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Hradil K.: **Společenstva ploštic v epigeonu dubo-habrových lesů v oblasti JZ Slovenska.**

Rozborem sběrů epigeické fauny ploštic na osmi lokalitách v Malých Karpatech a dvou lokalitách v Trnavské pahorkatině v letech 1999–2002 bylo zjištěno celkem 46 druhů náležejících do 17 čeledí. Ploštice byly sbírány kvadrátovou metodou a prosevy. Průměrná abundance byla 2,44 jedinců na 1 m^2. U jednotlivých druhů byla stanovena jejich dominance a konstance. Na základě výsledků RDA analýzy z 15 testovaných proměnných byl potvrzen signifikantní vliv zápoje korun (E_3) na složení společenstev ploštic. S eudominantním zastoupením byli zjištěny druhy *Legnotus limbosus* a *Eurygaster maura*, dominantní a subdominantní byly druhy *Plinthisus brevipennis, Megalonotus sabulicola, M. chiragra, Peritrechus nubilus* nebo *Raglius alboacuminatus*. Faunisticky zajímavý byl nález druhu *Myrmedobia exilis*.

STRUCTURE AND FUNCTION OF WEEVIL ASSEMBLAGES (Coleoptera, Curculionoidea) IN EPIGEON OF OAK-HORNBEAM FORESTS IN SW SLOVAKIA

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Abstract

Holecová M., Némethová D., Kúdela M.: Structure and function of weevil assemblages (Coleoptera, Curculionoidea) in epigeon of oak-hornbeam forests in SW Slovakia. Ekológia (Bratislava), Vol. 24, Suppl.2/2005, p. 179–204.

In 1999–2002, we studied the weevil assemblages in the epigeon of oak-hornbeam forests in SW Slovakia, with regard to assemblage structure, species richness, seasonal occurrence and ecological requirements of individual species. The investigation was performed on 10 study plots (forest stands of the age from 40 to 100 years) in the Malé Karpaty Mts and Trnavská pahorkatina hills, SW Slovakia. Each site was affected, to some extent by human activities of which forest fragmentation and pollution with calcareous dust were the most important. The soil macrofauna was collected by sifting the litter, surface layer of soil and remnants of twigs. Altogether 4,090 individuals of weevils classified into 78 species, 43 genera and 4 families were recorded. The number of species found at the particular sites ranged from 22 to 31 species. The mean abundance of weevils varied from 2.09 to 49.71 ind.m^{-2}. Geophilous species *Ceutorhynchus pallidactylus,* geobionts *Acalles fallax, Barypeithes chevrolati, Barypeithes mollicomus, Brachysomus hirtus, Trachodes hispidus* and geoxenes *Ceutorhynchus obstrictus* and *Sitona macularius* predominated in the material from the oak-hornbeam forest epigeon. The canopy architecture and content of exchange bases in the leaf litter from amongst 13 gradient and 2 categorial variables analysed had direct and significant influence on the structure of epigeic weevil assemblages. The forest fragmentation caused increase the abundance of herbicolous, euryhygric and ubiquitous species in the epigeon of island woods. The weevil community was less abundant and unstable in the forest site polluted with calcareous dust.

Key words: weevils, Curculionoidea, Coleoptera, epigeic assemblages, oak-hornbeam forests, SW Slovakia, ecology, human impacts

Introduction

The oak-hornbeam forests in Slovakia used to be the most frequent forest climatic zone formation at lower altitudes. In the past they covered continuous and large areas, especially in plains and lowlands from the altitude of approximately 100 m above sea level, in hilly and submountainous regions up to 600 m above sea level and in all the Inner–Carpathian hollows (Michalko, 1986). These forest stands in Slovakia as well as in the other countries of Europe have been under long-term human impact. There are just some fragments under considerable anthropogenic pressure in the present agricultural land. In the cultivated land they represent a refuge for many animal species.

Weevils belong to predominant beetle groups in the ecosystem of deciduous forests in Europe (Funke, 1971; Grimm, 1976; Schauermann, 1973, 1976; Nielsen, 1978 a, b, c; Holecová, 1991b, 1992; Dajoz, 2000, etc.). Geobiont species associated with forest floor and leaf litter are important phyllophages, mycophages but also decomposers of dead and decaying wood. They have an influence on soil and vegetation, both directly and indirectly (Wallwork, 1976; Speight, 1989; Dajoz, 2000). Due to their low mobility and inability to take flight they often live in isolated populations. They are sensitive indicators of negative human impacts such as forest fragmentation, clear cutting, pollution, disturbance, changes of soil moisture and vegetation (Holecová, 1986).

Soil beetles in the forests of the oak-hornbeam vegetation tier in various parts of Slovakia were studied by Drdul (1973, 1977, 1997), Kožíšek, Drdul (1991), Majzlan (1986, 1991).

Majzlan, Hošták (1996), Holecová (1991a, 1995), Holecová, Sukupová (2000, 2002), Holecová et al. (2002) focused on epigeic weevils.

Our research originated in the grant being concentrated on animal communities in oak-hornbeam forests in SW Slovakia. Several studies of various groups of soil microfauna (ciliates, naked amoebae) and arthropods (ants, spiders, bugs) in this territory have been already published (Holecová et al., 2005; Krumpálová, Bartoš, 2002; Krumpálová, Szabová, 2003; Mrva, Matis, 2000; Mrva, 2003; Štepanovičová, Országh, 2002; Tirjaková, Bartošová, 2004; Tirjaková, Mrva, 2005; Tirjaková et al., 2002).

The present study gives the results of four-year investigation (1999–2002) on weevil assemblages (Coleoptera, Curculionoidea) in epigeon of oak-hornbeam forests in SW Slovakia.

The aims of the study were the following:

- to characterise structure, dynamics and seasonal occurrence of weevil communities;
- to analyse representation of topic, trophic and ecological–bionomic groups;
- to find out biotic, abiotic and anthropic factors with an influence on weevil epigeic assemblages.

Study area

The investigation refers to 10 study plots (the age of forest stands varies from 40 to 100 years) in Malé Karpaty Mts and Trnavská pahorkatina hills (SW Slovakia). All the study plots are affected to a certain degree by human activities.

Cajla (CA), 48°20' N, 17°16' E, GRN (Grid Reference Number of the Databank of the Fauna of Slovakia) 7669c, 260–280 m a.s.l.: an 80–100 year old forest at the foot of the Malá cajlanská homola hill, oriented onto S and neighbouring meadows and vineyards on S and E, from N and W closed forest complexes. *Quercus dalechampii* and *Carpinus betulus* predominate in the tree layer.

Vinosady (VI), 48°19' N, 17°17' E, GRN 7669d, 280 m a.s.l.: a 60–80 year old forest at the foot of the Kamenica hill, oriented onto NW, W neighbouring drier subxerophilous meadows and shrub complexes. Besides *Quercus dalechampii*, the tree stratum consists of *Q. cerris* and *Acer campestre*.

Fúgelka (FU), 48°22' N, 17°19' E, GRN 7669b, 350 m a.s.l.: an 80–100 year old forest near the Dubová village, oriented onto S. Besides *Quercus dalechampii*, the tree stratum consists of *Acer pseudoplatanus*.

Lindava (LI) (Nature Reserve), 48°22' N, 17°22' E, GRN 7670a, 240 m a.s.l.: an 80–100 (120) year old forest near the village of Píla. *Quercus dalechampii* and *Q. cerris* predominate in the tree layer.

Horný háj (HH), 48°29' N, 17°27' E, GRN 7570b, 240 m a.s.l.: a larger complex of an island forest 60–80 years old near the village of Horné Orešany, surrounded by fields and vineyards, oriented onto W and SW. *Quercus cerris, Q. dalechampii, Carpinus betulus* and *Fraxinus excelsior* predominate in the tree layer.

Lošonec–lom quarry (LL), 48°29' N, 17°23' E, GRN 7570b, 340 m a.s.l.: an 80–100 year old forest oriented onto SW, neighbouring mesophilous meadows and pastures. The tree layer consists of *Quercus dalechampii, Q. cerris and Carpinus betulus*. The leaf litter, herbage undergrowth and trees are heavily covered with calcareous dust from a nearby quarry.

Lošonský háj grove (LH) (Nature Reserve), 48°28' N, 17°24' E, GRN 7570b, 260 m a.s.l.: an 80–100 year old oak-hornbeam forest oriented onto NE, surrounded by closed forest complexes. *Quercus dalechampii, Q. cerris* and *Carpinus betulus* predominate in the tree stratum.

Naháč–Kukovačník (NA), 48°32' N, 17°31' E, GRN 7471c, 300 m a.s.l.: a small forest island, approximately 40–60 year old surrounded by fields and pastures, oriented onto NE. *Quercus dalechampii, Q. cerris* and *Carpinus betulus* predominate in the tree layer.

Naháč – Katarínka 1 (NK1) (Nature Reserve), 48°33' N, 17°33' E, GRN 7471a, 340 m a. s. l.: a 40–60 year old forest oriented onto NW, surrounded by closed forest ecosystems. *Quercus dalechampii* and *Carpinus betulus* predominate in the canopy.

Naháč–Katarínka 2 (NK2), (Nature Reserve), 48°33' N, 17°32' E, GRN 7471a, 300 m a.s.l.: an 80–100 year old forest below the monastery ruins. *Quercus virgiliana, Q. cerris* and *Tilia cordata* predominate in the tree stratum.

The study plots LI and HH are situated in the Trnavská pahorkatina hills, the other ones in Malé Karpaty Mts. Managed oak-hornbeam forests cover the study area. According to the Geobotanic Map of Slovakia (Michalko, 1986) Carpathian mesophilous oak-hornbeam woods (*Carpinion betuli* I s s l e r 1931 em. M a y e r 1937) (the study plots CA, VI, FU, LL, LH, NA, NK1), subxerothermophilous forests with European turkey oak (*Quercion confertae–cerris* H o r v a t 1954) (the study plot LI), and Submediterranean xerothermophilous woods (*Quercion pubescentis–petrae* B r.–B l. 1931) (NK2) are considered as typical natural vegetation in this territory. The map, pedological and phytocoenological characteristics of the investigated area are given in detail by Zlinská et al. (2005).

