Terrestrial arthropods of the Domica Cave system and the Ardovská Cave (Slovak Karst) - principal microhabitats and diversity

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In 1997 an extensive biospeleological study was conducted on the structure of terrestrial arthropod communities of the Domica Cave system and the Ardovská Cave, both located in the Slovak Karst (Slovakia). Pitfall trapping with different fixation liquids and extraction of baits and organic debris (guano, rotten wood) were used as principal collecting methods. In total, over 140 species were registered during this initial period of study. Among them there were peculiar troglobitic forms, that is the palpigrade *Eukoenenia spelaea* (Peyerimhoff, 1902), the millipede *Typhloiulus* sp. and the springtails *Arrhopalites buekkensis* Loksa, 1969, *A. slovacicus* Nosek, 1975, *Deuteraphorura* cf. *kratochvili* (Nosek, 1963) and *Pseudosinella aggtelekiensis* (Stach, 1929). The study revealed great differences in arthropod communities between particular sites of both closely situated subterranean localities due to different microhabitat structure. Decaying wood, bat guano and sinter surfaces with percolating water represent the basic source of organic matter and nutrients for fauna within the studied caves. A total absence of troglobites and altered arthropod communities were observed within the passages in the Domica Cave open to the public. The potential human impact upon the assemblages of terrestrial arthropods is discussed.

Keywords: Biospeleology, Arthropoda, Slovak Karst, diversity, human impact.

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Introduction

Territory of the Slovak Karst is geomorphologically linked with the Aggtelek Karst in Hungary, both being part of the same geomorphological unit. The biospeleology of the Aggtelek Karst is well developed especially due to extensive observations of fauna in the Baradla Cave by Dudich (1932). Up to 1994, 435 animal species had been registered in this cave (Zicsi et al., 1994). Among the most peculiar terrestrial Arthropoda inhabiting this cave are the palpigrade *Eukoenenia spelaea vagvoelgyii* (Szalay, 1954), the dipluran *Plusiocampa spelaea* Stach, 1929, the collembolans *Arrhopalites aggtelekiensis* Stach, 1929 and *Pseudosinella aggtelekiensis* Stach, 1929, the linyphiid spider *Porrhomma profundum* Dahl, 1939 and the carabid beetle *Duvalius hungaricus hungaricus* (Csiki, 1903).

The history of biospeleology of the Domica Cave system and the Ardovská Cave is not so rich compared to the Baradla Cave. Nevertheless, 25 terrestrial arthropod species had been found in these caves up to 1995 (Table 1), some of them closely related to hypogean spaces. Noteworthy are the spider *Porrhomma profundum*, the dipluran *Plusiocampa spelaea* and the collembolan *Arrhopalites slovacicus*, all considered the troglobitic species. Recent papers made this list much longer. Collembola of the three above mentioned caves were studied in detail by Kováč (1998a,b; 2000a). Mocek (1997) reported the cavernicolous phorid dipteran *Triphleba antricola* from the Domica and the Ardovská Caves. In both caves the

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Table 1. List of arthropods of the Domica Cave (DC), Čertova Diera Cave (CDC) and Ardovská Cave (AC) based on literature published up till 1995 (● - troglobitic species, ❍ - eutroglophilous species).

Araneae	
● *Porrhomma profundum* Dahl, 1939	DC: Miller and Kratochvil (1940), Košel (1994); CDC: Košel (1994)
Porrhomma convexum (Westring, 1851).	DC: Miller and Kratochvil (1940) – orig. "*Porrhomma pygmaeum* f. *proserpina*", Košel (1994)
Opiliones	
❍ *Mitostoma chrysomelas* (Hermann, 1804)	CDC: Košel (1994)
Acari	
❍ *Oribellopsis cavatica* (Kunst, 1962)	CDC: Kunst (1962)
❍ *Uroobovella advena* (Trägardh, 1912)	CDC: Košel (1994)
Isopoda	
❍ *Mesoniscus graniger* (Frivaldszky, 1865)	DC: Staněk (1932) – orig. „*Asellus species?* prope *cavaticus* Schiödte", Kettner (1936), Frankenberger (1940), Gulička (1985); Košel (1994), CDC: Košel (1994), AC: Gulička (1985), Košel (1994)
Chilopoda	
Cryptops parisi Brolemann, 1920	AC: Gulička (1985), Országh et al. (1994)
Lithobius aeruginosus L. Koch, 1862	AC: Országh et al. (1994)
Diplura	
?● *Plusiocampa spelaea* Stach, 1929	AC: Paclt (1956)
Collembola	
❍ *Ceratophysella denticulata* (Bagnall, 1941)	DC: Nosek (1975a)
Protaphorura armata (Tullberg, 1869)	AC: Paclt (1957)
?Protaphorura troglophila (Nosek, 1975)	DC: Nosek (1975a)
Deuteraphorura sp.	AC: Paclt (1957) – orig. „*Onychiurus pseudinermis*"
Mesaphorura krausbaueri (Börner, 1901)	DC: Nosek (1975a)
❍ *Folsomia candida* Willem, 1902	DC: Paclt (1957)
Folsomia fimetaria Linné, 1758	DC: Nosek (1975a)
Lepidocyrtus insttratus Handschin, 1924	DC: Nosek (1975a)
❍ *Heteromurus nitidus* (Templeton, 1835)	DC: Paclt (1957) – orig. „*H. nitidus margaritaceus*"
Megalothorax minimus Willem, 1900	DC: Nosek (1975a)
● *Arrhopalites slovacicus* Nosek, 1975	DC: Nosek (1975a,b)
Coleoptera	
Choleva glauca Britten, 1918	AC: Růžička and Vávra (1993)
❍ *Duvalius hungaricus sziliczensis* (Csiki, 1912)	AC: Hůrka et al. (1989).
❍ *Quedius mesomelinus* (Marsham, 1802)	CDC: Košel (1994); AC: Gulička (1975)
Lepidoptera	
Scoliopteryx libatrix (Linné, 1758)	AC: Gulička (1975)
Triphosa dubitata (Linné, 1758)	AC: Gulička (1975)

