COBISS: 1.02

INVERTEBRATES OF THE MACOCHA ABYSS (MORAVIAN KARST, CZECH REPUBLIC)

NEVRETENČARJI BREZNA MACOHA (MORAVSKI KRAS, REPUBLIKA ČEŠKA)

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Abstract UDC 592:551.44(437.32)

Vlastimil Růžička, Roman Mlejnek, Lucie Juřičková, Karel Tajovský, Petr Šmilauer & Petr Zajíček: Invertebrates of the Macocha Abyss (Moravian Karst, Czech Republic)

The invertebrates of the Macocha Abyss, Moravian Karst, Czech Republic, were collected in 2007–2008 and 222 species were identified in total. The relative abundance of individual taxa of land snails, harvestmen, pseudoscorpions, spiders, millipedes, centipedes, terrestrial isopods, beetles, and ants was evaluated. The cold-adapted mountain and subterranean species inhabit the bottom and lower part of the abyss, whereas the sun-exposed rocky margins were inhabited by thermophilous species. Macocha harbors several threatened species that are absent or very rare in the surrounding habitats. In the forest landscape, the Macocha Abyss represents a natural habitat with a distinct microclimatic gradient, and is an excellent refuge area for psychrophilous as well as thermophilous species, which significantly contributes to maintenance of landscape biodiversity.

Key words: Ants, centipedes, beetles, biodiversity, harvestmen, land snails, light hole, millipedes, pseudoscorpions, terrestrial ispods, spiders.

Izvleček UDK 592:551.44(437.32)

Vlastimil Růžička, Roman Mlejnek, Lucie Juřičková, Karel Tajovský, Petr Šmilauer & Petr Zajíček: Nevretenčarji brezna Macoha (Moravski kras, Republika Češka)

Med vzorčenjem v letih 2007 in 2008 smo v jami Macoha določili 222 vrst nevretenčarjev. Ovrednotili smo relativno pogostost posameznih taksonov polžev, suhih južin, paščipalcev, pajkov, stonog, kopenskih enakonožcev, hroščev in mravelj. Na mraz prilagojene gorske in podzemeljske vrste naseljujejo dno in spodnji del brezna, toploljubne vrste pa naseljujejo kamnite površine soncu izpostavljenega roba. V Macohi je več ogroženih vrst, ki jih sicer v okoliški pokrajini ne najdemo. Kot habitat s specifično mikroklimo je Macoha izjemno zatočišče za vlagoljubne in toploljubne vrste, ki pomembno prispevajo k vzdrževanju biotske raznovrstnosti v pokrajini.

Ključne besede: Mravlje, stonoge, hrošči, suhe južine, kopenski polži, stonoge, psevdoškorpijoni, kopenski enakonožci, pajki, biotska raznovrstnost.

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Received/Prejeto: 19.08.2015

INTRODUCTION

Medium-sized types of relief (with a size of tens to hundreds square metres) play a very important role in terrestrial ecosystems. They are responsible for deviations in microclimatic conditions and consequently, for habitat differentiation, with a different composition of flora and fauna for each specific site. Cliffs and talus slopes represent natural habitats that exhibit very distinct gradients of environmental factors and accompanying biota (Larson *et al.* 2000; Růžička & Zacharda 2010; Růžička *et al.* 2012). The same is true for terrain depressions – sinkholes and abysses. Deeper vertical fissures, shafts and abysses usually represent a vertical cave entrance, which is less accessible than a horizontal cave entrance. The attention of biospeleologists mainly focuses on animals that inhabit deep spaces at the bottom of the cave, and the entrance sections remain poorly studied. Ecological studies that describe the vertical distribution of invertebrates along a depth gradient in caves are therefore rare (Růžička 1996; Mlejnek & Zajíček 2006; Sendra & Reboleira 2012).

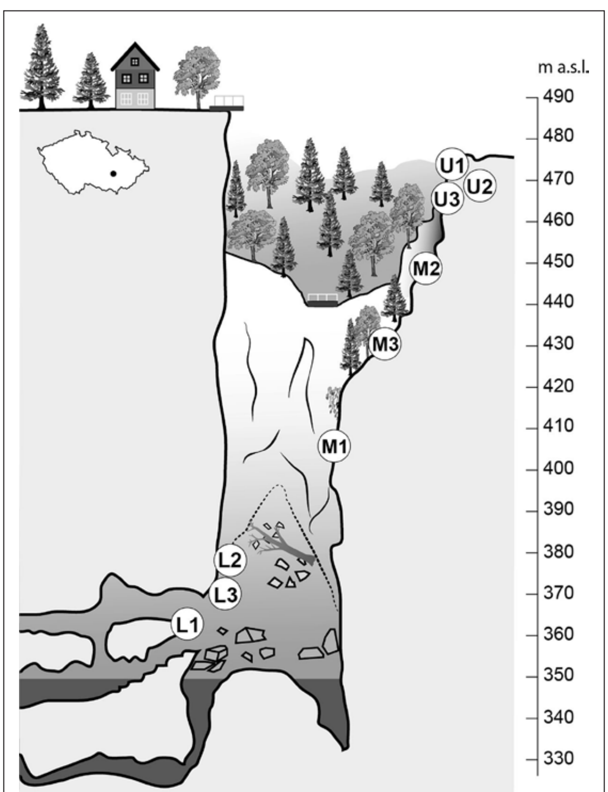

Fig. 1: Macocha Abyss. Longitudinal section with sampling locations on the upper margin (U1–3), in the middle part (M1–3), and the lower part (L1–3). A map of the Czech Republic with a location of the Macocha Abyss is inserted.

Fig. 2: Macocha Abyss (Photo: P. Zajíček).

Macocha Abyss is one of the deepest abysses of the light-hole type in Europe. Only solitery, unsystematic investigations of invetrebrates were done. Besides common ecologically indifferent land-snail species (sensu Ložek 1964) *(Alinda biplicata, Vitrina pellucida),* rock-dwelling species *(Helicigona lapicida, Faustina faustina),* and woodland species *(Arianta arbustorum, Monachoides incarnatus, Semilimax semilimax, Vitrea crystallina)* were recorded. The record of rare Carpathian species *Vitrea transsylvanica* from this isolated site is of prime importance (Ložek 1952; Vaněčková & Vašátko 1971; Kroupa 1973). The first spider species, *Porrhomma egeria,* typical of subterranean habitats, was recorded during initial investigations (Absolon 1904). Subsequent research on spiders was conducted by Růžička (1999b), who collected them among stones in the scree cone. The survey of beetles inhabiting the Macocha Abyss was presented by Hamet *et al.* (2012). The major part of the zoological investigations focused on the study of invertebrates that colonise deeper subterranean habitats; the invertebrates that inhabit the rock walls and upper rocky margins of the abyss remain still unstudied. Pseudoscorpions, harvestmen, terrestrial isopods, millipedes, centipedes and ants were collected only occasionally in the past and neither detailed nor summarising information has ever been published.

