

Chapter 8

The effect of metallurgic smelter pollution on spider communities (Arachnida, Araneae): preliminary observations

A.V. Tanasevitch

All-Russian Research Institute for Nature Protection, 113628, Znamenskoye-Sadki, Moscow, Russian Federation

Introduction

Spiders are one of the largest groups of arachnids. These obligatory and non-specialized predators play an important role in the structure of terrestrial ecosystems, and are an integral and dominating component of the soil fauna in all climatic zones of Eurasia. Their high biomass, high fecundity and broad food preferences make spiders one of the main regulators of arthropod abundance in soil, litter and above-ground vegetation. As primary and secondary consumers, spiders in their turn are a good feeding basis to subsequent elements of the terrestrial food chain, mainly reptiles, birds and mammals. The key role of spiders in terrestrial communities makes them an interesting and important object for study of matter and energy transfer in ecosystems.

Spiders have not been used often as an object of study in the environmental toxicology. It has, however, been shown clearly by some authors (Clausen 1986; Rabitsch 1995; Maelfait 1996) that these arthropods may respond sensitively to environmental changes, and they hold good prospects for bioindication and ecosystem monitoring.

This research was conducted with the following aims: 1) reveal any trends of heavy metal accumulation in spiders, as related to soil contamination produced by a metallurgic smelter, 2) establish effects of the metallurgic smelter pollution on terrestrial spider communities.

Materials and methods

Pollution-induced changes in spiders and their communities were studied for two months (25 May to 23 July, 1999) at two sites located at different distances from the Kosogorsky metallurgic smelter (Tula district, Russian Federation). These sites (#1 and #2) were the same as sites #1 and #2 out of four sites studied during 1997 and located along the contamination gradient from the source of emission (see for a detailed description Zaitsev *et al.* 1998). Information about litter and soil contamination at these sites is already available. Sites #1 and #2

have similar plant communities. The contamination by different heavy metals at site #1 was 1.5 to 14 times higher than at site #2.

Material was collected in two different ways. For the analysis of metal concentrations in spider bodies live animals were collected on June 25, 1999 at sites #1 and #2. Specimens were frozen and after identification of the species, they were processed in accordance with the procedure described in detail by Zaitsev *et al.* (1999), who also has performed the measurements. We did not apply ultrasonic cleaning to the samples. Males and females were analyzed separately. Juveniles were excluded from the study as it was not possible to identify them to species level.

Spider communities at the research sites were studied using conventional ecological field methods: pitfall trapping with 3% formaldehyde, litter sieving, and entomological scything. The traps were replenished once every two weeks. Collected material was preserved in 75% ethanol.

Results and discussion

Heavy metal accumulation in spiders

From the collected live and later frozen spiders only one species of wolf-spider (family *Lycosidae*), *Pardosa amentata* (Clerck, 1758), was chosen since it was collected at both sites, was abundant and represented by both sexes. The results of the metal analyses in this spider as compared to soil and litter metal contents are presented in Table 8.1.

Table 8.1. Heavy metal concentrations in *Pardosa amentata* ($\mu\text{g/g}$) at sites #1 and #2, determined using atomic absorption spectrometry. ND = below detection level.

Sex	Site #1					
	Cd	Cu	Zn	Fe	Pb	Mn
Males	24.0	120.5	369.8	429.7	103.1	82.8
Females	7.5	107.6	321.9	1023	ND	432.2
	Site #2					
	Cd	Cu	Zn	Fe	Pb	Mn
Males	9.2	118.1	346.0	350.8	ND	57.9
Females	ND	133.7	364.3	724.7	ND	48.0

Site #1 is located in the most contaminated area, close to the smelter and the concentrations of heavy metals in soil and litter were significantly higher than in site #2: the concentration of Cd in soil was 1.5 times higher, of Fe and Pb 2 times, of Cu 2.6 times, of Zn 3.2 times and of Mn 7. In litter these figures were: Zn: 1.6, Cu: 1.9, Mn: 4.0, Pb: 13.2, and Fe: 14 (see Zaitsev *et al.* 1998).

