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Spider (Arachnida: Araneae) distribution across the timberline in the Swiss Central Alps (Alp Flix, Grisons) and three morphologically remarkable species

Patrick Muff, Martin H. Schmidt, Holger Frick, Wolfgang Nentwig & Christian Kropf

Abstract: We collected 6251 adult epigeic spiders from the dwarf-shrub heath to subalpine coniferous forest on Alp Flix (CH, canton Grisons, 1950 m) between May 2005 and May 2006 using pitfall traps. Total species richness and activity density of all species decreased from the open land to the forest, although this pattern varied according to family. The distribution of the 102 species found indicates that the small area around a single tree at the timberline provides habitats for both open land and forest spider species as well as some possible timberline specialists. Five species were new to the canton Grisons: *Centromerita bicolor*, *Centromerita concinna*, *Hilaira excisa*, *Meioneta alpica* and *Tallusia experta*. Three species showed remarkable morphological characteristics and were analysed in more detail. We found males of *Pelecopsis radicicola* without the characteristic longitudinal depression on the raised carapace. It is shown that the males of *Meioneta alpica* have a considerably variable lamella characteristica, which is nevertheless distinct from the sister species *Meioneta ressli*. Because we found intermediate forms of the head region described for *Metopobactrus prominulus* and *M. schenkeli*, respectively, *M. schenkeli* is considered a **syn. nov.** of *M. prominulus*. This study shows that the known distribution and taxonomic status of various spider taxa in the Central Alps are still incomplete and further work on arthropods in remote areas should be strongly encouraged.

Key words: Diversity, dwarf-shrub heath, forest, habitat boundary, *Meioneta alpica*, *Metopobactrus prominulus*, *Pelecopsis radicicola*, pitfall traps

Knowledge about species diversity and activity across landscapes is indispensable to understand how landscape structure influences habitat quality. Since landscapes exist as mosaics of numerous different patch types, knowledge about the ecology of habitat edges is of particular importance (e.g. RIES et al. 2004). Spiders are abundant, species-rich and known to respond sensitively to environmental and structural conditions, which makes them suitable for studying organism–habitat relationships (e.g. WISE 1993, FOELIX 1996). However, despite extensive work, our knowledge about the distribution pattern of spiders across the Central Alps in general and Switzerland in particular is still limited (MAURER & HÄNGGI 1990, HÄNGGI 1993, THALER 1995, HÄNGGI 1999, HÄNGGI 2003). A recent study analysing the influence of environment and space on the differentiation of spider communities across an alpine timberline in Switzerland (MUFF et al. in prep.) provided faunistic data, which are reported here. Besides a short description of the distribution pattern of species from the open land to the forest, we focus on three morphologically remarkable species, two of them causing problems of identification since their first description. A discussion about other faunistically notable species of the study site can be found in FRICK et al. (2006).

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Material and Methods

Study site

Alp Flix (WGS84: 9°38'E, 46°31'N) is part of the Swiss Central Alps and belongs to the village of Sur in the canton Grisons, Switzerland. The alp is a southwest-exposed terrace of 15 km² at 1950 m above sea level. It is surrounded by 3000 m mountain peaks and a valley. Sampling was conducted in a 300 m long stretch of timberline plus fragments of the adjoining Norway spruce forest (Vaccinio-Piceion) to the northwest and the dwarf-shrub heath (Juniperion nanae) to the southeast. Each of the three parts covered approximately 3 ha. The site is located on a small slope inclined slightly towards the forest and is used for occasional cattle grazing throughout the vegetation period. For a more detailed description of the study area see HÄNGGI & MÜLLER (2001).

