Turkish Journal of Zoology

http://journals.tubitak.gov.tr/zoology/

Short Communication

Turk J Zool
(2017) 41: 375-378
© TÜBİTAK
doi:10.3906/zoo-1508-34

Can montane and cave centipedes inhabit soil?

Ivan Hadrián TUF[1,*], Oldřich KOPECKÝ[2], Jan MIKULA[1]
[1]Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University, Olomouc, Czech Republic
[2]Department of Zoology and Fisheries, Faculty of Agrobiology, Food, and Natural Resources, Czech University of Life Sciences, Prague, Czech Republic

Received: 18.08.2015 • **Accepted/Published Online:** 19.07.2016 • **Final Version:** 04.04.2017

Abstract: Communities of centipedes (Chilopoda) were studied at three localities in eastern Bohemia (Czech Republic) near the town of Skuteč using modified subterranean traps. Centipedes were trapped separately from depths of 5, 15, 25, 35, 45, 55, 65, 75, 85, and 95 cm to allow evaluation of the vertical distribution in the soil. Presence of centipedes in deeper soil profiles is related to their ability to colonize the subterranean environment. *Lithobius tenebrosus fennoscandius*, *L. lucifugus*, *L. macilentus*, *Cryptops parisi*, *Strigamia acuminata*, and *S. transsilvanica* inhabited deeper soil layers preferentially. This study shows that soil can be inhabited by cave centipedes or centipedes with montane distribution.

Key words: Chilopoda, milieu souterrain superficiel, mesovoid shallow substratum, superficial underground compartment, subterranean environment

There are many species inhabiting soil as spaces in soil offer free ecological niches (Růžička, 1999). Nevertheless, life underground is enabled by specific adaptations. Christiansen (1992) summarized exaptations as the key factor necessary for colonization of subterranean habitats, although we do not know for which environmental factors these preadaptations were evolved. Vandel (1965) suggested that cave species probably evolved from surface-dwelling species (terrestrial as well as aquatic ones). Recent studies support an alternative view: adaptations to life in soil are good preadaptations to life in caves as well as in the mesovoid shallow substratum (MSS, i.e. spaces in soil and bedrock mainly; Ortuño et al., 2013). Růžička (1999) showed that some troglomorphic species of spiders in Central Europe are related to species inhabiting forest soils, screes, rock fissures, mountain snowfields, and peat bogs. The vertical distribution of spiders in the soil was recently studied in forests (Deltshev et al., 2011; Laška et al., 2011; Růžička et al., 2011), peat bogs (Biteniekytė and Rėlys, 2006), and screes (Culver and Pipan, 2009; Pipan et al., 2011). Nevertheless, the vertical distribution of centipedes in soil and the MSS has rarely been studied (Nitzu et al., 1999; Ilie, 2003; Rendoš et al., 2012, 2016) and then at the community level only, so we do not have information about the distribution of individual species in the soil profile. The aim of this study is to describe the vertical distribution of individual centipede species at three localities with different soil conditions.

* Correspondence: ivan.tuf@upol.cz

The study was done at three localities in eastern Bohemia, 10 km northwest of Skuteč. The first locality, called *beech*, was in this type of wood near the village of Hluboká. The soil was covered by approximately 15 cm of leaf litter. The clay layer of 30 cm lay on cracked marl bedrock. The second locality was situated in slate *quarry* near the village of Hněvětice. This slate quarry soil profile was almost homogeneous, created by bigger stones (approx. 10–15 cm) with some amount of soil among them. The third locality was located in the *valley* of the Krounka River between Hněvětice and Předhradí. There was a scree slope of big stones (20–30 cm) partially filled by soil and detritus.

Centipedes were sampled using subterranean traps according to the alpine model of Schlick-Steiner and Steiner (2000), similar to that of López and Oromí (2010). Traps were made from long tubes buried in a vertical position from the soil surface to a depth of 130 cm. Walls of the tube were perforated in intervals of 10 cm. Inside the tubes there were systems of 10 pots with fixation solution, which collected the animals entering into tubes at depths of 5, 15, 25, 35, 45, 55, 65, 75, 85, and 95 cm, respectively. As a fixation solution, 4% formaldehyde was used. At each locality, three traps were installed in one hollow. The distance between traps was 50–60 cm. During installation of traps, the hollow was filled by material (soil, stones) considering the original stratification of stones. Traps were inspected once every 6 weeks from March 2005 to March 2006.

In total, 63 centipedes were collected by subterranean traps during 54 weeks or 1 year. This material comprised 11 species of centipedes (and 5 individuals of juveniles of the genus *Lithobius*). The highest number of species of centipedes inhabited the locality *valley* (7 species), while the locality *quarry* was inhabited by *Lamyctes emarginatus* only (Table).

