BEETLES (INSECTA: COLEOPTERA) IN THE NESTS OF MOUND-BUILDING MOUSE *Mus spicilegus* IN FOUR OROGRAPHIC UNITS IN SLOVAKIA

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Abstract. A total of 116 nests of *Mus spicilegus* from East and Central Slovakia was analysed. In 54 nests, beetles of 47 species of 14 families were found. The richest were Staphylinids (27 species – 57.4%, 308 individuals – 48.6%) and Cryptophagidae (4 species – 8.5%, 207 individuals – 32.6%), followed as number of species (4 – 8.5%) by Carabidae, while as number of individuals by Ptillidae (37 individuals – 5.8%) and Micropeplidae (29 individuals – 4.6%). All species were the most common species in different lowland ecosystems, inclusively of agroecosystems. The structure of the nests fauna strongly reflected seasonal activity of some Staphylinidae (*Oxypoda spectabilis, Phylodrepa ioptera*) with strong culmination in late autumns or abiotic conditions in the surroundings of the nests (hygrophilous species in the vicinity of the drainage canal in the Košická kotlina basin). The major part of the fauna consisted of predators (76.6 % of species – 57.6% of individuals), fungivores (12.8% of species – 33.9% of individuals) and detritophages (6.4% of species – 6.9% of individuals). The regional differences in fauna structure were observed especially between the Východoslovenská rovina lowland and the other three orographic regions due to the dry sandy soils in East Slovakia resulting in lower number of species and individuals.

Keywords: Beetles, Coleoptera, rodents, *Mus spicilegus*, nests, zoogeography, ecology, Slovakia.

Rezumat. Gândaci (Insecta: Coleoptera) din cuiburile speciei de şoareci *Mus spicilegus* din patru unităţi orografice, Slovacia. Au fost analizate coleopterele din 116 cuiburi de *Mus spicilegus* din Slovacia răsăriteană şi centrală. În 54 cuiburi au fost identificate coleoptere (gândaci) din 47 specii incluse în 14 familii. Cea mai bogată familie a fost familia Staphylinidae (27 specii – 57,4%, 308 indivizi – 48,6%) şi Cryptophagidae (4 specii – 8,5%, 207 indivizi – 32,6%), urmate ca număr de specii (4 specii – 8,5%) de familia Carabidae, iar ca număr de indivizi de familiile Ptillidae (37 indivizi – 5,8%) şi Micropeplidae (29 indivizi – 4,6%). Toate speciile identificate sunt specii frecvente în diferite ecosisteme de şesuri, inclusiv în agroecosisteme. Structura faunei cuiburilor a reflectat puternic activitatea sezonieră a unor Staphylinidae (*Oxypoda spectabilis, Phylodrepa ioptera*) care ating punctul culminant toamna târziu, sau în condiţiile abiotice din jurul cuiburilor (specii hidrofile de lângă un canal de drenaj din podişul Košická kotlina). Cea mai mare parte a gândacilor a fost reprezentată de prădători (76,6 % specii – 57,6% indivizi), fungivori (12,8% specii – 33,9% indivizi) şi detritophagi (6,4% specii – 6,9% indivizi). Diferenţele regionale au fost observate în mod special între şesul Východoslovenská rovina şi celelalte trei unităţi orografice datorită solurilor nisipoase uscate din Slovacia răsăriteană, de unde rezultă numărul scăzut al speciilor şi al indivizilor.

Cuvinte cheie: gândaci, coleoptere, rozătoare, *Mus spicilegus*, cuiburi, zoogeografie, ecologie, Slovacia.

INTRODUCTION

Mound-building mouse (*Mus spicilegus* PETÉNYI 1882) inhabits natural steppes and arable land along water streams in lowlands, rarely also open woods (MACHOLÁN, 1999). In southern parts of Slovakia it has the northern border of its geographical distribution and rarely occurs here at altitudes above 200 m (KRIŠTOFÍK & DANKO, 2003). From the morphologically almost identical house mouse (*Mus musculus* LINNAEUS 1758) it strikingly differs ethologically. In late summer it builds mounds consisting of loam and plant rests to hibernate and to accumulate food reserves that consist of weed and grass seeds. The specific nidobiology and subterranean placement of the nests of *Mus spicilegus* also differ from other Central European rodents. However, composition of the nests material is, to certain degree, similar to many bird nests. The specific structure of nest material, timing of their construction, specific temperature conditions in the nests interior caused by slope of the mounds making possible a considerable heating in sunny days, as well as, at least in arable land, a relatively short existence of its nests, put question, how these nests are attractive for arthropod fauna of arable land as a food source, a temporal cover or as a suitable cover for hibernation. There also exists the question to what degree these nests are inhabited by a specific fauna occurring only in them. From this viewpoint only the mites and fleas were analysed (MAŠÁN & STANKO, 2005; VÁRFALVYOVÁ *et al.,* 2010; STANKO & VÁRFALVYOVÁ, 2010). The generally epidemiological significance of populations of *Mus spicilegus* as host of many parasites was studied by STANKO *et al.* (2007) and KARBOWIAK *et al.* (2010).

The aim of this paper is to analyse the composition of beetle faunas found in an extensive number of the mound-building mouse nests (STANKO & VÁRFALVYOVÁ, 2010) and to compare it with the beetle fauna of fields and of some bird nests.

MATERIAL AND METHODS

Altogether 634 beetles were found in 54 nests of *M. spicilegus* among the total of 116 nests examined. The nests were collected in four geographic units and thirteen localities (STANKO & VÁRFALVYOVÁ, 2010). In East Slovakia they were collected in the Košická kotlina basin (surroundings of the villages Belža – 1 nest, Grajciar – 2 nests, Kechnec – 58 nests; 61 in total) and Východoslovenská rovina plain (Kráľovský Chlmec – 5 nests, Strážne – 1 nest, Streda nad

Bodrogom – 1 nest, Svätuše – 20 nests. Veľký Kamenec – 7; total 34 nests). In southern parts of Central Slovakia, they come from the Ipeľská pahorkatina hilly land (Bielovce – 3 nests, Demandice – 2 nests, Malé Kosihy – 3 nests, total 5 nests) and Hronská pahorkatina hilly land (Gbelce – 8 nests, Malá Mužla – 5 nests, total 13 nests). The nests were collected from April 2003 until November 2009, mainly in late autumn and spring. Most nests were obtained in November (47), April (18) and December (12). The distribution of nests over the geographic units and seasons is given in figure 1. In Hronská pahorkatina and Ipeľská pahorkatina hilly lands only the autumn/winter nests are represented, in the Košiská kotlina basin the nests from all three seasons are represented, but with the predominance of the autumn/winter nests. In contrast, in the Východoslovenská rovina plain the summer nests are absent. Most nests come from the Košická kotlina basin. The nests collected from November to late February are classified as late autumn/winter nests, those collected in late March and in April as spring nests and those collected in June as summer nests.

