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Upgrading knowledge on the Millipedes (Diplopoda) in Slovakia – a significant contribution of winter collections

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Abstract. During the winter 2017–2018 the occurrence of millipedes was studied in four mountainous areas in eastern and south-eastern Slovakia. These areas were mainly fragments of woodland in agricultural landscapes in the lowlands and foothills. The material was collected in areas without permanent snow cover. A total of 14 species were collected, including four remarkable ones. From the order Polydesmida, *Polydesmus transylvanicus* was recorded for the first time in Slovakia and the abundant occurrence of *Brachydesmus dadayi* is the second record of this species in this country. Both species originate from Southeastern Europe and may be part of the insular distribution of a relict fauna in the Pannonian Lowlands (Carpathian Basin) and the foothills of neighbouring mountainous areas. Presence of *Haplogona oculodistincta* (Chordeumatida: Verhoeffiidae) has not yet been published for Slovakia. In this study, it was recorded at many localities, including areas significantly altered by human activity. The species *Hungarosoma bokori* appears to occur more frequently than previously thought and is mainly active in winter. Finding these four species in winter considerably complements our knowledge of their biology, distribution and habitat preferences.

Key words. Millipedes, Slovakia, new records, rare occurrence, cold season.

INTRODUCTION

The considerable diversity of soil arthropods in Central Europe is unappreciated because it consists mainly of cryptic or minute species, living in natural habitats and microhabitats at sites with a specific microclimate and or in urban areas (Neobiota). However, the composition of this little-known fauna can be greatly increased by studying it in winter. In the literature, records of millipedes being present in winter are scattered and are mainly of species belonging to the order Chordeumatida.

Currently about 83 species of millipedes occur in Slovakia (Mock 2001, Kime & Enghoff 2013). Endemic and biogeographically interesting species of millipedes occur mainly at high altitudes in the Carpathians (mountainous forests, subalpine and alpine habitats) and in caves. Lowlands and uplands are environments inhabited by a relatively poor, common Central European fauna, but in the past the myriapods there were incompletely studied.

Winters in Central Europe are characterized by leaf-fall, temperatures below zero, snow covering the soil (although not continuously), accompanied by a low activity of soil invertebrates. Interesting discoveries of rare millipedes at the beginning of the cold period in November and December in 2017 raised a question: What else can be found during winter? In several dozens of sieved soil and litter samples collected throughout the winter of 2017/2018, we found two species of millipedes that complement the list of species known in Slovakia and another two

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species rarely found in Slovakia in the past. One of the latter species was last recorded in Slovakia 90 years ago. The aim of this contribution is to summarize the information on the four species of millipedes sampled during winter in Slovakia. Faunistic, morphological characteristics, maps of the distribution, and a brief review of the literature on the taxonomy and nomenclature are added for particular species.

MATERIAL AND METHODS

During the winter of 2017–2018 we studied millipedes in four mountainous regions in Eastern and South-eastern Slovakia: East Slovakian Uplands (Východoslovenská pahorkatina), Košice Basin (Košická kotlina), the southern parts of the Slanské vrchy Mts. and the Vihorlat Mts. We focused mainly on fragments of forests in agricultural landscapes in the lowlands and foothills, not permanently covered by snow cover or subject to persistent frosts. The winter of 2017/208 was relatively warm, with short periods of snow cover and frosty days followed by long periods of temperatures above zero.

Material was collected on cold days when the temperature was above freezing. Terrestrial invertebrates were extracted from leaf litter collected from 1 m^2 (mixture of 16 subsamples) using an entomological sieve (25×25 cm frame, 1×1 cm mesh sieve). This material was placed in a Berlese-Tullgren apparatus for 7–10 days and the invertebrates collected were fixed in pure ethanol. For species identification, literature along with the keys to the Central European fauna were used.

We extracted 687 millipedes from 39 samples. Fourteen species were identified (approx. 15% of the millipede fauna known from Slovakia). The most interesting findings are presented below.

RESULTS AND DISCUSSION

Polydesmida: Polydesmidae

Brachydesmus dadayi Verhoeff, 1895

Material. 41 ♂♂, 63 ♀♀, 1 juvenile.