Study design and spider sampling

We differentiated between five habitat zones which represented the whole gradient of habitat structures: the open land (dwarf-shrub heath, O), three microhabitats linked to a single spruce tree at the timberline and the forest (F). The three areas at the timberline were defined by their location relative to the tree as: next to the trunk (TT), at the end of branch cover (TB) and in the adjoining open area outside of branch cover (TO). In each of the five habitat zones we placed 15 pitfall traps. In O, F and TO the traps were randomly positioned at least 15 m apart from each other. For placing the traps in TB and TT, the tree nearest to the trap in TO was chosen. The mean distances between the traps in these three microhabitats were 4.1 m (TO – TB), 4.5 m (TO – TT) and 1.5 m (TB – TT). The traps consisted of white plastic cups with an upper diameter of 6.9 cm and a depth of 7.5 cm filled with a solution of 4% formaldehyde in water plus detergent (0.05% sodium dodecyl sulphate, SDS). Each trap was covered with a quadrangular transparent plastic roof (15 x 15 cm) fixed by three wooden rods 8 cm above ground. Due to the proximity of cattle and the toxicity of the trapping liquid we fenced off each trap with three plastic poles connected with ribbons. The traps were emptied monthly during the snow-free period (May 2005 to October 2005) and then left under the snow layer until May 2006, when they were emptied a final time.

Identification

Only adult spiders were identified to species level, juveniles were excluded. Identification was mainly carried out using NENTWIG et al. (2003), ROBERTS (1985, 1987) and WIEHLE (1956, 1960). For ad-

Tab. 1: Number of species (and individuals) according to family and season (A) or habitat zone (B). Letters behind individual numbers denote seasons (excluding winter) and habitats significantly different from each other according to pairwise Kruskal-Wallis tests (all $p < 0.05$, corrected for multiple comparisons after Holm). June: 27.5.–24.6.2005, July: 25.6. –23.7.2005, August: 24.7.–21.8.2005, September: 22.8.–18.9.2005, October: 19.9.–16.10.2005, winter: 17.10.2005–6.5.2006; for definition of habitat zones see text.

(A)	June	July	August	September	October	winter
Linyphiidae	48 (632d)	26 (179b)	25 (113a)	24 (146ab)	25 (365c)	39 (850)
Lycosidae	7 (2407d)	8 (658c)	6 (142b)	6 (45a)	6 (20a)	4 (8)
Gnaphosidae	7 (154d)	6 (46c)	6 (19b)	2 (25b)	4 (8a)	3 (3)
Thomisidae	7 (54b)	4 (14a)	4 (5a)	2 (4a)	2 (5a)	3 (9)
Theridiidae	3 (18b)	2 (3a)	2 (22b)	1 (45b)	1 (17b)	2 (12)
Philodromidae	1 (5a)	2 (2a)	1 (6ab)	1 (17b)	1 (8ab)	1 (22)
Hahniidae	1 (82b)	1 (3a)	1 (4a)	1 (5a)	1 (7a)	1 (33)
others	5 (9a)	2 (2a)	4 (6a)	3 (4a)	2 (2a)	5 (6)
Total	79 (3361d)	51 (907c)	49 (317ab)	40 (291a)	42 (432b)	58 (943)

(B)	O	TO	TB	TT	F	Total
Linyphiidae	34 (251a)	30 (444bc)	33 (423b)	40 (620c)	29 (547bc)	61 (2285)
Lycosidae	7 (1073c)	7 (1089c)	7 (788c)	5 (262b)	6 (68a)	8 (3280)
Gnaphosidae	6 (106c)	7 (73c)	7 (47b)	3 (10a)	4 (19a)	8 (255)
Thomisidae	6 (32b)	4 (25b)	4 (27b)	3 (6a)	1 (1a)	7 (91)
Theridiidae	1 (1a)	3 (12ab)	2 (37b)	2 (42b)	1 (25b)	3 (117)
Philodromidae	1 (33b)	2 (22b)	1 (5a)	0a	0a	2 (60)
Hahniidae	0a	0a	1 (2a)	1 (33b)	1 (99c)	1 (134)
others	4 (10b)	5 (11b)	2 (3a)	3 (3a)	2 (2a)	12 (29)
Total	59 (1506c)	57 (1676c)	56 (1332bc)	56 (976ab)	44 (761a)	102 (6251)

ditional literature used see FRICK et al. (2006). Nomenclature followed PLATNICK (2007). The material is stored in the Natural History Museum of Bern.

