THE IMPACT OF TOURISM AND LANDSCAPE MANAGEMENT IN THE ŠUMAVA NATIONAL PARK AND THE ŠUMAVA LANDSCAPE PROTECTED AREA ON THE EPIGEIC BEETLE COMMUNITIES

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Abstract

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The effect of tourism and various landscape management on the beetle communities were investigated using pitfall trapping in the montane area of the Central Europe (Šumava National Park and Landscape Protected Area). The pitfall traps were arranged on plots on the left and right side of the Lipno reservoir with the different anthropogenic pressure – the higher man pressure was traditionally on the left side of the Lipno reservoir. Beetle communities of the Norway spruce forest, ski trail, golf course, cultural meadow, parking plot, dam shore and the wetland were studied. The number of species discovered by pitfall trapping was lowest on the plots strongly affected by human activities (golf course and parking place). The skiing had no negative effect on epigeic beetles. Some species typical for open biotopes migrated to the ski trail and the forest species present at the edge of the forest and ski slope. The community structure of the spruce forest, reservoir shores and cultural meadows on both sides of the Lipno reservoir was very similar on both touristic frequented and ununvisited sides of the Lipno reservoir recreation area. Strong human pressure on the biotopes (golf course and parking place) resulted in the extinction of stenotopic and hygrophilous species. The percentage of polyphagous species increased in these biotopes. The main factors affecting the beetle communities were the regular and intensive management activities in the golf course and parking plot (cutting, irrigation, herbicide application, fragmentation and trammling).

Key words: epigeic beetles, communities, tourism, landscape management, Šumava National Park, Landscape Protected Area, southern Bohemia

Introduction

Tourism has long been accepted a "clean industry", without any negative impacts on the environment and acceptable as a perspective for sustainable development even in protected areas (Van der Duim, Caalders, 2002). On the other side we have some data about the negative effect of tourism on nature (Urry, 1992). At the same time, tourism is able to contribute to a growing awareness of the value of nature and to the protection of biodiversity. Tourism is the only means often to provide employment for the local population (Weaver, 1999).

We have only few concrete data about the effect of tourism on biodiversity only (Young et al., 2005). While most recreational impacts may be of minor long-term significance, some recreational developments, especially those associated with infrastructure as skiing developments (inlcuding the creation of ski lifts, car parking, etc.), may have severe and lasting impacts on biodiversity such as increased risks of floods and erosion, pollution, loss of vegetation, and abandonment of agricultural practices in the area (McGowan et al., 1999).

We have few data about the effect of some tourist equipment on the characteristics of biotopes and epigeic beetles. The effect of golf course construction on the water chemistry resulted in a significant impact on alkalinity, nitrogen and base cation concentration of streams (Winter, Dillon 2005). It means that these water characteristics affect both the soil characteristics, structure of vegetation and communities of epigeic invertebrates also. The effect of ski trails on a beetle community was studied by Strong et al. (2002). Authors argued that ski trails are strong barriers for to dispersal of forest beetles, mainly for flightless or dimorphic and primarly short-winged. Consequently, fragmentation of mountain slopes by ski trails, especially those that run perpendicular to the climatic gradient, may put isolated populations at a great risk of local extinction.

Communities of epigeic beetles were studied during the project about the human effect on ecosystems in submontane and montane areas in Czech Republic. These beetles represent one of the ecologicallly most sensitive insect groups with many highly specialized taxa (Thiele, 1977; Šustek, 1994; Boháč, 1999, 2003; Boháč et al., 2005).

The aim of this paper was to find what tourism and the different management practices connected with it have the essential influence on beetle communities in submontane and protected landscape of central Europe.

Research sites and methods

Stand and site characteristics

The study was provided near the Lipno village, about 15 km from Volary town (the Czech Republic). Mean annual temperature was 5.0 °C, annual precipitation was 900 mm. The ten experimental plots were established. The characteristic of studied plots are as follows:

1. Cultural forest on the left side of Lipno reservoir with intensive tourism. The plot with the Norway spruce forest. The surface of this plot was covered mainly by *Oxycoccus palustris, Equisetum sylvaticum* and different mosses. This plot was characterised by the highest values of organic matter and soil porosity.

