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Spiders along a pollution gradient (Araneae)

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Abstract: Thirty-one species were found during a study of the ground-living spiders at a distance of 2.5-30 km from a smelter, in Monchegorsk (Kola Peninsula, Russia). Three species were found in an industrial barren 2.5-5 km from the smelter. Two of them, *Steatoda phalerata* and *Agyneta gulosa*, were caught at the 2.5 km site. Eight species were collected in a heavily polluted area, 10 km from the smelter. Eighteen species were found both at the 20 km and 30 km sites. The spider assemblage in a slightly damaged spruce forest, 30 km S of the smelter complex, was more or less typical for the northern taiga forest-floor. Spider densities were very low (3-6 ind./sq.m.) at heavily polluted sites, and close to normal magnitude of northern conifer forests (60 ind./sq.m) at the 30 km site.

Key words: industrial barren, heavy metals, smelter, sulphur dioxide, taiga, Kola Peninsula

Introduction

In the late 1980's, news on heavy pollution loads from the Russian smelters in the Kola Peninsula and their possible effect on needle losses of pine in northern Finland, were the starting point for active studies on forest vegetation health. Connected with or included in this project, a great number of research groups studied pollution and monitored its effects on the nature in northern Finland, Russia and Norway (Tikkanen, Niemelä 1995). Many Russian scientists studied the pollution and its effects in the Kola Peninsula, especially in Monchegorsk but also in Nikel, Pechenga (e.g. Kozlov *et al.* 1993, Chernenkova *et al.* 1995).

Spiders, as some other predator groups, have been found at heavily polluted sites near the smelters (Bengtsson, Rundgren 1984, Koneva 1993, Koponen, Niemelä 1993, 1995). Therefore spiders have often been used as indicators in monitoring of effects of pollution (see e.g. Clausen 1987). In the present paper, we will give information on spider assemblages near the Severonikel smelter complex, Monchegorsk, based on materials collected by the second author in the early 1990s. For general data on the nature and degree of pollution in the area, see Kozlov *et al.* (1993). For the spider fauna of natural forests in the northern boreal taiga zone, see e.g. Koponen (1977, 1999) and Rybalov (2003).

Material and Methods

The study area lies near Monchegorsk (about 68°N, 33°E), in the spruce forest zone (Fig. 1). A pollution gradient was investigated from an eroded industrial barren, 2.5 km N of the smelter, to a little damaged spruce-dominated forest, 30 km S of the smelter, at five study sites (Table 1). Three of them, 2.5 km to 10 km, are situated in the most seriously damaged area found in satellite surveys by Mikkola, Ritari (1992) and classified as "forest dead area". The shrub and ground layers (including herb, moss and lichen vegetation) at a 20 and 30 km distance from the smelter resemble those in natural forests, although marks of decline are seen on spruce trees.

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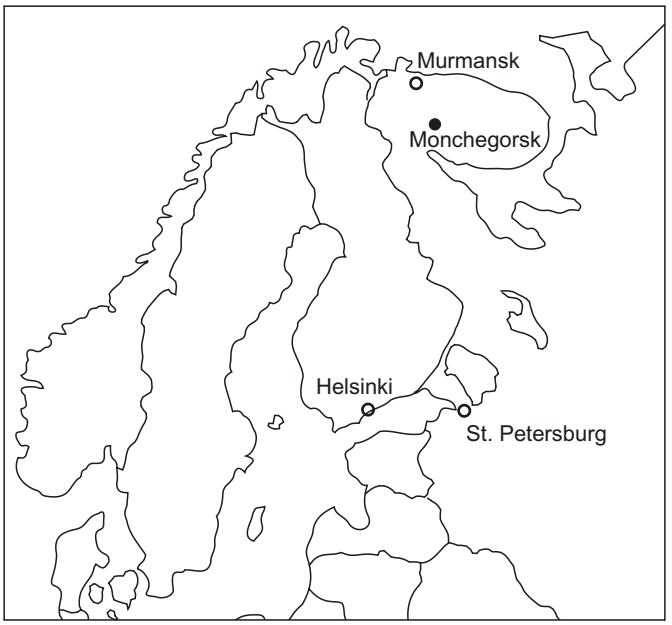

Fig. 1. Location of the study area.

