Spiders from steppe habitats of Pláně Nature Monument (Czech Republic) with suggestions for the local conservation management

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Abstract. Spiders from the steppe habitats of the Pláně Nature Monument (Czech Republic) were investigated. The spiders were sampled using pitfall traps and through sweeping of the herb vegetation. In total, 11634 individuals from 154 species in 88 genera from 25 families were recorded. Numerous threatened species listed in the Red List of the Czech spiders were found (CR – 1, EN – 1, VU – 11, LC – 23). 36 mainly xerothermic species were recorded, representing a valuable arachnofauna typical for the Pannonian Region. However, the studied area does not belong to this particular region. Several findings represent the northernmost occurrences of rare thermophilic spiders in the Czech Republic. Ten species (*Dysdera moravica, Megalepthyphantes pseudocollinus, Trichoncus affinis, Porrhomma errans, Alopecosa striatipes, Cheiracanthium oncognathum, Civizelotes pygmaeus, Zelotes aeneus, Thanatus arenarius, Talavera aperta)* are discussed in details and their records in the Czech Republic are mapped. Suggestions regarding the management of the area are given to improve the conditions for a high and valuable biodiversity.

Keywords: Araneae, biodiversity, inventory, richness estimation, xerothermic species

Zusammenfassung. Spinnen von Steppenhabitaten des Naturdenkmals Pláně (Tschechische Republik) mit Vorschlägen für das lokale Naturschutzmanagement. Die Spinnen von Steppenhabitaten des Naturdenkmals Pláně (Tschechische Republik) wurden untersucht. Die Erfassung erfolgte mit Bodenfallen und Kescherfängen in der krautigen Vegetation. Insgesamt wurden 11634 Individuen aus 154 Arten, 88 Gattungen und 25 Familien gefangen. Zahlreiche gefährdete Arten der Tschechischen Roten Liste wurden gefunden (CR/vom Aussterben bedroht – 1, EN/stark gefährdet – 1, VU/gefährdet – 11, LC/Vorwarnliste – 23). 36 überwiegend xerotherme Arten wurden erfasst, die zur wertgebenden Spinnenfauna der pannonischen Region gehören – allerdings zählt das Untersuchungsgebiet gar nicht zur pannonischen Region. Zehn Arten (*Dysdera moravica, Megalepthyphantes pseudocollinus, Trichoncus affinis, Porrhomma errans, Alopecosa striatipes, Cheiracanthium oncognathum, Civizelotes pygmaeus, Zelotes aeneus, Thanatus arenarius, Talavera aperta*) werden detailliert besprochen und Karten ihrer Nachweise in der Tschechischen Republik präsentiert. Einige der Nachweise sind die nördlichsten Vorkommen seltener thermophiler Arten in der Tschechischen Republik. Es werden Vorschläge zum Management des Gebietes gemacht, um die Bedingungen für eine hohe und wertvolle Biodiversität zu verbessern.

Differences in spider communities can be found even in small-scale patches within a given habitat (Samu et al. 1999, 2011, Pearce et al. 2004). At a community level, spiders are able to respond quickly and distinctly to short or sudden changes in the environment and some species reliably indicate the state of that environment (Buchar 1983, Samu et al. 2011, Košulič et al. 2016). Thus, spiders play an important role in practical nature conservation. The existence of species of conservation value should be taken into account during habitat management processing (Marc et al. 1999, Řezáč et al. 2015).

Since the middle of 20th century, intensification of agriculture, together with an abandonment of less productive lands, has been the major threat to invertebrates in Europe (Tscharntke et al. 2005). Pastures are transformed into a large blocks of fields for crop production or abandonment (Stoate et al. 2009). Lower demand for forage and poor-quality hay are the reasons why traditional grazing and mowing are no longer sustainable (Valkó et al. 2014). In the recent cultivated landscape, grasslands have a significant role in maintaining biodiversity by providing important habitats and refuges for many species (Duelli 1997). Thus, faunistic investigations in these habitats can provide important data useful for evaluation of the biodiversity state in the current landscape. For this reason, this research focuses on the Pláně Nature Monument (NM), an abandoned pasture with xeric grasslands in a south and south-eastern orientation.

Several zoological inventories that were carried out in the study area focused on the following taxa: Orthoptera, Mantodea, Heteroptera, Hymenoptera, Coleoptera, Lepidoptera, Diptera, Reptilia, Aves and Mammalia (Nenadál 1994). Additionally, a botanical inventory was conducted (Tichý 2016). Spiders have never been studied within the area of the Pláně NM; to date, only several findings from this region are known. Křížová (2001) found 146 species of spiders approximately 1.5 km away from this region, in Libochovka Valley, during an arachnological survey in 1999 to 2000. Since then, no further study was conducted in the surrounding areas of the Pláně NM (ČAS 2019).

The main objective of this research is a faunistic contribution on spiders from the steppe habitats of the Pláně NM, which could be beneficial to the area's conservation management. Consequently, relevant conservation management institutions could take into account these new findings and develop plans based on this research, which would eventually strengthen the protection of local biodiversity.

Material and methods

Study area

The Pláně NM is located in the district of Brno-venkov, 500 m north-west from the village of Kuřimská Nová Ves in the Southern Moravia region of the Czech Republic (Fig. 1, 49.35139°N, 16.30361°E) and belongs to the faunistic square 6663 of the faunistic zoological grid mapping system in the Czech Republic. The protected area has 11.1 ha and is mostly composed of forest and shrubs. The south and south-east parts are composed of a slope with rocks and xeric grasslands on shallow soils (approximately 1.2 ha). The natural forest communities of the study area are oak-hornbeam, acidophilic oak forests, and pine forests on the poor sandy soils with *Festuca ovina*, *Agrostis capillaris*, *Genista tinctoria* and *Luzula campestris*. The geological substrate is characterized by ortorula with

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Fig. 1: Study area (black square in the map) and sites with rectangles where the pitfall traps were placed and sweeping took place (ESRI 2013)

brown forest soils (Matuška 2016). In general, the Pláně NM lies in a distinctly colder region of South Moravia in the phytogeographical region of Mesophyticum along the border of the South Moravian and Highlands region (Skalický 1988, Slavík 1988, Buchar & Růžička 2002). The average annual temperature is 8 °C and the average annual rainfall is 579 mm (Matuška 2016). The average altitude is 450 m. Its surrounding landscape is heterogeneous with various habitat types like hedgerows with *Prunus spinosa*, mixed forests and cereal fields. The study area was traditionally maintained by sheep grazing, but there has been no management from 2009 to 2016 (Matuška 2016). Unfortunately, the Pláně NM is currently overgrowing with pine forest, invasive *Robinia pseudoacacia*, pioneer shrub species and expansive *Calamagrostis epigejos.*

Sample collection and study sites

The spiders were collected in two seasons: from 7. May to 15. Oct. 2017 and from 19. Apr. to 21. Sep. 2018. Pitfall traps and sweeping were used as the collection methods for epigeic and herb-dwelling spiders respectively. Each pitfall trap consisted of a plastic cup (500 ml, diameter 9 cm, depth 15 cm) buried in the ground where its rim is level with the soil surface. Each trap was filled with a 3-4% solution of formaldehyde and detergent as a killing and fixative fluid. Sweeping sampling was carried out only during favourable weather conditions, i.e. a minimum of 17 °C and sunshine (period between 10:00 h and 17:30 h). After collecting, the samples were preserved in 70% ethanol. The online application BioLib (2018) was used for the mapping of species occurrence, whereas the distribution data were taken from ČAS (2019).