Material and methods

The soil macrofauna was collected by the square method combined with sifting. At each study site, in about one-month intervals from March to November, the material was collected from the leaf litter and upper part of soil from 16 squares. Each square comprised 25x25 cm, i.e. altogether an area of $1 m^2$ was sifted, representing one sample. The samples were extracted using xereclectors of the Moczarski's type. The material is deposited at the Department of Zoology, Comenius University in Bratislava. In total, 310 samples were used for statistical analysis.

The species dominance is characterised by the scale proposed by Tischler (1949) and completed by Heydemann (1955): ED = eudominant, D = dominant, SD = subdominant, R = recedent, SR = subrecedent. The species constancy was expressed by categories according to Tischler (1949) and Schwerdtfeger (1975): EC = euconstant, C = constant, As = accessoric and A = accidental. The indices of Shannon–Wiener (H'), Pielou (e) and Simpson (c) were used as the alpha diversity indices (Odum, 1977; Spellerberg, Fedor, 2003). All the couples of Shannon–Wiener's diversity indices were compared with a t–test (Poole, 1974).

The trophic groups of weevil adults were established according to Brown, Hyman (1986). Four basic groups we distinguished: S1 = monophages, S2 = narrow oligophages, S3 = wider oligophages; and G = polyphages (S1 – S3 = specialists and G = generalists). Other ecological characteristics of weevil adults (habitat preference, humidity preference, topic groups, bionomic groups, relationship between weevil imagoes and subsoil) are given according to Koch (1992). The cluster analysis of weevil communities was done using the computer program NCLAS (Podani, 1993). The clustering method complete linkage in combination with Wishart's similarity ratio was used (Wishart, 1969).

Effects of environmental variables on weevil community composition were analysed using the redundancy analysis (RDA) ordination technique by CANOCO software program (ter Braak, Šmilauer, 1998). The values of species data used in the cluster analysis and RDA were transformed with log–transformation $Y' = \log (Y + 1)$. At all the study plots the following environmental variables were measured (range of values of gradient variables or categories of categorial ones are in brackets).

Gradient variables: pedological and chemical characteristics of leaf litter such as total organic carbon (3.80–14.40%); total nitrogen content (0.35–1.1%); content of exchange bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) (12.60–49.40 mval/100g); total acidity (1.8–14.9 mval/100g); pH of litter in H_2O (3.90–6.74); humus content (6.55–24.83%); age of a forest stand (40 – 100 years); cover of E_3: (65–80%); cover of E_2 (1–50%); cover of E_1 (40–100%); lying and standing dead wood (2–20%); forest fragmentation (0–50%); slope (0–45°).

Categorial variables: exposition of study plots (E, W, S, NE, NW, SW, SE); pollution by calcareous dust (present, absent).

Mean abundance and number of species among the localities were compared using single factor analysis of variance and Tukey's HSD test at significance level 0.05. The tests were performed with SPSS 11.0 for Windows.

Nomenclature of weevils was assumed according to Alonso–Zarazaga, Lyal (1999).

Results and discussion

Community structure

A total of 4,090 individuals of 78 species, 43 genera and 4 families (Anthribidae, Apionidae, Erirhinidae, Curculionidae) were examined during the four-year research (Table 1).

At the study sites 22 to 31 species were recorded. The mean abundance of weevils varied from 2.09 (the study plot LL) to 49.71 $ind.m^{-2}$ (the study plot HH) (Table 2).

The geobiont *Acalles fallax*, *Barypeithes mollicomus* and geophilous *Ceutorhynchus pallidactylus* occurred as eudominants, geoxenous *C. obstrictus* as dominant, geobiont *Barypeithes chevrolati*, *Brachysomus hirtus*, *Trachodes hispidus* and geoxenous *Sitona macularius* as subdominants.

The characteristic species spectrum is represented by three groups of species:

1. highly dominant species (eudominant, dominant, subdominant) with a high constancy (euconstant or constant) – geobionts *Acalles fallax, Barypeithes mollicomus, Trachodes hispidus*, geophilous species *Ceutorhynchus pallidactylus* and geoxenous species *C. obstrictus*, *Sitona macularius;*
2. euconstant or constant, non–dominant species – saproxylic geobionts *Acalles camelus*, *Ruteria hypocrita* and geoxenous species *Ceutorhynchus alliariae, C. scrobicollis* (herbicoles associated with *Alliaria petiolata*), *Coeliodes trifasciatus, Curculio glandium, Furcipus rectirostris, Phyllobius argentatus* (arboricolous species associated with tree canopy);
3. differential species – saproxylic geobionts *Acalles echinatus*, *Acallocrates colonnellii*, phyllophagous geobionts *Barypeithes albinae, Brachysomus dispar, B.rachysomus setiger*, and *Coeliodes proximus, C. rana, C. transverseoalbofasciatus* (arboricolous species associated with oaks but aestivating in leaf litter).

The first two groups of species have a wider ecological amplitude. The third group is represented by stenovalent species with only a low dominance and constancy and associated exclusively or namely with forests of the oak-hornbeam vegetation tier.

Seasonal occurrence and dynamics

Abundance of weevils in soil reflected two peaks: vernal (May – the 1st half of June) and serotinal to autumnal (August–September). The spring peaks were determined by typical geobionts of the *Barypeithes* and *Brachysomus* genera. The peaks in serotinal and autumnal were defined by some xylodetriticoles such as the species of *Acalles, Ruteria* genera, *Trachodes hispidus* and geophilous *Ceutorhynchus pallidactylus*. Seasonal dynamics in species richness corresponds with abundance dynamics as well. The peak appeared in vernal aspect (May–June) with species richness of 15 geobionts and 5 (in May), resp. 2 geophiles (in June). The second peak in species richness hints at serotinal (August) with a frequent occurrence of saproxylic geobionts (*Acalles* spp., *Ruteria*

T a b l e 1. List of weevil species and numbers of individuals found in the epigeon of oak-hornbeam forests in SW Slovakia during 1999–2002.

Family, species / study plot	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2	total	%	CD	Co	CC	Geo	Top	Tro	Bio-i	Hab	Hum
Anthribidae																					
Anthribus albinus (L i n n a e u s, 1758)	1	0	0	0	0	0	0	0	1	0	2	0.05	SR	20.00	A	GB	T	G	XF	ST	HY
Apionidae																					
Catapion seniculus (K i r b y, 1808)	0	0	0	0	0	0	1	1	0	0	2	0.05	SR	20.00	A	GX	H	S2	FF	EU	EH
Ceratapion gibbirostre (G y l l e n h a l, 1813)	1	0	0	0	0	1	0	0	1	0	3	0.07	SR	30.00	As	GX	H	S3	FF	EU	
Cyanapion columbinum (G e r m a r, 1817)	0	0	0	0	0	0	0	1	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	XE
Diplapion confluens (K i r b y, 1808)	0	0	0	0	2	0	0	0	0	0	2	0.05	SR	10.00	A	GX	H	S3	FF	EU	XE
Eutrichapion punctigerum (P a y k u l l, 1792)	1	0	0	0	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	EU	XE
Holotrichapion aestimatum (F a u s t, 1890)	0	0	0	0	0	0	0	1	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	XE
Holotrichapion pisi (F a b r i c i u s, 1801)	0	0	0	0	0	0	0	7	1	0	8	0.20	SR	20.00	A	GX	H	S2	FF	EU	XE
Ischnopterapion virens (H e r b s t, 1797)	1	0	0	0	0	0	1	0	0	0	2	0.05	SR	20.00	A	GX	H	S2	FF	EU	EH
Kalcapion pallipes (K i r b y, 1808)	0	0	0	0	2	0	0	0	0	0	2	0.05	SR	20.00	A	GX	H	S1	FF	ST	HY
Omphalapion hookerorum (K i r b y, 1808)	0	0	0	0	2	0	0	0	0	0	2	0.05	SR	20.00	A	GX	H	S3	FF	EU	XE
Protapion apricans (H e r b s t, 1797)	0	0	0	0	0	0	1	0	0	0	1	0.02	SR	10.00	A	GX	H	S1	FF	EU	EH
Protapion fulvipes (G e o f f r o y, 1785)	4	2	1	0	0	1	1	2	2	1	14	0.34	SR	80.00	EC	GX	H	S2	FF	UB	EH
Protapion trifolii (L i n n a e u s, 1768)	0	0	0	0	0	0	2	0	0	0	2	0.05	SR	10.00	A	GX	H	S2	FF	EU	XE
Protapion nigritarse (K i r b y, 1898)	0	1	0	0	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	EU	XE
Pseudapion rufirostre (F a b r i c i u s, 1775)	1	0	0	0	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	XE
Synapion ebeninum (K i r b y, 1808)	0	0	0	0	2	0	0	0	0	0	2	0.05	SR	10.00	A	GX	H	S3	FF	EU	EH
Trichopterapion holosericeum (G y l l e n h a l, 1833)	2	0	0	0	0	1	0	0	0	0	3	0.07	SR	20.00	A	GX	A	S1	FF	ST	EH
Erirhinidae																					
Tanysphyrus lemnae (P a y k u l l, 1792)	0	0	0	0	0	0	0	1	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	HY
Curculionidae																					
Acalles camelus (F a b r i c i u s, 1792)	0	0	1	1	0	18	2	14	4	32	72	1.76	R	70.00	C	GB	T	G	XF	ST	HY
Acalles fallax B o h e m a n 1844	0	0	58	0	40	62	4	74	69	98	405	9.90	ED	70.00	C	GB	T	G	XF	ST	HY
Acalles echinatus (G e r m a r, 1824)	16	1	0	20	0	6	0	0	0	0	43	1.05	R	40.00	As	GB	T	G	XF	ST	HY
Acallocrates colonnellii B a h r, 2003	0	0	0	2	6	0	0	0	0	6	14	0.34	SR	30.00	As	GB	T	S3	XF	ST	HY
Barypeithes albinae F o r m a n e k, 1903	0	0	8	69	1	0	0	0	0	0	78	1.91	R	30.00	As	GB	T	?	FF	ST	HY
Barypeithes chevrolati (B o h e m a n, 1843)	50	30	5	0	0	28	0	0	0	0	113	2.76	SD	40.00	As	GB	T	?	FF	ST	HY
Barypeithes mollicomus (A h r e n s, 1812)	0	0	0	0	455	7	1	9	191	118	781	19.10	ED	60.00	C	GB	T	G	FF	EU	HY
Bradybatus creutzeri G e r m a r, 1824	0	1	0	0	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	A	S2	FF	ST	XE
Bradybatus fallax G e r s t a e c k e r, 1860	0	0	1	0	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	A	S2	FF	ST	EH
Bradybatus kellneri B a c h, 1854	0	2	0	0	0	0	0	0	1	0	3	0.07	SR	20.00	A	GX	A	S2	FF	ST	EH