Statistical analysis

For comparisons of activity densities across seasons (excluding winter) and habitat zones we used pairwise Kruskal-Wallis tests (k = 9999 Monte Carlo permutations), because a Levene's test indicated that variances of the species data were not homogeneous. These analyses were conducted with the program SPSS 14.0 for Windows. All p-values were corrected for multiple comparisons after Holm (LEGENDRE & LEGENDRE 1998).

Morphological analysis

For the analysis of some morphological characteristics we used either an optical stereomicroscope Leica MZ16 for *Metopobactrus prominulus*, a low-voltage SEM Hitachi S-3500N for *Pelecopsis radicicola* and a standard SEM Philips XL 30 FEG for *Meioneta alpica* and *M. ressli*.

Results and Discussion

Spider distribution across the alpine timberline

We recorded 6251 adult individuals belonging to 102 species of 14 families. Total species richness and activity density of all species decreased from June towards the winter period, with a moderate increase in October (Tab. 1A). This general pattern varied at the family level, though. It applied best to Linyphiidae, whereas Lycosidae decreased constantly both in terms of species and individuals from June to winter. Both the number of all species and individuals decreased from the open land to forest (Tab. 1B). Species richness of single families did not show any clear pattern across the five habitat zones, although in most families it appeared to decrease in more shaded habitats. The accumulation of individuals in open areas, however, must be qualified when looking at single families. While Lycosidae, Gnaphosidae, Thomisidae and Philodromidae had higher densities in open zones, Linyphiidae, Theridiidae and Hahniidae preferred more shaded habitats. Clearly, in the three habitat zones at the timberline the species mostly followed these distinct trends in activity density across the open land and forest in a very gradual manner (Tab. 2). It is notable that all five habitat zones were dominated by certain species, but no species (with N ≥ 15 individuals) was found exclusively in only one habitat. Nine species were found with at least 50% of the individuals in the open land, six species in the forest and none, four and six species, respectively, in the three zones at the timberline (TO, TB and TT) (Fig. 1). Fig. 1 illustrates these species-specific patterns in activity density. For example, the lycosid *Alopecosa pulverulenta* clearly preferred the open land, while *A. taeniata* was found mainly around single trees in the timberline. Other species (e.g. *Scotinotylus alpigena*, *Cryphoeca silvicola*) preferred shaded habitats