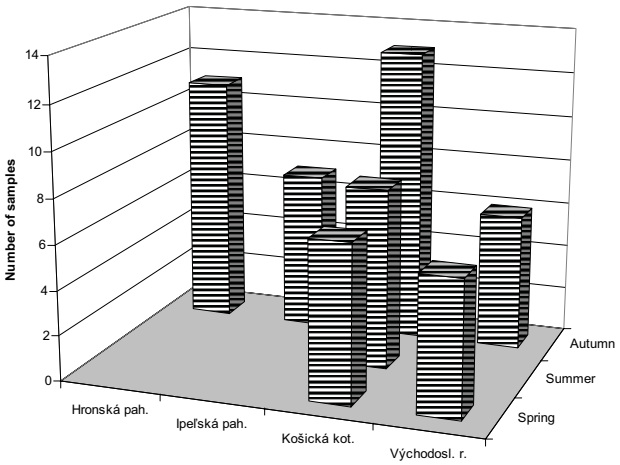

Figure 1. Spatial and seasonal distribution of 116 samples of beetles from nests of *Mus spicilegus.*
Figura 1. Distribuţia spaţială şi sezonieră a celor 116 probe de coleoptere din cuiburile de *M. spicilegus.*

The subterranean nests were obtained by excavating of the mounds. Spherical or oval nests of 7-22 cm in diameter were usually situated in depth of 10-50 cm under the ground surface, mostly under the central part of the mound (Fig. 2). The nest material consisted mainly of leaves of grasses or maize. The mounds with nests occurred on fields with stubbles (after harvesting of grain, maize or sunflower) overgrown with *Setaria* sp., *Stipa* sp. and *Amaranthus* sp. Some fields were bordered by windbreaks or bush belts.

Figure. 2. The subterranean nests of *Mus spicilegus* (left) and the food reserve (right) (photo M. Stanko).
Figura 2. Cuiburi subterane de *M. spicilegus* (stângă) şi rezerva de hrană (dreapta) (foto M. Stanko).

The arthropods were extracted from the nest material by means of Tullgren's funnels. The beetles were preserved and identified in alcohol. The beetles were identified using the key by FREUDE *et al.* (1964a, 1964b, 1967, 1974) and RÜCKER (1963). The material is deposited in the Institute of Parasitology of the Slovak Academy of Sciences in Košice.

The program PAST, version 2.16 (HARMLER, 2012), was used for statistical evaluation of the material. The principal coordinate analysis using the Kimura´s similarity index and the unweighted average linkage method using the

Horn's similarity index served to classify samples. The sample rarefaction was used to characterize the species richness of the material examined. Because of the large number of samples and a low number of species and individuals in each of them, the samples were pooled according to their provenience from four geographical units and three periods (spring, summer and late autumn to late winter). The data on the ecology of species were taken from BOHÁČ & MATĚJÍČEK, 2003, HICKS ,1959, FREUDE *et al.* (1964a, 1964b, 1967, 1974), ROUBAL (1930, 1936, 1939) and RÜCKER (1963).

The dominance and presence of species is characterized by the following scales: eudominant >10%, dominant 5-10%, subdominant 1-5%, recedent 0.5-1%, and subrecedent <0.5% and euconstant 75-100%, constant 50-75%, accessory 25-50% and accidental <25% (SCHWERDFEGER, 1975).

RESULTS

The material analysed consists of 634 individuals belonging to 47 species of 14 families (Table 1 and 2). The richest in number of species and individuals are Staphylinidae together with the closely related Micropeplidae, often being considered just as a subfamily of Staphylinidae (27 + 2 species, 308 + 29 individuals). They were followed by Cryptophagidae (4 species, 207 individuals), Ptiliidae (1 species, 37 individuals) and Carabidae (4 species, 16 individuals). These families represented 95.8% of all individuals and 80.8% of species. Next 9 species of 8 families were represented only individually (Table 1).

The number of species in individual nests ranged from 1 to 15 (mean 4.46, s.d. 3.01) while the number of individuals moved from 1 to 44 (mean 11.1, s.d. 10.1). Within the four orographic complexes, the richest in species and number of individuals were the samples from the Košická kotlina basin (Table 1), followed by the samples from Hronská pahorkatina and Ipeľská pahorkatina hilly lands. The poorest were the samples from the Východoslovenská rovina plain. These differences are, however, proportional, from a part, to the number of samples taken in each complex.

Within the entire material, the eudominant and constant species were: *Cryptocephalus dentatus*, *Heterothops dissimilis*, dominant and accessoric species were: *Oxypoda spectabili* and *Acrotrichis atomaria,* subdominant and accessoric species were: *Sunius melanocephalus, Atheta fungi Phylodrepa ioptera, Micropeplus fulvum, Oxytelus insecatus, Omalium rivulare, Quedius molochinus, Cryptocephalus scutelatus, Lathrobium longulum, Mycaetea subterranean* and *Trechus quadristriatus* (Table 1, Fig. 3).

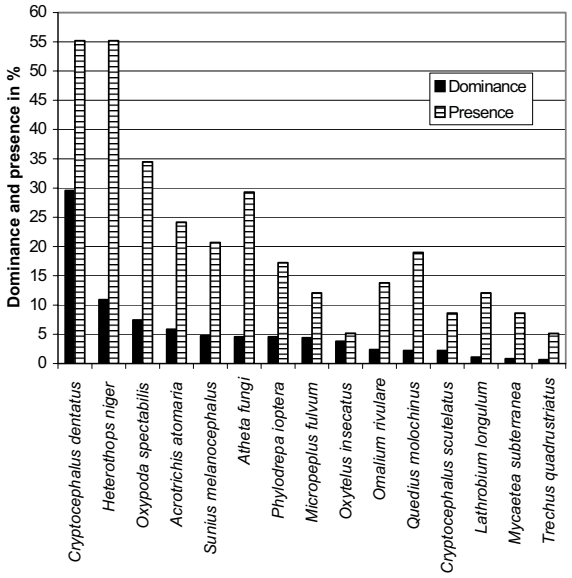

Figure. 3. Dominance and presence of 15 eudominant to subdominant species arranged in descendent order.
Figura 3. Dominanţa şi prezenţa celor 15 specii eudominante, dominante şi subdominante aranjate în ordine descendentă.

The species of the genus *Cryptocephalus, Mycaetea subterranea*, as well as the individually found *Atomaria linearis* and *Corticaria pubescens* (Table 1 and 2) are fungivorous inhabitants of litter or of accumulated moulding substances of plant origin.

The staphylinid *Oxypoda spectabilis* is a eurytopic species, with certain preference for humid forests habitats where its occurrence usually culminates in the late autumn. Together with some other species (within the studied material by *Arpedium quadrum* and *Olophrum piceum* (Table 1)*,* in forest ecosystems also by *Ocalea badia* ERICSON, 1837, it forms a characteristic autumnal to winter aspect and these species continue to occur until the early spring (ŠUSTEK, 2006). A similar position is taken also by both *Micropepluss* species (earlier included in to Staphylinidae).

