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Objekttyp: **Article**

Zeitschrift: **Mitteilungen der Schweizerischen Entomologischen Gesellschaft = Bulletin de la Société Entomologique Suisse = Journal of the Swiss Entomological Society**

Band (Jahr): **79 (2006)**

Heft 3-4

PDF erstellt am: **22.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-402918

MITTEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT
BULLETIN DE LA SOCIÉTÉ ENTOMOLOGIQUE SUISSE
79: 167–187, 2006

Faunistically remarkable spiders (Arachnida: Araneae) of the timberline in the Swiss Central Alps (Alp Flix, Grisons)

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Spiders of the timberline on Alp Flix (Switzerland, Canton Grisons, 1960 m) were collected between June 2002 and May 2004 around and on stand-alone Norway spruce trees (*Picea abies*) by means of pitfall traps, funnel traps, frame and litter sampling, branch eclectors, restricted canopy fogging, beating, sweep netting and hand sampling. 93 species were recorded, four of them endemic to the Alps and another six to the European mountain system. Five species are new to the Canton Grisons: *Evansia merens*, *Meioneta innotabilis*, *Moebelia penicillata*, *Obscuriphantes obscurus* and *Agroeca proxima*.

Most species can be classified as forest or open-land dwellers that contribute equally to species diversity, only few are generalists. 13 % of the species (27 % of the individuals) are winter-active. It is shown that stand-alone trees at the alpine timberline offer a broad range of habitats for a high number of spider species. This should be considered in future conservation and research efforts. Phenologies of certain species are included.

Keywords: Spiders, Araneae, faunistics, phenology, timberline, new records, Grisons, Central Alps, Switzerland.

INTRODUCTION

Faunistic data of diverse groups with differentiated habitat preferences of species represent one of the basic tools for many disciplines including conservation biology. Due to their often strict dependency on certain microclimatic factors and therefore sensitivity to environmental changes (Bauchhenss 1990; Wise 1993; Foelix 1996; Samu *et al.* 1999), species associations of spiders (Araneae) have a high indicator value, reflecting the status and the «health» of a habitat (Clausen 1986; Hänggi 1998; Thaler 1998). This makes them ideal subjects of study for many conservation and ecological problems.

The Alp Flix in the Canton Grisons is a hotspot of biodiversity in Switzerland (Hänggi & Müller 2001). In spite of this, only one preliminary study has been devoted to the spider fauna at this location (Hasselmann 2000; Hänggi & Kropf 2001). It has been previously shown that the diversity of spiders at the timberline exceeds that of the surroundings (Thaler 1989; Zingerle 1999a, b). The spider associations of different areas around single trees of the timberline and those of different strata, however, have not yet been studied. The timberline on Alp Flix with its mosaic patterns of open areas and stand-alone trees is, therefore, of particular faunistic and ecological interest.

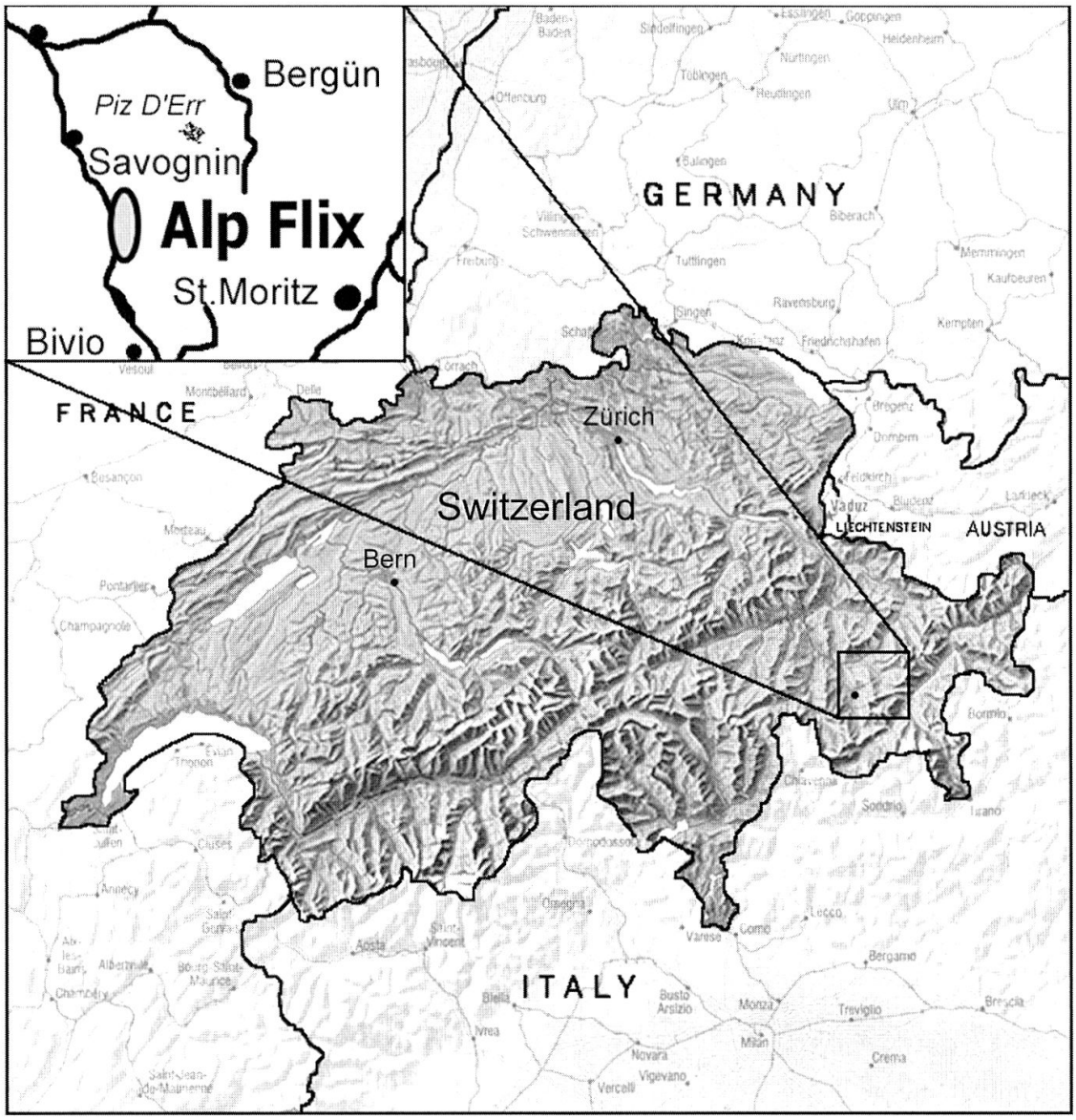

Fig. 1: Map of Switzerland with study site (modified after http://www.lib.utexas.edu/maps/switzerland.html; Courtesy of the University of Texas Libraries, The University of Texas at Austin).