The following design was used to assess the effect of conservation management methods on spider biodiversity in the study location (Hamřík 2019). Three sites in the study area were selected, wherein each had a total of 16 plots (4 m × 5 m) (Fig. 1). Two pitfall traps were placed in the centre of each plot, making a total of 32 pitfall traps for each site. Sweeping of herb vegetation took place inside each plot (20 sweeps per plot). In this publication, we present only the faunistic results.

Site 1 (452-448 m a.s.l.) and **Site 2** (442-439 m a.s.l.): These slightly steep slopes are characterized by southerly (Site 1) and south-east orientations (Site 2). They are often rocky and herbaceous vegetation is sparse with *Festuca ovina* growing on shallow soil. *Calamagrostis epigejos* and *Arrhenatherum elatius* prevail in nutrient-rich parts. Before 2005, sheep grazing and subsequent mowing with removal of the mown material took place at Site 2.

Site 3 (435-421 m a.s.l.): This site is characterized by a very steep slope with a south-easterly orientation. The lower part of the slope is covered with nutrient-rich soil and dense vegetation, represented by *Calamagrostis epigejos* and *Arrhenatherum elatius*. The upper part of the slope is rocky with sparse herbaceous vegetation, mainly *Festuca ovina*. Several trees and shrubs like *Prunus spinosa* and *Crataegus monogyna* are present at the site.

Species identification and classification

Using the identification keys of Heimer & Nentwig (1991) and Nentwig et al. (2019), only adult spiders were used and determined down to species level. Every species was categorized according to hunting strategies (Fig. 2): sensing-web weavers, sheet-web weavers, space-web weavers, orb-web weavers, ambush hunters, other hunters, ground hunters and specialists (Cardoso et al. 2011). The most up-to-date data on nomenclature were taken from the World Spider Catalog (WSC 2019) and the arrangement of families is based on the spider phylogenetic tree of Wheeler et al. (2017). The authors determined almost all species; taxonomically complicated taxa were revised and determined by another specialist (Petr Dolejš, National Museum in Prague). Each species was evaluated according to Buchar & Růžička (2002) and Řezáč et al. (2015) (Tab. 1): 1) occurrence level, 2) habitat preferences, 3) thermo preferences, 4) conservation status. Occurrence level is categorized according to the abundance based on the estimated number and distribution of grid squares with potential species occurrence (the presence of suitable habitats): very abundant (VA), abundant (A), scarce (S), rare (R), very rare (VR). Another evaluation is based on habitat preferences according to degree of habitat originality: climax preferences (C), seminatural habitats (SN), disturbed (D), artificial (A). Thermo preference is categorized according to occurrence of spider species in phytogeographic districts: Thermophyticum (T), Mesophyticum (M), Oreophyticum (O). The last evaluation is the conservation status which is based on the Red List categories: critically endangered (CR), endangered (EN), vulnerable (VU), least concern (LC). The basic values are written in regular font; the markedly preferred values are in bold; and some marginal but non-negligible values are in parentheses (see Tab. 1).

Species richness estimation

For estimation purposes, if the absolute species number in the 48 samples thoroughly represented alpha diversity of the study area, Jackknife1 resampling with 100 randomizations using the Software EstimateS 9.1 was performed (Colwell 2013).

Results and discussion

Faunistic overview

Overall, 11634 adult spiders belonging to 154 species in 88 genera of 25 families were collected (Tab. 1). Altogether, 133 species from 10532 specimens (91%) were caught by pitfall traps and 49 species from 1102 specimens (9%) were caught

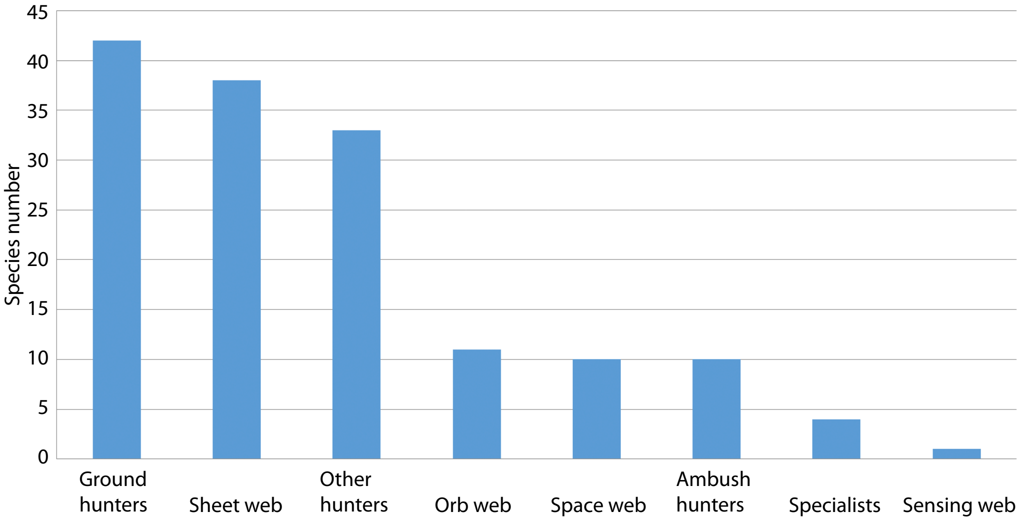

Fig. 2: Guild composition of spiders in steppe habitats of the Pláně NM

by sweeping. Spiders collected by pitfall trapping consisted mainly of actively hunting guilds such as ground and other hunters and several species of specialists from the family Dysderidae (Fig. 2).