Table 1. Survey of beetle species found in nests of *Mus spicilegus* in four orographic complexes and in the whole material and their trophic relations (D – dominance, P – presence; TR – trophic relations, C – carnivores, Co – coprophages, De – detritiphages, F – fungivores, Ph – phytophages).
Tabel 1. Lista speciilor de coleoptere identificate în cuiburi de *M. spicilegus* în patru complexe orografice şi în întregul material şi relaţii lor trofice (D – dominanţa, P – prezenţa TR – relaţii trofice, C – carnivori, Co – coprofagi, De – detritofagi, F– fungivori, Ph – fitofagi).

Family / species	TR	Geographic unit												All sites			
		Hronská pahorkatina			Ipeľská pahorkatina			Košická kotlina			Východoslov. rovina						
		Sum	Mean	P [%]	Sum	Mean	P [%]	Sum	Mean	P [%]	Sum	Mean	P [%]	Sum	Mean	D [%]	P [%]
Carabidae																	
Acupalpus meridianus (LINNAEUS 1761)	C							10	0.36	10.71				10	0.17	1.58	5.17
Anisodactylus binotatus (FABRICIUS 1787)	C							1	0.04	3.57				1	0.02	0.16	1.72
Pseudoophonus rufipes (DE GEER 1774)	C	1	0.09	9.09										1	0.02	0.16	1.72
Trechus quadristriatus (SCHRANK 1781)	C	3	0.27	18.18	1	0.14	14.29							4	0.07	0.63	5.17
Histeridae																	
Margarinotus neglectus (GERMAR 1813)	C							1	0.04	3.57	1	0.08	8.33	2	0.03	0.32	3.45
Ptiliidae																	
Acrotrichis atomaria (DE GEER 1774)	De	1	0.09	9.09	1	0.14	14.29	29	1.04	35.71	6	0.50	16.67	37	0.64	5.85	24.14
Leiodidae																	
Catops fuscus (PANZER 1794)	N	3	0.27	9.09	4	0.57	42.86	2	0.07	7.14				9	0.16	1.42	10.34
Micropeplidae																	
Micropeplus fulvum ERICHSON 1840	C	2	0.18	18.18	26	3.71	71.43							28	0.48	4.43	12.07
Micropeplus porcatus (FABRICIUS 1792)	C				1	0.14	14.29							1	0.02	0.16	1.72
Staphylinidae																	
Aleochara bilineata GYLLENHALL 1810	C	1	0.09	9.09	1	0.14	14.29	1	0.04	3.57				3	0.05	0.47	5.17
Arpedium quadrum (GRAVENHORST 1806)	C				1	0.14	14.29				1	0.08	8.33	2	0.03	0.32	3.45
Astenus gracilis (PAYKULL 1789)	C	1	0.09	9.09										1	0.02	0.16	1.72
Atheta sp.	C	1	0.09	9.09										1	0.02	0.16	1.72
Atheta fungi (GRAVENHORST 1806)	C	5	0.45	18.18	8	1.14	57.14	8	0.29	25.00	8	0.67	33.33	29	0.50	4.59	29.31
Heterothops niger KRAATZ 1868	C	13	1.18	81.82	7	1.00	57.14	41	1.46	50.00	8	0.67	41.67	69	1.19	10.92	55.17
Lathrobium brunipes (FABRICIUS 1792)	C							1	0.04	3.57				1	0.02	0.16	1.72
Lathrobium elongatum (LINNAEUS 1762)	C							5	0.18	17.86				5	0.09	0.79	8.62
Lathrobium longulum GRAVENHORST 1802	C				1	0.14	14.29	5	0.18	17.86	1	0.08	8.33	7	0.12	1.11	12.07
Lithocharis ochracea (GRAVENHORST 1802)	C							1	0.04	3.57				1	0.02	0.16	1.72
Medon castaneus (GRAVENHORST 1802)	C							2	0.07	3.57				2	0.03	0.32	1.72
Sunius melanocephalus (FABRICIUS 1792)	C				2	0.29	28.57	28	1.00	35.71				30	0.52	4.75	20.69
Mycetoporus lepidus (GRAVENHORST 1802)	C	3	0.27	18.18	1	0.14	14.29	1	0.04	3.57				5	0.09	0.79	6.90
Olophrum piceum (GYLLENHAL 1810)	C										1	0.08	8.33	1	0.02	0.16	1.72
Omalium caesum GRAVENHORST 1806	C				1	0.14	14.29				1	0.08	8.33	2	0.03	0.32	3.45
Omalium rivulare (PAYKULL 1789)	C	8	0.73	45.45	7	1.00	42.86							15	0.26	2.37	13.79
Oxypoda spectabilis MÄRKEL 1845	C	12	1.09	36.36	14	2.00	71.43	17	0.61	25.00	4	0.33	33.33	47	0.81	7.44	34.48
Oxytelus insecatus GRAVENHORST 1806	C							24	0.86	10.71				24	0.41	3.80	5.17

Oxytelus tetracarinatus (BLOCK 1799)	C										8	0.67	8.33	8	0.14	1.27	1.72
Paederus schoemheri CZWALINA 1899	C	1	0.09	9.09										1	0.02	0.16	1.72
Philonthus fimetarius (GRAVENHORST 1802)	C										4	0.33	16.67	4	0.07	0.63	3.45
Phylodrepa ioptera (STEPHENS 1874)	C	15	1.36	36.36	10	1.43	57.14	1	0.04	3.57	3	0.25	8.33	29	0.50	4.59	17.24
Quedius mesomelinus (MARSHAM 1802)	C										1	0.08	8.33	1	0.02	0.16	1.72
Quedius molochinus (GRAVENHORST 1806)	C	7	0.64	45.45	3	0.43	28.57	4	0.14	14.29				14	0.24	2.22	18.97
Rugilus rufipes GERMANR 1832)	C				2	0.29	28.57							2	0.03	0.32	3.45
Tachyporus hypnorum (FABRICIUS 1775)	C	1	0.09	9.09	1	0.14	14.29							2	0.03	0.32	3.45
Thyasophila angulata (ERICHSON 1837)	C	2	0.18	18.18										2	0.03	0.32	3.45
Zyras funestus (GRAVENHORST 1806)	C							2	0.07	3.57				2	0.03		3.45
Scarabaeidae																	
Onthophagus furcatus (FABRICIUS 1781)	Co										1	0.08	8.33	1	0.02	0.16	1.72
Anobiidae																	
Hemicoelus nitidus (HERBST 1792)	De	2	0.18	18.18	4	0.57	42.86							6	0.10	0.95	8.62
Cantharidae																	
Cantharis sp. larvae	C							7	0.25	10.71				7	0.12	1.11	5.17
Rhizophagidae																	
Rhizophagus perforatus ERICHSON 1845	De										1	0.08	8.33	1	0.02	0.16	1.72
Cryptophagidae																	
Atomaria linearis STEPHENS 1830	F	1	0.09	9.09				3	0.11	10.71				4	0.07	0.63	6.90
Cryptocephalus dentatus (HERBST 1793)	F	84	7.64	100.00	40	5.71	42.86	57	2.04	53.57	6	0.50	25.00	187	3.22	29.59	55.17
Cryptocephalus scutelatus NEWMAN 1834	F	11	1.00	27.27	1	0.14	14.29	2	0.07	3.57				14	0.24	2.22	8.62
Cryptophagus cellaris (SCOPOLI 1793)	F	1	0.09	9.09				1	0.04	3.57				2	0.03	0.32	3.45
Endomychidae																	
Mycaetea subterranea (FABRICIUS, 1801)	F	1	0.09	9.09	1	0.14	14.29	1	0.04	3.57	2	0.17	16.67	5	0.09	0.79	8.62
Lathridiidae																	
Corticaria pubescens (GYLLENHAL 1827)	F	1	0.09	9.09				1	0.04	3.57	1	0.08	8.33	3	0.05	0.47	5.17
Chrysomelidae																	
Chaetocnema coccina (MARSHAM 1802)	Ph	1	0.09	9.09										1	0.02	0.16	1.72
Number of individuals		**182**			**138**			**256**			**58**			**634**			
Number of species		**26**			**23**			**27**			**18**			**48**			
Number of positive samples		**11**			**7**			**28**			**12**			**58**			