2. Ski trail on the left side of Lipno reservoir with intensive tourism. The plot are situated in the internal part of the cultural forest. The surface is without vegetation or sparsely covered by particularly *Calluna* and *Polytrichum*. The significant plant species on the edge of the trail were *Calluna vulgaris, Vaccinium myrtillus, Avenella flexuosa* and mooses (*Polytrichum* spp.). The values of organic matter and soil porosity were relatively low. The character of soil surface was apparently irregular in comparison with other plots (Table 1).
3. Golf course on the left side of Lipno dam with intensive tourism. Heavily affected plot with regular irrigation, mowing, herbicide and fertilizers application. Plot is covered by the monoculture of grass (Table 1).
4. Parking place on the left side of Lipno dam with intensive tourism. Heavily affected plot with concrete roads and parking places and fragmented patches of grassland. Some grasses presents only (*Arhenatherum elatius, Dactylis glomerata* and *Holcus lanatus*). The plot was characteristic by low organic matter content, soil surface was flat in comparison with seminatural plots (Table 1).
5. Shore of the Lipno reservoir on the right side of Lipno dam without intensive tourism. Litoral biotope with some water and wetland plant species (*Molinion, Calthion*).
6. Cultural meadow on the right side of the Lipno reservoir without intensive tourism. Meliorated wet plot was situated in the wet spot in drained meadow. The density of vegetation was lower and the significant species were *Juncus effusus, Deschampsia caespitosa* and *Cirsium palustre.* The plot have the lower values of organic matter content and very flat soil surface (Table 1).
7. Shore of the Lipno reservoir on the right side of the Lipno reservoir without intensive tourism. The characteristics is the same as by the plot 5.
8. Cultural meadow on the right side of the Lipno reservoir without intensive tourism. The characteristics is the same as by the plot 6.
9. Wetland on the right side of the Lipno reservoir without intensive tourism. The plot is covered by wet meadows *Molinion* and *Calthion*. The dominant plant species are *Scirpus silvaticus*, *Bistorta major*, *Cirsium palustre* and *Angelica silvestris*.
10. Cultural spruce forest on the right side of the Lipno reservoir without intensive tourism. The characteristics is the same as by the plot 1. The number of tourists is markedly lower in comparison with the plot 1.
The degree of human impact on studied plots is briefly described in the Table 1.

T a b l e 1. Characteristic of studied plots on the left (l) and right (r) side of the Lipno reservoir after the degree of man pressure. +++ – very strong pressure, ++ – medium pressure, + low pressure (modified after Van der Duim, Caalders, 2002)

Plot	Cutting, mowing	Herbicide and fertilizers application, irrigation	Tourism pressure	Car pressure	Eutrophization
Spruce forest (l)	+	-	+	-	+
Ski trail (l)	++	+	++	-	+
Golf course (l)	+++	+++	+++	-	+++
Cultural meadow (l)	++	++	-	-	+
Parking place (l)	+++	++	+++	+++	++
Shore of the Lipno	-	-	+	-	-
reservoir (l)	-	-	-	-	-
Wetland (r)	++	++	-	-	+
Shore of the Lipno reservoir (r) Cultural meadow (r) Spruce forest (r)	+	-	+	-	+

Sampling and data analysis

The method of pitfall trapping was used for the collecion of beetles. A row of five pitfall traps (diameter 7 cm) was exposed in each plots at April 2003 and 2005. Pitfall traps were filled with a mixture of ethylenglykol. The material from the traps was collected every two weeks up to 27 November 2003 and 28 October 2005.

Ordination analysis by the DCA method (Hill, 1979; ter Braak, 1988) was made. The degree of human impact will be studied by finding of frequency of species of different ecological groups (Hůrka et al., 1996; Boháč, 1999). For this, the species were divided into groups groups as follows:

– Group R1 (relic species) includes species remaining from communities of past period, e.g. species with arcto- alpine, boreomontane and boreo-alpine occurrence, inhabiting mainly mountains and peatbogs, or only occurring in remains of forests stands, which because of their high species diversity resemble recent climax forests.
– Group R2 (specialists) encompasses species of both natural and managed forests.
– Group E (generalists or ubiquitous species) comprises eurytopic species that successfully occupy deforested sites and are also found in areas strongly affected by man.