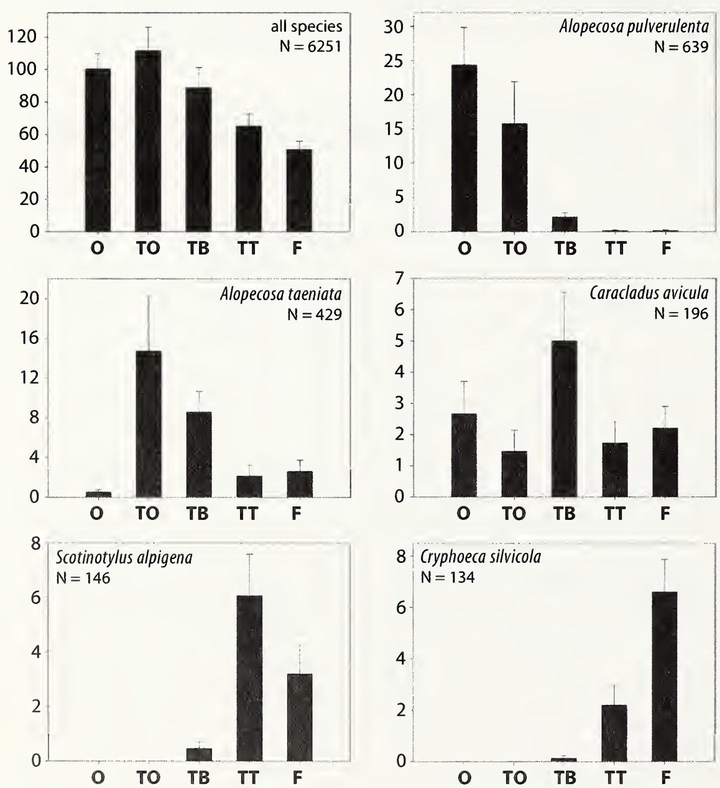

Fig. 1: Mean number (+ SE) of individuals of all species and of selected species across the five habitat zones (data from 15 pitfall traps pooled for each habitat over one year). Note that each of the five species shown is clearly dominant in one of the habitats (i.e. occurrence ≥ 50%, except for *Caracladus avicula*: occurrence = 38%).

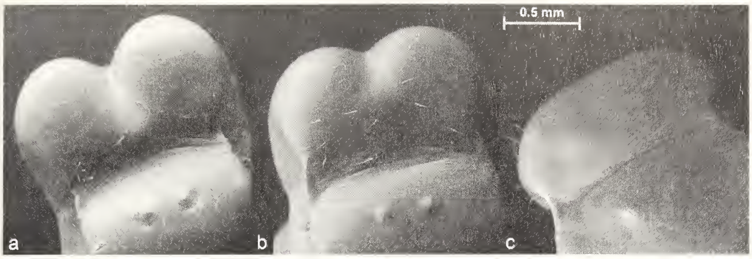

Fig. 2: Head region of three adult males of *Pelecopsis radicicola* (L. Koch, 1872) found on Alp Flix; frontal view.

with this, as most individuals of this species were found there. However, its status as a timberline specialist must be questioned, since in this study it also occurred in considerable numbers in the open land and inside the subalpine forest (40 and 33 individuals, respectively) (Tab. 2).

Our findings indicate that the alpine timberline with its stand-alone trees provides habitats for both open land and forest spider species as well as some possible timberline specialists. We thereby demonstrate the particular value of the timberline and of heterogeneous, spa-

and were found almost exclusively close to the tree trunks in the timberline or inside the forest, respectively. *Caracladus avicula* has been discussed as a habitat-specialist of the timberline by FRICK et al. (2007). Our results are partly in accordance