peculiar arachnid *Eukoenenia spelaea* (Palpigradida) was observed (Kováč, 1999; Kováč et al., 2002). Országh (2000) reported the chilopods *Lithobius austriacus* and *Cryptops parisi* from the Ardovská Cave. New data on sciarid dipterans were presented by Košel (2001). Šustek (2001) observed the cavernicolous staphylinid beetle *Atheta spelaea* in the Ardovská Cave. In the distributional study of the isopod *Mesoniscus graniger* Mlejnek and Ducháč (2001, 2003) provided new data on the presence of this species referring to all three caves, partly based on our collections from 1997. Mock et al. (2002) stressed the occurrence of the peculiar troglobitic millipede *Typhloiulus* sp. in the Domica Cave. Finally, the opilionid fauna of the caves was surveyed by Stašiov et al. (2003) and the oribatid mite communities by Ľuptáčik (2003). The Domica Cave and the Čertova Diera Cave belong to the Domica-Baradla Cave system, both located in Slovakia. They were selected for a more extensive study of those hypogean arthropods that primarily inhabit terrestrial habitats. In addition, the neighbouring Ardovská Cave was included in the study because of its natural environment devoided of human influence. The aims of the present paper are (1) to outline arthropod diversity of the Domica Cave system and the Ardovská Cave based on extensive collecting in 1997, (2) to analyse the presence of troglobites, endemic and relic species in the context of their geographical distribution, (3) to characterise principal microhabitats of the arthropods in studied subterranean spaces, and (4) to assess possible human impact on arthropod diversity and community composition in the parts of the Domica Cave open to the public.

Study area and localities

The Domica Cave (DC), the Čertova Diera Cave (CDC) and the Ardovská Cave (AC) are located on the south-western margin of the Silická Plateau in the Slovak Karst National Park and Biosphere Reserve.

They were created in the Middle-Triassic pale Wetterstein limestones of the Silica-Aggtelek Nappe. From the south-west the area is framed by non-karstic Neogene gravel sediments (Bella, 2000; Kučera, 1964). The Domica Cave and the Čertova Diera Cave belong to the Domica-Baradla Cave system extending over 25 000 m. The Domica Cave system (DC and CDC) was created along tectonic fissures by the activity of two subterranean streams - Styx and its tributary the Domický Stream - in three developmental levels, the upper one being genetically the youngest. The total length of the Domica Cave system is 5 900 m.

The entrance of the Domica is situated 339 m a. s. l., grid reference 48 ° 28′ 36′′ N, 20 ° 29′ 09′′ E. It is a dynamic cave with air temperature ranging between +10.2 °C and +11.4 °C, and humidity between 95 % and 98 % (Bella, 2000; Bella and Holúbek, 1999). Following sites in this cave were selected for the study: 1 – „Skupina sôch“, 2 – „Majkov dóm“, 3 – „Lono Matky Zeme“, 4 – „Suchá chodba“, 5 – „Dóm indických pagôd“, 6 – „Sieň netopierov“, 7 – „Spojovacia chodba“ (Samsonove stĺpy – Japonská čajovňa), 8 – „Panenská chodba“. The Domica is a show cave with 20-30 thousands of visitors yearly (Macko, 1996). All investigated sites were situated within the parts open to the public. The cave is characteristic by large heaps of bat guano at the sites 5 and 6. They were created by the activity of summer bat colonies dominated by the Mediterranean horseshoe bat (*Rhinolophus euryale*) (Uhrin et al., 1996).