The method of ecological analysis of beetle communities (Boháč, 1999) was used for evaluating of community structure particularly. Various characteristics (frequency of ecological groups according to their relation to the naturalness of biotopes, frequency of species with summer and winter activity of imagos, proportion of winged species, various body size groups, thermo- and hygropreference and geographical distribution) were used during this analysis. Increased influence of man was found to bring about an increase in the frequency of eurytopic species, an increase in the frequency of species with summer activity of imagos, and decrease in the proportion of species with winter activity of imagos. One peak in seasonal activity of staphylinids was found in biotopes with increased influence by man in contrast to two peaks in seasonal activity in semi-natural habitats. Furthermore, an increase was also seen in the proportions of winged species and individuals possessing a higher migrating ability, large body size (size Groups IV and V after Boháč, 1999), species with higher temperature and lower moisture preferences, and species with an area of occurrence wider than Europe. A decrease in the number of life forms was accompanied by a decrease in the beetle community index. More extensive human activity was also shown to bring about an alternation of the sex ratio.

Results

Beetle communities on studied plots

The number of species found in all studied plots was 125. Staphylinids and carabids were more numerous in comparison with other beetle families (48 and 35 species respectively). The number of occurred species was different in studied plots. The number of species was found in this order: cultural meadows on both left and right shore of reservoir with the different tourism intensity (69 and 72 species respectively), ski rail (65 species), wetland (60 species), spruce forest on both left and right shore of reservoir with the different tourism intensity (51 and 48 species respectively), dam shores on both left and right shore of reservoir with the different tourism intensity (38 and 50 species respectively), golf course and parking place (41 and 32 species respectively).

There are five main groups group of epigeic beetles after dominant species in single plots. The wetland community was completely different from all other plots due to the dominance of hygrophilous species, species of small size of body and stenotopic species (e.g. carabids of the genus *Bembidion, Pterostichus* and *Agonum,* staphylinids *Tachyporus transversalis, Quedius fuliginosus*).

The great species of the carabid beetles from genera *Carabus, Abax* and *Pterostichus* prevail in the spruce forest stands. Some of these species are characteristic for submontane and montane areas in Czech Republic (e.g. *Cacarbus linnaei*). The forest species and species living in shadow biotopes are characteristic for staphylinids of spruce forest stands (e.g. species of the genera *Anthobium, Stenus, Lathrobium, Gyrophaena, Atheta* and Oxypoda). Some other species occurred in pitfall traps in spruce forest not found in other plots (e.g. as some xylophagous species like long horn beetle *Spondylis buprestoides*).

The species composition of beetle communities of cultural meadows and ski trail was relatively similar due the great activity of some characteristic carabids with smaller body size (e.g. *Amara familiaris, Poecilus versicolor* and *P. cupreus, Calathus melanocephalus* and *Pseudoophonus rufipes*). Some great staphylinid species were characteristic for meadows (e.g. *Ocypus picipennis picipennis*). Some species from another beetle families belong to subdominant in meadow beetle communities (e.g. *Geotrupes stercorarius* from the family *Geotrupidae* and curculionid beetle *Otiorhynchus singularis*).

The species composition of beetle communities on ski trails differs from this of cultural meadows by the higher activity of some forest species (e.g. staphylinid beetles *Oxypoda alternans*) and some species not found in another plots (e.g. staphylinid beetles *Othius punctulatus* and *Rugilus mixtus*). The presence of stenotopic and endangered staphylinid species *Rugilus mixtus* living mainly in seminatural beech forest in Czech Republic is particular interest (Boháč, 1986). This species occurrs mainly on the edge between forest and ski trail in the detritus. It is possible that the opening of the dense and shadow spruce forest creates optimal microclimatical conditions for this species. Some ubiquitous carabid species are able to penetrate along the ski trail to forest stands in higher altitude of montane landscape (e.g. *Carabus granulatus granulatus*).

