Fenďa P., Ciceková J.: **Pôdne roztoče** (Acari, Mesostigmata) **dubových lesov Malých Karpát (Západné Slovensko).**

V rokoch 1999–2002 sme uskutočnili výskum mesostigmátnych roztočov v dvoch dubovo–hrabových lesoch Malých Karpát. Zistili sme 75 druhov patriacich do štyroch kohort (Antennophorina, Gamasina, Sejina, Uropodina). Spoločenstvá roztočov na lokalite Lošonec–lom ovplyvnenej vápenným prachom z neďalekého lomu vykazovali väčšie výkyvy v počte druhov a v početnosti počas roka. V prírodnej rezervácii Lošonský háj je zreteľný vplyv stabilnejších mikroklimatických podmienok v lese. Porovnaním spoločenstiev pôdnych roztočov v jednotlivých rokoch na študovaných lokalitách sa ukázalo, že teplota a vzdušná vlhkosť majú na druhovú skladbu a početnosť mesostigmátnych roztočov väčší vplyv ako typ pôdy, pH a vegetácie. Z faunistického hľadiska sme zaznamenali prvý nález druhu *Pergamasus canestrinii* pre územie Slovenska.

COMMUNITIES OF TERRESTRIAL ISOPODS (Crustacea: Isopoda: Oniscidea) IN EPIGEON OF OAK-HORNBEAM FORESTS OF SW SLOVAKIA

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Abstract

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Terrestrial isopods were studied in 10 oak-hornbeam forests in the Malé Karpaty Mts and in their vicinity. In total, seven species were recorded. Individual communities consisted from one to six species, *Protracheoniscus politus* and *Porcellium collicola* dominated in most of the studied sites. Beside the age of forest growth, the soil type and pH seems to be important environmental factors affecting the species richness of isopod communities.

Key words: Oniscidea, terrestrial isopods, Malé Karpaty Mts, Slovakia

Introduction

Terrestrial isopods (Crustacea: Isopoda: Oniscidea) represent one of the main groups of soil macrofauna importantly participated in soil-forming processes. They mechanically destroy dead leaves and others plant rests, they stir anorganic particles with fragments of dead organic matter and enhance thus surfaces of organic matter accessible for soil microorganisms (Hassall et al., 1987; Zimmer et al., 2005). Isopods are decomposers of animal carrions, too (Grassberger, Frank, 2004). On the other hands, together with millipedes play important role in food web as an source of calcium for insectivorous birds and other animals (Graveland, Vangijzen, 1994).

In SW Slovakia, the terrestrial isopods were studied by Gulička (1960) in the Svätojurský Šúr within the investigation of ecological consequences of changes of water regime and soil macrofauna. Population ecology and biology of terrestrial isopods were studied in the same site in the seventies by Krumpál (1973, 1976). A detail inventory of terrestrial isopod fauna was done in the Malé Karpaty Protected Landscape Area by Flasarová (Flasarová, 1980, 1986; Flasar, Flasarová, 1989).

Study area

The Malé Karpaty Mts are situated in the western part of Slovakia approximately between the towns Bratislava and Nové Mesto nad Váhom. It represents the most western part of Carpathian Mountains arch and SW corner of Central Western Carpathians. The highest peak (Záruby) amounts 768 m a.s.l. Fauna and flora in these mountains are enhanced by diffusion of Pannonian biogeographic elements. Within this mountain range, ten forest sites were investigated for terrestrial isopod fauna. Positions of sites on the map, their altitudes, expositions and slopes of uphill and phytocoenological and pedological characteristics are summarized in Zlinská et al. (2005).