Localities differed strongly in centipede vertical distribution patterns. Whereas *L. emarginatus* was recorded in *quarry* from upper layers exclusively (up to 15 cm), centipedes inhabited deep layers at *beech* (up to 75 cm) as well as at *valley* (whole profile). The highest number of species (5) was recorded in the deepest layer at *valley*.

Species associated with upper soil layers (i.e. depths of 5 and 15 cm) were *L. nodulipes*, *L. mutabilis*, and *L. agilis*, while *L. lucifugus*, *L. tenebrosus fennoscandius*, and both

Table. Vertical distribution of trapped centipedes (number of individuals / 3 traps / 1 year) and time pattern of presence at relevant depths (month span) at three studied localities.

	beech					*quarry*	*valley*							
depth	*Lithobius agilis* L.Koch, 1847	*Lithobius forficatus* (Linnaeus, 1758)	*Lithobius lucifugus* L.Koch, 1862	*Lithobius mutabilis* L.Koch, 1862	*Cryptops parisi* Brölemann, 1920	*Lamyctes emarginatus* (Newport, 1844)	*Lithobius lucifugus* L.Koch, 1862	*Lithobius macilentus* L.Koch, 1862	*Lithobius mutabilis* L.Koch, 1862	*Lithobius nodulipes* Latzel, 1880	*Lithobius tenebrosus fennoscandius* Lohmander, 1948	*Strigamia acuminata* (Leach, 1815)	*Strigamia transsilvanica* (Verhoeff, 1928)	Σ
5 cm	-	-	3	-	-	3	1	-	2	-	1	-	3	13
			5–7			6–7	5–6		5–6		10–11		10–11	
15 cm	2	-	-	1	-	4	1	-	2	1	-	-	-	11
	3–4			7–8		6–8	5–6		10–11	5–6				
25 cm	-	-	1	1	-	-	-	-	-	-	1	-	-	3
			9–10	7–8							10–11			
35 cm	-	-	-	-	1	-	1	-	-	-	-	-	-	2
					10–11		9–10							
45 cm	-	-	-	-	1	-	-	2	-	-	1	1	-	5
					10–11			9–10			9–10	10–11		
55 cm	-	-	1	-	-	-	-	-	-	-	-	-	-	1
			7–8											
65 cm	-	-	-	-	-	-	2	-	1	-	1	-	1	5
							6–8		10–11		6–7		1–2	
75 cm	-	1	-	-	-	-	-	-	-	-	2	1	1	5
		12–2									7–8	11–12	1–2	
85 cm	-	-	-	-	-	-	2	-	-	-	1	-	-	3
							6–8				7–8			
95 cm	-	-	-	-	-	-	2	1	-	-	1	4	2	10
							7–8	9–10			7–8	11–2	11–2	
Σ	2	1	5	2	2	7	9	3	5	1	8	6	7	58

recorded species of the genus *Strigamia* were present at lower depths (i.e. below 55 cm) predominantly. Centipedes were trapped frequently during summer (June–August) and winter (October–December) (Table).

Sampling of centipedes using three subterranean traps for 1 year yielded 63 trapped individuals. This number of trapped centipedes seems to be relatively low compared to common Barber traps (e.g., Tuf, 2015), but adequate in comparison to other published studies about subterranean traps: one unidentified centipede was trapped by several such traps during 2 weeks in Steinernes Meer in Carinthia, Austria (Schlick-Steiner and Steiner, 2000) and 69 specimens were trapped during 1 year in three traps in Western Carpathians Mts., Slovakia (Rendoš et al., 2012, 2016).

Beside the eurytopic species *Lithobius forficatus*, three species of the genus *Lithobius*, order Lithobiomorpha, were frequent in the whole profile and/or were more frequent in depths of 30 cm and more than in upper layers: *Lithobius tenebrosus fennoscandius*, *Lithobius lucifugus*, and *Lithobius macilentus*.

The presence of *L. tenebrosus fennoscandius* in the *valley* locality is remarkable, because this species was known from the Czech Republic from the Giant Mountains (Tajovský, 2000) and the Děčínský Sněžník (Hoher Schneeberg) Mountains (Tajovský, 1998) only, i.e. typical montane species distribution. The species is known from Scandinavia, as its name suggests. Recently was recorded in the MSS in Hranický kras and an abyss in Moravský kras Czech Republic, as well (Mikula, unpublished data; Růžička et al., 2016). It seems to be evident that this species from Nordic countries is able to survive in Central Europe in montane and subterranean conditions only, probably because of its preference for lower temperatures. Its presence in the MSS and deeper soil profiles can be a reason for underestimation of its distribution. Moreover, the nominate subspecies was recorded in soil layers in Banat and Cloşani, Romania, as well (Ilie, 2003).

