Ground-living spiders (Araneae) at polluted sites in the Subarctic

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Abstract: Spiders were studied around the Pechenganikel smelter combine, Kola Peninsula, north-western Russia. The average spider density was 6-fold greater and the density of Linyphiidae specimens 11.5-fold higher at slightly polluted sites, compared with heavily polluted sites. Altogether, 18 species from 10 families were found at heavily polluted sites, the theridiid *Robertus scoticus* clearly dominating (23.3 % of identifiable specimens), also *Neon reticulatus* (9.6 %), *Thanatus formicinus* (9.6 %) and *Xysticus audax* (8.2 %) were abundant. The most numerous among 58 species found at slightly polluted sites were *Tapinocyba pallens* (18.5 %), *Robertus scoticus* (13.7 %), *Maso sundevalli* (9.5 %) and *Alopecosa aculeata* (8.2 %). The family Linyphiidae dominated at slightly polluted sites, 64 % of species and 60 % of individuals; compared with heavily polluted sites, 23 % and 38 % respectively.

Key words: density, diversity, Kola Peninsula, smelter

In the late 1980's, reports of heavy pollution loads from the Russian smelters in the Kola Peninsula and their possible effect on needle losses among pine in northern Finland prompted active studies on effects of pollution on forest ecosystems in northern Finland, Russia and Norway (see KOZLOV et al. 1993, TIKKANEN & NIEMELÄ 1995).

Spiders, like some other predatory arthropod groups, have been observed at heavily polluted sites near smelters in northern Europe (BENGTSSON & RUDGREN 1984, KONEVA 1993, KOPONEN & NIEMELÄ 1994, KOPONEN & KONEVA 2006). Generally, markedly high concentrations of heavy metals have been found in spiders near pollution sources (BENGTSSON & RUNDGREN 1984, KOPONEN & NIEMELÄ 1995, MAELFAIT & HENDRICKX 1998), and spiders have often been used as indicators in monitoring the effects of pollution (e.g. CLAUSEN 1986). In the present paper, information will be given on spider assemblages near the Pechenganikel smelter complex, in the subarctic Kola Peninsula, NW Russia.

For general data on the nature and degree of pollution in the area, see KOZLOV et al. (1993, 2009) and NORWEGIAN POLLUTION CONTROL AUTHORITY (2002). Spider densities near the Pechenganikel smelter have been briefly dealt with by KONEVA & KOPONEN (1993). For the spider fauna of natural forests in the subarctic and northern boreal taiga zones in Fennoscandia, see e.g. KOPONEN (1977, 1999) and RYBALOV (2003).

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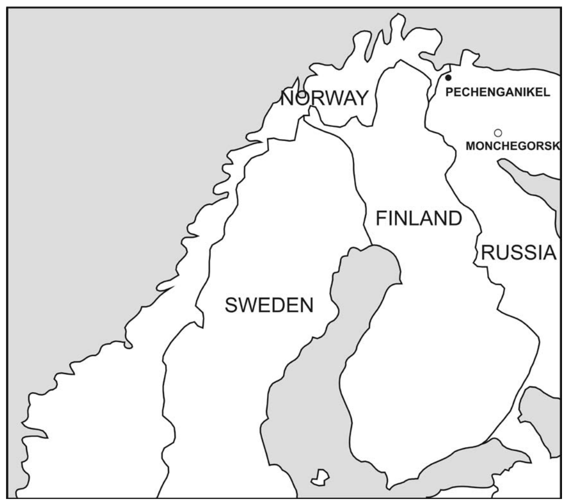

Figure 1: Pechenganikel (the study area) and Monchegorsk smelters in Kola Peninsula.

Material and Methods

The present study area, the Pechenganikel smelter combine (Nikel and Zapolyarny), ca 69°30'N, 30°20'E, is situated in a subarctic pine forest area, where there are also birch woods, bogs and treeless fells (Fig. 1). The altitude of sites varies between 100 and 200 m asl. The smelter is very close to Norway (only about 10 km from the border) and to Finland (40 km from the border), and the distance to the Arctic Ocean is about 50 km. The yearly mean temperature is about -1°C, and permanent snow cover lasts 6-7 months.

Yearly emission in 1990, just before the spider sampling, was about 250 000 tons SO_2, ca. 200 tons Cu, 300 tons Ni and 10 tons Co (see KOZLOV et al. 2009). This means that sulphur load was the same as in Monchegorsk smelter, central Kola Peninsula, but copper, nickel and cobalt loads were only 10 % of

Table 1: Composition of the spider fauna in the studied heavily (5 sites) and slightly polluted areas (9 sites), Pechenganikel.