The most abundant species were *Alopecosa cuneata* with 2603 individuals and *Pardosa palustris* with 1884 individuals. The next dominant species were *Alopecosa farinosa* with 537 individuals and *Alopecosa pulverulenta* with 487 individuals. The aforementioned spiders of the genus *Alopecosa* are typical for open steppe habitats (Buchar & Růžička 2002). *Alopecosa striatipes*, which is very rare in the Czech Republic and occurs only in the south-eastern part of the country (Kůrka et al. 2015), was caught from a high number of 387 individuals, mostly in Site 1 and can be considered abundant in the Pláně NM. The next result was the significantly high abundance of *Thanatus arenarius*, which is rare and only found in warm areas of central and south-eastern parts of the Czech Republic (Buchar & Růžička 2002, Košulič & Hula 2014). However, in the study area, a high number of 704 individuals were found mostly at Site 2. Both Sites 1 and 2 are typical of sparse herbaceous vegetation and stones/rocks on shallow soil, thus meeting the ecological requirements of these species (Ratschker & Roth 2000).

The family Linyphiidae was the most dominant with 32 species recorded (Tab. 1). However, only a few individuals of each species were caught. *Agyneta rurestris* was found to be quite common due to the non-restriction of ecological requirements and aerial dispersal using silk. The next species-rich families were Gnaphosidae (22 species), Lycosidae (14 species), Salticidae (12 species) and Theridiidae (12 species). The suitability for xerothermic herb-dwelling spiders is corroborated by the high abundance of 149 individuals of the scarce *Evarcha laetabunda*, which inhabits herbs on rock steppes (Buchar & Růžička 2002). The Lycosidae with 7104 and Gnaphosidae with 1367 individuals were the most abundant families. From the family Lycosidae, there were also species that are typical of forest edges (Buchar & Růžička 2002): *Pardosa lugubris* and *Trochosa terricola* were abundantly found at Site 3, which is adjacent to a forest.

At Site 3, the xerothermic species *Alopecosa trabalis*, which inhabits forest steppes and light south-exposed forests (Buchar & Růžička 2002), was also abundant (260 individuals). Site 3 is a good example of a xerothermic slope habitat with a south-eastern exposure that is adjacent to a forest, hence it provides suitable conditions for both typical steppe species and species typical of ecotones like forest edges. In the family Gnaphosidae there were a number of regionally important rare/scarce species like *Civizelotes pygmaeus*, *Drassyllus pumilus*, *Haplodrassus dalmatensis*, *Micaria formicaria*, *Zelotes aeneus*, *Zelotes aurantiacus*, *Zelotes electus* and *Zelotes longipes*, which all live under stones on rock steppes (Buchar & Růžička 2002). Their presence is due to the large amount of scattered small rocks and stones which serve as shelter for these ground hunters. For the record, these species are mostly found in their northernmost territory of distribution in Southern Moravia. *Zelotes electus* was abundantly found at Site 1 (84 individuals) and Site 2 (86 individuals), whereas *Zelotes auranticaus* was found at Site 3 (24 individuals). Site 2 had a xeric character while Site 3 had a lower amount of sparse vegetation and was adjacent to the forest. Both species have similar habitat preferences, therefore, it may be an effect of competition like that of other related species (Michalko et al. 2016).

In general, a valuable arachnofauna composition including 36 rare and scarce species (7 %) belonging to the Red List of Czech spiders (Řezáč et al. 2015) were discovered. It includes mainly species whose occurrence is typical of open steppes and grasslands at the early stages of succession: CR (critically endangered): *Alopecosa striatipes;* EN (endangered): *Drassyllus pumilus*; VU (vulnerable): *Neottiura suaveolens*, *Trichoncus affinis*, *Trichopterna cito*, *Cheiracanthium oncognathum*, *Phrurolithus minimus*, *Haplodrassus dalmatensis*, *Micaria formicaria*, *Civizelotes pygmaeus*, *Thanatus arenarius*, *Evarcha laetabunda*, *Talavera petrensis*.

It should be noted that the total spider diversity (154 species) was relatively high and this significantly enriches the surveyed area due to new findings. Altogether, 230 species of spiders are now known from the study area (faunistic square 6663) due to the presented faunistic study and previously published data (Křížová 2001). The occurrence of a wide spectrum of species also confirms the importance of xeric grasslands within the Pláně NM as a refuge for spider communities in the intensified agricultural landscape of Moravia. These stepping stones are very important in the overall biodiversity of arthropods in the modern landscape (Košulič et al. 2014, Šálek et al. 2018). The results also suggest that

Tab. 1: List of recorded species with ecological indicators, in taxonomical order. Occurrence level: VA (very abundant), A (abundant), S (scarce), R (rare), VR (very rare); habitat preference: C (climax), SN (seminatural), D (disturbed), A (artificial); thermo preference: T (termophyticum), M (mesophyticum), O (oreophyticum); conservation status: CR (critically endangered), EN (endangered), VU (vulnerable), LC (least concern)