Lithobius lucifugus is well known from different karstic areas (e.g., Folkmanová, 1951; Ilie et al., 2003; Ilie, 2004); this species shows an ability to inhabit caves as well as different underground artificial spaces (Novák and Dányi, 2010; Dvořák and Dvořáková, 2015; Růžička et al., 2016). The third species, *L. macilentus*, has been known from Czech caves for a long time (Vališ, 1904). All these species found in deep soil are cave species or montane species: the MSS offers a suitable substitute environment for species preferring lower temperatures. According to data of the Czech Hydrometeorological Institute, all these species were trapped during relatively warmer months in June–September (http://portal.chmi.cz/historicka-data/pocasi/uzemni-teploty?l=en) or dryer months of June and September–November (http://portal.chmi.cz/historicka-data/pocasi/uzemni-srazky?l=en). It seems evident that soil can be a refuge for these species, similarly as some talus slopes can be refuges for cold-adapted boreal species (Růžička et al., 2015).

Other species recorded in deeper layers, *Strigamia acuminata* and *Strigamia transsilvanica*, represent the order Geophilomorpha, the members of which are adapted to living in soils correspondingly with its English name, "soil centipedes" (see Tuf, 2015). Their prolonged segmented soft body with short legs is adapted to crawling through soil crevices. This shape of body is a direct adaptation to soil lifestyle by the increasing of body segment number during evolution (Minelli et al., 2009). Both these species were categorized as chasmatophiles, too, i.e. species inhabiting the entrance part of caves preferentially (Gulička, 1985). The species *Crytops parisi*, order Scolopendromorpha, also has a prolonged body and, like the previously mentioned species, it is a chasmatophile recorded in the MSS (Gulička, 1985; Mikula, unpublished data). Both species of *Strigamia*, as well as *L. forficatus*, common inhabitants of the soil surface (Tuf, 2015), were found in deep layers during winter. Such seasonal vertical migrations in soil were reported for these species also at a small scale of 0–5 cm and 5–10 cm (Tuf, 2002).

The presence of *Lamyctes emarginatus* at the locality *quarry* is remarkable. This species usually inhabits wetlands, banks of rivers, fields, and other disturbed localities (Andersson, 2006), which are typically very poor centipede communities consisting of a few species only. Its presence at *quarry* as an exclusive member of the centipede community is more evidence of its low ability to compete with other centipedes. Its "preference" for disturbed habitats is very probably caused by its inability to survive in the abundant presence of other centipedes.

The MSS and soil are inhabited by remarkable species of centipedes, which need stable temperature conditions; this may be a reason why we can find here some cave species as well as montane species, which try to avoid changes of temperature on the soil surface. Species with low ability to compete with other centipede species can also find suitable refuge in the MSS. We should pay attention to this subterranean environment so as to not underestimate the overall distribution of centipedes and mainly centipedes on the border of its distribution ranges; other studies using these subterranean traps are therefore desirable.

Acknowledgments

We thank Vratislav Laška for his help with the installation of traps. We are also thankful to three anonymous reviewers for their important advice and suggestions improving the quality of the manuscript.

References

Andersson G (2006). Habitat preferences and seasonal distribution of developmental stadia in *Lamyctes emarginatus* (Newport, 1844) (*L. fulvicornis* Meinert, 1868) and comparisons with some *Lithobius* species. Norw J Entomol 53: 311-320.

Biteniekytė M, Rėlys V (2006). Investigation of activity and vertical distribution of spiders in *Sphagnum* tussocks of peat bogs. Biologija 2006: 77-82.

Christiansen K (1992). Biological processes in space and time. Cave life in the light of modern evolutionary theory. In: Camacho AI, editor. The Natural History of Biospeleology. Madrid, Spain: Museo Nacional de Ciencias Naturales, pp. 453-478.

Culver DC, Pipan T (2009). Superficial subterranean habitats – gateway to the subterranean realm? Cave Karst Sci 35: 5-12.

Deltshev C, Lazarov S, Naumova M, Stoev P (2011). A survey of spiders (Araneae) inhabiting the euedaphic soil stratum and the superficial underground compartment in Bulgaria. Arachnol Mitt 40: 33-46.

Dvořák L, Dvořáková K (2015). Some invertebrates found in underground shelters of the Dyleňský Kras karst. In: Bartoš J, Dvořák L, editors. Dyleňský Kras. Mariánské Lázně, Czech Republic: Městské Muzeum ML, pp. 145–156 (in Czech with English abstract).

Folkmanová B (1951). About some Chilopods new for Morava. Sborn Kl Přír Brno 29: 98-104 (in Czech).