The aims of this study were (1) to describe the assemblages of selected groups of invertebrates in relation to the depth gradient, and (2) to assess the ecological and biogeographical significance of the Macocha Abyss, based on collected data and those in the literature.

MATERIALS AND METHODS

STUDY SITE

The Moravian Karst – formed from Devonian limestone – is the largest karst area in the Czech Republic, covering an area of 92 km^2. The landscape of the Moravian Karst region, covered by deciduous forests, is formed by plateaux with many sinkholes separated by deep canyons. The northern part of the Moravian Karst is drained by the Punkva River and its tributaries. The Amatérská Cave complex, which stretches for almost 34 km including contiguous caves, represents one of the largest cave systems in Europe (Hromas 2009).

Fig. 3: Traps hanging against the rock surfaces, were used to capture the invertebrates (Photo: P. Dolejš).

The Macocha Abyss (49.3733°N, 16.7293°E) is situated in the discharge area of this system. The dimensions of its opening are 174 × 76 m, and the depth of dry part is 139 m (Figs. 1 and 2). The abyss was opened by the collapse of the cavern ceiling during the last interglacial period; its present shape was consequently formed during the Pleistocene and Holocene (Kadlec & Beneš 1996; Kadlec *et al.* 2001).

Botanical research of the Macocha Abyss immediately followed speleological explorations (Absolon 1904, 1970). In total, 247 species of vascular plants have been reported to inhabit the slopes of abyss (Sutorý 2009). Species characteristic of sun-exposed rocky slopes occur on the upper margin and the occurrence of mountain plants is characteristic for the vertical rock walls (Straňák 1970). *Cortusa matthioli* grows on the lower part of the vertical rock walls and Macocha is the only locality of this plant species in the Czech Republic. The occurrence of rare and endangered bryophytes, e.g. *Buxbaumia viridis* and *Cololejeunea rossettiana*, is also characteristic for this locality (Straňák 1970).

TEMPERATURE MEASUREMENTS

Data-loggers (Model Minikin TH, EMS, Brno, Czech Republic) with internal thermistors (accuracy ± 0.2 °C) were used to register the temperature every 15 minutes at five depth levels from January 2007 to December 2008.

SAMPLING

Invertebrates were sampled at three depth levels: **U** – Upper margin, sun-exposed rock outcrops on the upper margin of the abyss; **M** – Middle part, shaded rock walls; **L** – Lower part, the cold bottom. Invertebrates were trapped using hanging board traps described by Růžička (1982, 1988, 2000) which are designed for the automatic collection of invertebrates on vertical rock walls (Fig. 3). The traps, made of rigid plastic, consist of a board (25 × 20 cm), which formed an artificial horizontal surface) and a can (13 cm high and 10.5 cm in diameter) inserted in the center of the board. The traps contained a mixture of 7 % formaldehyde and 10 % glycerol with a few drops of a surfactant. Each trap was hung from a hooked nail. A band of emery tape was stuck on the back edge of the trap and shaped to form a connection, or transit, between the board and the rock surface. Three traps were installed in each of the studied depth levels from October 2007 to September 2008 (Fig. 1).

DATA ANALYSIS

Counts of individual species were ln(x+1)-transformed before their use in multivariate statistical models, to increase the homogeneity of the variance.

Variation in the relative composition of invertebrate assemblages at individual trap locations was summarised by detrended correspondence analysis (DCA), with the down-weighting of rare species. The difference in invertebrate assemblages among the three sampled depth levels was tested using canonical correspondence analysis (CCA) with the Monte Carlo permutation test randomly permuting the nine sampling traps. The difference in species richness (number of recorded invertebrate taxa) among the three sampling depths was tested using a F-statistic based test for a generalised linear model (GLM) with an assumed quasi-Poisson distribution of the stochastic component.

Both the multivariate analyses and the GLM were performed using Canoco 5 software (ter Braak & Šmilauer 2012).

We used all available data, i.e. both the material collected during this study as well as other published and unpublished records. We evaluated basic informations on the distribution of species in the Czech Republic, on thermophilous and cold-adapted (mountain) species, and on troglophilous species. These data were excerpted from the literary sources and also unpublished datasets. The degree of vulnerability was evaluated according to the national Red List (Farkač *et al.* 2005), in the case of spiders according to the new version of the Red List (Řezáč *et al.* 2015).

RESULTS AND DISCUSSION

Basic thermal characteristics of the atmosphere in the Macocha Abyss in 2007 and 2008 were calculated (Tab. 1). The average annual temperature on the upper rock margin was 9.02 and 8.91 °C, respectively (in 2007 and 2008); such values are characteristic for the hottest regions of the Czechia, namely central Bohemia and southern Moravia. The average annual temperature at the bottom was 4.89 and 4.88 °C, respectively; such values are characteristic for mountain regions of the Czechia (Tolasz *et al.* 2007). The difference between mean annual air temperature on the upper margin and at the bottom of the abyss was 4.13 and 4.02 °C, respectively. The range between maximum and minimum temperature in the year diminishes to the half with increasing depth.

We evaluated the material of land snails, harvestmen, pseudoscorpions, spiders, millipedes, terrestrial isopods, beetles, and ants. Sampled invertebrates comprised 1,488 specimens belonging to 222 species (Appendix 1). The invertebrate communities found in Macocha are summarised by the ordination diagram in Fig. 4, which displays 30 most frequent invertebrate species. The first axis clearly reflects the sampling depth, decreasing from left to right, along the first, most important DCA axis (explaining 23.9 % of the total variation in species relative proportions). The positions of the nine traps clearly suggest that the community composition at the upper margins was most different from the other two sampled depths and also most variable (as observed by the spread of U1, U2, and U3 symbols along the second DCA axis). The differences between the traps exposed in middle positions and at the abyss bottom are much smaller, although

Tab. 1: Air temperatures (°C) in the Macocha Abyss. Min – annual air temperature minimum; Max – annual air temperature maximum; Average – average annual air temperature; Range – annual range of air temperatures.