The Staphylinids *Sunius melanocephalus, Heterothops niger, Omalim rivulare, Oxytelus tetracarinatus, Quedius molochinus, Lathrobium fovulum* and *Atheta fungi*, similarly as other staphylinids having been found less often in the nests (Table 1) are abundant eurytopic species occurring in all types of lowland ecosystems.

Table 2. Survey of beetle species found in nests of *Mus spicilegus* in three seasonal aspects (D – dominance, P – presence).
Tabel 2. Lista speciilor de coleoptere găsite în cuiburile de *M. spicilegus* în trei aspecte sezoniere (D – dominanţa, P – prezenţa).

Family / species	Season											
	Spring				Summer				Autumn			
	Sum	D [%]	Mean	P [%]	Sum	D [%]	Mean	P [%]	Sum	D [%]	Mean	P [%]
Carabidae												
Acupalpus meridianus					10	13.33	1.25	0.38				
Anisodactylus binotatus					1	1.33	0.13	0.13				
Pseudoophonus rufipes									1	0.23	0.03	2.78
Trechus quadristriatus									4	0.91	0.11	8.33
Histeridae												
Margarinotus neglectus	1	0.98	0.08	7.69	1	1.33	0.13	0.13				
Ptiliidae												
Acrotrichis atomaria					6	8.00	0.75	0.25	12	2.74	0.33	22.22
Leiodidae												
Catops fuscus									9	2.05	0.25	16.67
Micropeplidae												
Micropeplus fulvus									28	6.39	0.78	19.44
Micropeplus porcatus									1	0.23	0.03	2.78
Staphylinidae												
Aleochara bilineata	2	1.96	0.15	15.38					1	0.23	0.03	2.78
Arpedium quadrum	1	0.98	0.08	7.69					1	0.23	0.03	2.78
Astenus gracilis									1	0.23	0.03	2.78
Atheta sp.									1	0.23	0.03	2.78
Atheta fungi	3	2.94	0.23	23.08	2	2.67	0.25	0.25	24	5.48	0.67	33.33
Heterothops niger	21	20.59	1.62	69.23	10	13.33	1.25	0.50	38	8.68	1.06	52.78
Lathrobium brunipes					1	1.33	0.13	0.13				
Lathrobium elongatum	1	0.98	0.08	7.69	2	2.67	0.25	0.25	2	0.46	0.06	5.56
Lathrobium longulum	1	0.98	0.08	7.69	3	4.00	0.38	0.38	3	0.68	0.08	8.33
Lithocharis ochracea									1	0.23	0.03	2.78
Medon castaneus					2	2.67	0.25	0.13				
Mycetoporus lepidus	2	1.96	0.15	15.38					3	0.68	0.08	5.56
Sunius melanocephalus	9	8.82	0.69	23.08	6	8.00	0.75	0.38	15	3.42	0.42	16.67
Olophrum piceum	1	0.98	0.08	7.69								
Omalium caesum									2	0.46	0.06	5.56
Omalium rivulare	1	0.98	0.08	7.69					14	3.20	0.39	19.44
Oxypoda spectabilis	2	1.96	0.15	7.69					45	10.27	1.25	52.78
Oxytelus insecatus					24	32.00	3.00	0.38				
Oxytelus tetracarinatus	8	7.84	0.62	7.69								
Paederus schoemheri									1	0.23	0.03	2.78
Philonthus fimetarius	4	3.92	0.31	15.38								
Phylodrepa ioptera									29	6.62	0.81	27.78
Quedius mesomelinus									1	0.23	0.03	2.78
Quedius molochinus	1	0.98	0.08	7.69	1	1.33	0.13	0.13	12	2.74	0.33	25.00
Rugilus rufipes									2	0.46	0.06	5.56
Tachyporus hypnorum									2	0.46	0.06	5.56
Thiasophila angulata									2	0.46	0.06	5.56
Zyras funestus	2	1.96	0.15	7.69								
Scarabaeidae												
Onthophagus furcatus	1	0.98	0.08	7.69								
Anobiidae												
Hemicoelus nitidus	1	0.98	0.08	7.69					5	1.14	0.14	11.11
Cantharidae												
Cantharis sp. larvae									7	1.60	0.19	8.33
Rhizophagidae												
Rhizophagus perforatus									1	0.23	0.03	2.78
Cryptophagidae												
Atomaria linearis	1	0.98	0.08	7.69					3	0.68	0.08	8.33
Cryptocephalus dentatus	35	34.31	2.69	46.15	5	6.67	0.63	0.38	147	33.56	4.08	63.89

Cryptocephalus scutelaris	4	3.92	0.31	7.69					10	2.28	0.28	11.11
Cryptophagus cellaris					1	1.33	0.13	0.13	1	0.23	0.03	2.78
Endomychidae												
Mycaetea subterranea									5	1.14	0.14	13.89
Lathridiidae												
Corticaria pubescens									3	0.68	0.08	8.33
Chrysomelidae												
Chaetocnema coccina									1	0.23	0.03	2.78
Number of individuals	**102**				**75**				**250**			
Number of species	**21**				**15**				**37**			
Number of positive samples	**13**				**8**				**37**			

The carabid *Trechus quadristriatus* is preferably a eurytopic species of all types of open landscape ecosystems and disintegrated forests in lowlands and highlands. Although it occurs the whole growing season over, it tends to have also characteristic occurrence culmination in September – October, when it flies on large distances, often coming on light (ŠUSTEK, 1999).

The larvae of the genus *Cantharis* are characteristic representatives of the soil surface fauna from late autumn to early spring. They are active also in winter, if the temperature maintains above froze point.

The characteristic feature of habitat preference of *M. spicilegus* is to build up nests in river alluvia, in vicinity of water streams or standing water bodies. This is just the case of the nests collected in the Košická kotlina basin, where the nests were situated about 20 m of a waterlogged depression. In the nests it was reflected by the occurrence of *Anisodactylis signatus* and *Acupalpus meridianus* – two moderately hydrophilous carabids of open, non-forests habitats – and by *Oxytelus insecatus*, an eurytopic, but always strongly hydrophilous species of floodplain forests or shores of different water bodies and wetlands, as well as by the myrmecophilous staphylinid *Zyras funestus*.

