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Terrestrial isopods in the Western Carpathians

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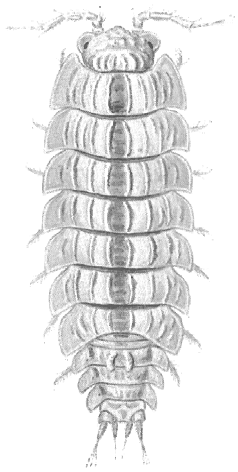

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Abstrakt

Predložená diplomová práca sa skladá z dvoch samostatných manuskriptov, pričom obidva pojednávajú o suchozemských rovnakonôžkach v Západných Karpatoch.

Prvý manuskript sa zaoberá spoločenstvami suchozemských rovnakonožiek Bílých Karpát, s ohľadom na ich rozšírenie v Západných Karpatoch. Výskum prebiehal na 26 lokalitách (lesné, lúčne aj zmiešané biotopy) a študovaní živočíchovia boli získavaní v období rokov 2003 až 2009 pomocou 4 metód odchytu: zemné pasce, tepelná extrakcia pôdnych vzoriek, tepelná extrakcia priesevov opadu a individuálny zber. Celkovo bolo zaznamenaných 16 druhov a boli nájdené bohaté spoločenstvá (7-10 druhov na polovici lokalít). Medzi spoločenstvami obývajúcimi lesy a spoločenstvami lúk a pastvín existujú rozdiely. *Armadillidium vulgare* a *Trachelipus rathkii* prevládali na lúkach a pastvinách, zatiaľčo *Protracheoniscus politus* a *Ligidium hypnorum* dominovali v lesoch. Najzaujímavejšími faunistickými výsledkami boli nálezy 2 reliktných druhov a to karpatský endemit *Hyloniscus mariae* a *Ligidium germanicum*, ktorý má v Českej Republike len ploškovité rozšírenie.

V druhom manuskripte sa pojednáva o spoločenstvách suchozemských rovnakonožiek v dubovo-hrabových lesoch na území Bratislavy. Živočíchovia boli zbieraní pomocou metódy priesevu opadu v rokoch 1999, 2000, 2005 a 2006 na 8 lokalitách, pričom väčšina lokaliít prináleží Malých Karpatom. Hodnotenými environmentálnymi faktormi boli vek lesa, krovinové poschodie, pH, obsah dusíka a množstvo humusu v pôde. Celkovo sme získali 10 druhov a relatívne bohaté spoločenstvá (3-7 druhov), ale zložené s bežných druhov. *Protracheoniscus politus* a *Porcellium collicola* boli najpočetnejšími druhmi. Medzi spoločenstvami prírodných a antropogénnych lokalít boli nájdené malé rozdiely. Mnohorozmerné techniky potvrdili vek lesa, krovinové poschodie a pH ako najdôležitejšie faktory, ktoré ovplyvňujú štruktúru spoločenstiev.

Kľúčové slová: žižiavky, Oniscidea, Bílé Karpaty, Malé Karpaty, Západné Karpaty

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Abstract

The submitted thesis is composed of two individual manuscripts and both deal with the terrestrial isopods in the Western Carpathians.

The first manuscript is devoted to terrestrial isopod communities of the White Carpathians with regard to distribution of woodlice in the Western Carpathians. Research was conducted in 26 localities (forests, meadows and mixture of biotopes) and studied animals were obtained between year 2003 and 2009 by using 4 methods: pitfall traps, heat extraction of soil samples, heat extraction of sieved litter and manual sampling. In total, 16 species were recorded and rich communities were found (7-10 species on half of localities). There are some differences between communities inhabiting forests and these inhabiting meadows or pastures. Armadillidium vulgare and *Trachelipus rathkii* predominated on White Carpathian meadows and pastures, while *Protracheoniscus politus* and *Ligidium hypnorum* predominated in forest habitats. The most interesting faunistical records are two relic species, Carpathian endemit *Hyloniscus mariae* and *Ligidium germanicum* (in the Czech Republic found with only patchy distribution).

The second manuscript is devoted to the communities of terrestrial isopods in oak-hornbeam forests on the territory of Bratislava. Animals were collected, using a method of litter sifting, in years 1999, 2000, 2005 and 2006, in 8 localities, where majority of studied localities belongs to the Little Carpathians. The evaluated environmental characteristics were the age of forest, cover of shrub layer, pH, content of nitrogen and amount of humus in soil. Overall we recorded 10 species. Relatively rich communities were found (3-7 species), but they were composed mainly of common species. *Protracheoniscus politus* and *Porcellium collicola* were the most abundant species. There are little differences in composition of communities between natural and anthropogenized sites. Multivariate techniques revealed that age of the forest, shrub layer and pH are the most important environmental factors influencing structure of assemblages.

Key words: woodlice, Oniscidea, White Carpathians, Little Carpathians, Western Carpathians

Declaration

I, Jana Štrichelová, hereby proclaim that I made this study on my own, under the supervision of Dr. Ivan H. Tuf and using only cited material.

In Olomouc, May 3, 2010

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I would like to thank to my thesis supervisor Ivan H. Tuf for dedication to the issue of soil fauna, patience, willingness, comprehensive support and help throughout this study. I would like to thank Dr. Karel Tajovský, Dr. Andrej Mock, Dr. Ferenc Vilisics and Dr. Milada Holecová for the data and literature provided, Marek Soviš for collecting part of material, Marea Grinvald and Bojana Božanić for helping with correcting the English in the manusrcripts. Furthermore, I thank my whole family, boyfriend and friends for their support.

1 Introduction

The submitted thesis is composed of two individual manuscripts. The first manuscript is devoted to terrestrial isopod communities of the White Carpathians with regard to distribution of woodlice in the Western Carpathians. The second manuscript deals with communities of terrestrial isopods in oak-hornbeam forests on the territory of Bratislava, while majority of localities lies in the area of the Little Carpathians. The aim of both studies was to contribute to the knowledge of Carpathian isopod fauna; the results of our work can provide good backround information about the part of Western Carpathian isopoda and allow comparative analysis with other parts.

The Carpathians form a great natural formation in southern and eastern part of Central Europe. Out of all the basic formations in Europe (Král 1999), this area (together with the Alps) is the most vertically and horizontally segmented. During the glacial periods, the Carpathians represented refugias for a great number of plant and animal species and the region from where the postglacial flora and fauna were spreading. The Carpathians are included in the list of global biodiversity hot spots as one of the world's key Palaearctic montane ecoregions. Owing to its relatively intact habitats and particularly extensive forest complexes, the Carpathians are one of Europe's most valuable refugia of primeval forest fauna (Witkowski et al. 2003). Carpathians has a remarkable natural and cultural heritage and represents unique ecosystem with an exceptionally high biological diversity rate. A considerable high number of endangered species and nearly 4,000 endangered plant species, can be found in the Carpathians. Speaking in numbers, that is almost 30% of the total European flora (Ruffini et al. 2006).

Investigations prove that woodlice play an important role in decomposition of dead plant material (Hassall et al. 1987). Terrestrial isopods represent one of the main groups of the soil macrofauna, which are taking part in the proceses of soil-forming and decomposition, nevertheless this group is still a bit neglected by the research works. Our knowledge of Central and Eastern European distribution of isopods is far from comprehensive. The noticeable development in isopod studies in all Carpathian countries started after the political changes in 1989. However, there is still majority of biodiversity valuable areas, which are insufficiently explored from the soil fauna point of view. Our work can provide essential data, contributing to the knowledge of the Carpathian isopod fauna.

References

Hassall, M., Turner, J.G., Rands, M.R.W. (1987): Effects of the terrestrial isopods on the decomposition of woodland leaf litter. Oecologia, 72: 597-604.

Král, V. (1999): Fyzická geografie Evropy, Academia Praha.

Ruffini, F.V., Streifeneder, T., Eiselt, B. (2006): Implementing an international mountain convention – An approach for the delimitation of the Carpathian Convention area. European Accademy, Bolzano/Bozen.

Witkowski Z.J., Król W., Solarz W. (eds.). (2003): Carpathian List Of Endangered Species. WWF and Institute of Nature Conservation, Polish Academy of Sciences, Vienna-Krakow

2 Terrestrial isopods (Isopoda: Oniscidea) of the White Carpathians (Czech Republic), with regard to distribution of woodlice in the Western Carpathians

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Abstract
This paper presents data concerning terrestrial isopods of the White Carpathians, investigated during years 2003-2009 on 26 meadow/pasture as well as forest localities. By using combination of 4 methods, we recorded 16 species, belonging to 8 families. The most common species were *Protracheoniscus politus*, *Trachelipus rathkii* and *Ligidium hypnorum.* Generally speaking, woodlice communities in this area are very rich; for example, half of the explored communities consisted of 7-10 species. Communities are influenced by character of the biotope and geographical location. Communities situated in the forest ecosystems were considerably richer than ones, found in the meadow/pasture ecosystems. We would like to emphasize high nature conservancy value of the area, as we found lack of introduced and cosmopolitan species as well as 2 relic species (*Hyloniscus mariae* and *Ligidium germanicum*).

Key words: Isopoda, Oniscoidea, woodlice, White Carpathians, Western Carpathians

Introduction
The Carpathians form a great natural formation in southern and eastern part of Central Europe. Out of all the basic formations in Europe, this area (together with the Alps) is the most vertically and horizontally segmented (Král 1999). The main reason for this segmentation phenomenon is its age, which ranks it among one of the youngest parts of Europe. At the very end of Tertiary, the sea retreated from lowlands and basins surrounded by mountain parts of Carpathians, which previously elevated at the end of

Mesozoic. During the glacial periods, the Carpathians represented refugia for a great number of plant and animal species and the region from where the postglacial flora and fauna were spreading.

The Carpathian range measures app. 1500 km and extends on the area of 203 000 km^2. There exists no standardized division of the Carpathians area, accepted in all Carpathian countries. According to the Czech, Slovak and Polish geography, the entire Carpathian chain is usually divided into the three major parts (see Figure 1): the Western Carpathians (Czech Republic, Poland, Slovakia, Hungary), the Eastern Carpathians (SE Poland, eastern Slovakia, Ukraine, Romania), and the Southern Carpathians (Romania, Serbia). It has to be mentioned that Romanian geography divides Carpathians into the Western, Southern, Eastern and Northern, which are according to our conception Western (Král 1999).

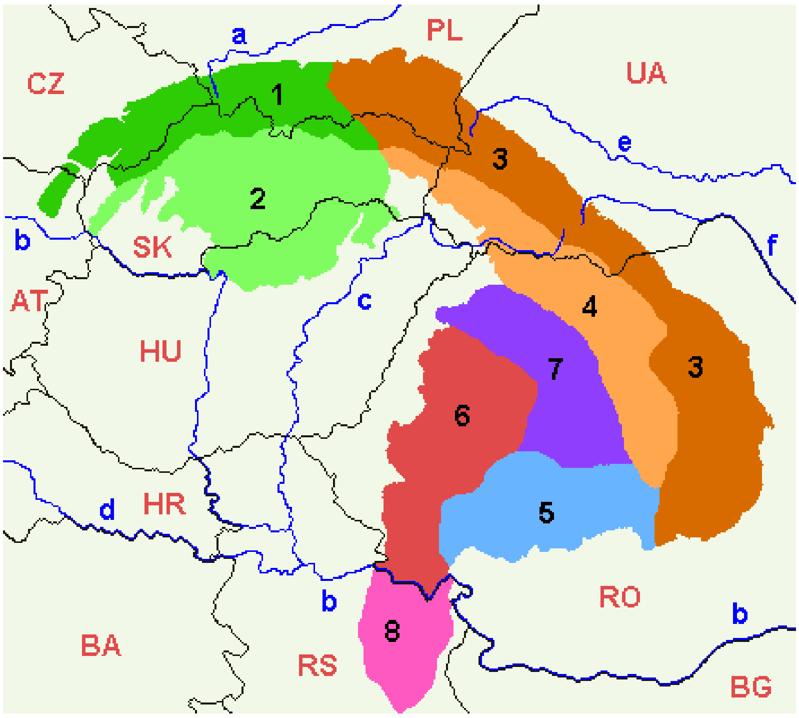


Figure 1: Division of the Carpathians. 1=Outer Western Carpathians, 2=Inner Western Carpathians, 3=Outer Eastern Carpathians, 4=Inner Eastern Carpathians, 5=Southern Carpathians, 6=Western Romanian Carpathians, 7=Transylvanian Plateau, 8=Serbian Carpathians, a=Vistula, b=Danube, c=Tisza, d=Sava, e=Dnestr, f=Prut, CZ=Czech Republic, SK=Slovakia, PL=Poland, UA=Ukraine, RO=Romania, AT=Austria, HU=Hungary, HR=Croatia, BA= Bosnia and Herzegovina, RS=Serbia, BG=Bulgaria (sensu http://en.wikipedia.org)

According to wikipedia, the geological border between the Western and Eastern Carpathians runs approximately along the line (south to north) between the towns Michalovce - Bardejov - Nowy Sącz - Tarnów. In older systems the border runs more to the east – at the line (north to south) along the rivers San and Osława (PL) – the town of

Snina (SK) – river Tur'ia (UA). Biologists, however, shift the border even further to the east.