	Min		*Max*		*Average*		*Range*	
Depth (m)	*2007*	*2008*	*2007*	*2008*	*2007*	*2008*	*2007*	*2008*
0	−9.9	−12.0	36.0	29.9	9.02	8.90	45.9	41.9
50	−8.7	−10.1	29.8	26.3	8.40	7.98	38.5	36.4
90	−5.7	−8.1	20.2	20.3	5.97	5.84	25.9	28.4
110	−6.8	−8.5	14.5	14.7	5.12	5.09	21.3	23.2
130	−7.6	−9.1	11.0	11.6	4.89	4.88	18.6	20.7

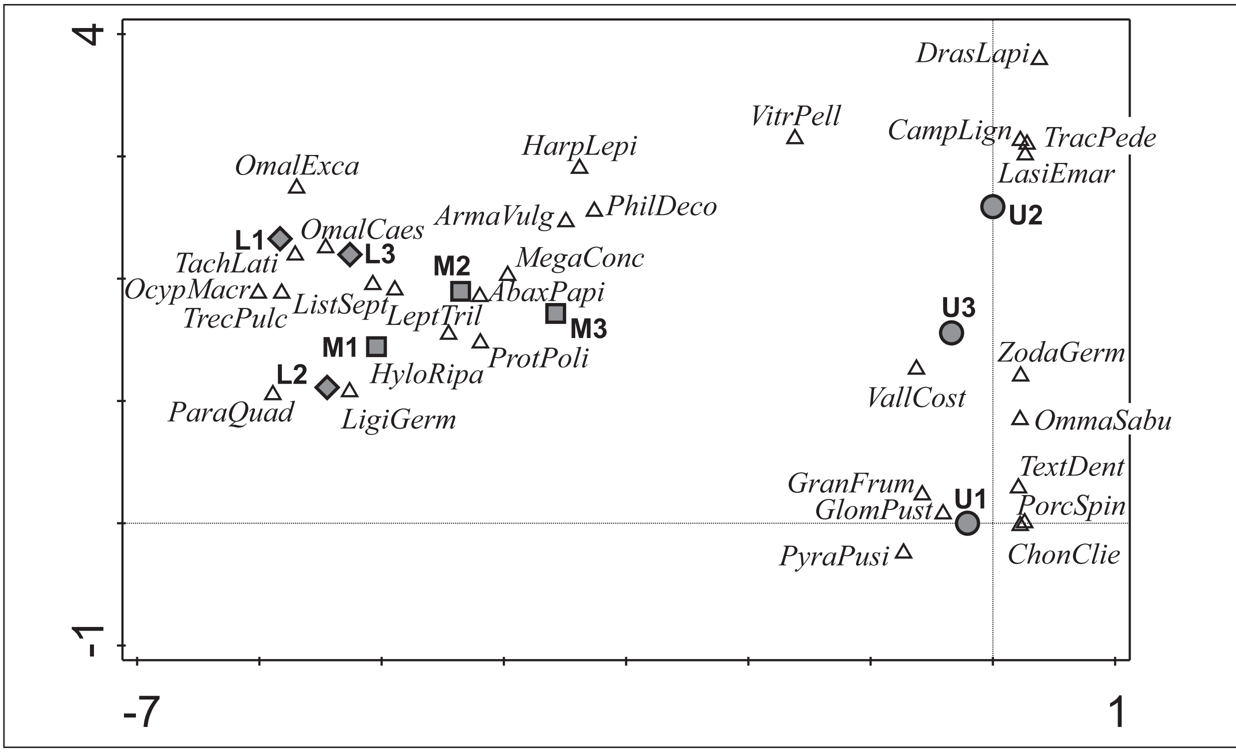

Fig. 4: Ordination diagram of DCA with the first two axes explaining 23.9 % and 10.8 %, respectively, of the total variation. The L1–L3 traps were in the lower part of the abyss; M1–M3 traps were in the middle part; U1–U3 traps were on the upper margin. Thirty invertebrate species with the highest sum of specimen counts are shown as follows: ***land snails:*** *ChonClie – Chondrina clienta, GranFrum – Granaria frumentum, PyraPusi – Pyramidula pusilla, VallCost – Vallonia costata, VitrPell – Vitrina pellucida;* ***harvestmen:*** *ParaQuad – Paranemastoma quadripunctatum; spiders: DrasLapi – Drassodes lapidosus, HarpLepi – Harpactea lepida, TextDent – Textrix denticulata, TracPede – Trachyzelotes pedestris, ZodaGerm – Zodarion germanicum;* ***terrestrial isopods:*** *ArmaVulg – Armadillidium vulgare, HyloRipa – Hyloniscus riparius, LigiGerm – Ligidium germanicum, PorcSpin – Porcellio spinicornis, ProtPoli – Protracheoniscus politus;* ***millipedes:*** *GlomPust – Glomeris pustulata, LeptTril – Leptoiulus trilobatus, ListSept – Listrocheiritium septentrionale, OmmaSabu – Ommatoiulus sabulosus;* ***beetles:*** *AbaxPapi – Abax parallelepipedus, MegaConc – Megasternum concinum, OcypMacr – Ocypus macrocephalus, OmalExca – Omalium excavatum, OmalCaes – Omalium caesum, PhilDeco – Philonthus decorus, TachLati – Tachinus laticollis, TrecPulc – Trechus pulchellus;* ***ants:*** *CampLign – Camponotus ligniperdus, LasiEmar – Lasius emarginatus.*

they still reproduce the relative ordering of these two sampling depths.

The results of constrained ordination (CCA) show that the depth gradient is very strong: the two constrained axes explain 38.2 % of the total inertia, which is a value very close to 40.4 %, which is explained by an unconstrained correspondence analysis (CA, without detrending). The effect of depth is highly significant (pseudo-F = 1.9, p = 0.001). The ordination diagram in Fig. 5 shows 16 best-fitting species among the 35 species with the highest frequency, i.e. the invertebrate taxa that best characterise the compositional differences among the three sampling depths.

The test of species richness differences among the sampling depths revealed no significant differences ($F_{2,6}$=0.599, n.s.) among the three depth levels.

The most numerous invertebrates in the catch from the upper margin of the abyss were the land snails *Pyramidula pusilla* and *Granaria frumentum,* the spider *Drassodes lapidosus,* millipedes *Ommatoiulus sabulosus* and *Glomeris pustulata,* and ants *Lasius emarginatus* and *Camponotus ligniperda.* All ant species (eight species) were collected exclusively on the upper margin. The beetle *Megasternum concinum,* and the isopods *Armadillidium vulgare* and *Protracheoniscus politus* were among the most numerous colonisers of the middle rock walls. The beetles *Trechus pulchellus, Omalium excavatum,* the millipede *Leptoiulus trilobatus,* and the isopod *Ligidium germanicum* were the most numerous inhabitants of the bottom. The beetles *Abax parallelepipedus* and *Omalium caesum* occurred abundantly in both shady levels.