CA – (Cajla) – forest (*Querco-Carpinetum poetosum nemoralis*) at the foot of the Malá cajlanská homola hill;
VI – (Vinosady) – forest (*Querco-Carpinetum poetosum nemoralis*) at the foot of the Kamenica hill;
FU – (Fúgelka) – forest (*Querco-Carpinetum melicetosum uniflorae*) near the Dubová village;
LI – (Lindava) – forest (*Quercetum petrae-cerris*) in the Lindava Nature Reserve near the Píla village in vicinity to the Malé Karpaty Mts;
HH – (Horný háj grove) – forest (*Querco-Carpinetum melicetosum uniflorae*) in vicinity to the Malé Karpaty Mts, near the Horné Orešany village, refuge within fields and vineyards;
LH – (Lošonský háj grove) – forest (*Querco-Carpinetum caricetosum pilosae*) in the Lošonský háj Nature Reserve;
LL – (Lošonec–lom quarry) – forest (*Querco-Carpinetum melicetosum uniflorae*) near the Lošonec quarry, litter, trees and herbs strongly covered by calcareous dust;
NA – (Naháč–Kukovačník) – small young forest island (*Querco-Carpinetum melicetosum uniflorae*) surrounded by fields and pastures;
NK1 – (Naháč–Katarínka) – young forest (*Querco-Carpinetum melicetosum uniflorae*) in the Naháč–Katarínka Nature Reserve;
NK2 – (Naháč–Katarínka) – old forest growth (*Lithospermo-Quercetum virgilianae*) in the Naháč–Katarínka NR under monastery ruin.

Material and methods

The material of isopods was collected in the years 1999 to 2002 in approximately monthly intervals; eight times per year in 1999–2001 and ten times per year in 2002. Sites LL, LH and HH were investigated in 2000–2002 period only. In each site the litter was sifted from 1 m² (16 squares of 25 × 25 cm). The sifted material was separated using xereclectors, and the animals were fixed in 75% ethylalcohol. Species were determined by using the key of Frankenberger (1959) and Schmölzer (1965), the used classification is according to Schmalfuss (2003).

The computer program JMP (SAS Institute Inc., 1995) was used for cluster analysis of isopod communities (Ward's method). Species diversity was evaluated according to Odum (1977), all couples of diversity values were tested with t-tests (Poole, 1974). Redundant analysis (RDA) was performed for evaluating of the relationships among distribution of species and main environmental factors using the programme CANOCO (ter Braak, Šmilauer, 1998). Species scores were divided by standard deviations, species data were not transformed and were centred by species, using the Monte Carlo Permutation test (500 permutations).

Results

In all sites, the occurrence of seven species of terrestrial isopods (Isopoda: Oniscidea) were recorded together (Table 1). The whole material included 3,798 specimens. Generally, the main dominants were *Protracheoniscus politus* (2,777 individuals) and *Porcellium collicola* (840 individuals). A total survey of coenoses in studied sites including the values of mean densities and diversity indexes is presented in Table 2, a survey of collected terrestrial isopods in individual years is given in Table 3.

T a b l e 1.: Survey of recorded species of terrestrial isopods.

Order: Isopoda
Suborder: Oniscidea
Family: Ligiidae
Ligidium hypnorum (C u v i e r, 1792)
Family: Trichoniscidae
Hyloniscus riparius (C.L. K o c h, 1838)
Family: Philosciidae
Lepidoniscus minutus (C.L. K o c h, 1838)
Family: Agnaridae
Orthometopon planum (B u d d e - L u n d, 1885)
Protracheoniscus politus (C.L. K o c h, 1841)
Family: Trachelipodidae
Trachelipus ratzeburgii (B r a n d t, 1833)
Porcellium collicola (V e r h o e f f, 1907)

Comparison of data from individual years showed, that total numbers of sampled isopods (in sum from all sites) were very similar in the years 2000–2002 (824, 893, and 833 ind. respectively), beside the year 1999 was more rich for isopods, when 1,248 individuals were obtained from seven sites only. No trends are evident from changes in density at individual sites (Table 3).