T a b l e 1. (Continued)

Family, species / study plot	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2	total	%	CD	Co	CC	Geo	Top	Tro	Bio-i	Hab	Hum
Brachysomus echinatus (B o n s d o r f f, 1785)	0	3	1	0	0	0	5	0	0	20	29	0.71	SR	40.00	As	GB	T	G	FF	EU	EH
Brachysomus dispar P e n e c k e, 1910	0	0	0	0	3	23	0	0	0	0	26	0.64	SR	30.00	As	GB	T	?	FF	ST	XE
Brachysomus hirtus (B o h e m a n, 1845)	0	0	0	1	3	0	0	16	0	134	154	3.77	SD	40.00	As	GB	T	?	FF	ST	XE
Brachysomus setiger (G y l l e n h a l, 1840)	0	7	0	0	0	0	0	0	0	0	7	0.17	SR	10.00	A	GB	T	G	FF	ST	XE
Calosirus apicalis (G y l l e n h a l, 1727)	0	0	0	0	1	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S3	FF	ST	HY
Ceutorhynchus alliariae C h. B r i s o u t, 1860	0	1	0	0	12	0	1	2	1	0	17	0.42	SR	50.00	C	GX	H	S1	FF	ST	HY
Ceutorhynchus chalibeus G e r m a r, 1824	0	0	0	0	3	0	4	0	2	0	9	0.22	SR	30.00	As	GX	H	S3	FF	ST	XE
Ceutorhynchus erysimi (F a b r i c i u s, 1787)	4	1	8	3	7	4	0	2	8	2	39	0.95	SR	90.00	EC	GX	H	S3	FF	UB	EH
Ceutorhynchus minutus (R e i c h, 1797)	0	1	0	0	0	1	0	0	0	0	2	0.05	SR	20.00	A	GX	H	S3	FF	UB	EH
Ceutorhynchus obstrictus (M a r s h a m, 1802)	3	5	16	48	30	2	0	84	100	16	304	7.43	D	90.00	EC	GX	H	S3	FF	UB	EH
Ceutorhynchus pallidactylus (M a r s h a m, 1802)	58	13	27	36	839	84	5	94	151	39	1346	32.91	ED	100.00	EC	GF	H	S3	FF	UB	EH
Ceutorhynchus rhenanus S c h u l t z e, 1895	0	2	0	0	0	0	0	0	0	0	2	0.05	SR	10.00	A	GX	H	S2	FF	ST	XE
Ceutorhynchus scrobicollis N e r e s et W a g n e r, 1924	0	2	0	1	2	0	3	0	4	39	51	1.25	R	60.00	C	GX	H	S1	FF	ST	HY
Ceutorhynchus typhae (H e r b s t, 1795)	4	2	2	3	10	2	1	3	11	5	43	1.05	R	10.00	A	GX	H	S3	FF	UB	EH
Coeliodes proximus S c h u l t z e, 1895	0	0	0	0	0	0	0	0	0	4	4	0.10	SR	10.00	A	GX	A	S2	FF	ST	XE
Coeliodes rana (Fabricius, 1787)	1	0	0	2	3	0	0	0	8	0	14	0.34	SR	40.00	As	GX	A	S2	FF	ST	XE
Coeliodes transverseoalbofasciatus G o e z e, 1777	0	0	0	2	0	0	0	0	1	0	3	0.07	SR	20.00	A	GX	A	S2	FF	ST	XE
Coeliodes trifasciatus B a c h, 1854	3	1	1	5	11	1	1	3	4	0	30	0.73	SR	90.00	EC	GX	A	S2	FF	ST	XE
Curculio glandium (M a r s h a m, 1802)	7	4	3	5	2	2	1	1	2	0	27	0.66	SR	90.00	EC	GX	A	S2	FF	EU	EH
Curculio pellitus (B o h e m a n, 1843)	2	0	0	0	0	0	0	0	0	0	2	0.05	SR	10.00	A	GX	A	S2	FF	ST	XE
Curculio venosus (G r a v e n h o r s t, 1807)	0	0	0	0	0	4	0	0	0	0	4	0.10	SR	10.00	A	GX	A	S2	FF	ST	EH
Furcipus rectirostris (L i n n a e u s, 1758)	1	0	0	0	0	0	3	3	1	1	9	0.22	SR	50.00	C	GX	A	S2	FF	ST	HY
Hypera nigrirostris (F a b r i c i u s, 1775)	0	0	3	0	0	0	1	2	0	0	6	0.15	SR	30.00	As	GX	H	S2	FF	EU	EH
Hypera postica (G y l l e n h a l, 1813)	0	0	0	0	2	0	0	1	0	0	3	0.07	SR	20.00	A	GX	H	S3	FF	EU	EH
Kyklioacalles suturatus (D i e c k m a n n, 1983)	4	3	4	0	0	2	0	0	0	0	13	0.32	SR	40.00	As	GB	T	G	XF	ST	HY
Leiosoma cribrum (G y l l e n h a l, 1834)	0	0	0	0	1	1	0	0	0	0	2	0.05	SR	20.00	A	GF	H	S2	FF	ST	HY
Microplontus campestris (G y l l e n h a l, 1837)	0	0	0	1	0	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S1	FF	ST	XE
Nedyus quadrimaculatus (L i n n a e u s, 1758)	0	0	0	0	1	0	0	0	0	1	2	0.05	SR	20.00	A	GX	H	S1	FF	UB	EH
Ophrohinus suturalis (F a b r i c i u s, 1775)	0	0	0	0	1	0	0	0	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	XE
Otiorhynchus ovatus (L i n n a e u s, 1758)	0	0	0	0	0	1	1	0	0	0	2	0.05	SR	20.00	A	GF	HA	G	FF	EU	XE

Table 1. (Continued)

Family, species / study plot	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2	total	%	CD	Co	CC	Geo	Top	Tro	Bio-i	Hab	Hum
Otiorhynchus raucus (Fabricius, 1777)	0	0	0	0	0	0	0	1	5	9	15	0.37	SR	30.00	As	GF	TH	G	FF	EU	EH
Phyllobius argentatus (Linnaeus, 1758)	3	1	3	2	9	0	3	7	10	4	42	1.03	R	90	EC	GX	A	G	FF	EU	EH
Phyllobius maculicornis Germar, 1824	0	0	0	1	0	0	0	0	0	0	1	0.02	SR	10	A	GX	A	G	FF	EU	EH
Polydrusus marginatus Stephens, 1831	1	0	1	8	3	0	3	0	0	3	19	0.46	SR	60.00	C	GX	A	G	FF	EU	XE
Polydrusus viridicinctus Gyllenhal, 1834	0	0	0	0	0	0	1	0	3	2	6	0.15	SR	30.00	As	GX	A	S2	FF	ST	XE
Rhinoncus bruchoides (Herbst, 1784)	0	0	0	0	0	0	0	1	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	ST	XE
Rhinoncus perpendicularis (Reich, 1797)	0	0	0	0	0	0	0	1	0	0	1	0.02	SR	10.00	A	GX	H	S2	FF	EU	EH
Rhynchaenus pilosus (Fabricius, 1781)	0	0	0	1	0	2	0	0	0	0	3	0.07	SR	20.00	A	GX	A	S2	FF	ST	EH
Ruteria hypocrita (Boheman, 1837)	4	1	5	1	4	5	0	4	1	12	37	0.90	SR	90.00	EC	GB	T	G	XF	ST	HY
Sciaphilus asperatus (Bonsdorff, 1785)	0	0	0	0	0	0	0	0	0	1	1	0.02	SR	10.00	A	GF	H	G	FF	EU	HY
Simo variegatus (Boheman, 1843)	0	0	0	0	0	0	0	0	0	1	1	0.02	SR	10.00	A	GX	A	G	FF	ST	XE
Sitona humeralis Stephens, 1831	0	0	0	0	4	0	0	0	0	0	4	0.10	SR	10.00	A	GX	H	S2	FF	EU	EH
Sitona lineatus (Linnaeus, 1758)	0	0	0	0	27	1	0	0	0	0	28	0.68	SR	20.00	A	GX	H	S2	FF	EU	EH
Sitona macularius (Marsham, 1802)	1	5	6	3	40	1	9	10	3	6	84	2.05	SD	100.00	EC	GX	H	S2	FF	EU	XE
Stenocarus cardui (Herbst, 1784)	0	0	0	0	0	0	0	0	2	0	2	0.05	SR	10.00	A	GX	H	S2	FF	ST	XE
Strophosoma melanogrammum (Forster, 1771)	1	4	5	0	0	0	2	0	0	0	12	0.29	SR	40.00	As	GX	A	G	FF	EU	EH
Trachodes hispidus (Linnaeus, 1758)	2	0	24	6	22	9	4	12	27	3	109	2.67	SD	90.00	EC	GB	T	G	XF	EU	EH
Trachyphloeus bifoveolatus (Beck, 1817)	0	0	0	0	0	0	7	0	0	0	7	0.17	SR	10.00	A	GB	T	G	FF	EU	XE
Tychius picirostris (Fabricius, 1787)	0	0	1	0	0	0	0	0	0	1	2	0.05	SR	20.00	A	GX	H	S2	FF	EU	NE
Total	**176**	**93**	**184**	**221**	**1550**	**269**	**68**	**357**	**614**	**558**	**4090**	**100.00**									

Symbols and abbreviations: % – dominance; CD – category of dominance: ED – eudominant, D – dominant, SD – subdominant, R – recedent, SR – subrecedent; Co – constancy in %; CC – category of constancy: EC – euconstant, C – constant, As – accessoric, A – accidental; Geo – interaction of weevils to subsoil: GB – geobiont, GF – geophilous, GX – geoxenous; Top – topic group: T – terricolous, TH – terriherbicolous, H – herbicolous, HA – herbiarboricolous; A – arboricolous; Tro – tropic group: S1 – monophages, S2 – narrow S2 – narrow oligophages, S3 – wider oligophages, G – generalists (polyphages); Bio-i - bionomical group of imagoes: XF – xylophagous (wood-eating), FF – phyllophagous (leaf-eating); Hab – habitat preference: ST – stenotopic, EU – eurytopic, UB – ubiquitous; Hum – humidity preference: HY – hygrophilous, XE – xerophilous, EH – euryhygric. Abbreviations of study plots see in Material and methods.