Two ecological studies devoted to the influence of stand-alone spruce trees on the small scale distribution of spiders at the timberline on Alp Flix (results of the diploma theses of A. Bolzern and H. Frick) provided a number of faunistically remarkable spider species that are reported here. The ecological data are published elsewhere (Bolzern & Hänggi 2005, Bolzern *et al.* 2005, Frick *et al.* 2007).

METHODS

Study site

Alp Flix (GPS coordinates: 769 400 / 154 350; WGS84 coordinates: N: 46° 31' 8.41", E: 9° 38' 47.12") is situated in the Swiss Central Alps in the Canton Gri-

sons and belongs to the village of Sur (Fig. 1). The exposed terrace on the south-west of Alp Flix is approximately 1000 m wide and ranges from 1950 m a.s.l. up to 2100 m. It is bordered in the north-east by steep mountains with an elevation of over 3000 m, and in the south-west by the valley of the river Julia. The geology includes granite, gneiss, quartzite, chalk and serpentine formations. These originated from moraine material from the nearby Err massive.

The study site is situated about 550 m north-east of the hamlet Salategnas at the lower edge of the terrace, between 1950 m and 1960 m above sea level. The south western border is defined by the anthropogenically affected forest edge where occasional cattle-grazing occurs throughout the vegetation period. The site is characterised by numerous stand-alone Norway spruce trees (*Picea abies*). In the north-east, the biotope changes to dwarf shrub heath, dominated by *Juniperus communis* and *Rhododendron ferrugineum*.

The climate on Alp Flix is defined as inneralpine-continental (Hänggi & Müller 2001) with a snow-free period from May to the end of October. The temperature extremes in summer range from 0°C at night to 30°C at daytime and in winter from -20°C to ca. +15°C (Fig. 2). The snow cover ranges from a few centimetres to more than one meter.

Study period

The studies occurred from June 2002 to May 2004. Funnel traps (FUN) and nearby pitfall traps (PTF) were used from June 2002 to June 2003 (leg. A. H.), and pitfall traps (PTB) from May 2003 to May 2004 (coll. H. F.). The same timetable applied for the frame (FRS) and litter sampling (LIT) and the sweep netting (SWE), conducted during the snow free time of 2003 (coll. H. F.). During that time, spiders were collected by using branch eclectors (BRE), beatings (BEA) and restricted canopy fogging (RCF) (coll. A. B.). Hand samples (coll. H. F., A. B.) were also taken sporadically between May 2003 and May 2004 at the timberline (HST) and at nearby sites (HSS).

SAMPLING METHODS FOR SPIDERS ON TREES

Branch eclectors (BRE): The branch eclector traps are essentially constructed after Behre (1989) and Mühlenberg (1993). The traps were filled with formaldehyde (4 %); a tenside (liquid soap, non-perfumed) was added. Two eclectors were positioned on each of six Norway spruce trees between 110 cm and 430 cm above the ground. All branches sampled had a diameter of roughly 5 cm.

Beating (BEA): 84 branches were beaten 20 to 25 times at a distance between 80 cm and 500 cm from the ground. Each branch was sampled only once. The spiders were collected on a white umbrella (Ø: 85 cm) and transferred into ethanol 75 %.

Restricted Canopy Fogging (RCF): 36 branches were separately enclosed by robust transparent sealed plastic bags (height 150 cm; width 100 cm; volume approx. 400 l) at a height of up to 240 cm above ground. The bags were filled with CO_2. 20 minutes later, the branch was shaken and the bag removed. Each branch was sampled only once.

Further information on these methods is given in Bolzern & Hänggi (2005).

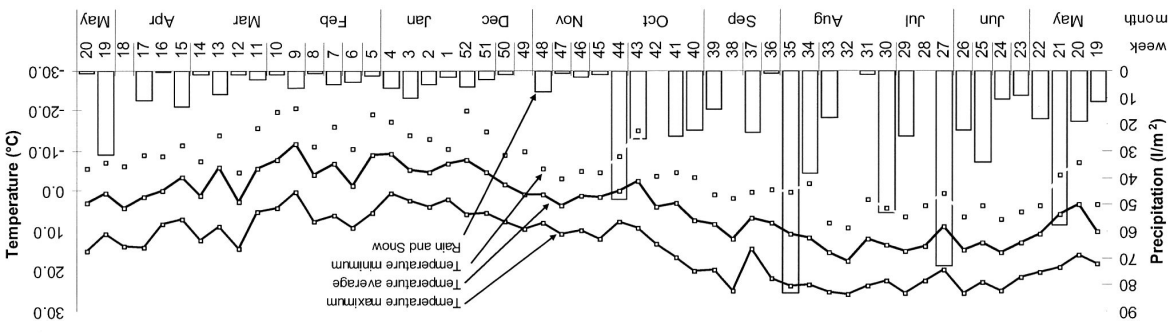

Fig. 2: Weather data of Radons (1870 m), opposite to Alp Flix on the other valley side. The data show average, minimum and maximum temperatures (in °C) and the total precipitation (bars, in l/m^2) per week from May 2003 to May 2004.

Sampling methods for ground dwelling spiders

Funnel traps (FUN): Plastic bottles (ca. 0.75 l) were used with a funnel (Ø: 15 cm) fixed on the top. At the lower end of the funnel, a wire-cross prevented small vertebrates from falling into the trap. The traps were covered by a plastic plate at 10 cm above the ground (Obrist & Duelli, 1996). Two funnel traps (filled with 4 % formaldehyde with a detergent) were installed in opposite corners of a rectangle of 2 x 3 m together with two pitfall traps (PTF) in the other corners that were of the same type as the PTBs described below.

Pitfall traps (PTB) at sites near the branch eclectors: White plastic cups with an upper diameter of 6.9 cm and a depth of 7.5 cm were filled with 4 % formaldehyde and 0.05 % SDS as tenside up to 3 cm under the rim. Quadrangular transparent plastic covers (15 x 15cm) were fixed at ca. 5 cm above the traps. Nine pitfall traps per tree were positioned around four trees of similar size (diameter ca. 5 m, height ca. 12 m) in three directions with three traps each. These trees were sampled with pitfall traps (PTB) and branch eclectors (BRE) exclusively.