The Leiodid *Catops fuscus* is a necrophagous species eating decaying detritus of animal origin and often occurring in litter in different ecosystem.

The presence of other species in nests can be considered as occasional in regard to their low abundance, but excepting the purely phytophagous flea beetle *Chaetocnema coccina*, their presence in the nests was motived by attraction of accumulated dead plant substances (*Hemicoelus nitidus, Rhizophagus perforates*) or excrement (*Onthophagus furcatus, Megartus neglectus*).

The representation of individual beetle families is given in figure 4. The richest in number of species and individuals were Staphylnidae and Cryptophagidae. Other families are much less represented. In all families, excepting the Carabids, the numbers of species and individuals were positively correlated. In Carabids the percentage of species was higher than the percentage of individuals from two reasons: (1) major part of nests was collected out of the activity period of Carabids and, (2) the used collecting methods give strongly different result than the pitfall trapping predominantly used in carabidologic studies (LŐVEI, 2006) and leading to catching of huge amounts of individuals.

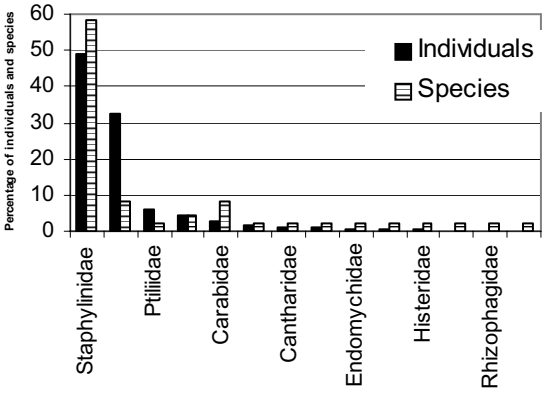

Figure 4. Relative quantitative and qualitative representation of 14 beetle families in nests of *Mus spicilegus.*
Figura 4. Reprezentarea cantitativă şi calitativă a celor 14 familii de coleoptere în cuiburile de *M. spicilegus.*

The relatively low number of species in individual nests is the reason of their considerable heterogeneity, which is illustrated by the ordination of the samples using the Kimura´s similarity index, which made escape a strong concentration the samples in a small part of the ordination space. There is not visible almost any clear regional or seasonal pattern in the position of the samples (Fig. 5). Only a part of the samples from the Košická kotlina basin tend to be situated in the left upper part of the ordination diagram and the samples in the left part of the diagram have approximately balanced representation of *Heterothops niger* and *Cryptocephalus dentatus*, whereas in most of those in the right side *Cryptocephalus dentatus.*

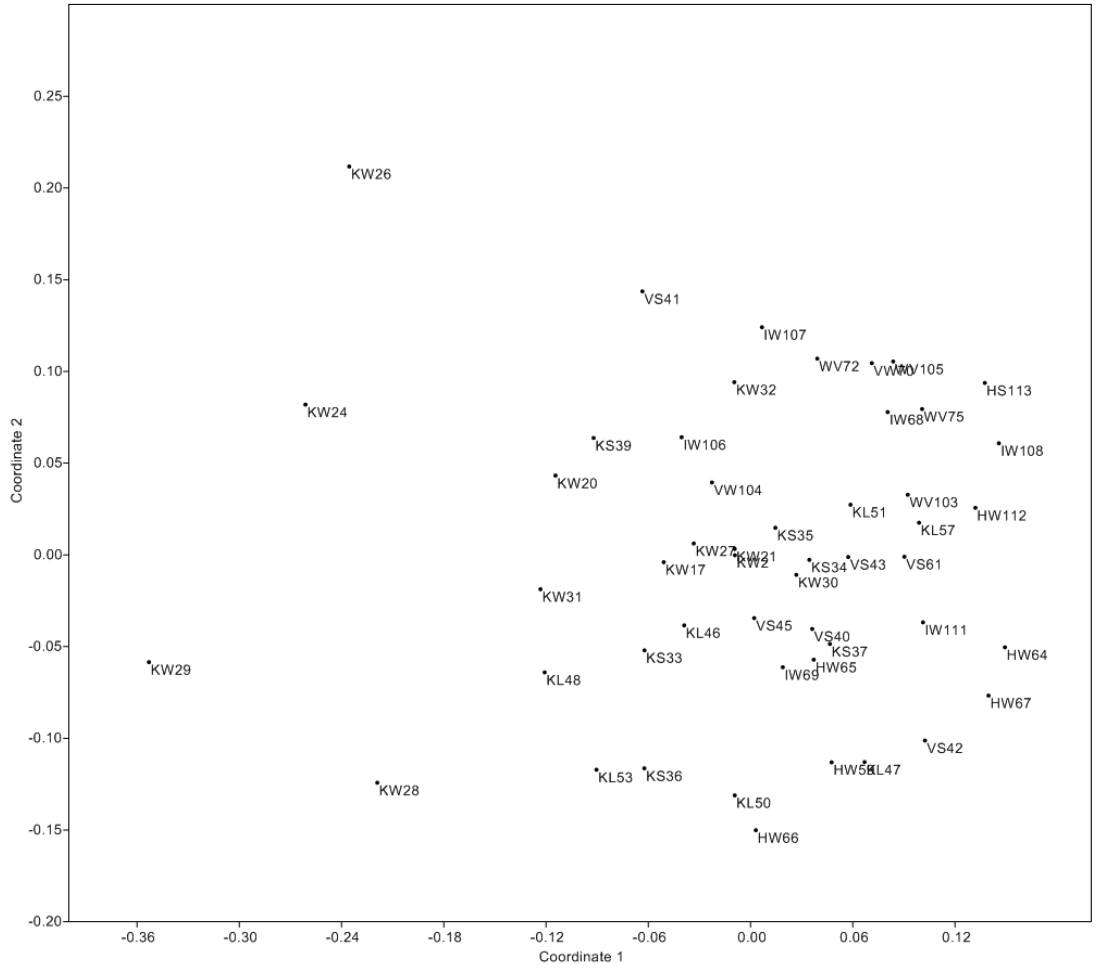

Figure 5. Principle coordinate ordination of individuals samples of beetles from the nests of *Mus spicilegus* (structure of sample codes: first letter – orographic unit, second letter – season, number – number of concrete sample, H – Hronská pahorkatina hilly land, I – Ipeľská pahorkatina hilly land, K - Košická kotlina basin, V – Východoslovenská rovina plain; S – spring, L – summer, W – late autumn and winter).
Figura. 5. Ordonarea după coordonata principală a probelor de coleoptere din cuiburile de *Mus spicilegus* (structura codurilor de probe – primul caracter – unitatea orografică, caracterul al doilea – sezonul, numărul – numărul probei; H – dealurile Hronská pahorkatina, I – dealurile Ipeľská pahorkatina, K – podişul Košická kotlina, V – şesul Východoslovenská rovina; S – primăvară, L – vară, W – toamnă târzie şi iarnă).