In the target area, the Western Carpathians, we can distinguish 4 geological zones: outer flysh zone, zone with isolated limestone rocks, central zone with transformed and underground ingenous rocks and limestone sediments and inner zone with overground ingenous rocks. The area of the Western Carpathians comprises about 70,000 km².

In this paper I would like to summarise studies about terrestrial isopods in the Western Carpathians. The area of the Western Carpathians stretches on the territory of 4 states, mostly on Slovakian territory. Other parts of the Western Carpathians are situated in the Eastern part of Moravia in the Czech Republic, northern part of Hungary and southern part of Poland. Existing data about terrestrial isopods from the Western Carpathians are presented in the Table 1 (shortened data).

The noticeable development in isopod studies in all these countries started after the political changes in 1989. The importance of nature conservation became stronger and the new governments initiated the establishment of many new nature reserves. The first step of natural protection measures was the precise assesment of the species richness. There is still majority of valuable areas, in the biodiversity sense, which are insufficiently researched from the soil fauna point of view.

Terrestrial isopods represent one of the main groups of the soil macrofauna, which are taking part in the proceses of soil-forming and decomposition. It is appropriate group for research, knowing that they are ecologically important decomposers and that some of the species are considered as bioindicators (Hopkin et al. 1986, Paoletti & Hassal 1999). Further, simple and economically undemanding methods can be used for study (Tufová & Tuf 2003). Terrestrial isopods inhabit different types of biotopes from lowlands to hills, from grassland to forests.

For comprehension of ecological demands and distribution of species, it is important to study fauna on larger geographical units by obtaining numerous material of specimens and using many different methods on different biotopes (Šťáhlavský & Tuf 2009). Terrestrial isopods of the Czech Republic were explored this way in the northwestern Bohemia (Flasarová 1995), the southern Moravia (Tajovský 1998a), Labské pískovce PLA (Tajovský 1997), Pálava PLA (Tajovský 1995), Podyjí NP (Tajovský 1998b) and Kokořínsko PLA (Tajovský 2006).

In this study we present data trying to cover most of the biotope types of the White Carpathians. The results of our work can provide good backround information about the part of the Western Carpathian isopoda and permit comparative analysis with other parts.

Czech Republic

Western Carpathians cover the area of eastern part of Moravia. Exploration of isopod fauna in the Czech part of Carpathians was initiated by Frankenberger (1941, 1942, 1944, 1954, 1959). He states findings of several species for Pálava hills, Chřiby, Vsetínske vrchy Hills, Vizovice, Beskydy and White Carpathians. One of the most interesting findings was the finding of *Hyloniscus mariae* on Solánec (Vsetínske vrchy Hills). Frankenberger (1944) found new species *Trachelipus difficilis* in Beskydy (mentioned as *T. waechtleri*). Flasarová (1958) investigated isopod fauna in Vsetínske Hills and Chřiby and recorded 10 species, important Carpathian element *Hyloniscus mariae* was present too. Spitzer et al. (2007), who investigated soil fauna in fir-beech forests of the Vsetínske vrchy Hills (by pitfall-trapping only), found 4 isopod species and consider only *Ligidium germanicum* as interesting one.

As for White Carpathians PLA, only Czech side is explored. Tajovský (2008), Tuf (unpublished faunistical inventories), Mikula (2004) and Štrichelová (2008) studied isopods here. Tajovský focused on meadow and grassland localities. He carried out a research within the wide project aiming to find out the options of grazing on permanent grasslands in the White Carpathians, from the biodiversity preserving point of view, as well as economical point of view. Besides the finding of negative impact of intensive grazing on abundance and species richness of soil fauna, he described 14 species of terrestrial isopods in the White Carpathian grasslands. There were found species with wide ecological valence, as well as species with high affinity to woodland or to moisture. Faunistically interesting is discovery of *Ligidium germanicum* in this area, due to its patchy distribution known only from few localities in Moravia and discovery of *Porcellionides pruinosus*, whose northern margin of the natural distribution lies here. Recently Tuf, Mikula and Štrichelová explored mainly forest localities of White Carpathians (8 species found) as a part of faunistical inventories of soil fauna in protected natural sites.

First complex study about isopod fauna of Pálava PLA was made by Tajovský (1995). There were found 16 species, representing 37 % of total number of terrestrial isopods in the Czech Republic. Faunistically interesting are *Armadillidium zenckeri* and *Armadilidium versicolor*, before known only from several localities in the Czech Republic.

As stated in Flasarová (2000), the check-list of terrestrial isopods of the Czech Republic contains 42 species, but after the discovery of new species *Philoscia muscorum* (Saska 2007) this number increased to 43 species. The richest species area is Kokořínsko PLA with 20 species (Tajovský 2006). In term of areas that belong to the Carpathians, the richest areas are Pálava NP and the White Carpathians PLA, both with 16 species.

Slovakia

Western Carpathians cover the main part of Slovakia. Frankenberger (1940) was the first one who studied isopods in this area. He gave the systematic overview of all the discovered species from many different localities. Until then, 34 species were recorded - Carpathian species *Hyloniscus mariae* was found in Tatry (High Tatras), Nízke Tatry (Low Tatras) and Levočské vrchy Hills. Later, Frankenberger (1959) published the monograph Oniscoidea as a part of Fauna of the Czechoslovak Republic, where he mentions rarer findings. In a detailed study Frankenberger (1964) devoted to the systematic appraisal of the Slovak material of the species *Orthometopon planum*.

We can consider the Little Carpathians as the most comprehensive studied area. Flasarová (1980, 1986) described fauna of the terrestrial isopods of the Little Carpathians by intensive sampling on more than 50 localities and had recorded 27 species. She also collected isopods from natural and synanthropic habitats. Interesting species *Hyloniscus transsilvanicus* (single locality in Slovakia) and *Armadillidium zenckneri* were reported. In 2005, Kuracina and Kabátová researched Devínska Kobyla, which belongs to the Little Carpathians and recorded 12 species. Finding of *Trachelipus arcuatus*, *Armadillidium opacum* and *Armadillidium pictum* are very interesting. The other research (Tuf & Tufová 2005) was targeted mainly on description of the communities in oak-hornbeam forests in this area. Štrichelová & Tuf (in press) recorded 10 species in the territory of Bratislava, during the investigation of localities belonging to the Little Carpatthians (except for 2 urban ones). Until now, 30 species were discovered in the Little Carpathians.

Gulička (1985) examined soil and cave macrofauna in Slovak karst regions and recorded 19 terrestrial isopod species for Slovak Karst and 14 species for Muránska planina (Muráň Plain). Flasarová (1994) published data about terrestrial isopods from occasional samplings made by Dr. Ján Brtek, who was collecting woodlice at several localities in Slovakia, during the period 1962-1991. He recorded 20 species living in both natural and synanthropic habitats. In paper about isopods of Danube Lowland, Flasarová (1998) mentioned some records from High and Low Tatras, Slovenský kras (Slovak Karst), Slovenské Rudohorie (Slovak Ore Mountains), Kremnické vrchy (Kremnica Mountains) and Štiavnické vrchy (Štiavnica Mountains). In the last of the mentioned areas, rare species *Trichoniscus noricus* was found. Topp et al. (2006) studied primeval forests situated in Central Slovakia. Beside the description of the impact of coarse woody debris (CWD) on the distribution pattern of isopods and millipedes living on the forest floor, 8 isopod species were recorded. Isopod density was about six times higher at sites close to CWD than at sites distant from CWD. Hudáková & Mock (2006) paid attention to isopods of Pieniny National Park and described 13 species, including Carpathian endemit *Hyloniscus mariae*.

Referring to the interesting species, big focus was put on the Carpathian species *Mesoniscus graniger*, which for a long period of time, was considered to be limited only to cave biotops. In first studies, carried by Strouhal (1939) and Frankenberger (1939), this species was found in Domica, Jasovská and Silická caves. Complete information about this species in Western Carpathians was given by Mlejnek & Ducháč (2001). They pointed out on occurence of *Mesoniscus graniger* in endogenous localities, such as in Nízke Tatry (Low Tatras) and Slovenský raj (Slovak Paradise). The most southern occurence of this species was discovered in Mátra Mountains in Hungary. Comprehensive study about the subterranean fauna in the Western Carpathians was performed by Košel (2007). He described conditions for the research in different historical periods during 150 years, mentioned all the authors who focused on subterranean fauna and all the cavernicolous species found during this period. Important scientists who were engaged in subterranean isopod researches were Gulička, Košel, Kováč, Ľuptáčik, Mock and Papáč.

Altogether there are 46 terrestrial isopod species recorded in Slovakia (Andrej Mock, personal communication). Including synanthropic forms, there are 40 natural and naturalized species. Other 6 species were found only in greenhouses. According to the number of species, the richest areas are Little Carpathians (30 species), Slovak Karst (20 species) and Pieniny (19 species).

Hungary

Farkas (2007) pointed out that real development of studies focused on Hungarian isopods started very late, in 1996. Although the studies about Hungarian woodlice fauna started over 150 years ago, there had been hardly any information about common, rare or characteristic species and their distribution in the country, up to 1996.

Northern Medium Mountains cover northern part of Hungary. It is a separate geomorphological area belonging to the Western Carpathians. First faunistical data on Hungarian terrestrial isopods were focused on subterranean isopod fauna and origin from Aggletek Karst. Aggtelek Karst is geologically connected to the Slovak Karst. Decidous forests with dominance of oak, hornbeam, beech, ash and maple, cover the area. Baradla cave at Aggtelek Karst was investigated by Schmidl (1856), Dudich (1932), Gere (1965) (in Forró & Farkas 1998) and the others. The most comprehensive study of isopods in Hungarian Carpathians was carried out by Vilisics et al. (2008), once again in Aggtelek Karst. Ten species were recorded by manual sampling only. They also found rare and sensitive species such as the only Hungarian endemic isopod *Haplophthalmus hungaricus* or Carpathian element *Trachelipus difficilis*. Considering the information about the low number of cosmopolitan or native generalist isopods, authors asses this area as of high nature conservancy value. This research aimed to discover and observe soil and litter dwelling macroinvertebrates (Mollusca, Isopoda) in and around the dolines of the plateau of Alsó-Hegy with special respect to microhabitat characteristics. This was the first designed faunistic research on surface active oniscids in the Aggtelek Karst area.

Forró & Farkas (1998) formed checklist, distribution maps and bibliography of woodlice in Hungary. In Carpathian part of Hungary, 26 species were recorded. Concerning Bükk Mountains, Ábrahám et al. in 1956 were the first ones to aim their studies on hydrobiological and faunistical research, partly focusing on isopods (Forró & Farkas 1998). More complex study about the terrestrial isopods of Bükk National Park was carried out by Allspach (2006). Fifteen species were recorded. The most notable result is the record of *Armadillidium opacum*, since it was the first time to record it in Hungary.

New species for Hungarian isopod fauna, *Ligidium intermedium* was recorded in Zemplén Mountains, by Kontschán (2002). Later Kontschán (2004) published data about isopod fauna of Hungarian Northern Mountains and recorded 14 species. Csordás et al. (2005) observed 2 rare species in Zemplén Mountains, *Oniscus asellus* and *Protracheoniscus major*.

Up to now, the check-list of Hungarian isopod fauna comprise 57 species (Ferenc Vilisics, personal communication). The areas with the highest rate of species diversity of terrestrial isopods in the Carpathian part of Hungary are Bükk Mountains (24 species) and Aggtelek Karst (20 species).

Poland

Series of mountain ranges in southern part of Poland, called Beskids, belong to the Western Carpathians. Dominiak (1961, 1962, 1970) was engaged in the research of Polish terrestrial isopods. His last comprehensive work (1970) describes all the species inhabiting Poland. *Ligidium germanicum* and *Hyloniscus mariae* appear to be dependent on Carpathian part of Poland. Altogether, There were 14 species recorded in the Carpathian part of Poland.

There are only few recent Polish data about terrestrial isopods in the Western Carpathians. Sywula & Jędryczkowski (2000) published data on crustaceans (including the terrestrial isopods) inhabiting Pieniny. Since 14 species were recorded, they considered this area as one with relatively high rate of species diversity. Rare species *Trichoniscus provisorius* was present. Two species attain the margin of distribution range, *Trachelipus difficilis* (western margin) and *Ligidium germanicum* (northwestern margin).

