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Millipedes (Diplopoda) of twelve caves in Western Mecsek, Southwest Hungary

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Abstract. Twelve caves of Western Mecsek, Southwest Hungary were examined between September 2010 and April 2013 from the millipede (Diplopoda) faunistical point of view. Ten species were found in eight caves, which consisted eutroglophile and troglobiont elements as well. The cave with the most diverse fauna was the Törökpince Sinkhole, while the two previously also investigated caves, the Abaligeti Cave and the Mánfai-kőlyuk Cave provided less species, which could be related to their advanced touristic and industrial utilization.

Keywords. Diplopoda, Mecsek Mts., caves, faunistics

INTRODUCTION

Although more than 220 caves are known from the Mecsek Mts., our knowledge on the invertebrate fauna of the caves in the region is rather poor. Only two caves, the Abaligeti Cave and the Mánfai-kőlyuk Cave have previously been examined in speleozoological studies which includeed the investigation of the diplopod fauna as well (Bokor 1924, Verhoeff 1928, Gebhardt 1933a, 1933b, 1934, 1963, 1966, Farkas 1957).

These extensive investigations resulted in recording ten and six millipede species in the Abaligeti Cave and the Mánfai-kőlyuk Cave respecttively, including three species new to science at that time, too (Gebhardt 1966).

Brachydesmus troglobius Daday, 1889, *Hungarosoma bokori* Verhoeff, 1928 and *Haasea hungarica* (Verhoeff, 1928) were considered to be endemic for the Abaligeti Cave. However, later Loksa (1961) mentioned the Kovácsi Hill (Keszthelyi Mts.) as a second locality of *H. bokori*. *H. hungarica* was also found in other localities in forest litter in the Kőszegi Mts. (Szalay 1942), on the Kovácsi Hill (Loksa 1961), and in the Dráva Region (Korsós 1998). Although *B. troglobius* proved to be rather widespread in the karstic regions of the former Yugoslavia (Mršić 1998, 1994, Ćurčić & Makarov 1998), the species was not yet found in other Hungarian caves.

All the six millipede species of the Mánfai-kőlyuk Cave (*Polyxenus lagurus* (Linnaeus, 1758), *Glomeris hexasticha* Brandt, 1833, *Haploporatia* sp., *Polydesmus collaris* C. L. Koch, 1847, *Ommatoiulus sabulosus* (Linnaeus, 1758) and *Leptoiulus* sp.) were found in the entrance region in humid leaf litter (Gebhardt 1966). *Heteroporatia* (now *Mastigona*) *méhelyi* Verhoeff, 1897, *Craspedosoma transsylvanicum* Verhoeff, 1897, and *Polyzonium germanicum* Brandt, 1837 have been found in plant debris in the Törökpince Sinkhole, that was hidrologically connected with the Western-II collateral of the Abaligeti Cave in that time, and was handled as a branch of that (Gebhardt 1933a). Gebhardt (1966) had also found *Gervaisia noduligera* (now *Trachysphaera scmidtii* Heller, 1858) in the deeper parts of the Abaligeti Cave, where the specimens were fed on woody debris. The three *Polydesmus* species, *P. complanatus* (Linnaeus, 1761), *P. collaris* C. L. Koch, 1847, and *P. denticulatus* C. L. Koch, 1847 proved to be quite common at the entrance region of the Abaligeti Cave (Gebhardt 1966).

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More recently, Korsós (2000) has published a short paper on the millipede fauna of the Abaligeti Cave, enlisting altogether 8 species however, only one of them (*Brachydesmus troglobius*) was categorized as eutroglobiont element. The rare species, *Hungarosoma bokori* and *Haasea hungarica* have both been successfully recollected (in 1991, and 1999 respectively).

Following these investigations, the original conditions of the two caves have considerably been affected by human impact. The Abaligeti Cave has been developed for the public, capable to receive thousands of tourists every year, while the Mánfai-kőlyuk Cave has been utilized by waterworks and has completely lost its natural character. Considering that these changes could have influenced the diversity of the caves, a repeated sample collection was reasonable. Our additional aim was to explore the millipede fauna of other caves in the Mecsek Mts. which were so far biospeleologically uninvestigated.

