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A survey of spiders (Araneae) inhabiting the euedaphic soil stratum and the superficial underground compartment in Bulgaria

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Abstract: In 2005 a team of Bulgarian zoologists started a project aiming to study the invertebrates inhabiting the deeper soil stratum (euedaphon) and the Superficial Underground Compartment (SUC) in Bulgaria. In the course of a four-year sampling, a total of 52 species of spiders were caught from 19 collecting sites and 9 geographical regions. They belong to the following families: Scytodidae (1), Segestriidae (1), Dysderidae (8), Nesticidae (1), Anapidae (1), Theridiidae (1), Linyphiidae (20), Agelenidae (3), Cybaeidae (1), Dictynidae (2), Amaurobiidae (2), Liocranidae (3), Corinnidae (1), Zodariidae (1), Gnaphosidae (5), and Salticidae (1). The family Anapidae, with the species *Zangherella relicta* (Kratochvíl, 1935) is recorded from three sites in the Pirin and Slavyanka mountains, and this represents the first record of the family, genus and species in Bulgaria. In spite of the active investigations of the epigean and cave spiders in these regions over the years *Z. relicta* was not found and it seems it occurs only in deeper subterranean habitats and nowhere else. Comparative study of almost topotypic specimens of *Z. relicta* from Montenegro with those collected from Bulgaria showed no variation in the shape of palp and female vulvae. Until the true identity of *Z. apuliae* (Caporiacco, 1949) from Italy is revealed, it remains unclear whether *Z. relicta* and *Z. apuliae* are conspecific, as it remains unclear whether the older records of *Z. apuliae* from the Balkan Peninsula refer to this species or to *Z. relicta*. *Pelecopsis mengei* (Simon, 1884) (Linyphiidae) and *Scotolathys simplex* Simon, 1884 (Dictynidae) are also reported from Bulgaria for the first time, the latter being also new to FYR of Macedonia. A faunistic overview of the spiders found in these underground environments is made, along with remarks on the distribution and ecology of some rare and interesting species. The presence of cave-dwelling and superficial spiders in the sampled sites indicates that SUC and euedaphon are inhabited by different ecotypes, e.g. litter- (tanathostromic), soil- (edaphic) and cave-(troglobitic) which at some places co-occur.

Key words: Anapidae, subterranean environments, troglomorphism, *Zangherella relicta*

There are various subterranean spaces that invertebrates inhabit. Depending mostly on their origins, size and distance from the surface one can distinguish different types of subterranean habitats, e.g. caves, lava tubes, microspaces in stony debris and screes, deep undreground micro- and macrospaces in the deeper gravel layers, etc. Each habitat has specific characteristics comprising temperature fluctuations, humidity, aeration, organic carbon levels, soil texture, etc. For instance daily temperature fluctuations exist in the surface of scree slopes and stony debris, while they cease completely at one-meter depth and after several dozens of metres inside large caves (RŮŽIČKA 1999). Organic carbon levels are higher in the Superficial Underground Compartment (SUC) than in caves (CULVER & PIPAN 2009). Animals that are adapted to living in complete darkness and with limited energy supplies usually acquire a specific appearance that includes depigmentation, micro- or anophthalmy, loss of wings, elaboration of extra-optic sensory structures, elongation of appendages (in cases of troglobionts) or shortening of appendages (in case of geobionts), cuticle thinning, etc. These morphological alterations known as troglomorphy are widespread in subterranean animals (CHRISTIANSEN 1962). Some species that inhabit SUC and deeper soil strata and have adapted to dwelling in these aphotic environments may have given rise to species occurring in caves (CULVER & PIPAN 2009). The vertical distribution of arthropods in the soil depends on the porosity of soil, soil type, temperature and humidity, as well as the amount of organic matter (LAŠKA et al. in press).

JUBERTIE et al. (1980) defined and described (in French) as the "Milieu Souterrain Superficiel" (MSS) one of the subterranean habitats where they found several troglomorphic invertebrates. In publications in English this particular environment is referred to as the "Superficial Underground Compartment" (SUC) or "Mesocavernous Shallow Stratum" (MSS) (Figs. 1-2). In addition to its geomorphologic structure,

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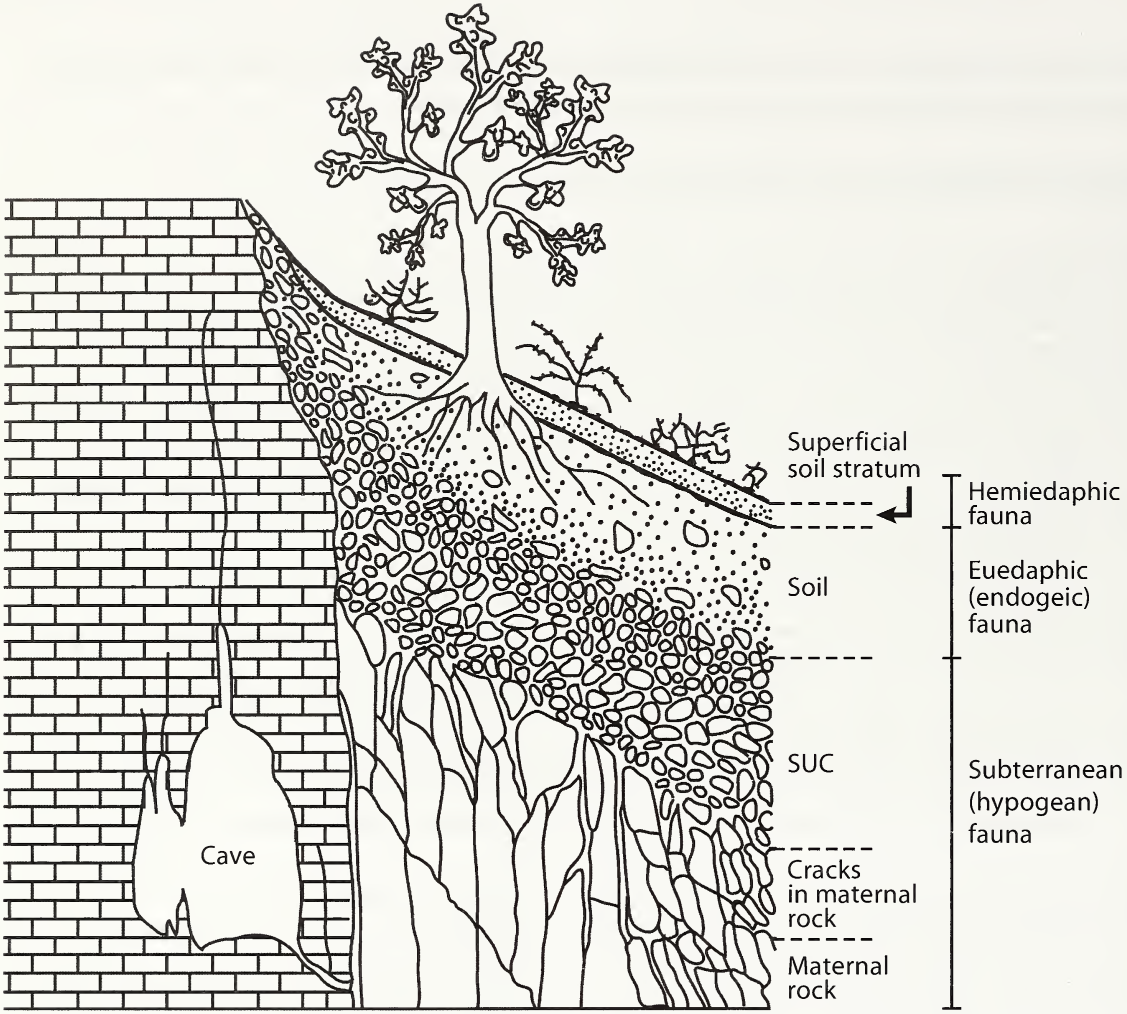


