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EARLY SUCCESSION OF A BOREAL SPIDER COMMUNITY AFTER FOREST FIRE

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ABSTRACT. Ground-living spiders were studied, using pitfall traps, 3–4 months after a wildfire, and then during three post-fire summers. The study area was a pine (*Pinus sylvestris*) forest in southwestern Finland. Lycosidae dominated in individual numbers at the burned site and Linyphiidae at the control. In species numbers, Linyphiidae dominated at both sites, and Lycosidae, Gnaphosidae and Theridiidae were more species-rich at the burned than control site. The lycosid *Xerolycosa nemoralis* was dominant at the burned site, and the linyphiid *Agyneta cauta* at the control. Abundant species found only at the burned site included *Xerolycosa nemoralis*, *Pardosa riparia*, *Acantholycosa lignaria* and *Micaria silesiaca*. *Tapinocyba pallens* and *Pardosa lugubris* occurred at both sites in large numbers. A slight positive effect of fire on the species richness was found. Species with more or less stable abundance at the burned site during the study period included *Pardosa riparia*, *P. lugubris* and *Diplostyla concolor*. Increasing abundance in successive years occurred for *Acantholycosa lignaria*, *Micaria silesiaca*, *Xerolycosa nemoralis* and for the family Lycosidae. *Euryopis flavomaculata*, *Agyneta rurestris*, *Tapinocyba pallens* and the family Linyphiidae showed a decreasing abundance during the study years. The spider community at the burned site remained clearly different compared to the control during three post-fire summers, primarily caused by the abundance of Gnaphosidae and Lycosidae.

Keywords: Araneae, ground-living spiders, post-fire succession, pine forest, Finland

Intensive and regular fires are a natural part of the ecology in many areas and have an effect on the fauna in those habitats. This is well-known in the Mediterranean-type of ecosystems (e.g., Stamou 1998; Moretti et al. 2004). But in the boreal taiga forest zone of the Holarctic, fires occur normally at long intervals, and the fauna living there is less adapted to the fires.

Forest fires are rare and small in Finland, mainly due to active fire control. The situation contrasts clearly with that in the boreal coniferous forest zone both in Russia and Canada where extensive areas of forest are yearly destroyed by fire (e.g., Koponen 1993). Therefore, little information is available on the effects of forest fire on spiders and their post-fire succession in Finland or in the whole of Fennoscandia. In Finland, Huhta (1971) studied succession after prescribed burning, and Koponen (1988, 1989, 1995) studied the effects of natural fire in a subarctic birch woodland in Finnish Lapland. Some data on the first post-fire summer at the present study site have been given by Koponen (2004). Hauge & Kvamme (1983) studied spiders from forest fire areas in Norway. In the present paper, the post-fire succession of ground-living spiders in a boreal forest in southwestern Finland is explored.

METHODS

The study area is situated in Tammela, Riihivalkama, east of the Torronsuo National Park (Finnish Grid 27°E: 6740:323); ca. 60°44′N, 23°45′E. The study site is a dry gentle slope with young pine (*Pinus sylvestris*) trees, diameter 20 cm or less.

The forest (about 150 hectares) was burned on 9–10 June 1997. It was totally burned: all moss and lichen as well as vascular plant vegetation was destroyed. The dead pines were still standing there in autumn 1997, but they were cut down and removed in May 1998. Under the 2–5 mm thick layer of ash and charcoal there was a humus layer, but locally only mineral soil. The black and open site was sunny, dry and warm, especially during the first post-fire year. The distance from non-burned forests to the study site was at least 150 m.

Ground living spiders were studied 3–4 months after the fire, in order to find colonizers or species which had survived the fire. Twenty-four pitfall traps with ethylene glycol

Table 1.—Ground and field layer vegetation around the traps at burned and control sites in Tammela, Finland. New plant species appearing at different stages of the succession are indicated by +.

Burned site	Coverage %	Plant species
1997 September	<1%	–
1998 May	<1%	–
July	10%	*Epilobium angustifolium*, *Ceratodon* moss
September	20%	
1999 May	30%	+*Luzula* + *Calluna vulgaris*
July	50%	
September	55%	
2000 May	60%	+*Deschampsia*
August	80%	+*Rubus idaeus*
Control site	100%	*Pleurozium* and *Dicranum* moss, *Linnaea borealis, Trientalis europea*, *Vaccinium vitis-idaea*, *V. myrtillus* etc, and *Pinus sylvestris*

and detergent (mouth diameter 60 mm, with covers) were placed there from 12 September–17 October 1997. During the following three summers, 10 similar traps were placed in the burned site and 10 in a control site about 300 m from the fire. Coverage of the ground and field layer vegetation was estimated visually around the traps (Table 1). There is no information available of the previous fire history of the study area. The climatic conditions varied during the study years; the summer 1998 was cool and rainy, 1999 was warm, and 2000 near the average.