Frame (FRS) and litter samples (LIT): Frames (FRS): Four trees were investigated per month without any additional sampling (except LITs) in the same month. Three samples of 22 x 22 cm (5 cm depth) per tree were cut out of the soil. All samples were taken in three different directions at random places under the branches. Specimens were extracted by a MacFadyen high-gradient funnel (MacFadyen 1962). The litter samples (LIT) were taken in the same way under the same trees, but only the litter layer was collected.

Sweep netting (SWE): The vegetation under four trees was sampled every month by sweep netting, without any additional sampling in the same month. Sampling was done ca. 2 m away from the tree trunk and at the outer border of the branch cover.

Determination

Specimens were determined mostly after Nentwig et al. (2003), Roberts (1985, 1987, 1995), and Wiehle (1956, 1960). Other literature used: Bosmans & de Smet (1993); Braun (1965); Buchar (1981); Buchar & Thaler (1995); de Blauwe (1973); Denis (1965); Grimm (1985, 1986); Hänggi (1989); Heimer & Nentwig (1991); van Helsdingen *et al.* (1977, 2001); Jantscher (2001); Knoflach (1992, 1996); Kronestedt (1990); Levi (1977); Locket *et al.* (1974); Logunov (1996); Logunov & Kronestedt (2003); Lugetti & Tongiorgi (1965, 1969); Miller (1967); Millidge (1975, 1979); Ovtsharenko *et al.* (1992); Pesarini (1996, 2000); Relys & Weiss (1997); Saaristo (1971); Snazell (1983); Szita & Samu (2000); Thaler (1969, 1970, 1971, 1972a, b, 1976, 1978a, b, 1981, 1983, 1987); Thaler & Buchar (1993); Tongiorgi (1966a, b); Wiehle (1937); Wunderlich (1972, 1980, 1985, 1986); Zabka (1997).

The nomenclature follows Platnick (2005) but the families are ordered alphabetically. The material is stored in the Natural History Museums of Bern and Basel.

RESULTS AND DISCUSSION

List of species

93 species from 13 families were found (Tab. 1, see Annex), including one species, *Maro lehtineni* newly discovered for Switzerland (Bolzern *et al.* 2005) and five species, *Evansia merens*, *Meioneta innotabilis*, *Moebelia penicillata*, *Obscuriphantes obscurus* and *Agroeca proxima* new for the Canton Grisons. Four species are endemic to the Alps, i.e. *Caracladus avicula*, *Scotinotylus clavatus*, *Tenuiphantes jacksonoides* and *Walckenaeria languida*. Another six species are classified as endemic to the European mountain system: *Erigonella subelevata*, *Arctosa renidescens*, *Pardosa blanda*, *Talavera monticola*, *Robertus truncorum* and *Xysticus macedonicus*. See Tab. 1 for a detailed list of all species.

Comments on first records, endemic and rare species and their phenology

Araneidae

Araniella displicata (Hentz, 1847)

Determination: Roberts (1985).

Comments: Only known locality of this species in Grisons (Hänggi 2000). All records in June.

Gnaphosidae

Drassodes cupreus (Blackwall, 1834)

Determination: Roberts (1995), Grimm (1985).

Comments: According to Thaler (1981, 2004), most high-altitude records of *D. lapidosus* should refer to *D. cupreus* (Blackwall, 1834). The species status of *D. lapidosus* and *D. cupreus* is under debate (e.g. Grimm 1985). See the detailed discussion by Bolzern & Hänggi (2006). Specimens were found between mid May and July.

Micaria aenea Thorell, 1874

Determination: Wunderlich (1980), Miller (1967).

Habitat: Most observations occurred in the subalpine belt between 1500 and 2000 m; in dry and sunny habitats; clearings, meadows, birch fen woods, coniferous forests, timberline and dwarf shrub heath (Hänggi *et al.* 1995; Muster 2001; Thaler 2004).

Distribution: Holarctic, eurosibirian (Thaler 2004); after Thaler (1997a; 1998; 2004) arctoalpine to boreomontane distribution.

Comments: Rarely found in Switzerland (Maurer & Hänggi 1990). The highest activity was observed in May and June (Fig. 3a).

Linyphiidae

Caracladus avicula (L. Koch, 1869)

Determination: Thaler (1969, 1972b).

Habitat: Subalpine belt; from subalpine coniferous forest up to the timberline (~1000–2000 m) (Thaler, 1999); epigeal (Maurer & Hänggi 1990); in forests and meadows (Hänggi *et al.* 1995; Muster 2001).

Distribution: Endemic to the Alps (Muster 2001; Thaler 1999).

