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Fenvalerate Concentrations in the Vegetation, Insects, and Small Mammals of an Old-field Ecosystem*

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Fenvalerate (Pydrin®, cyano [3-phenoxybenzyl]-methyl 4-chloro-&-[1-methylethyl] benzeneacetate) belongs to a group of relatively photostable synthetic pyrethroids having broad-spectrum insecticidal activity (Ohno et al. 1976, Elliot 1980-1985), sufficient stability for agricultural use (Ohkawa et al. 1978), and moderate mammalian toxicity (Shell Development Company 1975). The half-life of fenvalerate when incorporated into soil varied from 15 days to 3 months (Ohkawa et al. 1978, Williams and Brown 1979, Chapman and Harris 1981, Hill 1981). Variation in half-life is primarily related to the microbial activity in different soil types (Williams and Brown 1979). Due primarily to photodegradation, fenvalerate is generally less persistent on soil surfaces, with a half-life ranging from 2 days on light clay to 18 days on sandy loam (Mikami et al. 1980). On bean plants, the half-life was 14 days, with little fenvalerate translocation (Ohkawa et al. 1980). Hill et al. (1982) reported that the 9- to 11-day half-life of fenvalerate on alfalfa was influenced by growth-dilution and temperature. However, Schaefer et al. (1978) found that concentrations on pasture grass were more variable, with a relatively slower decomposition rate than has been reported on beans and alfalfa.

In this study, the concentration and movement of fenvalerate were monitored in vegetation, insects, and

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small mammals of an old-field site. This habitat provided a diverse and abundant animal community and was similar to fencerows, grass waterways, and other field margins that might be exposed to fenvalerate directly or as drift during typical field applications. The effects of fenvalerate on populations of nontarget invertebrates and small mammals were monitored concurrently and will be reported elsewhere.

MATERIALS AND METHODS

The study was conducted in central Iowa (42°10'N, 93°40'W) on a 6.8-ha old field site that was 25% permanent grassy waterways and 75% early successional growth dominated by meadow foxtail (Alopecurus pratensis), clovers, and broadleaved annuals. Early successional growth was mowed yearly in late August. The study area was divided into six 1-ha plots separated by 9-m wide fallow strips or, in the waterways, by a 60-cm aluminum barrier buried to a depth of 10 cm. The fallow strips were disked periodically for weed control. Three plots were chosen randomly to receive insecticide application; three served as controls.

Pydrin® (an emulsifiable concentrate formulation of fenvalerate provided by Shell Development Company, Modesto, CA) was applied to the sprayed plots at the rate of 0.112 kg AI/ha (0.1 lb/acre) on 9 June and 5 August 1980 and 10 June and 21 July 1981. In both years, the first application was made with a tractor-mounted tank sprayer, and the second with a high-clearance sprayer. Wind conditions were calm during all applications except on 9 June 1980, when there was a northerly wind of 15 to 20 kph (9-12 mph).

In 1980, samples of vegetation, short-horned grasshoppers (Acrididae), field crickets (Gryllidae), ground beetles (Carabidae), deer mice (Peromyscus maniculatus), and shorttail shrews (Blarina brevicauda) were collected at regular sampling periods before and after each insecticide application for 3 to 8 weeks. During each sampling period, one sample from each treated plot and one composite control sample were collected. In 1981, samples were collected again, but only after the second application, when they were taken more frequently immediately after application and limited to grasshoppers, ground beetles, deer mice, and meadow voles (Microtus pennsylvanicus).

During each sampling period, approximately 25 g of vegetation was collected with a hand-held grass clipper at fixed sampling points in each plot and placed in 4-l glass jars for transport. Samples were immediately homogenized in a commercial food processor or

refrigerated up to 20 h before homogenization. A portion of the homogenate was frozen until analysis.

Grasshoppers were captured with a 38-cm sweep net. Field crickets and ground beetles were live-trapped in randomly located pitfall traps. Small mammals were captured in Sherman live-traps in conjunction with a concurrent population-estimation study. One mouse was collected from each sprayed plot and a control plot during each sampling period. All animals were asphyxiated immediately with ethyl acetate, stored on ice in the field, and frozen until analysis. Skins and gastrointestinal tracts were removed from mammals.

All samples were analyzed at the Patuxent Wildlife Research Center, Laurel, MD, by procedures following Reichel et al. (1981). Samples were Soxhlet-extracted with hexane and cleaned up by gel-permeation chromatography with an in-line alumina column. Residues were quantified by gas-liquid chromatography with an electron capture detector, and the residues in one vegetation, one mouse, and one grasshopper sample were confirmed by gas-liquid chromatography-mass spectrometry. The method had an average recovery of 96% for fortified material, with a limit of quantification of 0.01 ppm wet weight.