Figure 1: Structural scheme of superficial underground compartment.

the SUC has specific microclimatic and hydrological characteristics. According to JUBERTHIE & DECU (1994) the SUC exists as interconnected microspaces in valley versant screes or similar fissures in the superficial zone of maternal rocks. It connects with other profound subterranean environments like caves by way of deep fissures (NEGREA & BOITAN 2001). It is also believed that the SUC represents an intermediate stratum where litter- (tanathostromic), soil- (edaphic) and cave- (troglobitic) species may occur together. Furthermore, several SUC specialists highly adapted to subterranean manner of life inhabit the SUC and never penetrate into epigeic habitats. An example of such species is the beetle *Speonomus hygrophylus* Jeannel, 1907 (cf. CULVER & PIPAN 2009).

The euedaphic [from the Greek words "eu-" (= good) and "edaphos" (= land, earth)] soil stratum, also known as endogeic stratum is composed of mineral soil, just beneath the humus layer (cf. NEGREA & BOITAN 2001).

The most serious contribution to the study of subterranean spiders and in particular those living in the stony debris and screes in Central Europe was made by Vlastimil RŮŽIČKA, who studied the underground spider assemblages in the Czech Republic, Romania, Montenegro and Austria (see e.g., RŮŽIČKA 1989, 1992; RŮŽIČKA & THALER 2002). However, this subject received very little attention in the other parts of Europe, and yet our knowledge of the underground spider assemblages in biodiversity-rich regions such as the Balkan Peninsula remains perfunctory. A profound review of spiders living in caves and hypogeic environments can be found in RIBERA & JUBERTHIE (1994).

The spiders living in superficial, hemiedaphic and cave environments in Bulgaria have been studied

Figure 2: General view of the collecting site near Bosnek, Vitosha Mts.

quite well for almost 120 years (see e.g., DELTSHEV & BLAGOEV 2003). At the same time though very little is known about the spiders inhabiting the strata below the upper soil layer, scree slopes, stony debris, and the network of micro-crevices in the maternal rock.

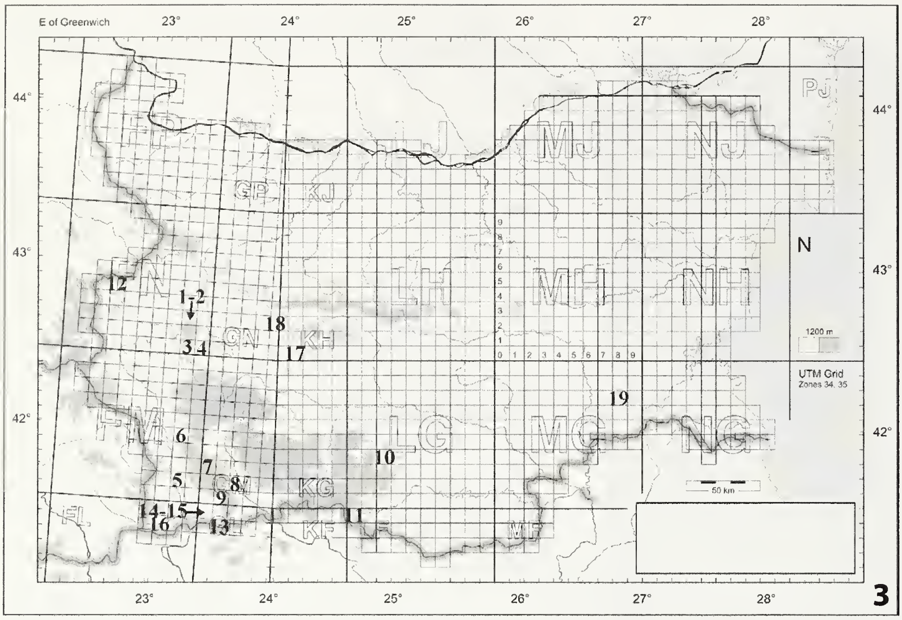
In 2005 a team of Bulgarian zoologists started a four-year project aiming to study the invertebrates inhabiting the subterranean environments in Bulgaria. Data resulting from this project have been published partially in taxonomic papers dealing with true bugs (SIMOV 2008), beetles (BEKCHIEV 2008; GUÉORGUIEV & BEKCHIEV 2009) and millipedes of the *Acanthopetalum richii* (Gray, 1832) group (STOEV 2008). Additionally, LAZAROV (2007) described the female of *Harpactea srednagora* Dimitrov & Lazarov, 1999 (Araneae: Dysderidae), a spider which was collected exclusively from subterranean habitats in Bulgaria. In other publications, LAZAROV & NAUMOVA (2010) and DELTSHEV et al. (in press), one further dysderid species was described from such environments in the Slavyanka and the Rhodopes mountains, and the thomisid spider *Cozyptila thaleri* Marusik & Kovblyuk, 2005 was reported for the first time from the country. The aim of the present study is to put on record the results of the study of the spiders inhabiting the SUC and the euedaphic soil stratum in Bulgaria.

