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Authors: Hamřík, Tomáš, and Košulič, Ondřej

Source: Arachnologische Mitteilungen: Arachnology Letters, 58(1) : 85-96

Published By: Arachnologische Gesellschaft e.V.

URL: https://doi.org/10.30963/aramit5812
Spiders from steppe habitats of Pláně Nature Monument (Czech Republic) with suggestions for the local conservation management

Tomáš Hamřík & Ondřej Košulič

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 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, Megaleptyphantes pseudocollinus, Trichoncus affinis, Porhomma errans, Alopecosa striatipes, Cheiracanthium oncognathum, Civeizelotes 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

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, Rezáč 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 (Tscharnkte 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 (Válko 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. Krížová (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 Kufímská Nová Ves in the Southern Moravia region of the Czech Republic (Fig. 1, 49.35199’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
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 (Skalíčky 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 hunting strategies (Fig. 2).

**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...
Spiders from steppes of Pláně Nature Monument (Czech Republic)

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 pulvoralenta 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 149 individuals of the critically endangered 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 species number

| Guild          | Species number |
|----------------|----------------|
| Ground hunters | 45             |
| Sheet hunters  | 40             |
| Other hunters  | 35             |
| Orb hunters    | 30             |
| Space web      | 25             |
| Ambush hunters | 20             |
| Specialists    | 15             |
| Sensing web    | 10             |

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

tat 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 Civizelesos pygmaeus, Drassyllus pamilus, Haplodrassus dalmatensis, Micaria formica, Zelotes arenarius, Zelotes aurantius, 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 aurantius 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 (Rézák 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 pamilus; VU (vulnerable): Neottiura suaveolens, Trichoborus affinis, Trichopterna citi, Cheiracanthium ongognathum, Phrurolithus minimus, Haplodrassus dalmatensis, Micaria formica, Civizelesos pygmaeus, Thanatus arenarius, Evarcha lactabunda, Talarva 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 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|---------|--------|--------|--------|------------------|---------------------|--------------------|--------------------|
| Segestriidae |        |        |        |                  |                     |                    |                    |
| Segestria senoculata (Linnaeus, 1758) | . | . | 2 | VA | C, SN | (T), M, (O) | – |
| Dysderidae |        |        |        |                  |                     |                    |                    |
| Dysdera moravia Řezáč, 2014 | . | 1 | 1 | R | C | T | LC |
| Harpactea bombergi (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 | – |
| Euryargyra flavomaculata (C. L. Koch, 1836) | 1 | . | . | A | C, SN | T, M | – |
| Lasaecola trisita (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 |
| Phyllobius 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 leucopus (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 scabra (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) | – |
| Phylloneta impressa L. Koch, 1881 | 2 | . | 1 | VA | C, SN | T, M, O | – |
| Entelecara acuminata (Wider, 1834) | 2 | . | . | A | C, SN | M | – |
| Erigone atrospina (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 tortensia Sundevall, 1830 | 1 | 1 | . | A | C, SN | (T), M | – |
| Linyphia triangularis (Clerck, 1757) | 1 | . | 2 | VA | C, SN, D | T, M | – |
| Megalephytaphantes pseudocollinus Saaristo, 1997 | . | . | 1 | VR | C | T | LC |
| Micargis 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 emphanus (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 | – |
| Peloeopsis elongata (Wider, 1834) | 4 | 1 | . | S | C | M | LC |
| Peloeopsis radicicola (L. Koch, 1872) | 2 | 1 | 1 | A | C, SN | M, (O) | – |
| Porrhomma errans (Blackwall, 1841) | 3 | . | . | VR | C, D | T | – |
| Stenomyphantes lineatus (Linnaeus, 1758) | 3 | . | 1 | A | C, SN, D | (T), M | – |
| Tapinocyba insecita (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 meigi Kulczyński, 1887 | 1 | . | . | VA | C, SN | T, M, O | – |
| Tenuiphantes tenax (Blackwall, 1852) | 2 | 2 | . | A | C, SN, D | T, M | – |
| Tiso vagans (Blackwall, 1834) | 1 | 2 | 2 | A | C, SN, (D) | M, (O) | – |
| Trichonus affinis Kulczyński, 1894 | . | . | 1 | R | C, SN | M | VU |
| Trichopterna cito (O. P.-Cambridge, 1872) | 1 | . | . | S | C | T, M | VU |
| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence 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)                 | –                   |

**Tetragnathidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Metellina segmentata (Clerck, 1757)          |        |        | .      | VA               | C, SN, D            | T, M, O             | –                   |
| Pachygnaetha degerei Sundevall, 1830         |        |        | 1      | 12               | VA, C, SN, D        | T, M, (O)           | –                   |
| Pachygnaetha listeri Sundevall, 1830         |        |        | .      | 1                | VA, C, SN           | (T), M              | –                   |

**Araneidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Allocata ceropegia (Walckenaer, 1802)         | 45     | 65     | 26     | VA               | C, SN, D            | (T), M, (O)         | –                   |
| Arorectus sturmi (Hahn, 1831)                 | .      | 1      | .      | VA               | C, SN               | T, M                | LC                  |
| Argiope braueni (Scopoli, 1772)               | 9      | 2      | 2      | A                | C, SN, D            | T, M                | –                   |
| Cercidius promicinus (Westring, 1851)         | 1      | .      | 1      | S                | C, SN               | T, M                | –                   |
| Hypsosinga albovittata (Westring, 1851)       | 18     | 44     | 26     | S                | C, SN               | T, M                | LC                  |
| Hypsosinga pygmaea (Sundevall, 1831)          | 1      | .      | 1      | S                | C, SN               | M                   | LC                  |
| Hypsosinga sangiunea (C. L. Koch, 1844)       | 10     | 11     | 1      | A                | C, SN               | (T), M              | –                   |
| Mangora acalypa (Walckenaer, 1802)            | 164    | 130    | 245    | VA               | C, SN, D            | T, M                | –                   |

**Proctopodidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Titanoeca quadrigrattata (Hahn, 1833)         | .      | .      | 1      | A                | C, SN               | T, M                | –                   |

**Lycosidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| 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 pul PUBLICA (Clerck, 1807)          | 150    | 65     | 272    | VA               | C, SN, D            | T, M, (O)           | –                   |
| Alopecosa striatipes (C. L. Koch, 1837)       | 191    | 122    | 74     | VR               | C                  | T                   | CR                  |
| Alopecosa trahilis (Clerck, 1835)             | 59     | 15     | 186    | S                | C, SN               | T, M                | –                   |
| Amulina albina (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, 1807)                | 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)           | –                   |
| Trabosa ruris (De Geer, 1778)                 | 20     | 5      | 55     | VA               | C, SN, D            | T, M                | –                   |
| Trabosa terricola (Thorell, 1856)             | 42     | 9      | 138    | VA               | C, SN, D            | T, M, (O)           | –                   |
| Xerobius miniata (C. L. Koch, 1834)           | 13     | 41     | 26     | S                | C, SN               | T, M                | –                   |
| Xerobius nemoralis (Westring, 1861)           | 5      | 5      | 3      | VA               | C, SN               | T, M, (O)           | –                   |

**Pisauridae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Pisaura mirabilis (Clerck, 1875)             | 8      | 5      | 19     | VA               | C, SN, D            | T, M                | –                   |

**Oxyopidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Oxyopes vamous (Martini & Goeze, 1778)        | .      | .      | 1      | S                | C, SN               | M                   | LC                  |

**Thomisidae**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Misupena vari (Clerck, 1875)                  | 1      | 2      | 2      | VA               | C, SN               | T, M                | –                   |
| Osypysta atomaria (Panzer, 1801)              | 2      | 2      | 3      | S                | C, SN               | T, M                | –                   |
| Osypysta cleavagea (Walckenaer, 1837)          | 32     | 18     | 24     | S                | C                  | T, M                | LC                  |
| Osypysta praticola (C. L. Koch, 1837)         | .      | .      | 1      | S                | C, SN               | T, M                | –                   |
| Synnema 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, 1875)             | 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**