After Jażdżewski (1997), woodlice fauna of Poland includes 36 species, but the most probably this number needs to be updated. Considering the number of species, Pieniny are the richest Carpathian area in Poland, but this information can be influneced by insufficient data, because no other comprehensive researches in the other Western Carpathian parts of Poland were done.

Table 1: List of terrestrial isopods inhabiting different geographical units in the Western Carpathians. References below the Table 1.

	Pálava[1]	Chřiby[2]	Vsetín Mts[3]	Moravian-Silesian Beskids[4]	Beskids[5]	Tatras[6]	Low Tatras[7]	Pieniny[8]	Veľká Fatra[9]
Armadillidium opacum	-	-	-	-	-	-	-	-	-
Armadillidium pictum	-	-	-	-	-	-	-	-	-
Armadillidium versicolor	+	-	-	-	-	-	+	+	-
Armadillidium vulgare	+	-	-	-	-	-	-	-	-
Armadillidium zenckeri	+	-	-	-	-	-	-	-	-
Cylisticus convexus	+	-	-	-	-	+	+	+	-
Haplophthalmus danicus	-	-	-	-	-	-	-	+	-
Haplophthalmus hungaricus	-	-	-	-	-	-	-	-	-
Haplophthalmus mengii	-	-	-	-	+	-	-	+	-
Haplophthalmus montivagus	-	-	-	-	-	-	-	-	-
Hyloniscus mariae	-	-	+	-	-	+	+	+	-
Hyloniscus riparius	+	-	+	-	-	+	+	+	+
Hyloniscus transsilvanicus	-	-	-	-	-	-	-	-	-
Lepidoniscus minutus	-	+	+	+	+	-	-	+	-
Ligidium germanicum	-	-	+	+	-	+	-	+	-
Ligidium hypnorum	-	-	+	+	-	-	+	+	-
Mesoniscus graniger	-	-	-	-	-	+	+	-	+
Oniscus asellus	+	-	-	-	-	-	-	-	-
Orthometopon planum	-	-	-	-	-	-	-	-	-
Platyarthrus hoffmannseggii	+	-	-	-	-	-	-	-	-
Porcellio laevis	-	-	-	-	-	-	-	-	-
Porcellio montanus	-	-	-	-	-	-	-	-	-
Porcellio scaber	+	-	-	-	-	+	+	+	-
Porcellio spinicornis	+	-	-	-	-	+	+	+	-
Porcellionides pruinosus	+	-	-	-	-	-	+	-	-
Porcellium collicola	+	+	-	-	-	-	-	-	-
Porcellium conspersum	-	-	+	+	-	-	+	+	-
Porcellium recurvatum	-	-	-	-	-	-	-	-	-
Protracheoniscus amoneus	-	-	-	-	-	-	-	-	-
Protracheoniscus major	-	-	-	-	-	-	-	-	-
Protracheoniscus politus	+	+	+	+	+	+	+	+	-
Trachelipus arcuatus	-	-	-	-	-	-	-	-	-
Trachelipus difficilis	-	-	+	+	+	+	-	+	-
Trachelipus nodulosus	+	-	-	-	+	-	-	+	-
Trachelipus rathkii	+	-	-	+	-	+	+	+	-
Trachelipus ratzeburgii	+	-	+	-	-	-	+	+	-
Trichoniscus noricus	-	-	+	-	-	-	-	-	-
Trichoniscus provisorius	-	-	-	-	-	-	-	+	-
Trichoniscus pusillus	+	-	+	-	-	-	+	+	-
Trichoniscus pygmaeus	-	-	-	-	-	-	-	-	-
Number of species	16	3	11	7	5	10	14	19	2

	Malá Fatra[10]	Žilina Basin[11]	Strážov Mts[10]	Little Carpathians[12]	Považský Inovec[13]	Tribeč[13]	Stredné Pohronie[14]	Slovenské stredohorie[15]	Slovak Ore Mts[16]
Armadillidium opacum	-	+	-	+	-	-	-	-	-
Armadillidium pictum	-	-	-	+	-	-	-	-	-
Armadillidium versicolor	-	-	-	+	-	-	-	-	+
Armadillidium vulgare	-	+	-	+	+	+	+	+	-
Armadillidium zenckeri	-	-	-	+	-	-	-	-	-
Cylisticus convexus	-	+	+	+	-	+	+	-	-
Haplophthalmus danicus	-	-	-	+	-	-	-	-	-
Haplophthalmus hungaricus	-	-	-	-	-	-	-	-	-
Haplophthalmus mengii	+	-	+	+	-	-	-	-	+
Haplophthalmus montivagus	-	-	-	-	-	-	-	-	-
Hyloniscus mariae	-	-	-	-	-	-	-	-	-
Hyloniscus riparius	+	+	+	+	+	+	-	-	-
Hyloniscus transsilvanicus	-	-	-	+	-	-	-	-	-
Lepidoniscus minutus	-	-	-	+	-	-	+	-	+
Ligidium germanicum	-	-	-	+	-	-	-	+	-
Ligidium hypnorum	+	+	+	+	+	+	+	+	+
Mesoniscus graniger	-	-	-	-	-	-	-	-	-
Oniscus asellus	-	-	-	+	-	-	-	-	-
Orthometopon planum	-	-	-	+	+	+	+	+	-
Platyarthrus hoffmannseggii	-	-	-	+	-	+	-	-	-
Porcellio laevis	-	-	-	+	-	-	-	-	-
Porcellio montanus	-	+	-	-	-	-	-	-	-
Porcellio scaber	+	+	-	+	-	+	+	+	-
Porcellio spinicornis	+	+	+	+	-	-	+	+	-
Porcellionides pruinosus	-	-	-	+	-	+	-	-	-
Porcellium collicola	-	+	+	+	-	+	+	+	-
Porcellium conspersum	-	-	-	+	+	-	-	-	-
Porcellium recurvatum	-	-	-	-	-	-	-	-	-
Protracheoniscus amoneus	-	-	-	-	-	-	-	-	-
Protracheoniscus major	-	-	-	+	-	-	-	-	-
Protracheoniscus politus	-	+	-	+	+	-	+	+	-
Trachelipus arcuatus	-	-	-	+	-	-	-	-	-
Trachelipus difficilis	-	-	+	-	-	-	-	-	-
Trachelipus nodulosus	-	+	+	+	+	+	+	+	-
Trachelipus rathkii	+	+	+	+	-	-	-	-	-
Trachelipus ratzeburgii	+	+	+	+	+	-	+	+	-
Trichoniscus noricus	-	-	-	-	-	-	-	+	-
Trichoniscus provisorius	-	-	-	-	-	-	-	-	-
Trichoniscus pusillus	-	+	-	+	+	-	-	-	-
Trichoniscus pygmaeus	-	-	-	+	-	-	-	-	-
Number of species	8	14	10	30	9	10	11	12	4

	Muráň Plain[17]	Slovak Karst[18]	Aggtelek Karst[19]	Zemplén Mts[20]	Bükk Mts[21]	Mátra Mts[22]	Karancs Mts[20]	Cserhát Mts[20]	Börzsöny Mts[20]
Armadillidium opacum	-	-	-	-	+	-	-	-	-
Armadillidium pictum	-	-	+	-	+	-	-	-	-
Armadillidium versicolor	+	+	-	-	+	-	-	-	-
Armadillidium vulgare	+	+	+	-	+	-	-	-	-
Armadillidium zenckeri	-	-	-	-	-	-	-	-	-
Cylisticus convexus	+	+	+	-	+	-	+	-	-
Haplophthalmus danicus	-	-	+	-	+	-	-	-	-
Haplophthalmus hungaricus	-	-	+	+	+	-	-	-	-
Haplophthalmus mengii	-	-	+	+	+	+	-	-	+
Haplophthalmus montivagus	-	-	-	-	+	-	-	-	-
Hyloniscus mariae	+	-	-	-	-	-	-	-	-
Hyloniscus riparius	+	+	+	-	+	-	+	+	+
Hyloniscus transsilvanicus	-	-	-	+	+	-	-	-	-
Lepidoniscus minutus	-	+	+	-	+	-	-	-	-
Ligidium germanicum	-	+	-	-	-	-	-	-	-
Ligidium hypnorum	+	+	+	-	+	-	-	-	-
Mesoniscus graniger	+	+	+	+	+	+	-	-	-
Oniscus asellus	-	-	-	+	-	-	-	-	-
Orthometopon planum	-	+	+	+	+	+	-	-	-
Platyarthrus hoffmannseggii	-	+	+	-	-	+	-	-	+
Porcellio laevis	-	-	-	-	-	-	-	-	-
Porcellio montanus	-	-	-	-	-	-	-	-	-
Porcellio scaber	+	+	-	-	+	-	-	-	-
Porcellio spinicornis	+	+	+	-	+	-	-	-	-
Porcellionides pruinosus	-	-	-	-	-	-	-	-	-
Porcellium collicola	-	+	+	-	+	-	+	+	+
Porcellium conspersum	+	+	+	-	+	-	-	-	-
Porcellium recurvatum	-	-	-	-	-	-	-	-	-
Protracheoniscus amoneus	-	-	+	-	+	-	-	+	-
Protracheoniscus major	-	-	-	+	-	-	-	-	-
Protracheoniscus politus	+	+	+	-	+	-	-	+	-
Trachelipus arcuatus	-	+	-	-	-	-	-	-	-
Trachelipus difficilis	-	-	+	-	+	-	-	-	-
Trachelipus nodulosus	-	+	-	-	+	-	-	-	-
Trachelipus rathkii	+	+	-	-	+	-	-	+	-
Trachelipus ratzeburgii	+	+	+	-	-	-	+	-	-
Trichoniscus noricus	-	-	-	+	-	+	-	-	+
Trichoniscus provisorius	-	-	+	-	-	-	-	-	-
Trichoniscus pusillus	-	-	-	-	-	-	-	-	-
Trichoniscus pygmaeus	-	-	-	-	-	-	-	-	-
Number of species	14	20	20	8	24	5	4	5	5

1: Tajovský 1995; 2: Frankenberger 1941, 1942, 1944; 3: Frankenberger 1942, Flasarová 1958, Spitzer et al. 2007; 4: Frankenberger 1941, 1942, 1944, Flasarová 1944; 5: Dominiak 1970 (Beskid Slaski, Wysoki, Sadecki); 6: Frankenberger 1940, Dominiak 1970, Flasarová 1994, 1999, Mlejnek & Ducháč 2001; 7: Frankenberger 1940, Flasarová 1999, Mlejnek & Ducháč 2001; 8: Sywula & Jedryczkowski 2000, Hudáková & Mock 2006 (PL+SK); 9: Flasarová 1994, Mlejnek & Ducháč 2001; 10: Flasarová 1994; 11: Frankenbereger 1940a; 12: Flasarová 1980, 1986, Kuracina & Kabátová 2005; 13: Frankenberger 1940; 14: Frankenberger 1940 (territory of dicstricts Žiar nad Hronom,Banská Štiavnica,Žarnovica and western Zvolen); 15: Flasarová 1994 (Vtáčnik, Kremnica Mts, Štiavnica Mts, Zvolen, Žiar, Javorie); 16: Frankenberger 1940, Flasarová 1999; 17: Gulička 1985; 18: Frankenberger 1940, Flasarová 1994, 1999 , Gulička 1985; 19: Forró & Farkas 1998, Kontschán 2004, Vilisics 2008; 20: Forró & Farkas 1998, Kontschán 2004; 21: Allspach 2006, Forró & Farkas 1998, Kontschán 2004; 22: Forró & Farkas 1998, Mlejnek & Ducháč 2001, Kontschán 2004

Material and methods

The target area, bilateral White Carpathians PLA (in original - CHKO Bílé Karpaty) is situated on the Czech-Slovak border area. The Czech part is 70 km long, with northeast – southwest orientation and altitude varying from 175 to 970 m. PLA was established in year 1980 on the area of 747 km^2. Characteristic feature for southern part is the vast complex of species-rich calcareous meadows, abounding with flowers and disperse solitaire trees. The aspect of countryside in central part of PLA was created in the period between 17. and 18. century, during Wallachian colonization. It is distinguished by scattered houses, alternating forest and non-forest areas with mozaic of wetlands, small forests, shrubs and patches. Northeastern part is situated in higher altitude and is covered mainly by old-growth beech forests (Mackovčin et al. 2002).

Considering the Slovak part of the area, so far, there are no data about the soil fauna published. Communities of terrestrial isopods inhabiting PLA on the Czech side have not either received much attention in the isopodological researches in the past, but some publications exist.

