## Assimilation of Zinc, Cadmium, Lead, Copper, and Iron by the Spider *Dysdera crocata*, a Predator of Woodlice

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Dysdera crocata is one of the commonest of the large British spiders. During the day, it resides in a silk chamber on the underside of stones and emerges only at night to hunt for prey. The members of the Genus Dysdera are unique in being the only animals to live exclusively on a diet of terrestrial isopods or `woodlice' (Bristowe 1958). Since woodlice contain the highest concentrations of zinc, cadmium, lead and copper of any terrestrial invertebrate (Hopkin & Martin 1982a 1982b 1984a), Dysdera crocata must have evolved the ability to assimilate essential nutrients the from digested tissues of woodlice without absorbing the toxic amounts of metals which they contain.

In this paper, an experiment is described on the assimilation of zinc, cadmium, lead, copper and iron by <u>Dysdera crocata</u> collected from a site in central Bristol. The spiders were fed on woodlice from their 'own' site, and on woodlice from a site contaminated by a smelting works which contained much higher levels of zinc, cadmium and lead than the spiders would have been used to in their normal diet.

## METHODS

Twelve specimens of Dysdera crocata, and about 100 specimens of the woodlouse Porcellio scaber, were collected from a small area of derelict land in the September 1983. A similar centre of Bristol during number of woodlice of the same species were also collected from Hallen Wood to the north-west of Bristol, a site contaminated with zinc, cadmium, lead and copper by a nearby smelting works (Hopkin & Martin 1982a). The spiders were transferred to individual petri dishes together with a folded piece of filter paper into which they retreated and spun a silk cell. The woodlice were maintained in plastic tanks on leaf litter from their 'own' site.

The spiders were divided into three groups of four and starved for 4 days. Those in the first group were each fed a single weighed specimen of <u>Porcellio scaber</u> from their 'own' site (Bristol) and the second group, a woodlouse from the population collected from near to the smelting works (Hallen). Three days later, the remains of the woodlice were replaced with a fresh specimen. The spiders were each fed twelve woodlice. The third group of spiders were not fed for the duration of the experiment (Starved).

At the end of the experiment the spiders, and twelve woodlice from each population, were oven-dried at 70C, weighed on a microbalance, digested individually in 2 ml of boiling concentrated Aristar grade nitric acid and diluted to 5 ml with deionised distilled water. Each sample of the remains of woodlice which had been fed to the spiders, were pooled, digested in 10 ml of Aristar grade nitric acid and diluted to 25 ml with deionised distilled water. The digests were analysed for zinc, cadmium, lead, copper and iron by flame (Varian AA775) or flameless (Varian GTA95) atomic absorption spectrophotometry.

The amounts of metals contained within the specimens of <u>Porcellio</u> <u>scaber</u> before they were fed to the spiders was estimated from plots of wet weight against metal content of whole woodlice. The amounts of metals removed from the woodlice during feeding could then be calculated by subtracting the amounts in the remains from these estimates. The amount of tissue removed during feeding was assessed in a similar way after the initial wet weights of the woodlice had been converted to dry weights from a plot of wet weight against dry weight of whole woodlice.

## RESULTS AND DISCUSSION

The hepatopancreas contains more than 50% of the zinc, cadmium, lead and copper in terrestrial isopods (Hopkin & Martin 1982a). Consequently, although the spiders removed only about 15% of the weight of woodlice during feeding, they ingested considerably larger proportions of the metals, particularly cadmium and lead (Table 1). Spiders which feed on insects remove similar proportions of metals, but a larger proportion of the weight of their prey (Breymeyer & Odum 1969, Lee et al 1978, van Hook & Yates 1975).

The natural diet of <u>Dysdera</u> <u>crocata</u> in central Bristol contains very large <u>amounts</u> of zinc and copper (Table 1). Indeed, on individual feeding occasions, the combined concentrations of these elements in the tissues removed from the woodlice may exceed 1% on a dry weight basis. However, at the end of the experiment, there were no significant differences between the concentrations of metals in the spiders fed on woodlice from their 'own' site, and those which had been starved (Table 2). Thus, almost all the metals consumed by the spiders pass through the gut without being assimilated.

