Bull. Environ. Contam. Toxicol. (1989) 43:415–420

Content of Some Heavy Metal Ions in Various Developmental Stages of the Social Wasp, *Dolichovespula saxonica* (Fabr.) (Hymenoptera, Vespidae)

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The rapid development of the chemical industry in recent times has contributed widely to environmental pollution by adding increasing amounts of persistent toxics, of which heavy metals are of substantial importance. Increased heavy metal production, especially cadmium, has enhanced the potential danger of toxic metals in the environment, including their effect upon metabolism of some essential elements in various organisms, as for instance iron and manganese (Gruden and Munič, 1987).
In terrestrial ecosystems insects play an important role in the transport and reintegration of both organic and inorganic matter. Thus, the usefulness of insects in monitoring toxicity is important, and their small size makes them convenient test organisms. Indeed, carnivorous and detritovorous insects such as ground beetles, ants, wasps or dung beetles can change the chemical and physical properties of their environment. It is of the utmost interest, therefore, to investigate heavy metal accumulation in such insects which occupy a high trophic levels and to which numerous herbivorous invertebrates are potential preys.

Dolichovespula saxonica (Fabr.) is a common social wasp, of palearctic, boreal-alpine areas. It nests above-ground, preferably in trees or wood country cottages (Kemper and Döhring, 1967).
The collection of water and various food, consisting of small insects, carrion, pollen, nectar, aphid-dew or food products, is accomplished only by imagines; larvae are fed and nourished by workers and females. Pretreated food is subsequently digested by larvae themselves (Brian, 1983).

This paper deals with an estimation of the impact of selected heavy metal ions on the relative contamination in various developmental stages and castes of Dolichovespula saxonica

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(Fabr.). The possibility of ascribing the optionally selected caste as an indicator in monitoring of environmental heavy metal pollution was tested and considered.

MATERIALS AND METHODS

All the examined developmental stages and castes of D. saxonica (Fabr.) (20 specimens in each sample) were inhabitants of the nests found in garrets of farm cottages in the village of Wola Szczygiełkowa in Świętokrzyski National Park.
Poisoned specimens were exsiccated at 60°C for 24 hr (in the presence of anhydrous $CaCl_2$), weighed and subsequently subjected to wet mineralization in 2 ml aliquots of a mixture of nitric and perchloric acids (3:1, v/v) at 60°C for 1 hour. After filtration (Synpor, 0.35 μm) samples were diluted 4-fold with deionized water, prior to being stored at -4°C. Heavy metal ions were estimated by atomic absorption spectometry using an AAS-1 apparatus (Carl Zeiss Jena).
Results are expressed in ppm as the mean ±1 S.D. All data were analyzed by the "Student's" t-test and partial correlation analysis.

RESULTS AND DISCUSSION

The data reported in Table 1 were obtained from a compilation of estimates of heavy metal levels (Cd, Fe, Pb and Zn) in the bodies of larvae, pupae, workers, males and females of D. saxonica (Fabr.). In spite of high individual variations of heavy metal contamination, the results indicate that the greatest levels of accumulation of were in larvae, workers and males, the lowest - in females and pupae. The lower concentrations in pupae may have resulted from active or passive excretion in exuviae during larval growth and development. While the greatest accumulation of heavy metals in larvae and workers could be easily explainable, the high concentration in males when compared to females is surprising.

A variety of experimental animal studies suggest that gastrointestinal absorption and toxicity of some metals depends greatly on their chemical form in the diet and on interactions with other dietary constituents, such as proteins, dietary fiber and other elements (Fox, 1976; Weigel et al., 1987). Since proteins prevail in the diet of larvae, and carbohydrates dominate the diet of females (Brian, 1983), it seems reasonable to speculate on the composition of various foods of different stages and consider this difference a reason for differential uptake of heavy metals.

The levels of cadmium in workers (Table 1) are distinctly prevalent. Cadmium toxicity in man and animals is well documented. Several pathophysiological signs of Cd accumulation have been observed, while studies investigating terrestrial invertebrates are still scarce. This element is known to be extremely toxic, even if present as a trace in animal cells.

