RŮŽIČKA V. 2007: Spiders on sandstone rocks in Central Europe with particular reference to the Bohemian Switzerland National Park. In HÄRTEL H., CÍLEK V., HERBEN T., JACKSON A. & WILLIAMS R. (eds), *Sandstone Landscapes*. Academia, Praha, pp. 143–147.

this volume, Sklenář et al., this volume). Plants from very different ecological groups (continental vs. oceanic, xerophytic vs. hygrophytic) may be found in habitats very close to each other. For example, in the Elbe Sandstones region, sub-Alpine-(sub-Arctic) vascular plant species such as *Viola biflora* and the bryophytes *Anastrophyllum michauxii* and *Lophozia grandiretis* are found only a few kilometres from localities of southern vascular plant species such as *Petrorhagia prolifera*, *Trifolium alpestre* and *Clematis recta*. Invertebrates show similar contrasts; weevils *Otiorhynchus lepidopterus* and *Notaris aterrimus* (Figure 2); leaf-beetles *Minota obesa* and *Timarcha metallica*; butterflies *Coleophora glitzella*, *Apotomis sauciana* and *Ancyllis myrtillana*; digger wasps *Pempredon montana* and *P. borealis* occur at habitats very close to habitats of thermophilic species such as the long-horned beetle *Xylotrechus antilope*, the locust *Chorthippus pullus* and the Mediterranean bees *Hylaeus cornutus* and *Sphecodes croaticus*. While the overall poverty of sandstone floras limits overall diversity, no matter how pronounced the mesoclimatic gradients are, in relative terms beta diversity is very high. This should lead to different shapes of species-area relationships in sandstone areas (low intercept, fast increase, but low plateau). Since the underlying ecological gradients should be rather easy to distinguish, and to quantify their spatial scales, sandstone areas thus should be a prime model landscape for the study of scale-dependent richness patterns.

Figure 2. Weevil *Notaris aterrimus* (Hampe, 1850) – the rare mountain species of debris forests (Photo by Jan Šmucar)

Spiders on sandstone rocks in Central Europe with particular reference to the Bohemian Switzerland National Park

Vlastimil Růžička[1]

Keywords: spiders, *Araneae*, sandstone rocks, microclimate, distribution area

Introduction

While the majority of the Central European landscape would be covered by forests without human influence, rocky areas form isolated, islet-like, natural, non-forest habitats. The surface of some of these non-forested areas is composed of bare bedrock or products of its erosional breakdown (without a soil layer) such as gravel, sand banks, sand dunes, scree slopes and rock outcrop habitats. These habitats harbour specialized spider species that depend on their specific substratum and microclimate (Růžička 2000). Out of these habitats, rock walls (and scree slopes) form one of the most distinct ecological gradients of any terrestrial ecosystem (Larson et al. 1989, Růžička et al. 1995). They provide habitats with extremely warm and cold microclimatic conditions in close proximity. They also belong to habitats almost unknown until now due to the technical and practical problems of sampling.

[1] Institute of Entomology, Czech Academy of Sciences, Branišovská 31, CZ-370 05 České Budějovice, Czech Republic, e-mail: vruz@entu.cas.cz

Sandstones can form extensive systems of rocks, sometimes with a broad spectrum of meso- and microhabitats due to their very dynamic relief. Sandstone rocks are characterised by a marked contrast between forested plateau and bare vertical rock walls (Balatka and Sládek 1984). Upper margins of rocks are dry, vertical rock walls can be sun-exposed, dry and bare, or shady and humid and hence covered by mosses. Spaces with an extremely cold climate can occur in deep gorges. The aim of this study is to evaluate available data on the species composition of spider assemblages in sandstone rocks, including new data about spiders on rock walls in the Bohemian Switzerland (České Švýcarsko) National Park.

Methods

Field collection and data analysis

In the Bohemian Switzerland National Park spiders were sampled at two localities: (i) Sun-exposed rock walls and rocky slopes on the border, north of Pravčická brána Arch, about 400 m a.s.l.; (ii) Shaded rock walls in Suchá Kamenice stream valley, south of Hřensko, about 200 m a.s.l.