The ecological classification of cave-dwelling animals was rather heterogeneous until the general acceptance of Sket's category system (2008). In this paper we give the categories of the millipede species of the investigated caves according to the new system. Troglobiont is a species with strong bounds to hypogean habitats. Eutroglophiles are essentially epigean species that are able to maintain a permanent subterranean population, while subtroglophiles are species inclined to perpetually or temporarily inhabit subterranean habitats, but are intimately associated with epigean habitats for some biological functions. Trogloxene is a species that only occurs sporadically in a hypogean habitat, and unable to establish subterranean population (Sket 2008).

MATERIAL AND METHODS

Between September 2010 and April 2013 we spent 22 collecting days in 12 caves of the Western Mecsek (Figure 1). We assigned different types of caves with various horizontal and vertical extensions (Table 1). The Törökpince Sinkhole was treated as an independent cave, as it has own cadastre number, and at present does not have active hidrological connection with the Abaligeti Cave.

Considering the vulnerability of the closed cave ecosystems and the relative low abundance of cave-dwelling animals, we did not use quantitative sampling methods which are generally not recommended. In most cases we did hand-collecting, but in the first year we also tried to set up pitfall traps in two occasions in the Törökpince Sinkhole and in the Abaligeti Cave, too.

Specimens were fixed and stored in 70 and 96% ethanol, and are deposited in the Myriapoda Collection of the Hungarian Natural History Museum. We used a Leica M125 stereo microscope, and the relevant publications (Blower 1985, Schubart 1934, Korsós 2008) for the identification of the samples. Gonopods, when it was necessary, were dissected and analysed under higher magnification.

RESULTS

GLOMERIDA

Doderiidae

Trachysphaera schmidtii Heller, 1858

Gervaisia noduligera Verhoeff, 1906
Trachysphaera noduligera: Strasser 1966
Trachysphaera schmidtii Heller, 1858: Sillaber 1987

Localities. Abaligeti Cave (23/11/2010, 08/06/2011), Törökpince Sinkhole (24/10/2010).

Remarks. Epigean populations from the Mecsek Mts. are well-known (Gebhardt 1966). Gebhardt (1933a) mentioned an observation of 90−100 specimens on wood debris in the Abaligeti Cave in July 1930. During our investigations we found the species in low abundance. A male specimen was found in the Eastern collateral and two females were collected feeding on the lamp flora of the entrance of the Western-II collateral, 380 m deep in the cave, where a permanent small population has been observed. We had a single record of a female specimen on the plain clay at the ending point (80 m deep) of the Törökpince Sinkhole.
Eutroglophile.