| Species                                      | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|----------------------------------------------|--------|--------|--------|------------------|---------------------|---------------------|---------------------|
| Allagena gracilens (C. L. Koch, 1841)         | 1      | 2      | 2      | A                | C, SN, (A)          | T, M                | –                   |
| Coelotes terrestris (Wider, 1834)             | 3      | 1      | 8      | VA               | C, SN               | (T), M, O           | –                   |
| Histropona 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 | Site 2 | Site 3 | Occurrence | Habitat preferences | Thermo preferences | Conservation status |
|-----------------------------|--------|--------|--------|------------|---------------------|--------------------|---------------------|
| Tegenaria campestris        | 2      |        | 6      | S          | C, SN               | T, M               | –                   |
| Tegenaria silvestris        | 1      |        |        | A          | C, SN               | M, (O)             | –                   |
| Cybaeidae                   |        |        |        |            |                     |                    |                     |
| Cybaea angustiarum          |        |        |        |            |                     |                    |                     |
| Hahniiidae                  |        |        |        |            |                     |                    |                     |
| Habnia nasa                 |        | 3      | 5      | S          | C, SN               | T, M               | –                   |
| Dictynidae                  |        |        |        |            |                     |                    |                     |
| Cicarina cicar             | 18     | 8      | 8      | VA         | C, SN, D            | (T), M             | –                   |
| Dictyna arundinacea         | 8      | 1      | 4      | VA         | C, SN, D            | (T), M             | –                   |
| Nigma flavescens            | 1      | 1      |        | A          | C, SN               | T, M               | –                   |
| Amaurobiidae                |        |        |        |            |                     |                    |                     |
| Callobius clausstarius     |        | 2      | 7      | A          | C, SN               | M, O               | –                   |
| Liocranidae                 |        |        |        |            |                     |                    |                     |
| Agroeca brunnea            | 6      | 2      | 6      | VA         | C, SN               | T, M               | –                   |
| Agroeca cuprea              | 20     | 18     | 27     | S          | C                   | T, M               | LC                  |
| Agroeca proxima             | 9      | 3      | 1      | S          | C, SN               | M, O               | –                   |
| Clubionidae                 |        |        |        |            |                     |                    |                     |
| Clubiona neglecta           | 1      | 5      | 1      | VA         | C, SN               | (T), M             | –                   |
| Clubiona terestris          |        | .      | 2      | VA         | C, SN               | M                  | –                   |
| Phrurolithidae              |        |        |        |            |                     |                    |                     |
| Phrurolithus festivus       |        | .      | 1      | VA         | C, SN               | T, M               | –                   |
| Phrurolithus minimus        | 1      | .      | .      | R          | C                   | SN                 | T, M               | VU                  |
| Gnaphosidae                 |        |        |        |            |                     |                    |                     |
| Civeizelotes pygmaeus       | 1      | 3      | 6      | R          | C                   | T                  | VU                  |
| Drassodes lapidosis         | 1      | 2      | 14     | VA         | C, SN               | T, M               | –                   |
| Drassodes pubescens         | 62     | 45     | 31     | VA         | C, SN               | T, M               | –                   |
| Drasylus latetarius         | 1      | .      | .      | A          | C, SN, D            | (T), M             | –                   |
| Drasylus praeficus          | 7      | 15     | 14     | A          | C, SN               | T, M               | –                   |
| Drasylus pamilus            | 3      | 1      | .      | R          | C                   | T, M               | EN                  |
| Drasylus pusillus           | 55     | 43     | 30     | A          | C, SN, (D)          | T, M               | –                   |
| Hoplodrassus dalmatensis    | 1      | 2      | 1      | R          | C                   | T                  | VU                  |
| Hoplodrassus signifer       | 106    | 106    | 111    | VA         | C, SN, D            | T, M, O            | –                   |
| Hoplodrassus silvestris     | 1      | 2      | 2      | A          | C, SN               | (T), M             | –                   |
| Haplopectra soerenseii      | .      | .      | 1      | S          | C, SN               | M                  | LC                  |
| Micaria formicaria          | 21     | 7      | 14     | R          | C, SN               | T, (M)             | VU                  |
| Micaria fulgens             | 9      | 4      | 34     | A          | C, SN               | T, M               | LC                  |
| Micaria palicaria           | .      | 1      | 6      | VA         | C, SN               | T, M, O            | –                   |
| Scotophaeus quadripunctatus | 1      | .      | .      | S          | C, SN, A            | –                  | –                   |
| Trachyzelotes pedestrus     | 4      | 2      | 16     | S          | C, SN               | T, (M)             | –                   |
| Zelotes aenesc             | 9      | 6      | 2      | R          | C, SN, D            | (T), M             | LC                  |
| Zelotes aurantiacuss        | 1      | 1      | 24     | R          | C                   | T                  | LC                  |
| Zelotes electus             | 84     | 86     | 9      | S          | C, SN               | T, M               | LC                  |
| Zelotes latreillei          | 8      | 3      | 4      | VA         | C, SN, D            | (T), M             | –                   |
| Zelotes longipes            | 6      | 190    | 2      | R          | C                   | T, (M)             | LC                  |
| Zelotes petrensis           | 71     | 75     | 93     | A          | C, SN               | T, M               | –                   |
| Miturgidae                  |        |        |        |            |                     |                    |                     |
| Zora nemoralis             | 1      | 1      | .      | A          | C, SN               | (T), M             | –                   |
| Zora silvestris             | 3      | .      | 6      | A          | C, SN               | M                  | –                   |
| Zora spinimana              | 4      | 2      | 5      | VA         | C, SN, D            | T, M, (O)          | –                   |
| Cheiracanthiidae            |        |        |        |            |                     |                    |                     |
| Cheiracanthium campestre    | 1      | .      | .      | VR         | SN                 | T                  | LC                  |
| Cheiracanthium ongagnostum  | 1      | .      | .      | R          | C, SN               | T, M               | VU                  |
Spiders from steppes of Pláně Nature Monument (Czech Republic)