The entrance of the Čertova Diera Cave is located at 375 m a. s. l. (Droppa, 1961), grid reference 48 ° 28′ 53′′ N, 20 ° 27′ 46′′ E. The air temperature in the cave is about +8.5 ° C (unpublished data). Three sites were selected for the study: 1 – „Vstupná sieň“, 2 – „Zadný dóm netopierov“, 3 – „Hlavný dóm netopierov“. Recently the cave is a well preserved part of the Domica Cave system consisting of intact cave habitats not open to the public. The bottom of site 3 is covered by a thick layer of old bat guano originating from the summer bat colonies of Schreiber′s bat (*Miniopterus schreibersi*). Several decades ago this species inhabited the cave in many individuals (over 1000), but recently, in spite of their protection, its number has dropped (Gaisler and Hanák, 1973; Uhrin et al., 1996).

The Ardovská Cave is roughly 1 600 m long, its entrance at 314 m a. s. l. (Bella and Holúbek, 1999), grid reference 48° 31′ 20′′ N, 20 ° 25′ 23′′E. A very restricted entrance leads to an environmentally stable cave, where a constant temperature of +10.8 °C and relative air humidity of about 97 % are maintained in the dark zone (Droppa, 1961). The whole cave consists of principally two levels of passages created by underground waters (Kučera, 1964). A temporal stream currently occurs in the lower and younger level of the cave. Arthropods were collected in the following sites: 1 – „Vstupný komín“, 2 – “Vstupná chodba“ (beginning of the passage), 3 – „Vstupná chodba“(middle part of the passage), 4 – „Hlavná chodba“, 5 – „Zrútený dóm“, 6 – „Zadná sieň“, 7 – „Dlhá chodba“. Our investigations were concentrated on the genetically older upper level (sites 2 – 6) with patches of bottom sediment rich in humus, except site 7 that was placed on the younger level of the cave. The cave is inhabited by small bat colonies consisting of several species (Gaisler and Hanák, 1973). Guano is not accumulated in heaps, but is rather dispersed in small patches on the cave floor in several parts, especially of the upper fossil level.

Materials and methods

In this paper we present results of investigations on terrestrial arthropods of the Domica Cave system and the Ardovská Cave carried out in 1997. Four collecting methods were used to survey the arthropod fauna of these caves:

1) pitfall trap exposure - 2 traps filled with 96 % ethylalcohol and 1 with 4 % water solution of formaldehyde were exposed at each site for two months,
2) bait exposure - one bait consisted of small pieces of biscuit was exposed at each site for two months and subsequently extracted in a high-gradient apparatus (Crossley and Blair, 1991),
3) extraction of organic matter (bat guano, rotten wood) and fine cave sediments in the apparatus as in the previous method,
4) collecting with plankton net from the water surface of the underground streams in the Domica Cave.

Results and Discussion

Diversity

The list of terrestrial arthropods of the three studied underground localities based on the initial sampling in 1997 (Table 2) comprises 149 taxa (including not further determined taxonomic groups). However, many taxa are just random cave dwellers, especially those that were collected at one site only. The reasons of such high diversity are several. Firstly, many species were detected only in the parts communicating with above-ground habitats, e.g. CDC site 1, AC – 1 and partly also DC – 7. In these parts, the forms not associated with hypogean habitats prevailed. Secondly, the presence of easily decomposed artificial organic matter (straw) significantly increased the total species number in the Domica Cave (DC-7). In this microhabitat also cave species occurred, while above-ground forms dominated. Thirdly, the Styx as an active subterranean stream of the Domica appeared to be an important means of transport for some epigeic Collembola. Small mammals may enrich arthropod diversity by passive transport in the fur of either free living edaphic forms or ectoparasites. In the case of a small mammal cadaver (CDC-2), except fleas, three species of Collembola and two gamasid mite species were registered. And finally, bat guano accumulations hosted a broad spectrum of arthropods, depending on the stage of substrate decomposition.

Many forms recorded are regular cave dwellers in localities under study. Most of them may be classified as troglophiles or guanophiles, or even eutroglophiles; e.g. the mites *Oribellopsis cavatica*, *Parasitus loricatus* and *Uroobovella advena*, the isopod *Mesoniscus graniger*, the collembolans *Folsomia candida* and *Protaphorura armata*, the trechine beetle *Trechus austriacus*, the dipteran fly *Bradysia forficulata*. Among the diversified arthropod communities several troglobites occurred: the palpigrade *Eukoenenia spelaea*, the diplopod *Typhloiulus* sp., and the collembolans *Arrhopalites buekkensis*, *A. slovacicus*, *Deuteraphorura* cf. *kratochvili*, and *Pseudosinella aggtelekiensis*.

Several species may be classified as endemics with their distribution limited to the Western Carpathians or even to a smaller area. Those are the four above-mentioned troglobitic Collembola (Kováč 2000b). Troglobitic species are widely accepted as Tertiary or better „thermophilic“ relics, as they exhibit morphological adaptations for cave life that apparently needed a long time to evolve (e.g. Vandel, 1965; Culver, 1982), and their relatives are primarily distributed *in the* tropics. At least they may be considered relics of one of the warm inter-glacials of the Pleistocene period. On the other hand, we collected several mite species that have boreo-montane or arcto-alpine distribution, which mainly inhabit caves in Central Europe. Such forms may be classified as glacial relics, i. e. remnants of cold Pleistocene periods. Similarly to the thermophilic relics they are preferentially cave dwellers in Central Europe. The examples are the rhagidiid mites *Coccorhagidia pittardi* and *Robustocheles hilli*, the latter recorded in Europe for the first time, up till present known from North America only (Zacharda, 1980 and pers. comm.). This is also the case of some *Porrhomma* species (Vandel, 1965). Also the uropodid mite *Uroobovella advena* fits well in this category, dwelling in marmot nests (*Marmotta marmotta*) in the alpine zone of the High Tatras (Mašán, 2000).