	Heavily polluted (H)	Slightly polluted (S)	S/H
Species	18	58	
Species/site	3.6	6.4	1.8
Families	10	13	
Individuals	101	1083	
Ind./m²	20.2	120.3	6.0
range	3-32	71-266	
Linyphiidae ind./m²	7.6	87.7	11.5
% of Linyphiidae (of spec.)	22.2	63.8	2.9
% of Linyphiidae (of ind.)	37.6	59.8	1.6
% of Lycosidae (of ind.)	10.9	11.7	1.1
% of the most dominant species	23.3	18.5	

that in Monchegorsk. The area of complete damage to forests was 45 km² and severe damage 300 km² around the Pechenganikel complex; in these areas SO_2 concentration was over 80 g/m³, and annual dry sulphur deposition ca 4 g/m² (GYTARSKY et al. 1997, NORWEGIAN POLLUTION CONTROL AUTHORITY 2002).

Spiders were collected at five study sites in heavily polluted areas, 2.5 – 7 km from the smelter, and at nine sites in slightly (or moderately) polluted areas, 6 – 55 km from the smelter.

The average cover of ground and field layer vegetation indicates the degree of pollution: 30 % coverage at heavily and 80 % at slightly polluted sites. Thus heavily polluted sites are more open and because the ground is often black, their microclimatic conditions in summer are more extreme, i.e. they are much drier and warmer than at slightly polluted sites.

Ground- and soil-living spiders were collected, in 1991–92 from 25 x 25 cm squares by hand-sorting. The field work was done by Dr. Galina G. Koneva (Moscow) and identification was by the author. The material consists of ca 620 identifiable spider specimens (of the total 1185 individuals) and is deposited in the Zoological Museum, University of Turku, Finland.

Results

Great differences were found (Table 1) in the density of spiders in heavily and slightly polluted areas, the averages being 20 and 120 ind./m² (ranges 3–32 and 72–266 ind./m²) respectively. The average spider density was 6-fold greater and the density of Linyphiidae specimens even 11.5-fold at slightly polluted sites. Also species number/site was higher at slightly polluted sites: 1.8-fold. Altogether, 18 and 58 species of spiders were caught in heavily (5 sites) and slightly (9 sites) polluted areas, respectively. Interestingly, as many as 10 families but only 18 species were found at heavily polluted sites, and at slightly polluted sites the material was much more species-rich, but represented no more than 13 families.

The theridiid *Robertus scoticus* clearly dominated at the heavily polluted sites (Table 2: 23.3 % of identifiable specimens), and was the second most abundant at the slightly polluted sites (Table 3: 13.5 %). Other abundant species at heavily polluted sites were *Neon reticulatus* (9.6 %), *Thanatus formicinus* (9.6 %), *Xysticus audax* (8.2 %), *Agyneta gulosa* (5.5 %), and *Alopecosa aculeata* (5.5 %). Of these, especially *A.*

Table 2: Total number of spider specimens found at five most polluted and damaged sites (2.5 – 7 km from the smelter), Pechenganikel.

Robertus scoticus	17	23.3 % of identifiable
Neon reticulatus	7	9.6
Thanatus formicinus	7	9.6
Xysticus audax	6	8.2
Agyneta gulosa	4	5.5
Alopecosa aculeata	4	5.5
Haplodrassus sp.	4	5.5
Dictyna uncinata	3	4.1
Evarcha falcata	3	4.1
Heliophanus sp.	3	4.1
Micaria alpina	3	4.1
Scandichrestus tenuis	3	4.1
Xysticus obscurus	3	4.1
Tapinocyba pallens	2	
Pardosa palustris	1	
Tetragnatha sp.	1	
Tibellus maritimus	1	
Walckenaeria antica	1	
Number of species	**18**	
Number of identifiable specimens	**73**	

Table 3: Total number of specimens of the most abundant spiders found at nine slightly polluted sites (6 – 55 km from the smelter), Pechenganikel.