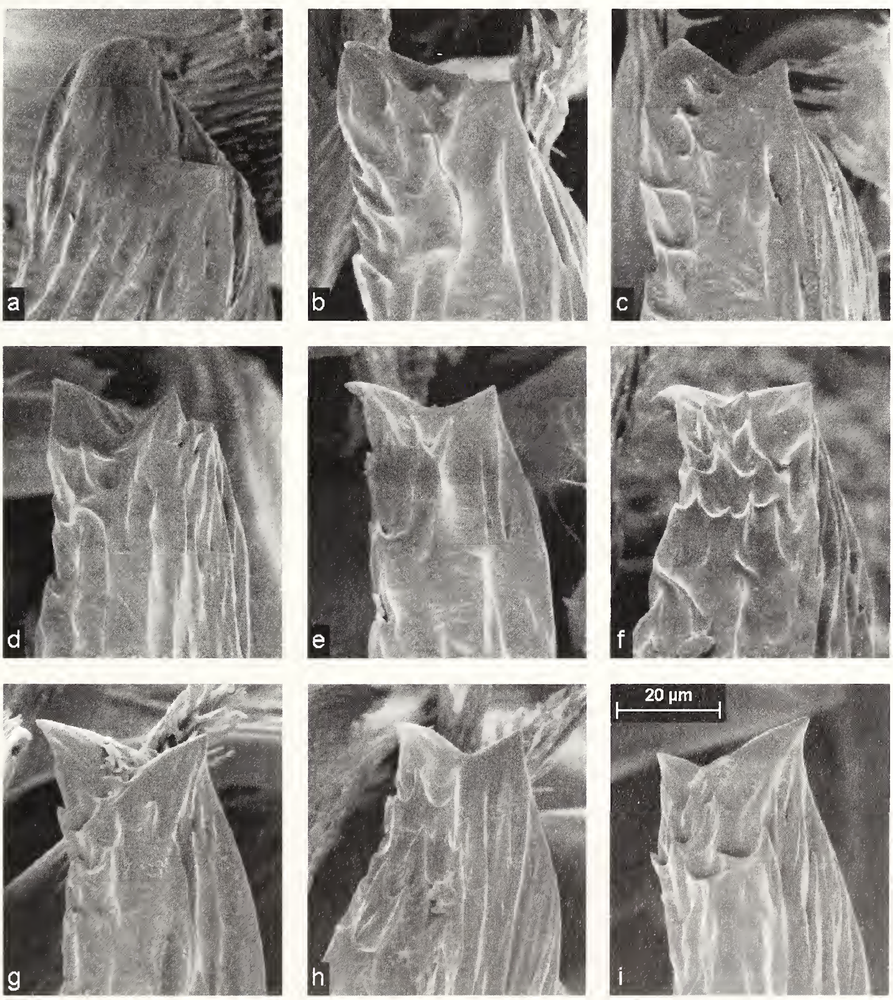

Fig. 3: Tip of lamella characteristica of *Meioneta ressli* Wunderlich, 1973 (a, Gastein, A) and *Meioneta alpica* (Tanasevitch, 2000) (b-i, Alp Flix, CH); dorsal view, left male palp.

tially limited structures in general in maintaining divergent invertebrate communities. For a more detailed description of the habitat zones and a full analytical discussion regarding the results see MUFF et al. (in prep.).

Some remarkable species

Our study revealed one species new to science (*Caracladus* sp. A, Tab. 2) which will be described elsewhere. Five species were new to the Canton Grisons: *Centromerita bicolor, Centromerita concinna, Hilaira excisa, Meioneta alpica* and *Tallusia experta*. Other remarkable species included *Meioneta orites* and *Panamomops palmgreni*, both endemic to the Alps. The following three species showed remarkable morphological characteristics and were analysed in more detail.

Pelecopsis radicicola (L. Koch, 1872)

THALER (1978) considered *Brachycentrum delesserti* Schenkel, 1925 a synonym of *Pelecopsis radicicola* since the characteristics of the first species were within the variation range of the latter. The only difference was the absence of the median longitudinal depression on the elevated male head region in *B. delesserti*. Our material from Alp Flix comprises individuals showing practically identical male and female genital organs, but a great and gradual variability regarding size and shape of the raised male head region (Fig. 2). This clearly emphasises the retention of only one species as suggested by Thaler.

Meioneta alpica (Tanasevitch, 2000)

In his initial description TANASEVITCH (2000: 211, sub *Agyneta*) characterised *Meioneta alpica* as being very closely related to *Meioneta ressli* Wunderlich, 1973 but "well distinguishable by the narrowed lamella characteristica and larger of it upper lobes, almost equal to lower one". However, in practice this differentiation has caused many problems. Here, we checked 11 males of *M. alpica* from Alp Flix, plus four males each of *M. ressli* from Ringkogel (Styria, A) and Gastein (Salzburg, A), respectively. Using this material we show the distinction of the two species based on the lamella characteristica (Fig. 3). Despite its great variability in *M. alpica* (b-i), it can be well distinguished from the lamella of *M. ressli* (a) with respect to the size and shape of the two lobes. However, since *M. alpica* has only recently been described and the separation by light microscope is rather difficult, it is possible that it has been confused with its sister species *M. ressli* or *M. rurestris* (C. L. Koch, 1836) in former studies. In the checklist of the Swiss spiders (BLICK et al. 2004) *Meioneta alpica* is not mentioned for Switzerland, even though the holotype was found in the canton Uri, Switzerland (TANASEVITCH 2000).