RESULTS AND DISCUSSION

Fenvalerate concentrations were as high as 12.1 ppm on vegetation immediately after application, but decreased to <1 ppm within 24 days. The rate of fenvalerate degradation was greater after the second application than the first (Fig. 1). Consequently, the half-life of fenvalerate on vegetation was 6 and 7 days after the 5 August 1980 and 21 July 1981 applications, compared with 11 days after the 9 June 1980 application. We concluded that little drift occurred between plots because fenvalerate ($\leq$0.08 ppm) was detected in only 4 of 20 control samples.

All insect samples contained less than 0.5 ppm fenvalerate, with the highest mean values found in short-horned grasshoppers (Table 1). These samples were collected from populations that were greatly reduced after application and may represent immigrants as well as survivors of the application. Because of reduced grasshopper populations, adequate samples could not be collected until several weeks after the 9 June 1980 and 21 July 1981 applications. Few dead grasshoppers were found on the sprayed plots, so residue information from pesticide mortalities is not available. Population levels were not affected and no fenvalerate was detected in grasshoppers on control plots.

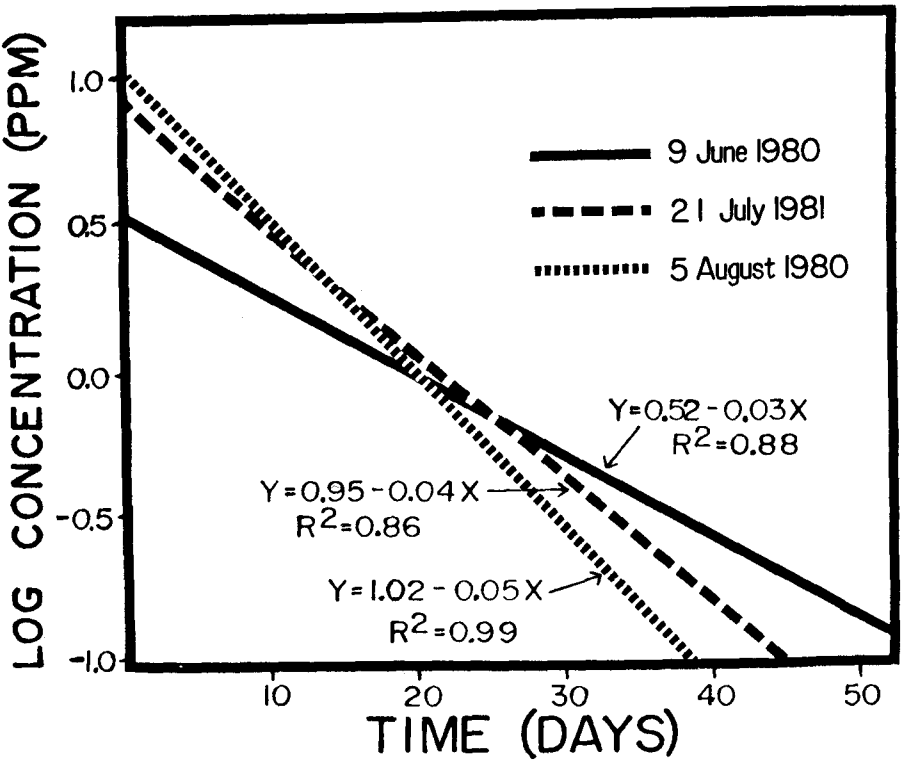

Figure 1. Decline of fenvalerate concentrations (ppm wet weight) in vegetation samples from three sprayed plots

In contrast to grasshoppers, population effects were not detected for ground beetle populations after fenvalerate applications, based on sampling with pitfall traps before and after all applications. Mean residues were less than 0.15 ppm (Table 1). Fenvalerate was not detected more than 17 days after applications in 1980, but was found in samples collected up to 24 days after the 21 July 1981 application. However, the last two collection dates (16 and 24 days postapplication) each had one sample containing concentrations that exceeded all other ground beetle samples. No fenvalerate was detected in ground beetles from control plots in 1980, but control-plot concentrations were similar to those of the sprayed plots in 1981. This difference may be related, in part, to the changes in species composition from carnivores to omnivores between years. The population was dominated by the carnivorous Evarthrus alternana in 1980, whereas the omnivorous Harpalus spp. dominated in 1981, with H.caliginosus contributing more than 50% of the biomass per sample. Because ground beetle samples consisted of several species in the proportion in which they were captured, we do not know if different species carried different fenvalerate concentrations.