Localities. **Site 1**: East Slovakian Uplands, at the boundary of the village Kazimír, slope of a small hill with volcanic tufa bedrock and topped by a ruined castle, covered with alluvium deposited by the Izra brook (48°31.512'N, 21°34.94'E, 149 m a. s. l.); date of collection 7 January 2018; 39 ♂♂, 56 ♀♀. **Site 2**: East Slovakian Uplands, suburbs Moldava nad Bodvou, limestone slope near the Moldavská Cave (48°36.731'N, 20°59.471'E, 232 m a. s. l.); date of collection 14 December 2017; 2 ♂♂, 7 ♀♀, 1 juvenile. **Site characteristics**: slopes with a narrow belt of dense vegetation and deep layers of leaf litter of *Robinia pseudoacacia*, *Acer* sp., *Sambucus nigra*, and *Salix* sp.

Description. Rather small, pale to white species, body 7–15 mm long. The gonopods are characterized by two parallel arms of similar shape and size (Fig. 1).

Taxonomic history. This species was first found at the edge of a swamp near Promontor village, now a suburb of Budapest (Hungary) and Verhoeff (1895) described this species based on the two males found in May. Isolated findings over a fairly large area and in different habitats of individuals in which the gonopods differed led to the description of various species and subspecies in the past, which are now considered to be invalid synonyms.

The only published finding of this species in Slovakia is for a locality near Zlaté Moravce (previously Aranysmarót) (Verhoeff 1941, Dudich 1958). It was also collected in winter (24March 1937). Northern records led Verhoeff (1941) to establish a separate subspecies, *B. dadayi dudichi*. The most recent published occurrence of this species, close to the locality we studied, is in the southernmost outpost of the Zemplén Mts. in Hungary, where 'a single male was found in a former vineyard and natural grassland area near an abandoned quarry' (Bogyó et al. 2012).

Distribution and ecology. Southeastern and Central Europe (Bulgaria, Romania, Serbia, Hungary and Slovakia) (Fig. 3). A hydrophilous species, known from deciduous forests in stony areas and the edges of wetlands, even from caves and synanthropic habitats (Kime & Enghoff 2011). In our study, *B. dadayi* was found in samples from a forested hill below the ruins of a medieval

castle above a river, alluvium deposited by the river in the village and on the forested slope near the entrance to a cave.

Polydesmus transylvanicus Daday, 1889

Material. 18 ♂♂, 36 ♀♀.

Localities. **Site 1**: Uplands in eastern Slovakia, near Kazimír, in the alluvium deposited by the Izra brook, south of the village (48°30.768'N, 21°35.793'E, 135 m a. s. l.); date of collection 19 November 2017; 1 ♂, 1 ♀. **Site 2**: bank of the Izra brook near Brezina, flooded forest (48°32.262'N, 21°33.492'E, 170 m a. s. l.); date of collection 2 April 2018; 17 ♂♂, 35 ♀♀. **Site characteristics**: wet to damp stream-side vegetation dominated by *Salix* sp. and *Acer campestre,* with a thin layer of plant litter on volcanic river sediments.

Description. Small (body 7–15 mm long, 0.9–0.13 mm wide), almost white species. Male gonopods are consistent with the original description of this species (Fig. 2).
Taxonomic history. This species was described twice based on material from the northern foothills in the Southern Carpathians (near Déva in Romania, collected by Ö. Tömösváry) (Daday 1889a, b). Both descriptions have the same text, only one of them has a picture of the gonopods (Daday 1889a). These texts also differ in the spelling of the species name, *P. transylvanicus* (Daday 1889a) followed by *P. transsylvanicus* (Daday 1889b). Later Attems (1940) transcribed the name as *P. transsilvanicus*, which is grammatically correct, but the priority of the name *P. transylvanicus* must be respected.

