AN EVALUATION OF *LYCOSA HILARIS* AS A BIOINDICATOR OF ORGANOPHOSPHATE INSECTICIDE CONTAMINATION

S. HODGE[1,2] and C.J. VINK[2,3]

[1]Centre for Environmental Toxicology (CENTOX), PO Box 84, Lincoln University, Canterbury, New Zealand
[2]Ecology and Entomology Group, PO Box 84, Lincoln University, Canterbury, New Zealand
[3]Author for correspondence

ABSTRACT

The potential of *Lycosa hilaris* as a bioindicator of organophosphate contamination was assessed experimentally in a crop of beans (*Phaseolus vulgaris*) in Canterbury, New Zealand. Although the numbers of *L. hilaris* caught in pitfall traps fluctuated significantly as the crop aged, there were no differences (P>0.05) in *L. hilaris* abundance in plots sprayed with diazinon or chlorpyrifos compared with plots of beans sprayed with water. The abundances of other beneficial arthropod predators (linyphiid spiders, harvestmen, centipedes) were also not affected by insecticide application (P>0.05). Although *L. hilaris* may not represent a good bioindicator, the use of this species as a laboratory bioassay organism should be further investigated, especially with respect to sublethal physiological responses.
Keywords: Lycosidae, bioindicator, insecticide, beneficial arthropod predators, *Lycosa hilaris*.

INTRODUCTION

With pressure from international markets on producers to minimize their use of agrichemicals (Wratten *et al*. 1998), the sustainability of agro-ecological systems is of increasing interest (Glen *et al*. 1993; Wratten *et al*. 1997). As measures of the 'health' of a system, various invertebrate bioindicators have been proposed (McGeoch 1998). Arthropod predators meet a number of the *a priori* criteria for environmental indicators provided by McGeoch (1998). They can be sampled, sorted and stored easily and the sampled individuals are expendable. As predators of insect pests, the role of lycosids in agricultural systems has economic significance and they are considered important non-target species for pesticides (Lang *et al*. 1999).

Lycosa hilaris Koch (Araneae: Lycosidae) has already been identified as an abundant arthropod predator in New Zealand agricultural land (Sivasubramaniam *et al*. 1997). Lycosidae have been considered in a number of investigations into integrated pest management (Hayes and Lockley 1990; Fagan *et al*. 1998) and the impact of pesticides on lycosids has been investigated (Hof *et al*. 1995).

This investigation aimed to examine the response of a field population of *L. hilaris* when exposed to organophosphate insecticides and to evaluate the use of *L. hilaris* as a bioindicator of contamination. The responses of other non-insect, macro-arthropod predators (centipedes, harvestmen and other spider families) to organophosphates were also monitored.

METHODS

The study was conducted on an area of loam soil in the Horticultural Research Area of Lincoln University, between November 1998 and January 1999. Half a hectare was divided into eighteen 10 x 10 m plots, arranged in a 6 x 3 rectangle, with a 4 m margin between the rows and between the columns. The ground was tilled and sprayed with the herbicide monolinuron (Aresin 50 WP) at 1.5 kg/ha. Two days later, the plots were sown with green beans (*Phaseolus vulgaris* L.) at a density of 14 seeds/m, with 375 mm between rows. The crop was irrigated as required.

One day after sowing, a single pitfall trap (85 mm diameter; 95 mm deep) was set into the centre of each plot. Ethylene glycol (50%) was placed in each trap to a depth of 30 mm as a preservative, with a drop of detergent added to act as a surfactant. The traps were collected one week later and new traps put into position. This weekly routine continued for five weeks.

Five weeks after sowing, the pitfall traps were removed and each plot was sprayed once with either chlorpyrifos (Lorsban 40 EC) at 220 g/ha in 200 litres of water, diazinon (Basudin 600 EW) at 780 g/ha in 200 litres of water or water at 200 litres/ha as a control. The chlorpyrifos and diazinon concentrations used were those recommended for use against aphids on vegetable crops. All sprays were applied at 300 kPa using a conventional spray boom. Each treatment was replicated six times and treatments were arranged in two 3 x 3 Latin squares over the eighteen plots. The pitfall traps were then replaced and trapping continued for a further five weeks. The traps were inspected weekly in the laboratory and their contents washed and sorted. The numbers of adult and juvenile *L. hilaris*, adult and juvenile harvestmen, other families of spiders and centipedes in each sample were recorded. Numbers were analysed using repeated measures ANOVA for the effects of time and treatment, accounting for variation due to column and row in the experimental design. The data were transformed as $\sqrt{(x + 3/8)}$ to increase normality.

RESULTS

L. hilaris was the only species of Lycosidae found in the bean crop and was the most abundant non-insect arthropod predator collected (Table 1). The next three most abundant groups were linyphiid spiders, adult harvestmen and centipedes. A further five families of spider were recorded but were not common enough to be considered useful as bioindicators (Table 1).

TABLE 1: Total numbers of non-insect arthropod predators collected in a bean crop over 180 'pitfall weeks'.