Material and Methods

The investigation was carried out in the period April 2006 – June 2009. Forty-three traps were set in the mountains of Vitosha, Pirin, Slavyanka, Belasitsa, Ruj, Western Rhodopes, Ichtimanska and Sashtinska Sredna Gora, and the Derventsky Heights (Fig. 3, Table 1). The trap was made of a PVC pipe with a diameter of 8 cm and two different lengths: 60 and 80 cm, respectively (Fig. 4). 108 holes with a diameter of 8 mm were made in the pipe, at a distance of 10 cm from its lower end (Fig. 4) and covering nearly 1/3 of its total length. A hole of 60 to 80 cm depth was dug in the ground where the pipe was placed vertically. After the proper positioning of the pipe, the space between the pipe and the hole was filled up, initially with gravel to the upper level of the holes and subsequently with soil and other particles up to the top of the pipe. A 10-centimetre plastic pot tied to a polythene rope was put at the bottom of the pipe. The pot was filled with etylenglycol with a few drops of formalin. The trap was covered tightly with a solid plastic cover and additionally with soil, tufts of grass and leaves to prevent penetration by the superficial fauna and infiltration of water during pouring rain. Description of each collecting site and the traps is given in Table 1. Usually, traps were checked and emptied once every three months, sometimes once or twice a year. All material was sorted down to a species level and put into 70% spirit. The entire collection is preserved in the Institute of Zoology, Bulgarian Academy of Sciences (IZ). Almost topotypic material of *Zangherella relicta* (Kratochvíl, 1935) was obtained for study from the Senckenberg Museum Frankfurt (SMF). All drawings were made with a camera lucida mounted on a Wild stereoscope. Nomenclature follows PLATNICK (2010).

Results

A total of 52 species of spiders from 19 collecting sites and 9 geographical regions was collected. They belong to the following families: Scytodiidae (1), Segestriidae (1), Dysderidae (8), Nesticidae (1), Anapidae (1), Theridiidae (1), Linyphiidae (20), Agelenidae (3), Cybaeidae (1), Dictynidae (2), Amaurobidae (2), Liocranidae (3), Corinnidae (1), Zodariidae (1), Gnaphosidae (5), and Salticidae (1). The family Anapidae, with the species *Zangherella relicta* (Kratochvíl,



Figures 3, 4: Map of the collecting sites. Numbers according to Table 1 (3); Scheme of the underground traps used in the study (4).

1935), as well as the species *Pelecopsis mengei* (Simon, 1884) (Linyphiidae) and *Scotolathys simplex* Simon, 1884 (Dictynidae) are recorded for the first time from Bulgaria (Tab. 2).

Interesting records of new or rare species

Dysderidae

Dysderids are frequent in underground habitats and in leaf-litter, and prefer warm and humid environmental conditions. Whilst there are very few cave records in Bulgaria, dysderids are quite often found in caves elsewhere and some species are even cave specialists, which have become adapted to this particular environment (e.g. CHATZAKI & ARNEDO 2006). In Bulgaria only *Harpactea babori* (Nosek, 1905) has been recorded from caves (DELTSHEV et al. 2003). Nevertheless, the family is well represented in the SUC and euedaphic stratum (Table 2), whereby species like, e.g., *Harpactea srednogora*, *H. deltshevi* and *Dysdera longirostris*, were found at several sites and were among the most abundant species in the traps. Besides depigmentation, none of the dysderids found in the underground habitats possess obvious troglomorphic features to be categorized as representing strictly geo- or troglobiontic ecomorphotypes.

Nesticidae

Nesticus cellulanus

Members of the family Nesticidae are prone to colonize shallow or deep subterranean spaces. KRATOCHVÍL (1933) described several morphological alterations in nesticids resulting from their subterranean manner of living. Out of the three species of *Nesticus* hitherto known from Bulgaria, in the SUC and euedaphic stratum we have only found *N. cellulanus*. This species is widespread throughout the country, and is among the most common spiders in Bulgarian caves (DELTSHEV et al. 2003, DELTSHEV & PETROV 2008). In the Czech Republic it occurs in shallow subterranean spaces in screes, cave entrances, and buildings (BUCHAR & RŮŽIČKA 2002).

Anapidae

Zangherella relicta (Figs. 5-13)

Pseudanapis relicta Kratochvíl, 1935: 18, pl. 1, f. 7-12. Type locality: Montenegro: 1 ♂, 1 ♀.

=?*Pseudanapis apuliae* sensu BRIGNOLI 1974, 1977, 1978, 1984, THALER & KNOFLACH 1998, nec CAPORIACCO 1949a: 4, f. 3-6.

Material examined. MONTENEGRO: 1 ♂, 1 ♀, Herceg Novi, Monastir Savina (Kotor Distr.), N42°27'7,2" E18°33'12.5", 50 m a.s.l., 11.V.2006, A. Schönhofer leg. (SMF). BULGARIA: 3 ♂♂, 2 ♀♀, Pirin Mts., village of Gospodintsi, collecting site PE, 5.V.2007, P. Stoev leg.; 2 ♂♂, Slavyanka Mts., village of Kalimantsi, collecting site S-2, 19.VI-13.VII.2007, M. Langourov and N. Simov leg. (IZ). 2 ♀♀, Slavyanka Mts., Livade, collecting site S-1, 1.VII-1.VIII.2007, N. Simov leg.

Diagnosis. Anterior median eyes absent; the palpal organ complex: cymbium and tibia fused, tegulum

Table 1: List of the collecting sites with their physical characteristics.