Land snails (Mollusca). In total 33 land-snail species have been recorded in the Macocha Abyss; 31 of them during this research. *Eucobresia nivalis* is classified as endangered. *Aegopis verticillus, Chondrina clienta, Discus perspectivus, Faustina faustina, Pupilla sterrii,*

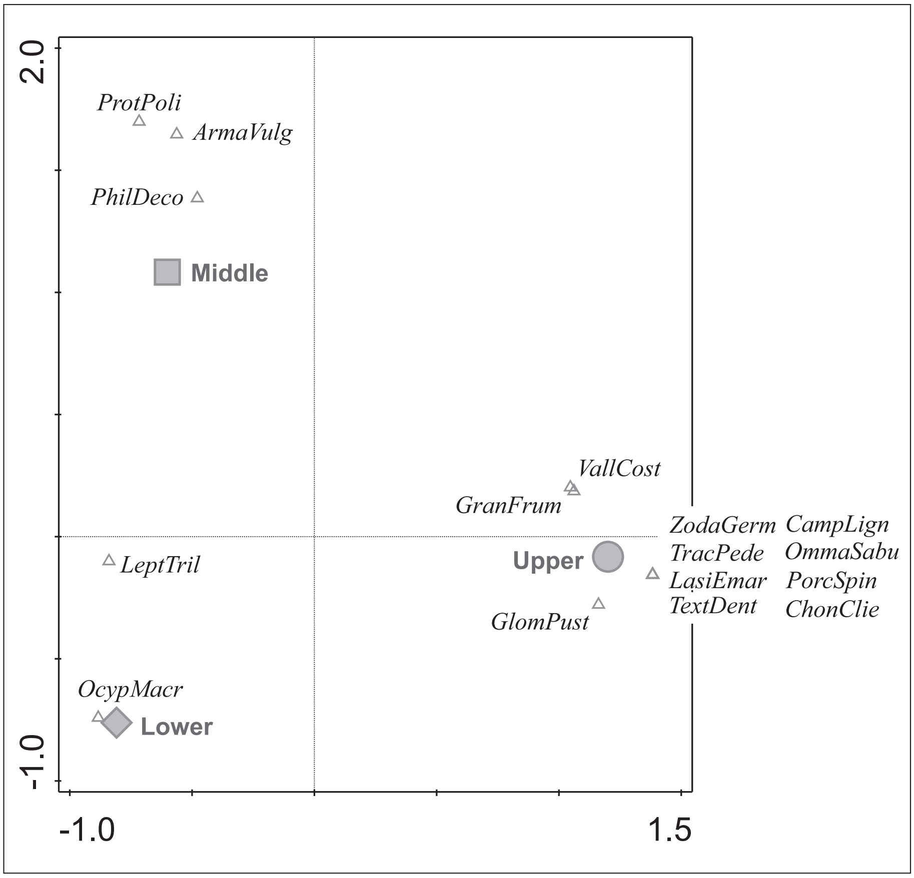

Fig. 5: Ordination diagram of CCA, displaying both constrained axes, which explained 23.7 % and 14.5 %, respectively, of the total variation. Plotted invertebrate taxa represent an intersection of the two subsets of 35 taxa with the highest specimen count and 35 taxa with the highest fit on the two displayed axes. Species acronyms are as in Fig. 3.

Pyramidula pusilla are classified as vulnerable. The sampling method probably affected the number and especially the quantity of sampled snails. However, a strong gradient of humidity is clearly reflected in the composition of the mollusc fauna. Although a community of steppe species occurs in small patches on the upper margin of the abyss, strictly forest species occur at the bottom, including hygrophilous species.

Chondrina clienta and *Pyramidula pusilla* are typical rock-dwelling species, which inhabit steep calcareous rock surfaces from which they can fall. *Vallonia costata* and *Granaria frumentum* inhabit small patches of short vegetation on sun-exposed slopes.

A typical Carpathian mountain species, *Vitrea transsylvanica,* occurred in the Moravian Karst in the Preboreal period (Ložek & Juřičková, unpublished). Thus, its survival in habitats with stable microclimatic conditions such as in the Macocha Abyss cannot be excluded.

Harvestmen (Opiliones). In total, six species were recorded in the Macocha Abyss, all during this research. They are mostly common forest species. The most numerous species, *Paranemastoma quadripunctatum,* occured equally frequently in the middle and bottom parts of the abyss.

Pseudoscorpions (Pseudoscorpionida). In total, three species were recorded in the Macocha Abyss, all during this research. All are commmon species found in moss and detritus.

Spiders (Araneae). In total, 87 species are known from the Macocha Abyss; 49 species were caught during our research. *Amaurobius jugorum, Arctosa lutetiana, Callilepis schuszteri, Improphantes improbulus,* and *Tenuiphantes zimmermanni* are classified as vulnerable.

Drassodes lapidosus, Zelotes apricorum, Callilepis schuszteri, Trachyzelotes pedestris, Zodarion germanicum, and *Heliophanus aenaeus,* which occurred on the upper margin, are thermophilous species that usually occur on rock and forest steppes, sun-exposed rock walls, and on the upper margins of sun-exposed scree slopes. The thermophilous species *Tricca lutetiana* was recorded in the Moravian Karst for the first time, despite intensive research on spiders in xerothermic habitats in the region (Niedobová *et al.* 2011). Based on the material collected from the upper margin, a new species *Dysdera moravica* was described. The Macocha abyss represents its type locality (Řezáč *et al.* 2014).

Numerous cold-adapted species were recorded at the bottom of abyss. The rare species, *Tenuiphantes zimmermanni,* which usually inhabits leaf litter in scree forests, was recorded in Moravia for the first time; *Micrargus georgescuae* usually inhabits the subalpine zone and inverse rocky gorges; *Anguliphantes tripartitus* occurs in peat bogs, mountain scree slopes, scree slopes with ice formation and in cold sandstone labyrinths (Růžička & Klimeš 2005; Růžička *et al.* 2010; Růžička & Zacharda 2010); *Porrhomma convexum, P. egeria,* and *Improphantes improbulus* are troglomorphic species (Růžička 1998, 1999a); *L. improbulus* colonises crevice systems, boulder slopes and cave entrances in Central Europe; *P. egeria* and *P. convexum* occur in cold mountain habitats, and the Moravian Karst cave systems at a depth of 80–100 m (Růžička *et al.* 2013).

Terrestrial isopods (Oniscidea). Disregarding the limestone bedrock, which usually features a rich isopod fauna, only eight species are known for the Macocha Abyss; all were caught during our research. The occurrence of hygrophilous species, such as *Hyloniscus riparius, Trichoniscus pusillus* and *Ligidium germanicum* is connected with the colder and more humid bottom of the abyss. The third species belongs to less frequent representatives of the Czech fauna and has a patchy occurrence mostly in the Eastern part of Central Europe.

Millipedes (Diplopoda). In total, 14 species were recorded in the Macocha Abyss, and 12 species were caught during this study. *Listrocheiritium septentrionale* and *Haploporatia eremita* were frequently sampled before this study, on the bottom of the abyss. The former species is endemic to the Hercynian mountains of Central Europe and is closely related to natural forest habitats, including inverse ravines or gorges. Besides the Macocha Abyss, it is known from talus forests in ravines of the Moravian Karst. *Haploporatia eremita* is characteristic of deciduous forests and is not limited only to limestone (the Moravian and Bohemian Karsts), nevertheless, it preferably inhabits wet, shady and colder forest slopes. A grater occurrence of *Leptoiulus trilobatus,* otherwise related to higher altitudes, corresponds with the more humid and colder character of the abyss bottom. *Brachydesmus superus* Latzel, 1884, which was recorded on the bottom of the Macocha Abyss outside the exposed traps only, is a typical permanent inhabitant of cave systems in the Moravian Karst. The list of millipede species is completed by *Mastigona bosniensis* (Verhoeff, 1897) known only from individual sampling as well.

