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Spiders of pseudokarst caves in northeastern Bohemia

RUZICKA V.*, KOPECKY** J.

*Institute of Entomology, Czech Academy of Sciences, Branisovská 31
370 05 Ceské Budejovice, Czech Republic

**Broumovsko Protected Landscape Region Authority
Komenského 107, 549 54 Police nad Metují, Czech Republic

RIASSUNTO

Le arenarie dell'area protetta del Broumovsko (Boemia nord-orientale) costituiscono un rifugio per alcuni relitti glaciali, specie psicrofile a distribuzione arcto (boreo) - alpina.

La temperatura delle cavità interne formatesi al fondo degli accumuli rocciosi non supera i 6 - 8° C in estate, e scende a circa -8° C in inverno.

L'attività degli animali e la ricchezza della loro comunità diminuiscono con l'aumentare della profondità e dell'isolamento degli spazi cavitari. Il ragno *Porrhomma egeria* è una specie caratteristica che abita nelle più profonde cavità del terreno in Europa centrale, nelle grotte carsiche, in quelle pseudocarsiche e negli accumuli rocciosi in questione.

Parole chiave: Relitti glaciali, Regione del Broumovsko, Boemia, Grotte pseudocarsiche, *Porrhomma egeria.*

ABSTRACT

The sandstone rocks of the Broumovsko Protected Landscape Region constitute a refugium for glacial relicts - psychrophilous species with an arcto(boreo) - alpine type of distribution. The temperature of the inner space of deep boulder accumulations does not exeed 6 to 8° C in summer, and decreases to ca -8° C during winter. The activity of the animals decreases and the species richness of their communities diminishes as the depth and isolation of the compartments increase. The spider *Porrhomma egeria* is a characteristic species inhabiting deep underground cavities in central Europe, in karst caves, in pseudokarst caves and in boulder accumulations.

Key words: Glacial relicts, Broumovsko region, Bohemia, Pseudokarst caves, *Porrhomma egeria.*

Introduction

Massive layers of Upper Cretaceous block sandstones just out in northeastern Bohemia, in the Bohemian Cretaceous Basin. Narrow gorges, broader canyons and "rock cities" are typical macroforms of the relief of these regions (BALATKA & SLÁDEK, 1984; VÍTEK, 1979). Ruzicka (1992) reported on the arachnofauna of sandstone rocks in the Czech Republic. Pseudokarst caves are typical mesoforms of sandstone relief. Of particular interest are boulder caves which arose in stone accumulations at the bottoms of gorges and canyons or at the feet of rock walls. Water streams, which clean the bottom parts of the accumulation of debris, constitute a factor assisting the formation of extensive systems of underground cavities (KOPECKY, 1990).

Region and Sites Investigated

The Broumovsko Protected Landscape Region was established as an area occupying 410 km^2: average January temperature -3 to -4 °C, average July temperature 15 to 16 °C; the average daily temperature is higher than 10 °C for 120 to 140 days per year. Total yearly precipitation is 850-1000 mm.

The sites examined were divided into four groups (Fig. 1).

1. Teplická Jeskyne cave

Teplická Jeskyne cave opens in a thick block accumulation on the bottom of the Skalni Potok valley at an altitude of 500 m in Adrspassko-Teplické Skály rocks National Reserve. The depth of the west-east oriented canyon reaches 80-120 m. On the right slope of the canyon lies a block field 500 m long and as much as 90 m high. The average size of individual blocks is 5-8 m. The surface of the field is overgrown by moss and covered by a mature spruce forest. The thickness of the soil-free boulder layer attains 20 m. An extensive system of underground cavities has evolved over an area 400 m long. So far, 1065 metres of corridors accessible to man have been recorded. The bottom is constituted by fluvial sand deposits. Ice filling appears every year.