The regional differences of beetle fauna in the nests are illustrated in figure 6. The samples from Central Slovakia form a central cluster on the highest similarity level of 0.83. The samples from the Košická kotlina basin join ~~to~~ them on the similarity level 0.52. Their separation is caused by a higher representation of the hydrophilous species and by a little higher number of species resulting from the higher number of samples examined (Table. 1). The samples from the Východoslovenská rovina plain take an isolated position due to the generally lower number of species (absence of Carabidae and Micropeplidae) and considerably lower representation of *Cryptophagus dentatus* and *Heterothops niger*. In general the clustering pattern results from the absence of spring and summer nests among the samples from Hronská pahorkatina and Ipeľská pahorkatina hilly lands, a similar composition but a larger number of samples and predominance of the autumn/winter samples in the Košická kotlina basin and, finally, from the generally lower number of samples and absence of autumn/winter samples in the Východoslovenská rovina plain (Fig. 1, Table 1 and 2).

The seasonal differences in beetle fauna in the nests are illustrated in figure 7. The samples from winter and spring are more similar due to higher number of co-occurring species on one hand and due to the occurrence of the hydrophilous Carabids *Acupalpus meridionalis* and *Anisodactylus signatus* and the staphylinid *Oxytelus insecatus* in the summer samples on other hand (Table 2).

The beetles are represented by small and very small species. There have been recorded adults of only five species (*Anisodactylus signatus, Pseudoophonus rufipes, Quedius mesomelinus, Quedius molochinus*) represented by 17 individuals and 7 larval cantharids (Table 1), whose length exceeds 10 mm, ranging from 12 to 16 mm. The size of other species fluctuated between 1 and 5 mm. Such a body size structure is typical to the late autumnal aspects of beetle fauna in natural deciduous forests or arable land (ŠUSTEK, 2002, 2006).

The recorded number of species cannot be at all considered as definitive species diversity of beetle fauna in the nests of *Mus spicilegus* in Central Europe. The high correlation of number of species and number of samples analysed (0.99 within the seasonal aspects, 0.41 within geographic regions) show that a more extensive material would bring a

much higher number of species. On other hand, the zoocoenological studies on field fauna in lowlands show that a limit of Carabidae approximates to about 100 species, while Staphylinidae approximates about 150 species (ŠUSTEK, 1994, 2006). Thus there were recorded about 4% of the potential number of Carabid species and about 15% of Staphylinids. In other families a similar estimate is difficult because of the lack of relevant zoocenological studies.

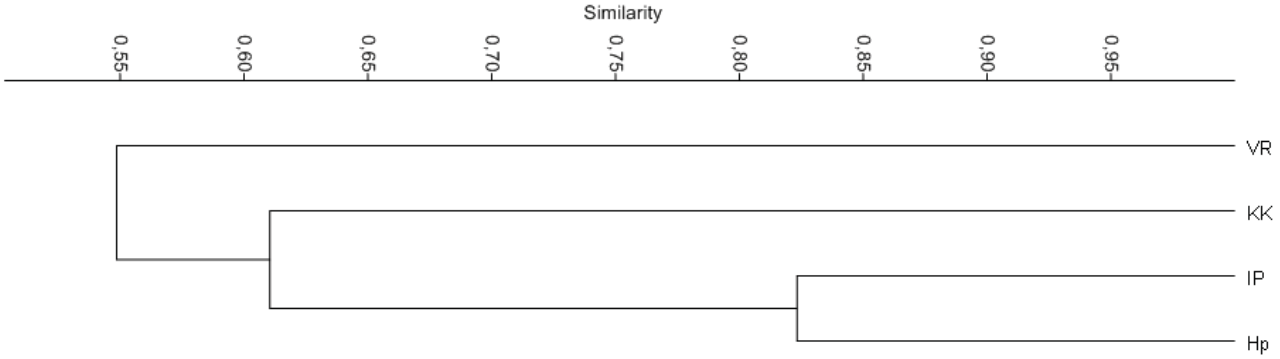

Figure 6. Hierarchical classification of the pooled samples from four orographic complexes (IP – Ipeľská pahorkatina, HP – Hronská pahorkatina, KK – Košická kotlina, VR – Východoslovenská rovina).
Figura 6. Clasificarea ierarhică a probelor, grupate din cele patru complexe orografice (IP – Ipeľská pahorkatina, HP – Hronská pahorkatina, KK – Košická kotlina, VR – Východoslovenská rovina).

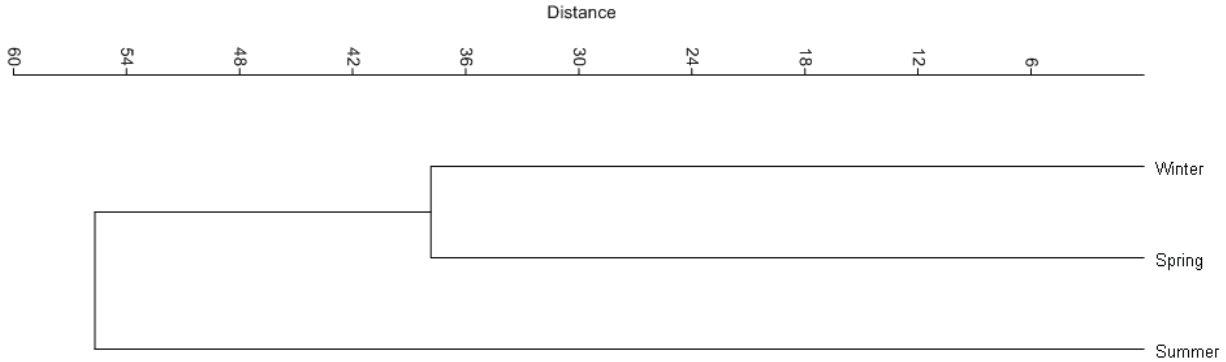

Figure 7. Hierarchical classification of the pooled samples of beetles from nests *of Mus spicilegus* from individual seasons.
Figura 7. Clasificarea ierarhică a probelor grupate de coleoptere din cuiburile de *M. spicilegus* pentru fiecare anotimp.

When analysing the increment of species number with increased number of nests (Fig. 8), the number of species increases suddenly within the first 24 samples examined. Then, its increase becomes almost linear and proportional to the increased number of samples. This increase has however limits given by species richness of individual families in the Central European lowlands and frequency of individual species in such ecosystems.

As to the trophic structure of beetle fauna, the absolutely predominant trophic group are the predators, both seasonally and regionally (Figs. 9, 10). It results especially from the high quantitative and quantitative representation of Staphylinidae and Micropepliidae. Besides these two families, the predators are represented by one species of Histeridae and larvae of the genus *Cantharis*. The qualitative and quantitative representation of predators in individual seasonal aspects shows inverse trends. Number of individuals peaks in summer, while the number of species in autumn. A similar inverse trend also exists in the regional aspect, where the highest number of individuals was in the Východoslovenská rovina plain and the lowest in the Hronská pahorkatina hilly land, whereas the lowest number of species was recorded in the Východoslovenská rovina plain and highest in the humid localities of the Košická kotlina plain.

