An annotated checklist of millipede fauna from Slovakia, with ecological and biogeographic characteristics

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Abstract

Background

Two decades have passed since the publishing of the last checklist of the millipedes of Slovakia. During this time, several new faunistic records have been added and taxonomic revisions have occurred. The present updated checklist summarises data on all millipede species recorded in Slovakia, including altogether 93 species.

New information

For each species, general habitat characteristics, ecological classification and distributional pattern are provided. Ecological classification is presented for the first time for the millipede species occurring in Slovakia and is proposed as a tool for ecological studies and for the nature protection purposes. Special remarks are given to the species newly found for Slovakia, *Geoglomeris subterranea* Verhoeff, 1908, *Brachyiulus lusitanus* Verhoeff, 1898, *Cylindroiulus britannicus* (Verhoeff, 1891), *C. parisiorum* (Brölemann & Verhoeff, 1896) and *Polydesmus burzenlandicus* Verhoeff, 1925, as well as to *C. arborum* Verhoeff, 1928, the species newly confirmed for Slovakia after more than 70 years.

Keywords

Diplopoda, ecological classification, distributional pattern, faunal list, new records

Introduction

Until 1993, Slovakia was part of several political units (Hungarian, Austro-Hungarian Monarchy, Czechoslovakia, Slovak Republic, Hungary); therefore, historical data on Slovak millipede fauna are not easy to find and there has been a lot of geographical confusion in trying to locate old published records. The studies on the millipedes in Slovakia have a long history, with the first papers published at the end of the 19th century (Nowicki 1867, Nowicki 1869, Nowicki 1870, Nowicki 1871, Karliński 1883a, Karliński 1883b, Latzel 1882, Latzel 1884, Chyzer 1886, Daday 1889, Daday 1896, Petricskó 1891, Petricskó 1892, Malesevics 1892, Attems 1895, Attems 1899, Verhoeff 1899a, Verhoeff 1899b). One of the most important authors working at that time in Slovakia was Ödön Tömösváry. He wanted to prepare a monograph on the myriapods of the Kingdom of Hungary, but died young and his findings were at least excerpted in the papers of Chyzer (1886), Daday (1889) and Daday (1896).

In the pre-war and interwar periods, K. W. Verhoeff, the phenomenal German zoologist, expanded the knowledge of the millipedes of our country. In addition, important information about the millipede fauna of Slovakia is included in historical monographs published by Attems (1926), Verhoeff (1928), Verhoeff (1932), Verhoeff (1937), Ortvay (1902) and Schubart (1934). A significant contribution to the knowledge of Slovak millipedes during the first half of the 20th century was done by other authors, including Jawlowski (Jawlowski 1930, Jawlowski 1938), Jermy (1942) and Loksa (Loksa 1954, Loksa 1957, Loksa 1962, Loksa 1968). In the second half of the 20th century, the most extensive research on millipedes in Slovakia was performed by Ján Gulička (1925–2009) (Gulička 1952, Gulička 1954, Gulička 1955, Gulička 1956a, Gulička 1956b, Gulička 1957, Gulička 1960b, Gulička 1965, Gulička 1985, Gulička 1986). Gulička's unpublished compendia (Gulička 1951, Gulička 1960a), which we have today and can work with, were not taken into account in the last published checklist (Mock 2001a). This last checklist included all the available information at that time and involved information for about 70 species reported for the whole territory of Slovakia. A new chapter of millipede research began at the end of the 20th century, conducted by several researchers, for example, Tajovský (1997), Mock (Mock 1998, Mock 1999a, Mock 1999b) and Stašiov (Stašiov 1997 , Stašiov 1998). Several studies on Slovak millipede fauna were published after Gulička's death (Gulička 2016*, Gulička et al. 2014, Gulička and Košel 2016*), based on material and manuscripts from his estate. Besides this, Gulička's unpublished compendia (Gulička 1951, Gulička 1960a), which we have today available and data listed there can be actually re-evaluated and taken into consideration, represent other sources for more complex overview of the millipede fauna of Slovakia.

Since 2001, the number of species has changed significantly, thus warranting a new update. The aim of this report is to update the list of millipede species and their distribution in Slovakia, to summarise published, as well as unpublished data and records, respecting recent taxonomic changes and to provide a useful tool in the form of ecological and geographical classification of species for other studies.

Materials and methods

The classification for Diplopoda used for this checklist follows the systematic arrangement by Shear (2011), while the nomenclature follows Kime and Enghoff (2011), Kime and Enghoff (2013), Kime and Enghoff (2017). We verified the system and nomenclature using MilliBase (Sierwald and Spelda 2021); however, we are reticent towards some proposals, for example, dividing the genera *Brachydesmus* and *Polydesmus* into other genera.