Species	Site 1	Site2	Site 3	Occurence level	Habitat preferences	Thermo preferences	Conservation status
Segestriidae							
Segestria senoculata (Linnaeus, 1758)	.	.	2	VA	C, SN	(T), **M**, (O)	–
Dysderidae							
Dysdera moravica Řezáč, 2014	.	1	1	R	**C**	**T**	LC
Harpactea hombergi (Scopoli, 1763)	.	.	1	A	C, SN	T, M	–
Harpactea lepida (C. L. Koch, 1838)	2	.	2	VA	C, SN	**M**, (O)	–
Harpactea rubicunda (C. L. Koch, 1838)	1	.	2	VA	C, SN, A	T, M	–
Theridiidae							
Asagena phalerata (Panzer, 1801)	10	3	8	A	C, SN	(T), **M**, (O)	–
Crustulina guttata (Wider, 1834)	.	.	1	A	C, SN	**M**	–
Enoplognatha latimana Hippa & Oksala, 1982	3	1	1	S	SN, **D**	T, M	–
Enoplognatha thoracica (Hahn, 1833)	2	3	2	A	C, SN, D	T, **M**	–
Euryopis flavomaculata (C. L. Koch, 1836)	1	.	.	A	C, SN	T, **M**	–
Lasaeola tristis (Hahn, 1833)	1	.	.	S	C, SN	**M**	LC
Neottiura bimaculata (Linnaeus, 1767)	3	.	.	VA	C, SN, D	T, M	–
Neottiura suaveolens (Simon, 1879)	2	.	.	R	**C**	**T**	VU
Phylloneta impressa L. Koch, 1881	37	47	5	VA	C, SN, D	T, M, (O)	–
Robertus arundineti (O. P.-Cambridge, 1871)	2	.	1	A	C, SN, D	(T), **M**	–
Robertus lividus (Blackwall, 1836)	5	.	.	VA	C, SN	T, M, O	–
Robertus neglectus (O. P.-Cambridge, 1871)	1	.	.	S	C, SN	(T), **M**	–
Linyphiidae							–
Agyneta rurestris (C. L. Koch, 1836)	6	3	8	VA	C, SN, D	T, M, O	–
Agyneta saxatilis (Blackwall, 1844)	2	3	2	VA	C, SN, (D)	**M**	–
Ceratinella brevis (Wider, 1834)	1	2	.	VA	C, SN	M, (O)	–
Ceratinella scabrosa (O. P.-Cambridge, 1871)	3	1	3	S	C, SN	M	–
Diplocephalus cristatus (Blackwall, 1833)	2	1	5	VA	C, SN, (D)	**M**, (O)	–
Diplocephalus picinus (Blackwall, 1841)	1	1	.	VA	C, SN	(T), M, (O)	–
Diplostyla concolor (Wider, 1834)	2	.	.	VA	C, SN	T, M, O	–
Entelecara acuminata (Wider, 1834)	2	.	.	A	C, SN	M	–
Erigone atra Blackwall, 1833	1	2	.	VA	C, SN, D	T, M, O	–
Erigone dentipalpis (Wider, 1834)	.	2	1	VA	C, SN, D	T, M, O	–
Linyphia hortensis Sundevall, 1830	1	1	.	A	C, SN	(T), **M**	–
Linyphia triangularis (Clerck, 1757)	1	.	2	VA	C, SN, D	T, **M**	–
Megalepthyphantes pseudocollinus Saaristo, 1997	.	.	1	VR	**C**	**T**	LC
Micrargus herbigradus (Blackwall, 1854)	1	1	1	VA	C, SN	(T), **M**, O	–
Microlinyphia pusilla (Sundevall, 1830)	1	.	.	VA	C, SN, D	T, M, O	–
Neriene emphana (Walckenaer, 1841)	.	1	.	A	C, SN	M	–
Neriene radiata (Walckenaer, 1841)	.	1	.	A	C, SN	**M**	–
Palliduphantes pallidus (O. P.-Cambridge, 1871)	5	3	1	VA	C, SN	T, **M**	–
Pelecopsis elongata (Wider, 1834)	4	1	.	S	**C**	**M**	LC
Pelecopsis radicicola (L. Koch, 1872)	2	1	1	A	**C**, SN	**M**, (O)	–
Porrhomma errans (Blackwall, 1841)	3	.	.	VR	C, D	**T**	–
Stemonyphantes lineatus (Linnaeus, 1758)	3	.	1	A	C, SN, D	(T), **M**	–
Tapinocyba insecta (L. Koch, 1869)	1	.	.	A	C, SN	(T), **M**	–
Tenuiphantes cristatus (Menge, 1866)	.	.	1	VA	C, SN	**M**, (O)	–
Tenuiphantes flavipes (Blackwall, 1854)	5	6	3	VA	C, SN	T, **M**	–
Tenuiphantes mengei Kulczyński, 1887	1	.	.	VA	C, SN	T, **M**, O	–
Tenuiphantes tenuis (Blackwall, 1852)	2	2	.	A	C, SN, D	T, M	–
Tiso vagans (Blackwall, 1834)	1	2	2	A	C, SN, (D)	**M**, (O)	–
Trichoncus affinis Kulczyński, 1894	.	.	1	R	C, SN	**M**	VU
Trichopterna cito (O. P.-Cambridge, 1872)	1	.	.	S	**C**	**T**, M	VU

Species	Site 1	Site2	Site 3	Occurence level	Habitat preferences	Thermo preferences	Conservation status
Walckenaeria antica (Wider, 1834)	1	.	.	VA	C, SN	(T), **M**, (O)	–
Walckenaeria atrotibialis (O. P.-Cambridge, 1878)	1	1	.	VA	C, SN	T, M, O	–
Walckenaeria dysderoides (Wider, 1834)	1	.	.	VA	C, SN	(T), **M**	–
Tetragnathidae							–
Metellina segmentata (Clerck, 1757)	.	.	1	VA	C, SN, D	T, **M**, O	–
Pachygnatha degeerii Sundevall, 1830	.	1	12	VA	C, SN, D	T, **M**, (O)	–
Pachygnatha listeri Sundevall, 1830	.	.	1	VA	C, SN	(T), **M**	–
Araneidae							
Aculepeira ceropegia (Walckenaer, 1802)	45	65	26	VA	C, SN, D	(T), **M**	–
Araneus sturmi (Hahn, 1831)	.	1	.	VA	C, SN	T, **M**	LC
Argiope bruennichi (Scopoli, 1772)	9	2	2	A	C, **SN**, D	T, M	–
Cercidia prominens (Westring, 1851)	1	.	.	S	**C**, SN	T, **M**	–
Hypsosinga albovittata (Westring, 1851)	18	44	26	S	**C**, SN	T, M	LC
Hypsosinga pygmaea (Sundevall, 1831)	1	.	.	S	**C**, SN	**M**	LC
Hypsosinga sanguinea (C. L. Koch, 1844)	10	11	1	A	C, SN	(T), M	–
Mangora acalypha (Walckenaer, 1802)	164	130	245	VA	C, SN, D	T, M	–
Titanoecidae							
Titanoeca quadriguttata (Hahn, 1833)	.	.	1	A	**C**, SN	**T**, M	–
Lycosidae							
Alopecosa cuneata (Clerck, 1757)	1374	663	566	VA	C, SN, D	T, M, (O)	–
Alopecosa farinosa (Latreille, 1817)	183	219	135	A	**C**, SN	T, M	–
Alopecosa pulverulenta (Clerck, 1757)	150	65	272	VA	C, SN, D	T, M, O	–
Alopecosa striatipes (C. L. Koch, 1837)	191	122	74	VR	**C**	T	CR
Alopecosa trabalis (Clerck, 1757)	59	15	186	S	C, SN	T, M	–
Aulonia albimana (Walckenaer, 1805)	16	1	52	A	C, SN	T, **M**	–
Pardosa lugubris (Walckenaer, 1802)	14	1	188	VA	C, SN, D	T, M, O	–
Pardosa palustris (Linnaeus, 1758)	394	1186	304	VA	C, SN, D	T, M, O	–
Pardosa pullata (Clerck, 1757)	22	22	6	VA	C, SN, D	T, M, O	–
Pardosa riparia (C. L. Koch, 1833)	77	42	144	A	C, SN	T, M, O	–
Trochosa ruricola (De Geer, 1778)	20	5	55	VA	C, SN, D	T, M	–
Trochosa terricola Thorell, 1856	42	9	138	VA	C, SN, D	T, M, (O)	–
Xerolycosa miniata (C. L. Koch, 1834)	13	41	26	S	C, SN	**T**, M	–
Xerolycosa nemoralis (Westring, 1861)	5	5	3	VA	C, SN	T, M, O	–
Pisauridae							–
Pisaura mirabilis (Clerck, 1757)	8	5	19	VA	C, SN, D	T, **M**	–
Oxyopidae							
Oxyopes ramosus (Martini & Goeze, 1778)	.	.	1	S	**C**, SN	M	LC
Thomisidae							
Misumena vatia (Clerck, 1757)	1	.	2	VA	C, SN	T, M	–
Ozyptila atomaria (Panzer, 1801)	2	2	3	S	C, SN	T, M	–
Ozyptila claveata (Walckenaer, 1837)	32	18	24	S	**C**	T, M	LC
Ozyptila praticola (C. L. Koch, 1837)	.	.	1	S	C, SN	T, M	–
Synema globosum (Fabricius, 1775)	2	1	5	R	C, SN	**T**, M	LC
Xysticus bifasciatus C. L. Koch, 1837	32	18	28	VA	C, SN, D	(T), **M**, (O)	–
Xysticus cristatus (Clerck, 1757)	75	62	36	VA	C, SN, D	T, **M**, (O)	–
Xysticus erraticus (Blackwall, 1834)	9	.	2	A	C, SN	(T), **M**	–
Xysticus kochi Thorell, 1872	38	76	47	A	C, SN, (D)	T, M	–
Xysticus lanio C. L. Koch, 1835	.	.	2	S	C, SN	T, **M**	–
Agelenidae							
Allagelena gracilens (C. L. Koch, 1841)	1	.	2	A	C, SN, (A)	T, M	–
Coelotes terrestris (Wider, 1834)	3	1	8	VA	C, SN	(T), M, O	–
Histopona torpida (C. L. Koch, 1834)	.	1	2	VA	C, SN	**M**, (O)	–
Inermocoelotes inermis (L. Koch, 1855)	4	14	73	VA	C, SN	M, O	–