No	No of traps	Station	Trapping period	Geographical area	Description
1.	1	VN-1	29.IV.2006	Vitosha Mts.	Northern slope, above Boyana, Boyanski kamak place, at the bottom of a 4-5 m deep microcave; dry, alt. *ca* 850 m; N 42°38'26.8" E23°16'32.1"; UTM FN82; samples taken at 50-60 cm depth.
2.	2	VN-2	30.IV.2006	Vitosha Mts.	Northern slope, two traps set ca. 30-35 m above Boyanski kamak, scree in mixed forest of *Fagus sylvatica* and *Carpinus betulus*; alt. *ca* 850 m; N42°38'26.8" E23°16'32.1"; UTM FN82; samples taken at 40-50 cm depth.
3.	3	VW	10-24.VI.2006	Vitosha Mts.	Western slope, three traps set near the cave Duhlata, village of Bosnek, limestone, stony substrate mixed with clay, alt. *ca* 950 m; N42°29'582", E23°11'727"; UTM FN80; samples taken at 40-70 cm depth.
4.	1	VE	27.V.2006	Vitosha Mts.	Eastern slope, *ca* 28 km south of Sofia, on the road Sofia-Samokov, Yarema place; forest of *Fagus sylvatica*, in a stony, sandy substrate, humid, alt. *ca* 1400 m; UTM FN90; N42°30'289" E23°19'262"; samples taken at 60-70 cm depth.
5.	2	PW	7.V.2006	Pirin Mts.	Western slope, two traps set in the Zandana place, above village of Ilindentsi, limestone, scree, dry soil/ sandy substrate, alt. *ca* 500 m; N41°39'022" E23°15'156"; UTM FM81; samples taken at 40-60 cm depth.
6.	1	PN-1	24.V.2006	Pirin Mts.	Northern slope, *ca* 6 km before Predela, humid ravine, *Fagus sylvatica* forest, at the base of a *Fagus* tree, thick layer of leaf litter, humid soil mixed with stones, alt. *ca* 680 m; N41°55'134" E23°15'696"; UTM FM84; samples taken at 40-50 cm depth.
7.	1	PN-2	24.V.2006	Pirin Mts.	Northern slope, *ca* 150-200 m of the Baikushevata mura place on the way to hut Vihren, at the base of a scree, subalpine vegetation with scattered *Pinus mugho* trees, alt. 1900 m; N41°45'980"' E23°25'233"; UTM GM03; samples taken at 40-50 cm depth.
8.	1	PE	25.V.2006	Pirin Mts.	Eastern slope, 3 km before village of Gospodintsi, Gotse Deltshev District, approx. 30 m sideward of the main road Bansko-Gotse Deltshev and *ca* 5-6 m off a small river; in a scree at the base of limestone rocks, close to a tree; alt. *ca* 600 m; N41°40'725" E23°43'502"; UTM GM21; samples taken at 40-50 cm depth.
9.	3	PS	25.V-18.VI.2006	Pirin Mts.	Southern slope, Popovi livadi Place, three traps set in a marble stone debris sideward the road and in a small valley with *Fagus* forest; alt. *ca* 1370-1560 m; N41°33 E23°37; UTM GM10; samples taken at 30-50 cm depth.
10.	3	WR-1	23.IV.2006	West Rhodopes Mts.	Central parts, three traps set *ca* 1100 m after the crossroad to village of Borovo towards the village of Belitsa; on the left side of the road, in a small rocky valley overgrown with bushes and *Pinus nigra*, *ca* 50 m sideward the road, alt. *ca* 650 m; N41°50'332" E24°51'533"; UTM LG23; samples taken at 30-70 cm depth.
11.	1	WR-2	14.VII.2007	West Rhodopes Mts.	Southern parts, near village of Koshnitsa, below the cave Uhlovitsa; right side slope, above the path, at the foot of hornbeam bushes, not far from an old *Fagus* sp. tree, humid and shady place, gravels in the soil, alt. *ca* 900 m; N41°30'802" E24°39'590"; UTM LF09; samples taken at 60-70 cm depth.
12.	3	EG	11.VI.2006	Ruj Mts.	Erma Gorge, *ca* 3 km of Tran Town, three traps set in close proximity to the tunnel; limestone, slope overgrown with hazel bush, ash-trees; rocky substrate, at the foot of rocks; alt. *ca* 700 m; N42°51'665", E22°38'949"; UTM FN34; samples taken at 40-50 cm depth.

No	No of traps	Station	Trapping period	Geographical area	Description
13.	1	**S-1**	4.VII.2006	Slavyanka Mts.	Livade place near the village of Goleshevo; limestone slope in a *Pinus* forest; *ca* 1700 m, N41°23'532", E23°36'307"; UTM GL18; samples taken at 40-50 cm depth.
14.	1	**S-2**	8.VI.2006	Slavyanka Mts.	Sveti Iliya place near the village of Kalimantsi; close to the chapel, below *Quercus coccifera* trees, alt. *ca* 500 m; N41°27'612", E23°29'448"; UTM GL09; samples taken at 40-50 cm depth.
15.	2	**S-3**	27.VI.2006	Slavyanka Mts.	Peshternik place, two traps set near the village of Kalimantsi; travertine, below *Salix* sp. and *Corylus* sp., alt. 380 m; N41°27'648", E23°29'680"; UTM GL09; samples taken at 40-60 cm depth.
16.	1	**BE**	13.VI.2008	Belasitsa Mts.	Near the village of Kamena, on the right side coast of the river Kamenitsa, *Platanus orentalis* forest, scree, *ca* 40m above the river, alt. *ca* 530 m; N41°21.460 E23°04.470; UTM FL78; samples taken at 60-70 cm depth.
17.	4	**SG-1**	29.IV.2006	Sashtinska Sredna Gora Mts.	Sveti Ivan place near Panagyurishte Town, four traps set in abandoned vineyard overgrown with scattered *Prunus* sp. trees and blackberries and in forest of *Pinus nigra*; deep soil layer, alt. *ca* 600 m; N42°31'004", E24°11'038"; UTM KH60; samples taken at 40-90 cm depth.
18.	2	**SG-2**	23.VI.2008	Ichtimanska Sredna Gora Mts.	Small church ca 2 km of village Smolsko, two traps set in front of the entrance of a small cave and in a scree close to the road, mixed broad leaved forest, alt. *ca* 600 m; N42°39'17", E23°55'11"; UTM GN42; samples taken at 40-70 cm depth.
19.	1	**DH**	10.V.2007	Derventsky Heights	Village of Dennitsa, close to the main motorway to the village of Stefan Karadzhovo, Yambol District, sink-hole in *Quercus* forest, at the base of a large stone; alt. *ca* 360 m; N42°15'475", E26°49'500"; UTM MG87; samples taken at 40-50 cm depth.