Table 1. Fenvalerate concentrations (ppm wet weight) in samples of short-horned grasshoppers and ground beetles from three sprayed plots and a composite from three control plots collected at various times after application.

Application date	Days after application	Fenvalerate concentrations (ppm wet weight)	
		Sprayed $\bar{X}$(SE)	Control
Short-horned grasshoppers			
9 June 1980	36	0.03(0.01)	ND[a]
	49	ND	ND
5 Aug 1980	7	0.33(0.08)	ND
	14	0.19(0.05)	ND
	21	0.12(0.03)	ND
Ground beetles			
9 June 1980	10	0.12(0.03)	ND
	17	ND	ND
	22	ND	ND
5 Aug 1980	6	0.14(0.04)	ND
	17	ND	ND
21 Jul 1981	-1	0.02(0.01)	0.02
	2	0.03(0.00)	0.06
	4	0.13(0.04)	0.02
	8	0.06(0.03)	0.10
	16	0.11(0.09)	0.02
	24	0.15(0.14)	ND

[a] ND = Not detected.

Five samples of field crickets collected from sprayed plots at 6 and 20 days after the 5 August 1980 application contained no more than 0.1 ppm fenvalerate. There was no effect on field cricket populations from fenvalerate applications.

The observed concentrations are similar to those in insects collected from fenvalerate-treated cotton fields (Bennett et al. 1983) in which the highest concentration (0.55 ppm) was found in ground beetles exhibiting tremors when captured. Considering the large population reductions experienced by many insect species and the poisoning symptoms observed in the ground beetles,

Table 2. Fenvalerate concentrations (ppm wet weight) in deer mice and meadow voles collected from three sprayed plots or one control plot after the 21 July 1981 application.

Days after application	Deer mice		Meadow voles	
	Sprayed X(SE)	Control	Sprayed X(SE)	Control
2	Ø.1Ø(Ø.1Ø)	NA[a]	Ø.Ø7(Ø.Ø2)	ND[b]
4	Ø.Ø9[c]	Ø.17	Ø.12(Ø.Ø2)	Ø.Ø9
8	Ø.Ø1(Ø.Ø1)	Ø.Ø4	Ø.46(Ø.27)	Ø.Ø2
21	Ø.Ø1(Ø.ØØ)	Ø.Ø1	Ø.Ø4(Ø.Ø3)	NC[d]

[a]NA = Not available; sample lost in analysis
[b]ND = Not detected
[c]Mean based on 2 samples; third lost in analysis
[d]NC = Not collected

fenvalerate concentrations higher than those reported may be lethal. In the present study, insect species not affected by fenvalerate (e.g., ground beetles and crickets) contained lower ($\leq$Ø.15 ppm) concentrations.

Three deer mice and two shrews collected in 198Ø were analyzed. No fenvalerate was found in the omnivorous deer mice. One shrew, an insectivore, contained Ø.Ø7 ppm fenvalerate. The deer mice and herbivorous meadow voles collected in 1981 contained less than Ø.3 ppm fenvalerate, except for one vole collected 8 days after application that contained 1.Ø ppm (Table 2). The highest concentrations in deer mice and voles occurred 2 and 8 days after application, respectively. Twenty of 23 mammalian samples analyzed from treated plots contained detectable concentrations, compared with only one of eight small mammals captured near fenvalerate-treated cotton fields (Bennett et al. 1983).

Two of three voles captured on control plots contained fenvalerate. The deer mice captured on control plots carried concentrations similar to those from sprayed plots. However, live-trapping records indicated that these deer mice were captured only on control plots during the previous 2 months. Considering the low amounts of fenvalerate detected on control-plot vegetation, deer mice may have consumed contaminated insects that had moved from sprayed plots, and/or mice movement into sprayed plots was not detected by trapping efforts.

In summary, initial concentration and half-life for

fenvalerate degradation (6 to 11 days) on old-field vegetation were consistent with values reported on several agricultural crops. Fenvalerate concentrations in live insect samples were less than 0.5 ppm, and due to its high insecticidal activity, higher concentrations may have been lethal. Concentrations were no more than 1.0 ppm in all mammalian samples, reflecting the low application rate, rapid environmental degradation, and efficient mammalian metabolism of fenvalerate.

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