Comments: Usually found only in small numbers. Diplochronous after Thaler

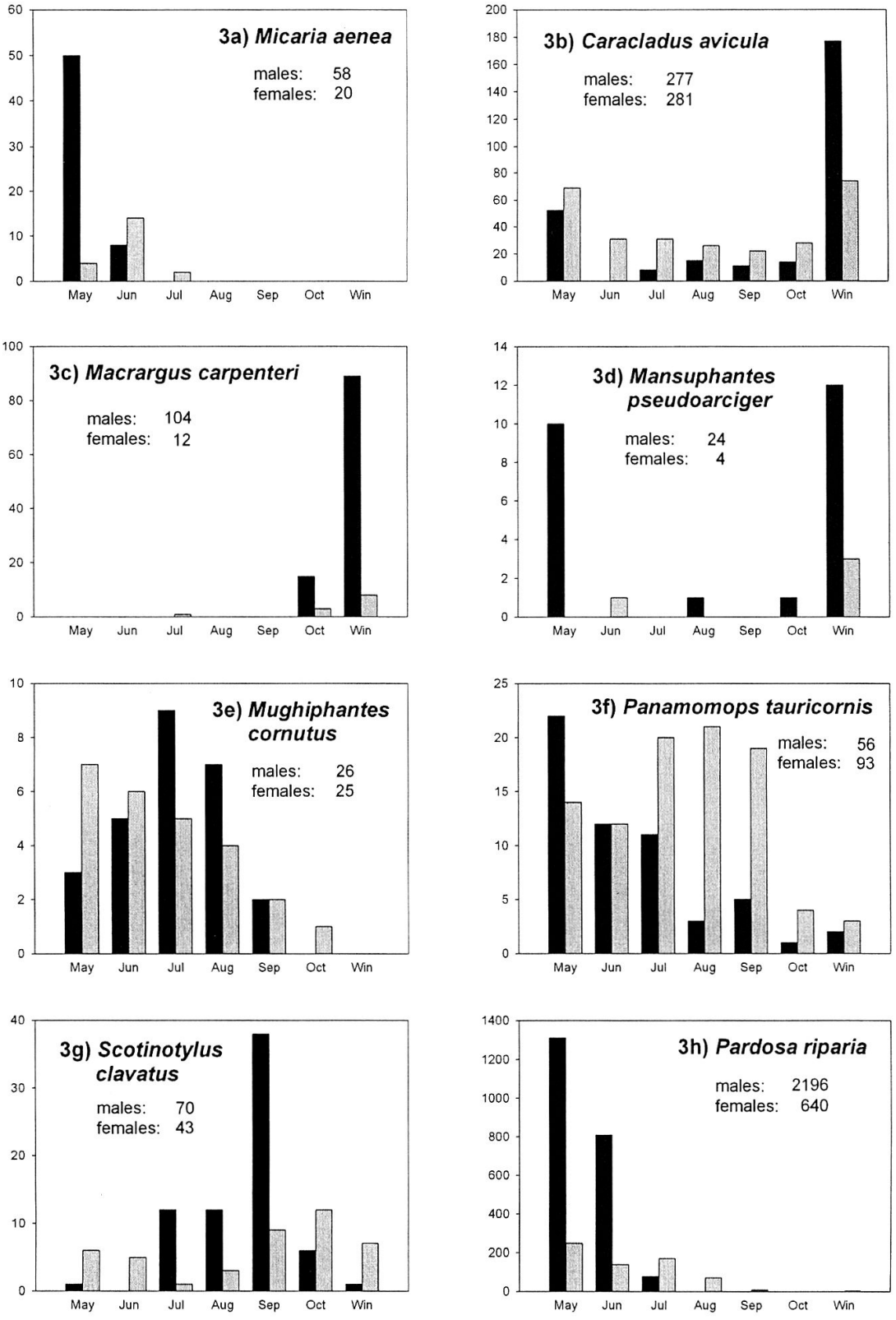

Fig. 3a-h: Phenologies of selected species for males (black) and females (grey) separately. The graphics are based on the data of Tab. 1 excluding the hand samplings. The sampling data were fit into the sampling periods of the pitfall traps (PTB). Abbreviations: May: 15. 05. 2003–14. 06. 2003; Jun: 14. 06. 2003–07. 07. 2003; Jul: 07. 07. 2003–04. 08. 2003; Aug: 04. 08. 2003–03. 09. 2003; Sep: 03. 09. 2003–28. 09. 2003; Oct: 28. 09. 2003–28. 10. 2003 and Win: 28. 10. 2003–24. 05. 2004.

(1999); however, main activity should be in lower altitudes between the end of March and mid May, in higher altitudes between June and September (Thaler 1972b). Muster (2001) found most of the specimens in June and July at similar sites. Here, the highest activity was observed between the beginning of November and mid June (Fig. 3b). So, the phenology of this species should be studied in more detail – on Alp Flix no diplochrony is detectable.

Evansia merens O. P.-Cambridge, 1900

Determination: Wiehle (1960).

Habitat: Myrmecophilous (Thaler *et al.* 1990); nidicolous in ant nests; mostly associated with ants from the *Formica fusca* group; sometimes under stones in dwarf shrub heath between 1900 and 2200 m (Thaler 1999).

Distribution: West-palaearctic, possibly extra-mediterranean (Thaler 1999).

Comments: First record for Grisons, second record for Switzerland after Schenkel's (1936) finding. We found two specimens in May at a site with a high abundance of *Formica* sp. Adults found during the whole year; most individuals found in autumn (Wiehle 1960).

Macrargus carpenteri O. P.-Cambridge, 1900

Determination: Wiehle (1956).

Habitat: Habitat preferences unclear; seems to be xerophilous (Thaler 1983). Thaler (1995b) found the species at the timberline and in the lower alpine zone (in dwarf shrubs and grass meadow); epigeal (Maurer & Hänggi 1990; Hänggi *et al.* 1995).

Distribution: Central Europe and West Siberia; the Alps mark the southern distribution border (Thaler 1995b).

Comments: *M. carpenteri* seems to be mature and active in winter (Thaler 1995b); we found males and females between the beginning of October and May exclusively (Fig. 3c). Our record is the second in Switzerland (Maurer & Hänggi 1990). A check of the material of *M. rufus* (Wider, 1834), a species that had formerly been confused with *M. carpenteri*, in the museums of Bern and Basel, revealed no misidentifications.

Mansuphantes pseudoarciger (Wunderlich, 1985)

Determination: Wunderlich (1985), Heimer & Nentwig (1991).

Habitat: montane; epigeal; in moderate humid moss of a *P. abies* forest. (Maurer & Hänggi 1990).

Distribution: Western Alps; France and Switzerland (Heimer & Nentwig 1991).

Comments: second observation in Switzerland, after Müller's (1985) finding; first record for Grisons. Adults were found nearly exclusively between November and early June (Fig. 3d). 70 % of all specimens in pitfall traps were caught in a range of about 1 m around tree trunks of *P. abies*.

Meioneta innotabilis O. P.-Cambridge, 1900

Determination: Roberts (1987).

Habitat: On bark of spruce (Muster 2001); from low altitudes up to the timberline (Thaler 1995b), also in cultivated spruce forests (Hänggi *et al.* 1995).

Distribution: Europe (Muster 2001).

Comments: One male between mid May and early June in branch eclector.