CA: In this site, only two species were collected. *Protracheoniscus politus* was more abundant than *Porcellium collicola*. Moreover, abundance of *P. collicola* decreased from 25% in 1999 to 0% in 2002 gradually. The highest mean density was in 1999 (8.0 ind.m^{-2}) and the lowest in 2001 (3.3 ind.m^{-2}).

VI: During the whole study, only *Protracheoniscus politus* was collected here. The highest mean density was recorded in 1999 (27.6 ind.m^{-2}) and the lowest in 2000 (4.6 ind.m^{-2}).

FU: Three species were collected in this forest site. *Protracheoniscus politus* was constant and dominant member of the present isopod community. *Porcellium collicola* was observed only in 2000 and 2002 years in a few specimens, and *Ligidium hypnorum*

T a b l e 2. Isopod communities in individual sites: dominance of species, selected coenological characteristics and t-test of species diversity (Poole, 1974) based on the summarized data from 1999–2002 (sites HH, LH and LL only 2000–2002).

Site	CA	VI	FU	LI	HH	LH	LL	NA	NK1	NK2
Ligidium hypnorum	-	-	0.7	-	-	-	-	-	-	0.2
Hyloniscus riparius	-	-	-	-	-	-	0.5	0.2	0.1	18.9
Lepidoniscus minutus	-	-	-	-	-	-	-	-	0.1	-
Orthometopon planum	-	-	-	-	-	-	0.5	-	-	0.2
Protracheoniscus politus	86	-	97.3	86	48.3	97.1	67	94.3	99.6	51.8
Trachelipus ratzeburgii	-	-	-	-	-	2.9	21.8	-	0.1	1
Porcellium collicola	14	100	2	14	51.7	-	10.1	5.3	-	27.9
Total individual	164	454	407	430	145	174	188	511	702	623
Number of species	2	1	3	2	2	2	5	3	4	6
Mean density (ind.m^{-2})	4.97	13.76	12.33	13.03	5.8	6.96	7.52	14.63	20.06	17.8
Pielou's index of equitability	0.59	0	0.13	0.58	1	0.19	0.55	0.17	0.02	0.6
Simpson's index of dominance	0.76	1	0.95	0.76	0.5	0.94	0.51	0.89	0.99	0.38
Shannon's index of species diversity	**0.41**	**0**	**0.14**	**0.4**	**0.69**	**0.13**	**0.89**	**0.24**	**0.03**	**1.08**
CA	-	164	325.02	296.17	168.3	332.65	347.67	323.37	200.79	253.8
VI	8.214***	-	407	430	145	174	188	512	702	623
FU	4.436***	4.146***	-	822.76	429.17	376.49	315.11	902.08	597.73	812.54
LI	0.022ns	13.275***	5.805***	-	458.57	342.46	291.73	941.98	675.44	915.18
HH	5.780***	122.469***	16.125***	9.315***	-	179.54	191.43	540.76	824.09	681.13
LH	4.128***	2.911**	0.174ns	5.057***	12.459***	-	343.29	377.4	221.72	290.55
LL	6.258***	14.999***	10.970***	7.266***	3.282**	10.206***	-	312.51	216.98	258.03
NA	2.876**	7.094***	1.998*	3.773***	13.654***	1.873ns	9.634***	-	756.13	994.61
NK1	7.182***	1.990*	2.876**	10.780***	38.440***	2.059*	13.940***	5.492***	-	1089.66
NK2	12.154***	43.261***	22.327***	17.117***	15.067***	18.485***	2.954**	20.361***	35.164***	-

Abbreviations of sites – see the text. T-test values are given below the diagonal and degrees of freedom above.
Significance levels: *** = $P < 0.001$; ** = $0.001 < P < 0.01$; * = $0.01 < P < 0.05$; ns = $0.05 < P$ (non-significant)

was collected in 1999 only. The highest mean density was in 1999 (22.5 ind.m^{-2}) and the lowest in 2000 (6.3 ind.m^{-2}).