Table 2. Species diversity test and basic coenological characteristics of weevil assemblages at study plots in 1999–2002.

Study plot	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2
Σ spp.	25	23	22	22	31	25	25	26	26	26
Σ GB spp.	6	7	8	6	8	9	6	6	6	8
Σ GF spp.	1	1	1	1	2	3	2	2	2	3
Σ GX spp.	18	15	13	15	21	13	17	18	18	15
MA±SE	5.7±1.23	3.0±0.80	5.8±0.88	7.0±1.10	49.7±16.60	8.2±1.25	2.2±0.48	10.5±1.51	17.2±3.22	18.1±2.92
MAGB±SE	2.5±0.82	1.6±0.75	3.4±0.52	3.2±0.91	17.2±7.35	5.0±0.88	0.7±0.25	4.0±0.63	9.4±2.37	13.6±2.80
MAGF±SE	1.9±0.79	0.4±0.18	0.9±0.31	1.1±0.52	27.1±14.25	2.7±0.94	0.0±0.03	2.9±0.85	4.9±2.04	1.5±0.52
MAGX±SE	1.2±0.28	1.0±0.21	1.5±0.34	2.7±0.47	5.4±0.95	0.7±0.22	1.2±0.29	4.0±0.97	5.0±1.36	2.8±0.43
e	0.67	0.8	0.76	0.68	0.42	0.68	0.92	0.66	0.6	0.7
c	0.2	0.14	0.15	0.18	0.38	0.18	0.06	0.18	0.2	0.15
H'	**2.154**	**2.493**	**2.334**	**2.114**	**1.444**	**2.191**	**2.959**	**2.181**	**1.987**	**2.222**
CA		211.390	343.528	351.344	224.119	346.788	201.697	322.251	258.944	248.298
VI	2.077*		178.880	173.556	110.143	164.405	159.250	148.993	122.857	119.077
FU	1.339ns	1.047ns		396.939	260.706	411.999	168.322	399.314	315.153	298.008
LI	0.306ns	2.536*	1.874*		323.340	476.095	163.459	482.724	392.947	370.527
HH	6.435***	8.002***	9.576***	7.519***		413.721	87.224	605.977	1358.224	1321.477
LH	0.283ns	2.064*	1.263ns	0.693ns	8.885***		153.328	583.636	504.455	473.986
LL	5.600***	2.911**	4.779***	6.596***	14.271***	6.166***		134.887	102.679	98.031
NA	0.213ns	2.199*	1.422ns	0.636ns	9.679***	0.100ns	6.518***		725.889	679.726
NK1	1.459ns	3.754***	3.538***	1.345ns	8.823***	2.270*	8.780***	2.352*		1165.871
NK2	0.600ns	2.023*	1.155ns	1.165ns	13.157***	0.361ns	6.732***	0.519ns	3.514***	

Symbols and abbreviations: Σ spp. – total number of species, Σ GB spp. – total number of geobiont species, Σ GF spp. – total number of geophilous species, Σ GX spp. – total number of geoxenous species, MA [ind.m^{-2}] – mean abundance of weevils, MAGB [ind.m^{-2}] – mean abundance of geobionts, MAGF [ind.m^{-2}] – mean abundance of geophilous species, MAGX [ind.m^{-2}] – mean abundance of geoxenes, H' – Shannon's index of species diversity, e – Pielou's index of equitability, c – Simpson' index of dominance.

T-test values are under the diagonal and degrees of freedom are above it.

Significance levels: *** = $P < 0.001$; ** = $0.001 < P < 0.01$; * = $0.01 < P < 0.05$; ns = $0.05 < P$ (non-significant).

Abbreviations of the study plots see in Material and methods.

hypocrita, Trachodes hispidus), geophiles (*Otiorhynchus raucus, Ceutorhynchus pallidactylus*). However, a rapid increase of number of geoxenous species (Fig. 1) is significant as well. The first group is formed by geoxenes, which migrate into the forest ecosystem from the nearby open habitats in the period of mild or severe drought and later to hibernate. Geoxenous species from the upper forest strata create the second group, which includes particularly arboricolous species, often aestivating in forest soil (e.g. the genera *Coeliodes* and *Curculio* from oaks, *Furcipus rectirostris* from wild cherries, an arboricolous generalist *Strophosoma melanogrammum*, etc.). The Table 3 presents the seasonal occurrence of the species.

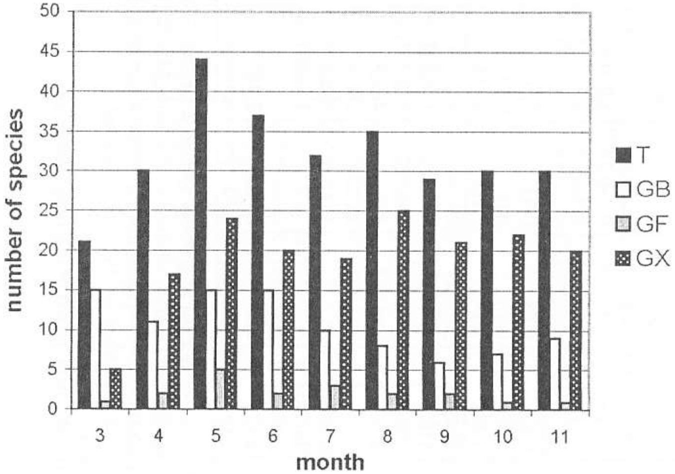

Fig. 1. Cumulative numbers of weevil species recorded in individual months of the field study (1999–2002). Explanations: T – total number of weevil species, G – geobionts, GF – geophiles, GX – geoxenes.

Ecological requirements of the weevil assemblages

According to the relationship between the weevil adults and subsoil, the curculionids were classified into three groups: geobionts living permanently in leaf litter, geophilous species living in other forest strata but occurring regularly in soil and geoxenous species occurring in leaf litter accidentally. The geoxenous species predominated qualitatively (by species number), but the geophilous species predominated quantitatively (by number of individuals). The quantitative proportion of geobiont and geophilous individuals is balanced (Fig. 2).

T a b l e 3. Seasonal occurrence of individual weevil species in epigeon of studied oak-hornbeam forests in SW Slovakia.

Family, species / month of occurrence	3	4	5	6	7	8	9	10	11
Anthribidae									
Anthribus albinus (L i n n a e u s, 1758)			+						+
Apionidae									
Catapion seniculus (K i r b y, 1808)									+
Ceratapion gibbirostre (G y l l e n h a l, 1813)							+	+	+
Cyanapion columbinum (G e r m a r, 1817)		+							
Diplapion confluens.luens (K i r b y, 1808)						+			+
Eutrichapion punctigerum (P a y k u l l, 1792)						+			
Holotrichapion aestimatum (F a u s t, 1890)				+					
Holotrichapion pisi (F a b r i c i u s, 1801)			+	+	+	+	+		
Ischnopterapion virens (H e r b s t, 1797)			+		+	+			
Kalcapion pallipes (K i r b y, 1808)			+						
Omphalapion hookerorum (K i r b y, 1808)								+	+
Protapion apricans (H e r b s t, 1797)									+
Protapion fulvipes (G e o f f r o y, 1785)	+	+			+	+	+	+	+
Protapion trifolii (L i n n a e u s, 1768)									
Protapion nigritarse (K i r b y, 1898)							+		
Pseudapion rufirostre (F a b r i c i u s, 1775)									+
Synapion ebeninum (K i r b y, 1808)			+						
Trichopterapion holosericeum (G y l l e n h a l, 1833)		+				+	+		
Erirhinidae									
Tanysphyrus lemnae (P a y k u l l, 1792)								+	
Curculionidae									
Acalles camelus (F a b r i c i u s, 1782)	+	+	+	+	+	+	+	+	+
Acalles fallax B o h e m a n, 1844	+	+	+	+	+	+	+	+	+
Acalles echinatus (G e r m a r, 1824)	+	+	+	+	+	+	+		+
Acallocrates colonnellii (B a h r, 2003)	+	+	+	+	+		+		
Barypeithes albinae F o r m a n e k, 1903	+		+	+	+	+			
Barypeithes chevrolati (B o h e m a n, 1843)	+	+	+	+	+				+
Barypeithes mollicomus (A h r e n s, 1812)	+	+	+	+	+	+			
Bradybatus creutzeri G e r m a r, 1824						+			
Bradybatus fallax G e r s t a e c k e r, 186				+					
Bradybatus kellneri B a c h, 1854			+	+					
Brachysomus echinatus (B o n s d o r f f, 1785)	+	+	+	+					
Brachysomus dispar P e n e c k e, 1910	+	+	+	+				+	
Brachysomus hirtus (B o h e m a n, 1845)	+	+	+	+				+	+
Brachysomus setiger (G y l l e n h a l, 1840)	+		+	+					
Calosirus apicalis (G y l l e n h a l, 1727)			+						
Ceutorhynchus alliariae C h. B r i s o u t, 1860		+	+	+	+	+			
Ceutorhynchus chalibeus G e rm a r, 1824				+	+	+	+		
Ceutorhynchus erysimi (F a b r i c i u s, 1787)		+	+	+	+	+	+	+	+
Ceutorhynchus minutus (R e i c h, 1797)				+		+		+	
Ceutorhynchus obstrictus (M a r s h a m, 1802)	+	+	+	+	+	+	+	+	+
Ceutorhynchus pallidactylus (M a r s h a m, 1802)	+	+	+	+	+	+	+	+	+
Ceutorhynchus rhenanus S c h u l t z e, 1895		+							+
Ceutorhynchus scrobicollis N e r e s h e i m e r et W a g n e r, 1924		+	+	+	+	+	+	+	+
Ceutorhynchus typhae (H e r b s t, 1795)	+	+			+	+	+	+	+
Coeliodes proximus S c h u l t z e, 1895			+		+	+		+	
Coeliodes rana (F a b r i c i u s, 1787)			+	+	+	+	+	+	+

T a b l e 3. (Continued)