The second most dominant groups are fungivores. Their seasonal dynamics is obviously connected with humidity. Therefore, they are much more represented, quantitatively and quantitatively, in the colder and more humid spring and (late) autumnal months. Both these trophic groups play quantitatively a really significant role in the nests of *M. spicilegus*.

The third most significant group is the detritophages. They were represented by two ecologically different groups - the enormously minute ptiliid *Acrotrichis atomaria* and a little larger Anobiid *Hemicoelus nitidus* and Rhizophagid *Rhizophagus perforatus*. Quantitatively their occurrence culminated in summer, while qualitatively in autumn and winter. This is however connected with larger number of autumnal and winter samples. Representation of other trophic groups has, quantitatively and qualitatively, more or less occasional character.

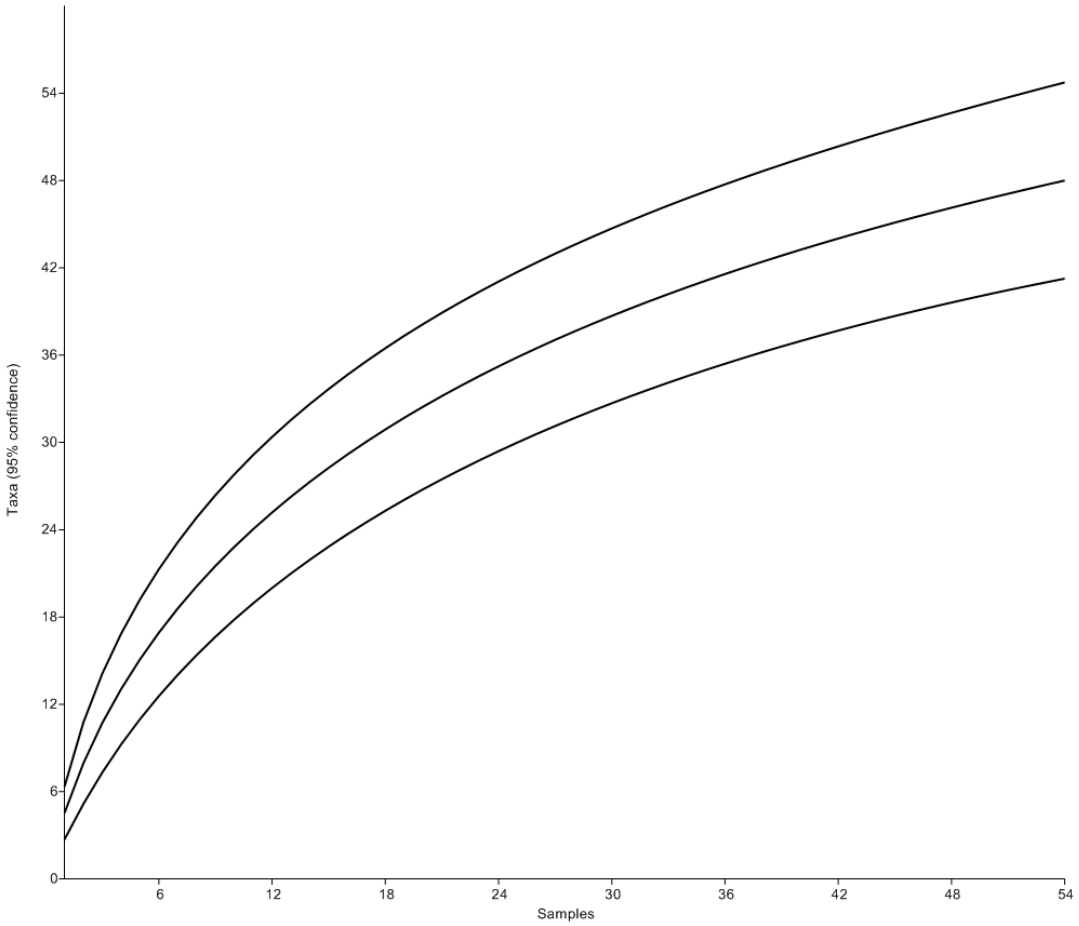

Figure 8. Areal curves of 54 samples of beetles from the nests of *Mus spicilegus*.
Figura 8. Curbe de areal pentru 54 probe de coleoptere din cuiburile de *M. spicilegus*.

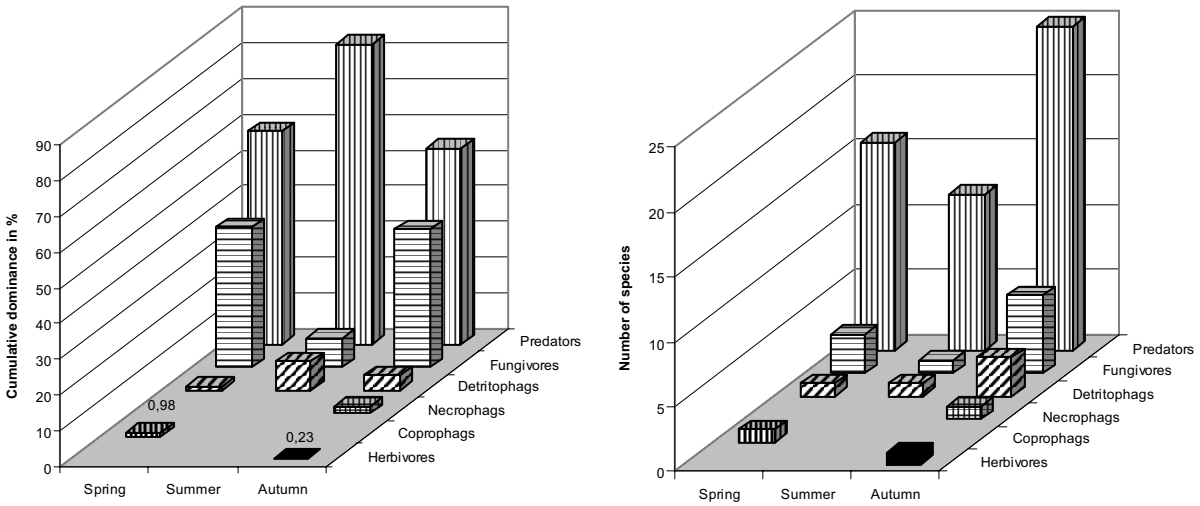

Figure 9. Seasonal changes in dominance (left) and in number of species (right) of six trophic groups of beetles in the nests of *M. spicilegus.*
Figura 9. Schimbările sezoniere ale dominanţei (stânga) şi a numărului de specii (dreapta) ale celor şase grupe trofice ale coleopterelor
din cuiburile de *M. spicilegus.*