Jawlowski (1933) describes a subspecies, *Polydesmus griseoalbus motasi,* collected from corn fields in 'Socola bei Jasi, Rumänien', a short distance from the border with the current Republic of Moldavia. He defines the subspecies as 9–10 mm long, white to slightly yellow in colour. The

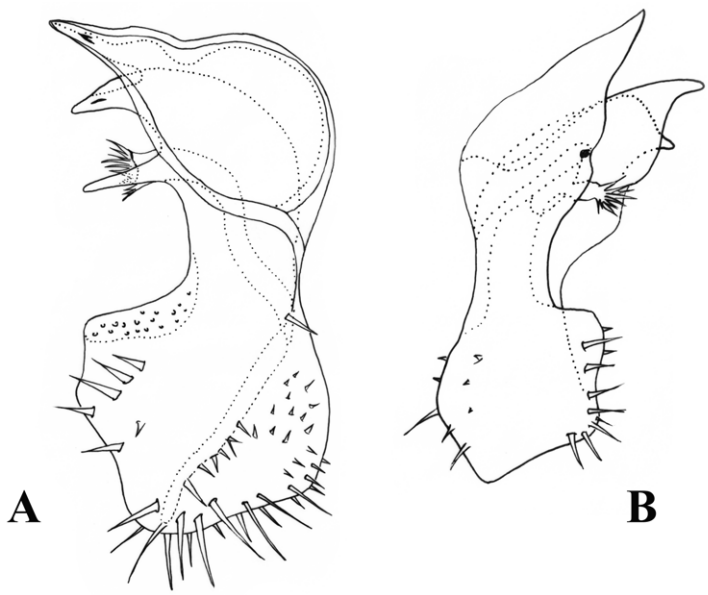


Fig. 1. *Brachydesmus dadayi*, male, gonopods (Kazimír village). A – right gonopod, exterior view; B – right gonopod, interior view. Not to scale.

description of the gonopods is relatively detailed. The length of the lateral arm and inner tooth on the terminal part of the tibiotarsus is slightly shorter than that recorded for individuals from Slovakia. Small tooth on the inner side of middle part of tibiotarsus appears to be extra. Kime