LI: Only two species were recorded in the litter in this forest. *Protracheoniscus P. politus* was more abundant than *Porcellium collicola*, which represented 14% of whole material. The highest mean density was in 2000 (21.4 ind.m^{-2}) and the lowest in 2002 (7.9 ind.m^{-2}).

HH: In this site, only two species were collected, too. *Protracheoniscus politus* was more abundant than *Porcellium collicola* in the first two years, in the last year *P. collicola* dominated. But in total evaluation dominances of both species were well-balanced. In this site the highest index of equitability was recorded (Table 2). The highest mean density was in 2002 (7.4 ind.m^{-2}) and the lowest in 2000 (4.3 ind.m^{-2}).

LH: In this site, two species were collected. In comparison with other forests, *Porcellium collicola* was missing here. *Protracheoniscus politus* was more abundant than *Trachelipus ratzeburgii*, which represented 3% of the whole sampled material. The highest mean density of the whole community was in 2000 (8.9 ind.m^{-2}) and the lowest in 2001 (5.4 ind.m^{-2}).

LL: Relatively rich community of isopods was sampled in this site. *Protracheoniscus politus*, *Porcellium collicola* and *Trachelipus ratzeburgii* were dominant species, and the species *Hyloniscus riparius* and *Orthometopon planum* were recorded in 2002, both in one specimen. The highest mean density was in 2001 (9.3 ind.m^{-2}) and the lowest in 2000 (5.1 ind.m^{-2}).

NA: In this site, *Protracheoniscus politus* predominated. *Porcellium collicola* represented only 5% of the whole sampled material and only 1 specimen of *Hyloniscus. riparius* was recorded. The highest mean density was in 1999 (20.9 ind.m^{-2}) and the lowest in 2002 (5.8 ind.m^{-2}).

NK1: Besides seven hundreds specimens of *Protracheoniscus politus*, three species *Trachelipus ratzeburgii*, *Hyloniscus riparius* and *Lepidoniscus minutus* were sampled, each in one specimen only. The isopod *Porcellium collicola* was missing. The highest mean density was in 1999 (39.5 ind.m^{-2}) and the lowest in 2001 (11.5 ind.m^{-2}).

NK2: The richest community (six species) inhabited litter in this site. *Protracheoniscus politus*, *Porcellium. collicola* and *Hyloniscus riparius* dominated, *Trachelipus ratzeburgii*, *Orthometopon planum* and *Ligidium hypnorum* were found in a few specimens. It corresponds with the highest index of species diversity (Table 2). The highest mean density was in 1999 and 2001 (23.4 ind.m^{-2}) and the lowest in 2000 (12.8 ind.m^{-2}).

Comparison of isopod communities based on the cluster analysis (Fig. 1) divided sites into two groups. One group coupled forests with one to three species, with *Protracheoniscus politus* and/or *Porcellium collicola* as dominant. In the second group were sites with other species or (as a subgroup) without *P. collicola*. The position of the species poor site LH in the diagram relatively closely together with NK1 can explain the highest percentage of *P. politus* (Table 1). Similar pattern shown set of t-tests where are not significant differences between sites CA and LI (in accord with cluster analysis), and between sites LH – FU and LH – NA, i.e. forests with 2-3 species and dominancy of *P. politus* more than 90% (Table 2).

T a b l e 3. Number of collected isopods during individual years in individual sites. Sites were inspected in 1999 to 2001 eight times per year, in 2002 ten inspections.