Undoubtedly, the overall arthropod diversity will increase with additional collecting of parietal fauna of the cave entrances. Further data from observations within the studied hypogean localities will be summarised in another paper. Among others, they revealed the occurrence of additional peculiar arthropod representatives, like the opilionid *Mitostoma chrysomelas* (Hermann, 1804), which is an important predatory species of the Ardovská Cave. In the same cave the epigeic symphylan *Symphylella major* Scheller, 1961 was observed as a dweller of cave sediments. The edaphic species *Stylopauropus pedunculatus* (Lubbock, 1867) is an inhabitant of the rotten wood in the Domica Cave. Here, in the long passage connected with the Baradla Cave an abundant population of the spider *Porrhomma profundum* M. Dahl, 1939 was detected. A not yet identified dipluran specimen was collected in the same passage on rotten wood.

The overall composition of terrestrial arthropod communities of the studied caves is mainly influenced by their geographical location. They are situated in the Slovak-Aggtelek Karst region that hosts, together with the Bükk Mts., the most diverse cavernicolous fauna within the Western Carpathians (Košel, 2000)

Microhabitat preferences

Rotten wood, bat guano and sinter surfaces with percolating water represent the basic source of organic matter and nutrients within the studied caves. The sediment of the fossil level of the Ardovská Cave needs special attention because of the presence of numerous populations of several peculiar cave Arthropoda.

Decaying wood offers permanently palatable wooden material that is an important substrate inhabited by visible microbial colonies, the saprophagous isopod *Mesoniscus graniger* and dipteran larvae. Isolated wood pieces completely covered by isopod casts were a good indicator of the activity of this faunal component. In decomposition of the wood earthworms played a role in some places, where their presence was evident by aggregated casts on clay sediment around the wood. The structure of earthworm communities in the Domica cave was studied by Zajonc (1961). Microphytophages were an important component of the fauna associated with rotten wood, especially the oribatid mites *Dissorhina ornata* and *Multioppia* cf. *glabra*, and the collembolans *Ceratophysella bengtssoni*, *Folsomia candida*, *Megalothorax minimus*, *Mesaphorura italica*, and *M. macrochaeta*. Often, also forms with higher locomotive activity, as the oribatid mite *Damaeus lengersdorfi* and the collembolans *Pseudosinella aggtelekiensis* and *Heteromurus nitidus* may be observed on the surface of the wood. Among the main predators the gamasid mites *Cyrtolaelaps chiropterae*, *Paragarmania dendritica*, *Prozercon traegardhi*, *Veigaia exigua*, and *V. nemorensis* were observed. Of the more mobile and bigger predators the staphylinid *Quedius mesomelinus* and the carabid *Trechus austriacus* were the most important.

Large guano heaps are characteristic for the Domica Cave. Fresh guano in the first stages of decomposition (usually the central surface of the pile) is covered with visible pale growths of microfungi. Leached older guano was certainly palatable for the saprophagous *M. graniger*. From the microphytophages oribatid mites *M.* cf. *glabra* and *Oribellopsis cavatica*, the uropodid mite *Uroobovella advena*, and the collembolans *Ceratophysella bengtssoni*, *C. denticulata*, *Deuteraphorura* cf. *kratochvili*, *F. candida* and *Protaphorura armata* were associated with this microhabitat, and therefore may be classified as guanophiles. Of the smaller predatory arthropods, the gamasid mites *Cyrtolaelaps chiropterae* and *C. mucronatus* were the most abundant. The more mobile predators were similar to those of the rotten wood.

Sinter surfaces with percolating water were another microhabitat inhabited by specific, mainly more mobile fauna. Nutrients and microflora transported by water from above-ground is possibly the food source for the troglobitic collembolans *Arrhopalites buekkensis* and *Pseudosinella aggtelekiensis*, often encountered on such surfaces. The leiodid beetle *Choleva glauca* was observed in higher numbers in this microhabitat too. Several limited parts of the fossil level of the Ardovská Cave provide this type of microhabitat.

