BOLL. ACC. GIOENIA SCI. NAT.	Vol. 26	n. 345	pp. 221-226	Catania 1993

Ground-living spiders in a polluted pine forest, SW Finland

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RIASSUNTO

Mediante trappole a caduta, sono stati studiati i ragni viventi sul suolo di una foresta di pino della Finlandia Sud-occidentale, lungo un gradiente di inquinamento.

Non sono state trovate significative differenze nel numero di specie per trappola lungo il gradiente (0.5, 3, 5, 9 km dalla fonderia), mentre esistono grandi differenze nella composizione delle specie tra i siti più inquinati e gli altri.

I *Lycosidae* risultano dominanti (57-80% degli individui), con *Xerolycosa nemoralis* più abbondante (78%) nei luoghi più inquinati e *Alopecosa aculeata* (43-76%), più frequente altrove.

Alcuni Linifidi pionieri (*Oedothorax apicatus, Erigone atra, Agyneta rurestris*) sono stati trovati solo nei siti più inquinati.

Parole chiave: Ragni, *Araneae*, Inquinamento, Foresta.

SUMMARY

Ground-living spiders were studied in a dry pine forest, using pitfall traps, along a pollution gradient in SW Finland. No statistical difference was found in spider numbers/trap along the pollution gradient (0.5, 3, 5, 9 km from smelter). Great differences were found in species composition, especially between the most polluted site and the others. The changes in coverage of the ground layer vegetation seemed to explain the faunal differences. *Lycosidae* dominated in the material (57-80% of indivs.), the most abundant species at the most polluted site was *Xerolycosa nemoralis* (78%), while at other sites *Alopecosa aculeata* was most abundant (43-76%). Some pioneer linyphids (*Oedothorax apicatus, Erigone atra, Agyneta rurestris*) were found at the most polluted site only.

Key words: Spiders, *Araneae*, Pollution, Forest.

Introduction

The industrial town of Harjavalta, with a smelter and a fertilizer factory is one of the most polluted forest areas of Finland. The yearly emission up until 1991 was 1000 tn, and after that 250 tn; high concentrations of heavy metals and other pollutants, especially Cu, Ni and Cr, were found in moss samples from the forest floor (JUSSILA & JORMALAINEN, 1991). A consequence of the long-term pollutent emission has been the dramatic destruction of pine forest in the surroundings of the factories.

The effect of pollution on certain tree-dwelling invertebrates has been studied previously in Harjavalta (e.g. HELIÖVAARA *et al.*, 1987; HELIÖVAARA & VÄISÄNEN, 1989; JUSSILA *et al.*, 1991). Nothing is known about the effect of pollution on the ground-living arthropod fauna in the area.

Study area, material and methods

The study area is situated in Harjavalta (about 61° 20' N, 22° 15' E); approximately 25 km SE of the city of Pori. There are two factories, producing copper & nickel and sulphuric acid & fertilizers, the first mentioned smelter being the main pollutor. The main pollutants are Cu, Ni, Cr, Cd, Pb & SO_2, others include Fe, Zn, V, As, Hg, Al (JUSSILA & JORMALAINEN, 1991).

Dry pine forests (*Calluna* and *Vaccinium* types), belonging to the boreal forest zone, were studied. Young 6-12 m tall *Pinus sylvestris* trees are growing on sandy soil; site I is 0.5 km, II 3 km, III 5 km, and IV 9 km from the smelter.

Ground layer vegetation (data from SALEMAA & VANHA-MAJAMAA, 1993): I) Black needle litter, barren sand spots, almost without vegetation (ground layer coverage 2 %); II) Needle litter, *Cetraria* lichens, no moss, vasculars: *Vaccinium*, *Empetrum* (ground layer coverage 37 %); III) *Cladonia* & *Cetraria* lichens, no moss, vasculars: *Vaccinium*, *Empetrum*, *Calluna* (ground layer coverage 74 %); IV) *Cladonia* & *Cetraria* lichens, *Pleurozium* moss, vasculars: *Vaccinium*, *Calluna*, *Deschampsia* (ground layer coverage 94 %).

At site I pines are dying and at site II they are suffering damage. Although little visible effect of pollution on vegetation could be seen at site(s III-)IV, the heavy metal concentration there is also markedly

higher than an average for Finnish forests (JUSSILA & JORMALAINEN, 1991).

The study period was 9 July - 19 August, 1992, and the collecting method pitfall trapping (20-36 traps/site). The diameter of the traps was 6 cm, the preservative ethylene glycol, and the traps were provided with covers. Because the activity peak of many wandering spiders (especially *Lycosidae* males) is in early summer, the present material probably does not include accidental wandering species. The material consists of ca. 1700 specimens.