The species composition of beetle communities of golf course and parking place is characteristic by the prevailing of smaller and ubiquitous species adapted to the living in open and heavy managed biotopes. The community is formed almost exclusively by four carabid species (*Poecilus versicolor* and *P. cupreus, Amara familiaris, Calathus fuscipes*). Other beetles important for epigeic activity in these intensively managed plots were well flying staphylinids (e.g. *Tachyporus chrysomelinus, Anotylus rugosus, Atheta fungi*).

The lowest number of beetle species was found on the shores of Lipno reservoir. The hygrophilous and well flying species prelailed in this biotope (e.g carabids of the genus *Bembidion*, staphylinids of genera *Philonthus* and *Lathrobium*) (Table 2.).

The impact of human activites on beetle communities

The ecological structure of beetle communities discovered by the pitfall trapping in individual plots differed very distinctly (Fig. 1). The ubiquitous beetle species were found in parking plot exclusively. The frequency of anthropotolerant and ubiquitous species was very high in golf course also (96%). The beetle communities of these biotopes were highly affected by the man.

T a b l e 2. Dominant carabid and staphylinid beetle species in studied plots with the different management and touristic pressure on left (l) and right (r) side of the dam in the Šumava National Park and the Šumava Landscape Protected Area

Plot	Species
Spruce forest (l)	*Carabus hortensis hortensis* L i n n a e u s, 1758, R2 *Carabus linnaei* P a n z e r, 1810 *Pterostichus nigrita* (P a y k u l l, 1790), E
Ski trail (l)	*Amara familiaris* (D u f t s c h m i d, 1812) *Poecilus versicolor* (S t u r m, 1824), E *Philonthus varians* (P a y k u l l, 1789), E *Poecilus cupreus* (L i n n a e u s, 1758) *Rugilus mixtus* (L o h s e, 1956), R1
Golf course (l)	*Pterostichus melanarius* (I l l i g e r, 1798) *Poecilus versicolor* (S t u r m, 1824), E *Poecilus cupreus* (L i n n a e u s, 1758) *Calathus fuscipes* (G o e z e, 1777), R2
Parking place (l)	*Amara familiaris* (D u f t s c h m i d, 1812) *Poecilus versicolor* (S t u r m, 1824), E *Pseudoophonus rufipes* (D e G e e r, 1774), E
Lipno reservoir shore (l)	*Bembidion lampros* (H e r b s t, 1784) *Carabus granulatus granulatus* L i n n a e u s, 1758, E *Carabus scheidleri scheidleri* P a n z e r, 1799, R2 *Poecilus cupreus* (L i n n a e u s, 1758), E *Omalium caesum* G r a v e n h o r s t, 1806, E
Cultural meadow (l)	*Poecilus versicolor* (S t u r m, 1824), E *Poecilus cupreus* (L i n n a e u s, 1758), E *Pterostichus melanarius* (I l l i g e r, 1798), E *Harpalus affinis* (S c h r a n k, 1781), E
Lipno reservoir shore (r)	*Carabus granulatus granulatus* L i n n a e u s, 1758, E *Carabus scheidleri scheidleri* P a n z e r, 1799, R2 *Poecilus cupreus* (L i n n a e u s, 1758), E *Lathrobium fulvipenne* G r av e n h o r s t, 1806, E
Cultural meadow (r)	*Poecilus versicolor* (S t u r m, 1824), E *Poecilus cupreus* (L i n n a e u s, 1758), E *Nebria brevicollis* (F a b r i c u s, 1792), E *Harpalus affinis* (S c h r a n k, 1781), E
Wetland (r)	*Bembidion lampros* (H e r b s t, 1784), E *Paederus riparius* (L i n n a e u s, 1758), R2 *Quedius fuliginosus* (G r a v e n h o r s t, 1802), R2 *Tachyporus transversalis* G r a v e n h o r s t, 1806, R1
Spruce forest (r)	*Carabus hortensis hortensis* L i n n a e u s, 1758, R2 *Carabus linnaei* P a n z e r, 1810, R2 *Pterostichus nigrita* (P a y k u l l, 1790), E *Pterostichus oblongopunctatus* (F a b r i c i u s, 1787), R2