The Severonikel smelter complex is one of most severe pollution sources in northern Europe. The SO_2 emission at the turn of 1980/90s was about 210 000 tn/year, and the amount of Ni and Co 2500 and 1700 tn/year, respectively (Barcan 2002). The sites are described in Table 1. The main heavy metals, Ni and Cu, drastically diminished in soil along the distance from the smelter (at 30 km only about 2% of that at 2.5 km; cf. also Barcan 1992). The same declining trend was true for Pb and Co, while values of Mn and Zn did not show such a trend (Table 1). For comparison, sulphate fallout at 10 km was 2-3 kg /sq m and at 30 km 0.1-0.3 kg /sq m (Gilyasova 1993).

Table 1. Content of heavy metals in horizon A_0 (mg/ kg) along the pollution gradient around the Monchegorsk smelter (from Stepanov *et al*. 1991).

Distance (km)	Cu	Ni	Mn	Zn	Pb	Co	Description of the site
2.5 N	2290	6220	36	32.3	18.2	35.1	badly eroded industrial barren
10 S	674	2068	160	22.4	15.9	15.5	forest vegetation almost vanished
20 S	52	332	82	28.9	9.1	5.7	marks of forest declination
30 S	46	115	325	24.9	8.2	4.4	first signs of forest declination

Ground-living spiders were collected from 25 x 25 cm squares, taken to the depth of mineral soil. Samples were sorted by hand in a laboratory. The number of replicates varied from 8 to 32 (Table 2). Field work was done during the summers of 1991-1992**.** The material is deposited in the Zoological Museum, University of Turku, Finland.

Table 2. Structure of spider assemblages along the pollution gradient; sites 2.5-30 km from the Monchegorsk smelter (1991-1992).

	2.5 km	5 km	10 km	20 km	30 km
Species found	2	2	8	18	18
Families found	2	1	6	8	6
% of Linyphiidae (ind.)	66.6	-	26.3	67.5	66.7
% of Theridiidae (ind.)	33.3	100.0	10.5	12.5	16.7
% of Lycosidae (ind.)	-	-	15.8	10.0	12.2
Ind./sq. m	6.0	3.0	10.5	34.5	59.5
SD	8.29	8.70	22.48	36.37	43.25
N	8	16	32	32	32

Results and Discussion

Altogether 31 species of spiders from nine families were collected. The density of spiders (Table 2) was very low (3-6 ind./sq m) in the eroded industrial barren area (2.5-5 km from the smelter), low (10 ind./sq m.) in the heavily polluted area (10 km) and rather low (35 ind/sq.m.) also at the slighly polluted site (20 km). The density of spiders in an area with some marks of degradation of trees (30 km apart from the smelter) was close to normal magnitude in northern conifer forests (60 ind./sq m; cf. Koponen 1977, Rybalov 2003). Near the smelter (2.5-5 km distance), only theridiids and linyphiids were found. At a distance of 10 km or more, 6-8 families were observed.

Only three species were found in the most heavily polluted areas (black, dead barren; 2.5-5 km from the smelter), theridiids *Steatoda phalerata* (Panzer, 1801) and *Robertus scoticus* Jackson, 1914, and the linyphiid *Agyneta gulosa* (L. Koch, 1869) (Table 3). Of these *S. phalerata* is known to be a thermophilous species (e.g. Hänggi *et al*. 1995) and *Agyneta* species are well-known ballooning pioneer species (Koponen, Niemelä 1993). *R. scoticus* is a rather eurytopic ground-dweller, commonly found in northern taiga forests (Rybalov 2003). Availability of food near the smelter may be an important limiting factor. According to Koneva (1993), only predators (spiders, centipedes, ground and rove beetles) were found in low numbers at the present heavily polluted sites. The gnaphosids *Micaria alpina* L. Koch, 1872 and *Gnaphosa* sp., and the philodromid *Thanatus formicinus* (Clerck, 1757), all thermophilous species (cf. Hänggi *et al.* 1995), were found at a 10 km distance (still a heavily destroyed site) as well as the salticid *Evarcha falcata* (Clerck, 1757). The lycosids, often found in open forests, *Alopecosa aculeata* (Clerck, 1757) and *Pardosa hyperborea* (Thorell, 1872) were found starting at 10 and 20 km distance, respectively.