We do not include the subspecific categories as subspecies, nor all the relevant literature since that information has been included by the author of the last published checklist (Mock 2001a). References are listed at the species where the first records for Slovakia were documented for the first time after the year 2000. In addition, habitat evaluation for each species is included, applied specifically to the area of Slovakia, following adapted categorisation proposed by Tuf and Tufová (2008) and marked by a letter in caps:

- **Relic species (R)** - stenotopic species inhabiting exclusively undisturbed habitats with low impact of human activities, for example, the nature-closest forests, remnants of steppes, caves, stony debris, mountain habitats.
- **Adaptable species (A)** - species inhabiting nature-close habitats (various types of forests or meadows), able to penetrate artificial and man-made habitats (parks, abandoned gardens, graveyards, greenhouses etc.).
- **Eurytopic species (E)** - species with the widest ecological valence, frequently found in forested and non-forested biotopes and in man-made plots (fields, brownfields etc.).
- **Synanthropic species (S)** - species inhabiting a wide spectrum of man-made habitats, missing in natural biotopes, species significantly synanthropic, although occasionally found in natural, mainly altered, sites.
- **Exotic species (X)** – this category includes mostly tropical species, non-native or introduced species, found exclusively in hothouses.

Ecological classification of each species (Kime and Enghoff 2011, Kime and Enghoff 2017) is provided in Notes, marked by lowercase letters:

- **(c) -** corticolous
- **(e) -** epigeic
- **(ed) -** edaphic
- **(h) -** hygrophilous
- **(m) -** mountainous
- **(n) -** nidicolous
- **(tb) -** troglobitic
- **(tp) -** troglophilous
- **(x) -** xerophilous

We would like to note that we did not adopt this habitat evaluation scheme mechanically, but we evaluate each species, based on the knowledge about its ecology in Slovakia. Question mark **(?)** next to the classification refers to problematic data on the occurrence of the species.

In addition, a general geographical category that outlines the distribution of each species is included in the list (Kime and Enghoff 2011, Kime and Enghoff 2017).

Data resources

Records from Slovakia compiled from the published literature and additional collected material are summarised. The actually sampled material is in the collection at the workplace of the authors' team. Part of the data was obtained by preliminary revision of the collection by J. Gulička, including his unpublished compendia. A large portion of Gulička's complete written legacy is lost. However, his views on the taxonomy, biogeography and ecology of individual species can be found in Gulička's additionally handwritten notes in the monographs of other authors (e.g. Verhoeff 1928, Schubart 1934 etc.).

Updated list of the millipede fauna of Slovakia

Order Polyxenida

Family Polyxenidae

Polyxenus lagurus (Linnaeus, 1758)

Distribution: West Palearctic and Nearctic

Notes: A, c, n

Order Glomerida

Notes: The order Glomerida, according to published data, is represented by three genera in Slovakia – *Trachysphaera, Glomeris* and *Geoglomeris* (Lang 1954, Kime and Enghoff 2011, Kime and Enghoff 2013, Kocourek et al. 2017). Genus *Glomeris* is rather problematic, as it represents a complex of species, characterised by inconsistency and unreliable determination information in the old literature. *G. tetrasticha*, *G. hexasticha* and *G. pustulata* represent well-confirmed species, occurring in the territory of Slovakia. Only one old record of *G. klugii* from Slovakia exists. In the area of Slovakia, some populations of the species of the genus *Glomeris* are characterised by a remarkable variety of colouration, which could indicate the ongoing speciation processes.

Family Glomeridae

Glomeris hexasticha Brandt, 1833

Distribution: South, Central and East European

Notes: A, e, x

Glomeris klugii Brandt, 1833

Distribution: West and South European

Notes: A, e, ?

The species (known under synonyms *G. conspersa* and *G. undulata* in older literature) is characterised by a south-western occurrence in Europe (Kime and Enghoff 2011). It has been confirmed in most of the neighbouring countries (Poland, Czech Republic, Austria and Hungary). For Slovakia, only one record of this species has been recently discovered, in the millipede collection of Czech arachnologist František Miller (1902–1983), housed in the National Museum, Prague (Dolejš and Kocourek 2020). One female specimen of *G. klugii* is included in the collection, labelled with April 1930, Turčianske Teplice District, Žilina Region. Based on this information, a series of sampling from this area has been conducted, but unsuccessfully. Therefore, a mistake in localisation made by collector is highly possible.