Family, species / month of occurrence	3	4	5	6	7	8	9	10	11
Coeliodes transverseoalbofasciatus G o e z e, 1777			+	+	+				
Coeliodes trifasciatus B a c h, 1854		+			+	+	+	+	+
Curculio glandium (M a r s h a m, 1802)		+	+	+	+	+		+	+
Curculio pellitus (B o h e m a n, 1843)			+		+				
Curculio venosus (G r a v e n h o r s t, 1807)		+							
Furcipus rectirostris (L i n n a e u s, 1758)			+			+	+	+	
Hypera nigrirostris (F a b r i c i u s, 1775)	+	+					+	+	+
Hypera postica (G y l l e n h a l, 1813)							+	+	
Kyklioacalles suturatus (D i e c k m a n n, 1983)	+		+	+	+	+		+	+
Leiosoma cribrum (G y l l e n h a l, 1834)			+		+				
Microplontus campestris (G y l l e n h a l, 1837)					+				
Nedyus quadrimaculatus (L i n n a e u s, 1758)							+	+	
Ophrohinus suturalis (F a b r i c i u s, 1775)				+					
Otiorhynchus ovatus (L i n n a e u s, 1758)			+				+		
Otiorhynchus raucus (F a b r i c i u s, 1777)		+	+	+	+	+			
Phyllobius argentatus (L i n n a e u s, 1758)			+	+					
Phyllobius maculicornis G e r m a r, 1824			+				+		
Polydrusus marginatus S t e p h e n s, 1831	+	+	+	+					+
Polydrusus viridicinctus G y l l e n h a l, 1834			+	+	+				
Rhinoncus bruchoides (H e r b s t, 1784)						+			
Rhinoncus perpendicularis (R e i c h, 1797)								+	
Rhynchaenus pilosus (F a b r i c i u s, 1781)			+						
Ruteria hypocrita (B o h e m a n, 1837)	+	+	+	+	+	+	+	+	+
Sciaphilus asperatus (B o n s d o r f f, 1785)			+						
Simo variegatus (B o h e m a n, 1843)						+			
Sitona humeralis S t e p h e n s, 1831						+		+	
Sitona lineatus (L i n n a e u s, 1758)			+	+	+	+	+	+	
Sitona macularius (M a r s h a m, 1802)		+	+	+	+	+	+	+	+
Stenocarus cardui (H e r b s t, 1784)							+		
Strophosoma melanogrammum (F o r s t e r, 1771)			+	+		+	+	+	+
Trachodes hispidus (L i n n a e u s, 1758)	+	+	+	+	+	+	+	+	+
Trachyphloeus bifoveolatus (B e c k, 1817)	+			+					
Tychius picirostris (F a b r i c i u s, 1787)		+							+

With regard to habitat preference, the weevil beetles were classified into four groups: terricoles (16 spp.) living in the leaf litter; terriherbicoles (1 sp.) associated with the litter and herbage undergrowth; herbicoles preferring the herbage stratum (41 spp.); herbiarboricoles associated with both herbaceous and woody plants (1 sp.) and arboricoles associated with woody plants (19 spp.). In total, the herbicoles predominated by number of species and individuals (Fig. 3). The terricoles and arboricoles predominated quantitatively in the spring aspect. The herbicoles occurred more numerously during both the summer and autumnal aspects (e.g. the herbicolous species *Ceutorhynchus palidactylus* aestivated here, other species were possibly searching for their hibernation place or occurred accidentally in the forest epigeon).

Considering the trophic requirements of weevil adults, four groups were distinguished: monophages (S1) associated with one plant species (7 spp.); narrow oligophages (S2) associated with one plant genus (35 spp.); wider oligophages (S3) living on more genera from one plant family or relative families (13 spp.), unknown

trophics (4 spp.), and polyphages or generalists (G) (19 spp.). Trophic specialists (S1–S3) predominated both by number of species and individuals (Fig. 4).

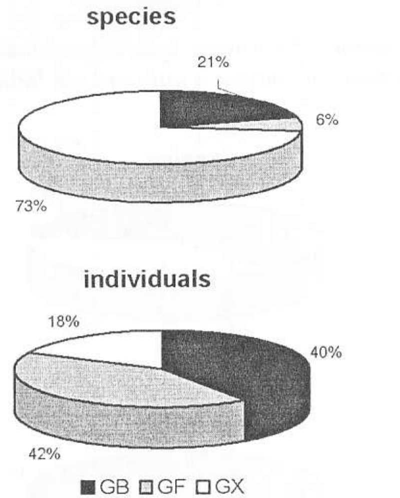

Fig. 2. Percentages of weevil groups according to their relationship to subsoil.
Explanations: GB – geobionts, GF – geophiles, GX – geoxenes.

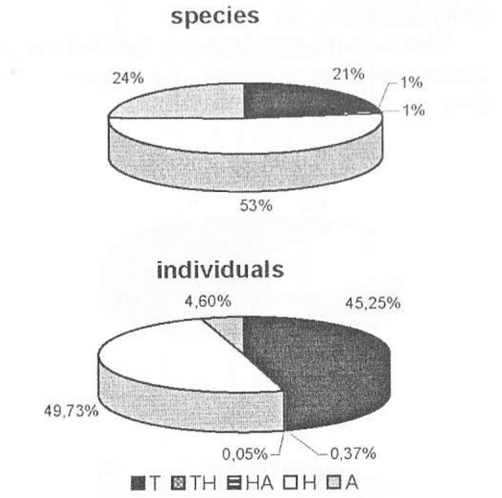

Fig. 3. Percentages of weevil topic groups. Explanations: T – terricoles, TH – terriherbicoles, HA – herbiarboricoles, H – herbicoles, A – arboricoles.

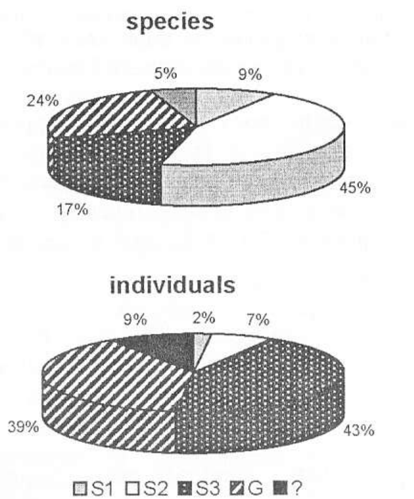

Fig. 4. Percentages of weevil trophic groups. Explanations: S1 – monophages, S2 – narrow oligophages, S3 – wider oligophages, G – generalists, ? – unknown.

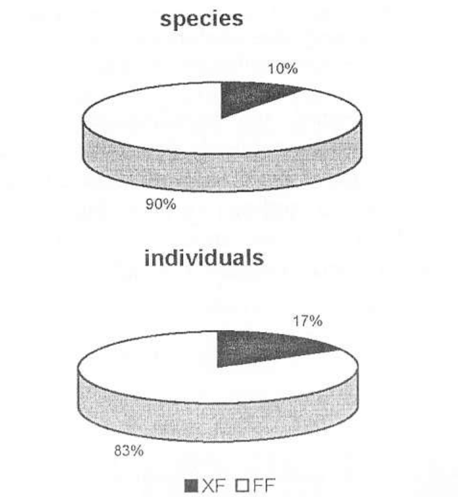

Fig. 5. Percentages of weevil bionomic groups. Explanations: XF – xylophages (wood-eating), FF – phyllophages (leaf-eating).

Two bionomical groups of weevil adults are distinguishable in the examined material: phyllophages (leaf-eating curculionids) (70 spp.) and xylophages (wood-eating, namely saproxylic weevils) (8 spp.). Phyllophages predominated both by number of species and individuals (Fig. 5).

The weevil adults differ in their habitat preference. Stenotopic species predominated qualitatively but a quantitative proportion between stenotopic a eurytopic is balanced (Fig. 6).

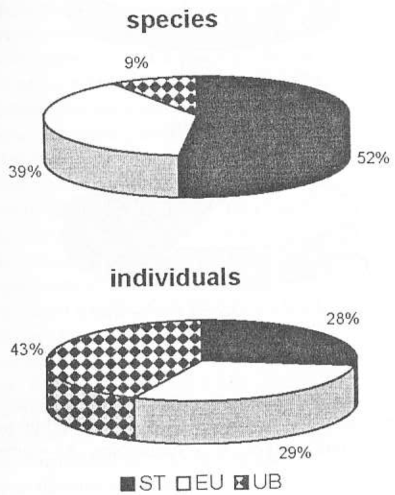

Fig. 6. Percentages of weevil groups according to their habitat preference. Explanations: ST – stenotopic, EU – eurytopic, UB – ubiquitous.

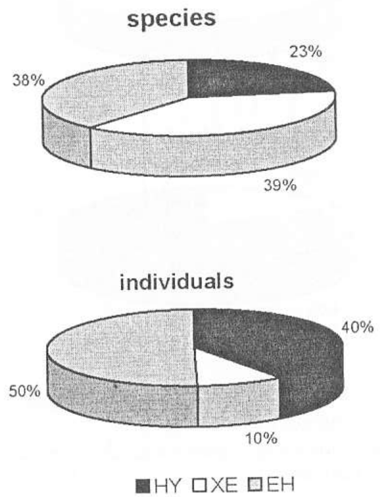

Fig. 7. Percentages of weevil groups according to their moisture preference. Explanations: HY – hygrophilous, XE – xerophilous, EH – euryhygric.

With regard to humidity preference, euryhygric and hygrophilous species predominate quantitatively (by number of individuals) (Fig. 7). However, amongst the stands compared there are significant differences in a qualitative-quantitative structure of the species according to their humidity preferences. The lowest quantity of the hygrophilous species appeared in the forest fragments (HH, NA) and in the stand polluted by limestone dust (LL) (35, 31, resp. 27%).

Comparison of weevil assemblages

Hierarchical classification

Based on a qualitative–quantitative similarity (Wishart's similarity ratio, complete linkage) the hierarchical classification divided the weevil taxocoenoses into two separate clusters connected on the low level of their similarity (Figs 8, 9).