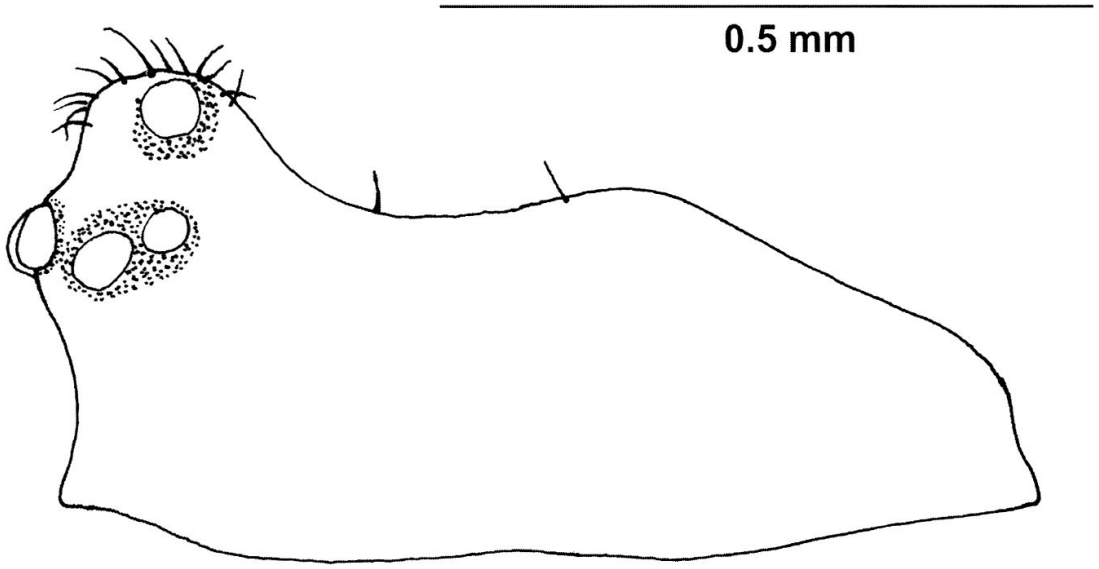

Fig. 4: Prosoma of male *Metopobactrus schenkeli* Thaler, 1976 from Alp Flix. Drawing by A. Bolzern.

First recorded observation for Grisons and first record since Schenkel (1923). He found males in June in a vegetable field close to Basel. Findings by Lessert (1907, 1910) were under tree bark of spruce trees in June in Bad Ragaz (St. Gallen) and Bex (Vaud).

Metopobactrus schenkeli Thaler, 1976

Determination: Thaler (1976), Hänggi (1989), Nentwig *et al.* (2003).

Habitat: In leaf litter of dwarf shrub heath and meadows (Maurer & Hänggi 1990).

Distribution: In the Swiss and Italian Alps, including northern Italy (Hänggi 1989; Platnick 2005) mostly in higher regions up to the nival zone (Maurer & Hänggi 1990). Findings in and around Venice (Thaler 1976; Hansen 1995) suggest that this species is also present in lower altitudes. Thaler (1976, 1978a) discusses the southern distribution of *M. schenkeli* and vicariance with *M. prominulus* (O. P.-Cambridge, 1872).

Comments: We found two males in funnel traps (FUN) in early July at the forest edge and one male in a pitfall trap (PTB) under *P. abies* in winter. The males of *M. schenkeli* differ from those of *M. prominulus* by the elevated head region (Fig. 4) and from those of *M. nadigi* Thaler, 1976 and *M. ascitus* (Kulczyński, 1894) by the shape of the tibia of the pedipalp and position of the trichobothria on metatarsi I and IV (position in our specimens: 0.8 on metatarsus I and between 0.8 and 0.82 on metatarsus IV).

Our record is from the drainage area of the river Rhine and is together with findings near Davos (Maurer & Walter 1984) the most northern one. So, *M. schenkeli* is more widely distributed than expected and could occur in sympatry with *M. prominulus*.

Mughiphantes cornutus Schenkel, 1927

Determination: Thaler (1972), Heimer & Nentwig (1991).

Habitat: Mainly distributed in subalpine forest between 1500 and 2000 m (Thaler 1995b); only a few specimens found in higher subalpine belt in the Alps (Thaler 1972a); epigeal; in forest litter (Maurer & Hänggi 1990).

Distribution: Boreo-montane/boreo-alpine and also in South Siberia (Thaler 1995b).

Comments: The main activity was observed between May and August, covering nearly the whole snow-free period (Fig. 3e). After Thaler (1972a) the species should be diplochronous. 85 % of all observed specimens from pitfall traps were caught directly at the tree trunk or in a range of about 1 m around the tree trunk of *P. abies*.

Panamomops tauricornis (Simon, 1981)

Determination: Wiehle (1960).

Distribution: Previously considered to be endemic to the Alps but recently also recorded from North Asia (Eskov 1994; Thaler 1999).

Comments: Rare species, diplochronous (Thaler 1995a). We found adult specimens all through the year with the main activity between mid May and end of July (Fig. 3f).

Porrhomma cf. campbelli O. P.-Cambridge, 1900

Determination: Thaler (1991), Roberts (1987).

Comments: Confusion with *P. pallidum* (22 males, 15 females in our sample) possible. Determination of one intermediate female uncertain. If this species is correctly identified, it would be the second recorded observation in Grisons (Maurer & Hänggi 1990).

Scotinotylus clavatus (Schenkel, 1927)

Determination: Thaler (1970).

Distribution: Endemic to the Alps with Nearctic twin species *Scotinotylus sacer* (Crosby, 1929) (Thaler 1999).

Comments: Diplochronous after Thaler (1999); females long-living and overwintering (Thaler 1995a); adults were observed in all months, males had the highest activity between July and September, diplochrony was not detectable. Females were equally common between September and mid June (Fig. 3g). Most specimens close to the tree trunks of *P. abies*.

Stemonyphantes conspersus (L. Koch, 1879)

Determination: Thaler (1983), Roberts (1987).

Comments: Second recorded observation in Switzerland and Grisons, first one by Maurer & Hänggi (1989); mainly active in winter (Muster 2001); most specimens were found between October and early June (Fig. 3h).

Tenuiphantes jacksonoides (van Helsdingen, 1977)

Determination: van Helsdingen *et al.* (1977).

Habitat: Subalpine spruce forest up to grass heath, 1500–2500 m (Thaler 1995b); more in open vegetation than in forests (van Helsdingen *et al.* 1977); epigeal (Maurer & Hänggi 1990);

Distribution: Narrow endemic of the Eastern Alps (Thaler 1995b; Muster 2001).