Reference: Dolejš and Kocourek (2020)

Glomeris mnischechi Nowicki, 1870

Distribution: West Carpathian

Notes: R, e

Glomeris mnischechi is considered the only endemic species of the order Glomerida north of the Alps. According to Kime and Enghoff (2011), the species inhabits mountainous biotopes of Slovakia (Belianske Tatras Mts., Pieniny Mts.) and Poland. However, literature contains many controversial data about diagnostic characteristics, as well as ecological demands (Mock 2001a, Kravcová and Mock 2014). Nowicki originally offered two descriptions of *G. mnischechi* (Nowicki 1870, Nowicki 1871), without any illustration. In addition, the author used different transcription for the species names in both cases, *Glomeris mnischechi* (Nowicki 1870) and *Glomeris mniszechii* (Nowicki 1871). After this confusion, the species was described several times in the old literature, under various synonyms (Latzel 1884, Gulička 1951,

Gulička 1960a, Dziadosz 1966). Other authors considered the species to be subspecies of *G. hexasticha*, due to the striking similarity of both species (e.g. Jawlowski 1938). Although the taxonomic status of the species remains unresolved, recent molecular analyses of several representatives of *G. hexasticha* from the type locality of *G. mnischechi* suggest the presence of several separate species; therefore, the existence of *G. mnischechi* and its occurrence in Slovakia cannot be ruled out.

Glomeris pustulata (Fabricius, 1781)

Distribution: South and Central European

Notes: A, e, c

Glomeris tetrasticha Brandt, 1833

Distribution: Central and East European

Notes: A, e

Some authors mentioned the occurrence of *Glomeris connexa* C. L. Koch, 1847 in Slovakia. This species is characteristic for its south-western European distribution (Kime and Enghoff 2011). In the literature from the last century, there is a lot of data on the findings and its occurrence. However, it should be noted that, in most cases, under this name, there were referred other species, especially *G. tetrasticha* (Kime and Enghoff 2011, Kocourek et al. 2017). From Slovakia, no recent reliable records of its occurrence are available; therefore, the older data on this species name are preliminarily all included under *G. tetrasticha*. However, due to the findings from the Czech Republic, very close to the border with Slovakia, the occurrence of this species cannot be ruled out.

Geoglomeris subterranea Verhoeff, 1908

Distribution: West and Central European

Notes: R, ed, tp, h

This species was described by Verhoeff (1908) from the neighbourhood of Dresden, Germany, where two females were found on limestone near a brook. In his monograph on the millipede fauna of Czechoslovakia, Lang (1954) presented the finding of *G. subterranea* in the only Slovak locality from the vicinity of the Bratislava City (Malé Karpaty Mts.). However, he did not comment on the finding and attached only a picture taken from other literature (Schubart 1934). Since the cited monograph contains many ambiguities and unreliable data, this information is considered doubtful (Gulička 1986, Mock 2001a). In the area of Slovakia, it was found only recently (Haľková et al., unpublished), repeatedly, in karst springs and wetlands on karst bedrock. Detailed morphological study (including SEM), supported by molecular

analysis, confirmed the identity of *G. subterranea*, without any apparent morphological adaptations to aquatic and semi-aquatic habitat. The possibility that this species is not strictly limited to the terrestrial environment has already been suggested by Noll (1939), although his findings were completely forgotten in recent literature. Noll mentioned the presence of *Geoglomeris jurassica* (a younger synonym of *G. subterranea*) in the water of three wells in Northern Bavaria, Germany. The author explained its occurrence as random, presuming the animals entered the well through crevices in the wall.

Trachysphaera acutula (Latzel, 1884)

Distribution: Carpathian

Notes: R, ed, tp, h

Trachysphaera costata (Waga, 1857)

Distribution: East and Central European

Notes: R, ed, m

Trachysphaera gibbula (Latzel, 1884)

Distribution: Alpine and West Carpathian

Notes: R, ed

Order Polyzoniida

Family Polyzoniidae

Polyzonium eburneum Verhoeff, 1907

Distribution: East Alpine and West Carpathian

Notes: R, e

Polyzonium germanicum Brandt, 1837

Distribution: European

Notes: A, e, h

Polyzonium transsilvanicum Verhoeff, 1898

Distribution: East Carpathian

Notes: R, h

Order Julida

Family Blaniulidae

Archiboreoiulus pallidus (Brade-Birks, 1920)

Distribution: West, North, Central and East European

Notes: R, ed, tp

Reference: Mock et al. (2015)

Blaniulus guttulatus (Fabricius, 1798)

Distribution: European

Notes: S, ed

Cibiniulus slovacus Antić, Mock & Enghoff, 2015

Distribution: West Carpathian

Notes: R, ed, tp

Choneiulus palmatus (Němec, 1895)

Distribution: European

Notes: S, ed

Reference: Mock (2001b)

Nopoiulus kochii (Gervais, 1847)