Several outstanding forms were extracted from the sediment of the fossil floor of the Ardovská Cave. The substratum was inhabited by a dense population of the palpigrade *Eukoenenia spelaea* (Kováč et al., 2002), the collembolans *Deuteraphorura* cf. *kratochvili* and *Pseudosinella aggtelekiensis*, and a broad variety of other troglophilous arthropods (Table 2). One possible reason for the unusual diversity of cavernicolous animals is that the Ardovská Cave offers a suitable and stable cave microclimate. Moreover, the dark-coloured substrate is rich in organic matter, partly consisting of charcoal ash originating in a Neolithic settlement (Kučera, 1974) and in some patches also of bat guano. This thin layer of organic material is evidently mixed with limestone grains by the activity of earthworms and especially of enchytraeids. The acidity of the substratum is comparable to pale clay sediments of the Domica Cave, ranging between pH 8.2 – 8.6. However, the organic matter content of the sediment was evidently higher in the Ardovská Cave – 2.3 % vs. 0.98 % (Nováková et al., this volume).

Human impact

The environmental conditions in the Domica Cave enabled us to discuss the problem of human impact upon the cave arthropod communities. Show parts of the caves are extremely rich in species, which is remarkable especially when considering Collembola assemblages. Part of the species has been transported from above-ground habitatsby hypogean streams. A great variety of forms was associated with straw as fast decomposing organic matter. Not very surprisingly the troglobites *Arrhopalites buekkensis*, *Deuteraphorura* cf. *kratochvili* and *Pseudosinella aggtelekiensis* were totally absent in the show parts of the Domica in contrast to the Čertova Diera Cave and the Ardovská Cave that are not open to public. Among the frequent species in the Domica show parts was the collembolan *Heteromurus nitidus*, likely an ecological vicariant of the troglobitic *P. aggtelekiensis*. *H. nitidus* is a polymorphic species with wide ecological valence (Gruia, 1998) known to be attracted by earthworm excreta (Salmon and Ponge, 2001). However, the presence of earthworms is not the determining factor of the occurrence of *H. nitidus* in particular cave sites. The activity of earthworms is apparent also in the Ardovská Cave, but this collembolan has not been found in this cave yet. A broad spectrum of saprotrophic microfungi detected in the Domica Cave (Nováková et al., this volume) is probably important as potential food for the ubiquitous *H. nitidus*.

Possible reasons of such an alteration of the collembolan community are probably connected with changes in the microflora. „Lamp flora“ around lamp bulbs – mainly aerophilic green algae (Nováková et al., this volume) may attract originally epigeic fauna. This option is less probable, since only a the poor species richness of “lamp flora“ was detected in the cave due to systematic chemical removal of green patches around light bulbs (Nováková et al., this volume). Passive transport of allochthonous species on footwear and clothes of visitors is also less probable because of rather low attendance of the cave by the public (Macko, 1996). The most serious factor seems to be anthropogenic eutrophication of the cave from the Styx tributary that collects rainfall waters from agriculturally used watershed. During heavy floods in 1955, 1964, 1977, and 1981 surface soil and plant debris were transported into the cave and covered its floor by a thick layer in large spaces along the stream (Macko, 1996). In spite of the fact that after each event the allochtonous sediments were removed, the floods undoubtedly represented an important route of transport way for nutrients, allochthonous microflora and invertebrate fauna from the adjacent watershed, mainly consisting of pastures. During the 1980s retention polders were constructed in the watershed thus considerably reducing torrential waters entering the cave. However, at present the underground tributary of the Styx still enables fauna to enter the cave during heavier rainfalls, when even amphibians appear in the cave (unpublished data).

Conclusion

It is necessary to analyse the chemical composition (pH, nutrient content) of various cave substrates (wood, guano at different stages of decomposition, fine sediments) to explain the relationships between abundance and diversity of arthropod communities, the abiotic environment, and other biotic components of the cave ecosystem. Data on the structure of microflora communities may be very important to shed more light on the principal interactions between cave organic matter, microflora and cave fauna.

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Table 2. List of arthropod taxa of the Domica Cave (DC), Čertova Diera Cave (CDC) and Ardovská Cave (AC) recorded in 1997 (s – soil/sediment, d – rotten wood, g- bat guano, k – cadaver of small mammal, n – bait, w – water surface, pet – pitfall trap with ethylacohol, pfo– pitfall trap with formaldehyde, + 1 individual, ++ 2-9 individuals, +++ 10-100 individuals, ++++ more than 100 individuals. For abbreviations of cave sites see chapter Study area and localities (● - troglobitic species, ❍ - eutroglophilous species).