The concentrations of metals in spiders decreased in the following sequence: Fe > Zn > Cu > Cd > Mn/Pb (Table 8.1, Fig. 8.1). Heavy metal accumulation patterns in arthropods have been reported in the literature on several occasions. Rabitsch (1995) has demonstrated that in general males accumulated more heavy

metals than females. In his research the concentrations of Pb, Cd, Cu and Zn in males were 1.5 to 2 times higher than in females. We did not obtain such asymmetric results. Cadmium was actually 3 times higher in males, on the other hand the concentration of Fe in females was 2.1 to 2.4 times higher than in males (at both sites). Concentrations of Cu and Zn in spiders at the two sites were more or less similar, were not sex-specific and not dependent on the metal concentration in soil and litter.

Changes in the spider communities

The two compared biotopes in sites #1 and #2 had a vegetation dominated by *Salix*, *Carpinus* and *Urtica* on the bank of the river; the spider community was not rich in species. In total more than 600 individuals of adult spiders of 21 species belonging to seven families were found in sites #1 and #2 during two months of pitfall trapping and litter sieving (Table 8.3, see Annex). The majority of these spiders belonged to litter- and surface-dwelling species which represent the soil mesofauna, well known as a sensitive and adequately responsive component of terrestrial communities and indicating industrial contamination. A summary of the results of this study is presented in Table 8.2.

The number of collected species at both sites was not high, which can be explained by the simplicity of the communities, as well as by incomplete sampling. Although collected material did not completely represent the fauna of the biotopes, it is possible to make some preliminary conclusions.

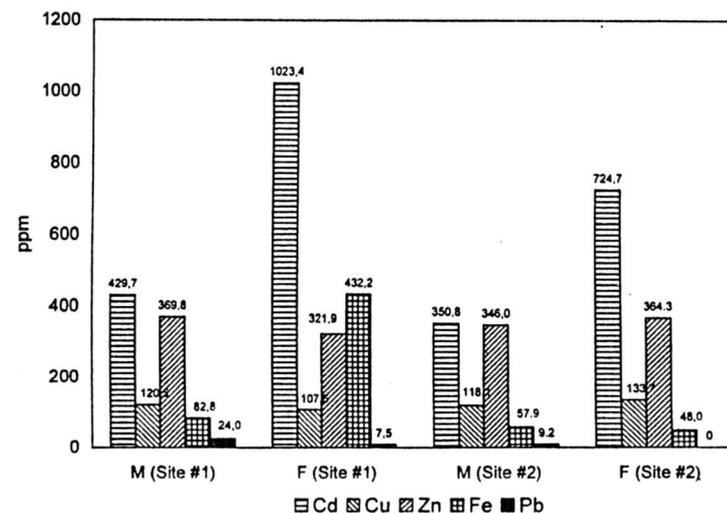


Fig. 8.1. Metal concentrations in wolf spiders (*Pardosa amentata*), collected from two sites near the Kosogorsky steel factory. Site #1 is the most polluted. M = males, F = females.

Table 8.2. Comparison of spider populations at sites with different industrial contamination levels (results from pitfall trapping and litter sieving).

Species groups	Number of species	
	Site #1	Site #2
Soil and litter dwelling	6	14
Surface dwelling	5	5
Others	2	2
Total	13	21

As shown above, the heavy metal contents in soil and litter in site #2 were much lower than in site #1. This fact directly or indirectly affected the composition of spider communities. It is clear (Table 8.2) that there is an increasing trend of spider species richness from the most to the less polluted site (from 13 to 21 species). The number and percentage of species which belonged to soil and litter dwelling groups increased from 6 to 14 species, mainly due to the family Linyphiidae.

There were some differences in the active density of spider populations, demonstrated by the results of pitfall trapping. The number of spiders caught by traps in site #2 was 1.8 times higher than in site #1. The increase of diversity and density of the spiders communities going from heavily polluted to less polluted is probably partly due to a general increase of soil and litter invertebrate diversity, among which there are many potential preys for spiders.

Although some authors (e.g. Luczak 1980) consider spider communities to depend only weakly to industrial contamination, this study has demonstrated the reverse: spider communities are suitable as bioindicators of environmental pollution.

Conclusions

Concentrations of Cd and Fe in the wolf-spider *Pardosa amentata* were sex-dependent and correlated with levels in soil and litter, however, Cu and Zn were sex-specific and not dependent on metal concentration in soil and litter. In both sexes the metal concentrations decreased in the sequence: Fe > Zn > Cu > Cd > Mn/Pb. Heavy metal contamination of study sites resulted in a general degradation of the spider communities: a decrease of their diversity and density, mainly due to the elimination of the soil and litter-dwelling group of linyphiids.