Distribution: Euro-Caucasian

Notes: S, ed

Proteroiulus fuscus (Am Stein, 1857)

Distribution: European

Notes: E, c, n

Family Nemasomatidae

Nemasoma varicorne C. L. Koch, 1847

Distribution: European

Notes: R, c, n

Family Julidae

Brachyiulus bagnalli (Brolemann, 1924)

Distribution: South and Central European

Notes: E, e, n, x

Brachyiulus lusitanus Verhoeff, 1898

Materials

a. scientificName: *Brachyiulus lusitanus* Verhoeff, 1898; class: Diplopoda; family: Julidae; taxonRank: species; genus: *Brachyiulus*; specificEpithet: *lusitanus*; country: Slovakia; locality: Košice Basin, Košice – a city park (Mestský park) at the railway station; verbatimElevation: 210 m a.s.l.; locationRemarks: leaf litter (*Acer platanoides, Aesculus hippocastaneum*); verbatimCoordinates: 48°43'20.4"N 21°15'52.5"E; eventDate: 18-12-2018; fieldNotes: co-existing with *Nopoiulus kochii, Cylindroiulus parisiorum, Ophyiulus pilosus*; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: FDA29C7C-2F78-5739-8BB3-4DBC92CF1F07

b. scientificName: *Brachyiulus lusitanus* Verhoeff, 1898; class: Diplopoda; family: Julidae; taxonRank: species; genus: *Brachyiulus*; specificEpithet: *lusitanus*; county: Slovakia; locality: Košice Basin, Košice – a city park (Mestský park) at the railway station; verbatimElevation: 210 m a.s.l.; locationRemarks: leaf litter (*Acer platanoides, Aesculus hippocastaneum*); verbatimCoordinates: 48°43'20.4"N 21°15'52.5"E; eventDate: 18-12-2018; fieldNotes: co-existing with *Nopoiulus kochii, Cylindroiulus parisiorum, Ophyiulus pilosus*; individualCount: 2; sex: female; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: C2B03976-6630-57CB-991E-E7F2F0745FFD

Distribution: European

Notes: A, e

According to Kime and Enghoff (2017), the species is distributed in Western and Central Europe and Balkans, but also Algeria, Egypt and Iran. It was introduced into Australia and North America. The species can be found in forests, in addition to open

land, meadows, cornfields and vineyards. It has been recorded under stone debris, as well as city parks and heated greenhouses.

Cylindroiulus boleti (C. L.Koch, 1847)

Distribution: South and Central European

Notes: R, e

Cylindroiulus arborum Verhoeff 1928

Materials

a. scientificName: *Cylindroiulus arborum* Verhoeff, 1928; class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *arborum*; country: Slovakia; locality: Burda Mts.; verbatimElevation: 190 m a.s.l.; locationRemarks: forest (*Quercus* spp., *Carpinus betulus*, *Fraxinus excelsior*), decomposed wood from an oak-tree cavity; verbatimCoordinates: 47°50'39.84"N 18°49'16.92"E; eventDate: 2017-06-16; fieldNotes: co-existing with *Proteroiulus fuscus* and juveniles of *Haasea flavescens*; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: 9324FFF8-5D78-5265-A741-D1B4F1D45888

b. scientificName: *Cylindroiulus arborum* Verhoeff, 1928; class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *arborum*; country: Slovakia; locality: Burda Mts.; verbatimElevation: 190 m a.s.l.; locationRemarks: forest (*Quercus* spp., *Carpinus betulus*, *Fraxinus excelsior*), decomposed wood from an oak-tree cavity; verbatimCoordinates: 47°50'39.84"N 18°49'16.92"E; eventDate: 2017-06-16; fieldNotes: co-existing with *Proteroiulus fuscus* and juveniles of *Haasea flavescens*; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: E627CC37-B3FC-5FE2-BCEB-88908BF9628F

c. scientificName: *Cylindroiulus arborum* Verhoeff, 1928; class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *arborum*; country: Slovakia; locality: Burda Mts.; verbatimElevation: 190 m a.s.l.; locationRemarks: forest (*Quercus* spp., *Carpinus betulus*, *Fraxinus excelsior*), decomposed wood from an oak-tree cavity; verbatimCoordinates: 47°50'39.84"N 18°49'16.92"E; eventDate: 2017-06-16; fieldNotes: co-existing with *Proteroiulus fuscus* and juveniles of *Haasea flavescens*; individualCount: 16; lifeStage: juveniles; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: C1CD8B04-EED0-53A3-8661-D35A6C0637A4

Distribution: Central and East European

Notes: R, e

Mainly lowland species with Central and East European distribution (Kime and Enghoff 2017). The species usually prefers forest habitats, found mostly in deadwood and leaf litter, although several records are from hothouses and other artificial habitats. New record after more than 70 years in Slovakia (see Dudich 1958, Mock 2001a).