Comments: Second recorded observation in Grisons, first after van Helsdingen *et al.* (1977), third record for Switzerland. Adults are found from June to Sep-

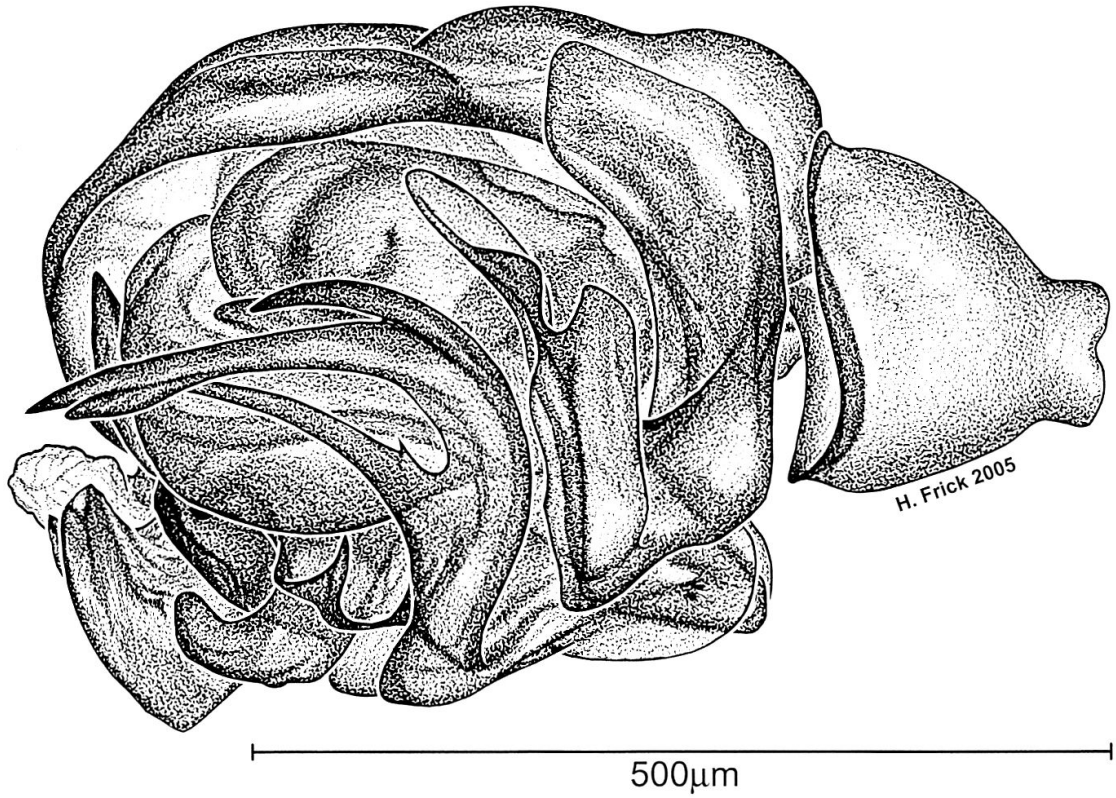

Fig. 5: Male palp of *Tenuiphantes jacksonoides* (van Helsdingen, 1979); prolateral view. Drawing by H. Frick.

tember (van Helsdingen *et al.* 1977). Our specimen is slightly different from the drawing of van Helsdingen *et al.* (1977); it lacks one process on the inner part of the lamella (Fig. 5). Apart from this, the male palp fits well to *T. jacksonoides*.

Lycosidae

Pardosa riparia (C. L. Koch, 1833)

Determination: Tongiorgi (1966a), Tongiorgi (1966b).

Habitat: In light forests of pine, spruce, and larch, with high grass below, up to 2000 m (Thaler 1995a; 1997a); epigeal; mostly humid meadows in higher altitudes (Maurer & Hänggi 1990; Hänggi *et al.* 1995); mountain pastures (Muster 2001).

Distribution: Palaearctic (Maurer & Hänggi 1990).

Comments: The eudominant species at the timberline of Alp Flix. The maximum activity occurred between mid May and July (Fig. 3h). Females displayed high variability in colour and shape of the epigyne. However, species specific traits according to Tongiorgi (1966a; b) were clearly visible.

Thomisidae

Xysticus audax (Schrank, 1803) / *X. macedonicus* Šilhavý, 1944

Determination: Jantscher (2001).

Habitat: *X. audax*: euryzonic forest species; dry and wet meadows; epigeal and arboricolous up to the dwarf shrub heath to ca. 2100 m, sometimes in open sites and above the timberline (Maurer & Hänggi 1990; Muster 2001; Thaler 1997b; 2004).

X. macedonicus: Euryzonic up to 2400 m, in the Alps up to 2160 m, thermophilous, open-land, alpine grass, debris, dry forests, mixed deciduous forests, epigeal (Kropf & Horak 1996; Thaler 1997b; Muster 2000).

Distribution: *X. audax* in Europe, Siberia, Asia Minor, Japan, Sachalin (Maurer & Hänggi 1990); *X. macedonicus* is endemic to the European mountain system (Muster 2001).

Comments: The females of *X. audax* can be easily confused with *X. macedonicus* and *X. cristatus* (Clerck, 1757). Several females appeared to be intermediate between *X. audax* and *X. macedonicus* and were counted as *X. audax*; however, one female clearly matched the drawings of *X. macedonicus* (Jantscher 2001). Males are mostly distinct (Jantscher 2001). Still, it seems that even after the elaborate work by Jantscher (2001) problems to distinguish these two species remain. *X. audax* and *X. macedonicus* occur syntopically but with different microhabitat preferences (Hänggi 2003; Muster 2000). Second record from Switzerland, first one also on Alp Flix (Hänggi 2003).

CONCLUSION

The timberline on Alp Flix has been shown to harbour a rich community of spider species with diverse ecological preferences, alpine-endemic species and faunistic rarities. Presumably, this is also true for other invertebrates. The spectrum of species covers only few generalists. There are equal numbers of forest and open-land species; together they comprise roughly 90 % of the species. 3 species can be classified as myrmecophilous. $^2/_3$ of the species are active during the vegetation period, 12 species (13 %) are winter-active and remarkably represent 27 % of the total number of individuals (the remaining species are active the whole year or are badly known in this respect).

24 % of the species and 76 % of the individuals were collected by pitfall traps exclusively (Tab. 1). This is most probably due to the fact that pitfall trapping was used more intensively than the other methods. So, the assessed fauna is clearly biased by the sampling method. Future studies and conservation efforts should pay special attention to the timberline - a major part of the invertebrate diversity of the region could possibly be maintained in this relatively small area.

ACKNOWLEDGEMENTS

We are deeply indebted to all the people who helped us during our field work, especially to Victoria Spinas (Sur, CH) for her support on the alp. Special thanks go to the «Schatzinsel Alp Flix» foundation and to Dr. Jürg Paul Müller (Chur, CH) who made available accommodation at the study site. The late Prof. Dr. Konrad Thaler (Innsbruck, A) kindly checked the determination of *Scotargus pilosus*, *Metopobactrus schenkeli* and *Tenuiphantes jacksonoides* which is greatly acknowledged. We are grateful to Theo Blick (Hummelthal, D) for important comments on an earlier version of the manuscript. For technical help, material and fruitful discussions we thank Dr. Denise Wyniger (Luzern, CH), Roland Mühlethaler (Basel, CH), Prof. Dr. Jürg Zettel (Bern, CH) and Alain Jacob (Bern, CH). We are also grateful to Gianni Savoldelli (Randons, CH) for the weather data and Halinka Lamparski (Perth, AUS) and Tristan Derham (Perth, AUS) for correcting the English of an earlier version of the manuscript. H.F. cordially thanks his parents for continuous help and support.