Spiders were trapped using a hanging- board trap described by Růžička (2000) which is designed for automatic collecting of invertebrates on vertical rock walls. The traps were made of rigid plastic and consist of a board (25 × 20 cm) and a can (13 cm high and 10.5 cm in diameter) inserted in the centre of the board. The traps contained a mixture of 7% formaldehyde and 10 % glycerol with a few drops of a surfactant (e.g., washing-up liquid). Each trap was hung from a nail, and a band of emery tape was stuck on the back edge of the trap that was shaped to form a join between the board and the rock surface. Four traps were installed in each of the habitats studied in the Bohemian Switzerland National Park from October 1999 to October 2000.

Data from other regions and data analysis

Data from Růžička (1992), who found 82 species, and from Růžička and Kopecký (1994), reporting 29 species, were used as the source for the Broumovsko Protected Landscape Area in northeastern Bohemia. This data set contains a total of 91 species. Woźny and Czajka (1985a, b) reported data on the occurrence of three principal species in the Góry Stołowe Mountains in Poland. Further, data from Růžička (1992) on the occurrence of 14 selected species in ten sandstone rock localities in the Czech Republic was used.

Species characteristics given by Buchar and Růžička (2002) were used to provide basic ecological information. The species are classified here according to the humidity of the habitats inhabited: very dry (vd), dry (d), semi-humid (s-h), humid (h), very humid (vh). Furthermore, each species is characterised by the phytogeographic region inhabited: Thermophyticum – T (the region of thermophilous flora and vegetation), Mesophyticum – M (the region with the flora and vegetation of the temperate zone, i.e. the region of deciduous forests), and Oreophyticum – O (the region of mountain flora and vegetation; spruce prevails in the natural forests). Species nomenclature follows Buchar and Růžička (2002).

Results and discussion

Thirty. nine species were found in the Bohemian Switzerland National Park (Table 1). Although only a part of the total gradient was sampled, there are clear differences between the habitats that can be used to evaluate the meso- and microclimatic gradient. Some of the species collected in the Bohemian Switzerland National Park occur only on sun-exposed rocks. This assemblage is characterised by the presence of species with a preference for Thermophyticum and very dry habitats. Typical species include *Xerolycosa nemoralis*, *Drassodes lapidosus*, *Zelotes puritanus*, *Zelotes petrensis*, *Aelurillus v-insignitus*, *Zodarion germanicum*, *Episinus truncatus* (Table 1). These are often found at the edge of the rock formations in heather (*Calluna vulgaris*; Duffey 1966, 1993); these are inhabited by numerous thermophilous spider species (Table 2).

The remainder of the species collected in the Bohemian Switzerland National Park occur only on shaded rocks. This assemblage is characterised by the presence of species with a preference for Mesophyticum and semi-humid habitats. These include *Nesticus cellulanus*, *Hahnia pusilla*, *Amaurobius fenestralis*, *Callobius claustrarius*, *Harpactea lepida*, *Cicurina cicur*, *Histopona torpida* (Table 1).

A remarkable feature of sandstone rocks is the occurrence of cold-adapted spider species otherwise present in mountains and peat bogs (Table 2; see Růžička 1992, Woźny and Czajka 1985a, b). These species are found in the cold gorges of sandstone labyrinths, similar to the occurrence of mountain plant species (Sýkora and Hadač 1984; Härtel 2002).

Further, there are spider species that live occasionally, primarily, or exclusively on rocks of lower altitudes (Růžička 2000) although these were not included in the classification of major habitat types for European spiders (Hänggi et al. 1995). Three taxa from the Czech arachnofauna (Buchar and Růžička 2002) were found exclusively on bare rocks: *Segestria bavarica*, *Lepthyphantes pulcher* and *Bathyphantes simillimus simillimus*. *S. bavarica* occurs in the warmest territories of Central Bohemia and South Moravia on limestone, andesite and serpentinite rocks; but it was not recorded in sandstone regions. *L. pulcher* was recorded in these sandstone regions, as well as on quartzite and granite. The occurrence of *Bathyphantes simillimus* in Central Europe is known in the Czech Republic, Slovakia, Poland, Germany,