Species	Site 1	Site2	Site 3	Occurence level	Habitat preferences	Thermo preferences	Conservation status
Tegenaria campestris C. L. Koch, 1834	2	.	6	S	C, SN	T, M	–
Tegenaria silvestris L. Koch, 1872	1	.	.	A	C, SN	**M**, (O)	–
Cybaeidae							
Cybaeus angustiarum L. Koch, 1868	.	.	6	A	**C**, SN	M, O	–
Hahniidae							
Hahnia nava (Blackwall, 1841)	.	3	5	S	**C**, SN	T, M	–
Dictynidae							
Cicurina cicur (Fabricius, 1793)	18	8	8	VA	C, SN, D	(T), **M**	–
Dictyna arundinacea (Linnaeus, 1758)	8	1	4	VA	C, SN, D	(T), **M**	–
Nigma flavescens (Walckenaer, 1830)	1	1	.	A	C, SN	T, **M**	–
Amaurobiidae							
Callobius claustrarius (Hahn, 1833)	.	2	7	A	C, SN	M, O	–
Liocranidae							
Agroeca brunnea (Blackwall, 1833)	6	2	6	VA	C, SN	T, **M**	–
Agroeca cuprea Menge, 1873	20	18	27	S	**C**	**T**, M	LC
Agroeca proxima (O. P.-Cambridge, 1871)	9	3	1	S	C, SN	M, O	–
Clubionidae							
Clubiona neglecta O. P.-Cambridge, 1862	1	5	1	VA	C, SN	(T), **M**	–
Clubiona terrestris Westring, 1851	.	.	2	VA	C, SN	M	–
Phrurolithidae							
Phrurolithus festivus (C. L. Koch, 1835)	.	.	1	VA	C, SN	T, **M**	–
Phrurolithus minimus C. L. Koch, 1839	1	.	.	R	**C**, SN	**T**, M	VU
Gnaphosidae							
Civizelotes pygmaeus (Miller, 1943)	1	3	6	R	**C**	**T**	VU
Drassodes lapidosus (Walckenaer, 1802)	1	2	14	VA	C, SN	T, M	–
Drassodes pubescens (Thorell, 1856)	62	45	31	VA	C, SN	T, M	–
Drassyllus lutetianus (L. Koch, 1866)	1	.	.	A	C, SN, D	(T), **M**	–
Drassyllus praeficus (L. Koch, 1866)	7	15	14	A	**C**, SN	T, **M**	–
Drassyllus pumilus (C. L. Koch, 1839)	3	1	.	R	**C**	**T**, M	EN
Drassyllus pusillus (C. L. Koch, 1833)	55	43	30	A	C, SN, (D)	T, M	–
Haplodrassus dalmatensis (L. Koch, 1866)	1	2	1	R	**C**	**T**	VU
Haplodrassus signifer (C. L. Koch, 1839)	106	106	111	VA	C, SN, D	T, M, O	–
Haplodrassus silvestris (Blackwall, 1833)	1	2	2	A	C, SN	(T), **M**	–
Haplodrassus soerenseni (Strand, 1900)	.	.	1	S	**C**, SN	**M**	LC
Micaria formicaria (Sundevall, 1831)	21	7	14	R	C, SN	T, (M)	VU
Micaria fulgens (Walckenaer, 1802)	9	4	34	A	C, SN	T, M	LC
Micaria pulicaria (Sundevall, 1831)	.	1	6	VA	C, SN	T, M, O	–
Scotophaeus quadripunctatus (Linnaeus, 1758)	1	.	.	S	C, SN, A	–	–
Trachyzelotes pedestris (C. L. Koch, 1837)	4	2	16	S	**C**, SN	**T**, (M)	–
Zelotes aeneus (Simon, 1878)	9	6	2	R	C, SN, D	(T), M	LC
Zelotes aurantiacus Miller, 1967	1	1	24	R	**C**	**T**	LC
Zelotes electus (C. L. Koch, 1839)	84	86	9	S	**C**, SN	T, M	LC
Zelotes latreillei (Simon, 1878)	8	3	4	VA	C, SN, D	(T), **M**	–
Zelotes longipes (L. Koch, 1866)	6	100	2	R	**C**	T, (M)	LC
Zelotes petrensis (C. L. Koch, 1839)	71	75	93	A	C, SN	T, M	–
Miturgidae							–
Zora nemoralis (Blackwall, 1861)	1	1	.	A	C, SN	(T), **M**	–
Zora silvestris Kulczyński, 1897	3	.	6	A	C, SN	**M**	–
Zora spinimana (Sundevall, 1833)	4	2	5	VA	C, SN, D	T, **M**, (O)	–
Cheiracanthiidae							
Cheiracanthium campestre Lohmander, 1944	.	1	.	VR	SN	T	LC
Cheiracanthium oncognathum Thorell, 1871	1	.	.	R	C, SN	T, M	VU