Cylindroiulus britannicus (Verhoeff, 1891)

Material

a. scientificName: *Cylindroiulus britannicus* (Verhoeff, 1891); class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *britannicus*; country: Slovakia; locality: Košice Basin, Košice, Public cemetery; verbatimElevation: 225 m a.s.l.; locationRemarks: leaf litter (*Tilia cordata, Fraxinus excelsior, Acer platanoides*); verbatimCoordinates: 48°41'42.420"N 21° 15'35.130"E; eventDate: 2020-05-26; fieldNotes: co-existing with *Blaniulus guttulatus*, *Choneiulus palmatus, Cylindroiulus caeruleoncictus, Ophyiulus pilosus*; individualCount: 5; sex: male; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: 07618FD5-47AE-58FD-B9ED-E6AFC10AC9F2

Distribution: Cosmopolitan

Notes: S, c, e

Species with European distribution, in Britain and Ireland found beneath the bark of dead deciduous tree trunks and stumps (Blower 1985). It appears to be predominantly or entirely synanthropic in most other countries, occurring primarily in cities and cultivated areas (Kime and Enghoff 2017). The same applies to the first findings of the species in Slovakia, where it was found in city parks.

Cylindroiulus burzenlandicus Verhoeff, 1907

Distribution: Carpathian

Notes: R, e, m

Cylindroiulus caeruleocinctus (Wood, 1864)

Distribution: Cosmopolitan

Notes: S, e

Reference: Mock (2006)

Cylindroiulus latestriatus (Curtis, 1845)

Distribution: Atlantic, North-western and Central European

Notes: S, e

Reference: Mock (2001b)

Cylindroiulus parisiorum (Brölemann & Verhoeff, 1896)

Materials

a. scientificName: *Cylindroiulus parisiorum* (Brölemann & Verhoeff, 1896); class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *parisiorum*; country: Slovakia; locality: Košice Basin, Košice – a city park (Mestský park) at the railway station; verbatimElevation: 210 m a.s.l.; locationRemarks: leaf litter (*Acer platanoides, Aesculus hippocastaneum*); verbatimCoordinates: 48°43'20.4"N 21°15'52.5"E; eventDate: 2018-12-18; fieldNotes: co-existing with *Nopoiulus kochii, Brachiulus lusitanus, Ophyiulus pilosus*; individualCount: 21; sex: male; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: E73614D2-7223-587A-89D1-361A048BFAF6

b. scientificName: *Cylindroiulus parisiorum* (Brölemann & Verhoeff, 1896); class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *parisiorum*; country: Slovakia; locality: Košice Basin, Košice – a city park (Mestský park) at the railway station; verbatimElevation: 210 m a.s.l.; locationRemarks: leaf litter (*Acer platanoides, Aesculus hippocastaneum*); verbatimCoordinates: 48°43'20.4"N 21°15'52.5"E; eventDate: 2018-12-18; fieldNotes: co-existing with *Nopoiulus kochii, Brachiulus lusitanus, Ophyiulus pilosus*; individualCount: 28; sex: female; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: E5580CDA-F02A-56DA-A42F-9A89FFEBDDC6

c. scientificName: *Cylindroiulus parisiorum* (Brölemann & Verhoeff, 1896); class: Diplopoda; family: Julidae; taxonRank: species; genus: *Cylindroiulus*; specificEpithet: *parisiorum*; country: Slovakia; locality: Košice Basin, Košice – a city park (Mestský park) at the railway station; verbatimElevation: 210 m a.s.l.; locationRemarks: leaf litter (*Acer platanoides, Aesculus hippocastaneum*); verbatimCoordinates: 48°43'20.4"N 21°15'52.5"E; eventDate: 2018-12-18; fieldNotes: co-existing with *Nopoiulus kochii, Brachiulus lusitanus, Ophyiulus pilosus*; individualCount: 28; sex: female; lifeStage: adult; identifiedBy: A. Mock; basisOfRecord: PreservedSpecimen; occurrenceID: B6567042-B19D-5685-A635-F439190AB521

Distribution: European

Notes: S, e, c

The species has European distribution; however, the captures apart from England are scattered and isolated. Its occurrence is associated with human activity. According to Kime and Enghoff (2017), it is relatively rare, some records are likely to be incorrect due to possible confusion with other *Cylindroiulus* species. Findings in synanthropic habitat represent the first records for Slovakia.