The yearly study periods were: 9 May–27 September 1998; 15 May–28 September 1999; 14 May–10 August 2000. We removed the traps in August 2000 due to interference by people visiting the site. The spider material, deposited on the Zoological Museum, University of Turku, consisted of about 1100 identifiable specimens from the burned and 1540 from the control site. Nomenclature is mainly after Platnick (2004), except *Agyneta*/*Meioneta*.

RESULTS

Altogether 91 species of ground-living spiders were found, 70 at the burned site and 59 at the unburned control site. The family Linyphiidae clearly dominated in species numbers.

Post-fire autumn.—The spiders were trapped 3–4 months after the fire in autumn 1997. Altogether, 16 species were found during this short, autumnal collecting period. *Tapinocyba pallens* (O.P.-Cambridge 1872) clearly dominated (25.0%), and *Tenuiphantes mengei* (Kulczynski 1887) (13.6%) and *Agyneta rurestris* (C.L. Koch 1836) (11.4%) were also abundant. *Agroeca proxima* (O.P.-Cambridge 1871), *Pardosa lugubris* (Walckenaer 1802), *Trochosa terricola* Thorell 1856, *Porrhomma pallidum* Jackson 1913, *Gnaphosa bicolor* (Hahn 1833) and *Haplodrassus signifer* (C.L. Koch 1839) were represented by at least two specimens. Linyphiids were the dominant spider family in terms of individuals (Table 2) and half of the species caught were linyphiids. For a more detailed description of the results from the autumn 1997, see Koponen (2004).

Following summers.—The general composition of the spider assemblages at the burned and control sites is shown in Table 2. Linyphiids dominated in the number of species, at both the control site as well as at the burned site, during the study years. Species numbers of Lycosidae, Gnaphosidae and Theridiidae were higher at the burned than the control site. Faunal similarity, as percentage of species found at both sites, in 1998, 1999 and 2000 was 28%, 35% and 25% respectively. The situation in 2000 was somewhat biased by the destroyed traps at the burned site (see above). There were no great differences in the yearly species richness between the sites; however, during the 1998 and 1999 summers, more species were found at the burned site: 39 vs. 35 and 51 vs. 46 respectively (Table 2).

The family Linyphiidae was dominant in individual numbers at the control site (69.6–86.7%) during the whole study period, and

Table 2.—Family composition of individuals (%) and species (no. of species) of the spider fauna at the burned (bu) and control (co) sites, 1997–2000. Trapping periods: 12 September–17 October 1997, 9 May–27 September 1998, 15 May–28 September 1999, 14 May–10 August 2000.

	1997	1998		1999		2000	
	bu	bu	co	bu	co	bu	co
Individuals							
Linyphiidae	75.4	59.4	86.7	29.0	82.9	15.9	69.6
Lycosidae	10.8	32.5	2.3	64.8	8.5	62.0	18.7
Gnaphosidae	6.2	2.2	1.1	3.1	0.7	20.9	3.0
Theridiidae	1.5	4.3	1.4	2.1	1.4	0.9	0.4
Others	6.2	1.6	8.5	1.0	6.5	0.3	8.3
Species							
Linyphiidae	8	21	22	22	29	9	24
Lycosidae	3	7	2	8	4	6	3
Gnaphosidae	2	4	2	7	2	6	4
Theridiidae	1	3	1	4	1	4	2
Others	2	4	8	10	10	5	12
Total	16	39	35	51	46	30	45

also at the burned site during early succession (1997–98) while Lycosidae dominated at the burned site during the two following summers (1999–2000: 62.0–64.8%) (Table 2). No trend was found in catches (#individuals/trap/day) between the sites; in 1998 and 2000 more specimens were caught at the burned and in 1999 at the control site (Table 2).

The most abundant species at both sites, 1998–2000, are shown in Tables 3–4. The lycosid *Xerolycosa nemoralis* (Westring 1861) was the dominant species at the burned site during the whole period (Table 3). *Pardosa riparia* (C.L. Koch 1833), *P. lugubris* and *Alopecosa pulverulenta* (Clerck 1957) (Lycosidae), and *Diplostyla concolor* (Wider 1834) (Linyphiidae) were also abundant, 1998–2000. *Euryopis flavomaculata* (C.L. Koch 1836) and *Agyneta rurestris* were abundant during the first post-fire summer (1998) but later they were less numerous. *Tapinocyba pallens* had a similar but less clear trend. On the other hand, *Micaria silesiaca* L. Koch 1875 and *Acantholycosa lignaria* (Clerck 1757) were trapped in good numbers during the latter summers (1999–2000).