Tapinocyba pallens	101	18.5 % of identifiable
Robertus scoticus	75	13.7
Maso sundevalli	52	9.5
Alopecosa aculeata	45	8.2
Micrargus herbigradus	29	5.3
Hahnia ononidum	26	4.8
Macrargus rufus	18	3.3
Centromerus arcanus	16	2.9
Pardosa hyperborea	15	2.7
Evarcha falcata	12	2.2
Agyneta gulosa	11	2.0
Palliduphantes antroniensis	11	2.0
Xysticus obscurus	11	2.0
Minyriolus pusillus	10	
Microcentria pusilla	7	
Neon reticulatus	7	
Sisicus apertus	7	
Macrargus multesimus	6	
Porrhomma pallidum	6	
Xysticus audax	6	
Cnephalocotes obscurus	5	
Walckenaeria karpinskii	5	
Gnaphosa microps	4	
Micaria alpina	4	
Pardosa palustris	4	
Pocadicnemis pumila	4	
Scotinotylus alpigena	4	
Scandichrestus tenuis	4	
Haplodrassus signifer	3	
Hilaira herniosa	3	
Microneta viaria	3	
Tenuiphantes mengei	3	
Zora nemoralis	3	
Bolyphantes luteolus	2	
Cercidia prominens	2	
Clubiona trivialis	2	
Gnaphosa sticta	2	
Gonatium rubens	2	
Pelecopsis mengei	2	
Robertus lyrifer	2	
Semljicola faustus	2	
Tenuiphantes tenebricola	2	
Thanatus formicinus	2	
Agnyphantes expunctus	1	
Agyneta conigera	1	
Agyneta subtilis	1	
Bolehthyphantes index	1	
Decipiphantes decipiens	1	
Dictyna sp.	1	
Diplocentria bidentata	1	
Gonatium rubellum	1	
Oreonetides vaginatus	1	
Tetragnatha sp.	1	
Tibellus maritimus	1	
Walckenaeria dysderoides	1	
Walckenaeria lepida	1	
Walckenaeria nudipalpis	1	
Zornella cultrigera	1	
Number of species	**58**	
Number of identifiable specimens	**547**	

aculeata and also *Agyneta gulosa* were found in good numbers at slightly polluted sites. Altogether, four linyphiid species (i.e., *Agyneta gulosa, Scandichrestus tenuis, Tapinocyba pallens,* and *Walckenaeria antica*) were found among the total 18 species (22 %) at heavily polluted sites. Only one linyphiid was among the six most abundant spider species (Table 2). The percentage of Lycosidae specimens was about 11 % (Table 1).

The most abundant species at slightly polluted sites (Table 3) were *Tapinocyba pallens* (18.5 %), *Robertus scoticus* (13.7 %), *Maso sundevalli* (9.5 %), *Alopecosa aculeata* (8.2 %), *Micrargus herbigradus* (5.3 %), *Hahnia ononidum* (4.8 %), and *Macrargus rufus* (3.3 %).

The dominant species of the slightly polluted sites, *Tapinocyba pallens*, was found at the heavily polluted sites but only in small numbers. About 64 % of all species and 60 % of specimens at slightly polluted areas belonged to the family Linyphiidae. Three linyphiids were among the six most abundant species. The percentage of Lycosidae was 12 % of all individuals caught (Table 1).

Discussion

Leg deformations or other injuries caused by pollution, could not be found in spiders collected at the polluted sites. Deformations have been observed previously in, e.g., oribatid mites near a smelter (Eeva & Penttinen 2009).

The average spider density (about 120 ind./m^2) at slightly polluted sites was of the same magnitude as found previously in natural northern boreal or subarctic forests (e.g. Koponen 1977). Also the species composition and the great proportion of Linyphiidae among species and specimens in slightly polluted areas resembled the situation in natural forest habitats. The family Linyphiidae is known to dominate in the ground layer of northern areas (e.g. KOPONEN 1993).

Proportions of Lycosidae specimens were almost equal and rather low at heavily and slightly polluted sites, i.e. 11 % and 12 %, respectively. In southern Finland, *Xerolycosa* and *Alopecosa* species dominated at the most polluted sites near a smelter (KOPONEN & NIEMELÄ 1994). On the other hand, lycosids were not found in the eroded industrial barren area close to the Monchegorsk smelter, central Kola Peninsula (KOPONEN & KONEVA 2006). However, different collecting methods, pitfall traps in southern Finland and hand-sorting both in Pechenganikel and Monchegorsk, must be borne in mind.

When spiders along a pollution gradient were studied by KOPONEN & KONEVA (2006) near the Monchegorsk smelter complex, *Robertus scoticus* and *Agyneta gulosa* were also found there in the most polluted areas (black, dead barren sites 2.5–5 km from the smelter). In addition to these two species, only *Steatoda phalerata* occurred at the most polluted sites. *S. phalerata* was not found in the Pechenganikel area at all; which may have conditions too harsh for this thermophilous species. Of the present species found at heavily polluted sites, *Micaria alpina, Alopecosa aculeata*, *Evarcha falcata* and *Tapinocyba pallens* were caught in good numbers at rather heavily polluted sites in Monchegorsk (10 km from the smelter). The spider densities near the Monchegorsk smelter were lower than in the present study area (KOPONEN & KONEVA 2006), probably indicating the effect of much greater copper and nickel emissions at Monchegorsk (see Material and Methods).