Acknowledgements. I am grateful to Mr. A.S. Zaitsev (Moscow) who has performed heavy metal analysis of the spiders, to Mr. K. Gongalskii (Moscow) for assistance in spider collection, as well as to Dr. R.O. Butovsky (Moscow) for help in this investigation.

References

- Clausen, I.H.S. (1986) The use of spiders (Araneae) as ecological indicators. *Bull. Br. arachnol. Soc.* 7, 83–86.
- Luczak, J. (1980) The effect of spiders living in forests on spider communities in crop fields. In: J. Gruber and H. Egermann (eds) *Verhandlungen 8 Internationaler Arachnologen-Kongress abgehalten an der Universität für Bodenkultur Wien, 7–12 Juli, Vienna*, pp. 109–114.
- Maelfait, J.-P. (1996) Soil spiders and bioindication. In: N.M. van Straalen and D.A. Krivolutsky (eds) *Bioindicator Systems for Soil Pollution*. Kluwer Academic Publishers, Dordrecht, pp. 165–178.
- Rabitsch, W.B. (1995) Metal accumulation in arthropods near a lead/zinc smelter in Arnoldstein, Austria. III. Arachnida. *Environ. Pollution* 90, 249–257.
- Zaitsev, A.S., Verhoef, S.C., Pokarzhevskii, A.D., Filimonova, Z.V., and Butovsky, R.O. (1998) General description of the Kosaja Gora research area. In: N.M. van Straalen and R.O. Butovsky (eds) *Pollution-induced Changes in Soil Invertebrate Food-webs*. Report D98013, Department of Ecology and Ecotoxicology, Vrije Universiteit, Amsterdam and Moscow, pp. 31–44.

Annex to Chapter 8

Table 8.3. List of spiders collected in sites #1 and #2 (abbreviations: L - litter-dwelling; S - surface-dwelling; O - other).

Site 1		Site 2	
Fam. Linyphiidae		Fam. Theridiidae	
<i>Gongylidium rufipes</i> (L., 1758)	L	<i>Robertus lividus</i> (Bl., 1836)	L
<i>Microneta viaria</i> (Blackwall, 1841)	L	Fam. Linyphiidae	
<i>Oedothorax apicatus</i> (Bl., 1850)	L	<i>Agyreta ramosa</i> Jacks., 1912	L
<i>Tmeticus affinis</i> (Bl., 1855)	L	<i>Bathypantes nigrinus</i> (Westr., 1851)	L
Fam. Tetragnathidae		<i>Diplocephalus picinus</i> (Bl., 1841)	L
<i>Pachygnatha listeri</i> Sund., 1830	O	<i>Diplostyla concolor</i> (Wid., 1834)	L
Fam. Lycosidae		<i>Gongylidium rufipes</i> (L., 1758)	L
<i>Alopecosa aculeata</i> (Cl., 1758)	S	<i>Microneta viaria</i> (Bl., 1841)	L
<i>Pardosa amentata</i> (Clerck, 1758)	S	<i>Oedothorax apicatus</i> (Bl., 1850)	L
<i>P. prativaga</i> (L.Koch, 1870)	S	<i>Tmeticus affinis</i> (Bl., 1855)	L
<i>Pirata hygrophilus</i> Thor., 1872	S	<i>W. nudipalpis</i> (Westr., 1851)	L
<i>Trochosa terricola</i> Thor., 1856	S	<i>W. unicornis</i> O.P.-Cambr., 1861	L
Fam. Clubionidae		Fam. Tetragnathidae	
<i>Clubiona lutescens</i> Westr., 1851	O	<i>Pachygnatha listeri</i> Sund., 1830	O
Fam. Thomisidae		Fam. Lycosidae	
<i>Ozyptila praticola</i> (C.L.Koch, 1837)	L	<i>Alopecosa aculeata</i> (Cl., 1758)	S
Fam. Gnaphosidae		<i>Pardosa amentata</i> (Cl., 1758)	S
<i>Zelotes pusillus</i> (C.L.Koch, 1833)	L	<i>P. prativaga</i> (L.Koch, 1870)	S
		<i>Pirata hygrophilus</i> Thor., 1872	S
		<i>Trochosa terricola</i> Thor., 1856	S
		Fam. Clubionidae	
		<i>Clubiona lutescens</i> Westr., 1851	O
		Fam. Thomisidae	
		<i>Ozyptila praticola</i> (C.L.Koch, 1837)	L
		Fam. Gnaphosidae	
		<i>Zelotes lutetianus</i> (L.Koch, 1866)	L
		<i>Z. pusillus</i> (C.L.Koch, 1833)	L