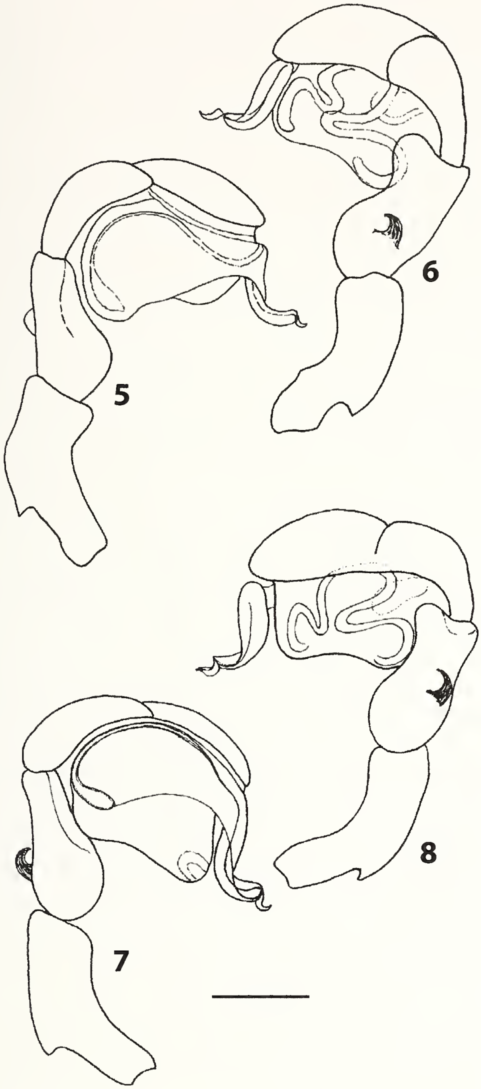
voluminous, spermophore with many coils, embolic division consisting of filiform embolus and conductor (Figs. 5-8).

Description. See e.g., KRATOCHVÍL (1935), THALER & KNOFLACH (1998).

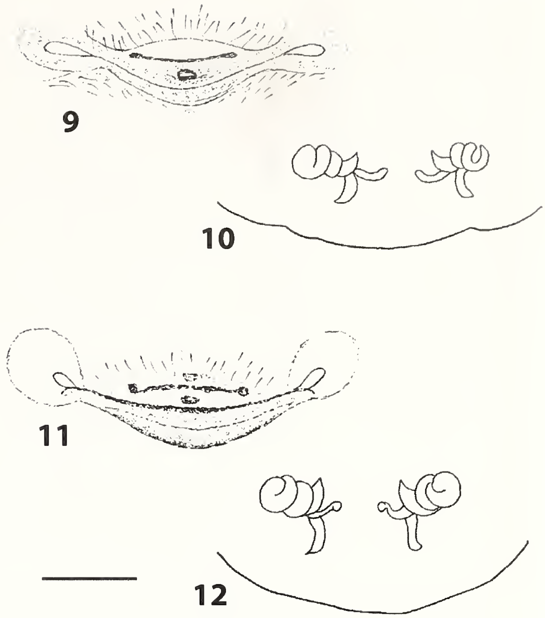
Remarks. Anapidae comprises araneoid spiders occurring in leaf-litter and moss on the ground of moist forests. The family has its highest diversity in the tropics, with only a few patchy distributed genera and species in the Holarctic region (PLATNICK & FORSTER 1989). Only two genera out of 38, namely *Comaroma* Bertkau, 1889 (1 species) and *Zangherella* Caporiacco, 1949 (3 species), occur in Europe (PLATNICK 2010).

KRATOCHVÍL (1935) described *Pseudanapis relicta* from a cave in the surroundings of Kotor, Montenegro. Later CAPORIACCO (1949a) described *Pseudanapis apuliae* from a cave in the surroundings of Otrando, Italy. The genus *Zangherella* Caporiacco, 1949 was erected by CAPORIACCO (1949b) to accommodate the species *Z. minima* from Libya. BRIGNOLI (1968) re-described *Z. apuliae* and suggested that it might be a junior synonym of *P. relicta*. In another publication (BRIGNOLI 1970) he synonymised *Z. minima* with *Pseudanapis algerica* (Simon, 1895) but later on (BRIGNOLI 1981) retracted the synonymy of the genus *Zangherella* with *Pseudanapis* Simon, 1905, and assigned to it the species *Z. algerica*, *Z. apuliae* and *Z. relicta*. Having at their disposal specimens from Greece, THALER & KNOFLACH (1998) revised the genus *Zangherella* and its distribution and stated that according to the original descriptions the main difference between *relicta* and *apuliae* concerned the number of spines on tarsus I (4 in *relicta* vs. 6 in *apuliae*). The authors studied several transitional cases where distal spines were only weakly developed and considering the completely identical shape of palps they argued that both species might actually be conspecific (THALER & KNOFLACH 1998). They also provided new illustrations of palps of specimens from Greece. The whereabouts of the type material of *P. relicta* are unknown and it is believed to have been lost during the Second World War (cf. BRIGNOLI 1968).

The almost topotypic material of *Zangherella* collected in Herceg Novi, Montenegro and the abundant material amassed using subterranean traps



Figures 5-8: *Zangherella relicta*: **5** – male palp, prolateral view; **6** – male palp, retrolateral view (Herceg Novi); **7** – male palp, prolateral view; **8** – palp, retrolateral view (Pirin Mts.). Scale bar: 0.15 mm.