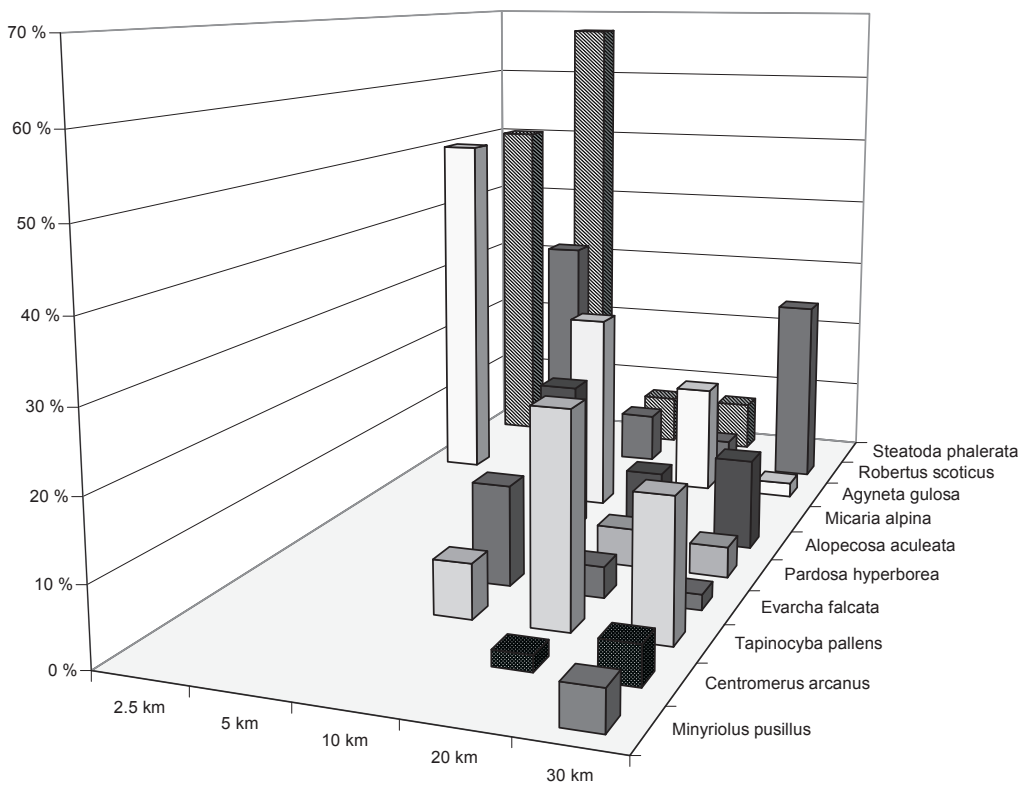

Fig. 2. Distribution of spider species along the pollution gradient, sites 2.5-30 km from the Monchegorsk smelter. Percentages of the identifiable specimens at each site.

The closest distance from the smelter for the typical forest-floor linyphiids (e.g. Huhta 1965) *Tapinocyba pallens* (O.P.-Cambridge, 1872), *Centromerus arcanus* (O.P.-Cambridge, 1873) and *Minyriolus pusillus* (Wider, 1834) was 10 km, 20 km and 30 km, respectively (Table 3, Fig. 2). Other typical taiga forest species (cf. Huhta 1965, Koponen 1999), found in low numbers 20-30 km from the smelter, included *Hahnia ononidum* Simon, 1875, *Robertus lividus* (Blackwall, 1836), *Macrargus rufus* (Wider, 1834), *Maso sundevalli* (Westring, 1851), *Palliduphantes antroniensis* (Schenkel, 1933), and *Walckenaeria dysderoides* (Wider, 1834) (Table 3). Of the field layer species, *Evarcha falcata* was found at a distance of 10 km and *Xysticus audax* (Schrank, 1803) and *Singa* sp. at 20 km from the smelter.