ZUSAMMENFASSUNG

Von Juni 2002 bis Mai 2004 wurden an der Waldgrenze auf Alp Flix (Schweiz, Graubünden, 1960 m) Spinnen um und auf einzeln stehenden Fichten (*Picea abies*) gesammelt. Dabei kamen verschiedene Methoden wie Barberfallen, Trichterfallen, Stech- und Gesiebeproben, Asteklektoren, CO_2-

Begasungen, Klopfschirme, Netzfänge und Handaufsammlungen zum Einsatz. 93 Arten wurden erfasst, darunter vier Endemiten der Alpen und sechs des Europäischen Gebirgssystems. Fünf Arten waren neu für den Kanton Graubünden: *Evansia merens*, *Meioneta innotabilis*, *Moebelia penicillata*, *Obscuriphantes obscurus* und *Agroeca proxima*.

Abgesehen von ein paar Generalisten konnten die meisten Arten entweder als Offenland- oder Waldarten klassifiziert werden. Beide Typen waren etwa gleich häufig. 13% der Arten (27% der Individuen) sind winteraktiv. Es konnte gezeigt werden, dass einzeln stehende Bäume der alpinen Übergangszone ein breites Spektrum von Habitaten für eine hohe Anzahl Spinnenarten bieten. Dies sollte in zukünftigen Schutz- und Forschungsprojekten berücksichtigt werden. Für einige Arten wurden Phänologien erstellt.

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(received September 14, 2005; accepted June 1, 2006)

Annex:
Tab. 1: List of all species found from June 2002 to May 2004 on Alp Flix (Grisons, Switzerland) with a variety of methods. Abbreviations: BRE: branch eclector; BEA: beating; RCF: restricted canopy fogging; FUN: funnel trap; PTF: pitfall traps near the funnel traps; PTB: pitfall traps under trees with branch eclectors; FRS: frame samples; LIT: litter samples; SWE: sweep nettings; HST: hand samples at the timberline; HSS: hand samples at nearby sites.

taxa	methods on branches			methods on the ground						hand sampling		m/f	total
	BRE	BEA	RCF	FUN	PTF	PTB	FRS	LIT	SWE	HST	HSS		
Amaurobiidae													
Coelotes terrestris (Wider, 1834)						1/0						1/0	1
Araneidae													
Aculepeira ceropegia (Walckenaer, 1802)										0/2	0/1	0/3	3
Araneus diadematus Clerck, 1757										0/2		0/2	2
Araneus quadratus Clerck, 1757										1/6	1/0	2/6	8
Araniella displicata (Hentz, 1847)		0/2								1/0		1/2	3
Parazygiella montana (C.L. Koch, 1834)	0/1										0/1	0/2	2
Dictynidae													
Dictyna arundinacea (Linnaeus, 1758)		3/3	0/5							2/5		5/13	18
Mastigusa arietina (Thorell, 1871)						0/3						0/3	3
Gnaphosidae													
Drassodes cupreus (Blackwall, 1834)				3/0		6/0						9/0	9
Drassodes pubescens (Thorell, 1856)				3/0		7/4						10/4	14
Gnaphosa leporina (L. Koch, 1866)				1/0	1/1	7/3						9/4	13
Haplodrassus signifer (C.L. Koch, 1839)				16/11	4/0	29/29						49/40	89
Micaria aenea Thorell, 1871				12/5	10/1	36/14						58/20	78
Micaria pulicaria (Sundevall, 1831)						0/2				1/0		1/2	3
Zelotes talpinus (L. Koch, 1872)				1/0		1/0				0/1		2/1	3
Hahniidae													
Cryphoeca silvicola (C.L. Koch, 1834)	15/7	0/4	0/1			141/59	0/2	0/2	1/1			157/76	233
Linyphiidae													
Agnyphantes expunctus (O. P.-Cambridge, 1875)	55/12	4/72	5/37			28/60			2/2	2/13	0/2	96/198	294
Agyneta cauta (O. P.-Cambridge, 1902)				4/0	2/0	32/11						38/11	49
Anguliphantes monticola (Kulczyński, 1881)						8/1						8/1	9
Bolephthyphantes index (Thorell, 1856)						2/5						2/5	7
Bolyphantes alticeps (Sundevall, 1833)				1/1	4/0	7/18			3/1			15/20	35
Bolyphantes luteolus (Blackwall, 1833)	0/1			5/3	11/4	113/89	0/1		1/5			130/103	233
Caracladus avicula (L. Koch, 1869)	0/1			11/10	5/8	251/219	10/34	0/7	0/1			277/280	557

taxa	methods on branches			methods on the ground						hand sampling		m/f	total
	BRE	BEA	RCF	FUN	PTF	PTB	FRS	LIT	SWE	HST	HSS		
Centromerus arcanus (O. P.-Cambridge, 1873)						3/0						3/0	3
Centromerus pabulator (O. P.-Cambridge, 1875)				4/0	11/0	75/31	1/4					91/35	126
Ceratinella brevis (Wider, 1834)						1/0						1/0	1
Erigone atra Blackwall, 1833											1/0	1/0	1
Erigonella subelevata (L. Koch, 1869)						9/6						9/6	15
Evansia merens O. P.-Cambridge, 1900						0/2						0/2	2
Gonatium rubens (Blackwall, 1833)				0/1		0/8	0/1					0/10	10
Improphantes nitidus (Thorell, 1875)						136/122	0/1	0/1				136/124	260
Lepthyphantes nodifer Simon, 1884						0/1						0/1	1
Macrargus carpenteri (O. P.-Cambridge, 1894)				1/0	5/0	98/12						104/12	116
Mansuphantes pseudoarciger (Wunderlich, 1985)						24/4						24/4	28
Maro lehtineni Saaristo, 1971				1/0		7/1						8/1	9
Meioneta innotabilis (O. P.-Cambridge, 1863)	1/0											1/0	1
Meioneta rurestris (C.L. Koch, 1836)				0/1								0/1	1
Metopobactrus schenkeli Thaler, 1976				2/0		1/0						3/0	3
Micrargus alpinus Relys & Weiss, 1997						3/2						3/2	5
Minicia marginella (Wider, 1834)							0/1					0/1	1
Moebelia penicillata (Westring, 1851)	0/1											0/1	1
Mughiphantes cornutus (Schenkel, 1927)						26/25						26/25	51
Mughiphantes mughi (Fickert, 1875)	3/1	0/3	1/3			5/4			3/2	7/8		19/21	40
Obscuriphantes obscurus (Blackwall, 1841)	1/0					1/0			0/1			2/1	3
Panamomops tauricornis (Simon, 1881)						46/37	4/34	6/22				56/93	149
Pelecopsis elongata (Wider, 1834)				0/1		208/150	2/5	3/4				213/160	373
Pelecopsis radicicola (L. Koch, 1872)				1/3	1/2	6/1	6/9					14/15	29
Pityohyphantes phrygianus (C.L. Koch, 1836)	0/2	0/10	0/4			2/1				1/13	0/1	3/31	34
Porrhomma cf. *campbelli* F.O. P.-Cambridge, 1894						0/4						0/4	4
Porrhomma pallidum Jackson, 1913						22/15						22/15	37
Scotargus pilosus Simon, 1913				1/2		5/2						6/4	10
Scotinotylus alpigena (L. Koch, 1869)						536/92	8/19	1/1	0/1			545/113	658
Scotinotylus clavatus (Schenkel, 1927)						69/20	1/20	0/3				70/43	113