Four methods were used on 26 localities in different natural habitats in the White Carpathians, Czech Republic, between 2003 and 2009. It was manual sampling at favourable microsites, pitfall traps (different numbers at localities), heat extraction of soil samples (3-5 samples, several times per year), heat extraction of sieved litter (on some localities). The majority of localities were researched intensively for 1-2 years. The short description of localities (for more detailed characteristics see Mackovčin et al. 2002) is given below:

1. Okrouhlá – 49°2'48''N, 18°3'27''E, Nature reserve, 620-655 m a.s.l., forest with dominance of *Fagus sylvatica* (*Quercus, petraea, Acer pseudoplatanus, Acer platanoides, Tilia cordata, Ulmus glabra, Cerasus* avium, 130 years old
2. Sidonie – 49°3'9''N, 18°4'24''E, Nature reserve, 425-560 m a.s.l., forest with dominance of *Fagus sylvatica*, 170 years old
3. Chladný vrch – 49°1'31''N, 18°0'32''E, Nature sight, 550-575 m a.s.l., forest (*Carici pilosae-Fagetum*), 150-170 years old
4. Bílé potoky – 49°6'56''N, 18°1'39 ''E, Nature reserve, 380-500 m a.s.l., 2 meadow enclaves bordered by mixed deciduous forest, 120 years old
5. Pod Vrchy – 49°4'37''N, 17°56'21''E, Nature sight, 330-370 m a.s.l., forest (*Carici pilosae-Carpetinum*), 70 years

6. Javořina – 48°51'34"N, 17°40'27"E, National nature reserve, 835-970 m a.s.l., forest (dominance of *Fagus sylvatica, Dentario enneaphylli-Fagetum, Lunario-Aceretum)*
7. Vápenky – 48°52'31"N, 17°38'27"E, Nature sight, 470-570 m a.s.l., forest (*Carici pilosae-Fagetum*),
8. Uvezené – 48°54'30"N, 17°38'53"E, Nature sight, 490-570 m a.s.l., forest *(Carici pilosae-Carpinetum*
9. Hutě – 48°59'26"N, 17°54'30"E, Nature reserve, 450-535 m a.s.l., meadows and pastures (*Anthoxantho-Agrostietum*) with forest fragments (*Fagus sylvatica*)
10. Ve Vlčí – 48°55'47"N, 17°51'24"E, Nature reserve, 580-720 m a.s.l, pastures (*Anthoxantho-Agrostietum*) with forest fragments (*Fagus sylvatica*)
11. Hrozenkovský lom – 48°58'24"N, 17°52'15"E, abandoned quarry - forest/meadow
12. Skaličí – 48°59'40"N, 17°52'53"E, rocky limestone outcrop, forest (*Fagus sylvatica*)
13. Pod Žitkovským vrchem – 48°59'11"N, 17°52'59"E, Nature reserve, 480-620 m a.s.l., meadows and pastures (*Violion caninae*, *Calthion*) with forest fragments
14. Pod Hribovňou – 48°55'58"N, 17°50'43"E, Nature sight, 550-640 m a.s.l., meadows and pastures (*Anthoxantho-Agrostietum*) with dispersed trees
15. Brumov – 49°05´58´´N / 18°01´59´´E, 400 m a.s.l., pasture
    – 49°06´15´´N / 18°01´48´´E, 400 m a.s.l., meadow
16. U zvonice – 48°56´23´´N / 17°47´20´´E, Natural sight, , 630-670 m a.s.l., meadow (*Anthoxantho-Agrostietum, Filipendulenion*)
17. Lopenické sedlo – 48°56´20´´N / 17°48´00´´E, 700 m a.s.l., pasture
18. Trnovský mlýn – 48°53´47´´N / 17°34´44´´E, 450 m a.s.l., pasture / meadow
19. Jazevčí – 48°52'18"N, 17°33'45"E, National nature reserve, 340-473 m a.s.l., meadow (*Cirsio-Brachypodion pinnati*) / pasture
20. Záhumenice – 48°53'42"N, 17°41'9"E, Natural sight, 500 m a.s.l., meadow (*Calthion, Sparganio-Glycerion fluitantis, Cirsio-Brachypodion pinnati*)
21. Výzkum – grassland/forest (experimental area for monitoring of successional development of soil fauna), 430 m a.s.l.
22. Čertoryje – 48°51'31"N, 17°24'42"E, National nature reserve, 350-445 m a.s.l., meadow (*Cirsio-Brachypodion pinnati*) with dispersed trees (*Quercus sp., Tilia sp.*)

23. Drahy – 48°55'16"N, 17°38'16"E, Nature reserve, 400-513 m a.s.l., meadow (*Cirsio-Brachypodion pinnati*)
24. Porážky – 48°53'8"N, 17°37'26"E, National nature reserve, 540-610 m a.s.l., meadow (*Cirsio-Brachypodion pinnati, Angelico-Cirsietum oleracei*
25. Strání – intensively grazed pasture
26. Ploščiny – 49°8'18"N, 18°3'40"E, Nature reserve, 670-739 m a.s.l., meadow with dispersed trees (*Carpinus betulus, Juniperus communis, Fagus sylvatica, Abies alba*)

The key of Frankenberger (1959) was used for isopod indetification, valid nomenclature followed by Schmalfuss (2003). We used Ward’s method for cluster analysis of isopod communities in the statistical programme JMP (SAS Institute Inc., 1995).

Results

In total, 16 isopod species (Table 2), belonging to 8 families (see Supplement 1) were captured in 26 localities in the White Carpathians. Communities were formed of 1 to 10 species. Species with the greatest frequence were *Protracheoniscus politus* (19 localities), *Trachelipus rathkii* (18 loc.) and *Ligidium hypnorum* (18 loc.). These species appear to be typical for the White Carpathians. Two relict species were recorded, Carpathian endemit *Hyloniscus mariae* on the locality Javořina and *Ligidium germanicum* on 10 forest localities. The community richest in number of species was found in the site Pod Hribovňou (10 species), where the mozaic of meadows, pastures and dispersed trees covers the area. Other rich communities, in which 9 species were found, were recorded in the sites Javořina, Pod Žitkovským vrchem and Čertoryje.

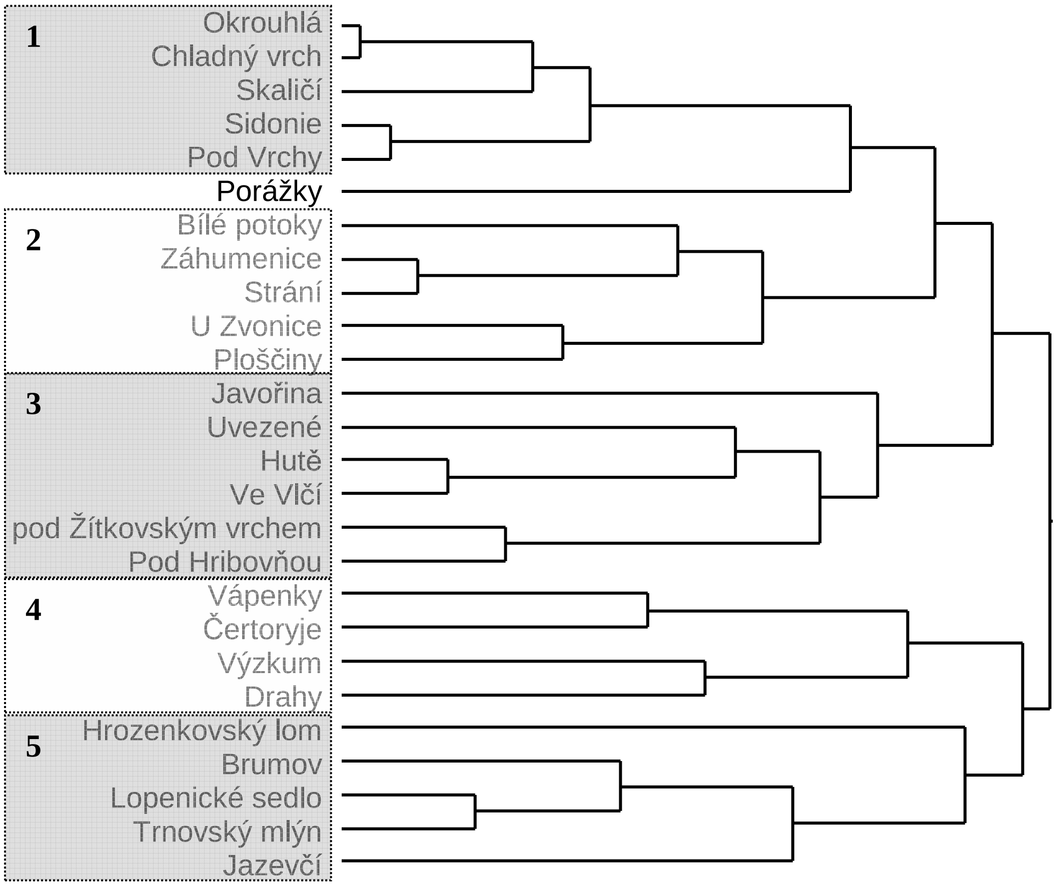
Table 2: Survey of collected material of terrestrial isopods. Present (+), not present (-). (For abbreviation of localities by numbers see the chapter Material and methods.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Armadillidium vulgare	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	+	+	+	+	+	+	+	+	-
Cylisticus convexus	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplophthalmus mengii	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Hyloniscus mariae	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyloniscus riparius	-	-	-	-	+	+	+	+	+	+	-	+	+	+	-	-	-	-	-	-	+	+	+	-	-	-
Lepidoniscus minutus	+	+	+	-	+	-	-	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-
Ligidium hypnorum	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	-	-	+	-	+	+	-	+	-	+
Ligidium germanicum	+	+	+	-	+	+	-	-	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	+	-	-
Platyarthrus hoffmannseggii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-
Porcellionides pruinosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-
Porcellium collicola	-	-	-	-	-	-	-	+	+	+	+	-	+	+	+	+	+	+	+	-	-	+	+	-	-	-
Porcellium conspersum	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
Protracheoniscus politus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-	-	+	+	+	+	+	+	+
Trachelipus rathkii	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+
Trachelipus ratzeburgii	+	+	+	+	+	+	-	+	+	+	-	+	+	+	-	-	-	-	-	+	-	-	-	-	-	+
Trichoniscus pusillus	-	+	-	+	+	+	+	+	-	+	-	-	+	+	-	-	-	-	-	-	+	+	-	-	-	-
Number of species	6	7	6	4	8	9	7	6	7	8	5	7	9	10	3	4	1	2	5	4	8	9	7	7	3	4

Similarity of communities of the White Carpathians

We compared localities according to presence/absence of species and the results in cluster analysis are presented in Figure 2. The most similar sites seem to be Okrouhlá and Chladný vrch. We can divide localities into 5 groups. The first one is composed of northern forest sites with rich communities of terrestrial isopods. Meadow sites from central and northern part of area with medium-rich commmunities are arranged into the second group. The third group contains the richest localities from the central part of the area and includes both forest and meadow. The fourth group is formed out of southern forest and southern meadow sites with rich communities. Meadow localities with the smallest number of species are arranged into the fifth group.

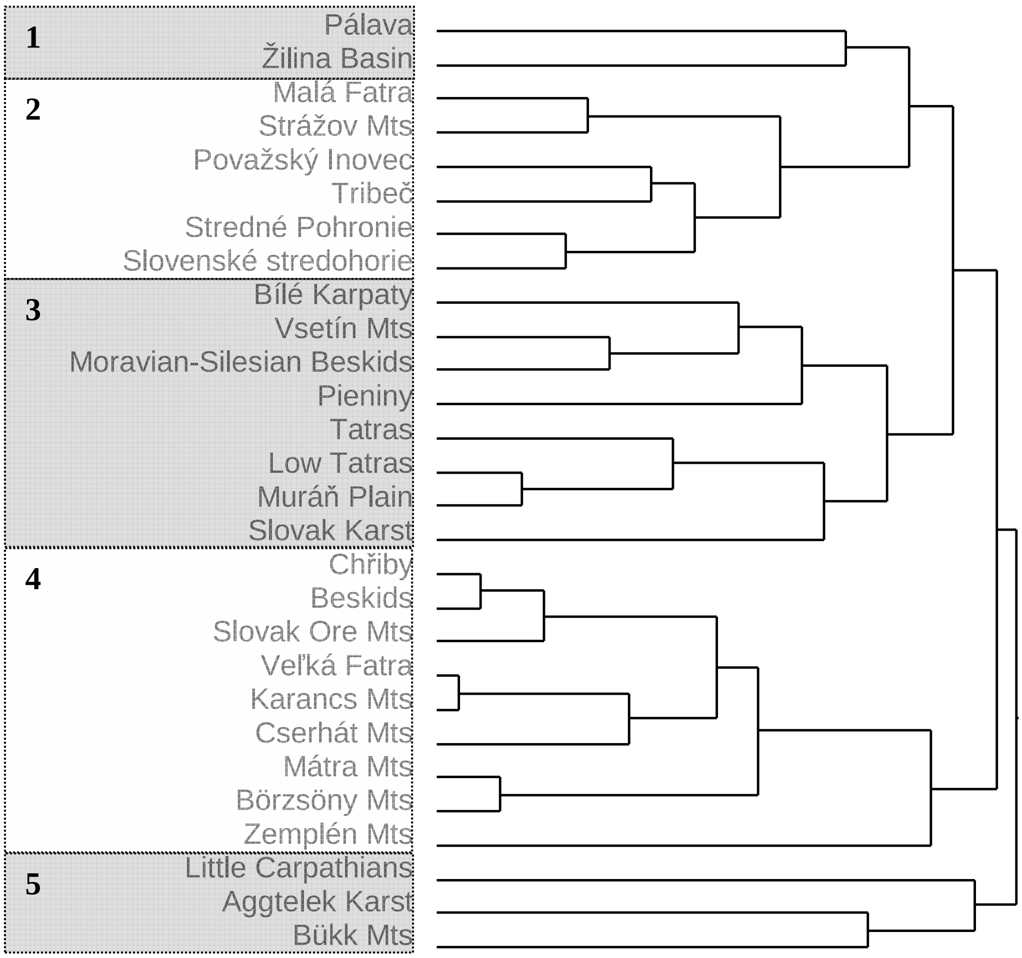
Figure 2: The (dis)similarity of communities of terrestrial isopods after their presence at locality. (Numbers represent groups of similar localities, see text above.)