Site	CA				VI				FU				LI			
Year	'99	'00	'01	'02	'99	'00	'01	'02	'99	'00	'01	'02	'99	'00	'01	'02
L. hypnorum	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
H. riparius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. minutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O. planum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. politus	49	35	25	32	-	-	-	-	177	47	78	94	98	164	43	65
T. ratzeburgii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. collicola	15	7	1	-	221	37	131	65	-	2	-	6	15	7	32	6
Total	64	42	26	32	221	37	131	65	180	49	78	100	113	171	75	71

Site	HH			LH			LL			NA				NK1				NK2			
Year	'00	'01	'02	'00	'01	'02	'00	'01	'02	'99	'00	'01	'02	'99	'00	'01	'02	'99	'00	'01	'02
L. hypnorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
H. riparius	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	-	-	33	8	69	8
L. minutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
O. planum	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
P. politus	21	32	17	67	42	60	38	45	43	158	135	133	57	315	133	91	160	132	58	51	82
T. ratzeburgii	-	-	-	4	1	-	3	21	17	-	-	-	-	-	1	-	-	-	5	-	1
P. collicola	13	12	50	-	-	-	-	8	11	8	8	10	1	-	-	-	-	21	31	66	56
Total	34	44	67	71	43	60	41	74	73	167	143	143	58	316	134	92	160	187	102	187	147

Abbreviations of sites – see the text

T a b l e 4. Presence of isopod species during the year based on the summarized data from all sites and all years.

	Trapped individuals									Proportion of population									
Month	III	IV	V	VI	VII	VIII	IX	X	XI	III	IV	V	VI	VII	VIII	IX	X	XI	ind. total
Ligidium hypnorum																			4
Hyloniscus riparius																			121
Lepidoniscus minutus																			1
Orthometopon planum																			2
Protracheoniscus politus																			2.777
Trachelipus ratzeburgii																			53
Porcellium collicola																			840

The first part of table corresponds with recording probability of these species – increasing intensity of colour corresponds with increasing total numbers of isopods in these four categories: white – not recorded, bright grey 1–9 ind., dark grey 10–49 ind., black ≥ 50 ind. The second part of table shows patterns of changes in densities of individual species, with dominancy in these four categories: white – 0 %, bright grey 1–9 %, dark grey 10–49 %, black ≥ 50 %. Numbers of collected individuals are presented in the last column.

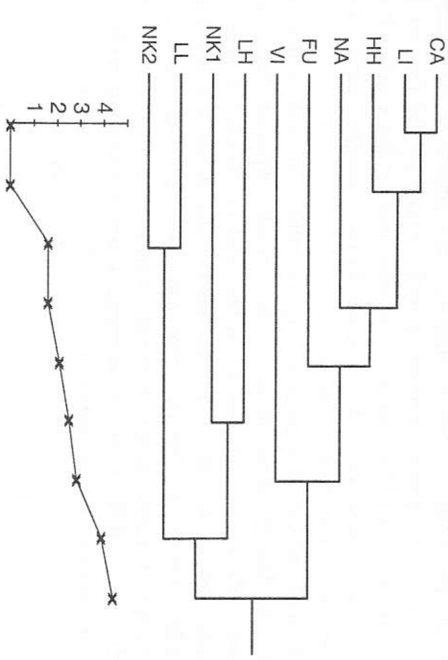

Fig. 1. Cluster analysis of dissimilarity of isopod assemblages on individuals study plots according to their species presence/absence (JMP, Ward method), for abbreviations of sites see text.