Centipedes (Chilopoda). Only seven species are known from this specific locality, all were caught during our research. Surprisingly, six species were recorded by trapping on rock walls in the middle part of the abyss. The recording of *Lithobius lucifugus* is the most intriguing finding, as it is also characteristic for the bottom of the abyss and is known almost exclusively from subterranean habitats in scree slopes and caves (Tajovský 2001).

Beetles (Coleoptera). In total, 267 beetle species were recorded in the Macocha Abyss, including 98 species caught during this research. *Byrrhus luniger* and *Meligethes buyssoni* are classified as critically endangered. *Geodromicus nigrita, Gyrinus distinctus, Lycoperdina bovistae, Mniophila muscorum, Ocalea rivularis,* and *Ochthephilus aureus* are classified as endangered. *Autalia longicornis, Drilus concolor, Endomychus coccineus, Lesteva monticola, Melanotus crassicollis, Omalium rugatum, Omalium validum, Rhizophagus cribratus, Tasgius winkleri, Tetralaucopora longitarsis,* and *Trichophya pilicornis* are classified as vulnerable.

The thermophilous species *Danacea pallipes* (Dasytidae), which usually occurs in steppes, and *Melanotus crassicollis* (Elateridae), usually found in forest-steppe habitats, were recorded on the upper rocky margin of abyss.

The assemblage of cold-adapted species collected at the bottom of abyss was rich in species. *Choleva nivalis* and *C. spadicea, Omalium validum,* and *Tetralaucopora longitarsis,* are mountain species, which occur at lower altitudes exclusively in localities with an atmospheric temperature inversion. *Catops longulus* and *Ochthephilus aureus* are known as inhabitants of cave entrances, and the former species also inhabits scree slopes. Two critically endangered species, *Byrrhus luniger* and *Meligethes buyssoni* were also collected at the bottom of the abyss.

Ants (Hymenoptera, Formicidae). In total, eight species were recorded in the Macocha Abyss, all during our investigations. They are mainly thermophilous species (Lasius emarginatus, Temnothorax unifasciatus), or wood-living species (Camponotus ligniperda).

Similar distribution of thermophilous and montaneous species across vertical gradient of sinkholes was also found in higher plants. Bátori *et al.* (2014) studied vascular plants in karst sinkholes in Hungary and concluded that many plants, particularly mountain species, are restricted to the bottom of sinkholes, whereas many species of drier and warmer forests have colonised the upper slopes and rims. Thus, such locations can be considered as reservoirs for many vascular plant species, and are therefore particularly important from a conservation point of view. The mean depth/diameter ratio of studied sinkholes was about 0.20. We documented the same pattern on steeper depth gradient for invertebrates (the depth/diameter ratio of the Macocha Abyss is 1.1).

CONCLUSIONS

In the region of deciduous forests, the Macocha Abyss represents an open habitat with a very distinct microclimatic gradient. The assemblages of invertebrates at its bottom and upper margins substantially differ. The bottom and shady rock walls harbor numerous cold-adapted invertebrates, which usually inhabit the mountain and subalpine belt, as well as caves and other subterranean habitats. In contrast, the upper margin is colonised by species that typically occur on rock and forest steppes and in other xerothermic habitats. The Macocha Abyss harbors several threatened invertebrate species that are absent or are very rare in the surrounding habitats. Being located in a woodland area, the Macocha Abyss significantly contributes to the protection and maintenance of regional landscape biodiversity.

ACKNOWLEDGEMENTS

This research was conducted with institutional support RVO:60077344. The contribution of P.S. was supported by the center of Excellence PLADIAS, 14-36079G. We thank the Ministry of the Environment for permission to perform research within the National Nature Reserve. We also appreciate the efforts of the taxonomists who helped us with identification of arthropods: Pseudoscorpiones – F. Štáhlavský; harvestmen and ants – P. Bezděčka; beetles – M. Boukal, R. Cséfalvay, P. Čížek, M. Fikáček, J. Jelínek, P. Krásenský, J. Krátký, V. Kubáň, J. Mertlik, J. Prouza, P. Průdek, J. Růžička, A. Šíma, M. Švarc, Z. Švec, D. Trávníček, and Z. Vancl. We thank V. Ouhrabka for a drawing of the longitudinal section of the abyss.

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Appendix 1. List of species with the number of specimens catched in traps installed on Upper margin (U1–3), in Middle part (M1–3), and in Lower part (L1–3). Ecological characterstics (Eco): Th – thermophil, Mt – mountain, cold-adapted, Tr – troglophil.