Similarity of communities from geographic units of the Western Carpathians

We used data available from geographical units belonging to the Western Carpathians and our new data from the White Carpathians. They were compared according to the presence/absence of species and the results can be seen in cluster analysis (Figure 3). Areas were divided into 5 groups. The first one includes areas with very rich communities (14-16 species), the second group contains medium rich areas (8-12 species) from the central part of Slovakia. Mountainous areas, where *Hyloniscus mariae* occurred, were arranged into the third group. The fourth group is formed out of the areas with the smallest number of species (2-8 species). Areas with the richest communities (20-30 species) are forming the fifth group. The most similar areas are Veľká Fatra (SK) and Karancs Mts (HU), probably due to small number of species recorded.

Figure 3: The (dis)similarity of communities of terrestrial isopods after their presence at geographic unit. (Numbers represent groups of similar localities, see text above.)



Discussion

Altogether 16 species of terrestrial isopods were recorded on 26 localities in the White Carpathians, using combination of 4 methods. For the Czech Republic, 43 species of terrestrial isopods are known so far, which means that gathered material represents 37 % of the Czech fauna. Area of the White Carpathians is rich for woodlice species, since on the half of localities we found very rich communities composed of 7-10 species and only on 4 localities 3 and less species. In comparison with other areas from the Western Carpathians, it is the fifth richest area together with Pálava (16 species), after the Little Carpathians (30 species), Bükk Mts (24 species), Aggtelek and Slovak Karst (both 20 species) and Pieniny (19 species). Little Carpathians is the neighbouring area, so it is expected that more species exist in the White Carpathians and this area deserves more attention, mainly the Slovak part. However, it has to be mentioned that high number of species in Little Carpathians can also be caused by the fact that Flasarová (1986) collected material in natural and anthropogenous biotopes (intravillan of villages) too, while in all other species rich regions mentioned, woodlice were collected from more or less natural biotopes. Urban environment offers greater microhabitat diversity and favourable conditions to synanthropic species, which is proved by the fact that rich communities of approximately 15 species can be found in the cities (Riedel et al. 2009). Since accessibility of calcium is an important factor for distribution of terrestrial isopods (Sutton 1972), karst regions are richer in species than other (Vilisics et al. 2008). Usually in forest habitats, number of species on one locality can vary from 3 to 7 (Farkas et al. 1999, Tajovský 2002), meaning that forest localities of White Carpathians are very rich (6-10 species).

In our study, we tried to cover various biotopes of the White Carpathians; in total we had 8 forest sites, 10 meadow or pasture sites and 8 sites with mixture of both types of environment. There are differences in woodlice species between forest biotopes, agriculture cultivated sites and pastures (e.g. Paoletti 1987). For example *Trachelipus rathkii* is very common, eurytopic species, known from diverse, even from pretty disturbed biotopes and biotopes in inicial phase of succession (Tajovský 2001). According to Schmidt (1997) this species usually avoids forests. However, it was present nearly in all forest sites from our study area. It is known that species typical for forests (*Lepidoniscus minutus*, *Trachelipus ratzeburgii*, *Protracheoniscus politus*) rarely penetrate to open habitats. This statement was confirmed in our study, excerpt for *P. politus* which abounded nearly on all the localities. Typical inhabitants of White Carpathian meadows and pastures are *Armadillidium vulgare* and *Trachelipus rathkii*. Both are cosmopolitan and can colonise forest habitats. *A. vulgare* is species introduced to all parts of the world by human activities (Schmalfuss 2003), less common in forests (Allspach 2006). Since it was present only in one forest locality – Vápenky (Nature sight, a bit men-influenced), we consider White Carpathian forest localities as naturally valuable. Species with high affinity to woodland (*Hyloniscus riparius*, *Trichoniscus pusillus*) can be also found in grasslands (Sutton 1968). *Protracheoniscus politus* and *Ligidium hypnorum* are typical species for forest habitats of White Carpathians (Tajovský 2008). We can assume that on the meadows in mountainous areas, there are often hygrophilous and forest species, fauna quite similar to the one in the forests. Although these are open ecosystems, there are humidity and temperature conditions similar to the ones in the forests (Tomescu et al. 2005).

From the zoogeographical point of view, species from Europe and Central Europe are predominant (Schmalfuss 2003). Species having distribution from Central Europe to Balkan Peninsula compose one big group (*L. minutus, P. politus, H. riparius, P. collicola, L. germanicum*). It may be explained by the fact that after the last glacial period, significant amount of the present central-european fauna came from the Balkans to the Carpathian basin (Farkas 2007).

Lack of introduced and synanthropic species shows that there is small effect of human acitivity on isopod fauna. Only one introduced species, *Porcellionides pruinosus*, was recorded, but the finding is faunistically interesting because the White Carpathians seem to be nothernmost limit of its original nature habitat (Southern Europe and mediterranean region). Its findings further north are only from synanthropic sites (Frankenberger 1959). Very important is record of Carpathian endemit *Hyloniscus mariae*. It was found on Javořina, national nature reserve with high biodiversity value, where old beech forests cover the area.

When evaluating the (dis)similarity of communities of the White Carpathians, geographical as well as ecological gradient (character of the biotope – meadow/pasture/forest) was evident. Evaluation of (dis)similarity of communities from different geographical units from the Western Carpathians was more complicated, because of the not well-proportioned scientific attention. Some of the areas were researched comprehensively due to more thorough research activity, from some of them we have only sporadic records. White Carpathians arranged into group with Moravian-Silesian Beskids, Tatras, Low Tatras, Pieniny, Muráň Plain and Slovak Karst. All these (except M-S Beskids) were assessed as those with very high biodiversity value (see Supplement 2). White Carpathians were evaluated as valuable due to its high biodiverzity (Webster et al. 2001).

In conclusion, we recorded 16 species for the White Carpathians. *Armadillidium vulgare* and *Trachelipus rathkii* predominated on White Carpathian meadows and pastures. *Protracheoniscus politus* and *Ligidium hypnorum* are common species for the forest habitats of the White Carpathians. Detected communities are very rich (7-10 species on half of localities), especially in forest sites. Moreover, two relic species, *Hyloniscus mariae* and *Ligidium germanicum,* were recorded. Lack of introduced and cosmopolitan species indicates high nature conservancy value of the area. Results of our work confirmed that diversity of habitats in the White Carpathians offers favourable environment for rich communities of terrestrial isopods.

References

Allspach A. 1996. The terrestrial Isopods of the Bükk National Park (Crustacea; Isopoda; Oniscidea), pp. 71-74. In: Mahunka S. (eds): The fauna of the Bükk National Park, II., Hungarian Natural History Museum, Budapest.

Csordás B., Kontschán J. & Hegyessy G. 2005. Két ritka ászkarák (*Oniscus asellus* Linnaeus, 1758 és *Protracheoniscus major* (DOLLFUS, 1903)) újabb előfordulásai Magyarországon (Crustacea: Isopoda: Oniscidea). Folia Musei Historico Naturalis Matrensis **29:** 81-83.

Farkas S. 2007. The terrestrial isopod fauna of South Transdanubia (Hungary). Somogyi Múzeumok Közleményei **17:** 159-168.

Farkas S., Hornung E. & Morschhause T. 1999. Composition of isopod assemblages in different habitat types, pp. 37-44. In: Tajovský K., Pižl, V. (eds), Soil Zoology in Central Europe, ISB ASCR, České Budějovice.

Flasarová M. 1958. K poznání moravskoslezských Oniscoideí. Časopis Slezského muzea v Opavě **7:** 100-130.

Flasarová M. 1980. *Hyloniscus transsilvanicus* (Verhoeff, 1901) im Gebirge Malé Karpaty in der Westslowakei. Faunistische Abhandlungen, Staatliches Museum für Tierkunde Dresden **7:** 273-278.

Flasarová M. 1986. Isopoda (Asellota, Oniscidea) of the Little Carpathians, pp. 183-216. In: Nosek, J. (eds): The Soil Fauna of the Little Carpathians, Slovak Academy of Science, Bratislava.

Flasarová M. 1994. Über einige Landasseln aus der Slowakei, gesammelt von Herrn Dr. Ján Brtek (Crustacea: Isopoda: Oniscidea). Faunistische Abhandlungen Staatliches Museum für Tierkunde Dresden **19:** 135-140.

Flasarová M. 1995. Die Isopoden Nordwestböhmens (Crustacea: Isopoda: Asellota et Oniscidea). Acta Sc. Nat. Brno **29:** 1-156.

Flasarová M. 1998. Bericht über Isopoden (Asellota et Oniscidea) im Slowakischen Donaugebiet. Acta Musei Nationalis Pragae, Seies B, Historia Naturalis **54:** 61-78.

Flasarová M. 2000. Übersicht über die faunistische Erforschung der Landasseln (Isopoda, Oniscidea) in der Tschechische Republik. Crustaceana **73:** 585-608.

Forró L. & Farkas S. 1998. Checklist, preliminary distribution maps and bibliography of woodlice in Hungary (Isopoda: Oniscidea). Miscnea. Zool. Hung. **12:** 21-44.

Frankenberger Z. 1939. O jeskynním isopodu *Mesoniscus graniger* Friv. z Domice. Věstník královské české společnosti Nauk. 1-12.

Frankenberger Z. 1940. Oniscoidea Slovakiae. Sborník entomolog. Odd. Nár. Musea v Praze **18:** 60-69.

Frankenberger Z. 1941. Poznámky o českých Isopodech. II. Věda přírodní **20:** 151-152.

Frankenberger Z. 1942. Poznámky o českých Isopodech. III. Věda přírodní **21:** 85-88, 119-121.

Frankenberger Z. 1944. Oniscoidea Čech a Moravy. Věst. Královské české spol. nauk **8:** 1-28.

Frankenberger Z. 1954. Řád: Stejnonožci – Isopoda, pp. 499-507. In: Hrabě S. et al. (eds), Klíč zvířeny ČSR , Verlag Čs. Akademie věd, Praha.

Frankenberger Z. 1959. Stejnonožci suchozemští – Oniscoidea, Fauna ČSR **14**, SAV, Praha.

Gruner H.E. 1966. Krebstiere oder Crustacea. V. Isopoda. Die Tierwelt Deutschlands **53:** 151-380.

Hopkin S.P., Hardisty G.N. & Martin M.H. 1986. The Woodlouse *Porcellio scaber* as a 'Biological Indicator' of Zinc, Cadmium, Lead and Copper Pollution. Environmental Pollution (Series B) **11:** 271-290.

Hudáková J., & Mock A. 2006. Suchozemské rovnakonôžky (Isopoda: Oniscidea) Pieninského národného parku. Entomofauna carpathica **18:** 47-55.

Jażdżewski K. 1997. Malacostraca, pp. 167-174. In: Razowski J. (eds), Wykaz zwierąt, Polski IX, Wyd. Inst. I. Syst. Ewolucji zwierąt PAN, Krakow.

Kontschán J. 2002. *Ligidium* fajok újabb adatai hazánkból és egy Magyarország faunájára új ászkarák, a *Ligidium intermedium* RADU, 1950 előkerülése a Zempléni hegységből (Crustacea: Isopoda: Oniscidea). Folia Entomologica Hungarica **63:** 183-186.

Kontschán J. 2004. Néhány adat az Északi-középhegység ászkarák faunájához (Crustacea: Isopoda: Oniscidea). Folia Musei Historico Naturalis Matrensis **28:** 91-93.