 $\frac{\text{Table 1}}{\text{crocata}}$ : Consumption of tissue and metals by <u>Dysdera</u>  $\frac{\text{crocata}}{\text{site in Bristol, and Hallen Wood close to a smelting works.}$ 

Bristol	dw	Zn	Cđ	Pb	Cu	Fe
Wa	82.6	1095	7.50	16.3	1589	326
SE	(10.3)	(136)	(0.94)	(2.0)	(205)	(41)
Wb	70.5	717	2.89	6.52	836	208
SE	(9.4)	(104)	(0.15)	(0.72)	(110)	(29)
Wa-Wb	12.1	378	4.61	9.8	753	118
0 Po	14.6%	34.5%	61.4%	59.9%	47.4%	36.3%
Hallen	dw	Zn	Cđ	Pb	Cu	Fe
Wa	87.1	2019	141	152	1951	204
SE	(20.4)	(505)	(35)	(38)	(485)	(50)
Wb	72.4	1163	41.3	65.2	1043	132
SE	(18.7)	(280)	(12.4)	(17.2)	(316)	(28)
Wa-Wb	14.7	856	100	87	908	72
010	16.9%	42.48	70.78	57.1%	46.5%	35.1%

Wa=estimated mean dry weight (dw, mg) and metal content (nmol) of woodlice fed to Dysdera crocata. Wb=mean dry weight and metal content of remains of woodlice discarded after feeding by Dysdera crocata. Wa-Wb=amounts of tissue and metals consumed by Dysdera crocata.

%=percentage of original amounts of tissue and metals in woodlice removed by Dysdera crocata during feeding. (n=4 pooled samples of 12 woodlice, SE=standard error)

Spiders fed on woodlice from Hallen, which consumed a mean of 100 and 87 nmol of cadmium and lead respectively (Table 1), contained only 4.66 and 1.30 nmol of these metals at the end of the experiment, amounts which were not significantly different from those in starved individuals (Table 2). Therefore, <u>Dysdera crocata</u> are able to prevent zinc, cadmium and lead from being assimilated even when these metals are present at concentrations in the food which are 2, 20 and 10 times greater than they would experience feeding on woodlice from their 'own' site (Table 1). In contrast, centipedes from uncontaminated sites are unable to prevent cadmium from accumulating to lethal concentrations in the cells of the midgut when fed on the hepatopancreas of only three woodlice from a site near to the smelting works (Hopkin & Martin 1984b).

<u>Table 2</u> : Mean dry weight (dw mg), and amounts (nmol) and concentrations ( $\mu$ mol/g) of metals in <u>Dysdera</u> <u>crocata</u> at the end of the experiment (SE=standard error, n=4 for each treatment).

	Zn	Cd	Pb	Cu	Fe
nmol	212	4.81	2.86	191	97.4
S.E.	(71)	(1.26)	(2.03)	(71)	(21.7)
µmol/g	19.4	0.489	0.142	17.6	8.09
S.E.	(3.1)	(0.080)	(0.064)	(3.5)	(0.28)

Starved (dw=12.04, SE=4.66)

Fed Bristol woodlice (dw=10.02, SE=0.68)

	Zn	Cd	Pb	Cu	Fe	
nmol	282	4.04	1.44	281	56.9	
SE	(78)	(1.07)	(0.51)	(99)	(13.1)	
µmol/g	28.7	0.398	0.148	27.6	5.68	
SE	(7.9)	(0.100)	(0.051)	(9.9)	(1.25)	

Fed Hallen woodlice (dw=11.80, SE=4.27)

	Zn	Cd	Pb	Cu	Fe
nmol	271	4.66	1.30	137	63.6
µmol/g SE	22.8 (2.3)	0.331 (0.064)	0.163 (0.057)	16.9 (4.6)	7.45 (1.24)

Since Dysdera crocata is so effective at restricting the assimilation of metals into its tissues, why do the spiders store such large amounts of zinc and copper? One possible explanation would be as a deterrent to predators which may find the zinc and copper distasteful. Indeed, Dysdera crocata, with its cream coloured abdomen and orange/red cephalothorax, is a very conspicuous animal (see colour photograph in Bristowe 1958) and makes little attempt to escape if persuaded to emerge from its silk retreat during daylight hours.

Studies are required on the distribution of metals in Dysdera crocata to determine how the spider manages to store such large amounts of zinc and copper within its tissues with no obvious ill effects.

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