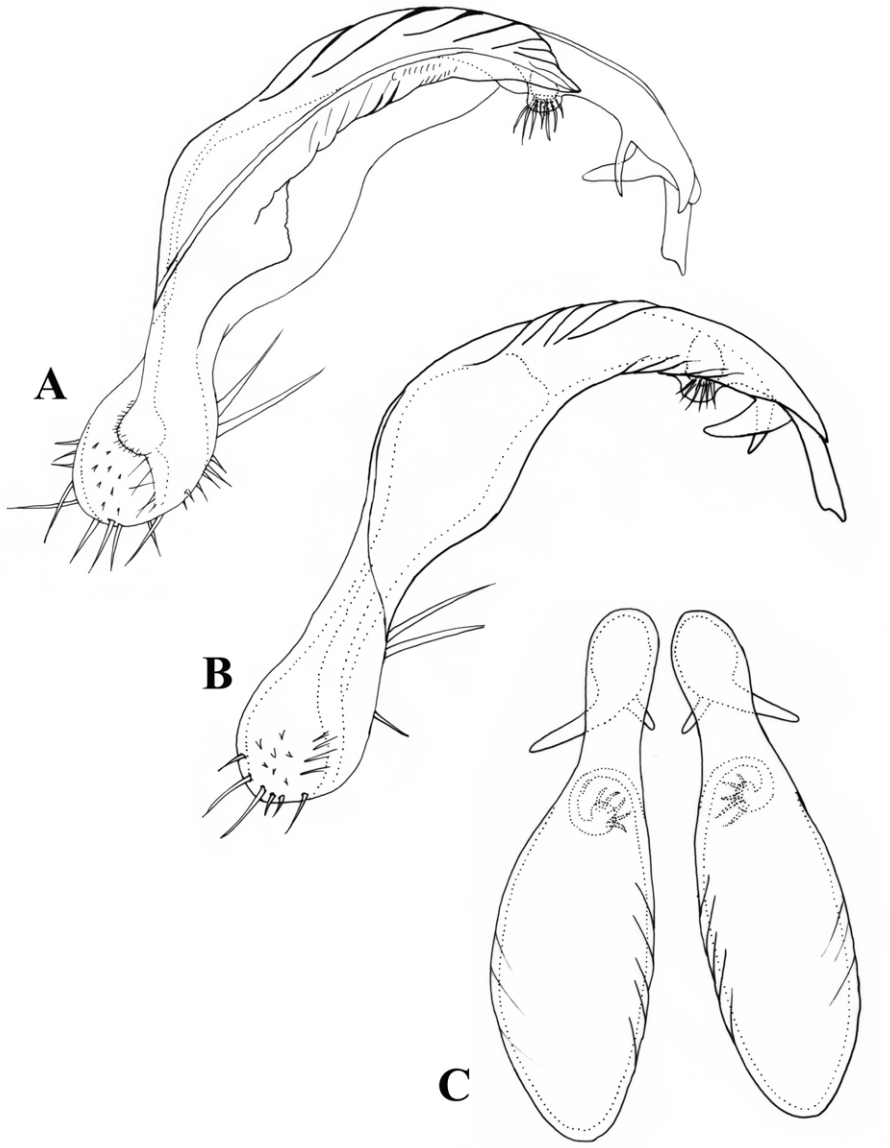
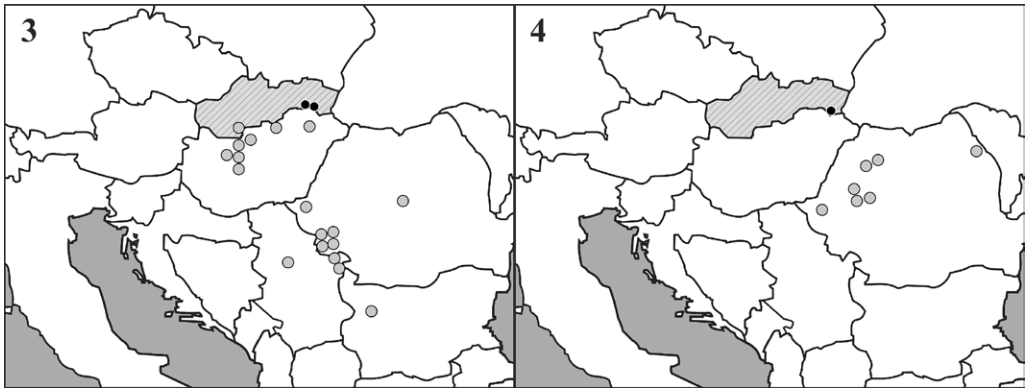


Fig. 2. *Polydesmus transylvanicus*, male, gonopods (Brezina). A – left gonopod, interior view; B – left gonopod, exterior view; C – gonopods, anterior view. Not to scale.



Figs. 3, 4. Distribution of the species studied in the order Polydesmida. 3 – *Brachydesmus dadayi*; grey dots: published findings (Kime & Enghoff 2011, Bogyó et al. 2012, Sierwald & Spelda 2018), black dots: new records for Slovakia. 4 – *Polydesmus transylvanicus*; grey dots: published data (Jawlowski 1933, Kime & Enghoff 2011), black dot: new record for Slovakia.

& Enghoff (2011) separate *P. motasi* as a species without any further explanation. However, the structure of the gonopods indicate that *P. motasi* and *P. transylvanicus* are the same species. Similarly, it is regarded as a separate subspecies of *P. transylvanicus* by Attems (1940). Attems (1940) also lists *Polydesmus frondivagus* Verhoeff, 1898, as well as *P. griseoalbus motasi* Jawlowski, 1933 as synonyms of this species. His revision includes the localities Siebenburgen, Kom. Hunyad: Hátszeg, Déva, Temesvár and Socola bei Jasy. Attems uses the names *P. transsilvanicus transsilvanicus* and *P. t. motasi*.