Species	**Site 1**	**Site2**	**Site 3**	**Occurence level**	**Habitat preferences**	**Thermo preferences**	**Conservation status**
Sparassidae							
Micrommata virescens (Clerck, 1757)	.	.	1	VA	C, SN	**M**	–
Philodromidae							
Philodromus albidus Kulczyński, 1911	.	.	1	A	C, SN, D	T, M	–
Philodromus cespitum (Walckenaer, 1802)	.	2	.	VA	C, SN, D	T, **M**	–
Philodromus dispar Walckenaer, 1826	1	.	1	S	C, SN	**T**, M	–
Thanatus arenarius Thorell, 1872	318	362	24	R	**C**	**T**	VU
Thanatus formicinus (Clerck, 1757)	101	39	34	A	C, SN	T, M	LC
Thanatus striatus C. L. Koch, 1845	1	.	.	A	C, SN	(T), M	LC
Tibellus oblongus (Walckenaer, 1802)	1	.	.	S	C, SN	T, M	–
Salticidae							
Euophrys frontalis (Walckenaer, 1802)	.	1	.	A	C, SN	T, M	–
Euophrys petrensis C. L. Koch, 1837	5	4	3	S	C, SN	T, M	VU
Evarcha arcuata (Clerck, 1757)	3	1	7	VA	C, SN	T, **M**	–
Evarcha laetabunda (C. L. Koch, 1846)	68	42	39	S	**C**	**T**, (M)	VU
Heliophanus cupreus (Walckenaer, 1802)	1	1	2	A	C, SN	T, M	–
Heliophanus flavipes (Hahn, 1832)	12	6	17	A	**C**	(T), **M**	–
Hypositticus pubescens (Fabricius, 1775)	1	.	.	VA	C, SN, A	**M**	–
Pellenes tripunctatus (Walckenaer, 1802)	.	1	.	S	**C**	**T**	LC
Phlegra fasciata (Hahn, 1826)	34	21	35	A	C, SN	T, M	–
Sibianor aurocinctus (Ohlert, 1865)	1	.	.	A	C, SN	T, **M**	LC
Talavera aequipes (O. P.-Cambridge, 1871)	3	3	2	A	**C**, SN	T, M	–
Talavera aperta (Miller, 1971)	1	.	.	R	**C**, SN	T, M	LC

the study area serves as an important refuge for thermophilic spiders that are normally not present in this otherwise colder mesophytic region. This is supported by the high occurrence of typically Pannonian species, for whom this area represents their northernmost distribution limit (Buchar & Růžička 2002, Kůrka et al. 2015).

Species richness estimation

The species accumulation curve did not reach the asymptote and showed a rising character, which means that the spider diversity was not sampled in their entirety and the diversity is expected to be significantly higher than the 154 species collected. Jackknife 1 estimator calculated a total estimated richness of 194.15 ± 6.26 (standard deviation) species for the study area (Fig. 3).

Faunistically remarkable species

All the species mentioned below belong to rare, xerothermic species and the Pláně NM is their northernmost distribution not only in South Moravia, but even in Moravia as a whole. Aside from the *Thanatus arenarius,* the following findings are the first for the faunistic square 6663.

Dysdera moravica (Fig. 4 a)

This species belongs to a large complex of morphologically similar species which mainly occur in northern Italy and in the northwest of the Balkan Peninsula (Řezáč et al. 2012). *Dysdera moravica* is European species that occurs in Serbia, Croatia, Romania, Hungary, Slovakia, Austria, Germany and the Czech Republic (Nentwig et al. 2019). In the Czech Re-

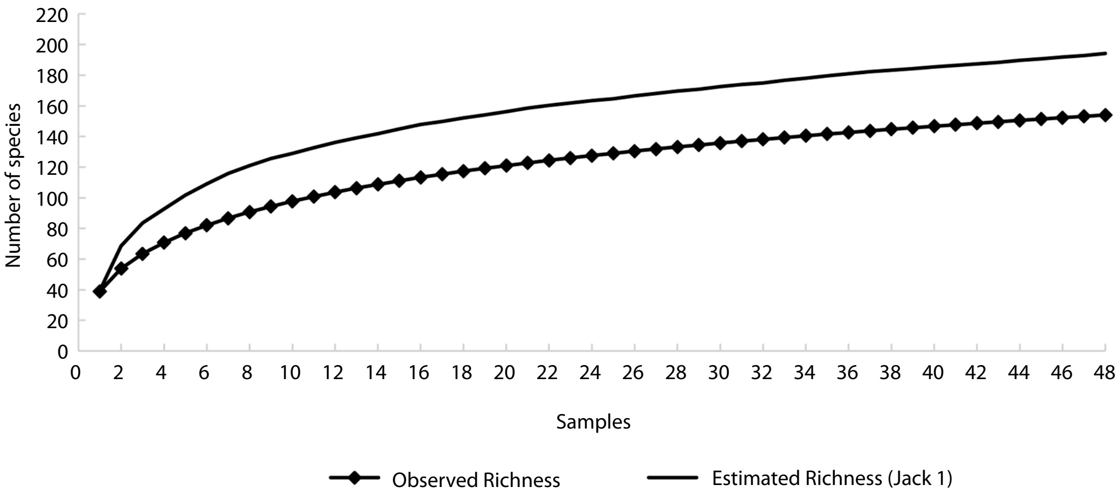

Fig. 3: Number of species in 48 samples in relation to the number of species expected by a Jackknife1 estimator in the Pláně NM

public, this species occurs only in the Pannonian region and its close surroundings. This is a xerothermic species that live in areas with rugged terrain on south oriented slopes with xerothermic oak forests, oak-hornbeam forests or bushes (Řezáč 2012, Košulič 2017).
Location: Two individuals were captured in pitfall traps. At Site 2, one individual was caught in sparse vegetation and another individual was caught on bare soil at Site 3.

***Megalepthyphantes pseudocollinus* (Fig. 4 b)**
In Europe, the species was found in Hungary, Austria, Czech Republic, Slovakia, Ukraine, Belarus, Russia (Southern European, Central European, Western European, Eastern European) and Finland, outside Europe it occurs in Russia (West Siberia), the Caucasus, Turkey and Iran (Nentwig et al. 2019). Within the Czech Republic, it has been mapped from only a few areas of Pannonian regions (Buchar & Růžička 2002, Bryja et al. 2005). It was discovered in semixeric habitats in Brtnice-Střížov, the most western area of the species' occurrence in the Czech Republic (Svatoň & Jelínek 1998). It is a very rare species that inhabits xerothermic habitats like stony debris in steppes (Bryja et al. 2005).
Location: One individual of the species was captured in a pitfall trap in mesophilic vegetation at Site 3.

***Porrhomma errans* (Fig. 4 d)**
This species has a north-western and central European distribution and was also recorded in Italy (Růžička 2018, WSC 2019). It is a rare species with an unclear ecological requirement (Kůrka et al. 2015, BAS 2019). *Porrhomma errans* is known from different habitats like beet fields, steppe habitats or floodplain forests (Miller 1974, Bryja et al. 2005, Hula et al. 2012).
Location: The species was sampled by sweeping at Site 1. Three individuals were sampled both in sparse and dense vegetation.