Table 1. Concentrations of heavy metal ions in various stages of *D. saxonica* (Fabr.) (x±1 S.D.; n=20). Superscripts refer to the relevant couples compared. Those undisplayed mean differences at significance level of at least p=1.00

	Cd (ppm)	Fe (ppm)	Pb (ppm)	Zn (ppm)	Body mass (mg)
larvae	9.40 ± 4.07*	747.28 ± 199.05	67.11 ± 43.79	416.68 ± 63.85	34.22 ± 12.79
pupae	4.84 ± 2.02**	142.04 ± 56.39	54.15 ± 14.81*	175.12 ± 18.48	45.75 ± 6.76*
males	6.13 ± 3.75	241.79 ± 68.83	84.93 ± 31.86**	189.19 ± 33.38*	23.26 ± 5.44**
females	1.54 ± 0.76	95.20 ± 19.68*	16.94 ± 5.78	86.69 ± 12.94	90.52 ± 10.55
workers	17.62 ± 4.42	395.16 ± 50.03	74.66 ± 37.91***	361.35 ± 40.68**	21.53 ± 1.36***
	*males p=0.999 **males p=0.901	*pupae p=0.999	*larvae p=0.885 **larvae p=0.920 workers p=0.814 ***larvae p=0.713 pupae p=0.983	*pupae p=0.942 **larvae p=0.999	*larvae p=0.999 **Larvae p=0.999 ***Males p=0.907

It has sterilizing, teratogenic and carcinogenic effects. Bound cadmium is known to be more potent in altering iron metabolism than inorganic Cd, and may infludence this metabolism by competitively inhibiting intestinal Fe uptake or by depleting body stores of the metal (Hamilton and Valberg, 1974). Our results confirm the above, partly at least, with regard to larvae and workers (also in females to a lesser degree) where the highest accumulation of Cd were found (Tables 1 and 2).

Table 2. Partial correlation coefficients of body mass and of heavy metal content in various developmental stages of D. saxonica (Fabr.). These of significance of at least 0.95 are boldfaced.

		Fe	Pb	Zn	Mass
larvae	Cd	**-0.757**	-0.271	-0.067	0.284
	Fe		-0.249	-0.038	0.250
	Pb			**-0.590**	**0.814**
	Zn				**0.726**
pupae	Cd	0.334	**-0.806**	0.272	**-0.625**
	Fe		**0.605**	-0.210	0.063
	Pb			0.380	-0.426
	Zn				**0.525**
males	Cd	0.246	-0.383	0.395	**-0.806**
	Fe		0.183	-0.155	0.442
	Pb			0.329	-0.099
	Zn				0.278
females	Cd	-0.260	0.349	-0.442	**-0.868**
	Fe		0.038	-0.211	-0.155
	Pb			0.337	**0.560**
	Zn				-0.401
workers	Cd	**-0.642**	**0.692**	**-0.508**	0.090
	Fe		**0.624**	-0.433	0.320
	Pb			**0.612**	-0.308
	Zn				0.190

The existence of interaction between zinc and cadmium in living systems and their importance were also demonstrated, in fact, by a combined treatment with Zn and Cd. In some tissues, zinc competes with cadmium for metal binding sites in cytosol proteins, exerting antagonistic effects on uptake of cadmium. Generally, it exhibits protective action in the toxic effects of cadmium. Regrettably, nearly all reports dealing with this subject concern aquatic organisms (Gruden and Munič, 1987; Hemelraad et al., 1987; Roelfzema et al., 1987; Weigel et al., 1987). Correlation between Zn and Cd, as evidenced in Table 2, is poorly significant in general; however, the highest negative correlations are attributed to workers and females.

When comparing the absolute values of heavy metal content, expressed in ppm, the concentrations of iron and zinc are one-two orders higher than the relevant ones of cadmium and lead. A plausible explanation for this result is that iron and zinc are actively taken up by numerous organisms and the nutritional requirement for such in living organisms is derived from the significant role these metals play in metabolism of cells. In invertebrates, iron is less significant as it is generally ruled out in importance of oxygen-carrying proteins in the hemolymph (Hamilton and Valberg, 1974; Roelfzema et al., 1987).

The differential accumulation of heavy metals in the bodies of various life stages and castes of D. saxonica (Fabr.) indicates the necessity for careful examination of the castes chosen as indicators of heavy metal contamination in pollution monitoring studies. It should be noted that other species of wasps or social insects may follow a similar accumulation pattern, but definite proof of this awaits further quantification by testing other species with different zoogeographic ranges.

Acknowledgments.

Dr. Eligiusz SERAFIN from our University is greatly acknowledged for his advisory assistance in cation determinations.

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Received January 31, 1989; accepted March 25, 1989.