The species *Polydesmus subscabratus* Latzel, 1884, has very similar gonopods. The distinction between it and *P. transylvanicus* is also not stated by the authors as *P. subscabratus*, according to the original description (Latzel, 1884) based on material from Serbia, is a larger (15–18 mm, 2.2–2.6 mm), dark-brown or a brick-red-brown colour. Only an image of the apical part of the gonopod is published. It differs significantly from our material from Slovakia (smaller body and almost completely free of pigment). Loksa (1954) wrote in his revision of Carpathian species in the genus *Polydesmus* that the gonopods of *P. transylvanicus* are free of lamellae. Our male individuals have gonopods with what appears to be 'lamellae', clearly visible to the naked eye on the inside of the tibiotarsus (a rough, ribbed bead on the inner side of the tibiotarsus, which extends from the posterior edge of the gonopod in a slightly convex arc to the front edge of the gonopod, where it joins the gonopod approximately one third of the way along its length), which is consistent with Attems (1940). In addition, Daday (1889a) mentions that *P. subscabratus* from the surroundings of Velejte village (= Veľaty, southeastern Slovakia) and Sátoraljaújhely (Hungary, part of the town is on the left side of the border river Rónyva-Roňava, which is now in Slovakia as Slovenské Nové Mesto), which are less than 10 km and 20 km from the localities we studied along Izra brook. However, Korsós (1994) does not mention this species occurring in Hungary. Consequently, these findings were questioned and currently remain unconfirmed (Mock 2001), disregarding the fact, that Daday must have known that these two species were different.

Distribution and ecology. This species, according to Kime & Enghoff (2011) and our data, occurs only in the foothills of the Carpathians from north-western Romania to south eastern Slovakia.

According to Jawlowski (1933), the easternmost occurrence is in Romania, near the border with Moldavia (Fig. 4). These authors describe this species habitats as 'In the litter of small woods, overgrown and neglected gardens. In earth, including molehills.' According to our observation it seems to be a highly hydrophilous species, as it was found in samples from floodplain forest growing on the alluvium deposited by a river. Our records are the first for Slovakia and from outside Romania (Kime & Enghoff 2013, Mock 2001).

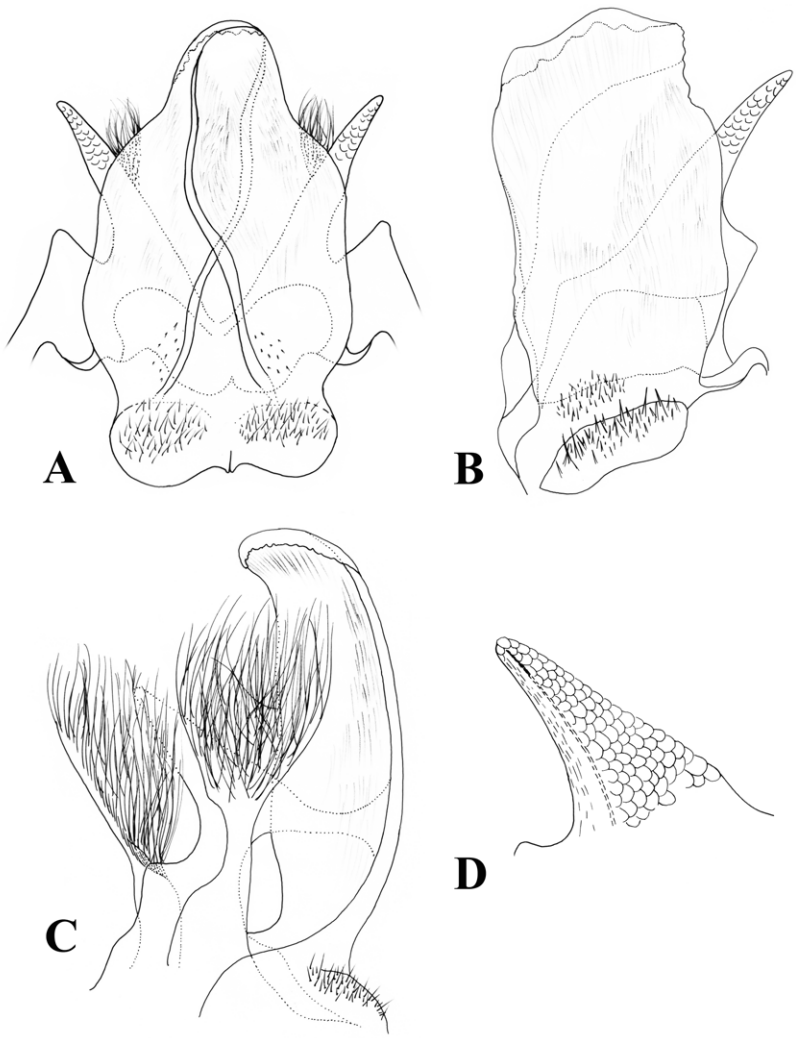


Fig. 5. *Haplogona oculodistincta*, male, gonopods (Jozefova Pusta). A – gonopods, anterior view; B – right anterior gonopod, anterior view; C – right anterior gonopod, medial view; D – right anterior gonopod, detailed medial view of posterior process. Not to scale.