Species	**U1**	**U2**	**U3**	**M1**	**M2**	**M3**	**L1**	**L2**	**L3**	**Eco**
Mollusca										
Aegopinella pura (Alder, 1830)	–	–	–	–	–	–	–	3	–	
Aegopis verticillus (Lamarck, 1822)	1	–	–	–	–	–	–	–	2	
Alinda biplicata (Montagu, 1803)	–	–	–	1	–	1	–	2	–	
Arianta arbustorum (Linné, 1758)	–	–	–	7	–	–	–	2	–	
Arion fuscus (Draparnaud, 1805)	–	–	–	–	–	–	–	1	–	
Chondrina clienta (Westerlund, 1883)	8	7	2	–	–	–	–	–	–	
Clausilia parvula Férussac, 1807	1	2	1	–	–	–	–	–	–	
Cochlodina laminata (Montagu, 1803)	–	–	–	–	–	–	–	–	1	
Deroceras reticulatum (O. F. Müller, 1774)	–	–	–	–	–	–	–	–	3	
Discus perspectivus (M. von Mühlfeld, 1816)	1	–	–	–	–	–	–	–	–	
Discus rotundatus (O. F. Müller, 1774)	–	–	–	–	–	–	–	–	2	
Ena montana (Draparnaud, 1801)	–	–	–	–	–	–	–	–	1	
Eucobresia diaphana (Draparnaud, 1805)	–	–	–	–	–	–	–	1	–	
Eucobresia nivalis (Dumont & Mortillet, 1854)	–	–	–	–	–	–	–	1	–	
Euconulus fulvus (O. F. Müller, 1774)	2	–	–	–	–	–	–	–	–	
Faustina faustina (Rossmässler, 1835)	–	–	–	–	–	–	–	2	–	
Granaria frumentum (Draparnaud, 1801)	9	9	3	–	–	2	–	–	–	
Helicigona lapicida (Linné, 1758)	1	–	1	–	–	–	–	–	–	
Helicodonta obvoluta (O. F. Müller, 1774)	–	1	–	–	–	–	–	–	–	
Isognomostoma isognomostomos (Schröter, 1784)	–	–	–	3	–	1	–	–	–	
Limax cinereoniger Wolf, 1803	1	–	–	–	–	–	–	–	1	
Monachoides incarnatus (O. F. Müller, 1774)	–	1	1	–	–	–	–	–	–	
Oxychilus cellarius (O. F. Müller, 1774)	–	–	–	–	–	–	–	1	2	
Pupilla sterrii (Voith, 1840)	3	1	1	–	–	1	–	–	–	
Pyramidula pusilla (Vallot, 1801)	7	1	14	–	–	2	–	–	–	
Semilimax semilimax (J. Férussac, 1802)	–	–	–	–	–	–	–	1	1	
Truncatellina cylindrica (A. Férussac, 1807)	2	–	1	–	–	–	–	–	–	
Vallonia costata (O. F. Müller, 1774)	2	3	2	–	–	1	–	–	–	
Vertigo pusilla O. F. Müller, 1774	–	1	1	–	–	–	–	–	–	
Vitrea crystallina (O. F. Müller, 1774)	–	–	–	–	–	–	–	2	1	
Vitrina pellucida (O. F. Müller, 1774)	–	2	3	–	–	3	–	–	–	
Araneae										
Agroeca cuprea Menge, 1873	2	–	–	–	–	–	–	–	–	
Alopecosa pulverulenta (Clerck, 1757)	–	1	–	–	–	–	–	–	–	
Amaurobius jugorum L. Koch, 1868	4	–	–	–	–	–	–	–	–	
Arctosa lutetiana (Simon, 1876)	4	1	–	–	–	–	–	–	–	Th
Ballus chalybeius (Walckenaer, 1802)	1	–	–	–	–	–	–	–	–	
Callilepis schuszteri (Herman, 1879)	–	9	2	–	–	–	–	–	–	Th
Centromerus arcanus (O. P.-Cambridge, 1873)	–	–	–	3	–	–	–	2	1	
Centromerus sellarius (Simon, 1884)	–	–	–	–	–	6	–	–	–	
Ceratinella major Kulczyński, 1894	–	–	–	–	–	–	–	–	1	
Clubiona terrestris Westring, 1851	–	–	–	–	–	–	–	1	–	
Coelotes terrestris (Wider, 1834)	3	–	–	–	–	–	–	–	–	
Crustulina guttata (Wider, 1834)	–	1	–	–	–	–	–	–	–	
Cybaeus angustiarum L. Koch, 1868	–	–	–	1	–	–	–	–	4	

Species	U1	U2	U3	M1	M2	M3	L1	L2	L3	Eco
Diplocephalus latifrons (O. P.-Cambridge, 1863)	–	–	–	–	–	–	–	–	2	
Diplocephalus picinus (Blackwall, 1841)	–	–	–	–	–	–	–	–	5	
Diplostyla concolor (Wider, 1834)	–	–	–	–	–	–	–	–	1	
Drassodes lapidosus (Walckenaer, 1802)	–	29	1	–	–	–	–	–	–	Th
Dysdera lantosquensis Simon, 1882	–	1	1	–	–	–	–	–	–	
Dysdera moravica Řezáč, 2014	–	1	–	–	–	–	–	–	–	Th
Haplodrassus silvestris (Blackwall, 1833)	–	1	–	–	–	–	–	–	–	
Harpactea hombergi (Scopoli, 1763)	1	1	1	–	–	–	–	–	–	
Harpactea lepida (C. L. Koch, 1838)	–	1	–	–	2	1	–	1	5	
Heliophanus aeneus (Hahn, 1832)	–	8	–	–	–	–	–	–	–	Th
Histopona torpida (C. L. Koch, 1837)	–	–	–	–	–	–	–	1	–	
Inermocoelotes inermis (L. Koch, 1855)	–	–	–	–	–	–	–	1	1	
Liocranum rupicola (Walckenaer, 1830)	1	4	1	–	–	–	–	–	–	
Macrargus rufus (Wider, 1834)	–	–	–	–	–	–	1	–	–	
Neriene radiata (Walckenaer, 1841)	–	–	1	–	–	–	–	–	–	
Paidiscura pallens (Blackwall, 1834)	–	–	1	–	–	–	–	–	–	
Palliduphantes alutacius (Simon, 1884)	–	–	–	–	–	1	–	–	1	
Pholcus opilionoides (Schrank, 1781)	–	2	–	–	–	–	–	–	–	
Pisaura mirabilis (Clerck, 1757)	–	1	–	–	–	–	–	–	–	
Platnickina tincta (Walckenaer, 1802)	–	–	–	–	–	–	–	1	–	
Saaristoa firma (O. P.-Cambridge, 1905)	–	–	–	–	–	–	–	–	1	
Saloca diceros (O. P.-Cambridge, 1871)	–	–	–	–	–	–	–	–	5	
Segestria senoculata (Linné, 1758)	–	1	–	–	–	–	–	–	–	
Tegenaria silvestris L. Koch, 1872	–	1	–	–	–	–	–	–	–	
Tenuiphantes cristatus (Menge, 1866)	–	–	–	–	–	–	–	–	1	
Tenuiphantes zimmermanni (Bertkau, 1890)	–	–	–	–	–	–	–	–	1	Mt
Textrix denticulata (Olivier, 1789)	2	2	3	–	–	–	–	–	–	
Theridion varians Hahn, 1833	–	–	1	–	–	–	–	–	–	
Trachyzelotes pedestris (C. L. Koch, 1837)	1	6	2	–	–	–	–	–	–	Th
Xerolycosa nemoralis (Westring, 1861)	–	3	–	–	–	–	–	–	–	
Walckenaeria dysderoides (Wider, 1834)	–	–	–	–	–	–	–	1	–	
Xysticus luctuosus (Blackwall, 1836)	–	1	–	–	–	–	–	–	–	
Zelotes apricorum (L. Koch, 1876)	1	11	–	–	–	–	–	–	–	Th
Zelotes aurantiacus Miller, 1967	–	3	–	–	–	–	–	–	–	
Zodarion germanicum (C. L. Koch, 1837)	2	3	3	–	–	–	–	–	–	Th
Zora nemoralis (Blackwall, 1861)	–	1	–	–	–	–	–	–	–	
Opiliones										
Lacinius dentiger (C. L. Koch, 1848)	1	–	6	–	–	1	–	–	–	
Mitostoma chrysomelas (Hermann, 1804)	–	–	–	–	–	–	–	–	1	
Nemastoma lugubre (Müller, 1776)	–	–	–	1	3	2	–	–	–	
Oligolophus tridens (C. L. Koch, 1836)	–	–	–	–	–	1	–	1	–	
Paranemastoma quadripunctatum (Perty, 1833)	–	–	–	10	–	–	–	7	3	
Trogulus tricarinatus (Linné, 1767)	–	–	–	–	–	–	–	–	1	
Pseudoscorpiones										
Chthonius fuscimanus Simon, 1900	–	–	–	–	–	5	–	–	–	
Chthonius tetrachelatus (Preyssler, 1790)	–	1	2	–	–	–	–	–	–	
Neobisium carcinoides (Hermann, 1804)	–	–	–	1	–	1	–	–	–	