Metopobactrus prominulus (O. P.-Cambridge, 1872) = *Metopobactrus schenkeli* Thaler, 1976

According to THALER (1976) *Metopobactrus schenkeli* differs from *Metopobactrus prominulus* by the shape of the male head region, which is concave and more elevated in profile in *M. schenkeli* and flat in *M. prominulus*. Male palps and females are indistinguishable. Since our material comprises individuals with intermediate characteristics (Fig. 4), we are not able to distinguish the two species, as it was done in former studies (e.g. THALER 1978, HANSEN 1995, FRICK et al. 2006). We therefore consider *Metopobactrus schenkeli* Thaler, 1976 a **syn. nov.** of *Metopobactrus prominulus* (O. P.-Cambridge, 1872).

Conclusion

Our study demonstrates that the known distribution and taxonomic status of various spider taxa in

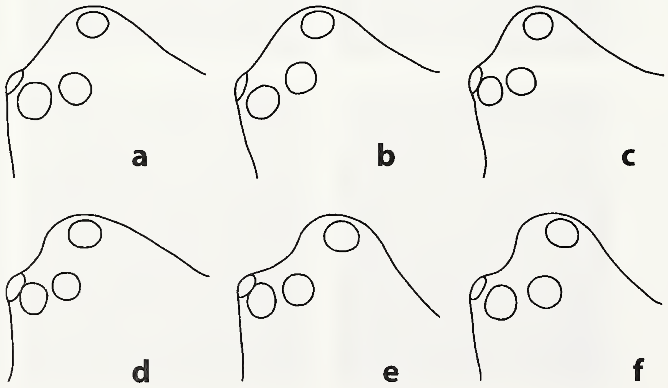

Fig. 4: Head region of six males of *Metopobactrus prominulus* from Alp Flix; lateral view. Note the gradual increase in concavity from a ("*M. prominulus*") to f ("*M. schenkeli*").

the Central Alps are still incomplete. Our data contribute one species new to science, five species new to the Grisons fauna and highlight three interesting taxonomic questions. This is remarkable because the canton Grisons and Alp Flix in particular belong to the best studied areas in the Swiss Central Alps in terms of spiders (THALER 1995, HÄNGGI & MÜLLER 2001, FRICK et al. 2006). Hence, further work on arthropods in remote areas of the Alps is strongly encouraged.

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Tab. 2: Number of individuals of all species found from May 2005 to May 2006 on Alp Flix according to habitat zone (males/females) and in total. Numbers are in bold where a species occurred with at least 50% of the individuals (if N ≥ 15). Asterisks denote species new to the canton Grisons.