In general, more or less typical ground-layer fauna of northern coniferous forests was observed at a 30 km distance from the Severonikel smelter, in an area where some marks of pollution can still be seen, especially in spruce trees, and where marked concentration of heavy

Table 3. Distribution of spider species along the pollution gradient, sites 2.5-30 km from the Monchegorsk smelter (1991-1992). Percentages of the identifiable specimens at each site are given for 12 abundant species.

Species	**2.5 km**	**5 km**	**10 km**	**20 km**	**30 km**
Steatoda phalerata (Panzer, 1801)	50%	67%	7%	7%	-
Robertus scoticus Jackson, 1914	-	33%	7%	4%	26%
Agyneta gulosa (C. L. Koch, 1869)	50%	-	-	15%	2%
Micaria alpina L. Koch, 1872	-	-	27%	-	-
Alopecosa aculeata (Clerck, 1757)	-	-	20%	9%	12%
Evarcha falcata (Clerck, 1757)	-	-	13%	4%	2%
Tapinocyba pallens (O. P.-Cambridge, 1872)	-	-	7%	27%	18%
Robertus lividus (Blackwall, 1836)	-	-	-	7%	-
Pardosa hyperborea (Thorell, 1872)	-	-	-	5%	4%
Centromerus arcanus (O. P.- Cambridge, 1873)	-	-	-	2%	5%
Maro sublestus Falconer, 1915	-	-	-	-	5%
Minyriolus pusillus (Wider, 1834)	-	-	-	-	5%
Gnaphosa sp.	-	-	+	-	-
Thanatus formicinus (Clerck, 1757)	-	-	+	-	-
Gonatium rubens (Blackwall, 1833)	-	-	-	+	-
Hahnia ononidum Simon, 1875	-	-	-	+	-
Haplodrassus sp.	-	-	-	+	-
Macrargus multesimus (O. P.- Cambridge, 1875)	-	-	-	+	-
Maso sundevalli (Westring, 1851)	-	-	-	+	-
Scotinotylus alpigena (L. Koch, 1869)	-	-	-	+	-
Singa sp.	-	-	-	+	-
Walckenaeria dysderoides (Wider, 1834)	-	-	-	+	-
Xysticus audax (Schrank, 1803)	-	-	-	+	-
Agyneta decora (O. P.- Cambridge, 1871)	-	-	-	-	+
Macrargus rufus (Wider, 1834)	-	-	-	-	+
Palliduphantes antroniensis (Schenkel, 1933)	-	-	-	-	+
Pardosa palustris (Linnaeus, 1758)	-	-	-	-	+
Pocadicnemis pumila (Blackwall, 1841)	-	-	-	-	+
Ozyptila arctica Kulczyński, 1908	-	-	-	-	+
Tenuiphantes mengei Kulczyński 1887	-	-	-	-	+
Xysticus obscurus Collet, 1877	-	-	-	-	+

metals was found in the ground (Table 1). The amount of sulphur dioxide and heavy metal pollution has decreased markedly since completion of the field work on this paper. Ten years later, the SO_2 emission was one fifth and that of Ni and Cu about half of the amount at the turn of the 1980/90s (Barcan 2002). However, the contamination in this area has increased all this time, much greater decrease of pollutants would be needed to stop it. So the present situation in the area is worse than it was in 1991-1992.

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Паяци по градиент на екологично замърсяване (Araneae)

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(Резюме)

При изследване на района около металургичния комбинат в град Мончегорск (Колски полуостров, Русия) са установени тридесет и един вида наземно живеещи паяци. Три вида са намерени в силно замърсена индустриална зона на 2,5-5 km от комбината, като два от тях – *Steatoda phalerata* и *Agyneta gulosa* – са уловени на 2,5 km. Осем вида са установени в силно замърсен район на разстояние от 10 km, а по единадесет вида на съответно 20 и 30 km. Комплексът от видове, който е регистриран в слабо повлияна от замърсяването смърчова гора, намираща се на 30 km от завода, е приблизително еднакъв с този на незамърсени гори в северната тайга. В силно замърсените райони плътността на паяците е ниска (3-6 инд./m²), а на 30 km от комбината е приблизително близка до нормалната за северните иглостни гори (60 инд./ m²).