2. Pod Luciferem cave

Pod Luciferem cave occurs in a block accumulation at the bottom of

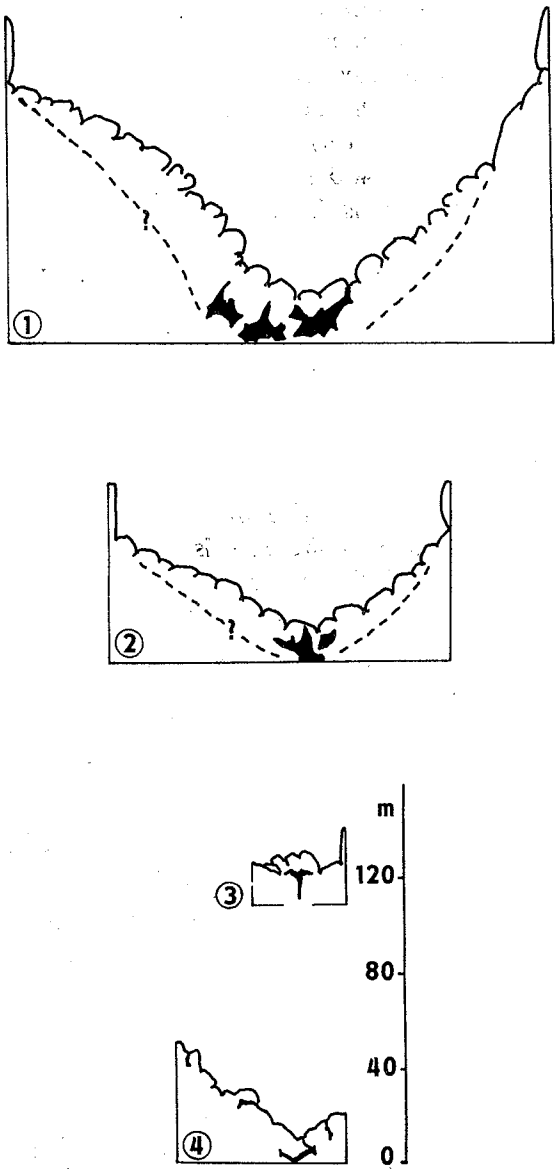

Fig. 1. Scheme of the caves investigated. 1. Teplická Jeskyne, 2. Pod Luciferem, 3. Korenka, 4. caves on the Hejda mesa.

the short, steep, north-west oriented Martinkovicky Potok valley, at an altitude of 560 - 600 m in Broumovské Steny walls National Reserve. The depth of the canyon reaches as much as 60 m. The average size of the blocks exceeds 10 m, the thickness of the soil-free block layer on the canyon bottom attains 15 m. A system of underground cavities, with a total length of approximately 400 m, has developped over an area 250 m long. Fluvial sand and gravel is the major material of the cave bottom, but bare bedrock also occurs.

3. Caves in gorges

The depth of these caves in gorges, which are no deeper than 50 m, does not exceed 10 m.

1) Korenka cave is on one of the structural surfaces of the Teplické Skály at 685 m altitude. The cave developed beneath fallen blocks of rock and is a continuation of a fissure which reaches the bottom of the rock formation. The bottom of the cave is constituted by soft, wet, sandy-loam sediment. About 40 m of the cavities are accessible to man.

2) A boulder cave in a gorge in the Bludiste region in the Teplické Skály, about 700 m altitude, approximately 10 m long.

3) A boulder cave in the central part of the Kovárova Rokle gorge in the Broumovské Steny, about 600 m altitude, approximately 20 m long.

4. Caves at the sides of the Hejda mesa

Hejda Hill is a mesa 0.5 km^2 in area and 80 m high. Boulder and crevice type caves: Horní Sluj, Písecná, Plesnivá and Pod Kamenem, 580 - 620 m altitude. The depth of these caves is less than 10 m, and they are usually shorter than 20 m. The soil-sand bottom is frequently covered with drifted leaves.

Methods

Specimens of invertebrates were collected by using double pitfall traps filled with formaldehyde (RUZICKA, 1982) through 1990-1993 period. Material was also obtained by hand collecting on cave walls through the 1986 - 1993 period.

The temperature patterns were monitored in the Korenka, Písecná and Horní Sluj caves in 1984-1987: temperature was measured around

noon, once a month. Minimo-maximal thermometers were employed to monitor the temperature in the Teplická Jeskyne cave over the period of May 1992 to July 1993.

Spider activity is expressed by means of the formula $A = 365.N_2/t.p.o.$ (specimens/m/year). The species richness index was calculated as $d = S_2 - 1/\ln N_2$. In the formulae, o is the trap circumference (0.24 m), p is the number of traps at the locality, t is the number of days for which the traps were functional, N_2 is the number of specimens trapped, and S_2 is the number of species trapped.

Results

Temperature (Fig. 2)

The temperature at three different sites in the Teplická Jeskyne cave varied within the limits of -6 to +4, -3.5 to +6, and -8 to +6 °C, respectively. The maximum range of temperature fluctuations observed in the whole cave system was thus -8 to +6 °C.

The temperature ranges observed in the Korenka cave in three succesive years were -3.0 to +12.0, -5.7 to +13.0, and -7.2 to +13.2 °C, respectively. In the Písecná cave on Hejda, the temperature in two successive years varied within the ranges of -14.0 to +12.5 and -8.0 to +11.0 °C.

The respective figures for the Horní Sluj cave on Hejda are -14.0 to +13.5 and -7.5 to +14.0 °C. The minimum (with respect to the method used) range of temperature fluctuations observed in the superficial cavities studied was thus -14 to +14 °C.

Spiders

A total of 131 spider specimens, belonging to 29 species, were collected in the caves (Table 1).