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 (Rézáč 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-

| Species | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|---------|--------|--------|--------|-----------------|---------------------|-------------------|--------------------|
| Micrommata virescens (Clerck, 1757) | . | . | 1 | VA | C, SN | M | – |
| Philodromus albidus Kulczyński, 1911 | . | . | 1 | A | C, SN, D | T, M | – |
| Philodromus cepitum (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 | – |

| Species | Site 1 | Site 2 | Site 3 | Occurrence level | Habitat preferences | Thermo preferences | Conservation status |
|---------|--------|--------|--------|-----------------|---------------------|-------------------|--------------------|
| 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, D | T, M | – |
| Evarcha lactabunda (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 flaviipes (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, D | T, M | – |
| Sibianor auricinctus (Ohlert, 1865) | 1 | . | . | A | C, SN, D | T, M | LC |
| Talavera aequipes (O. P. -Cambridge, 1871) | 3 | 3 | 2 | A | C, SN | T, M | LC |
| Talavera aperta (Miller, 1971) | 1 | . | . | R | C, SN | T, M | LC |

Fig. 3: Number of species in 48 samples in relation to the number of species expected by a Jackknife 1 estimator in the Pláně NM

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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 (Rézác 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.

*Megalephyphantes 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 seminiferous habitats in Břtnice–Strížov, 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.

*Porhomma 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). *Porhomma 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, Rézác et al. 2015, Blíčk 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 epigonic 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 pitfalls traps from all sites, but most came from Site 1 and Site 2. The individuals were caught in the sparse and also dense vegetation.

*Ihanatus 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). Krížová (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. Megalepithyphantes 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. 2014). Burning is inappropriate because it supports the spread of expansive *Calamagrostis epigejos* (Házi et al. 2011, Desk 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 mowing or grazing is requested. It is necessary to leave some older shrubs such as *Crateagus 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).

**Acknowledgements**

The authors would like to thank Petr Dolejš (National Museum in Prague) for the determination and revision of spider taxa that were difficult to identify. We likewise extend our warm appreciation to Denise Paulina V. Doble and Nicole H. Cernohorsky for the English proofreading; to Anna Foltýnová, Josef Hamřík, Ondřej Dohnal, Pavla Vymazalová, Šárka Mašová, Viktoria Košuličová, Vojtěch Václavík, Zdeněk Sucharda and the members of ZO ČSOP Eresus and ZO ČSOP Náměšťské rybníky for their assistance during fieldwork. Additionally, we are grateful to the reviewers and editor (Theo Blick) for their comments that significantly improved the manuscript. This research was performed within the Zoological inventory of spiders in the Pláně Nature Monument and was financially supported by the South Moravian Region. The study was financially supported by the Specific University Research Fund of the Faculty of Forestry and Wood Technology, Mendel University in Brno (LDF_PSV_2017004/2017).

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