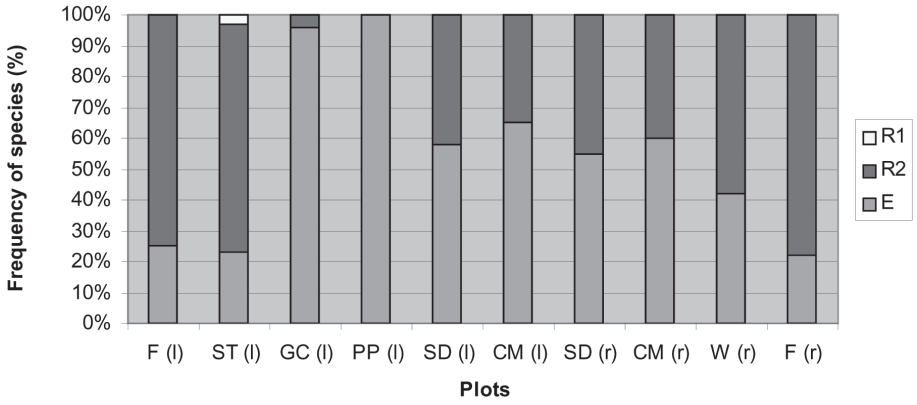

Fig. 1. The effect of man activities on ecological structures of epigeic beetle comunities (R1 – relic species of the first order, R2 – relic species of the second order, E – ubiquitous species) in studied experimental plots on left (l) and right (r) side of the Lipno reservoir with different intensity of tourism in the Šumava National Park and the Šumava Landscape Protected Area (F – spruce forest (l), ST – ski trail, GC – golf course, PP – parking plot, SD – reservoir shore (l), CM – cultural meadow (l), SD – reservoir shore (r), CM – cultural meadow (r), W – wetland, F – spruce forest (r).

The frequency of ubiquitous species in the less managed plots (cultural meadows on the left and right side of the Lipno reservoir) was lower than in the intensively managed parking place and golf course (60–65%). The percentage of mesophilous and hygrophilous species is increasing in these biotopes (40–45%). Xerophilous species of open agricultural landscape with good migrating abilities were found in cultural meadows individually only (e.g. staphylinids *Anotylus rugosus* and *Oxytelus tetracarinatus*).

The frequency of anthropotolerant species in shore plots of Lipno dam is relatively high and close to this in cultural meadows (55–58%). This fact can be affected by the artificial origin of the Lipno reservoir and by the less stabilization of plant and beetle communities.

The ecotone character of ski trail on the border of meadow and spruce forest is probably fact of the relative high percentage of stenotopic and more sensitive beetle species (more than 70%). This share of forest insects is similar to those of spruce forests on both sides of the dam.

The share of more sensitive species in community of beetles of wetland is closer to forest beetle commnities (58%).

Ordination of beetle communities

The community data were ordinated using DCA method. The ordination of pitfall trapping is apparent from Fig. 2 and 3. Beetle communities from spruce forest on both dam side (pitfall traps 5–10 and 31–35) were closely related and relatively well separated from other