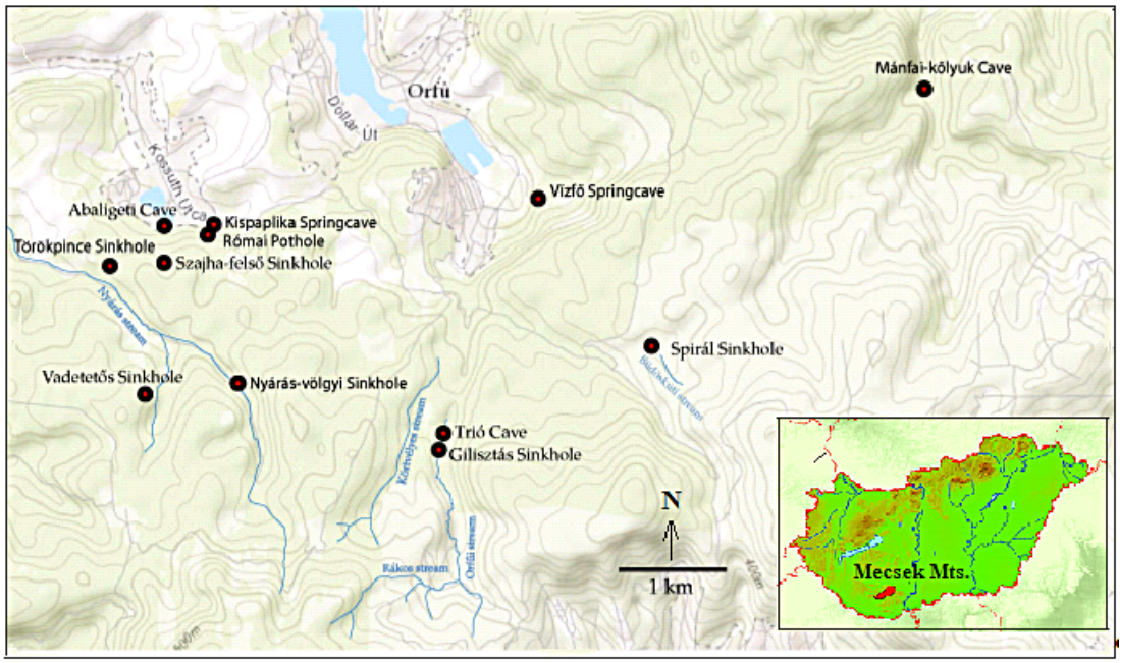

Figure 1. Location of the 12 examined caves in the Western Mecsek

Table 1. Basic data of the caves examined

Name of cave	Cadastre number	Settlement	Coordinates of entrance Y (Decimal degree)	Coordinates of entrance X (Decimal degree)	Entrance's altitude above sea level (m)	Horizontal extension of cave (m)	Vertical extension of cave (m)
Abaligeti Cave	4120-1	Abaliget	578,056.429	88,434.520	218,770	1764	49
Gilisztás Sinkhole	4120-70	Orfű	580,693.262	86,268.727	307,704	134	51
Kispaplika Springcave	4120-22	Abaliget	578,537.570	88,409.775	220,337	50	10
Mánfai-kőlyuk Cave	4120-2	Mánfa	585,324.364	89,720.420	240,121	360	12
Nyárás-völgyi Sinkhole	4120-31	Kővágószőlős	578,760.081	86,896.453	291,643	34	19
Római Pothole	4120-222	Abaliget	578,465.730	88,298.610	247,932	26	24
Spirál Sinkhole	4120-130	Pécs	582,719.925	87,242.072	350,280	1000	86
Szajha-felső Sinkhole	4120-16	Abaliget	578,056.137	88,041.665	283,508	125	42
Törökpince Sinkhole	4120-13	Abaliget	577,544.640	88,007.391	275,791	87	7
Trió Cave	4120-71	Orfű	580,722.262	86,347.182	301,035	250	58
Vadetetős Sinkhole	4120-27	Kővágótöttös	577,872.842	86,795.058	320,701	180	36
Vízfő Springcave	4120-3	Orfű	581,611.158	88,670.206	211,174	330	27

CHORDEUMATIDA

Haaseidae

Haasea hungarica (Verhoeff, 1928)

Orobainosoma hungaricum Verhoeff, 1928
Haasea hungarica: Hoffman 1980
Haasea hungarica: Korsós 2000

Locality. Kispaplika Springave (07/10/2010), Trió Cave (29/04/2013).

Remarks. There are some records of epigean populations from Tubes Hill and Dömörkapu (Mecsek Mts.), as well as from the Kőszegi Mts. (Szalay 1942), the Keszthelyi Mts. (Loksa 1961) and the Dráva Region (Korsós 1998). In the Abaligeti Cave *H. hungarica* was found in the deepest parts of the main passage and in a hall 300 m deep, called Karthago's Ruins, feeding on wood remains (Gebhardt 1933a). The first collection was made by Elemér Bokor in 1922, on which the original description by Verhoeff (1928) was based. Gebhardt (1933a) mentioned a specimen collected from the cave with reduced pigmentation of the ocelli. We have a single record of a female specimen from the entrance shaft of the Kispaplika Spring cave, and a small population − feeding on woody debris − was also found in a collateral of the Trió Cave. These were the first records in the Mecsek Mts. from other cave than the Abaligeti Cave.
Eutroglophile.

Mastigona bosniensis (Verhoeff, 1897)

Heteroporatia bosniense: Verhoeff, 1897b, Schubart 1934
Heteroporatia bosniensis: Attems 1899
Mastigona bosniensis: Jeekel 1970
Mastigona mehelyi Verhoeff, 1897: Lazányi & Korsós 2009

Locality. Nyárás-völgyi Sinkhole (14/01/2012).

Remarks. The species *Mastigona mehelyi* (Verhoeff, 1897), mentioned by Gebhardt (1966), has already been considered as a junior synonym of *M. bosniensis* (Korsós & Lazányi 2008, Lazányi & Korsós 2009). Up to now, only epigean records of this species were known from the Dráva Region (Korsós 1998) and the Keszthelyi Mts. (Kovácsi Hill) (Loksa 1961). A single female specimen was collected from 20 m deep from the vertical Nyárás-völgyi Sinkhole.
Trogloxene.