At the control site, the composition of abundant linyphiid species was rather stable during the study years (1998–2000), see Table 4. In contrast to the burned site with lycosids dominating, here linyphiids were most numerous. They were represented primarily by the species *Agyneta cauta* (O.P.-Cambridge 1902), *Tapinocyba pallens*, *Centromerus arcanus* (O.P.-Cambridge 1873) and *Agyneta conigera* (O.P.-Cambridge 1873). These were followed, based on total abundance, by the lycosids *Pardosa lugubris*, which was, however, caught in low numbers during the first summer, and *Alopecosa aculeata* (Clerck 1757). Typical species at the control site were also the linyphiids *Diplocentria bidentata* (Emerton 1882), *Walckenaeria antica* (Wider 1834), *W. cucullata* (C.L. Koch 1836), *Minyriolus pusillus* (Wider 1834), *Tenuiphantes alacris* (Blackwall 1853), *T. tenebricola* (Wider 1834), and *Bathyphantes parvulus* (Westring 1851). From other families, *Zora nemoralis* (Blackwall 1861), *Z. spinimana* (Sundevall 1833), *Haplodrassus soerenseni* (Strand 1900) and *Cryphoeca silvicola* (C.L. Koch 1834) can be mentioned.

Abundant species found only at the burned site included *Xerolycosa nemoralis*, *Pardosa riparia*, *Acantholycosa lignaria*, *Micaria silesiaca*, *Phrurolithus festivus* (C.L. Koch 1835) and *Agyneta rurestris*; and *Tapinocyba pallens* and *Pardosa lugubris* were found at both sites. Faunistically interesting species at the burned site included *Agyneta gulosa* (L. Koch 1869) (a northern species in Finland), and *Troxochrota scabra* Kulczynski 1894 and *Troxochrus nasutus* Schenkel 1925 (rare, mainly southern species).

Table 3.—The most abundant spiders trapped at the burned site, 1998–2000. Number of individuals (n), percentage and rank (only for the 10 most abundant in each year) are given.

	1998			1999			2000		
	n	%	Rank	*n*	%	Rank	*n*	%	Rank
Xerolycosa nemoralis	29	11.9	(1)	92	20.4	(1)	103	36.8	(1)
Tapinocyba pallens	27	11.2	(2)	36	8.0	(4)	2	0.5	
Alopecosa pulverulenta	25	10.3	(3)	36	8.0	(4)	4	1.1	(10)
Pardosa riparia	24	9.9	(4)	71	15.8	(2)	34	12.1	(2)
Euryopis flavomaculata	21	8.7	(5)	8	1.8		1	0.3	
Agyneta rurestris	16	6.6	(6)	9	2.0	(10)	3	0.8	
Pardosa lugubris	15	6.2	(7)	21	4.7	(6)	19	6.8	(4)
Centromerus arcanus	9	3.7	(8)	2	0.4		—		
Diplostyla concolor	8	3.3	(9)	42	9.3	(3)	10	3.6	(6)
Tenuiphantes mengei	7	2.9	(10)	10	2.2	(9)	—		
Micaria silesiaca	—			11	2.4	(7)	26	9.3	(3)
Walckenaeria antica	2	0.8		11	2.4	(7)	9	2.4	(7)
Acantholycosa lignaria	—			4	0.9		18	6.4	(5)
Gnaphosa bicolor	2	0.8		1	0.2		8	2.1	(8)
Phrurolithus festivus	—			2	0.4		7	1.9	(9)

DISCUSSION

The number of species caught 3–4 months after the fire was rather high, although the trapping period was short (see also Koponen 2004). This can, at least partly, be a result of the number of traps in 1997 (24 vs. 10 in following summers). Whether some of the species had survived the fire is unknown. Some stationary invertebrates (gastropods, millipedes, female coccids) were also caught in the traps during the autumn of 1997. These seem to have survived under large stones or in the soil (see also Punttila et al. 1994), the same may be true for some spiders. On the other hand, silk lines were seen in great numbers on the burned ground indicating ballooning.

Pioneer species at the burned site are *Agyneta* species (subgenus *Meioneta*), e.g. *A. rurestris*, which was caught in highest numbers among the pioneer species, as well as *Erigone atra* Blackwall 1833 and *Oedothorax retusus* (Westring 1851) (cf. Merrett 1976; Winter et al. 1983; Koponen & Niemelä 1994). None of them was found at the control site.