France and Belgium (Růžička 1994, Blick and Molenda 1997). The subterranean, long-legged, depigmented subspecies *B. s. buchari* is widely distributed in scree slopes. The nominate, normally pigmented subspecies *B. s. simillimus* survives exclusively in very limited region of sandstone rocks in the border territory between Bohemia and Poland (Figure 1). Several other species, which occur on bare rock surfaces, were also recorded on sandstone rocks (Table 2). The occurrence of *Zelotes puritanus* in Europe is known in the Czech Republic, Poland and Austria (Růžička 2000). The first record in Europe was described as

Phytogeographic district	Humidity	Species	A	B
T, M, O	vd, d, s-h	*Xerolycosa nemoralis*	30/5	–
T, M	**vd**, d	*Drassodes lapidosus*	16/2	–
T, (M)	**vd**	*Zelotes puritanus*	11/5	–
M	d	*Alopecosa aculeata*	7/1	–
T, M	vd, d, s-h	*Zelotes petrensis*	5/2	–
M, **O**	d, s-h, h	*Alopecosa taeniata*	1/3	–
T, M, (O)	vd, d, **s-h**, h	*Trochosa terricola*	3/1	1/–
T, **M**	**vd**, d	*Aelurillus v-insignitus*	3/–	–
T, M	vd, d	*Zodarion germanicum*	1/1/1	–
T	vd, **d**	*Episinus truncatus*	2/–	–
T, **M**, (O)	s-h, h	*Bathyphantes gracilis*	1/–	–
M	vd, d	*Crustulina guttata*	–/1	–
T, M, O	**vd, d**–(h, vh)	*Haplodrassus signifer*	1/–	–
M	d, **s-h**	*Haplodrassus umbratilis*	1/–	–
M, O	s-h	*Lepthyphantes pulcher*	–/1	–
(T), **M**, (O)	s-h	*Philodromus collinus*	1/–	–
(T), **M**	vd, (d, s-h)	*Stemonyphantes lineatus*	1/–	–
T, **M**	d, s-h	*Walckenaeria furcillata*	–/1	–
(T), **M**	s, s-h	*Zora nemoralis*	1/–	–
M	h, vh	*Nesticus cellulanus*	–	1/4/12
M	vd, d, **s-h**, h	*Hahnia pusilla*	–	7/–
M, O	(d), s-h, h	*Amaurobius fenestralis*	–	3/–/2
M, O	d, **s-h, h**	*Callobius claustrarius*	–	5/–
M, (O)	s-h	*Harpactea lepida*	–	3/2
M, O	s-h	*Coelotes inermis*	–	2/1
M, **O**	s-h, h	*Lepthyphantes alacris*	–	1/2
(T), **M**	(d), s-h, h	*Cicurina cicur*	–	–/2
(T), M, (O)	s-h	*Diplocephalus picinus*	–	2/–
M, O	d, **s-h**, h	*Histopona torpida*	–	2/–
T, **M**	d, s-h	*Lepthyphantes flavipes*	–	1/1
(T), **M**, O	**s-h**, h	*Micrargus herbigradus*	–	1/1
(T), **M**	h, vh	*Tetragnatha montana*	–	–/2
(T), M, O	d, **s-h**, h	*Coelotes terrestris*	–	–/1
M, O	s-h, **h**	*Cybaeus angustiarum*	–	–/1
M, O	s-h	*Lepthyphantes tenebricola*	–	1/–
(T), **M**	d, **s-h**	*Linyphia hortensis*	–	1/–
M, O	d, **s-h**	*Macrargus rufus*	–	–/1
T, **M**, O	h	*Metellina merianae*	–	1/–
T, M, O	(vd)–s-h–(vh)	*Walckenaeria atrotibialis*	–	1/–