Results

No statistically significant difference was found, along the distance (or pollution) gradient, in individual numbers/trap (Table 1). *Lycosidae* dominated at all sites (57-80% of individuals); other families with a high proportion were *Linyphiidae* (s.lat.) and *Gnaphosidae* (Table 2). No trend in family structure was found along the pollution gradient.

Table 1. Individual numbers (ind./trap: mean ± S.E.) of spiders along the pollution gradient in Harjavalta; 9 July - 19 August 1992.

Sites:	I	II	III	IV
Distance km:	0.5	3	5	9
Araneae	15.6 ± 3.01	10.8 ± 1.57	18.4 ± 2.58	15.7 ± 1.75

Table 2. Proportion (%) of main families (of individuals) along the pollution gradient in Harjavalta; 9 July - 19 August 1992.

Sites:	I	II	III	IV
Distance km:	0.5	3.0	5.0	9.0
Lycosidae	77.8	57.0	80.3	62.0
Linyphiidae (s. lat.)	14.3	20.3	9.6	25.9
Gnaphosidae	6.0	16.6	8.6	5.7
Others	1.9	6.1	1.5	6.4
No. of families	7	7	7	9

Altogether, 51 species of 11 families were collected. The species number/site varied between 11 (site I where number of linyphid species was low, particularly) and 36 (IV). Two lycosid species dominated, *Xerolycosa nemoralis* at the most polluted site (I: 78%) and *Alopecosa*

aculeata at other sites (43-76%) (Table 3). Other lycosids, *Pardosa lugubris* and *Trochosa terricola* were found only at less polluted sites (II-IV).

In addition to the xero- and photophilous lycosid *Xerolycosa nemoralis*, three "pioneer" linyphid species *Oedothorax apicatus*, *Erigone atra* and *Agyneta rurestris* were found at site I (these linyphids only there). Typical forest floor linyphids (e.g. *Tapinocyba pallens*, *Silometopus elegans*, *Walckenaeria antica* and *W. atrotibialis*) were not caught at site I. Only a few species (e.g. *Zelotes petrensis*) occurred more or less equally at all sites. Sixteen species of the 51 found, included in Table 3, comprises 84% of individuals caught.

In general, the coverage of ground vegetation (varying from 2% to 94%) seems to explain the structure of spider fauna found along the pollution gradient.

Table 3. Proportion (%) of spider species along the pollution gradient in Harjavalta; 9 July - 19 August, 1992.

Sites:	I	II	III	IV	
Distance km:	0.5	3	5	9	
% Ind.	%	%	%	%	
					Total ind.
Xerolycosa nemoralis	77.5	10.5	1.8	0.2	288
Alopecosa aculeata	0.3	42.9	76.6	55.7	865
Pardosa lugubris	-	2.7	1.2	0.9	20
Trochosa terricola	-	1.0	0.6	5.4	30
Zelotes petrensis	2.9	4.4	4.4	0.5	53
Zelotes clivicolus	-	4.1	0.8	0.2	18
Haplodrassus signifer	0.3	5.4	2.0	2.4	40
Evarcha falcata	0.6	0.7	-	1.4	10
Xysticus audax	-	2.4	0.8	2.1	21
Oedothorax apicatus	4.8	-	-	-	15
Erigone atra	1.9	-	-	-	6
Agyneta rurestris	1.9	-	-	-	6
Tapinocyba pallens	-	0.7	1.2	0.5	12
Silometopus elegans	-	1.0	0.9	0.5	11
Walckenaeria antica	-	1.0	0.8	0.7	11
Walckenaeria atrotibialis	-	-	0.5	0.7	6
Total ind. number	315	296	654	424	1686

Discussion

The total spider numbers/trap were not affected by the pollution gradient. The marked number of spiders in traps at the heavily polluted site (I) may be partly due to the habitat. It has lost most of its ground vegetation, and warm, open sites are often favourable trapping areas for wandering spiders (cf. KOPONEN, 1989). The occurrence of spiders in heavily polluted areas near smelters has also been shown in the Kola peninsula (STEPHANOV *et al.*, 1991; KONEVA & KOPONEN, 1993) and in Sweden (BENGTSSON & RUNDGREN, 1984).

However, great differences were found in species composition along the pollution gradient. Especially the most polluted site differed from others. The most polluted site was characterized by the lycosid *Xerolycosa nemoralis*, and some pioneer linyphids which were not found at other sites. Pollution had created a suitable habitat for those species. The great number of juveniles of *X. nemoralis* found at site I indicates that this spider seems to have permanent populations at heavily polluted sites. No growth anomalies were found in spiders at the most polluted site.

Our results indicate that species normally living in dry, rather open natural habitats have also dispersed to the polluted areas, which have similarities to their original habitat.

Acknowledgements

We wish to thank Kalervo Heikka for sorting the material and Alice Moore for checking the English.

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