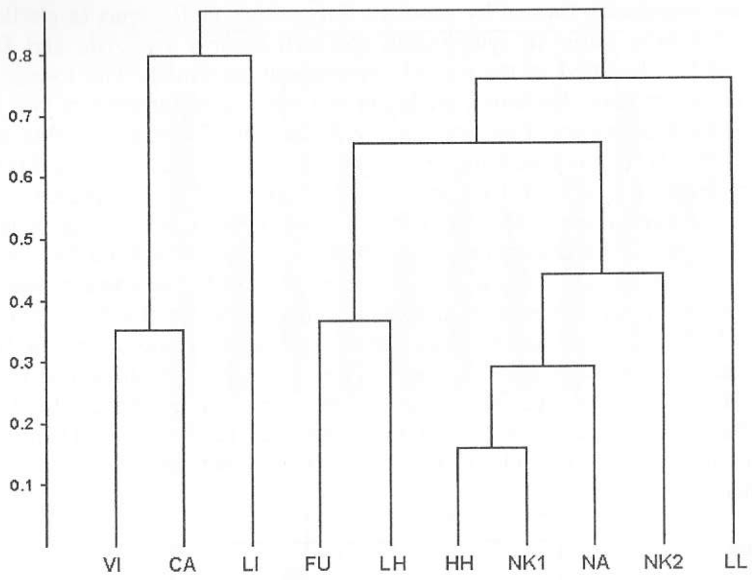

Fig. 8. Hierarchical classification of weevil assemblages in the forest epigeon of individual study plots according to their qualitative-quantitative similarity (Wishart's similarity ratio, complete linkage). Vertical axis designates dissimilarity. The dendrogram based on qualitative–quantitative representation of all recorded weevil species.

The first cluster is built up of the coenoses VI and CA communicating with LI on the low level of their similarity. The study sites VI and CA are situated close to each other from the geographical point of view and are in contact with open landscape. In such light and drier forests with 100% undergrowth the communities are typical by quantitative dominance of phyllophagous geobionts, especially *Barypeithes chevrolati* (CA, VI) and *B. albinae* (LI) (Fig. 10). *Acalles echinatus*, *Ruteria hypocrita* (CA, VI, LI) *Kyklioacalles suturatus* (CA, VI), *Trachodes hispidus* (CA, LI) appear mutually as xylophagous geobionts.

The second cluster with its three divisions (1. FU+LH, 2. HH+NA+NK1+NK2, 3. LL) includes the other assemblages. The first division contains the communities from the sites FU and LH, representing old closed forest stands (80–100 years of age) with significant canopy (80%) and lower density of undergrowth (40, resp. 75%) with sufficient amount of decaying wood. There is no significant difference between the compared assemblages (Table 3). The communities are typical by quantitative dominance of xylophagous geobionts, particularly *Acalles fallax* (*A. camelus, Kyklioacalles suturatus, Ruteria hypocrita, Trachodes hispidus* as well). *Barypeithes chevrolati* is the only phyllophagous geobiont mutual for both the compared coenoses (Table 1). The second division may be determined by the communities at the sites HH, NA, HK1 and NK2 being situated in the northern part of the study area. The compared coenoses are abundantly formed by geobiont *Barypeithes mollicomus* (a phyllophagous species) and *Acalles fallax* (a xylophagous species). *Ruteria hypocrita* and *Trachodes hispidus* may be classified as the mutual xylophagous geobionts. The lowest diversity refers to the community HH with a gradation and massive occurrence of two species – *Barypeithes mollicomus* and *Ceutorhynchus pallidactylus*. There is a highly significant difference ($P < 0.001$) between the diversity of this assemblage ($H' = 1.444$) and the other coenoses of the second division (NA, NK1, NK2). The dominance of the HH assemblage has been concentrated onto low species richness, what actually appears in a higher value of the dominance index ($c = 0.382$). On the other hand the communities NA, NK1 and NK2 are typical by higher richness of codominant species with a consequence of lower values of the dominance index (NA: $c = 0.175$, NK1: $c = 0.200$, NK2: $c = 0.153$). The quantitatively poor assemblage LL represents a separate line of the second cluster on the low level of similarity towards the first two divisions. With a high diversity ($H' = 1.959$) the species appear in low quantities and hence the differences amongst their dominance are supposed to be minimal ($c = 0.064$). There is a high significant difference ($P < 0.001$) (Table 2) in diversity between this coenosis and the other studied assemblages.

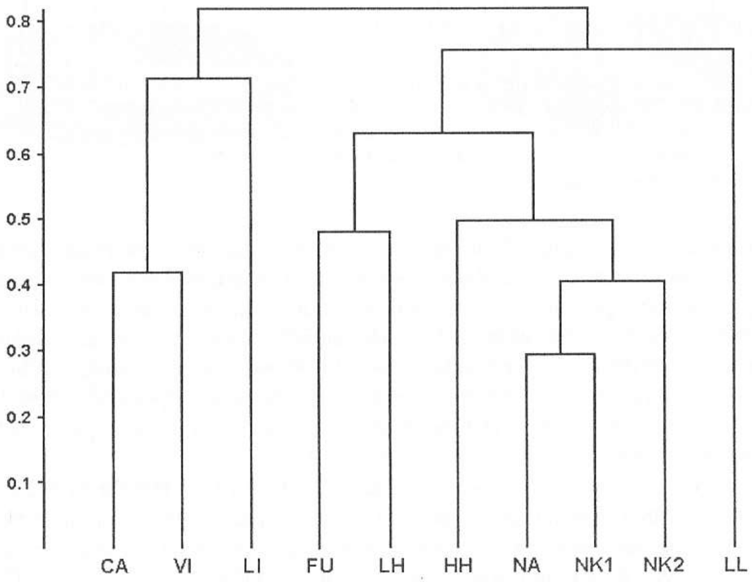

Fig. 9. Hierarchical classification of weevil assemblages based on species associated with forest floor according to their qualitative-quantitative similarity (Wishart's similarity ratio, complete linkage). Vertical axis designates dissimilarity.

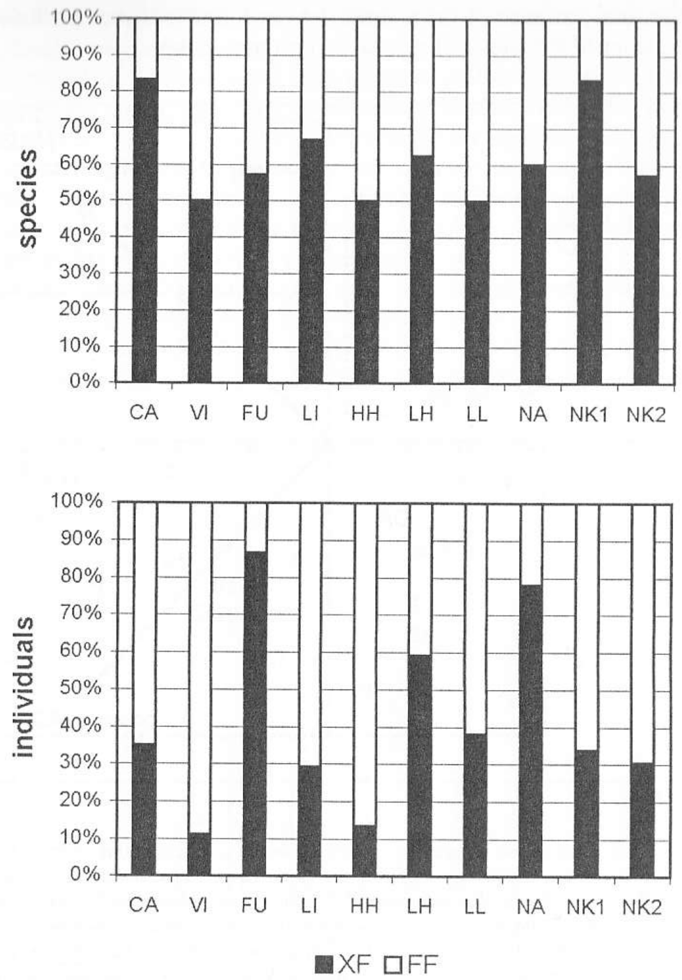

Fig. 10. Qualitative and quantitative proportion of bionomic groups within geobiont species. Explanations: XF – xylophagous (wood-eating), FF – phyllophagous (leaf-eating), horizontal axis (study plots, abbreviations see in Material and methods).

Relationship between weevil assemblages and environmental variables

Twenty weevil species associated with the forest floor (geobionts and geophiles) were selected for the redundancy analysis. The cover of tree stratum and content of exchange bases in leaf litter from amongst 13 gradient and 2 categorial variables were significant and explanatory in the analysis (P value of the Monte Carlo permutation test was lower than 0.05). The result of redundancy analysis is shown in Fig. 11. Eigenvalues of the two first canonical axes are $\lambda_1 = 0.316$ and $\lambda_2 = 0.114$. The first two canonical axes account for 43% of the total variance of the species data and 100% of the species–environment relation. The scatter of the sites and species forms three groups.

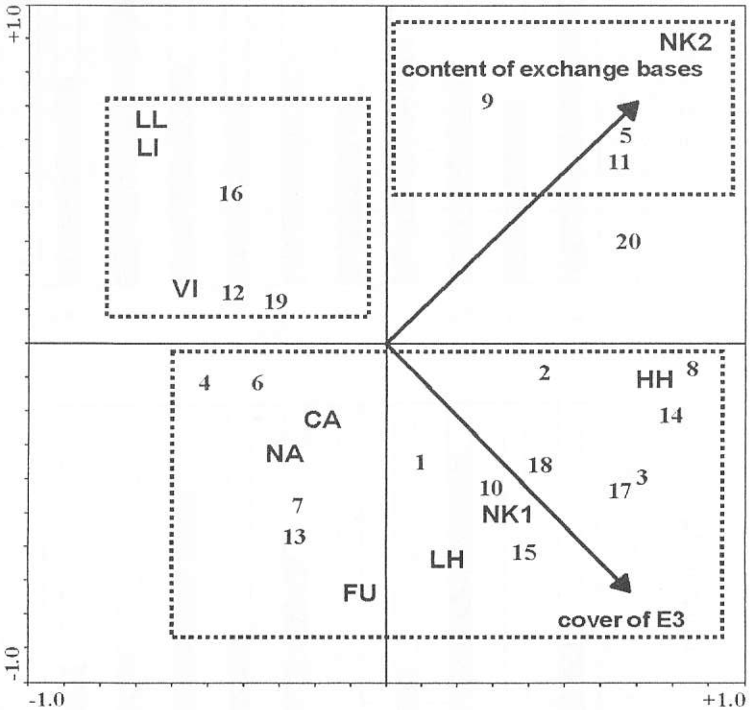

Fig. 11. RDA ordination diagram of weevil geobiont and geophilous species, study plots and environmental factors. Symbols: 1 – *Anthribus albinus*, 2 – *Acalles camelus*, 3 – *Acalles fallax*, 4 – *Acalles echinatus*, 5 – *Acallocrates colonnellii*, 6 – *Barypeithes albinae*, 7 – *Barypeithes chevrolati*, 8 – *Barypeithes mollicomus*, 9 – *Brachysomus echinatus*, 10 – *Brachysomus dispar*, 11 – *Brachysomus hirtus*, 12 – *Brachysomus setiger*, 13 – *Kyklioacalles suturatus*, 14 – *Ruteria hypocrita*, 15 – *Trachodes hispidus*, 16 – *Trachyphloeus bifoveolatus*, 17 – *Ceutorhynchus pallidactylus*, 18 – *Leiosoma cribrum*, 19 – *Otiorhynchus ovatus*, 20 – *Otiorhynchus raucus*, 21 – *Sciaphilus asperatus*. Abbreviation of study plots see in Material and methods.