Figures 9-12: *Zangherella relicta*: **9** – epigyne; **10** – vulva, dorsal (Herceg Novi); **11** – epigyne; **12** – vulva, dorsal (Pirin Mts.). Scale bar: 0.15 mm.

Figure 13: Habitus of *Zangherella relicta* (specimen from Slavyanka Mts.).

in Bulgaria made it possible to compare *vis-a-vis* the available specimens. We were not able to find any reliable differences between the Montenegrin and Bulgarian specimens when studying the structure of the vulva and the male palp (compare Figs. 5-6, 9-10 with 7-8, 11-12). They also correspond well with the illustrations of specimens of *Z. apuliae* reported by THALER & KNOFLACH (1998) from Greece. We were not able to obtain comparative material of *Z. apuliae* from Italy nor to examine the type material and could not decide whether the two species, *relicta* and *apuliae* are conspecific, as presumed by BRIGNOLI (1968). Combined molecular and morphological analysis is required to determine whether *Z. apuliae* is a valid species of a possibly restricted distribution in the Apennines or whether there is only one valid species, *Z. relicta*, distributed from the Apennines to Asia Minor.

Table 2: List of the spiders found in the euedaphic soil stratum and the SUC in Bulgaria.

Species	VN-1	VN-2	VW	VE	PW	PN-1	PN-2	PE	PS	WR-1	WR-2	EG	S-1	S-2	S-3	BE	SG-1	SG-2	DH
Scytodidae																			
Scytodes thoracica (Latreille, 1802)														X					
Segestridae																			
Segestria senoculata (Linnaeus, 1758)									X										
Dysderidae																			
Dysdera hungarica Kulczyński, 1897						X													
Dysdera longirostris Doblika, 1853			X						X				X				X	X	
Harpactea deltshevi Dimitrov & Lazarov, 1999	X	X		X						X			X						
Harpactea pr. *deltshevi*										X									
Harpactea mentor Lazarov & Naumova, 2010									X				X						
Harpactea saeva (Herman, 1879)							X					X						X	
Harpactea samuili Lazarov, 2006								X					X	X	X				
Harpactea sredgnagora Dimitrov & Lazarov, 1999		X	X			X			X	X	X	X	X			X	X	X	
Nesticidae																			
Nesticus cellulanus (Clerck, 1757)			X												X				
Anapidae																			
Zangherella relicta (Kratochvíl, 1935)								X					X	X					
Theridiidae																			
Robertus mediterraneus Eskov, 1987														X			X		
Linyphiidae																			
Antrohyphantes rhodopensis (Drensky, 1931)									X										
Centromerus acutidentatus Deltshev, 2005	X	X																	
Centromerus capucinus (Simon, 1884)																	X		
Centromerus cavernarum (L. Koch, 1872)		X										X							
Centromerus lakatnikensis (Drensky, 1931)		X	X			X	X			X			X		X		X		X
Centromerus milleri Deltshev, 1974												X							
Diplostyla concolor (Wider, 1834)			X			X		X	X	X		X	X				X		
Lepthyphantes centromeroides Kulczyński, 1914												X							
Lepthyphantes leprosus (Ohlert, 1865)	X		X		X				X		X	X							
Mansuphantes mansuetus (Thorell, 1875)							X						X						
Mioxena blanda (Simon, 1884)															X				
Palliduphantes alutacius (Simon, 1884)		X		X															
Palliduphantes istrianus (Kulczyński, 1914)	X		X								X						X		X

Species	VN-1	VN-2	VW	VE	PW	PN-1	PN-2	PE	PS	WR-1	WR-2	EG	S-1	S-2	S-3	BE	SG-1	SG-2	DH
Palliduphantes spelaeorum (Kulczyński, 1914)																X	X		
Palliduphantes trnovensis (Drensky, 1931)																		X	
Pelecopsis mengei (Simon, 1884)																	X		
Sintula retroversus (O. P.-Cambridge, 1875)													X						
Tenuiphantes tenuis (Blackwall, 1852)													X						
Walckenaeria antica (Wider, 1834)													X						
Walckenaeria mitrata (Menge, 1868)													X						
Agelenidae																			
Histopona tranteevi Deltshev, 1978										X		X	X						
Tegenaria domestica (Clerck, 1757)			X																
Malthonica silvestris (L. Koch, 1872)	X																		
Cybaeidae																			
Cybaeus balkanus Deltshev, 1997												X							
Dictynidae																			
Cicurina cicur (Fabricius, 1793)	X	X										X						X	
Scotolathys simplex Simon, 1884														X					
Amaurobiidae																			
Eurocoelotes brevispinus (Deltshev & Dimitrov, 1996)													X						
Eurocoelotes jurinitschi (Drensky, 1915)	X	X	X	X									X						
Liocranidae																			
Agroeca cuprea Menge, 1873			X																
Apostenus fuscus Westring, 1851		X																	
Sagana rutilans Thorell, 1875		X																	
Corinnidae																			
Phrurolithus festivus (C.L. Koch, 1835)			X																
Zodariidae																			
Zodarion pirini Drensky, 1921													X						
Gnaphosidae																			
Drassyllus villicus (Thorell, 1875)														X					
Echemus angustifrons (Westring, 1861)								X											
Gnaphosa modestior Kulczyński, 1897																		X	
Trachyzelotes pedestris (C.L. Koch, 1837)														X					
Zelotes erebeus (Thorell, 1871)									X										
Salticidae																			
Euophrys frontalis (Walckenaer, 1802)														X					

Distribution: *Z. relicta* is known from the cave Golobrazhnitsa and Herceg Novi, Kotor District, Montenegro (KRATOCHVÍL 1935, present study) and the mountains Pirin and Slavyanka in Bulgaria (present study). Records, possibly referable to *Z. relicta* (all sub *Z. apuliae*): Greece: Epirus (BRIGNOLI 1977, 1984), Corfu, Lefkada, Cephalonia (BRIGNOLI 1974, THALER & KNOFLACH 1998); Turkey: v. Salihli, Manisa (BRIGNOLI 1978).