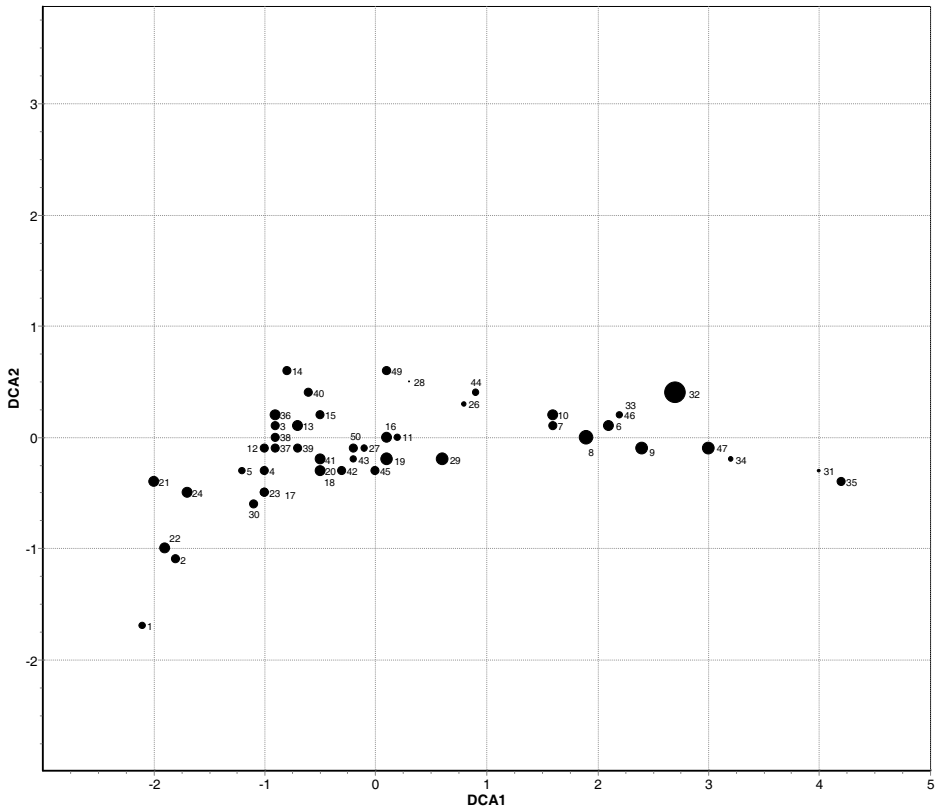

Fig. 2. Ordination of pitfall traps in studied plots on the left (l) and right (r) side of the Lipno reservoir by the method of DCA. The value of the third ordination axis is indicated by the size of mark. The pitfall trap 25 is not mentioned (the value of DCA2 = 15.6). 1–5 golf course (l), 6–10 spruce forest (l), 11–15 cultural meadow (l), 16–20 shore of the Lipno reservoir (l), 21–25 parking plot (l), 26–30 ski trail (l), 31–35 spruce forest (r), 36–40 cultural meadow (r), 41–45 shore of the Lipno reservoir (r), 46–50 wetland (r).

of plots on the right side of the figures. The beetle communities of cultural meadows, ski trail, wetland and shores of Lipno reservoir are placed approximately in the center of figures. There are not great differences in position of pitfall trapps of these biotopes. The beetle community of ski trail is sligthly spleted more close to beetle communities of forest biotopes. The beetle communities of parking place and golf course are clearly separated on the left side of figures.

The gradient between managed and seminatural plots corresponded clearly with 1st ordianation axis which explains substantial part of data variability, whereas second axis seems to be more important for explanation of variability among managed plots.