Cylindroiulus vulnerarius (Berlese, 1888)

Distribution: West and Central European

Notes: X, e, h

Reference: Mock (2001b)

Enantiulus nanus (Latzel, 1884)

Distribution: European

Notes: A, e, h

Enantiulus tatranus (Verhoeff, 1907)

Distribution: West Carpathian

Notes: R, e, m

Enantiulus transsilvanicus (Verhoeff, 1899)

Distribution: East Carpathian

Notes: R, e

Reference: Gulička et al. (2014)

Julus curvicornis Verhoeff, 1899

Distribution: Carpathian

Notes: R, e

Julus scandinavius Latzel, 1884

Distribution: Central European and Scandinavian

Notes: A, e, n

Julus scanicus Lohmander, 1925

Distribution: Central European

Notes: A, e, h

Julus terrestris Linnaeus, 1758

Distribution: North, Central, South and East European

Notes: R, e, h

Kryphioiulus occultus (C. L. Koch, 1847)

Distribution: East European

Notes: A, e, x

Leptoiulus baconyensis (Verhoeff, 1899)

Distribution: East and Central European

Notes: R, e

Leptoiulus cibdellus (Chamberlin, 1921)

Distribution: North and Central European, Baltic

Notes: R, e, h, n

Leptoiulus liptauensis (Verhoeff, 1899)

Distribution: West Carpathian

Notes: R, e, m

Leptoiulus noricus Verhoeff, 1913

Distribution: Sudetico-Carpathian

Notes: R, e, m

Leptoiulus mariae Gulička, 1952

Distribution: West Carpathian

Notes: R, e, tp

Leptoiulus proximus (Němec, 1896)

Distribution: North, Central and East European

Notes: A, e

Leptoiulus tatricus Gulička, 1956

Distribution: West Carpathian

Notes: R, e, m

Leptoiulus trilobatus (Verhoeff, 1894)

Distribution: Central and East European

Notes: A, e

Leptoiulus tussilaginis (Verhoeff, 1907)

Distribution: West Carpathian

Notes: R, e, m

Megaphyllum projectum Verhoeff, 1894

Distribution: Central and East European

Notes: A, e

Megaphyllum silvaticum (Verhoeff, 1898)

Distribution: East and Central European

Notes: R, e, m

Megaphyllum unilineatum (C. L. Koch, 1838)

Distribution: South and Central European, Balkan

Notes: E, e, x

Ommatoiulus sabulosus (Linnaeus, 1758)

Distribution: European

Notes: E, e, x

Ophyiulus pilosus (Newport, 1842)

Distribution: European

Notes: E, e

Unciger foetidus (C. L. Koch, 1838)

Distribution: European

Notes: E, e, h

Unciger transsilvanicus (Verhoeff, 1899)

Distribution: Central European

Notes: A, e

Xestoiulus carpathicus (Verhoeff, 1907)

Distribution: North Carpathian

Notes: R, e, m

Xestoiulus laeticollis (Porat, 1889)

Distribution: East and Central European

Notes: R, e, h, n

Reference: Tajovský et al. (2001)

Order Chordeumatida

Family Chordeumatidae

Melogona broelemanni (Verhoeff, 1897)

Distribution: Central European, Balkan

Notes: S, e

Reference: Mock and Tajovský (2002)

Melogona transsylvanica (Verhoeff, 1897)

Distribution: East Carpathian

Notes: A, e

Reference: Mock and Tajovský (2002)

Melogona voigtii (Verhoeff, 1899)

Distribution: North and Central European

Notes: S, e

Reference: Mock and Tajovský (2002)

Family Brachychaeteumatidae

Brachychaeteuma bradeae (Brolemann & Brade-Birks, 1917)

Distribution: West European

Notes: R, tp

Reference: Kováč et al. (2005)

Family Trachygonidae

Heteroacrochordum evae Loksa, 1960

Distribution: West Carpathian

Notes: R, ed

Reference: Mock et al. (2019)

Family Hungarosomatidae

Hungarosoma bokori Verhoeff, 1928

Distribution: West Carpathian

Notes: R, e, h

The first description of the species was published by Verhoeff (1928), based on a single female specimen from the Abaliget Cave in Hungary. Detailed analysis of diagnostic characteristics, based on the fresh material from the type locality, as well as all available museum material, was presented only recently by Mock et al. (2016). However, the authors overlooked the apparent similarity of the diagnostic features with that of *Ochogona cervina* (Verhoeff, 1899), recently pointed out by Antić et al. (2018). Gonopods of both species appear to be identical, nevertheless, a synonymy was not formally established. Minute differences between Verhoeff's description of *O. cervina* and our knowledge of *H. bokori* must be reviewed. In addition, in order to justify the name of the family Hungarosomatidae and its position in the Chordeumatida system, the decision as to which genus the species belongs: *Ochogona*, *Octeicosisoma*, *Triakontizona* or *Ceratosoma,* has to be resolved (Haľková and Mock 2018, Korsós and Lazányi 2020).