Chordeumatida: Verhoeffiidae

Haplogona oculodistincta (Verhoeff, 1893)

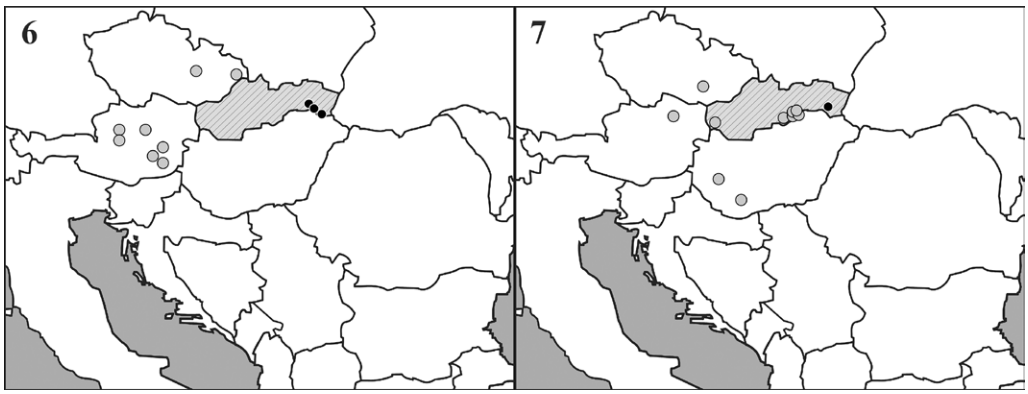
Material. 51 ♂♂, 120 ♀♀.

Localities. **Site 1**: Uplands in eastern Slovakia, village Kalša, fragment of forest near a small creek (48°37.035'N, 21°32.759'E, 170 m a. s. l.); dates of collection 4 November 2017, 4 January 2018; 6 ♂♂, 21 ♀♀. **Site 2**: Uplands in eastern Slovakia, Jozefova pusta (Slovenské Nové Mesto village), both banks of the river Roňava (48°36.836'N, 21°32.823'E, 190 m a. s. l.); date of collection 18 November 2017; 44 ♂♂, 94 ♀♀. **Site 3**: Košice Basin, Nad Jazerom city district, slope of old river basin (48°41.305'N, 21°17.596'E, 194 m a. s. l.); date of collection 10 January 2018; 1 ♂, 5 ♀♀. **Site characteristics**: dense vegetation, abundant leaf litter and humus, *Salix* sp., *Acer* sp., *Corylus avellana.*

Description. Small (8–10 mm), a 'milky-white to yellow-white' species (Kocourek 2001). Gonopods very different from those in other species in the same genus, consistent with the original drawings of Attems (1895) and Verhoeff (1899) (Fig. 5). Head with 10–13 ocelli in a triangular field, body consisting of 30 diplosegments (Kocourek et al. 2017).

Taxonomic history. Verhoeff (1893) included *Haplogona oculodistincta* in the genus *Chordeuma*. Description of this species was simply based on external features of females and its larger number of ocelli (16+16) compared to other species of '*Chordeuma*'. American author O. F. Cook (1895) published a review of North American chordeumatids, in which he also revised some European taxa and established the genus *Haplogona* for this species. This revision has long been overlooked, therefore, several junior objective synonyms have appeared in the literature, including the genera *Verhoeffia* Broelemann, 1895 and *Latzelia* Verhoeff, 1895. Italian author Silvestri (1898) established the genus *Protochordeuma* for his species *Haplogona gestri*. Today, four valid species are distinguished within the genus *Haplogona*, all from around the Alps. The family Verhoeffiidae is monotypical (Kime & Enghoff 2013, Sierwald & Spelda 2018). The gonopods do not differ from what is recorded by Verhoeff (1893) and Kocourek et al. (2017).