JULIDA

Julidae

Unciger foetidus (C. L. Koch, 1838)

Iulus foetidus C. L. Koch, 1838: Latzel 1884, Ortvay 1902
Julus foetidus: Chyzer 1886, Daday 1889, Petricskó 1891, 1892
Oncoiulus foetidus: Verhoeff 1928, 1941, Dudich 1958
Unciger foetidus: Schubart 1934, Blower 1985

Localities. Törökpince Sinkhole (21/08/2010).

Remarks. A widespread litter-dwelling species of the Mecsek and the Keszthelyi Mts., usually inhabiting undisturbed deciduous forests (Lazányi & Korsós 2009). A female specimen was found in the entrance region of the Törökpince Sinkhole.
Trogloxene.

Cylindroiulus luridus (C. L. Koch, 1847)

Julus luridus C. L. Koch, 1838: Latzel 1884, Ortvay 1902
Cylindroiulus luridus: Verhoeff 1907, Schubart 1934

Locality. Törökpince Sinkhole (21/08/2010).

Remarks. Similarly to the previous species, *C. luridus* is also a widespread forest-dwelling species. Its occurrence in the first 15 m of the Törökpince Sinkhole is probably by chance.
Trogloxene.

Blaniulidae

Blaniulus guttulatus (Fabricius, 1798)

Julus guttulatus Fabricius, 1798
Blaniulus guttulatus: C. L. Koch 1863, Daday 1889, Dudich 1958, Blower 1985

Locality. Törökpince Sinkhole (27/10/2010).

Remarks. A common forest species in Hungary. A single female specimen was collected in pitfall trap near the ending point of the Törökpince Sinkhole, 80 m deep in the cave.
Trogloxene.

***Boreoiulus tenuis* (Bigler, 1913)**

Monocobates tenuis Bigler, 1913
Boreoiulus tenuis: Blower 1985

Localities. Törökpince Sinkhole (27/10/2010).

Remarks. Distributed in the Atlantic region. Due to its preference towards cool climate, the species frequently inhabits barks in Hungary. We have some records so far from Szenyér and Keszthely (Korsós *et al.* 2006), Somogy county. A single female individual was collected 80 m deep in the Törökpince Sinkhole with a pitfall trap. This is the first record from the Mecsek Mts.
Subtroglophile.

POLYDESMIDA

Polydesmidae

***Brachydesmus troglobius* Daday, 1889**

Brachydesmus troglobius: Verhoeff 1928

Localities. Abaligeti Cave (22/09/2010, 04/11/2010, 23/11/2010, 25/11/2010, 09/12/2010, 07/08/2011, 23/08/2012), Törökpince Sinkhole (07/08/2011, 23/08/2012).

Remarks. The species had first been in the Abaligeti Cave by János Pável (date is not known), and then it had been described by Daday (1889) as an endemic species of the cave. Since then other records from the Abaligeti Cave were published by Bokor (1924), Gebhardt (1934, 1963, 1966), Korsós (2000) and Korsós *et al.* (2006). *B. troglobius* was collected in numerous caves from the Dinaric Karst, too (Mršić 1998, 1994, Ćurčić & Makarov 1998). Although Gebhardt (1966) mentioned an observation of an epigean population in winter 1956, found on plant debris covered by snow close to limestone rocks near Dömörkapu (Mecsek Mts.), this record should be treated with caution because of the lack of preserved specimen. Therefore *B. troglobius* is still considered to be an obligate cave-dwelling invertebrate.

During our investigations it proved to be the most frequently encountered millipede species of the Abaligeti Cave. We have collected altogether 14 specimens, including males, in seven occasions. They were distributed in the main passage, the Eastern collateral, and the Western-II collateral, too, feeding on the lamp flora or wood remains, or just walking on the clay or on the rocks. We found a population in the deeper zone of the Törökpince Sinkhole as well. Two male, three female, and one juvenile specimens were collected from that place. This is the first record in Hungary from another place than the Abaligeti Cave.
Troglobiont.