Some preliminary data on gamasid mites at the four sampling sites near the Kosogorsky metallurgical plant (1997-1998). Identification of the mites was done by Yu.V. Lopatina and A.D. Petrova-Nikitina, Moscow State University, Dept. of Entomology. + = abundance smaller than 5%, ++ = abundance between 5% and 10%, +++ = abundance between 10% and 15%, ++++ = abundance above 15%.

Taxonomic groups	site 1	site 2	site 3	site 4
Parasitidae				
<i>Parasitus</i> (<i>Vulgarogamasus</i>) <i>magnus</i> Kramer, 1876	+	-	-	+
<i>P. (V.) monticola</i> Berlese, 1905	+	-	-	-
<i>P. (V.) cavernicola</i> (Tragardh, 1912)	+	-	-	+
<i>P. (V.) lunulatus</i> (Muller, 1859)	+	-	-	+
<i>P. (V.) kraepelini</i> Berlese, 1904	-	+	-	-
<i>P. (Coleogamasus) consanguineus</i> Oudemans et Voigts 1904	-	+	-	-
<i>Pergamasus quisquiliarum</i> (G. et R. Canestrini, 1882)	+	+	-	+
<i>P. septentrionalis</i> (Oudemans, 1902)	+	+	+++	+
<i>P. crassipes</i> (Linne, 1758)	+	+	+++	+
<i>P. runciger</i> Berlese, 1904	-	-	-	+
<i>Lysigamasus lapponicus</i> Tragardh, 1910	+	+	-	+++
<i>Lysigamasus misellus</i> Berlese, 1904	+	++++	+	+
<i>Lysigamasus vagabundus</i> Karg, 1968	+	+++	+	+
<i>L. nasellus</i> Karg, 1968	-	+	-	-
<i>L. celticus</i> Bhattacharyya, 1963	-	+	+	-
<i>Leptogamasus suecicus</i> (Tragardh, 1936)	+	++	+	-
<i>Amblygamasus stramenis</i> Karg, 1971	+	+	+	+
<i>Holoparasitus excipuliger</i> Berlese, 1905	+	+	+	+
Veigaiidae				
<i>Veigaia kochi</i> (Tragardh, 1901)	-	+	-	-
<i>V. nemorensis</i> (C. L. Koch, 1839)	+	+	++++	+
<i>V. cervus</i> (Kramer, 1876)	+	-	++	+
<i>V. exigua</i> (Berlese, 1916)	+	+	++	+
<i>V. decurtata</i> Athias-Henriot, 1961	+	-	+	-
Aceosejidae				
<i>Lasioseius bicolor</i> (Berlese, 1918)	+	+	+	+
<i>Iphidozercon gibbus</i> Berlese, 1903	-	-	-	+
Rhodacaridae				
<i>Rhodacarus mandibularis</i> Berlese, 1921	+	+	-	+
<i>Dendrolaelaps disetosimilis</i> Hirschmann, 1960	+	+	+	-
<i>Gamasellus montanus</i> (Willmann, 1936)	-	-	+	+
Macrochelidae				
<i>Geholaspis mandibularis</i> (Berlese, 1904)	-	+	-	++
Pachylaelaptidae				
<i>Pachylaelaps magnus</i> Halbert, 1915	+	-	-	-
<i>P. longisetis</i> Halbert, 1915	++	+	+	+++
<i>P. pectinifer</i> (G. et R. Canestrini, 1882)	+	-	-	+
<i>P. littoralis</i> Halbert, 1915	+	-	-	-
<i>P. furcifer</i> Oudemans, 1903	+	+	++	+
<i>P. sculptus</i> Berlese, 1921	-	+	-	-