Species	U1	U2	U3	M1	M2	M3	L1	L2	L3	Eco
Oniscidea										
Armadillidium vulgare (Latreille, 1804)	–	1	–	7	15	35	–	–	1	
Hyloniscus riparius (C. Koch, 1838)	–	–	–	–	–	11	–	7	5	
Lepidoniscus minutus (C. Koch, 1838)	–	–	–	–	6	–	–	–	–	
Ligidium germanicum Verhoeff, 1901	–	–	–	–	–	2	–	21	3	
Oniscus asellus Linné, 1758	–	–	–	–	4	–	–	1	1	
Porcellio spinicornis Say, 1818	4	3	3	–	–	–	–	–	–	Th
Protracheoniscus politus (C. Koch, 1841)	–	–	–	2	13	11	–	1	–	
Trichoniscus pusillus Brandt, 1833	–	–	–	–	–	–	–	4	3	
Diplopoda										
Enantiulus nanus (Latzel, 1884)	1	–	–	–	–	–	–	3	–	
Glomeris connexa C. L. Koch, 1847	1	–	–	2	–	1	–	–	–	
Glomeris hexasticha Brandt, 1833	2	–	–	1	–	–	–	2	–	
Glomeris pustulata Latreille, 1804	10	7	7	–	–	–	–	–	1	
Glomeris tetrasticha Brandt, 1833	–	1	–	–	–	–	–	–	–	
Haploporatia eremita (Verhoeff, 1909)	–	–	–	–	–	–	–	1	2	
Leptoiulus trilobatus (Verhoeff, 1894)	–	–	–	2	–	6	–	3	32	Mt
Listrocheiritium septentrionale Gulička, 1965	–	–	–	–	–	4	2	4	4	
Ochogona caroli (Rothebuehler, 1900)	–	–	–	–	–	1	–	–	–	
Ommatoiulus sabulosus (Linné, 1758)	12	19	23	–	–	–	–	–	–	Th
Polydesmus complanatus (Linné, 1761)	–	–	–	2	–	3	–	–	–	
Trachysphaera costata (Waga, 1857)	–	–	–	–	–	2	–	–	–	
Chilopoda										
Lithobius agilis C. L. Koch, 1847	–	–	–	–	2	–	–	–	–	
Lithobius lucifugus L. Koch, 1862	–	–	–	–	1	1	–	–	–	Tr
Lithobius mutabilis L. Koch, 1862	–	–	–	–	3	2	–	–	–	
Lithobius muticus C. L. Koch, 1847	–	–	2	–	–	2	–	–	1	
Lithobius nodulipes Latzel, 1880	–	–	–	–	3	–	–	–	–	
Lithobius tenebrosus Meinert, 1872	1	–	–	–	–	–	–	–	–	
Strigamia acuminata (Leach, 1815)	–	–	–	–	–	3	–	–	–	
Coleoptera										
Abax ovalis (Duftschmid, 1812)	–	–	–	–	–	–	–	1	5	
Abax parallelepipedus (Piller & Mitterpacher, 1783)	–	–	2	17	32	–	2	4	34	
Abax parallelus (Duftschmid, 1812)	–	–	–	–	–	–	–	–	1	
Acidota cruentata (Mannerheim, 1831)	–	–	–	–	–	–	–	1	–	
Agrypnus murinus (Linné, 1758)	–	1	–	–	–	–	–	–	–	
Alosterna tabacicolor (De Geer, 1775)	1	–	–	–	–	–	–	–	–	Th
Amara ovata (Fabricius, 1792)	–	–	–	1	–	–	–	–	–	
Amara similata (Gyllenhal, 1810)	–	–	–	–	1	–	–	–	–	
Anoplotrupes stercorarius (Hartmann, 1791)	–	–	–	4	1	–	–	–	–	
Anotylus rugosus (Fabricius, 1775)	–	–	–	–	–	–	–	–	1	
Anthobium atrocephalum (Gyllenhal, 1827)	–	–	–	–	–	–	–	–	8	
Aphthona pygmaea (Kutschera, 1861)	–	–	1	–	–	–	–	–	–	
Aphthona venustula Kutschera, 1861	1	–	–	–	–	–	–	–	–	
Aphthona violacea (Koch, 1803)	–	–	1	–	–	–	–	–	–	

Species	U1	U2	U3	M1	M2	M3	L1	L2	L3	Eco
Aptinus bombarda (Illiger, 1800)	–	–	–	–	16	–	–	–	–	
Athous haemorrhoidalis (Fabricius, 1801)	1	–	–	–	–	–	–	–	–	
Atomaria badia Erichson, 1846	–	–	–	–	–	–	1	–	–	
Barypeithes chevrolati (Boheman, 1843)	–	–	–	–	–	–	–	1	2	
Barypeithes mollicomus (Ahrens, 1812)	–	1	–	–	–	–	–	–	2	
Barypeithes pellucidus (Boheman, 1843)	5	3	–	–	–	–	–	–	–	
Byrrhus luniger Germar, 1817	–	–	–	–	–	–	–	1	–	
Carabus convexus convexus Fabricius, 1775	–	–	1	–	–	–	–	1	1	
Carabus glabratus glabratus Paykull, 1790	–	–	–	–	–	–	1	–	–	
Carabus irregularis irregularis Fabricius, 1792	–	–	–	3	–	–	–	–	–	
Cartodere nodifer (Westwood, 1839)	–	–	–	–	–	–	–	4	–	
Catops picipes (Fabricius, 1792)	–	2	–	–	–	–	–	–	1	
Catops tristis tristis (Panzer, 1794)	–	–	–	–	–	2	–	–	–	
Cetonia aurata (Linné, 1758)	–	1	–	–	–	–	–	–	–	
Ceutorhynchus pallidactylus (Marsham, 1802)	–	–	–	–	–	–	–	1	–	
Chaetocnema picipes Stephens, 1831	–	–	–	1	–	–	–	–	–	
Choleva nivalis (Kraatz, 1856)	–	–	–	–	–	1	–	–	–	Mt
Cychrus attenuatus (Fabricius, 1792)	–	–	–	–	–	–	–	1	1	
Cychrus caraboides Linné, 1758	–	–	–	4	–	–	–	–	1	
Danacea pallipes (Panzer, 1793)	1	1	–	–	–	–	–	–	–	Th
Dinerella vincenti Johnson, 2007	–	–	–	–	–	–	–	1	–	
Domene scabricollis (Erichson, 1840)	–	–	–	–	1	–	–	–	–	
Eusphalerum sorbi (Gyllenhal, 1810)	–	–	–	–	–	–	–	1	–	
Glischrochilus quadrisignatus (Say, 1835)	–	–	1	1	–	1	–	–	–	
Hermeophaga mercurialis (Fabricius, 1792)	1	–	–	–	–	–	–	–	–	
Idolus picipennis (Bach, 1852)	2	2	–	–	–	–	–	–	–	
Ischnosoma longicorne (Mäklin, 1847)	–	–	–	–	1	–	–	–	–	
Isomira murina (Linné, 1758)	1	–	–	–	–	–	–	–	–	
Lagria hirta (Linné, 1758)	1	1	2	–	–	–	–	–	–	
Leistus piceus piceus Frölich, 1799	–	–	–	4	–	–	–	1	2	
Lesteva longoelytrata (Goeze, 1777)	–	–	–	–	–	–	2	1	2	
Longitarsus kutscherai (Rye, 1872)	–	–	–	–	–	–	–	1	–	
Longitarsus melanocephalus (De Geer, 1775)	–	–	–	1	–	–	–	–	–	
Longitarsus nigrofasciatus (Goeze, 1777)	–	–	–	–	–	–	–	–	1	
Longitarsus parvulus (Paykull, 1799)	–	–	–	1	–	–	–	2	2	
Lordithon lunulatus (Linné, 1760)	–	–	–	1	–	–	–	–	–	
Lycoperdina bovistae (Fabricius, 1792)	–	1	–	–	1	–	–	–	1	
Megarthrus depressus (Paykull, 1789)	–	–	–	–	–	–	–	–	1	
Megasternum concinum (Marsham, 1802)	–	–	–	–	–	18	–	1	6	
Melanotus crassicollis (Erichson, 1841)	–	5	–	–	–	–	–	–	–	Th
Meligethes brunnicornis Sturm, 1845	–	1	–	–	–	–	–	–	–	
Molops elatus (Fabricius, 1801)	–	–	–	–	–	–	1	–	–	
Molops piceus piceus (Panzer, 1793)	–	1	–	–	–	–	–	–	1	
Mycetoporus niger Fairmaire & Laboulbéne, 1856	–	–	–	1	–	–	–	–	13	
Nedyus quadrimaculatus (Linné, 1758)	–	–	–	–	–	–	–	1	1	
Ocypus macrocephalus (Gravenhorst, 1802)	–	–	–	2	–	–	1	3	9	
Ocypus tenebricosus Gravenhorst, 1846	1	–	–	–	–	1	–	–	1	
Oiceoptoma thoracicum (Linné, 1758)	–	–	–	2	–	–	–	–	–	
Omalium caesum (Gravenhorst, 1806)	–	–	–	4	–	9	26	6	94	