Palpigradida	
● *Eukoenenia spelaea* (Peyerimhoff, 1902)	AC: 3s++
Pseudoscorpionida (indet.)	DC: 7d+; AC: 1s+, 3s+
Araneae (indet.)	DC: 1s+, 2d?, 4d?, 4pet++, 5g?, 6g?, 7d?, 7n+++; CDC: 3g++, *3pet++;* AC: 3pet?, 5g++
Centromerus cavernarum (L.Koch, 1872)	CDC: 3pet++
Pholcus phalangioides (Fuesslin, 1775)	CDC: 2d+
Porrhomma sp.	CDC: 3g+, 3pet++
Opiliones	CDC: 3pet++, 3pfo+
Acari	
Oribatida	
Achipteria cf. *nitens* (Nicolet, 1855)	CDC: 3g++
Acrogalumna hungarica (Willmann, 1938)	AC: 3s+
Atropacarus striculus (C. L. Koch, 1836)	AC: 3s+
Brachychthoniidae sp.	DC: 6g++; CDC: 1s++, 3g++
❍ *Damaeus lengersdorfi* (Willmann, 1954)	DC: 4pet++; CDC: 1s++, 2g+, 3g++, 3pet+, 3pfo+
Damaeus cf. *lengersdorfi* (Willmannn, 1954)	AC: 1d+
Damaeus sp. 1	CDC: 1s++
Damaeus sp. 2	DC: 7n+; CDC: 1s+++, 3g+
Ceratozetes peritus Grandjean, 1951	CDC: 2d++, 2g+++
Chamobates tricuspidatus Willmann, 1953	CDC: 1s+
❍ *Dissorhina ornata* (Oudemans, 1900)	DC: 5g+++, 6g++, 7d++; CDC: 2d++, 2g++, 3g+++; AC: 3s++, 5g+++
Haplozetes vindobonensis (Willman, 1935)	AC: 3s++
Microppia minus (Paoli, 1908)	AC: 3s+
Minuthozetes sp.	AC: 3s+
❍ *Multioppia* cf. *glabra* (Miihelčič, 1955)	DC: 7d++; CDC: 1s+++, 2d+++, 2g+++, 2pfo++, 3g+++; AC: 3s++
Oppiella obsoleta (Paoli, 1908)	DC: 7d+
Oppiella cf. *marginedentata* (Sttrenzke, 1951)	AC: 3s+
Oribatula tibialis (Nicolet, 1855)	DC: 7n+
Oribella pectinata (Michael, 1885)	DC: 7d++
❍ *Oribellopsis cavatica* (Kunst, 1962)	DC: 6g++; CDC: 2d++, 2g+++, 3g++++, 3pfo+
Spherozetes pyriformis (Nicolet, 1855)	AC: 3s++
Suctobelba sp. 1	DC: 7d++
Suctobelba sp. 2	CDC: 2g+
Actinedida	
Rhagidiidae	
Coccorhagidia pittardi Strandtmann, 1971	AC: 1s+, 3s+
Poecilophysis weyerensis (Packard, 1888)	DC: 7d++
Robustocheles hilli (Strandtmann, 1971)	AC: 3s+
Robustocheles cf. *hilli* (Strandtmann, 1971)	DC: 7d+
other Actinedida	DC: 1s+, 2d+, 4d++, 4pet+, 5g++, 6g+, 7d+++; CDC: 1s+, 3g++; AC: 1d++, 3s++, 5d++, 5g++
Gamasida	
Gamasina	
Ameroseius plumigerus (Oudemans, 1930)	DC: 1s+; AC: 1d++, 3s++, 5s++
Arctoseius semiscissus (Berlese, 1982)	DC: 7n++; AC: 1d++
❍ Cyrtolaelaps chiropterae *Karg, 1971*	C: 5g+++, 7d++++; CDC: 2d++, 2g+++, 2k+, 2pfo++; AC: 2pfo++, 6pfo++, 7G++++
❍ *Cyrtolaelaps mucronatus* (G. et R. Canestrini, 1881)	CDC: 1s+, 2d+, 2g+++, 2pfo+++; AC: 1d+, 7g++++
Eulaelaps stabularis (C.L.Koch, 1836)	CDC: 1s+
Geholaspis longispinosus (Kramer, 1876)	DC: 5g++; CDC: 1s++, 3g+
Geholaspis longulus (Berlese, 1887)	CDC: 1s++
Geholaspis mandibularis (Berlese, 1904)	DC: 7d++; CDC: 1s+; AC: 1s++
Hypoaspis aculeifer (Canestrini, 1883)	AC: 5d++
Hypoaspis vacua (Michael, 1891)	DC: 7d+
Hypoaspis sp.	AC: 7g++++
Pachylaelaps longisetis Halbert, 1915	DC: 7d+
❍ *Paragarmania dendritica* (Berlese, 1918)	CDC: 2k+, 2pfo+;AC: 1s++, 1d++, 3s+++, 5s++, 5d++
❍ *Parasitus loricatus* (Wankel, 1861)	DC: 4pet++, 5g++, 6g++; CDC: 2g+, 3g+, 3pet++, 3pfo++;AC: 2pfo++, 3s++, 3n++, 3pet++, 6pfo++, 7g++
Parasitus fimetorum (Berlese, 1903)	DC: 5g+
Pergamasus barbarus Berlese, 1904	CDC: 1s++
Pergamassus crassipes (Linné, 1758)	AC: 1s+
Pergamassus mediocris Berlese, 1904	DC: 7d++
Proctolaelaps pygmaeus (Müller, 1860)	CDC: 1s++
❍ *Prozercon traegardhi* (Halbert, 1923)	DC: 2d+++, 7d++++; AC: 1d+++, 5d+++

Table 2. Continuation.