Common forest species were found in superficial underground cavities. The frequency of occurrence of specialized psychrophilous species increased with depth and isolation of the cavities. Specimens of *Bathyphantes simillimus* were observed in all caves sited in gorges or in contact with the deep spaces of the rock formation, whereas no observation of this species has yet been made in the superficial caves on the circumference of the Hejda mesa. *Porrhomma egeria* was only found in two extensive cave systems, where the temperature is largely con-

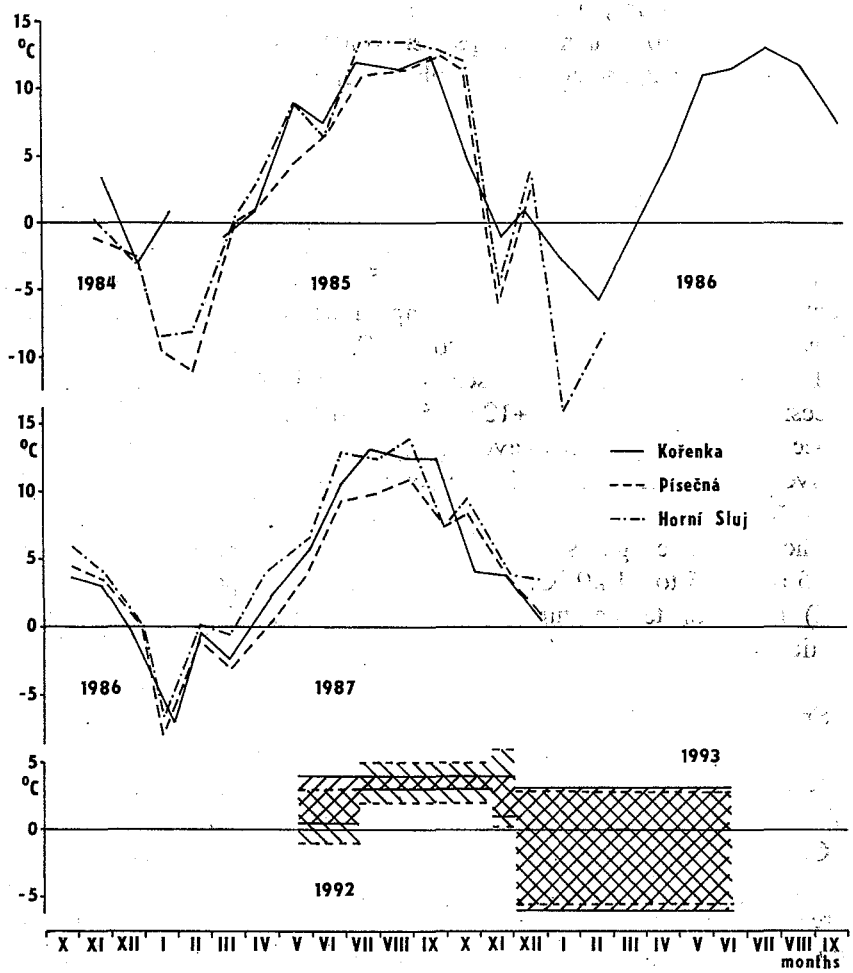

Fig. 2. Year-round temperature course in Korenka, Písecná and Horní Sluj caves (measured around noon, once a month) and temperature ranges on two minimo-maximal thermometers in Teplická Jeskyne cave.

Table 1. Overview of the material (♀/♂/j) and characteristics of the communities. 1 - Teplická Jeskyne cave, 2 - Pod Luciferem cave, 3 - Korenka cave and underground spaces in the Kovárova Rokle gorge and in Bludiste, 4 - caves on Hejda; n - number of traps, N_1 - total number of specimens, N_2 number of specimens in traps, S_1 - total number of species, S_2 - number of species in traps, A - activity (specimens/m/year), d - species richness index.