Species	**U1**	**U2**	**U3**	**M1**	**M2**	**M3**	**L1**	**L2**	**L3**	**Eco**
Omalium excavatum Stephens, 1834	–	–	–	–	–	1	6	–	20	
Omalium rivulare (Paykull, 1789)	–	–	2	–	–	7	–	–	–	
Omalium rugatum Mulsant & Rey, 1880	–	–	–	1	–	1	1	1	–	
Otiorhynchus laevigatus (Fabricius, 1792)	–	–	–	–	–	–	–	–	1	
Philonthus decorus (Gravenhorst, 1802)	–	1	–	5	–	15	–	1	–	
Phyllotreta nigripes (Fabricius, 1775)	–	–	–	2	–	–	1	1	–	
Phyllotreta vittula (Redtenbacher, 1849)	–	–	–	–	–	–	–	–	3	
Platycerus caraboides (Linnaeus, 1758)	–	–	–	–	–	–	–	–	1	
Polydrusus picus (Fabricius, 1792)	1	–	–	–	–	–	–	–	–	
Proteinus atomarius Erichson, 1840	–	–	–	–	1	1	–	–	–	
Proteinus crenulatus Pandellé, 1867	–	–	–	–	–	2	–	–	–	
Proteinus laevigatus Hochhut, 1872	–	–	–	–	–	1	–	–	–	
Pterostichus burmeisteri Heer, 1841	–	–	–	–	2	6	–	–	–	
Quedius fuliginosus (Gravenhorst, 1802)	–	–	–	–	–	–	–	–	3	
Quedius fumatus (Stephens, 1833)	–	–	–	–	–	–	–	–	1	
Quedius limbatus (Heer, 1839)	–	–	–	–	–	–	–	–	3	
Quedius mesomelinus (Marsham, 1802)	–	–	–	–	–	–	–	1	7	
Quedius paradisianus (Heer, 1839)	–	–	–	–	–	–	–	–	1	
Quedius suturalis Kiesenwetter, 1847	–	–	–	–	–	–	–	–	9	
Rugilus rufipes Germar, 1836	–	–	1	–	–	–	–	–	–	
Scaphisoma boleti (Panzer, 1793)	–	–	–	–	–	–	–	–	1	
Scopaeus cognatus (De Geer, 1775)	1	–	–	–	–	–	–	–	–	
Scopaeus sulcicollis (Stephens, 1833)	2	–	–	–	–	–	–	–	–	
Syntomium aeneum (P. Műller, 1821)	–	–	–	–	–	–	1	–	1	
Tachinus laticollis Gravenhorst, 1802	–	–	–	4	–	–	–	–	10	
Tachinus pallipes pallipes (Gravenhorst, 1806)	–	–	–	–	–	1	–	–	–	
Tachinus rufipennis Gyllenhal, 1810	–	–	–	–	–	–	–	–	2	
Tachinus rufipes (Linné, 1758)	–	–	–	1	–	–	–	–	–	
Tachyporus atriceps Stephens, 1832	–	–	–	–	–	–	–	1	–	
Tachyporus obtusus (Linné, 1767)	–	–	–	–	–	–	–	–	3	
Tasgius winkleri Bernahuer, 1906	–	1	–	–	–	–	–	–	–	
Trechus pilisensis sudeticus Csiki, 1975	–	–	–	3	–	1	–	–	1	
Trechus pulchellus Putzeys, 1846	–	–	–	3	–	–	–	2	19	
Trechus quadristriatus (Schrank, 1781)	–	–	–	–	–	–	–	–	1	
Trichotichnus laevicollis (Duftschmid, 1812)	–	–	–	3	–	–	–	–	2	
Formicidae										
Camponotus ligniperdus (Latreille, 1802)	1	16	23	–	–	–	–	–	–	
Dolichoderus quadripunctatus (Linnaeus, 1771)	–	1	1	–	–	–	–	–	–	
Formica fusca Linné, 1758	2	–	1	–	–	–	–	–	–	
Lasius emarginatus (Olivier, 1792)	4	55	14	–	–	–	–	–	–	
Myrmica sabuleti Meinert, 1861	–	2	6	–	–	–	–	–	–	
Ponera coarctata Latreille, 1802	–	1	–	–	–	–	–	–	–	
Temnothorax crassispinus (Karavaiev, 1926)	1	1	1	–	–	–	–	–	–	
Temnothorax unifasciatus (Latreille, 1798)	–	24	–	–	–	–	–	–	–	