Linyphiidae

Antrohyphantes rhodopensis

This species was hitherto known only from caves of the Western Rhodope Mts. and from the orophyte zone of the Rila and Pirin mountains (DELTSHEV 1996, DELTSHEV & PETROV 2008). Its presence in subterranean environments in southern Pirin adds very little to its geographical distribution but shows that the species is a subterranean specialist which is likely to be restricted to colder microhabitats and suitable humidity.

Centromerus milleri

This species was hitherto known only from Dupnitsa cave in the Strandzha Mts., the European part of Turkey (anophthalmic population, Deltshev, unpublished), Maronia cave in north-eastern Greece, several caves in the Eastern Rhodope Mts. and Stapalkata Cave in the Western Rhodope Mts., Bulgaria (DELTSHEV & PETROV 2008). The new record from the Ruj Mts. significantly extends its range in north-western direction and indicates a possibly wider distribution. The anophthalmic population in the cave Dupnitsa is of special interest, as it might represent a new, closely related troglobitic species. A molecular study of the different populations may reveal the routes of colonization, specialisation and evolution of the species in the different parts of its distribution area. The Ruj population does not show any obvious morphological difference from the other Bulgarian population.

Centromerus acutidentatus

The species belongs to the *sylvaticus*-group of the genus *Centromerus* Dahl, 1886 and is currently known from caves in Bulgaria, FYR Macedonia and Serbia (DELTSHEV & ĆURČIĆ 2002). As well as in caves, the species has also been found in the detritus of forests, and now also in the Vitosha Mts. at a depth of 40-60 cm.

Centromerus cavernarum

This species is known in Bulgaria from 10 caves in the West Rhodope Mts. (Lepenitsa, Zmiin Burun, Cheloveshkata peshtera), Stara Planina Mts. (Prelaz, Prikazna, Zlatnata peshtera), Pirin Mts. (Starshelitsa), Strandzha Mts. (Hambarcheto) and the Predbalkan (Bacho Kiro, Gurlyova dupka) (BERON 1994, DELTSHEV et al. 2003), as well as from other subterranean soil habitats. It occurs among detritus and deep under stones in beech and spruce forests, in void systems, and in screes (LASKA et al. in press). It is also quite common in caves in the Czech Republic and Slovakia (cf. RŮŽIČKA 2007).

Lepthyphantes centromeroides

This species is comparatively widespread on the Balkan Peninsula and can be considered as an example showing the process of cave colonization and subterranean adaptation. It occurs in caves, but also in the humus and ground detritus (DEELEMAN-REINHOLD 1978: 196-200).

Genus *Palliduphantes* Saaristo & Tanasevitch, 2001

The genus is represented in Bulgaria by 6 species: *Palliduphantes alutacius*, *P. istrianus*, *P. pallidus*, *P. pillichi*, *P. spelaeorum* and *P. trnovensis*. They are characteristic and widespread in caves and occur also in humus and ground detritus (DELTSHEV 1980, DELTSHEV & PETROV 2008).

Pelecopsis mengei

The species is widespread in the Holarctic region (PLATNICK 2010), and this represents the first record from Bulgaria. So far it is known only from the region of Panagyurishte, where it was found in the soil at a depth of 40-90 cm.

Agelenidae

Histopona tranteevi

So far this species was known only from a few caves in the Western Rhodope Mts. (DELTSHEV & PETROV 2008). The new records from subterranean habitats in Ruj, the Western Rhodopes and Slavyanka mountains suggest that it is much more widespread than previously thought. The species is obviously inclined to dwell in semiaphotic and aphotic environments. The Ruj locality lies quite apart from the other two and suggests that the species also occur in similar habitats in Serbia.

Dictynidae

Cicurina cicur

The majority of the species of the genus *Cicurina* (*Cicurella*) Chamberlin & Ivie, 1940 show a clear preference for life in subterranean environments, as just in North America over 60 cave-dwelling species with a different degree of cave adaptation have been described (PAQUIN & DUPÉRRÉ 2009). *C. cicur* is the only representative of this genus in Europe. As well as in subterranean habitats, it was also recorded from caves in Eastern Bulgaria (Shumen Distr. and Strandzha Mts.). It also lives under stones, in leaf-litter and in decaying wood in forests, in open habitats in microspaces with high humidity (BUCHAR & RŮŽIČKA 2002). In Germany it is active in winter (Blick pers. comm.).

Scotolathys simplex

Besides the underground samples, the species was also recently found from epigeic habitats near the village of Kamenitsa, Maleshevska Planina Mts., SW Bulgaria N 41.6496°, E 23.1607°, alt. 200 m (1♂, 1 ♀, 12.VI.2005, S. Lazarov leg.) and from FYR of Macedonia (2 ♀♀, Veles Town, near Mladost Lake, N 41.7755°, E 21.755°, alt. 240 m, 19.IV.2002, S. Lazarov leg.), which are the first records of this genus and species from both countries. The species is widely distributed in the Mediterranean region, being hitherto known from Algeria, Greece, Bulgaria, FYR of Macedonia, Spain and Ukraine (MARUSIK el al. 2009, PLATNICK 2010). GERTSCH (1946) suggested the synonymy of the genus *Scotolathys* Simon, 1884 with the genus *Lathys* Simon, 1884, but the former was recently resurrected by MARUSIK el al. (2009).

Discussion

Twenty-five per cent of the spiders (13 species) found in the SUC and euedaphic stratum are also known from caves. All of them show one or more troglomorphic traits (Table 3) and thus they could be considered true hypogeicolous animals (subterranean specialists). The remaining species are either surface dwelling (e.g. *Eurocoelotes jurinitschi*, *Gnaphosa modestior*) species or they had accidentally fallen in the traps when they were laid (*Euophrys frontalis*).

In a survey of the spiders living in deeper soil layers in the Czech Republic, LASKA et al. (in press) found 48 species of spiders, of which five, *Pallidupbantes alutacius*, *Centromerus cavernarum*, *Diplostyla concolor*, *Nesticus cellulanus*, and *Cicurina cicur*, the authors considered more or less bound to subterranean environments. *P. alutacius* was found to occur at a maximum depth of 95 cm, *C. cavernarum* at 75 cm, *D. concolor* at 15 cm, and both *N. cellulanus* and *C. cicur* at 85 cm. These species were also found during our study, as *D. concolor* was found at 8 collecting sites. Another frequently collected species was *Harpactea srednagora,* which was found at 11 sites.