species / locality	1	2	3	4
Saaristoa firma (O.P.-Cbr., 1901)	1/--	--	--	--
Bathyphantes nigrinus (Westr., 1851)	1/--	--	--	--
Histopona torpida C.L.K., 1834	1/1	--	--	--
Lepthyphantes tripartitus Miller & Svaton 1978	2/8	--/1	--	--
Porrhomma egeria Simon, 1884	2/--	--/1	--	--
Centromerus pabulator (O.P.- Cbr., 1875)	1/1	--/1	--	--
Meta menardi (Latr., 1804)	--	--/--/2	--	--
Bathyphantes simillimus (L. Koch, 1879)	7/9	--1	8/11	--
Lepthyphantes alacris (Bl., 1853)	4/2	--	2/--	--
Micrargus herbigradus (Bl., 1854)	1/1	1/1	1/--	1/1
Coelotes terrestris (Wid., 1834)	--/1	--	--/1	--
Metellina merianae (Scop., 1763)	--/6	--	--	--/1/1
Nesticus cellulanus (Cl., 1757)	--/1	--	--	--/--/2
Macrargus rufus (Wid., 1844)	1/2	--	--	1/--
L. tenebricola (Wid., 1834)	--	--	1/--	--
Tapinocyba affinis (Less., 1910)	--	4/--	--	1/--
Cryphoeca silvicola (C.L.K., 1834)	--	--/1	1/--	4/2
Sisicus apertus Holm, 1939	--	--	1/--	--
Centromerus sylvaticus (Bl., 1841)	--	--	--/1	--
Thyreosthenius parasiticus (Westr., 1851)	--	--	1/3	--/1
Amaurobius fenestralis (Strom., 1768)	--	--	1/--	2/1
Harpactea lepida (C.L.K., 1839)	--	--	--	6/3
Diplocephalus latifrons (O.P.-Cbr., 1863)	--	--	--	1/1
Porrhomma pallidum Jacks., 1913)	--	--	--	1/--
Tegenaria silvestris (L. K., 1872)	--	--	--	--/1
Lepthyphantes kochi Kulcz., 1898	--	--	--	1/--
Labulla thoracica (Wid., 1834)	--	--	--	--/1
Mangora acalypha (Walck., 1802)	--	--	--	--/--/1
n	7	4	1	5
N_1	53	13	32	33
N_2	14	13	8	30
S_1	13	8	10	15
S_2	6	8	6	13
A	8,9	16,8	21,8	30,9
d	1,9	2,7	2,4	3,5

siderably lower than 6 °C in summer.

The highest activity level (49.1 specimens/m/year) was found for spiders in traps laid in superficial underground spaces on the Hejda mesa, where the bottom is covered by loamy soil and by a layer of leaf litter. This activity decreased with increasing depth and isolation of spaces reaching a minimum of 8.9 specimens/m/year, deep in the labyrinth of the Teplická Jeskyne. The highest (3.5) and lowest (1.9) species richness was observed in the caves on Hejda and in the depths of the Teplická Jeskyne, respectively.

Discussion

Temperature

An annual temperature range of 4.4 to 17.2 °C was observed at the end of the 60 m long Pekárna cave in the Moravian Karst (PELÍSEK, 1970; QUITT, 1982). At the end of the 300 m system of the Bycí Skála cave, the temperature was constantly at 8.5 °C. In the superficial underground cavities, the highest temperatures are about 14 to 17 °C, as in karst caves at depths down to 100 m. In the Teplická Jeskyne cave the highest value is 6 °C, hence about 2 °C less than in closed cave systems hundreds of metres deep. While karst caves at depths of 50 m and more do not usually freeze, caves at the bottom of block accumulations do, the temperature decreasing down to -7 to -8 °C. The overall cold microclimate and freezing of the Teplická Jeskyne cave is due to cold air streaming down into the cave from the extensive block accumulation above it.

Spiders

Sisicus apertus is known to occur over a wide region in Scandinavia, Karelia, East Siberia and Alaska. In central Europe, *Sisicus apertus* has been recorded from the Swiss canton of Graubunden (1910 m, Vogelsanger 1948), in the Stubaier Alps of the Tyrol (2300 m, THALER, 1969), and in Slovakia in the High Tatra (1300 m, MILLER, 1974). Its finding represents a new record for the Czech Republic.

Northern species *Bathyphantes simillimus* occurs in central Europe exclusively in boulder accumulations and in sandstone rocks (RUZICKA, 1988a, 1992).

The cold microclimate also accounts for the occurrence of the nor-

thern mite species *Rhagidia gelida*, which has recently been found in central Europe in the Teplické Skály rocks and Broumovské Steny walls (ZACHARDA, 1993).

The material from one trap in Teplická Jeskyne, which was laid on a gravel bank, was more rich in both species and specimens than the material from six traps, which were laid on sandy surface. This fact is consistent with the finding of NEUHERZ (1979) that, in caves, invertebrates occur more frequently in dissected spaces among stones and near rock crevices than in free, uniform space in the centre of caves.

Apart from randomly observed species and the hemisynanthropic *Meta menardi* and *Nesticus cellulanus*, only the species *Porrhomma egeria* was found in the deep space of the Moravian Karst caves (KRATOCHVÍL, 1933; MILLER and KRATOCHVÍL 1940). SANOCKA-WOLOSZYNOVA (1981) found that *Porrhomma egeria* is a typical species of deep parts of caves in Poland and referred to it as a "troglobiont in *statu nascendi*". For this species, SANOCKA (1982) described a progressive regression of the eyes correlated with the depth of the cave system. Loss of eyes, however, was observed neither in the specimen collected within the present study nor in specimen from other boulder debris (RUZICKA, 1988b and unpublished data). MILLER (1974) reported the occurrence of *Porrhomma egeria* in boulder debris in the surroundings of snow fields in the alpine zone of the High Tatra.

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