Saprosecans baloghi Karg, 1964	CDC: 1s++
❍ *Veigaia exigua* (Berlese, 1917)	DC: 2d++, 7d+++; CDC: 1s++, 2g++
Veigaia kochi (Trägardh, 1901)	CDC: 1s++
❍ *Veigaia nemorensis* (Koch, 1839)	DC: 2d++, 7d++; CDC: 2g++, 3g++; AC: 1d++, 5d++
Uropodina	
Dinychus perforatus Kramer, 1886	DC: 7d+
Nenteria dobrogensis Feider et Hutu, 1971	DC: 5g++
Trachyuropoda sp.	DC: 7d+
❍ *Uroobovella advena* (Trägardh, 1912)	DC: 5g+++, 6g++++, 7d+++; CDC: 1s+, 2g+++, 3g+++
Uroobovella rackei (Oudemans, 1912)	CDC: 1s++
Acaridida	DC: 2d++, 5g++, 7d++; CDC: 1s+++; AC: 3s++, 5d+++, 5g++++, 6pet+
Tarsonemida	DC: 4d++, 5g++, 6g+++, 7d++; CDC: 2d+, 2g+++, 3g+++; AC: 3s++, 3n+, 5d+ , 5g++++
Isopoda	
❍ *Mesoniscus graniger* (Frivaldszky, 1865)	DC: 1n++, 3n+, 7d+++, 7pet+++; CDC: 1d+, 2pet+++, 2pfo++, 3g+++, 3pet+++, 3pfo++; AC: 3n++, 3pet+++, 4pet++, 5pet++, 6pet+++
Porcellium conspersum (C.L.Koch, 1841)	DC: 7d+
Trichoniscus cf. *pygmaeus* Sars, 1899	DC: 7d+
Chilopoda	
Lithobius austriacus Verhoeff, 1937	DC: 4pet+; AC: 3pet+
Diplopoda	
❍ *Brachychaeteuma bradae* (Brolemann et Brade-Birks, 1917)	DC: 7n+
Melogona transsilvanica (Verhoeff, 1897)	AC: 1d+
Polyzonium germanicum Brandt, 1831	AC: 1d+
❍ *Trachysphaera costata* (Waga, 1857)	CDC: 1s+
● *Typhloiulus* sp.	DC: 7d+
Pauropoda	
Allopauropus gracilis (Hansen, 1902)	CDC: 3g++
Collembola	
● *Arrhopalites buekkensis* Loksa, 1969	AC: 4pet++, 6pet++++, 6pfo++
Arrhopalites caecus (Tullberg, 1871)	DC: 8w++
❍ *Arrhopalites pygmaeus* (Wankel, 1860)	DC: 8w++; CDC: 2k+; CDC: 2g+, 2d++, 2pfo+, 3g++; AC: 1s+, 1d+, 3s++, 3n++, 3pet+++, 4pet+++, 5g+++, 5pet++
● *Arrhopalites slovacicus* Nosek, 1975	DC: 1pet+, 4pet+; AC: 3s++
❍ *Ceratophysella bengtssoni* Agren, 1904	DC: 4d++, 5g++, 6g+++, 7d++++, 7n++++; CDC: 1s+++
❍ *Ceratophysella denticulata* (Bagnall, 1941)	DC: 6g++; CDC: 1s+++; CDC: 2g++++, 2d+, 2pet+++, 2pfo++++, 3g++++, 3pet+++, 3pfo++
Ceratophysella scotica Carpenter et Evans, 1899	DC: 7d+
Ceratophysella sigillata (Uzel, 1891)	DC: 6g++
Desoria sp.	DC: 6g++, 7d+
Desoria propinqua (Axelson, 1902)	CDC: 1s++
Deutonura albella (Stach, 1920)	AC: 1d++
● *Deuteraphorura* cf. *kratochvili* (Nosek, 1963)	AC: 3s++, 3n+++, 3pet+, 5g+++, 7g++
Endonura cf. *szeptyckii* Weiner, 1973	DC: 7d+, AC: 1d+++
Entomobrya marginata (Tullberg, 1871)	AC: 5g+
❍*Folsomia candida* Willem, 1902	DC: 3s++, 4d+++, 7d++, 8w++; AC: 3n+, 5g++++ , 5d++++
Folsomia kerni Gisin, 1948	DC: 5g+, 7d+++
Folsomia lawrencei Rusek, 1984	CDC: 1s++, 3g+++
Folsomia penicula Bagnall, 1939	AC: 3s+
Folsomia quadrioculata (Tullberg, 1871)	DC: 3pet+
Folsomides angularis (Axelson, 1905)	AC: 1s+
Friesea albida Stach, 1949	DC: 7d++
Friesea truncata Cassagnau, 1958	DC: 6g+
Heteraphorura variotuberculata (Stach, 1934)	DC: 5g+, 7d+; AC: 3s+
Heteromurus nitidus Templeton, 1835	DC: 4d+++, 7n++, 7pet+, 8w++
Hypogastrura purpurescens Lubbock, 1867	DC: 2w++, 8w++
Isotomiella minor (Schäffer, 1896)	DC: 1n+, 3pet+, 1s+++; AC: 3s++
Kalaphorura carpenteri (Stach, 1919)	CDC: 1s+, 2g+++, 2d++, 3g++, 3pfo+
Lepidocyrtus lanuginosus (Gmelin, 1788)	AC: 7g+
Lepidocyrtus lignorum (Fabricius, 1775)	CDC: 2d+
Lepidocyrtus violaceus (Fourcroy, 1785)	DC: 7d++
Megalothorax incertus Börner, 1903	DC: 4d++, 6g++, 8w+; CDC: 1s+, 2d+; AC: 3s+, 5d++
❍ *Megalothorax minimus* Willem, 1900	DC: 2d+, 7d+++; CDC: 2d++, 3g++; AC: 1d+++, 3s++, 5d+
Mesaphorura critica Ellis, 1976	DC: 4d+++; AC: 5g+
Mesaphorura hylophila Rusek, 1982	DC: 2d++
Mesaphorura italica Rusek, 1971	DC: 4d++, 7d+; CDC: 2g++, 2d++, 3g++; AC: 5g++