Košel V. 2007. História výskumu subteránnej fauny v Západných Karpatoch (1841–1990). Univerzita Komenského, Bratislava, 84 pp.

Kuracina D. & Kabátová A. 2005. Terestrické rovnakonôžky (Crustacea: Isopoda: Oniscoidea), pp. 56-57. In: Majzlan O. et al. (eds.), Fauna Devínskej Kobyly, APOP, Bratislava.

Král V. 1999. Fyzická geografie Evropy, Academia, Praha, 350 pp.

Mackovčin P., Jatiová M. et al. 2002. Zlínsko. In: Mackovčin P. & Sedláček M. (eds), Chráněná území ČR, svazek II., AOPK ČR and EkoCentrum Brno, Praha.

Mikula J. 2004. Faunisticko-ekologická studie suchozemských stejnonožců (Crustacea: Isopoda: Oniscidea) CHKO Bílé Karpaty. Bachelor thesis, Palacky University Olomouc, Faculty of Science, Department of Ecology and Environmental Science. 22 pp.

Paoletti M.G. 1987. Terrestrial isopods in agroecosystems of the low-lying plain in north-eastern Italy, pp. 423-426. In: Striganova, B.R. (eds), Soil Fauna and Soil Fertility, Proc. 9th Int. Coll. on Soil Zoology, Nauka, Moscow.

Paoletti M.G. & Hassall M. 1999. Woodlice (Isopoda: Oniscidea): their potential for assessing sustainability and use as bioindicators. Agriculture, Ecosystems & Environment **74:** 157-165.

Riedel P., Navrátil M., Tuf I.H. & Tufová J. 2009. Terrestrial isopods (Isopoda: Oniscidea) and millipedes (Diplopoda) of the City of Olomouc, pp. 125-132. In: Tajovský K., Schlaghamerský J. & Pižl V. (eds), Contributions to Soil Zoology in Central Europe III., Institute of Soil Biology, Biology Centre, ASCR, v.v.i., České Budějovice.

Schmalfuss H. 2003. World catalog of terrestrial isopods (Isopoda: Oniscidea). Stuttgarter Beiträge zur Naturkunde, Serie A, 341 pp.

Schmidt C. 1997. Revision of the European species of the genus *Trachelipus* Budde-Lund, 1908 (Crustacea: Isopoda: Oniscidea). Zool. J. Linnean Soc. **121:** 129-244.

Schmölzer K. 1965. Bestimmungsbücher zur Bodenfauna Europas - Ordnung Isopoda (Landasseln). Akademie Verlag, Berlin, 468 pp.

Spitzer L., Tuf I.H., Tufová J. & Tropek R. 2007. Příspěvek k poznání fauny epigeických bezobratlých dvou přírodních jedlobukových lesů ve Vsetínských vrších (Česká republika). Práce a Stud. Muz. Beskyd, Přírodní vědy **19:** 71-82.

Strouhal H. 1939. Einige bemerkenswerte Vorkommnisse von Wirbellosen, besonders Isopoden, in der Ostmark. Festschrift zum 60. Geburtstage von Prof. Dr. E. Strand. **5:** 68-80.

Sutton S.L. 1968. The population dynamics of *Trichoniscus pusillus* and *Philoscia muscorum* (Crustacea, Oniscoidea) in limestone grassland. Journal of Animal Ecology **37:** 425-444.

Sywula T. & Jędryczkowski W.B. 2000. Skorupiaki (Crustacea). Flora i Fauna Pienin – Monografie Pieninskie **1:** 107-110.

Štrichelová J. 2008. Spoločenstvá suchozemských rovnakonožiek na vybraných lokalitách Bílých Karpát. Bachelor thesis, Palacky University Olomouc, Faculty of Science, Department of Ecology and Environmental Science, Olomouc, 42 pp.

Štrichelová J. & Tuf I.H (in press). Communities of terrestrial isopods (Oniscidea) in oak-hornbeam forests on the territory of Bratislava.

Šťáhlavský F. & Tuf I.H. 2009. Štírci (Arachnida: Pseudoscorpiones) CHKO Litovelské Pomoraví. Acta rerum naturalium **7:** 97-102.

Sutton S.L. 1972. Invertebrate types - Woodlice. Ginn & company limited, London, 144 pp.

Tajovský K. 1995. Oniscidea, Diplopoda, Chilopoda, pp. 87-97. In: Rozkošný R. & Vaňhara J. (eds), Terrestrial Invertebrates of the Pálava Biosphere Reserve of UNESCO, I., Folia Fac. Sci. Nat. Univ. Masarykianae Brunensis, Biologie **92**.

Tajovský K. 1997. Terrestrial Arthropods (Oniscidea, Diplopoda, Chilopoda) of the Protected Landscape Area Labské pískovce. 4th Central European Workshop on Soil Zoology. Abstracts. České Budějovice, Czech Republic, April 23-24, **1997:** 41.

Tajovský K. 1998a. Diversity of terrestrial isopods (Oniscidea) in flooded and nonflooded ecosystems of southern Moravia, Czech Republic. Isr. J. Zool. **44:** 311-322.

Tajovský K. 1998b. Mnohonožky (Diplopoda) a suchozemští stejnonožci (Oniscidea) Národního parku Podyjí. Thayensia (Znojmo) **1:** 137-152.

Tajovský K. 2001. Colonization of colliery spoil heaps by millipedes (Diplopoda) and terrestrial isopods (Oniscidea) in the Sokolov region, Czech Republic. Restoration Ecology **9:** 365-369.

Tajovský K. 2002. Mnohonožky (Diplopoda), stonožky (Chilopoda) a suchozemští stejnonožci (Oniscidea) Národní přírodní rezervace Žofínský prales v Novohradských horách, pp. 157-161. In: Papáček M. (eds), Biodiverzita a přírodní podmínky Novohradských hor, JčU a EntÚ AV ČR.

Tajovský K. 2006. Suchozemští stejnonožci (Isopoda: Oniscidea) CHKO Kokořínsko. Bohemia centralis **27:** 189-197.

Tajovský K. 2008. Suchozemští stejnonožci (Oniscidea), pp. 217-218. In: Jongepierová I. (eds), Louky Bílých Karpat, ZO ČSOP Bílé Karpaty, Veselí nad Moravou.

Tomescu N., Muresan D., Olaru L. & Radu H. 2005. Terrestrial isopod communities (Crustacea, Isopoda) in riverside coppices and meadows of mountainous, hilly and depression areas. Studia Biologia **2:** 19-25.

Topp W., Kappes H., Kulfan J. & Zach P. 2006. Distribution pattern of woodlice (Isopoda) and millipedes (Diplopoda) in four primeva forests of the Western Carpathians (Central Slovakia). Soil Biology & Biochemistry **38:** 43-50.

Tufová J. & Tuf I.H. 2003. Druhové bohatství půdních bezobratlých - metodologický artefakt, pp. 107-114. In: Štykar J. (eds), Geobiocenologie a její využití v péči o les a chráněná území, MZLU Brno & Školský lesní podnik Masarykův les Křtiny, Geobiocenologické spisy 7.

Tuf I.H. & Tufová J. 2005. Communities of terrestrial isopods (Crustacea: Isopoda: Oniscidea) in epigeon of oak-hornbeam forests of SW Slovakia. Ekológia (Bratislava) **24:** 113-123.

Vilisics F., Nagy A., Sólymos P., Farkas R., Kemencei Z., Páll-Gergely B., Kisfali M. & Hornung E. 2008. Data on the terrestrial isopod fauna of the Alsó-Hegy, Aggtelek National Park, Hungary. Folia faunistica Slovaca **13:** 19-22.

Webster R., Holt S. & Avis Ch. 2001. The Panda homepage. http://wwf.panda.org/ (accessed 27.5.2010).

http://en.wikipedia.org

Supplement 1: List of species recorded in the White Carpathians

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Order: Isopoda

Suborder: Oniscidea

Family: Ligiidae

Ligidium germanicum Verhoeff, 1901

Ligidium hypnorum (Cuvier, 1792)

Family: Trichoniscidae

Haplophthalmus mengii (Zaddach, 1844)

Hyloniscus mariae Verhoeff, 1908

Hyloniscus riparius (C. Koch, 1838)

Trichoniscus pusillus Brandt, 1833

Family: Platyarthridae

Platyarthrus hoffmannseggii Brandt, 1833

Family: Philosciidae

Lepidoniscus minutus (C. Koch, 1838)

Family: Cylisticidae

Cylisticus convexus (De Geer, 1778)

Family: Trachelipodidae

Porcellium collicola (Verhoeff, 1907)

Porcellium conspersum (C. Koch, 1841)

Protracheoniscus politus (C. Koch, 1841)

Trachelipus rathkii (Brandt, 1833)

Trachelipus ratzeburgii (Brandt, 1833)

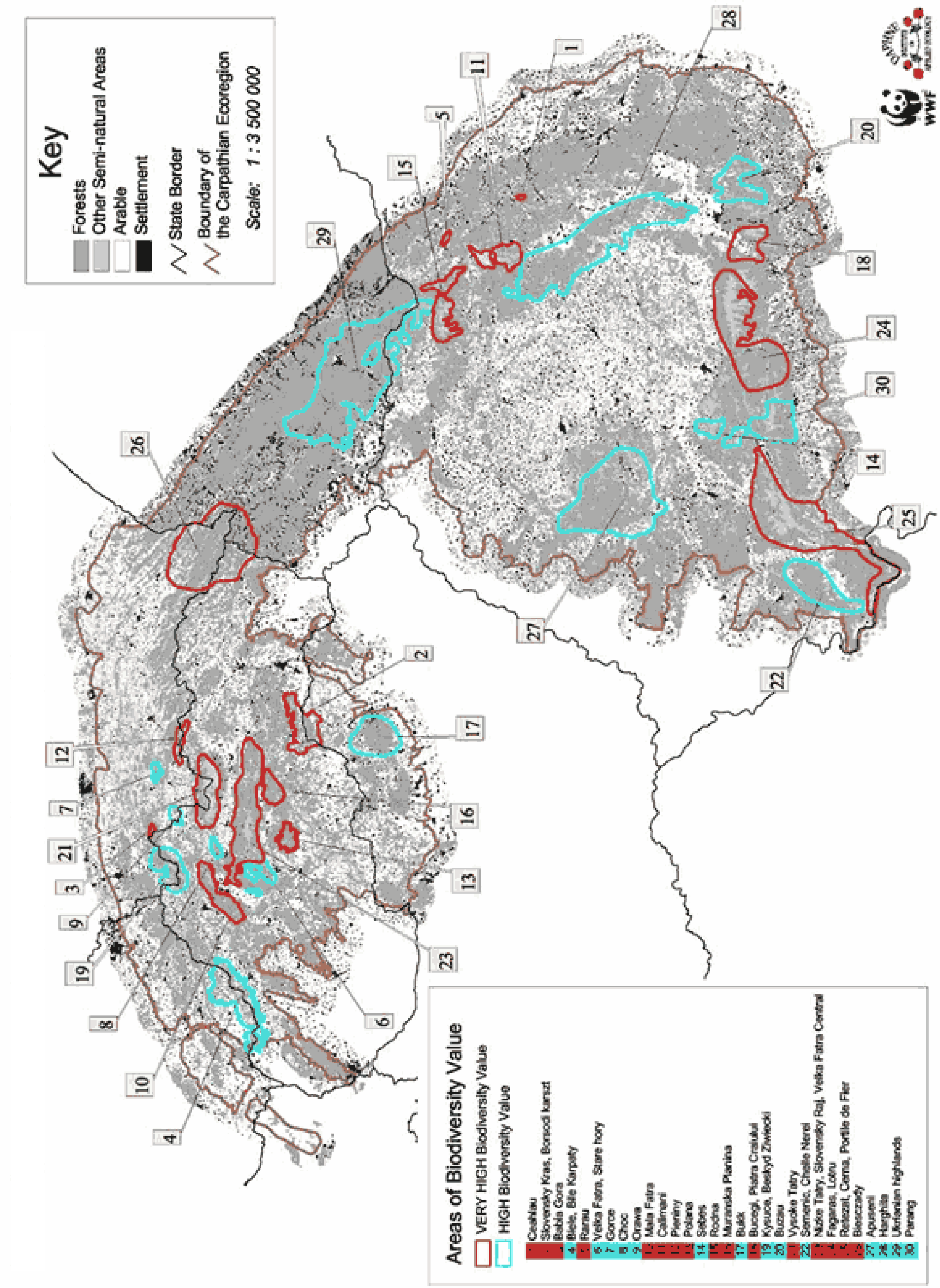
Family: Porcellionidae

Porcellionides pruinosus (Brandt, 1833)

Family: Armadillidiidae

Armadillidium vulgare (Latreille, 1804)

Supplement 2: Priority areas for biodiversity conservation in the Carpathians (http://wwf.panda.org/)



3 Communities of terrestrial isopods (Oniscidea) in oak-hornbeam forests on the territory of Bratislava

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Abstract

Terrestrial isopods were studied in 10 sites near or in the city of Bratislava. We recorded 10 species in total and communities were formed from 3 to 7 species. In all the sites, *Protracheoniscus politus* and *Porcellium collicola* predominated, other species occured only occasionally. Main factors affecting structure of communities seems to be age of forest, shrubs layer and pH.