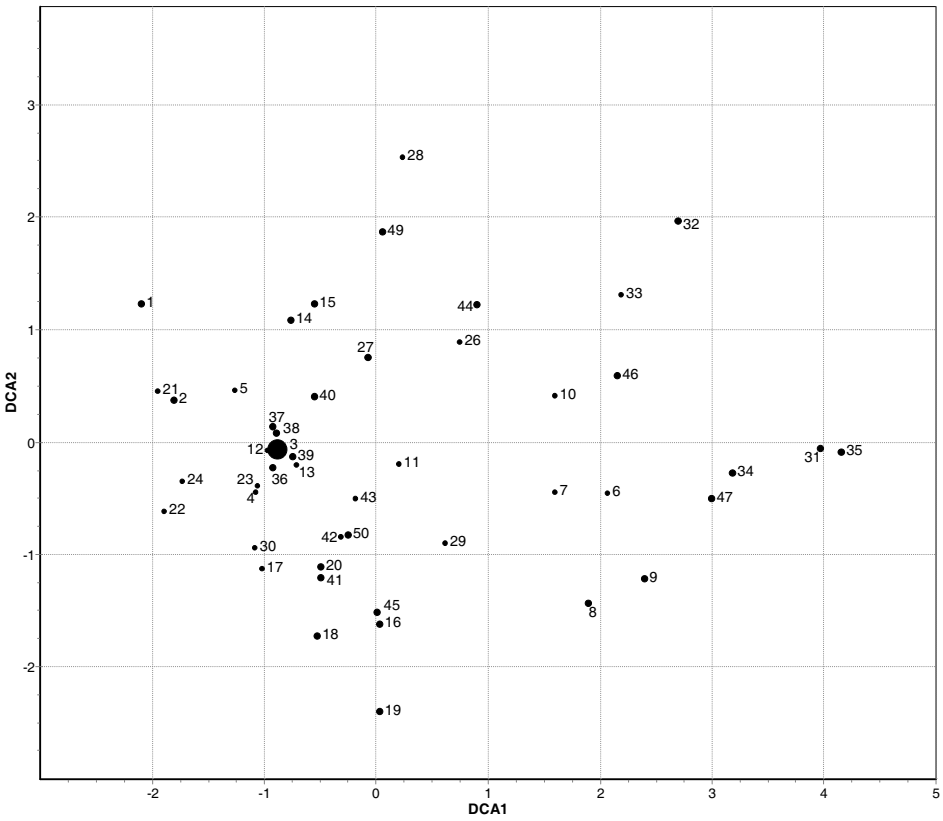

Fig. 3. Ordination of pitfall traps in studied plots on the left (l) and right (r) side of the Lipno reservoir using the method DCA with the removal of the distinct plot number 25. The value along the third ordination axix is indicated by the size of mark. 1–5 golf course (l), 6–10 spruce forest (l), 11–15 cultural meadow (l), 16–20 shore of the Lipno reservoir (l), 21–25 parking plot (l), 26–30 ski trail (l), 31–35 spruce forest (r), 36–40 cultural meadow (r), 41–46 shore of the Lipno reservoir (r), 46–50 wetland (r).

Discussion

In agreement with another authors (e.g. Thiele, 1977; Georges, 1994; Hůrka et al., 1996) the carabid fauna recorded by pitfall trapping of meadows, the spruce forest display relatively high species richness. The highest number of beetles species and carabids particularly in cultural meadows of Šumava National Park and Šumava Landscape Protected Area was caused by the low intensity of management. This low management intensity resulted in optimal microclimatic characteristics (e.g. soil moisture) and has positive effect on the surface irregularity (the presence of litter) on meadows (Boháč et al., 2005). It is known

that small elevations formed by plants and their rests in meadow biotope play the positive role as the shelter for epigeic beetles (Luff, 1966; Sotherton, 1985, Boháč et al., 2005). All mentioned characteristics create optimal condition for mesophilous carabid and staphylinid species which were found in closely related seminatural plots (e.g. staphylinids *Mycetoporus erichsonanus, Olophrum assimile, Acidota cruentata*). These species settle wet seminatural habitats (wet forests, springs, peat bogs, shores of ponds and streams).

The increasing number of polyphagous beetles in communities of heavy affected biotopes (parking place and golf course) was found in the Šumava Mts. This fact is known for carabids only, where polyphagous Carabidae increased with the disturbance (Kimberling et al., 2001). It seems, that within the family Carabidae, some species tolerate disturbances better, because of their opportunistic feeding habitats and dispersal ability. Staphylinid beetles, which have more diverse trophic relationships, are more adapted to colonize biotopes with strong human pressure (Boháč, 1999). On the other side staphylinids are more hygrophilous and sensitive to dessication and it is the reason the it abundance in stronly affected biotopes is not so high as by carabids.

Beetles species related to fungi were found exclusively in spruce forest plots (e.g. staphylinids *Mycetoporus splendidus, Oxypoda alternans*). Cutting of trees on ski trail affected the structure of beetle community by increasing of the number of species preferring open habitats (e.g. carabids of the genera *Poecilus* and *Amara*). It seems that the number of great beetle predators decreased (e.g. species of the genera *Abax* and *Carabus*). It confirms the fact that predators may dissapear as their prey populations decline or become fragmented by disturbance (Kimberling et al., 2001).