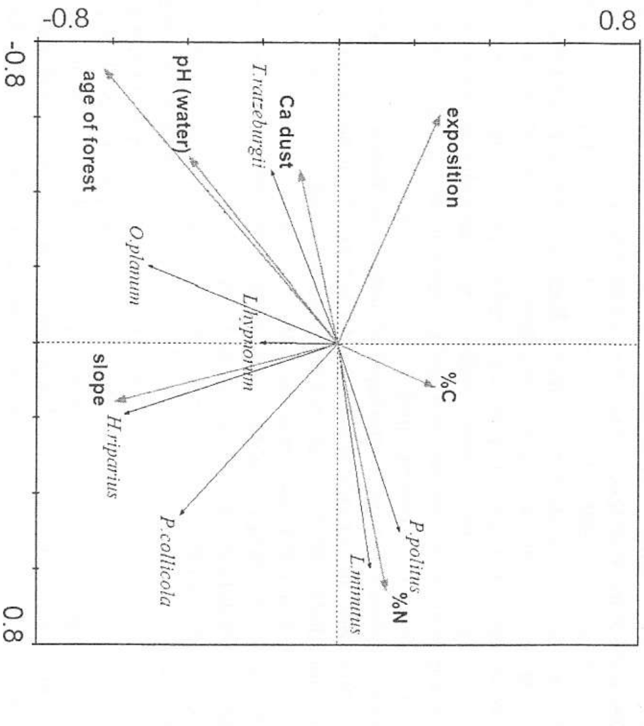

Fig. 2. RDA analysis of community structure and selected environmental factors. Individual axes explain 0.235; 0.077; 0.014; 0.002 of variability, all canonical axes explain 0.328. Abbreviations: exposition – degree of southern exposition of site, %C – content of carbon, %N – content of nitrogen, Ca dust – presence of calcareous dust at surfaces, slope – rate of slope of hillside.

Redundancy analysis (Fig. 2) showed that the most important environmental factor seemed to be age of forest growth (expressed in the graph by the longest arrow in the third quadrant), although the oldest forests were inhabited on the average by 3.3 species and the youngest ones by 4 species. Nevertheless, in the youngest forests, the species *P. politus* represented more than 90% of community.

The occurrence of individual species during the year is summarised in the Table 4. *Lepidoniscus minutus* was extracted in June only, two other species, *Ligidium hypnorum* and *Orthometopon planum*, were detected in the field in the start and/or in the end of vegetation season (April, October and November). The other species were recorded during all months. Although *Protracheoniscus politus*, *Porcellium collicola* and *Trachelipus ratzeburgii* were numerous during whole year, from the second part of Table 4 is evident, that their densities decreased during months with unfavourable conditions (March, summer, late autumn).

Discussion

Generally, the total number of species found in studied sites is low. This result was caused by (1) used method (litter sifting only), (2) apparently also by a low number of studied sites and (3) more or less uniform type of forests, too.

Flasarová (Flasarová, 1986; Flasar, Flasarová, 1989) listed for the Malé Karpaty Mts in total 27 species, but she used individual collecting. Thus she sampled isopods from diverse microhabitats, not only from forest litter. She collected isopods under stones, pieces of wood, under the bark of stumps and fallen trunks, under loose plaster of castle masonry, i.e. from microhabitats with usually higher moisture and/or higher content of calcium. In addition, she elaborated material completed during eight years (1978–1985) and collected in about 110 sampling sites.

Numbers of species in isopod communities sampled by Flasarová varied from one to 11. Forest community of isopods in her studies consisted from two to three species only. The rich communities with five and more species were sampled in wet sites (shores of brooks and creeks) and/or in synanthropic habitats (quarry, villages and village greens, abandoned yards, churchyards, castle ruins, holiday resorts etc.). Most of terrestrial isopods are hygrophilous, from this reason in more humid sites there form richer communities. For example, the communities in Central Moravian floodplain forests consist from five to eight species (Tuf, 2003). Poor communities (2–3 three species) in studied sites can be determined by relatively dry type of forests in comparison with humid riparian growths. Similarly, pitfall trapping in oak forests, used as another method for sampling of isopods, served 4–7 species per studied site (Farkas et al., 1999).

Some isopod species recorded by Flasarová (1986) and missing in this research are frequently associated with man-influenced environments like ruins, quarries, yards etc. (*Armadillidium vulgare* (L a t r e i l l e, 1804), *A. versicolor* S t e i n, 1859, *Porcelio spinicornis* S a y, 1818, *Protracheoniscus major* (D o l l f u s, 1903), *Oniscus asellus* L i n n a e u s, 1758), some of them are more endogeic or associated with deeper soil layers (*Haplophthalmus mengei* (Z a d d a c h, 1844), *H. danicus* B u d d e - L u n d, 1880, *Androniscus roseus* (C. K o c h, 1838), *Trichoniscus pusillus* B r a n d t, 1833, *T. pygmaeus* S a r s, 1898, *Hyloniscus transsilvanicus* (V e r h o e f f, 1901)) or they are myrmecophilous (*Platyarthrus hoffmannseggii* B r a n d t, 1833).