The dominant species at the burned site, *Xerolycosa nemoralis*, has been found in Finland as a colonizer of open, dry and warm areas, often human-influenced. These areas include dried peat bogs (Koponen 1979) and heavily polluted areas (Koponen & Niemelä 1994). In a study of burned pine forests in northern Germany, Schaefer (1980) found *X. nemoralis* in high numbers in young pine plantations but not at the burned sites, where *Pardosa lugubris* dominated among lycosids. *Pardosa lugubris* was one of the most abundant species both at the burned and control site in Tammela.

Pardosa riparia, *Acantholycosa lignaria*, *Micaria silesiaca* and *Phrurolithus festivus*, species found only at the burned site, have often been caught in open areas (e.g., Hänggi et al. 1995; Marusik et al. 2004). Species preferring open and warm areas, like many lycosids, have often been caught in high numbers at burned localities (Brabetz 1978; Schaefer 1980; Koponen 1993, 2004; Buddle et al. 2000). Niwa & Peck (2002) studied the influence of prescribed fire on spiders in conifer stands in Oregon and found, in agreement with the present study, that Lycosidae and Gnaphosidae were more numerous at burned and Linyphiidae at unburned sites.

A slight positive effect of fire on the species richness could be seen (cf. also Moretti et al. 2004). The species-rich fauna at the burned site was a combination of pioneer species (e.g., *Agyneta rurestris*, *Oedothorax retusus*), of thermophilous (*Xerolycosa nemoralis*, *Micaria silesiaca*) and eurytopic (*Diplostyla concolor*) species often preferring open sites, and of some typical pine forest species (*Tapinocyba pallens*, *Centromerus arcanus*). On the other hand, both species and individual

Table 4.—The most abundant spiders trapped at the control site, 1998–2000. Number of individuals (n), percentage and rank (only for the 10 most abundant in each year) are given.

	1998			1999			2000		
	n	%	Rank	*n*	%	Rank	*n*	%	Rank
Centromerus arcanus	44	16.1	(1)	70	8.8	(4)	21	5.6	(6)
Tapinocyba pallens	43	15.8	(2)	77	9.7	(3)	22	5.9	(5)
Agyneta cauta	20	7.3	(3)	158	20.0	(1)	56	14.9	(1)
A. conigera	17	6.2	(4)	86	10.9	(2)	24	6.4	(4)
Diplocentria bidentata	13	4.8	(5)	10	1.3		11	2.3	(8)
Walckenaeria antica	13	4.8	(5)	18	2.3		6	1.3	
Diplostyla concolor	11	4.0	(7)	20	2.5	(7)	8	1.7	(10)
Zora nemoralis	11	4.0	(7)	4	0.5		2	0.4	
Bathyphantes parvulus	9	3.3	(9)	9	1.1		1	0.2	
Tenuiphantes tenebricola	9	3.3	(9)	18	2.3		6	1.3	
Pardosa lugubris	4	1.5		44	5.6	(5)	51	13.6	(2)
Alopecosa aculeata	8	2.9		15	1.9		29	7.7	(3)
Minyriolus pusillus	7	3.6		30	3.8	(6)	8	1.7	(10)
Walckenaeria cucullata	8	2.6		19	2.4	(8)	8	1.7	(10)
Tenuiphantes alacris	5	1.8		19	2.4	(8)	6	1.3	
Cryphoeca silvicola	5	1.8		19	2.4	(8)	4	0.8	
Zora spinimana	1	0.4		—			12	2.5	(7)
Haplodrassus soerenseni	2	0.7		5	0.6		11	2.3	(8)

numbers outside of the four main families (Linyphiidae, Lycosidae, Gnaphosidae and Theridiidae) were higher at the control than at the burned site (see Table 2), indicating a generally more diverse fauna in the unburned forest.

Some general trends in the spider assemblage at the burned site could be found during the study years. Species with more or less stable abundance at the burned site include *Pardosa riparia*, *P. lugubris* and *Diplostyla concolor*. Increasing abundance in successive years was true for *Acantholycosa lignaria*, *Micaria silesiaca*, *Xerolycosa nemoralis* and for the family Lycosidae. On the other hand, *Euryopis flavomaculata*, *Agyneta rurestris*, *Tapinocyba pallens* and the whole Linyphiidae showed decreasing numbers during the study years. The spider community at the burned site remained clearly different compared with the control during the study period's three post-fire summers. This was primarily caused by the species diversity and abundance of Gnaphosidae and Lycosidae.

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