Emissions of heavy metals and especially sulphur dioxide have decreased greatly since the field work of this paper. According to KOZLOV et al. (2009), the decrease in emissions from 1985 (heavy pollution period) to 2005 was for SO_2 about 70 %, Co 75 %, Cu 20 %, and Ni 15 %. However, pollution in the study area has continued all the time, and emissions at the beginning of this century were still above the critical level for sensitive biota (NORWEGIAN POLLUTION CONTROL AUTHORITY 2002). Thus the environment for the ground-living fauna is nowadays not better than in the early 1990s.

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References

BENGTSSON G. & S. RUNDGREN (1984): Ground-living invertebrates in metal-polluted forest soils. – Ambio 13: 29-33

CLAUSEN I.H.S. (1986): The use of spiders (Araneae) as ecological indicators. – Bulletin of the British arachnological Society 7: 83-86

EEVA T. & R. PENTTINEN (2009): Leg deformities of oribatid mites as an indicator of environmental pollution. – Science of the Total Environment 407: 4771-4776 – doi: 10.1016/j.scitotenv.2009.05.013

GYTARSKY M.L., R.T. KARABAN & I.M. NAZAROV (1997) On the assessment of sulphur deposition on forests growing over the areas of industrial impact. – Environmental Monitoring and Assessment 48: 125-137 – doi: 10.1023/A:1005744301889

KONEVA G.G. (1993): Changes in soil macrofauna around "Severonikel" smelter complex. In: KOZLOV M.V., E. HAUKIOJA & V.T. YARMISHKO (Eds): Aerial pollution in Kola Peninsula. Kola Scientific Center, Apity. pp. 362-364

KONEVA G.G. & S. KOPONEN (1993): Density of ground-living spiders (Araneae) near smelter in Kola Peninsula. In: KOZLOV M.V., E. HAUKIOJA & V.T. YARMISHKO (Eds): Aerial pollution in Kola Peninsula. Kola Scientific Center, Apity. p. 365

KOPONEN S. (1977): Spider fauna (Araneae) of Kevo area, northernmost Finland. – Reports from the Kevo Subarctic Research Station 13: 48-62

KOPONEN S. (1993): On the biogeography and faunistics of European spiders: latitude, altitude and insularity. – Bulletin de la Société Neuchâteloise des Sciences Naturelles 116 (1): 141-152

KOPONEN S. (1999): Common ground-living spiders in old taiga forests of Finland. – The Journal of Arachnology 27: 201-204

KOPONEN S. & G.G. KONEVA (2006): Spiders along a pollution gradient (Araneae). – Acta Zoologica Bulgarica, Suppl. 1: 131-136

KOPONEN S. & P. NIEMELÄ (1994): Ground-living spiders in a polluted pine forest, SW Finland. – Bollettino della Accademia Gioenia di scienze naturali 26 (345): 221-226

KOPONEN S. & P. NIEMELÄ (1995): Ground-living arthropods along pollution gradient in boreal pine forest. – Entomologica Fennica 6: 27-131

KOZLOV M.V., E. HAUKIOJA & V.T. YARMISHKO (Eds) (1993): Aerial pollution in Kola Peninsula. Kola Scientific Centre, Apatity. 419 pp.

KOZLOV M.V., E.L. ZVEREVA & V.E. ZVEREV (2009): Impacts of point polluters on terrestrial biota. Environmental Pollution 15. Springer, Dordrecht, Heidelberg, London, New York. 466 pp.

MAELFAIT J.-P. & F. HENDRICKX (1998): Spiders as bio-indicators of anthropogenic stress in natural and semi-natural habitats in Flanders (Belgium): some recent developments. In: SELDEN P.A. (Ed): Proceedings of the 17th European Colloquium of Arachnology, Edinburgh 1997. British arachnological Society, Dorcester. pp. 293-300

NORWEGIAN POLLUTION CONTROL AUTHORITY (SFT) (2002): Air pollution effects in the Norwegian–Russian border area. International cooperation on environmental issues and environmental protection in the polar areas, TA-1860, Oslo. 34 pp. http://www.sft.no/publikasjoner/internasjonalt/1860/ta1860.pdf [accessed 1.VII.2009]

RYBALOV L. (2003): Population of soil-dwelling invertebrates of the old-growth spruce forest of the Nature Reserve Friendship. In: HEIKKILÄ R. & T. LINDHOLM (Eds): Biodiversity and conservation of boreal nature. – The Finnish Environment 485: 206-211

TIKKANEN E. & I. NIEMELÄ (Eds) (1995): Kola Peninsula pollutants and forest ecosystems in Lapland: final report of the Lapland Forest Damage Project. Ministry of Agriculture and Forestry & Finnish Forest Research Institute, Helsinki. 82 pp.