Gulička J (1985). Soil and cave macrofauna of karst mountains of Western Carpathians (1). Slovenský kras 23: 89-129 (in Slovak).

Ilie V (2003). Chilopoda species from the edaphic and subterranean environments of the Cloşani karstic area (Romania). Trav Mus Nat Hist Nat "Grigore Antipa" 45: 129-137.

Ilie V (2004). Data on the Chilopoda species from the western Bihor Mountains (Romania). Trav Mus Nat Hist Nat "Grigore Antipa" 46: 67-73.

Ilie V, Negrea S, Mitič B (2003). The diversity of the Chilopoda species from the karstic area of the Anina mountains (Banat, Romania). Arch Biol Sci Belgrade 55: 93-99.

Laška V, Kopecký O, Růžička V, Mikula J, Véle A, Šarapatka B, Tuf IH (2011). Vertical distribution of spiders in soil. J Arachnol 39: 393-398.

López H, Oromí P (2010). A pitfall trap for sampling the mesovoid shallow substratum (MSS) fauna. Speleobiology Notes 2: 7-11.

Minelli A, Chagas A Jr, Edgecombe GD (2009). Saltational evolution of trunk segment number in centipedes. Evol Dev 11: 318-322.

Nitzu E, Giurginca A, Ilie V, Vặnoaica L (1999). First note on the edaphic and subterranean fauna from the evaporitic karstic regions of Romania. Trav Inst Speol Emil Racovita 37-38: 143-157.

Novák J, Dányi L (2011). A *Lithobius stygius infernus* Loksa, 1948 taxonómiai helyzetének tisztázása. Állattani Közlemények 96: 15-22.

Ortuño VM, Gilgado JD, Jiménez-Valverde A, Sendra A, Pérez-Suárez G, Herrero-Borgoñón JJ (2013). The "Alluvial Mesovoid Shallow Substratum", a new subterranean habitat. PLoS One 8: e76311.

Pipan T, López H, Oromí P, Polak S, Culver DC (2011). Temperature variation and the presence of troglobionts in terrestrial shallow subterranean habitats. J Nat Hist 45: 253-273.

Rendoš M, Mock A, Jászay T (2012). Spatial and temporal dynamics of invertebrates dwelling karstic mesovoid shallow substratum of Sivec National Nature Reserve (Slovakia), with emphasis on Coleoptera. Biologia 67: 1143-1151.

Rendoš M, Mock A, Miklisová D (2016). Terrestrial isopods and myriapods in a forested scree slope: subterranean biodiversity, depth gradient and annual dynamics. J Nat Hist 50: 2129-2142.

Růžička V (1999). The first steps in subterranean evolution of spiders (Araneae) in Central Europe. J Nat Hist 33: 255-265.

Růžička V, Laška V, Mikula J, Tuf IH (2011). Morphological adaptations of *Porrhomma* spiders inhabiting soil. J Arachnol 39: 355-357.

Růžička V, Mlejnek R, Juřičková L, Tajovský K, Šmilauer P, Zajíček P (2016). Invertebrates of the Macocha Abyss (Moravian Karst, Czech Republic). Acta Carsologica 45: 71-84.

Růžička V, Zacharda M, Šmilauer P, Kučera T (2015). Can paleorefugia of cold-adapted species in talus slopes resist global warming? Boreal Env Res 20: 403-412.

Schlick-Steiner BC, Steiner FM (2000). Eine neue Subterranfalle und Fänge aus Kärnten. Carinthia II 190: 475-482 (in German).

Tajovský K (1998). Terrestrial arthropods (Oniscidea, Diplopoda, Chilopoda) of Labské pískovce Protected Landscape Area (North Bohemia, Czech Republic). In: Pižl V, Tajovský K, editors. Soil Zoological Problems in Central Europe. České Budějovice, Czech Republic: Institute of Soil Biology ASCR, pp. 235-242.

Tajovský K (2000). Centipedes (Chilopoda) of Giant Mountains. Opera Concortica 36: 385-389 (in Czech).

Tuf IH (2002). Contribution to the knowledge of vertical distribution of soil macrofauna (Chilopoda, Oniscidea). In: Tajovský K, Balík V, Pižl V, editors. Studies on Soil Fauna in Central Europe. České Budějovice, Czech Republic: Institute of Soil Biology ASCR, pp. 241-246.

Tuf IH (2015). Different collecting methods reveal different ecological groups of centipedes. Zoologia (Curitiba) 32: 345-350.

Vališ J (1904). Preliminary check-list of Moravian myriapods. Věst Král Čes Spol náuk tř 2 28: 1-12 (in Czech).

Vandel A (1965). Biospeleology. The Biology of Cavernicolous Animals. Oxford, UK: Pergamon Press.