Table 1. A survey of material collected in the Bohemian Switzerland National Park. A – sun-exposed rock walls near Pravčická brána Arch, B – shaded rock walls in the Suchá Kamenice Stream valley. male/female/juv. Phytogeographic district inhabited: T – Thermophyticum, M – Mesophyticum, O – Oreophyticum. Humidity of the habitats inhabited: vd – very dry, d – dry, s-h – semi-humid, h – humid, vh – very humid. The basic values are printed in normal font, the markedly preferred values are printed in bold, and some marginal values are in parentheses

Zelotes kodaensis (Miller and Buchar 1977). The species was recorded on rock steppes and was considered to occur only in Bohemian Thermophyticum (Buchar 1993). Later, it was found to be a typical inhabitant of rocks (Růžička 2000). In the warmest territory of central Bohemia, it has now been recorded on sandstone rocks in the Bohemian Switzerland National Park and on phonolite rocks on Klíč Hill (Figure 2). This spider can only effectively be sampled using hanging traps as described previously. It suggests that this species can be widely overlooked due to its inaccessible (rock wall) habitat.

Characteristic	Sun-exposed rock walls	Bare rock surface	Cold gorges
T; vd, d	*Episinus truncatus*		
T, M; vd, d	*Zodarion germanicum*		
T, M; **vd**, d	*Drassodes lapidosus*		
T, (M); **vd**	*Zelotes puritanus*		
T, **M**; **vd**, d	*Aelurillus v-insignitus*		
M; h, vh		*Nesticus cellulanus*	
M, O; s-h		*Lepthyphantes pulcher*	
M, O; s-h		*Thyreosthenius parasiticus*	
(T), **M**, (O); h, vh		*Meta menardi*	
T, **M**, O; h		*Metellina merianae*	
M, O; s-h, h		*Bathyphantes s. simillimus*	*Bathyphantes s. simillimus*
M, **O**; h, **vh**			*Centromerus arcanus*
O; h, vh			*Centromerus pabulator*
M, O; h			*Dicymbium tibiale*
M, O; h			*Diplocentria bidentata*
M, O; vh			*Diplocephalus helleri*
M, **O**; s-h, h			*Lepthyphantes alacris*
O; h			*Lepthyphantes mughi*
(M), **O**; h			*Lepthyphantes tripartitus*
O; s-h			*Mecynargus morulus*
M, **O**; h			*Porrhomma egeria*
M, (O); s-h			*Porrhomma pallidum*
O, h			*Sisicus apertus*

Table 2. Major ecological groups of spiders (thermophiles, inhabitants of bare rock surface, and cold-adapted species) found on sandstone rocks. Phytogeographic region: T – Thermophyticum, M – Mesophyticum, O – Oreophyticum. Humidity of the habitats inhabited: vd – very dry, d – dry, s-h – semi-humid, h – humid, vh – very humid. The basic values are printed in normal font, the markedly preferred values are printed in bold, and some marginal values are in parentheses