Of all the species found in the SUC and euedaphon only *Antrohyphantes rhodopensis*, *Centromerus milleri* and *Zangherella relicta* have a distinct troglomorphic appearance. All three are also known from caves. If we adopt the recent classification of subterranean biota (SKET 2008), where troglobionts are defined as "strongly bound to hypogean habitats", then the species mentioned above should be considered troglobionts. However, there are some alternative classifications of the subterranean animals, e.g. that of DECU et al. (2006) who distinguish between hypogeicolous and cavernicolous fauna, and further subdivide the former category into colluviotroglobitic, eluviotroglobitic, cleitrotroglobitic and volcanotroglobitic, based on the origins and texture of the substrate (colluvic, eluvic, cleitric and volcanic MSS, respectively). According to the latter classification *Zangherella relicta*, which was found only at a depth of 40-50 cm, could be considered a true colluviotroglobite, if it is proved that in Bulgaria it occurs only in the SUC and is absent in caves or superficial soil layers. *Histopona tranteevi* and *Centromerus milleri* were hitherto known only from a limited number of caves (DELTSHEV & PETROV 2008) but turned out to also live below 30 cm depth in the SUC and euedaphon. It is evident that the boundary between true troglobionts and true geobionts is very vague and there is no unequivocal tool for identifying to which of these two categories an animal belongs. Table 3 summarizes the distribution of the species found in subterranean habitats in Bulgaria and provides information on their troglomorphic traits. There are several highly adapted cavernicolous species such as *Centromerus bulgarianus* and *Troglohyphanthes drenskii*, which are so far unknown from soil strata and the SUC and might thus represent true cave-dwellers. Other troglomorphic species, which are usually considered either eutroglophiles or troglobites, such as *Centromerus cavernarum*, *C. lakatnikensis*, *C. milleri*, *Lepthyphantes centromeroides*, *Palliduphantes istrianus*, *P. spelaeorum* and *P. trnovensis* have been recorded from both caves and deeper soil strata and their habitat preferences are in need of more profound studies.

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Table 3: List of the cave-dwelling and subterranean spiders in Bulgaria with their troglomorphic traits and habitats inhabited.

Taxa	Deep Cave	Shallow cave; Cave entrances	Eueda-phon and SUC	Troglomorphic traits
Leptonetidae				
Protoleptoneta bulgarica Deltshev, 1972		+		Depigmentation, elongation of legs
Protoleptoneta beroni Deltshev, 1977		+		Depigmentation, elongation of legs
Nesticidae				
Nesticus beroni Deltshev, 1977		+		Depigmentation, microphthalmy, elongation of legs
Nesticus cellulanus (Clerck, 1757)		+	+	Partial depigmentation, elongation of legs
Nesticus eremita Simon, 1879		+		Depigmentation, elongation of legs
Anapidae				
Zangherella relicta (Kratochvíl, 1935)			+	Depigmentation, microphthalmy, dwarfism
Theridiidae				
Robertus frivaldszkyi (Chyzer, 1894)	+			Depigmentation
Linyphiidae				
Antrohyphantes balcanicus (Drensky, 1931)	+			Depigmentation, microphthalmy, elongation of legs
Antrohyphantes rhodopensis (Drensky, 1931)	+	+	+	Depigmentation, microphthalmy, elongation of legs
Antrohyphantes sophianus (Drensky, 1931)	+			Depigmentation, microphthalmy, elongation of legs
Centromerus acutidentatus Deltshev, 2005		+	+	Depigmentation
Centromerus bulgarianus (Drensky, 1931)	+			Depigmentation, anophthalmy
Centromerus capucinus (Simon, 1884)		+	+	Depigmentation
Centromerus cavernarum (L. Koch, 1872)	+		+	Depigmentation
Centromerus lakatnikensis (Drensky, 1931)	+		+	Depigmentation
Centromerus milleri Deltshev, 1974	+	+	+	Depigmentation, anophthalmy, microphthalmy
Diplocephalus foraminifer (O.P.- Cambridge, 1875)	+	+		Depigmentation
Diplostyla concolor (Wider, 1834)			+	Depigmentation
Lepthyphantes centromeroides Kulczyński, 1914	+			Depigmentation, elongation of legs
Lepthyphantes leprosus (Ohlert, 1865)		+	+	Partial depigmentation, elongation of legs
Microctenonyx subitaneus (O.P.- Cambridge, 1875)	+	+		Depigmentation

Taxa	Deep Cave	Shallow cave; Cave entrances	Eueda-phon and SUC	Troglomorphic traits
Palliduphantes alutacius Simon, 1884		+	+	Depigmentation, elongation of legs
Palliduphantes byzantinus (Fage, 1931)	+			Depigmentation, elongation of legs
Palliduphantes istrianus Kulczyński, 1914	+		+	Depigmentation, elongation of legs
Palliduphantes pallidus (O.P.- Cambridge, 1871)		+		Depigmentation, elongation of legs
Palliduphantes pillichi (Kulczyński, 1915)	+			Depigmentation, elongation of legs
Palliduphantes trnovensis (Drensky, 1931)	+		+	Depigmentation, elongation of legs
Palliduphantes spelaeorum (Kulczyński, 1914)	+			Depigmentation, elongation of legs
Porrhomma convexum (Westring, 1861)	+	+		Depigmentation
Porrhomma microps (Roewer, 1931)	+			Depigmentation, microphthalmy, anophthalmy
Thyreosthenius parasiticus (Westring, 1851)	+	+		Depigmentation
Troglohyphanthes drenskii Dentshev, 1973	+			Depigmentation, microphthalmy, anophthalmy
Troglohyphanthes bureschianus Deltshev, 1975		+		Depigmentation, elongation of legs
Agelenidae				
Histopona tranteevi Deltshev, 1978	+	+	+	Depigmentation, elongation of legs
Dictynidae				
Cicurina cicur (Fabricius, 1793)		+	+	Depigmentation

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