Species	O	TO	TB	TT	F	Total
Amaurobiidae						
Coelotes terrestris (Wider, 1834)	1/1					2
Araneidae						
Araneus diadematus Clerck, 1757	0/1					1
Hypsosinga albovittata (Westring, 1851)		1/0				1
Clubionidae						
Clubiona diversa O. P.-Cambridge, 1862	0/1					1
Clubiona reclusa O. P.-Cambridge, 1863				0/1		1
Dictynidae						
Dictyna arundinacea (Linnaeus, 1758)	1/0					1
Dictyna pusilla Thorell, 1856					1/0	1
Mastigusa arietina (Thorell, 1871)		0/1	0/1	0/1		3
Gnaphosidae						
Drassodes cupreus (Blackwall, 1834)	**8/4**	5/1	1/0	1/0		20
Drassodes pubescens (Thorell, 1856)	8/3	6/2	5/0	1/0	2/0	27
Gnaphosa leporina (L. Koch, 1866)	**18/10**	1/2	0/1			32
Haplodrassus signifer (C. L. Koch, 1839)	15/11	16/9	9/3	5/3	4/4	79
Micaria aenea Thorell, 1871	6/1	9/3	19/2		8/0	48
Micaria pulicaria (Sundevall, 1831)		0/1				1
Zelotes subterraneus (C. L. Koch, 1833)			1/0			1
Zelotes talpinus (L. Koch, 1872)	19/3	13/5	5/1		1/0	47
Hahniidae						
Cryphoeca silvicola (C. L. Koch, 1834)			2/0	29/4	**69/30**	134
Linyphiidae						
Agnyphantes expunctus (O. P.-Cambridge, 1875)			0/6	2/14	**5/25**	52
Agyneta cauta (O. P.-Cambridge, 1902)	18/13	**52/19**	21/3	2/0		128
Agyneta conigera (O. P.-Cambridge, 1863)				1/0	1/0	2
Anguliphantes monticola (Kulczyński, 1881)				6/3	3/0	12
Asthenargus perforatus Schenkel, 1929		1/0		1/1	1/1	5
Bolephthyphantes index (Thorell, 1856)	1/1	2/1	1/1	1/1		9
Bolyphantes alticeps (Sundevall, 1833)	3/0	11/6	2/8	0/1	4/9	44
Bolyphantes luteolus (Blackwall, 1833)	11/14	**35/26**	4/9	2/8		109
Caracladus avicula (L. Koch, 1869)	18/22	4/18	17/58	9/17	17/10	190
Caracladus sp. A		0/1		0/1	6/5	13
Centromerita bicolor (Blackwall, 1833) *	3/0					3
Centromerita concinna (Thorell, 1875) *	1/0					1
Centromerus arcanus (O. P.-Cambridge, 1873)	1/0		3/0	2/0	3/1	10
Centromerus pabulator (O. P.-Cambridge, 1875)	8/1	87/9	74/7	28/4	72/29	319
Ceratinella brevis (Wider, 1834)	1/1			2/0		4
Erigone atra Blackwall, 1833	1/0					1

Species	O	TO	TB	TT	F	Total
Erigone dentigera O. P.-Cambridge, 1874	1/0					1
Erigone dentipalpis (Wider, 1834)	1/0	1/0		1/0		3
Erigonella subelevata (L. Koch, 1869)	2/1	1/1	0/1			6
Evansia merens O. P.-Cambridge, 1900		0/1				1
Gonatium rubens (Blackwall, 1833)	2/2	**7/6**	3/1	0/1		22
Hilaira excisa (O. P.-Cambridge, 1871) *		0/1				1
Improphantes nitidus (Thorell, 1875)	0/2		4/0	53/14	43/20	136
Macrargus carpenteri (O. P.-Cambridge)	**25/4**	5/2	3/0	3/0		42
Mansuphantes pseudoarciger (Wunderlich, 1985)	1/0	3/1	2/0	**7/2**	2/0	18
Maro lehtineni Saaristo, 1971	2/0	1/0	1/0		1/0	5
Meioneta alpica (Tanasevitch, 2000)*	**10/6**	1/1				18
Meioneta orites (Thorell, 1875)	5/2	3/2			1/0	13
Meioneta rurestris (C. L. Koch, 1836)	2/6	0/1				9
Metopobactrus prominulus (O.P.-Cambridge, 1872)	2/0	2/1	5/1	2/2		15
Micrargus alpinus Relys & Weiss, 1997	0/1			1/0	0/1	3
Microctenonyx subitaneus (O. P.-Cambridge, 1875)	1/0					1
Microlinyphia pusilla (Sundevall, 1830)	1/0					1
Minicia marginella (Wider, 1834)	1/1	**6/5**	1/1	1/0		16
Minyriolus pusillus (Wider, 1834)					1/1	2
Mughiphantes cornutus Schenkel, 1927			1/1	2/0	**9/10**	23
Mughiphantes mughi (Fickert, 1875)		1/0	2/1	0/8	**13/13**	38
Obscuriphantes obscurus (Blackwall, 1841)				0/2		2
Panamomops palmgreni Thaler, 1973	1/0					1
Panamomops tauricornis (Simon, 1881)			1/1	**33/23**	9/3	70
Pelecopsis elongata (Wider, 1834)			7/11	**17/10**	2/7	54
Pelecopsis radicicola (L. Koch, 1872)	2/6	5/11	20/9	16/9	4/2	84
Pityohyphantes phrygianus (C. L. Koch, 1836)				1/0		1
Pocadicnemis pumila (Blackwall, 1841)			1/0			1
Porrhomma campbelli F. O. P.-Cambridge, 1894	0/2	0/1			2/2	7
Porrhomma pallidum Jackson, 1913			3/0	4/4	**14/17**	42
Scotargus pilosus Simon, 1913			2/1	5/3	5/1	17
Scotinotylus alpigena (L. Koch, 1869)			7/0	**75/16**	37/11	146
Scotinotylus clavatus (Schenkel, 1927)			7/0	38/11	**51/7**	114
Stemonyphantes conspersus (L. Koch, 1879)			0/1	1/0	5/2	9
Tallusia experta (O. P.-Cambridge, 1871) *	0/1					1
Tapinocyba affinis Lessert, 1907	2/1	19/1	75/4	92/18	31/7	249
Tenuiphantes cristatus (Menge, 1866)		2/0	1/0			3
Tenuiphantes mengei Kulczyński, 1887	11/27	25/54	9/17	18/10	5/4	180
Tenuiphantes tenebricola (Wider, 1834)					9/3	12
Thyreosthenius biovatus (O. P.-Cambridge, 1875)				0/3		3
Thyreosthenius parasiticus (Westring, 1851)				0/4		4
Tiso vagans (Blackwall, 1834)				1/0		1
Walckenaeria antica (Wider, 1834)			2/1			3
Walckenaeria languida (Simon, 1914)				3/0		3
Walckenaeria monoceros (Wider, 1834)		1/0	0/1			2
Liocranidae						
Agroeca proxima (O. P.-Cambridge, 1871)		3/1	2/0	0/1		7