Introduction

Terrestrial isopods belong to these groups of soil macrofauna, which take part in soil-forming processes. They are decomposers of organic matter and thereby they participate in nutrient circulation in nature. Their food mainly consists of plant residues, dead or decomposed. As well, they play important role in food web as a source of calcium for insectivorous birds and other animals (Graveland and Vangijzen, 1994). Terrestrial isopods are the only one group of crustaceans adapted on terrestrial environment. Countries around Mediterranean Sea are considered to be their cradle from where they spread across nearly all over the world (Frankenberger, 1944). Their biotopes are situated from seacoast to high mountains. Central-European species generally need biotopes with lack of light, higher moisture and stable temperature.

Terrestrial isopods are frequently used as biomonitoring model group of soil invertebrates (Paoletti and Hassall, 1999), they are studied for their relations to environmental factors (Zimmer et al., 2000, Zimmer, 2004, Jabin et al., 2004, Gongalsky et al., 2005). The effect of urbanisation on woodlice assemblages is apparent in the abundance patterns of dominant species and the relative distribution of isopod species (Hornung et al., 2004, Vilisics et al., 2007), besides these studies, the fauna of terrestrial isopods was studied in several cities as Budapest (Korsós et al., 2002) or Olomouc (Riedel et al., in press) or Košice (Palkovičová and Mock, 2008) too.

In the south-western Slovakia, terrestrial isopods were studied several times. Gulička (1960) and Krumpál (1973, 1976) investigated impact of flooding to woodlice in the Svätojurský Šúr.

Flasarová (1980, 1986, Flasar and Flasarová, 1989) described the fauna of terrestrial isopods of Little Carpathians Protected Landscape Area (=PLA) by intensive sampling on the more than 50 localities. The other research was targeted mainly on description of communities in oak-hornbeam forests at the area of (Tuf and Tufová, 2005).

Material and methods

Terrestrial isopods were studied at eight forest localities near or in Bratislava City. The short description of localities (for more detailed characteristics see Zlinská et al. 2005):

1. BR- Briežky – forest (*Querco-Carpinetum melicetosum uniflorae*), 80-100 years old, acid subsoil, 340 m a.s.l.)
2. DK1- Devínska Kobyla 1 – National nature reserve, forest (*Querco-Carpinetum melicetosum uniflorae*), 60-80 years old, acid subsoil, 340 m a.s.l.
3. DK2- Devínska Kobyla 2 – National nature reserve, forest (*Aceri-Carpinetum*), 40-60 years old, in valley, neutral to alkaline subsoil, 300 m a.s.l.
4. DK3- Devínska Kobyla 3 – National nature reserve, forest (*Corno-Quercetum*), 60-80 years old, acid subsoil, 360 m. a.s.l.
5. KO- Koliba – Forest (*Querco-Carpinetum melicetosum uniflorae*), 90-100 years old, acid subsoil, 380 m. a.s.l.
6. MD- Mlynská dolina – Forest antropogenized fragment, 80-100 years old, acid subsoil, 190 m a.s.l.
7. HP- Horský park – Fragmented and antropogenized area, 60-70 years old, acid subsoil, 212 m. a.s.l.
8. DH- Dúbravská Hlavica – Forest (*Carici pilosae-Fagetum*), 80-100 years old, acid subsoil, 350 m a.s.l.

Research was done in years 1999, 2000, 2005 and 2006. Terrestrial isopods were collected from sites approximately once a month, eight to nine times per year. We started research on 5 localities in 1999 and in 2005 localities DK3, MD and HP were added. We used only one method – litter sifting. At each locality we sifted a litter from

1 m^2, zoological material was separated using xereclectors and animals were fixed in 75% ethylalcohol. Woodlice were identified by Frankenberger's (1959) monograph and used classification is after Schmalfuss (2003).

We used Ward's method for cluster analysis of isopod communities in the computer programme JMP (SAS Institute Inc., 1995). Quantitative data were analyzed using the programme CANOCO for Windows 4.5©. With Redundant analysis (RDA) we evaluated relations among distribution of species and environmental factors. Species data weren't transformed and were centred by species. The model was evaluated using Monte Carlo Permutation test with 499 permutations.

Results

In total, 2209 individuals of terrestrial isopods belonging to 10 species were caught on all 8 localities (Table 1). Communities are formed from 3 to 7 species and the most abundant species were *Protracheoniscus politus* (55%) and *Porcellium collicola* (39%). Period 1999-2000 was more rich for isopods than two other years, when there were obtained thrice more individuals in total than in 2005-2006.

DK1: Four species were recorded in this forest locality. *P. politus* was the most abundant species and represented 64 % of present isopod community. *Hyloniscus riparius* and *Orthometopon planum* were found only in few specimens.

DK2: The richest community was found in this locality. In general, *P. collicola* predominated, but in 2006 was missing. *P. politus* was found in every year in relatively stable numbers. *H. riparius* was recorded during whole period but only in few specimens. Four other species were found irregularly in few exemplars.

DK3: We recorded three species in this locality. *P. collicola* predominated, *P. politus* represented 36 % of sampled material and *H. riparius* was found only in one exemplar.

DH: In this locality, rich isopod community was present. *P. politus* predominated during whole period. *P. collicola* and *Trachelipus ratzeburgi* were abundant, too. Then we found *H. riparius* in few exemplars and one specimen of *O. planum*.

KO: In this locality, three species were collected, too. *P. politus* was dominant (77 %) and present during whole period of research. Two other species, *P. collicola* and *T. ratzeburgi* were found in low abundances.

BR: Three species were collected in this locality. *P. politus* was present and dominant species (93 %) in whole period of years. *P. collicola* was observed only in 2006 and only in one exemplar. *T. ratzeburgi* was always found in few specimens, except 2005.

MD: Rich isopod community, compound of five species in low abundances, was sampled in this locality. *P. collicola* was dominant, but present only in 2006. In 2005 we recorded only two species, *P. politus* and *O. planum*, each in one exemplar. *Trachelipus rathkii* and *Armadillidium vulgare* were found each in one exemplar.

HP: We recorded here rich isopod community, too. *P. collicola* was predominant during both years. *H. riparius*, *O. planum*, *A. vulgare* and *Cylisticus convexus* were sampled in few exemplars only in 2005. *T. ratzeburgi* and *T. rathkii* were found in one exemplar in both years. The isopod *P. politus* was missing.

Table 1: Survey of collected material of terrestrial isopods (DK3, MD and HP were sampled for 2 years only). (For abbreviation of localities see chapter Material and methods.)

	BR	DK1	DK2	DK3	KO	MD	HP	DH	sum
Hyloniscus riparius	0	1	19	1	0	0	10	8	39
Platyarthrus hoffmannseggii	0	0	1	0	0	0	0	0	1
Orthometopon planum	0	5	2	0	0	4	0	1	12
Protracheoniscus politus	203	289	144	17	187	1	0	367	1208
Cylisticus convexus	0	0	0	0	0	0	3	0	3
Trachelipus rathkii	0	0	0	0	0	1	2	0	3
Trachelipus ratzeburgii	14	0	3	0	32	0	1	22	72
Porcellionides pruinosus	0	0	1	0	0	0	0	0	1
Porcellium collicola	1	159	515	29	25	28	83	20	860
Armadillidium vulgare	0	0	0	0	0	1	9	0	10
	218	454	685	47	244	35	108	418	2209

Seasonal distribution of terrestrial isopod species (Table 2) shows *P. politus* and *P. collicola* as the species present in high density during whole vegetation period. Two other species, *H. riparius* and *T. ratzeburgii*, were present through almost whole period, with the peak in August and May-July respectively. The other species were recordable occasionally only.

Table 2: Seasonal distribution of terrestrial isopods (evaluation concerning the whole material from 2 or 4 years). Black patch means over 50 ind., less dark patch means from 10 to 50 ind., grey means up to 10 ind. (For abbreviation of localities see chapter Material and methods.)

	IV	V	VI	VII	VIII	IX	X	XI	XII
Hyloniscus riparius		grey	grey	grey	dark	grey	grey		grey
Platyarthrus hoffmannseggii	grey								
Orthometopon planum		grey	grey		grey	grey			grey
Protracheoniscus politus	black	black	black	black	black	black	black	black	dark
Cylisticus convexus			grey		grey				
Trachelipus rathkii		grey						grey	
Trachelipus ratzeburgii	grey	dark	dark	dark	grey		grey	grey	grey
Porcellionides pruinosus						grey			
Porcellium collicola	black	black	black	black	black	black	black	dark	grey
Armadillidium vulgare		grey			grey	grey			

We compared localities according to presence/absence of species and there are results in cluster analysis (Fig. 1). Evidently aside is urban site HP. Only on this site there wasn't common species *P. politus* at all. Closest are sites BR and KO, two localities affected by pollutants of chemical factories until 1990. Among other sites, we found no obvious similarities.

Figure 1: The dissimilarity of communities of terrestrial isopods after their presence at locality. (For abbreviation of localities see chapter Material and methods.)

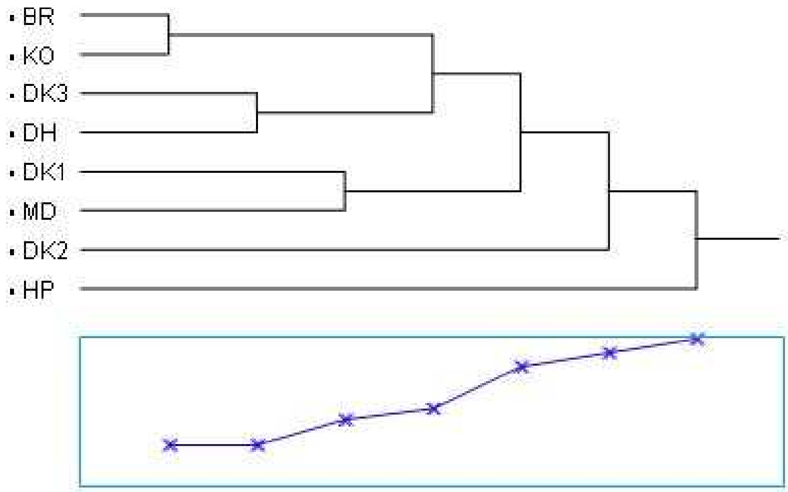
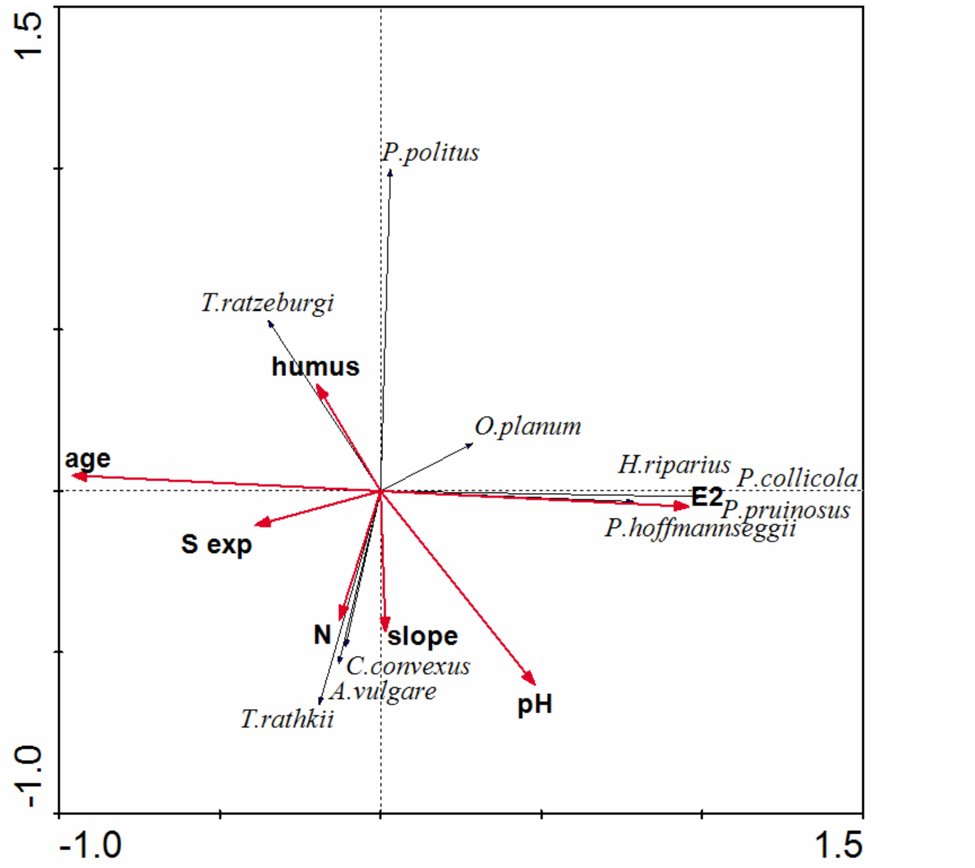


Figure 2: The RDA ordination biplot illustrating distribution of terrestrial isopods in relation to environmental variables.