Reference: Papáč et al. (2014)

Family Craspedosomatidae

Beskidia jankowskii (Jawlowski, 1938)

Distribution: East Carpathian

Notes: R, e, m

Reference: Gulička et al. (2014)

Craspedosoma raulinsii Leach, 1814

Distribution: West, Central and South European

Notes: A, e

Craspedosoma transsilvanicum Verhoeff, 1897

Distribution: South and Eastern European

Notes: R, e

Chelogona carpathicum (Latzel, 1882)

Distribution: West Carpathian

Notes: R, e, m

Ochogona caroli (Rothenbuhler, 1900)

Distribution: Central European

Notes: R, e

Reference: Gulička et al. (2014)

Family Haasidae

Haasea flavescens (Latzel, 1884)

Distribution: South and Central European

Notes: A, e

Hylebainosoma gulickai (Tajovský, Mock & Papáč, 2014)

Distribution: West Carpathian

Notes: R, tb

Hylebainosoma tatranum Verhoeff, 1899

Distribution: North Carpathian

Notes: R, e, m

Family Entomobielziidae

Entomobielzia kimakowizii (Verhoeff, 1897)

Distribution: East Carpathian

Notes: R, e

Reference: Gulička et al. (2014)

Family Attemsiidae

Allorhiscosoma sphinx (Verhoeff, 1907)

Distribution: West Carpathian

Notes: R, tp

Mecogonopodium carpathicum Mock & Tajovský, 2008

Distribution: West Carpathian

Notes: R, tp

Family Mastigophorophyllidae

Haploporatia eremita (Verhoeff, 1909)

Distribution: Central European

Notes: R, e

Mastigona bosniensis (Verhoeff, 1897)

Distribution: Central and East European

Notes: E, e

Mastigophorophyllon cirriferum Verhoeff, 1899

Distribution: West Carpathian

Notes: R, e, m

Family Verhoeffiidae

Haplogona oculodistincta (Verhoeff, 1893)

Distribution: Alpine

Notes: S, e

Reference: Haľková and Mock (2018)

Order Polydesmida

Family Polydesmidae

Brachydesmus dadayi Verhoeff, 1895

Distribution: South, Central and East European

Notes: A, e, h

Brachydesmus superus Latzel, 1884

Distribution: European

Notes: S, e, h

Polydesmus burzenlandicus Verhoeff, 1925

Distribution: South-eastern Carpathian

Notes: R, e, c

Polydesmus burzenlandicus is a small hygrophilous representative of the order Polydesmida, widespread mainly in the south-eastern Carpathians (Kime and Enghoff 2011) The species inhabits forest habitats of the mountainous landscape. It was recently documented from the area of the Latorica PLA (Mock et al. 2021). These findings represent the first record for Slovakia.

Reference: Mock et al. (2021)

Polydesmus complanatus (Linnaeus, 1761)

Distribution: North, Central, South and East European

Notes: E, e, h

Polydesmus denticulatus C. L. Koch, 1847

Distribution: European

Notes: E, e

Polydesmus inconstans Latzel, 1884

Distribution: European

Notes: S, e, h

Reference: Mock (2004)

Polydesmus komareki Ložek & Gulička, 1962

Distribution: East Carpathian

Notes: R, e, m

Polydesmus montanus Daday, 1889

Distribution: East Carpathian

Notes: R, e, c, m

Polydesmus polonicus Latzel, 1884

Distribution: East Carpathian

Notes: R, e, m

Polydesmus subscabratus Latzel, 1884

Distribution: South Carpathian

Notes: R, e, tp, ?

South Carpathian endemic species with affinity to wet forested habitats. From Slovakia, only one questionable historical record is documented from the vicinity of the Veľaty Village (Daday 1889), significantly isolated from the rest of the area of its known distribution in the Southern Carpathians (Kime and Enghoff 2011, Kime and Enghoff 2013). Its occurrence in Slovakia, however, can be supported by the recent findings of *P. transylvanicus* Daday, 1889 in nearby locations within the Eastern Slovak Plain (Haľková and Mock 2018), the species with similar biogeography and ecology as *P. subscabratus*.