Not only moisture, but also availability of calcium is important factor for distribution of terrestrial isopods, too. Calcium is structural element of isopod integument (e.g. Fabritius, Ziegler, 2003). Both studied sites with higher numbers of species (LL – 5 and NK2 – 6) are on the Rendzina soil type with higher content of calcium. In addition, site LL was relatively permanently covered by dust from neighbouring limestone quarry. Both above mentioned sites LL and NK2 were characteristic by pH value higher than 6. Such conditions are preferred by terrestrial isopods as well (Sastrodihardjo, Van Straalen, 1993). Beside these facts, both sites had high values of slope, 8–10° in LL and 45° in NK2 (Holecová, Sukupová, 2002; Zlinská et al., 2005). The higher slope can support higher diversity of microhabitats, for instance in connection with humidity gradient etc. In the site with the higher slope (NK2) was one from dominant species hygrophilous isopod *Hyloniscus riparius*, stable member of communities from floodplain forests (Tajovský, 1999; Tuf, 2003).

The most important factor in RDA analysis is age of forest growth. Beside some irregularities (VI, HH), index of species diversity and index of equitability are positively correlated with age of studied forest. It is in accord with similar trend documented by Tajovský (2001) for terrestrial isopod communities in afforested mine sites and well know for diverse groups of soil invertebrates in primary forest succession (Dunger et al., 2001).

Explanation for the highest densities in the year 1999 can be a rainy summer (158 % of mean precipitation for June) and the warmer start and end of the vegetation season – April warmer by 1.8 °C and September warmer by 3.6 °C than mean temperature recorded for these months (Zlinská et al., 2005). Such seasonal conditions can be optimal for development of isopod populations. Otherwise during dry summer they migrate deeper into the soil (Tuf, 2002) and are not detectable by sieving of litter.

The records of the hygrophilous species *Ligidium hypnorum* on two sites only in the spring and autumn months can be caused by higher humidity of litter during these periods (Harding, Sutton, 1985). On the contrary, presence of *Orthometopon planum* only during could months is surprising and accidental, because this species is originated from Mediterranean region and in Slovakia it prefers warm forests (Frankenberger, 1959).

In conclusion, relatively poor but typical terrestrial isopod communities with predominating two species *Protracheoniscus politus* and *Porcellium collicola* were described from the several oak-hornbeam forests from the SW Slovakia. Number of species varied among 1 to 6 with mean density from 5 to 20 ind.m^{-2}. The most abundant species was stable during mean year cycle, other more rare species were recorded occasionally during moths with favourable climatic conditions. From the analysis, the main factors affecting structure of communities seems to be age of forest growth, pH and content of Ca (influenced by calcareous dust and soil type).

Translated by P. J. Fedor

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Tuf I.H., Tufová J.: **Společenstva stejnonožců** (Crustacea: Isopoda) **v epigeonu dubo-habrových lesů JZ Slovenska.**

Na vybraných deseti lokalitách, reprezentujících dubohabrové porosty v prostoru CHKO Malé Karpaty a blízkého okolí byla zkoumána společenstva suchozemských stejnonožců. Celkem bylo nalezeno sedm druhů, přičemž jednotlivá společenstva byla tvořena jedním až šesti druhy. *Protracheoniscus politus* a *Porcellium collicola* byli v těchto společenstvech dominantními druhy, přičemž průměrná abundance na jednotlivých lokalitách se pohybovala mezi 5 až 20 ind.m^{-2}. Z testovaných environmentálních faktorů nejvýznamněji ovlivňovaly druhovou bohatost společenstev stejnonožců stáří porostu, půdní typ (dostatek vápníku) a pH půdy.