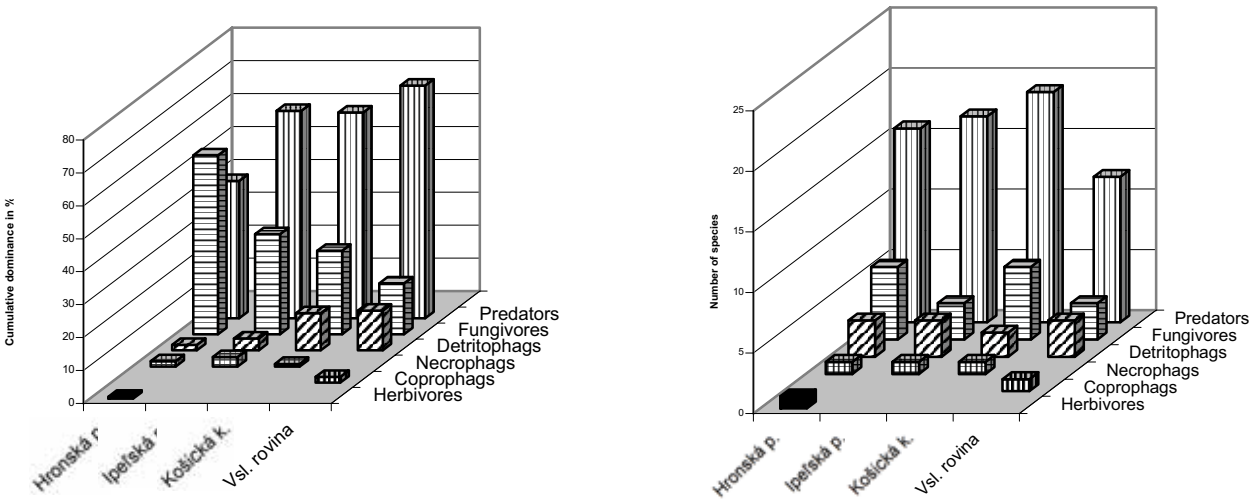

Figure 10. Regional changes in dominance (left) and in number of species (right) of six trophic groups of beetles in the nests of *M. spicilegus.*
Figura 10. Schimburile regionale ale dominanţei (stânga) şi a numărului de specii (dreapta) ale celor şase grupe trofice ale coleopterelor din cuiburile de *M. spicilegus.*

DISCUSSIONS

The major part of the beetle fauna in the nests of *Mus spicilegus,* represented by Staphylinids and Carabids, strongly resembles the soil surface fauna in fields of different crops (OBRTEL, 1969, 1970; ŠUSTEK, 1994) and in the case of the more eurytopic Staphylinids also the forest fauna of lowlands, in particular of floodplains (ŠUSTEK, 2006). Its composition shows that it is just a derivate of this fauna, consisting of the most abundant species occurring in arable land. As shown by the nests collected in the Košická kotlina basin or in the Východoslovenská rovina plain, it reflects the local or regional differences in the fauna.

Similarly as in subterraneous nests of some other mammals, like fox (ROUBAL, 1935) or moles (ROUBAL, 1930) we have not recorded any specialized nidicolous species characteristic of these species. This is a striking difference from nests of ants, where many highly specialized myrmecophilous species exist (FREUDE *et al.,* 1964a, 1964b, 1967, 1974; ROUBAL, 1930, 1936; BOHÁČ & MATEJÍČEK, 2003) or birds, where the nidicolous species like *Haploglossa puncticollis* (KIRBY, 1832) and *Gnathoncus buyssoni* AUZAT, 1917 are characteristic for nests of a wide spectrum of birds (HICKS 1959, KRIŠTOFÍK *et al.,* 1993, 1996, 2001, 2002, 2003, 2005, 2007, 2009; ŠUSTEK & HORNYCHOVÁ, 1983, ŠUSTEK & KRIŠTOFÍK, 2002, 2003, 2009) or even just for a single bird species, like *Haploglossa nidicola* (FAIRMAIR, 1852) in sand martin (HICKS, 1959; ŠUSTEK & JURÍK, 1980; KRIŠTOFÍK *et al.,* 1994).

The probable reason of this difference is the building of the nests of *M. spicilegus* in late summer and their inhabiting only out of the growing season, as well as their situation deep under the ground surface. Thus, they can be penetrated.

The predominating predators have a rich food offer in the nests of *M. spicilegus* due to a high abundance of parasitic mites and fleas in these nests (MAŠÁN & STANKO, 2005; STANKO *et al.,* 2007, STANKO & VÁRFALVYOVÁ, 2010, VÁRFALYOVÁ *et al.,* 2010). In this regard the high representation is similar to the nests of birds, excepting those of penduline tit, where their abundance is low (KRIŠTOFÍK *et al.,* 1993, 1995).

The second very similar feature of the nests of *M. spicilegus* and of the nests of all bird species is the high representation of the fungivores. They are attracted to the bird nests by the accumulated moulding plant materials serving just as construction material, whereas in the nests of *M. spicilegus* also as food reserve. The plant material in the mounds starts to mould already in autumn and in spring is always completely mouldy. In the bird nests, the fungivorous beetle occurs relatively abundantly even in the nest with very poor (penduline tit - KRIŠTOFÍK *et al*. 1993, 1995) or unspecialised beetle fauna (shrikes – KRIŠTOFÍK *et al.,* 2002). However, there is a striking difference in their taxonomic composition. In the bird nests, they are mostly represented by the extremely minute Lathridiids and to some degree also by the *Atomaria* species, (JURÍK & ŠUSTEK 1980, KRIŠTOFÍK *et al*. 1993, 1996, 2001, 2002, 2003, 2005, 2007, 2009; ŠUSTEK & KRIŠTOFÍK, 2002, 2003, 2009), while in the nests of *M. spicilegus* they are represented by three a little larger species of the genus *Cryptophagus,* whereas the Latridiids only by a single species.

Unlike the bird nests, where excrement, rests of food of animal origin (especially in nests of birds of pray, owls and bee-eaters), destroyed eggs, as well as the keratin particles and feather are very attractive for many necrophagous, saprophagous or coprophagous beetle species, these trophic groups were very little represented in the nests. It is caused by the fact that *M. spicilegus* used the nests as a cover and more during frost periods.

CONCLUSIONS

The structure of beetle fauna in the nests of *M. spicilegus* is strongly dependent on the soil surface fauna in fields and reflects its seasonal aspects and regional or even local variability resulting from increased humidity or neighbourhood of a water stream or table. There have not been recorded any species, which could be considered as specific for these nests.

The regional differences between the Východoslovenská rovina plain and other three orographic complexes result from the different soil composition in the Východoslovenská rovina plain. The observed differences between the other three regions would be smaller, if a larger material is examined.

A very low number of individuals and species was observed in Carabids, which represents during the growing season a predominant component of the ground surface fauna in fields, but in late autumn their activity drops strongly.

The trophic structure characterized by a high predominance of predators and fungivores reflects a rich food offer in the nests represented by a rich fauna of ectoparasitic mites and fleas and by mouldy plant material accumulated in the nests. Predominance of these trophic groups is very similar to beetle fauna of bird nests, but unlike them the fungivorous Lathriididae are almost completely replaced by little larger species of the genus *Cryptophagus*.

Other trophic groups are represented in the nests only negligibly. In the concrete cases they may be attracted by decaying substances of plant or animal origin or excrement, but their presence in the nests can be generally taken as occasional.

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