***Alopecosa striatipes* (Fig. 4 e)**
Alopecosa striatipes is an extra-Mediterranean faunal element with a distribution area that extends from the Atlantic coast (Buchar & Thaler 2004). In Europe, the species occurs in Macedonia, Serbia, Montenegro, Croatia, Slovenia, Bulgaria, Romania, Ukraine, Slovakia, Czech Republic, Poland, Germany, Belgium, Switzerland and France, outside Europe the species was recorded in Turkey and the Caucasus (Nentwig et al. 2019). The species is known very rarely from the south-eastern part of the Czech Republic (Kůrka et al. 2005). The species occurs in xerothermic habitats like rock steppes, xeric grasslands and edges of pine forests (Buchar & Růžička 2002, Bryja et al. 2005). In general, it is a rare and endangered spider species belonging to most of the Red Lists in Central European countries (Gajdoš & Svatoň 2001, Řezáč et al. 2015, Blick et al. 2016).
Location: The species was very common within the study area and was found at every site. The highest abundance was at Site 1, where 191 individuals were caught. Altogether, there were 386 individuals captured in pitfall traps and one individual was swept. The species has a strong population that needs to be highlighted for nature protection and habitat management of this location.

***Cheiracanthium oncognathum* (Fig. 4 f)**
This species is widely distributed in Europe, but only with sporadic findings all over the known distribution area (Nentwig et al. 2019). In the Czech Republic, the species rarely inhabits deciduous trees and bushes at lower and middle altitudes (Dolanský 2011). The biotopes of this species have a character of forest edges on sandy subsoil, steep slopes with sparse vegetation or rocky outcrops with aluminum benches. This species lives very covertly and sometimes makes webs in detritus or in sand not deep underground (Dolanský 2011). According to Dolanský (2011), *Cheiracanthium oncognathum* probably does not penetrate into steppe habitats, which is contrary to the present study's findings.
Location: One individual was collected in a pitfall trap in sparse vegetation at Site 1. This finding is one of the northernmost occurrences of this rare spider species from the Moravian region.

***Civizelotes pygmaeus* (Fig. 4 d)**
Civizelotes pygmaeus has a distribution area from Europe including Italy, Slovenia, Austria, Hungary, Slovakia, Czech Republic, Poland, Ukraine, Romania, Macedonia, Russia (Eastern European) to Kazakhstan (Nentwig et al. 2019). In the Czech Republic, it is a rare species of epigeic spider occurring under stones on rock steppes, sand quarries and vineyard terraces (Buchar & Růžička 2002, Košulič & Hula 2014). In the southern part of the Czech Republic, it is quite an abundant species, however it prefers warm locations with presence of early stages of succession (Košulič et al. 2014).
Location: There were 10 individuals collected by pitfall traps in the study area. All individuals were caught in the sparse vegetation or in the spots with a high proportion of stones at all three sites.

***Zelotes aeneus* (Fig. 4 h)**
This species is widely distributed in Europe, except Northern Europe (Nentwig et al. 2019). In the Czech Republic, it is a rare species with occurrence under stones in steppe habitats, post-industrial biotopes in early stages of succession and grazed grasslands (Paschetta et al. 2013). In the southern part of the Czech Republic, this species is very rare with only a few records (ČAS 2019).
Location: Altogether, in the study area, 17 individuals were sampled in the pitfall traps from all sites, but most came from Site 1 and Site 2. The individuals were caught in the sparse and also dense vegetation.

***Thanatus arenarius* (Fig. 4 i)**
This Palaearctic species, widely distributed in Europe, rarely occurs in the south-eastern and north-eastern part of the Czech Republic (Szita & Samu 2000, WSC 2019). Habitats of this species are sand dunes, rock steppes, heathlands and it is quite abundant in vineyards, especially on terraces with initial stages of succession (Buchar & Růžička 2002, Košulič & Hula 2014). Křížová (2001) recorded the species approximately 1.5 km away from the Libochovka Valley in 1999 to 2000.
Location: This xerothermic spider was sampled in pitfall traps with 704 individuals at all three sites. The highest abundance was at Site 2 where 362 individuals were caught. It was found both in sparse and dense vegetation, however, this