Distribution and ecology. It occurs in the south-eastern part of the Alps (Austria, North Italy, Slovenia, Croatia and eastern Czechia) (Fig. 6). Recording it in Eastern Slovakia greatly extends the area of its distribution and possibly indicate this species has recently colonized landscapes



Figs. 6, 7. Distributions of the species studied in the order Chordeumatida. 6 – *Haplogona oculodistincta*; grey dots: old findings (www.gbif.org), black dots: new records for Slovakia. 7 – *Hungarosoma bokori*; grey dots: old data (Mock et al. 2016), black dot: new record for Slovakia.

markedly altered by human activity (e.g. Kocourek 2001). The places where this species is recorded in Slovakia, small woods on the outskirts of municipalities, city parks, village cellars and ruins of a castle, are examples of landscapes strongly affected by humans. A characteristic feature is its aggregated occurrence. It becomes relatively highly abundant at suitable locations. First record of it occurring in Slovakia.

Chordeumatida: Hungarosomatidae

Hungarosoma bokori (Verhoeff, 1928)

Material. 13 ♀♀.

Localities. **Site 1**: Uplands in eastern Slovakia, village Kalša, bank of the Roňava river (48°37.035'N, 21°32.759'E, 170 m a. s. l.); dates of collection 7 January 2018, 13 January 2018, 14 February 2018; 10 ♀♀. **Site 2**: bank of the Terebľa river, near Kalša (48°36.444'N, 21°31.879'E, 240–250 m a. s. l.); date of collection 18 November 2017; 3 ♀♀. **Site characteristics**: fragmented forests, rich vegetation, *Salix* sp., *Alnus* sp., *Corylus* sp.

Description. Very small species (6.0–6.6 mm long, 0.6–07 mm wide), light brown, with a darker head, antennae and dorsum of trunk segments; the metazonites are darker than the prozonites.
Taxonomic history. This species is probably the only European representative of Chordeumatidae, which has parthenogenetic 'populations' that make it difficult to identify them as the essential features for identification are male gonopods. Recently, diagnostic characteristics based on the material from the type locality of *Hungarosoma bokori* (Abaliget Cave, south-western Hungary) were added (Mock et al. 2016). However, the authors overlooked the similarity of these features with that of *Ochogona cervina* (Verhoeff, 1899). This apparent need of synonymization was recently pointed out by Antić et al. (2018). Gonopods of both species are probably identical, however, minute differences between Verhoeff's description of *O. cervina* and our knowledge of *H. bokori* have to be reviewed. In addition, these uncertainties raise the need to establish the correct name for this genus. The decision as to which genus it belongs: *Ochogona*, *Octeicosisoma*, *Triakontizona* or *Ceratosoma* has also to be resolved in order to justify the name of the family Hungarosomatidae and its position in the Chordeumatida system.
Distribution and ecology. The distribution of this species is considered to be a relict one as it coincides exactly with that part of the Carpathian Basin that was not flooded by the Tertiary Pannonian Sea (Croatia, Hungary, Austria, Czechia, and Slovakia) (Fig. 7). This species is rarely found in caves, cave entrances and debris, and forests, mostly on limestone bedrock. We found it recently in litter samples from fragmented forests near rivers on andesite bedrock. Some of these findings come from the immediate surroundings of human settlements and from agricultural landscapes, which raises questions about whether this is a synantropic species. Findings presented in this study indicate a more frequent occurrence of this species than originally thought mainly because it is most active in winter (discussed recently by Mock et al. 2016).

CONCLUSIONS

Winter is the season that most millipedes survive in shelters deep in the soil or in powdery wood, etc. and only a few are active in the leaf litter and humus. However, some species are well adapted to winter conditions and the adults are most active during this period of the year. Less competition make winter an attractive period for low temperature tolerant species. Although these species were described long ago, there are only a few sporadic records of their occurrence in Central Europe.

A c k n o w l e d g e m e n t s

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