Species	O	TO	TB	TT	F	Total
Lycosidae						
Alopecosa accentuata (Latreille, 1817)	**13/1**	8/1	1/1		1/0	26
Alopecosa pulverulenta (Clerck, 1757)	**325/41**	220/17	25/7	0/2	2/0	639
Alopecosa taeniata (C. L. Koch, 1835)	6/2	**190/31**	118/11	29/3	30/9	429
Arctosa renidescens Buchar & Thaler, 1995	12/3	**28/9**	7/1	1/2	1/0	64
Pardosa blanda (C. L. Koch, 1833)	44/22	39/24	10/9	1/1		150
Pardosa ferruginea (L. Koch, 1870)					1/0	1
Pardosa mixta (Kulczyński, 1887)	**5/8**	4/0	0/1			18
Pardosa riparia (C. L. Koch, 1833)	430/161	366/152	528/69	184/39	20/4	1953
Philodromidae						
Philodromus vagulus Simon, 1875		0/1				1
Thanatus formicinus (Clerck, 1757)	**31/2**	18/3	5/0			59
Salticidae						
Evarcha arcuata (Clerck, 1757)		0/1				1
Talavera monticola (Kulczyński, 1884)	4/1	2/0				7
Sparassidae						
Micrommata virescens (Clerck, 1757)		1/1			1/0	3
Theridiidae						
Robertus lividus (Blackwall, 1836)		1/0	4/0	3/1		9
Robertus truncorum (L. Koch, 1872)		5/4	27/6	30/8	17/8	105
Steatoda phalerata (Panzer, 1801)	1/0	2/0				3
Thomisidae						
Ozyptila atomaria (Panzer, 1801)	**8/1**	4/1	3/0	1/0		18
Xysticus audax (Schrank, 1803)	2/1	1/1	4/0	3/0		12
Xysticus bifasciatus C. L. Koch, 1837	3/0					3
Xysticus cristatus (Clerck, 1757)	2/0					2
Xysticus gallicus Simon, 1875	6/3	3/0				12
Xysticus luctuosus (Blackwall, 1836)	6/0	15/0	19/0			40
Xysticus macedonicus Šilhavý, 1944			0/1	0/2	1/0	4
all families	1112/394	1236/440	1074/258	718/258	515/394	6251

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