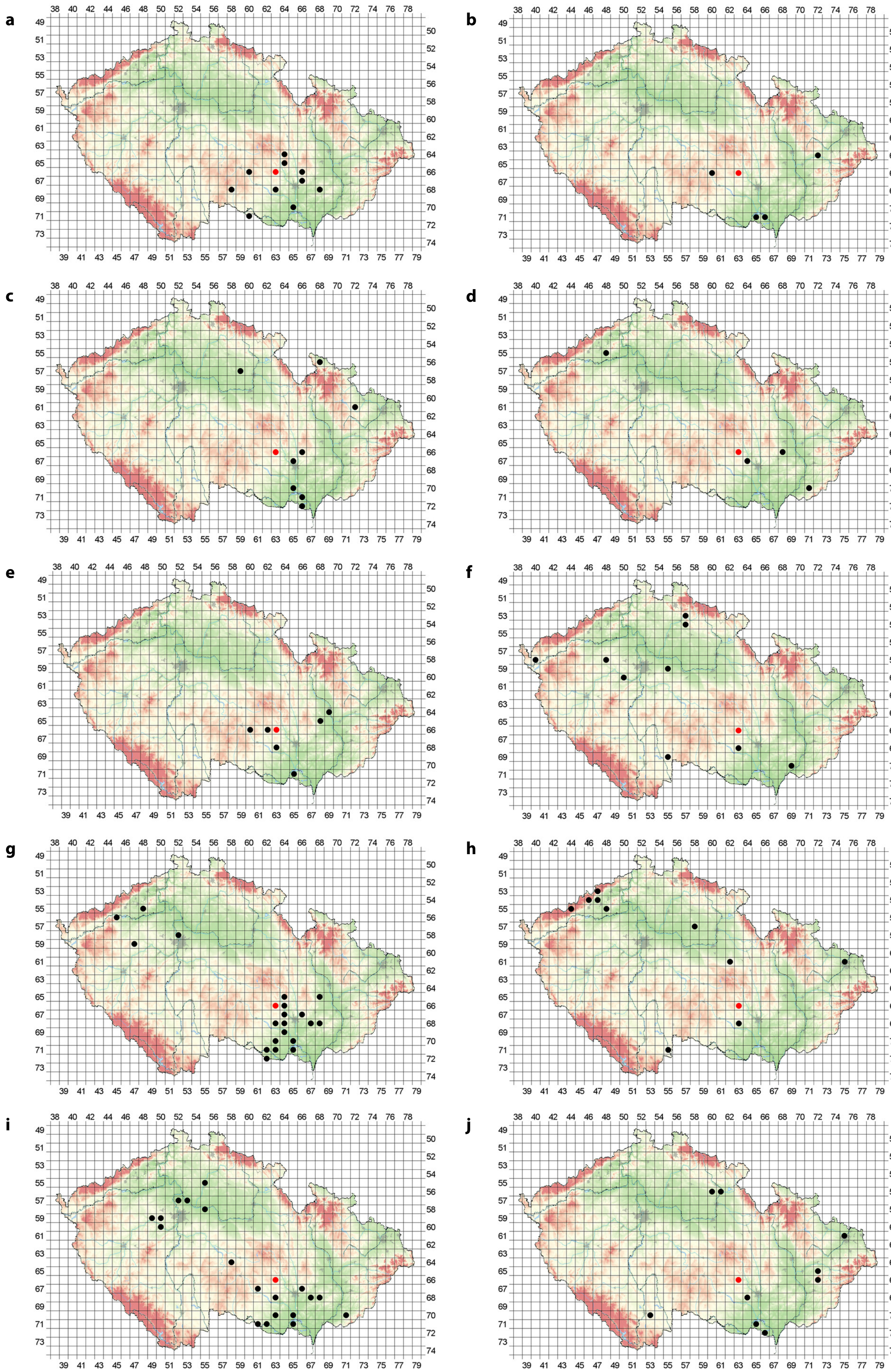

Fig. 4: Distribution maps of faunistically remarkable species collected in the study area (red dot). **a.** *Dysdera moravica*; **b.** *Megalepthyphantes pseudocollinus*; **c.** *Trichoncus affinis*; **d.** *Porrhomma errans*; **e.** *Alopecosa striatipes*; **f.** *Cheiracanthium oncognathum*; **g.** *Civizelotes pygmaeus*; **h.** *Zelotes aeneus*;, **i.** *Thanatus arenarius*, **j.** *Talavera aperta*

study suggests that open and barren surfaces are strong determinants for this species of spider.

***Talavera aperta* (Fig. 4 j)**
This species occurs from Europe to Central Asia and is considered a rare European species (Grbić et al. 2015, Nentwig et al. 2019). In Europe, the species was recorded in Serbia, Romania, Ukraine, Russia (Central European), Hungary, Slovakia, Austria, Czech Republic, Poland, Germany, Netherlands, Belgium, Switzerland, France and Italy (Nentwig et al. 2019). This xerothermic epigeic spider lives in various habitats like oak forest, vineyards and dry forest edges from different parts and altitudes of the eastern part of the Czech Republic (Buchar & Růžička 2002, Bryja et al. 2005).
Location: At Site 1, only one individual was collected by sweeping of the sparse vegetation

Suggestions for conservation managements
The results show that Sites 1 and 2 are the most valuable parts of the study area. These parts are typical for their south or south-easterly orientation and sparse vegetation with scattered small rocks and barren surfaces. A high abundance of the threatened ground-dwelling spiders *Alopecosa striatipes* and *Thanatus arenarius* inhabiting open xeric habitats confirm the high value of these sites. The high abundance of these very rare species at Site 2 is likely due to sheep grazing that took place before 2005 and subsequent mowing with the removal of the mown materials. The recent grazing and mowing led to the reduction of plant biomass, which provided a suitable habitat (initial stages of succession) for xerothermic species such as *Alopecosa striatipes*, *Thanatus arenarius*, *Zelotes aeneus, Zelotes electus*, etc. However, part of Sites 1 and 2 is threatened by overgrowth and homogenization caused by the expansion of competitive plant species like *Calamagrostis epigejos* and *Arrhenatherum elatius*. This study suggests performing short-term extensive sheep grazing supplemented by mowing in order to reduce only the ungrazed areas with *Calamagrostis epigejos* (Konvička et al. 2005, Jongepierová et al. 2018). Burning is inappropriate because it supports the spread of expansive *Calamagrostis epigejos* (Házi et al. 2011, Deák et al. 2014). Furthermore, the sites are surrounded by a bush of *Prunus spinosa* and *Rosa canina*, which reduce the size of xeric, steppe patches, hence reduction of these shrubs is strongly recommended.

In contrast, rare and endangered spiders including xerothermic species were discovered in smaller numbers at Site 3. However, there was a higher occurrence of *Alopecosa trabalis* and *Agroeca cuprea*, which are more common in forest-steppes or forest edges than in xerothermic open habitats. A threat to the rocky south-east exposed slope of Site 3 is the overgrowth of expansive shrubs and the accumulation of biomass from leaves, which can strongly change microhabitat conditions (Ausden 2007). In the lower part of the site, there are areas with uniform mesophilic vegetation that are slowly expanding to the upper parts with xerothermic vegetation. In particular, this study proposes the reduction of bushes in the lower part of the slope, thus creating a larger area for xerothermic species. Certainly, regular management in the form of mosaic mowing or grazing is requested. It is necessary to leave some older shrubs such as *Crataegus monogyna* that provide suitable habitats for species like *Synema globosum*, *Trichoncus affinis, Cheiracanthium oncognathum* and more species preferring shadier habitats.

Historically, this study acknowledges that grazing was only conducted at small scales, using a limited amount of livestock. This management approach is beneficial to the overall biodiversity of arthropods. Large scale overgrazing, on the other hand, usually has negative impacts on many organisms (Milchunas et al. 1998, Ausden 2007). Therefore, this study suggests the continuation of grazing which should be carried out in a manner that does not allow the entire area of the reserve to be grazed. Small non-grazed fences should be maintained within the grazed areas. These places serve as refuges for invertebrates for whom grazing is not suitable (Konvička et al. 2005). Additionally, prescribed burning in the early spring is suggested in small scales around selected places of the protected area (including all study sites); this can replace mowing. According to Niwa & Peck (2002), this management can reduce the biomass accumulation that is usually caused by homogeneous mowing (e.g., Noordijk et al. 2010). Burning, together with small-scale grazing and mowing, can enhance the diversity of various habitats, which in turn can improve overall biodiversity (Ausden 2007). In this context, it is also appropriate to leave some small-scale unmanaged parts in all of the sites of the protected area to create a mosaic of habitats in different stages of succession as this will provide biotopes for a wide spectrum of arthropods that may not all profit from regular disturbances such as *Agroeca cuprea* living in detritus among vegetation (Batáry et al. 2010).

In conclusion, diversification of management must be carried out in parts of the area throughout the year. Accordingly, each organism has the opportunity to find suitable habitats; if one of the interventions is poorly undertaken, other methods will compensate for its negative effects (Di Giulio et al. 2001, Ausden 2007, Bucher et al. 2016).

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