Polydesmus tatranus Latzel, 1884

Distribution: Carpathian

Notes: R, e, h, m

Polydesmus transylvanicus Daday, 1889

Distribution: Carpathian

Notes: R, e, h

Reference: Haľková and Mock (2018)

Family Paradoxosomatidae

Oxidus gracilis (C. L. Koch, 1847)

Distribution: Cosmopolitan

Notes: X, e

Strongylosoma stigmatosum (Eichwald, 1830)

Distribution: East and Central European, Baltic

Notes: A, e, tp, h

Family Pyrgodesmidae

Poratia digitata (Porat, 1889)

Distribution: North, West and Central European

Notes: X, e, c, h

Reference: Mock (2001b)

Family Oniscodesmidae

Amphitomeus attemsi (Schubart, 1934)

Distribution: East and Central European

Notes: X, e, c, h

Reference: Mock (2001b)

Discussion

The increase in faunistic research over the past two decades has resulted in significant expansion of knowledge of the Slovak millipede fauna. Since the last published review of millipede species from the territory of Slovakia (Mock 2001a), 23 species have been added, resulting at present in 93 species. Within the whole Carpathian Region, Romania still represents the country with the richest fauna, with 170 recorded millipede species (Giurginca 2021). Nevertheless, compared to the total species number of millipedes from neighbouring countries, 94 from Poland (Stojałowska and Staręga 1974, Wytwer 1997), 77 from the Czech Republic (Tajovský and Tuf 2016, Kocourek et al. 2017), 107 species from Hungary (Korsós and Lazányi 2020), 190 from Austria (extrapolation, Geiser 2018) and 75 from Germany (Hauser and Voigtländer 2019), 93 species recorded for Slovakia constitute a strikingly high number, considering the rather small area of the country. In addition, new findings are still expected for the whole territory of Slovakia since numerous locations remain less investigated, as well as records of non-native species are likely to emerge.

Most of the unclear and questionable data that were preliminarily excluded from the list are from the older literature. One of the most recent studies, creating confusion due to imprecision in accurate and reliable determination, was published by Topp et al. (2006). The authors investigated the biodiversity of woodlice and millipede faunas of the primeval forest of Central Slovakia. The authors' team, however, lacked a taxonomist and, as a result, species not occurring in our country or species with strictly synanthropic occurrence were listed, such as such as *Mycogona germanica*, *Allaiulus nitidus* or *Blaniulus guttulatus* and *Cylindroiulus latestriatus* (as *Aneuloboiulus frisius*). From the

faunistic point of view, the article is very inaccurate and should be approached with great caution.

The millipede fauna of Slovakia can be characterised as a combination of European, Alpine-Atlantic and Carpathian elements, with the occasional influence of Caucasian and Balkan fauna (Kime and Enghoff 2011, Kime and Enghoff 2017). From the biogeographical aspect, a relatively high number of endemic species are represented in the country. This is presumably linked to the Carpathians. Compared to the Alps, the geographical repartition of the Carpathian fauna was less affected by glaciations, allowing the isolation of the Carpathian Regions surrounded by the Paratethys (Holdhaus 1954). The presence of a significant proportion of endemic fauna characterises the millipede fauna of Slovakia as exceptional in Central Europe. Gulička and Košel (2016) have mentioned the presence of 28 Carpathian endemic species of millipedes in Slovakia. A large part of these species is defined as Western-Carpathian. However, the border between the Eastern and Western Carpathians crosses the eastern part of the country, resulting in the representation of the eastern Carpathian fauna. Nevertheless, it should be noted that this border is not strict and is not consistent for all the species. For some species, the term Northern-Carpathian endemic is more appropriate. Some species even can be characterised by microendemism (e.g. *Leptoiulus tatricus*, *Mecogonopodium carpathicum* and *Hylebainosoma gulickai*). The presence of the Western Carpathians has an undeniable influence on the composition of Slovak millipedes. Almost 20% of the species are represented by rare mountainous fauna and more than 10% are characteristic for their preference of cave habitat.

According to ecological classification, 50% of Slovak millipede fauna are represented by stenotopic species inhabiting exclusively undisturbed habitats with a low impact of human activities. A total of 20% can be classified as adaptable and only 7% can be classified as eurytopic. While the original classification, proposed by Tuf and Tufová (2008), is applicable to most of the species, the categorisation does not sufficiently segregate non-native, introduced species occurring exclusively in a specific environment (e.g. tropical species in greenhouses). Therefore, we added and used two categories to this classification, in order to distinguish synanthropic and exotic species. These categories include the remaining 13% of millipede species of Slovakia.

Despite the increased interest in faunistic research, the millipede fauna of Slovakia has not yet been completely investigated. Several findings are still to be determined at the species level. Such findings include subadult and female individuals of *Typhloiulus* sp. from the Domica Cave (Papáč et al. 2014) and a representative of the family Trichopolydesmidae (Akkari and Enghoff 2011). Both taxa are connected to the cave environment.

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