination of the communities (Fig. 7). In the right top corner is closely situated the community from the reference site and site with laying timber, where are no open landscape species, eurytopic species are represented negligibly and all species are mesohygrophilous with slightly increased requirements for humidity. In the center there are communities from other deforested, where the open landscape species predominated quantitatively and their presence shifts the communities along the humidity gradient about by one degree. Influence of secondary damaging by fire is shown by shifting of both communities from Tatranské Zruby lower along the vegetation cover gradient and also slightly to more xerophilous communities.

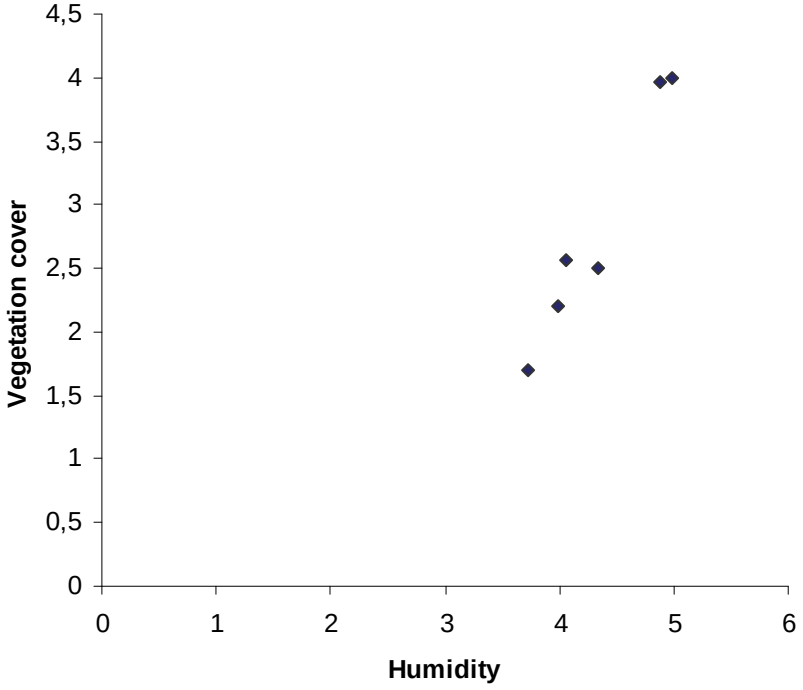


**Figure 7.** Direct ordination of the communities according preference of species for humidity and vegetation cover.
**Figura 7.** Ordinația directă a cenozelor după preferința lor pentru umiditate și acoperișul vegetal

## DISCUSSION AND CONCLUSIONS

The result obtained so far indicate clearly that wind disaster strongly affected structure of Carabid communities. However ,as such it has not affect species composition as such. It resulted only in a considerable decrease of abundance of individuals of species. The much more destructive factor was removing of the laying timber from the major part of the area affected and the damaging of litter and upper layer of soil where the forest Carabids develop and search for cover. However, even under such conditions a considerable part of original stenotopic species survives being replaced by open landscape species with higher invasive power. Still more destructive was the fire damaging secondarily the soil surface. Whereas in the non-burned sites were invaded to considerable by *Amara erratica*, a montane species, the burned sited were invaded more by species typical of fields, meadows and ruderals in lowland and middle altitudes. Their invasion is also an affect cutting the secondary herbage vegetation in one of the sites in Tatranské zruby, which has already been artificially re-afforested. Iinvasion of these, however, was not so massive, as it would happen in lower altitudes (e. g. Šustek 1984). There was not observed even any strong invasion of *Pseudoophonus rufipes*, very expansive and abundant field species, which undertakes intensive migrations in warm night by the turn of July and August.

The most sensitive species to deforestation were *Pterostichus unctulatus* followed by *Carabus linei*, *Carabus auronitens*, *Calathus micropterus*, *Pterostichus foveolatus* and *Pterostichus burmeisteri*. On the contrary, *Carabus glabratus* and *Carabus violaceus* exhibites a considerable tolerance to deforestation. The tolerance degree of individual species can not be, however, generalized. It can be illustrated by *Pterostichus foveolatus*, which was relatively sensitive in this case, at altitudes of 1000-1100 m, but which successfully survives in subalpine meadows at altitudes of 1700-2000 m, in more humid climate.

The obtained results confirm rightfulness of opinions of nature protectors, who demanded to let the fallen timber in situ. On other hand, they show that the communities in the damaged areas have preserved at least some original species and still are able to restore its original structure autonomously.

**ACKNOWLEDGEMENTS**

This study was financially supported by the grant 2/7079/27 of the Grant Agency VEGA.

**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. 307p.

CĂLINESCU R. 1944. *Întroducere în biogeografia României*. Bucurşti 205p.

HŮRKA K. 1996. *Carabidae of the Czech and Slovak republics*. Edit. Kaborek. Zlín. 565p.

MAGURA T., TOTHMERESZ B., ELEK Z. 2003: *Diversity and composition of carabids during a forestry cycle*. Biodivers conserv 12: 73-85.

MICHALKO J. 1985: *Geobotanická mapa ČSSR, Slovenská socialistická republika. Textová časť.* Editora Veda, Bratislava. 165 p.

ŠUSTEK Z. 1984. *Carabidae and Staphylinidae in two forest reservations and their reactions on surrounding human activity*. Biológia (Bratislava). 39: 137-162.

ŠUSTEK Z. 1984. *Influence of clear cutting on ground beetles (Coleoptera, Carabidae) in a pine forests*. Communicationes Inst. For. Čechoslov. **12:** 243-254.

ŠUSTEK Z. 2000. *Spoločenstvá bystruškovitých (Coleoptera, Carabidae) a ich využitie ako doplnkovej charakteristiky geobiocenologických jednotiek: problémy a stav poznania*. Geobiocenologické spisy. Brno. **5:** 18-30.

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

ŠUSTEk Z. 2005. *Bystruškovité (coleoptera, Carabidae) a ich reakcie na zmeny vegetačného krytu vo vysokohorských ekosystémoch.* Folia faunistica Slovaca. **10**(5): 19-22.

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

ŠUSTEK Z. & ŽUFFA M. 1988: *Spoločenstvá bystruškovitých a drobčíkovitých (Coleoptera, Carabidae et Staphylinidae) Štátnej prírodnej rezervácie Kľačianska Magura v Chránenej krajinnej oblasti Malá Fatra.* Ochrana prírody. **9:** 229-251.

THIELE H-U. 1977. *Carabid beetles in their environments*. Edit. Springer-Verlag. Berlin-Heidelberg-New York. 369p.

**Šustek Zbyšek** Institute of Zoology, Slovak Academy of Sciences,
Dúbravská cesta 9, 845 06 Bratislava
e-mail: zbysek.sustek@savba.sk