Group		Specimens collected
Lycosa hilaris	- adults	440
	- juveniles	447
Other spider families:		
	Clubionidae	1
	Corinnidae	1
	Graphosidae	9
	Ctenidae	1
	Linyphiidae	280
	Salticidae	4
Harvestmen	- adults	173
	- juveniles	71
Centipedes		114

The abundance of *L. hilaris* adults was significantly affected by time (Fig. 1a; $P<0.001$) but not by insecticide treatment ($P>0.50$). The abundance of *L. hilaris* juveniles was not affected by time (Fig. 1b; $P>0.05$) or by insecticide treatment ($P>0.30$). Data for the other groups were patchy, with a high proportion of zero records in the data. For the linyphiid spiders, harvestmen (juvenile & adults) and centipede groups, sampling period significantly affected abundance ($P<0.005$) but there were no significant effects of insecticide treatment ($P>0.50$) and no interaction between treatment and time ($P>0.15$).

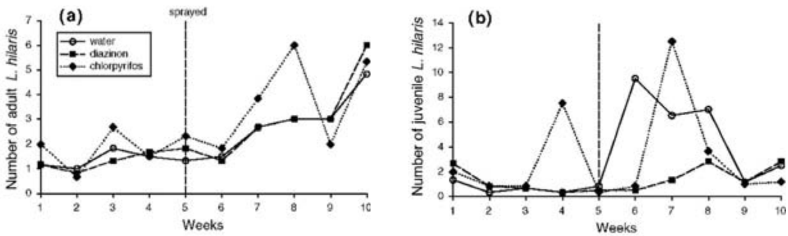

FIGURE 1: Mean numbers of (a) adult and (b) juvenile *Lycosa hilaris* captured per week in pitfall traps in a *Phaseolus vulgaris* crop in Canterbury, New Zealand.

DISCUSSION

None of the groups of predators examined, including *L. hilaris*, showed any clear population response to the application of organophosphates at the recommended field rates. *L. hilaris*, however, represents the group of arthropods that most closely met the criteria suggested by McGeoch (1998). They were the most abundant group and fairly well represented in all samples and, although the New Zealand Lycosidae are currently being revised, the taxonomy of this genus has been dealt with previously (Vink 1996). As *L. hilaris* is often the only or dominant lycosid present in agricultural systems, it can be readily identified and sorted from other spiders in the samples.

McGeoch (1998) defined an "environmental indicator" as "a species … that responds predictably, in ways that are readily observed and quantified, to environmental disturbance or to a change in the environmental state." There are then two sub-classes to which arthropod predators could be assigned: (1)"detectors", which are organisms naturally present in a system and show a measurable response to environmental change, e.g. changes in behaviour, mortality, age-class structure, and (2)"bioassay organisms", which can be used in the laboratory to detect the presence (or concentration) of contaminants. From the results here it would appear that *L. hilaris* is unsuitable as a detector of organophosphate contamination in the field at the rates used, although population responses may be found at higher levels of contamination (e.g. rates recommended for pasture). In order to further evaluate the use of *L. hilaris* as a bioassay organism, acute and sublethal responses to organophosphates are being examined in the laboratory (Van Erp *et al*. 2000).

ACKNOWLEDGEMENTS

We thank Warwick Shaw, Martin Longley and Rhonda Pearce for helping with field work. Bruce Chapman, Kathryn O'Halloran and Steve Wratten provided useful comments on the manuscript. Financial support was provided by the New Zealand Foundation for Research, Science and Technology (project # 96-LCR-15-4844).

REFERENCES

Fagan, W.F., Hakim, A.L., Ariawan, H. and Yuliyantiningsih, S., 1998. Interactions between biological control efforts and insecticide application in tropical rice agroecosystems: the potential role of intraguild predation. *Biological Control 13:* 121-126.

Glen, D.M., Greaves, M.P. and Anderson, H.M. (Eds), 1993. Ecology and Integrated Farming Systems. John Wiley & Sons, Chichester. 329 pp.

Hayes, J.L. and Lockley, T.C., 1990. Prey and nocturnal activity of wolf spiders (Araneae: Lycosidae) in cotton fields in the Delta region of Mississippi. *Environ. Entomol. 19:* 1512-1518.

Hof, A., Heimann, D. and Rombke, J., 1995. Further development for testing the effects of pesticides on wolf spiders. *Ecotoxicol. Environ. Safety 31:* 264-270.

Lang, A., Filser, J. and Henschel, J.R., 1999. Predation by ground beetles and wolf spiders on herbivorous insects in a maize crop. *Agric. Ecosystems Environ. 72:* 189-199.

McGeoch, M.A., 1998. The selection, testing and application of terrestrial insects as bioindicators. *Biol. Rev. 73:* 181-201.

Sivasubramaniam, W., Wratten, S.D. and Klimaszewski, J., 1997. Species composition, abundance, and activity of predatory arthropods in carrot fields, Canterbury, New Zealand. *N. Z. J. Zool. 24:* 205-212.

Van Erp, S., Booth, L.H. and O'Halloran, K., 2000. Organophosphate toxicity in wolf spiders (Lycosidae): An evaluation of sublethal responses. *N.Z. Plant Prot. 53:* 447.

Vink, C.J., 1996. The taxonomy and systematics of a group of New Zealand Lycosidae (Araneae) (wolf spiders). M.Sc. Thesis, Lincoln University, New Zealand.

Wratten, S.D., Hofman, M., Thomsen, S., Williams, P., Groves, G., Eason, C. and Greer, J., 1997. Measuring sustainability in agricultural systems. *Proc. 50th N.Z. Plant Prot. Conf.:* 514-519.

Wratten, S.D., Wearing, H., King, D. and Davis, S., 1998. Market-driven IPM in New Zealand - has it delivered? *Proc. 6th Australasian Appl. Entomological Res. Conf.*: 153-159.