The species *Brachysomus echinatus, Acallocrates colonnellii, Brachysomus hirtus* (the upper right quadrant of the ordination diagram) prefer the litter with a higher content of exchange bases (49.40 mval/100g) and lower acidity (NK2: pH in H_2O = 6.74; the soil type is Rendzic Leptosols).

The second group involves sites and species situated in the central part of RDA diagram (the upper left quadrant of the scatter). The forest sites LL, LI, VI have lower tree canopy (65–70%) and/or are influenced by open, non-forest habitats in their close vicinity. This group is formed by xerophilous species living in forest habitats, forest ecotons, shrub formations but also in grassland (*Otiorhynchus ovatus, Trachyphloeus bifoveolatus, Brachysomus setiger*).

The third group (the lower left and right quadrant of the diagram) comprises namely hygrophilous species preferring shady forest sites (CA, NA, FU, HH, LH, NK1) with higher cover of tree stratum (75–90%). Twelve forest species (*Acalles camelus, A. echinatus, A. fallax, Ruteria hypocrita, Kyklioacalles suturatus, Anthribus albinus, Trachodes hispidus, Barypeithes albinae, B. chevrolati, B. mollicomus, Leiosoma cribrum, Brachysomus dispar*) and one ubiquitous species (*Ceutorhynchus pallidactylus*) can be included in this most numerously represented group.

Otiorhynchus raucus is an euryhygric species living in open habitats, forests with lower canopy as well as shady and more humid forest stands.

Direct and significant influence of canopy architecture was observed also in epigeic spiders (Krumpálová, 2005), bugs (Hradil, 2005) and ants (Holecová et al., 2005).

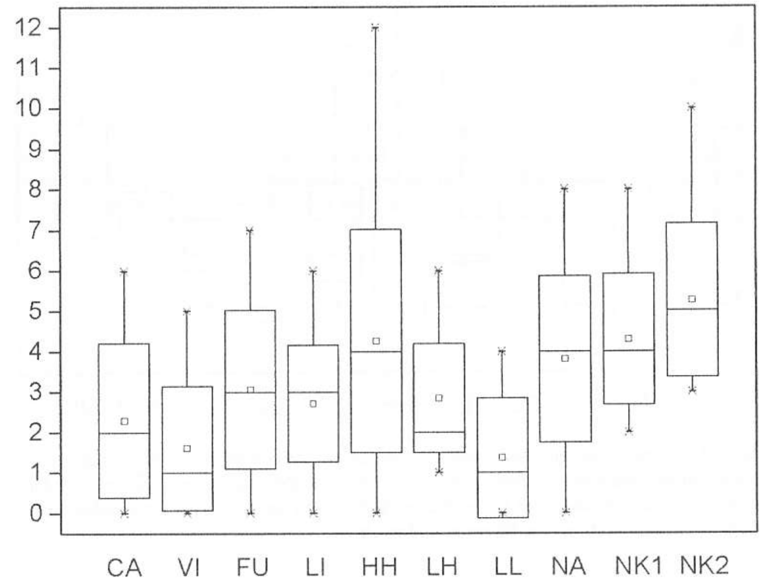

Fig. 12. Number of weevil species recorded in the epigeon of the study plots. Explanations: median (median horizontal line), arithmetic mean (□) ± standard deviation (box), 1st and 99th percentile (x) and range (vertical lines) are displayed; for study plots abbreviations see Material and methods.

Number of species and abundance

Qualitative and quantitative data were compared using single-factor analysis of variance (ANOVA). Mean number of species was significantly different amongst the study plots ($F = 14.2$; $P < 0.001$). Five partially overlapping homogenous subsets were recognised. Mean number of the species in LL was significantly lower than in FU, NA, HH, NK1, NK2. Mean number of the species in CA and VI was significantly lower than in HH, NK1, NK2. On the contrary, the mean number of the species in NK2 was significantly higher than that in LL, VI, CA, LI, LH, FU (Fig. 12). Significant differences were found in mean number of geobiont species among the study plots (F = 10.2; P < 0.001). Three, partially overlapping homogenous subsets were recognised. Mean number of geobiont species in NK2 was significantly higher than that in all the other study plots and mean number of geobiont species LL was significantly lower than in FU, LH, NA, NK1, NK2 (Fig. 13).

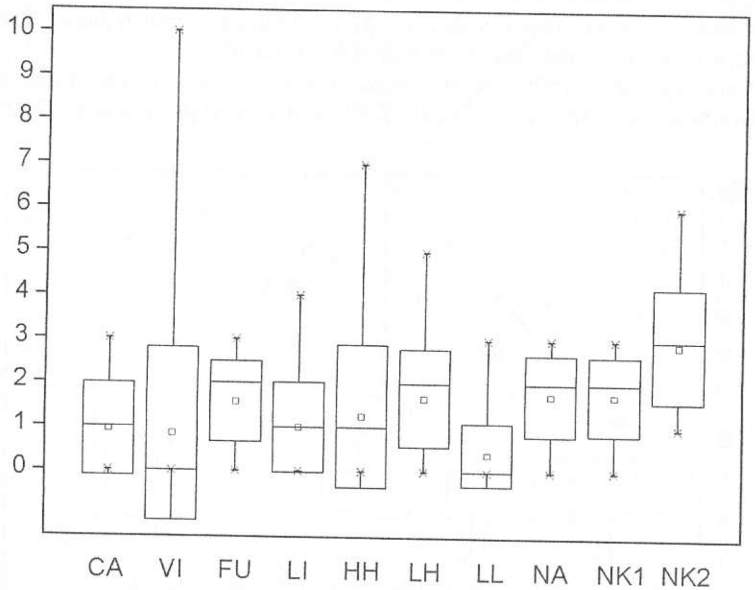

Fig. 13. Number of geobiont weevil species in the epigeon of the study plots. Explanations: median (median horizontal line), arithmetic mean (□) ± standard deviation (box), 1st and 99th percentile (x) and range (vertical lines) are displayed; for study plots abbreviations see Material and methods.

Mean abundance of weevils was significantly different among the study plots (F = 6.5; P < 0.001). Mean abundance in the study plot HH was significantly higher than that in all other localities, while no significant differences were found among the remaining study plots (Fig. 14). Similarly, significant differences were found in the mean abundance of geobiont species among the localities (F = 4.3; P < 0.001). Three, partially overlapping homogenous subsets were recognized: the first consists of LL, VI, CA, LI, FU, NA, LH and NK1 (P = 0.402); the second of CA, LI, FU, NA, LH, NK1 and NK2 (P = 0.094); the third of NK1, NK2 and HH (P = 0.549). Mean abundance of geobionts at the sites LL and VI was significantly lower than in HH and NK2 (Fig. 15).

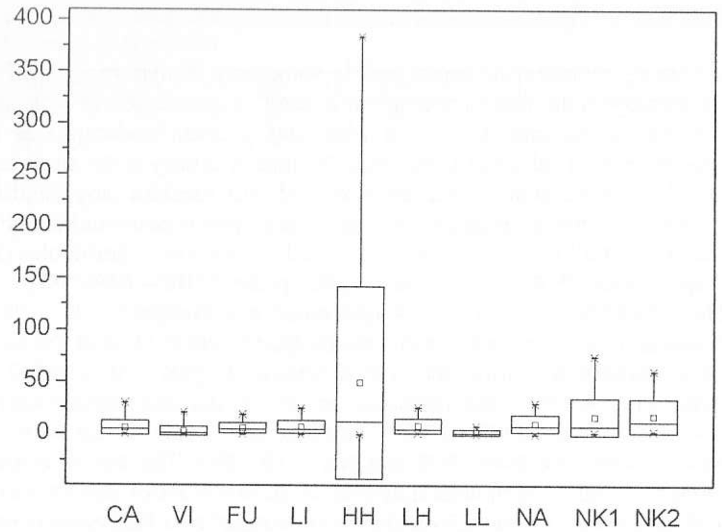

Fig. 14. Abundance of weevils recorded in the epigeon of the study plots (ind.m^{-2}). Explanations: median (median horizontal line), arithmetic mean (□) ± standard deviation (box), 1st and 99th percentile (x) and range (vertical lines) are displayed; for study plots abbreviations see Material and methods.

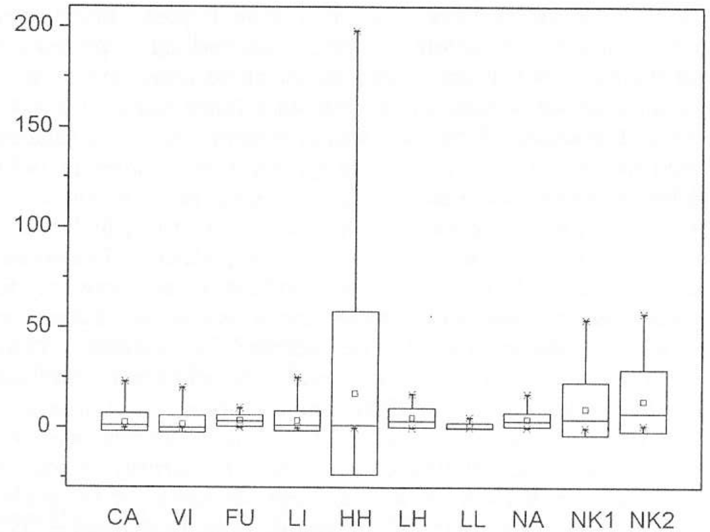

Fig. 15. Abundance of geobiont weevil species recorded in the epigeon of the study plots (ind.m^{-2}). Explanations: median (median horizontal line), arithmetic mean (□) ± standard deviation (box), 1st and 99th percentile (x) and range (vertical lines) are displayed; for study plots abbreviations see Material and methods.