The number of all beetle species in the ski trail was not different markedly from the number of species living in the spruce forest. It confirm the fact that small disturbances (e.g. small scale clear-cutting) increases the diversity of carabids in the spruce stands (Huber, Baumgarten, 2005). Even some typical forest species (e.g. *Pterostichus oblongopunctatus* and *P. burmeisteri*) maintained relatively large populations after small clear cutting. They seems to be more flexible than other forest species and may recover with higher numbers of individuals after the stand becomes denser.

The higher number of hygrophilous beetle species is characteristic for beetle community of wetland and dam shores (e.g. carabid genus *Bembidion* and staphylinid genera *Quedius* and *Lathrobium*). The unnatural character of shores of artificial dam is the reason of relatively low number of species in beetle comunities and its high percentage of ubiquitous species.

We can conclude, that the tourism has the negative effect on the beetle communities by construction of some technical equipment with very strong management only (e.g. parking plots and golf courses). The small disturbances (e.g. small scale clear cutting by the construction of ski trails) has the positive effect on the characteristics of beetle communities.

Conclusion

The different management of landscape on the beetle communities were studied using pitfall trapping in the montane area of Central Europe with the different tourist pressure

(Šumava National Park and Landscape Protected Area). The experimental plots were situated in the next biotopes with the different intensity of management – Norway spruce forest, ski trail, golf course, cultural meadow, parking place, shore of dam and wetland. There were evident differencies in the number and ecological characteristic of species discovered by pifallall trapping on plots strongly affected by man (golf course and parking place). The skiing has no negative effect on epigeic beetles. Some species typical for open biotopes and species with higher termpreferendum migrate to the meadow on the ski trail. The community structure on both spruce forest, dam shores and cultural meadows was the same on tourist attractive and unattractive sides of the Lipno reservoir recreation area. Strong human pressure on biotopes (golf course and parking place) resulted in the extinction of stenotopic and hygrophilous species and the increasing of the percentage of polyphagous species. The main factors affecting the beetle communities were the regular and intensive management in golf course and parking plot (cutting, irrigation, herbicide application, fragmentation and trammling).

Translated by J. Boháč

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Boháč J., Šrubař V., Matějka K., Šťastný J.: **Vliv turismu a managementu krajiny v Šumavském národním parku a Chráněné krajinné oblasti na společenstva epigeických brouků.**

Studovali jsme vliv turismu a různého managementu krajiny na společentva epigeických brouků. Byly použity metody zemních pastí v Šumavském národním parku a Chráněné krajinné oblasti. Pasti byly rozmístěny na pravé a levé straně Lipenské nádrže s různě intenzivním turistickým ruchem (pravý břeh je méně zatížen turistikou) na biotopech s různě intenzivním managementem (smrková monokultura, sjezdovka, golfové hřiště, kulturní louka, parkoviště, břeh přehrady a mokřad). Byl zjištěn průkazný rozdíl v počtu druhů a jejich ekologických nárocích na plochách s nejvyšším antropogenním ovlivněním. Silný stupeň antropogenního ovlivnění společenstev brouků byl prokázán na plochách s nejsilnějším managementem (golfové hřiště a parkovací plocha). Sjezdovka neměla negativní dopad na společenstva brouků. Naopak na okraji sjezdovky se vyskytovaly některé stenotopní lesní druhy se zvýšeným termopreferendem. Průsekem pro sjezdovku migrovaly do lesního prostředí některé druhy žijící jen v otevřené krajině. Vliv různé intenzity turistické návštěvnosti v lese, loukách a pobřežní zóně Lipenské nádrže na epigeické brouky nebyl prokázán. Silný vliv člověka vede u společenstev brouků k vymizení stenotopních a hygrofilních druhů a ke zvýšenému zastoupení polyfágních druhů. Hlavním faktorem ovlivňujícím společenstva brouků byl pravidelný a intenzivní management (kosení, zavlažování, aplikace hnojiv a herbicidů, fragmentace a vyšlapávání).