taxa	methods on branches			methods on the ground						hand sampling		m/f	total
	BRE	BEA	RCF	FUN	PTF	PTB	FRS	LIT	SWE	HST	HSS		
Pityohyphantes phrygianus (C.L. Koch, 1836)	0/2	0/10	0/4			2/1				1/13	0/1	3/31	34
Porrhomma cf. *campbelli* F.O. P.-Cambridge, 1894						0/4						0/4	4
Porrhomma pallidum Jackson, 1913						22/15						22/15	37
Scotargus pilosus Simon, 1913				1/2		5/2						6/4	10
Scotinotylus alpigena (L. Koch, 1869)						536/92	8/19	1/1	0/1			545/113	658
Scotinotylus clavatus (Schenkel, 1927)						69/20	1/20	0/3				70/43	113
Stemonyphantes conspersus (L. Koch, 1879)	14/2	2/3	0/2	1/0		8/5						25/12	37
Tapinocyba affinis Lessert, 1907				1/0	0/1	177/46	30/116	2/6				210/169	379
Tenuiphantes cristatus (Menge, 1866)						2/5						2/5	7
Tenuiphantes jacksonoides (van Helsdingen, 1977)						1/0						1/0	1
Tenuiphantes mengei (Kulczyński, 1887)				1/6	2/0	18/15			0/1			21/22	43
Tenuiphantes tenebricola (Wider, 1834)						4/2			1/0			5/2	7
Thyreostenius biovatus (O. P.-Cambridge, 1875)				0/1		0/9						0/10	10
Walckenaeria antica (Wider, 1834)				1/0		15/2						16/2	18
Walckenaeria languida (Simon, 1914)						0/1						0/1	1
Walckenaeria mitrata (Menge, 1868)						0/1						0/1	1
Walckenaeria monoceros (Wider, 1834)						1/0						1/0	1
Liocranidae													
Agroeca proxima (O. P.-Cambridge, 1871)				2/0		4/0						6/0	6
Lycosidae													
Alopecosa accentuata (Latreille, 1817)				2/0	1/0							3/0	3
Alopecosa pulverulenta (Clerck, 1757)				17/4	9/2	40/16				2/0		68/22	90
Alopecosa taeniata (C.L. Koch, 1835)				119/17	24/6	303/43		0/1	0/1	3/2		449/70	519
Arctosa renidescens Buchar and Thaler, 1995				11/1	14/4	28/17						53/22	75
Pardosa blanda (C.L. Koch, 1833)				49/9	7/1	41/27				2/9	1/1	100/47	147
Pardosa ferruginea (L. Koch, 1870)				0/1								0/1	1
Pardosa mixta (Kulczyński, 1887)										3/19	0/1	3/20	23
Pardosa riparia (C.L. Koch, 1833)				257/95	104/35	1835/510				36/70	2/1	2234/711	2945
Pirata piraticus (Clerck, 1757)											0/1	0/1	1
Trochosa terricola Thorell, 1856						1/0						1/0	1

taxa	methods on branches			methods on the ground						hand sampling		m/f	total
	BRE	BEA	RCF	FUN	PTF	PTB	FRS	LIT	SWE	HST	HSS		
Philodromidae													
Philodromus cespitum (Walckenaer, 1802)	4/0	0/2										4/2	6
Philodromus collinus C.L. Koch, 1835						1/0						1/0	1
Philodromus vagulus Simon, 1875	2/2					0/1					0/1	2/4	6
Thanatus formicinus (Clerck, 1757)				0/1	2/0	18/1				0/1		20/3	23
Salticidae													
Evarcha arcuata (Clerck, 1757)											1/0	1/0	1
Salticus scenius (Clerck, 1757)											2/2	2/2	4
Talavera monticola (Kulczyñski, 1884)							0/1					0/1	1
Sparassidae													
Micrommata virescens (Clerck, 1757)	2/0		0/1			1/1					1/0	4/2	6
Theridiidae													
Achaearanea ohlerti (Thorell, 1870)			0/2							0/2		0/4	4
Robertus truncorum (L. Koch, 1872)				1/0	1/0	20/12	0/10	1/0				23/22	45
Steatoda phalerata (Panzer, 1801)						1/0						1/0	1
Theridion impressum L. Koch, 1881		0/1	3/1							3/17	0/2	6/21	27
Thomisidae													
Ozyptila atomaria (Panzer, 1801)				1/0								1/0	1
Xysticus audax (Schrank, 1803)	3/1	1/0		2/1	1/0	12/3			0/1	0/1		19/7	26
Xysticus bifasciatus C.L. Koch, 1837											1/0	1/0	1
Xysticus gallicus Simon, 1875						1/0					0/1	1/1	2
Xysticus luctuosus (Blackwall, 1836)				5/0		8/0						13/0	13
Xysticus macedonicus äilhavy, 1944			0/1									0/1	1
number of individuals **m/f**	100/31	10/100	9/57	537/174	219/65	4492/1774	62/258	13/47	11/17	64/171	10/15	5527/2709	
total	131	110	66	711	284	6266	320	60	28	235	25		8236
number of species	15	10	10	37	21	69	15	10	12	19	17		93
number of exclusive species per method	2	0	1	3	0	22	2	0	0	1	3		34