Human impact

All the study stands represent managed and, in some way, human-modified forests. The most serious anthropogenic impact appears in a stand fragmentation (a lack of originally continuous forest habitat and its contact with nearby open landscape) as well as in particulate pollution with calcareous dust from the nearby quarry at the site LL.

Although the forest stand fragmentation did not declare any significant and explainable impact within a complex analysis of the weevil communities (Fig. 11) the separate evaluation of all the sites hints at increased proportion of herbicoles (HH – 62% of the total specimens), NA – 60%), euryhygric species (HH – 62%, NA – 61%) and ubiquists (HH – 58%, NA – 51%) in the fragmented forest complex.

The calcareous dust pollution from the nearby quarry was evident at the site LL, what was actually considerable during the low precipitation years (2000, 2001). Humus content in litter (LL: 6.55%) was measured as low in the comparison with the other stands (CA – 11.21%, VI – 13.79%, FU – 24.83%, LI – 14.48%, HH – 16.55%, LH – 12.76%, NA – 12.41%, NK1 –12.76% and NK2 – 9.31%). The weevil coenosis in LL behaves as unstable and from the qualitative–quantitative point of view it seems poor in geobionts (Figs. 13, 15). Of the 25 species recorded during a four–year period there is only one xerophilous geoxene (*Sitona macularius*) being present in epigeon during three seasons (1999, 2000 and 2001, respectively). Only 3 species were recorded within two seasons (two geobionts living also in non–forest habitats: *Brachysomus echinatus, Trachyphloeus bifoveolatus* and one geoxene: *Strophosoma melanogrammum*). The typical forest geobionts preferring dead wood (*Acalles fallax, A. camelus* and *Trachodes hispidus*) were observed just in 1999, when the maximum precipitation referred to the spring and summer months. Therefore the calcareous dust was repeatedly flowed out from the forest floor and its vegetation. Occurrence of the remaining 21 weevil species was confirmed only in one season. Unlike the other forest stands, the weevil species structure at this anthropically affected site was different in each year (apart from the 4 above mentioned species) (Table 4). Fourteen species were recorded in 1999 – *Acalles camelus, A. fallax, Brachysomus echinatus, Ceutorhynchus pallidactylus, C. scrobicollis, Coeliodes trifasciatus, Curculio glandium, Furcipus rectirostris, Phyllobius argentatus, Polydrusus marginatus, P. viridicinctus, Sitona macularius, Trachodes hispidus, Trachyphloeus bifoveolatus.* In the vegetation period 2000 there were only four species observed – *Barypeithes chevrolati, Brachysomus echinatus, Sitona macularius, Strophosoma melanogrammum.* In 2001 we recorded five species – *Ceutorhynchus alliariae, C. chalibeus, Sitona macularius, Strophosoma melanogrammum, Trachyphloeus bifoveolatus* and in 2002 nine species – *Catapion seniculus, Ischnopterapion virens, Protapion apricans, P. trifolii, Ceutorhynchus chalibeus, C. typhae, Hypera nigrirostris, Otiorhynchus ovatus, Polydrusus marginatus.* Mean abundance of all the weevils (MA) as well as mean abundance of the geobiont weevil species (MAGB) reached low values in all the seasons (arithmetic mean ± SD, MA: 1999 = 5,57 ± 2,149 ind.m^{-2}, 2000 = 1.00 ± 2,138 ind.m^{-2}, 2001 = 0.88 ± 0,835 ind.m^{-2}, 2002 = 1.63 ± 2.326 ind.m^{-2}; MAGB: 1999 = 2,71 ± 1,704 ind.m^{-2}, 2000 = 0.25 ± 0,463 ind.m^{-2}, 2001 = 0.25 ± 0.707 ind.m^{-2}, 2002 – geobiont species were absent).

T a b l e 4. Number of weevil species recorded in individual study plots from one to four years of the research.

Study plot	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2
1 year	14	8	9	8	16	15	21	11	9	8
2 years	5	7	6	6	6	2	3	5	7	5
3 years	2	4	4	3	3	3	1	2	3	7
4 years	4	4	3	5	6	5	0	8	7	6

Abbreviation of the study plots see in Material and methods.

Epigeic weevil assemblages are likely to be sensitive to mechanical disturbance of habitats, particulate, chemical pollution and also to forest cutting. Majority of typical weevil geobionts are apterous or brachypterous. They have low mobility and are not able to survive unfavourable conditions (Holecová, 1986). On the contrary, the woodlands affected by imissions are to a higher extent attacked by leaf-feeding insects (mainly moth caterpillars, beetles, aphids, etc.). This fact was observed at the Lošonec–quarry by Bulánková and Holecová (1998, 2000) as well as by other authors in various parts of Slovakia (Bulánková, 1990; Cicák et al., 1999; Kulfan et al., 2002, 2004, etc.). Only a few species (in general mostly known as "pests") can thrive in areas with pollution impacts. Such the gradations often lead into an abundance increase of their natural predators and parasitoids. Bulánková and Holecová (1998, 2000) hinted at considerably higher abundance of Nabidae predators in the forest habitat polluted by calcareous dust (LL) in the comparison with the background without pollution impact.

The effects of air pollutants on insects have been reviewed by several authors (Alstaed et al., 1982, Dopcherty et al., 1997, ect.). It is evident that any polluted area has its own special features (pollutants and other anthropogenic impacts, abiotic conditions, flora, fauna, ect.). Also, differences in response of particular insect species to pollution are apparent. The factors act in many combinations and interferences (Cicák et al., 1999; Führer, 1985; Kulfan, 1988; Kulfan et al., 2002, 2004; Zelinková et al., 2004).

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Holecová M., Némethová D., Kúdela M.: **Štruktúra a funkcia spoločenstiev nosáčikov** (Coleoptera, Curculionoidea) **v epigeóne dubovo-hrabových lesov JZ Slovenska.**

V rokoch 1999–2002 sme študovali štruktúru a dynamiku taxocenóz nosáčikov (Coleoptera, Curculionoidea) v epigeóne dubovo-hrabových lesov. Výskum sme uskutočnili na 10 študijných plochách, v lesných porastoch veku 40–100 rokov patriacich do zväzov *Carpinion betuli, Quercion confertae-cerris, Q. pubescentis-petrae.* Študované lesné porasty sa nachádzajú v orografických celkoch Malé Karpaty a Trnavská pahorkatina. Pôdnu makrofaunu sme zbierali metódou presevov v mesačných intervaloch. Materiál sme extrahovali v xereklektoroch Moczarskeho typu. Celkove sme zozbierali 4 090 jedincov, ktoré patrili do 78 druhov, 43 rodov a 4 čeľadí. Na jednotlivých študijných plochách sme zistili od 22 do 31 druhov. Priemerná abundancia nosáčikov dosahovala hodnoty od 2.1 do 49.7 ex.m^{-2} Charakteristické druhové spektrum bolo zastúpené 3 skupinami druhov: (1) druhmi s vysokou hodnotou dominancie a konštantnosti – *Acalles fallax, Barypeithes mollicomus, Trachodes hispidus, Ceutorhynchus pallidactylus, C. obstrictus, Sitona macularius;* (2) druhmi s vysokou konštantnosťou, ktoré nedominujú – *Acalles camelus, Ruteria hypocrita, Ceutorhynchus alliariae, C. scrobicollis, Coeliodes trifasciatus, Curculio glandium, Furcipus rectirostris, Phyllobius argentatus*; (3) diferenčnými druhmi – *Acalles echinatus, Acallocrates colonnellii, Barypeithes albinae, Brachysomus dispar, B. setiger, Coeliodes proximus, C. rana, C. transverseoalbofasciatus.* RDA ordinácia ukázala, že z vybraných 13 gradientových a 2 kategoriálnych premenných má na štruktúru spoločenstiev Curculionoidea priamy a signifikantný vplyv zápoj stromovej etáže a obsah výmenných báz (Ca^{2+}, Mg^{2+}, K^+, Na^+) v pôde. Fragmentácia porastov mala za následok vzrast početnosti herbikolných, euryhygrických, ubikvistických druhov. Nestabilné a kvantitatívne chudobné bolo spoločenstvo porastu zaprášeného vápenatým prachom z blízkeho lomu.

BIODIVERSITY OF SELECTED INVERTEBRATE GROUPS IN OAK-HORNBEAM FOREST ECOSYSTEM IN SW SLOVAKIA

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Abstract

Holecová M., Krumpál M., Országh I., Krumpálová Z., Fedor P.: Biodiversity of selected invertebrate groups in oak-hornbeam forest ecosystem in SW Slovakia. Ekológia (Bratislava), Vol. 24, Supplement 2/2005, p. 205–222.

The paper summarizes analyses of 4–year long coenological research on micro- and macrofauna in oak-hornbeam forest ecosystems in SW Slovakia. The studied forest ecosystems, 40–100 years of age, are situated in the orographic units of the Malé Karpaty Mts. and Trnavská pahorkatina hills and may be classified into 3 vegetation types: *Carpinion betuli, Quercion confertae-cerris* and *Quercion pubescentis-petraeae.* In total we determined 39,987 invertebrates (except for Protozoa) and thus recorded 575 species of 4 phyla (Ciliophora, Rhizopoda, Tardigrada, Arthropoda). Twelve taxocoenoses of ciliates, naked amoebae, water bears, pseudoscorpions, spiders, mesostigmatid mites, terrestrial isopods, centipedes, millipedes, earwigs, bugs, weevils were analysed more in detail. Apart from forest epigeon we were focused on some other microhabitats, such as decaying wood mater, mosses and dendrotelmae. Of the studied microfauna just the community from decaying wood possessed affinity to soil. In the other microhabitats (dendrotelmae and mosses) species are predominantly interacted with aquatic environment. There are stronger bonds onto soil at arthropods, represented particularly by epigeic, partially by typically edaphic species. Of the 15 analysed variables just age of a stand, depth of leaf litter, undergrowth coverness of canopy and sporadically pollution (dust from the quarry) appeared as significantly influencing the studied arthropod communities.

Key words: invertebrates, coenoses, oak-hornbeam forest, epigeon, mosses, decaying wood, tree-holes, SW Slovakia tree-holes, SW Slovakia