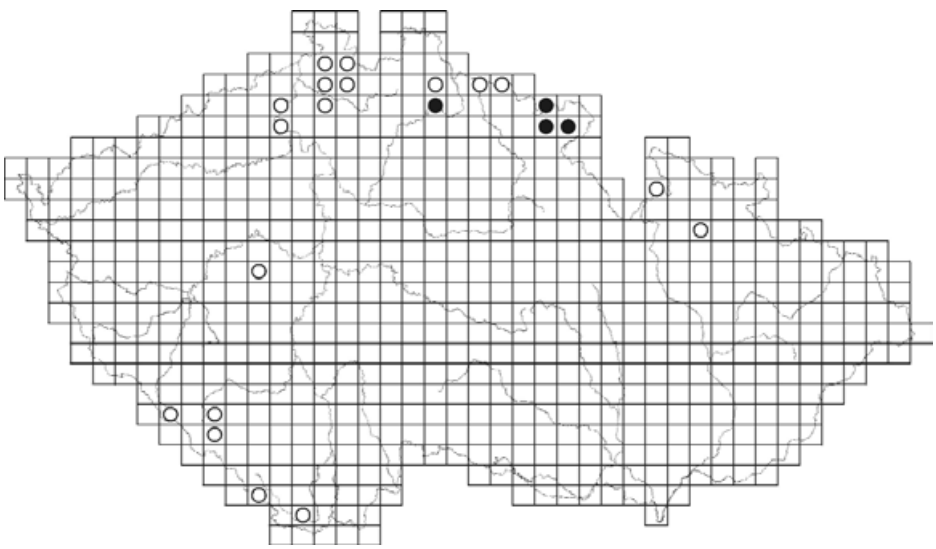

Figure 1. Distribution of *Bathyphantes simillimus simillimus* on sandstone rocks (black circles) and Bathyphantes simillimus buchari on scree slopes (open circles) in the Czech Republic

Conclusions

Sandstone rocks can harbour spider species specialised for the life on the rock surface. Due to their microclimatic diversity, sandstone rocks host thermophilous spider species (in altitudes higher than their main distribution area) and psychrophilous spider species (in altitudes lower than their main distribution area). Due to the inaccessibility of rock walls, the occurrence of some spider species can be still overlooked. *Bathyphantes simillimus simillimus* is an exclusive inhabitant of sandstone rock labyrinths.

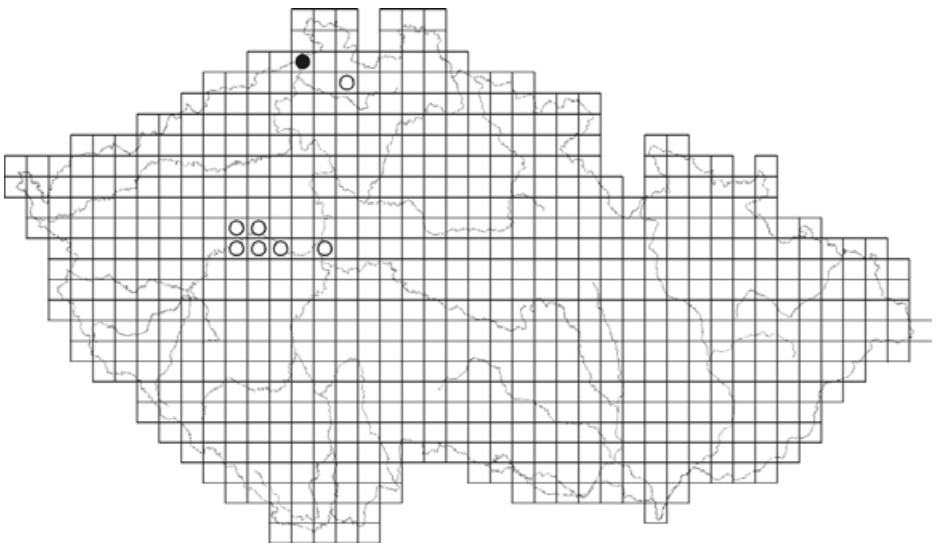

Figure 2. Distribution of *Zelotes puritanus* on sandstone rocks (black circle) and in other habitats (open circles) in the Czech Republic

Distribution of earthworms (*Lumbricidae*) in Bohemian Switzerland (Czech Republic)

Václav Pižl[1]

Keywords: earthworms, soil fauna, oligochaetes, sandstone area, assemblages

Introduction

Earthworms form a large proportion of the biomass of the overall soil fauna in many soils and occupy a central position in the trophic network being preyed upon by many invertebrate and vertebrate predators (Lee 1985). They enhance the formation of soil structure and the incorporation and transformation of organic matter in soils, and their importance in affecting physical and chemical properties of soil is generally accepted (Edwards 1998). On the other hand, the composition of their community could indicate the nature of soil processes and the effects of both natural and anthropogenic stressors. A good knowledge of earthworm fauna is, therefore, important not only from the point of view of nature conservation, but also as a useful tool in monitoring anthropogenic impacts on the environment.

It is believed that sandstone areas represent conditions which are hostile to earthworms, limiting the establishment of populations

Institute of Soil Biology, Academy of Sciences of the Czech Republic, Na Sádkách 7, CZ-370 05 České Budějovice, Czech Republic, e-mail: pizl@upb.cas.cz