The length of gradient in species data was shorter than 1.805 from that reason we selected Redundancy analysis. RDA of isopod assemblages and selected environmental factors (Fig. 2) explain 99.3% of species variability. The model is significant (F = 23.33; p = 0.0280). The first axis explains 60.4% of species variability; the second axis explains 38.7%.

Species *H. riparius*, *P. pruinosus*, *P. hoffmannseggi* and *P. collicola* preferred localities with dense shrub layer and low age. *T. rathkii*, *C. convexus* and *A. vulgare* were present at steeper localities with high content of nitrogen and *T. ratzeburgii* occupied localities with high amount of humus in soil.

Discussion

Until now, for the area of Malé Karpaty there were discovered 30 species (Flasarová 1986, Kuracina and Kabátová 2005 cited in Hudáková and Mock 2006). In territory of Bratislava we recorded 10 species. Communities of terrestrial isopods are formed from 3 to 7 species. We can consider them as relatively rich, because typical forest woodlice community consists from 3 to 7 species (Farkas et al. 1999, Tajovský 2002). Usually, in urban areas we can find richer communities, composed of about 15 species; it is explained by higher diversity of microhabitats in cities (Riedel et al. in press). Several researches confirmed that species richness of terrestrial isopods in urban localities is the same or higher than richness of natural, not disturbed localities (Hornung et al., 2007). After Vilisics et al. (2007), there is a mass occurrence of dominant species in natural habitats such as forests.

P. politus was dominant and the most abundant species in localities BR, DK1, KO and DH. On the other hand, *P. collicola* was dominant and the most abundant in DK2 and 3, MD and HP. Last two localities are anthropogenized forest fragments in fact directly in the city of Bratislava. There were found rich communities of isopods, formed of 5 and 6 species. From all the sites, only here we recorded cosmopolitan species *A. vulgare*, which is associated with men-influenced environments. Other two species, *T. rathkii* and *C. convexus*, were recorded only at this site. These species are cosmopolitan, too. In most cases, new habitats are colonised by species of broad tolerance, mainly by cosmopolitan species (Vilisics et al. 2007). As for collected numbers of specimens is concerned, these two sites have lowest abundances of isopods (together with DK3). Explanation for this can be impact of anthropogenic activity. Changes in abundance would influence decomposition process and modify nutrient in the soil (Vilisics et al. 2007). Other reason may be relatively steep slope of these sites.

In RDA analysis, age of forest growth turned out to be the most important environmental factor. Other important factors are cover of shrub layer, pH, content of nitrogen and amount of humus in soil. Soil heterogeneity could vary with phases of the forest cycle, since humus forms change with the age of trees (Salmon et al., 2006). Species *T. rathkii* seems to be fixed on localities with high amount of humus in soil. Young forest has high cover of E2 and it causes high abundances of isopods. The highest E2 is in DK2 (55 %), the site with the most species and the highest abundances of them and with relatively young 50 years old forest. We recorded here the richest community of terrestrial isopods composed of 7 species. Maximum environmental heterogeneity is in the intermediate succession phase (Salmon et al., 2008), in which this forest appears. Other reason of high diversity may be neutral to alkaline character of soil with pH 7.32. Soil in the rest of sites is acid.

In conclusion, in Bratislava we described relatively rich but typical isopod communities, formed from 3–7 species with predominant *P. politus* and *P. collicola*. These species were present in stable abundances during whole year and other rare species appeared irregularly according to optimal climatic conditions. There are little differences in composition of communities between natural and anthropogenized sites. According to analysis the most important environmental factors impacting structure of assemblages are age of the forest, shrub layer and pH.

References

FARKAS, S., HORNUNG, E., MORSCHHAUSE, T. 1999. Composition of isopod assemblages in different habitat types. In: TAJOVSKÝ K., PIŽL, V. (eds.): Soil Zoology in Central Europe. Proc. of the 5th Central European Workshop on Soil Zoology. Institute of Soil Biology, České Budějovice: 37–44.

FLASAR, I., FLASAROVÁ, M. 1989. Ergänzungen zur Monographie "The Soil Fauna of the Little Carpathians" (Mollusca et Isopoda). Faunistische Abhandlungen, Staatliches Museum für Tierkunde Dresden 17: 1–18.

FLASAROVÁ, M. 1980. Hyloniscus transsilvanicus (V e r h o e f f, 1901) im Gebirge Malé Karpaty in der Westslowakei. Faunistische Abhandlungen, Staatliches Museum für Tierkunde Dresden 7: 273–278.

FLASAROVÁ, M. 1986. Isopoda (Asellota, Oniscidea) of the Little Carpathians. In: Nosek, J. (ed.): The Soil Fauna of the Little Carpathians. Ústav experimentálnej biológie a ekológie SAV, Bratislava: 183–216.

FRANKENBERGER, Z. 1944. Oniscoidea Čech a Moravy. Věstník Král. Čes. Spol. Nauk, tř.mat.-přír. 8: 1–28.

FRANKENBERGER, Z. 1959. Terrestrial Isopods – Oniscoidea (in Czech). Fauna SR, svazek 14. N SAV, Praha, 216 pp.

GRAVELAND, J., VANGIJZEN, T. 1994. Arthropods and seeds are not sufficient as calcium sources for shell formation and skeletal growth in passerines. Ardea, 82: 299–314.

GULIČKA, J., 1960. Impact of changing water regime to soil macrofauna of Svätojurský Šúr (in Slovak). Acta Fac. Rerum Nat. Univ. Comenianae, Zool., 4: 437–486.

GONGALSKY, K.B., SAVIN, F.A., POKARZHEVSKII, A.D., FILIMONOVA, Z.V. 2005. Spatial distribution of isopods in an oak–beech forest. Eur. J. Soil Biol., 41: 117–122.

HORNUNG, E., TÓTHMÉRÉSZ, B., MAGURA, T., VILISICS, F. 2007. Changes of isopod assemblages along an urbane- suburbane-rural gradient in Hungary, European Journal of Soil Biology 43: 158–165.

HUDÁKOVÁ, J., MOCK, A. 2006. Suchozemské rovnakonôžky (Isopoda: Oniscidea) Pieninského národného parku. Entomofauna carpathica, 18: 47–55.

JABIN, M., MOHR, D., KAPPES, H., TOPP, W. 2004. Influence of deadwood on density of soil macro-arthropods in managed oak-beech forest. Forest Ecol. Manage., 194: 61–69.

KORSÓS, Z., HORNUNG, E., SZLÁVECZ, K., KONTSCHÁN, J. 2002. Isopoda and Diplopoda of urban habitats: new data to the fauna of Budapest. Annls hist.-nat. Mus. natn. Hung., 94: 193-208.

KRUMPÁL, M. 1973. Seasonal dynamics of terrestrial isopod populations (Isopoda, Oniscoidea) in Jurský šúr Nature Reserve (in Slovak). Biológia, Bratislava, 28: 879–884.

KRUMPÁL, M. 1976. Knowledge from biology isopode reproduction in Jurský šúr. Acta Fac. Rerum Nat. Univ. Comenianae, Zool., 20: 63–67.

PALKOVIČOVÁ, S., MOCK, A. 2008. Epigeická makrofauna (Oniscidea, Diplopoda) Botanickej záhrady Univerzity P. J. Šafárika v Košiciach. Študentská vedecká konferencia, Univerzita Komenského v Bratislavě, Bratislava, Zborník príspevkov, 1. zväzok – biologická sekcia: 242-244.

PAOLETTI, M.G., HASSALL, M. 1999. Woodlice (Isopoda: Oniscidea): their potential for assessing sustainability and use as bioindicators. Agriculture, Ecosystems & Environment, 74: 157–165.

RIEDEL P., NAVRÁTIL M., TUF I.H., TUFOVÁ J. in press. Terrestrial isopods (Isopoda: Oniscidea) and millipedes (Diplopoda) of the City of Olomouc (Czech Republic). Contributions to Soil Zoology in Central Europe, 3.

SALMON, S., FRIZZERA, L., CAMARET, S. 2008. Linking forest dynamics to richness and assemblage of soil zoological groups and to soil mineralization processes. Forest Ecology and Management 256: 1612–1623.

SALMON S., MANTEL, J., FRIZZERA, L., ZANELLA, A. 2006. Changes in humus forms and soil animal communities in two developmental phases of Norway spruce on an acidic substrate. Forest Ecology and Management 237: 47–56.

TUF, I.H., TUFOVÁ, J. 2005. Communities of terrestrial isopods (Crustacea: Isopoda: Oniscidea) in epigeon of oak-hornbeam forests of SW Slovakia, Ekológia (Bratislava) Vol. 24, Supplement 2/2005: 113–123.

VILISICS, F., ELEK, Z., LOVEI, G., HORNUNG, E. 2007. Composition of terrestrial isopod assemblages along an urbanisation gradient in Denmark, Pedobiologia 51: 45–53.

ZIMMER, M. 2004. Effects of temperature and precipitation on a flood plain isopod community: a field study. European Journal of Soil Biology, 40: 139–146.

ZIMMER, M., BRAUCKMANN, H.J., BROLL, G., TOPP, W. 2000. Correspondence analytical evaluation of factors that influence soil macro-arthropod distribution in abandoned grassland. Pedobiologia, 44: 695–704.

ZLINSKÁ, J., ŠOMŠÁK, L., HOLECOVÁ, M. 2005. Ecological characteristic of studied forest communities of an oak-hornbeam tier in SW Slovakia. Ekológia (Bratislava), 24, Suppl. 2, p. 3–19.

4 Summary

The submitted thesis aims to contribute to the knowledge of Western Carpathian isopod fauna, since terrestrial isopods are often neglected group of soil macrofauna. The object of research were communities of the terrestrial isopods of the White Carpathians and of oak-hornbeam forests on the territory of Bratislava (mainly from the localities belonging to the Little Carpathians). The benefit of the research is presented by providing good backround information about part of the Western Carpathian isopoda and permiting comparative analysis in the other parts.

Individuals of terrestrial ispods were collected using four methods: pitfall traps, heat extraction of soil samples, heat extraction of sieved litter and manual sampling at favourable microsites. Research was conducted on various localities, forests, meadows, pastures and anthropogenized fragments.

The first manuscript focuses on terrestrial isopod communities of the White Carpathians and relations between isopod fauna of White Carpathians and of different geographic units from the Western Carpathians. Big focus was put on determinating distribution of the woodlice in the Western Carpathians by collecting all the published data from this area. Studied animals from the White Carpathians were collected between year 2003 and 2009, in 26 forest as well as meadow/pasture localities. The majority of localities was intensively examined for 1–2 years. We recorded 16 species in the White Carpathians. There are some differences between communities inhabiting forests and these inhabiting meadows or pastures. *Armadillidium vulgare* and *Trachelipus rathkii* predominated on White Carpathian meadows and pastures, while *Protracheoniscus politus* and *Ligidium hypnorum* predominated in forest habitats. Detected communities were very rich (7-10 species on half of localities), especially in forest sites. The most interesting faunistical records are two relic species, Carpathian endemit *Hyloniscus mariae* and *Ligidium germanicum* (in the Czech Republic found with only patchy distribution). Lack of introduced and cosmopolitan species indicates high nature conservancy value of the area.

The second manuscript is devoted to the communities of terrestrial isopods in oak-hornbeam forests on the territory of Bratislava, where majority of studied localities belongs to the Little Carpathians. Animals were collected in years 1999, 2000, 2005 and 2006. Eight sites were examined 8-9 times per year, using only litter sifting. The

evaluated environmental characteristics were the age of forest, cover of shrub layer, pH, content of nitrogen and amount of humus in soil. We recorded 10 species in the territory of Bratislava, described communities are relatively rich (3–7 species), but mainly composed of common species. *Protracheoniscus politus* and *Porcellium collicola* were predominant species, present in stable abundances. Other species appeared rarely, irregularly and only in small numbers. There are little differences in composition of communities between natural and anthropogenized sites.

Results from those two Western Carpathian areas show that great diversity of habitats offers favourable environment for rich communities of terrestrial isopods. On the other hand, also in areas with high nature conservancy value, there exist cosmopolitan or introduced species.