Table 2. Continuation.

Mesaphorura jirii Rusek, 1982	AC: 5g+++, 5d++
Mesaphorura macrochaeta Rusek, 1976	DC: 2d++, 4d+++, 6d++, 7d++
Mesaphorura tenuisensillata Rusek, 1974	DC: 6g+++
Mesaphorura cf. pongei Rusek, 1982	DC: 2d+
Micraphorura absoloni (Börner, 1901)	DC: 5g+
Oncopodura crassicornis Shoebotham, 1911	DC: 7d++
Orchesella bifasciata Nicolet, 1842	CDC: 3g+
Orthonychiurus rectopapillatus (Stach, 1933)	DC: 7d++
Parisotoma notabilis (Schäffer, 1896)	DC: 7d+; AC: 1d+++
Pogonognathellus flavescens (Tullberg, 1871)	CDC: 2k+
❍ *Proisotoma minuta* (Tullberg, 1871)	DC: 8w+
Protaphorura armata Tullberg, 1869	DC: 2w+, 3pet+, 4d+, 7d+, 8w++; CDC: 2g+++, 2pfo+, 5g++; AC: 1s++++, 1d++++, 3s++, 3n+++
Protaphorura aurantiaca (Ridley 1880)	DC: 7d++; AC: 3s+
Protaphorura campata (Gisin, 1952)	DC: 7d++
Protaphorura pseudovanderdrifti (Gisin, 1957)	CDC: 1s+++
Pseudachorutes palmiensis Börner, 1903	AC: 2pfo+, 3s++
● *Pseudosinella aggtelekiensis* (Stach, 1929)	CDC: 2pet+, 3pet++; AC: 3s+, 3pet+++, 4pet++++, 5pet++, 6pet++++, 6pfo++
Pseudosinella horaki Rusek, 1985	CDC: 2k+
Stenaphorurella quadrispina (Börner, 1901)	DC: 6g+
Supraphorura furcifera (Börner, 1901)	DC: 6g++
Tomocerus sp.	DC: 7d+
Wankeliella petterseni Rusek, 1975	CDC: 2d+
Willemia scandinavica Stach, 1949	DC: 6g++
Psocoptera	
Lepinotus inquilinus Heyden, 1850	CDC: 2pfo+
Psyllipsocus ramburii Sélys-Longchamps, 1872	CDC: 3pfo+
Coleoptera	
Carabidae	
❍ *Trechus austriacus* Dejean, 1831	DC: 1n+, 3pfo+, 7pet++
Staphylinidae	
❍ *Atheta spelaea* (Erichson, 1840)	AC: 3s+
❍ *Quedius mesomelinus* (Marsham, 1802)	DC: 4pet+, 7pet+; AC: 3pet++, 5pet+
Leiodidae	
Catops longulus Kellner, 1846	DC: 4pet+, DC: 5pet+
Cryptophagidae	
Caenoscelis subdeplanata Brisout de Barneville, 1882	AC: 5pet+
Cryptophagus thomsoni Reitter, 1875	DC: 4pet++
Ptiliidae	
Ptenidium punctatum (Gyllenhal,1827)	DC: 7d+
Diptera	
Trichoceridae	
❍ *Trichocera regelationis* (Linné, 1758)	DC: 7pet++; CDC: 3pet +++; AC: 2pfo++, 3pet++, 5pet++
Sciaridae	
❍ *Bradysia forficulata* (Bezzi, 1914)	DC: 7pet+++; CDC: 3 pet++, 3pfo++; AC: 2pfo++, 3pet+++, 5pet+++
Phoridae:	CDC: 3pet+++; AC: 2pet++, 5pet+++
Sphaeroceridae	AC: 5pet++
Siphonaptera	
Ctenophthalmus solutus Jordan et Rothschild, 1920	CDC: 2k+