***Polydesmus collaris* C. L. Koch, 1847**

Polydesmus collaris: Korsós 1994, Korsós *et al.* 1999

Localities. Vadetetős Sinkhole (08/12/2010), Törökpince Sinkhole (21/08/2010, 24/10/2010, 24/11/2010), Nyárás-völgyi Sinkhole (23/11/2010), Mánfai-kőlyuk Cave (11/12/2010), Abaligeti Cave (10/04/2013), Szajha-felső Sinkhole (10/09/2010).

Remarks. This attractive polydesmid is quite widespread in Southwest Hungary. It has records from Baranya (Daday 1889, Korsós et al. 2006), Tolna (Loksa 1954), Dráva (Korsós 1996, 1998), Somogy (Korsós 2001), and the Zselic region (Korsós et al. 2006). The species was also collected in the Bakony Mts. (Korsós et al. 2001). We have new records of two male, three female, and three juvenile individuals from the entrance aera of six caves from the Western Mecsek.
Trogloxene.

***Polydesmus complanatus* (Linnaeus, 1761)**

Julus complanatus Linnaeus 1761
Polydesmus illyricus: Verhoeff 1893
Polydesmus complanatus Porat 1870, Lohmander 1925, Loksa 1954

Localities. Törökpince Sinkhole (21/08/2010, 24/10/2010), Mánfai-kőlyuk Cave (20/11/2011).

Remarks. One of the most common millipede species in Hungary occurring in almost every type of habitats (Lazányi & Korsós 2009). It has previously been mentioned by Gebhardt (1966) from several epigean localities of the Mecsek Mts., *e.g.* Mélyvölgy, Hidas Valley, Tubes and Misina Hills. We collected two male, two female, and one juvenile specimens in the first 10 m of the Törökpince Sinkhole. A female individual was found 15 m deep in the Mánfai-kőlyuk Cave as well.
Trogloxene.

DISCUSSION

Approximately 10% of the total Hungarian millipede fauna (of 103 species) was present in the investigated caves of the Mecsek Mts. Although 60% of these 10 species were epigean, the presence of subtroglophile, eutroglophile, and troglobiont elements prove that cavernicolous habitats have some obvious advantage for millipedes. Shear (1984) considered that many cave species are relics of old taxa searching for a better microhabitat during the last glacial period. Furthermore, due to the isolation of such habitats, a high degree of endemism could have developed in cave millipedes. It is also a well-known fact, that predation and competition for resources are less intensive in subterranean habitats then in epigean ones, due to the absence of higher trophic levels, to the low abundance of the species, and to the relatively constant environmental factors (Culver & Pipan 2008).

Among the 12 caves visited we had diplopod records from 8 caves. The one with the most diverse fauna was the Törökpince Sinkhole, where 6 species were found. The first few meters of this horizontal cave, situated in a deciduous woodland above Abaliget village, contain a massive amount of organic matter in all seasons, which explains the relative high number of trogloxene millipede species, like *U. foetidus*, *B. tenuis*, *P. collaris*, and *C. luridus*. The deeper parts of the cave with its constant temperature and humidity provide ideal shelter for the eutroglophile and troglobiont species, such as *T. schmidtii* and *B. troglobius*.

Among the three diplopod species, *B. troglobius*, *H. bokori*, and *H. hungarica* that were previously considered to be endemic to the Abaligeti Cave, only *B. troglobius* was now found, which seemingly maintains a rather stable population in the cave, using all types of vegetal organic material. Although the appearance of the lamp flora is both an aesthetic and a conservational problem in public caves like the Abaligeti Cave, the vegetation confined to them seemed to be a permanent energy source for not only *B. troglobius*, but also for *T. schmidtii*. Therefore we suggest careful protection against the lamp flora with the lowest disturbance towards the invertebrate fauna. The absence of the 7 previously recorded millipedes could also be related with the recent utilization of the cave and the surrounding area.

Similar comments can be made about the Mánfai-kőlyuk Cave, where the intrusive introduction of waterworks has led to the disappearance of the suitable microhabitats with their original inhabitants, and the introduction of epigean, urban-habitat dwelling species (Angyal 2012).

We have found two new localities of the rare eutroglophile species, *H. hungarica*, which means that the exploration of the millipede fauna in the Mecsek Mts. is required to extend to more caves, for getting a better knowledge about the distribution of the species in the area.

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