Perturbation Effects on Deer Mouse Populations in Corn Agroecosystems[1]

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ABSTRACT. **_Peromyscus maniculatus_ living in or near agricultural fields are often exposed simultaneously to insecticide stress and temporary lack of cover at the time of planting. The effects of these two perturbations on _P. maniculatus_ populations in experimental agroecosystems were investigated. Eight 0.1-ha enclosures were planted in field corn (_Zea mayes_). Four enclosures were treated with COUNTER® insecticide at the time of planting and four were left as untreated controls. Four pair of adult _P. maniculatus_ were released into each enclosure and their population dynamics monitored for five weeks following treatment. No significant differences were found between _Peromyscus_ densities in control and insecticide-treated plots or between sex ratios and trapping efficiencies. Also, no significant differences were found in habitat use by male and female mice. Predation, however, appeared to have caused a decline in population densities during week two in both treated and control plots.**

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INTRODUCTION

Small mammals have been used successfully as indicators of pesticide stress effects on agroecosystems (Barrett 1968, Pomeroy and Barrett 1975, Spencer and Barrett 1980, Barrett 1988). Small mammals are frequently exposed to pesticides (e.g., herbicides, fungicides, and insecticides) in agroecosystems. COUNTER® 15-G (15% active ingredient by weight, granular form) is an organophosphate insecticide-nematicide produced by American Cyanamid Company, Princeton, NJ, and is used extensively on corn against soil insects and above-ground pests (American Cyanamid Company 1985). The active ingredient in COUNTER® is Turbufos: S-{[(1,1 dimethylethyl) thio] methyl} 0.0-diethyl phosphorodithioate.

COUNTER® has previously been field tested and found to have minimal impact on wildlife (Labisky 1973). More recent studies, however, have shown COUNTER® to be potentially harmful to mammalian populations (Dingledine 1985). A nonreplicated research design lacking control plots for comparison, however, made these results questionable. Because of these contradictory findings, additional research is needed to evaluate the effects of COUNTER® 15-G on mammalian populations, administered at standard application rates. The present study was designed to evaluate the effects of COUNTER® on the deer mouse (*Peromyscus maniculatus*) within replicated agroecosystems using a mesocosm approach (Barrett et al. 1976). The mesocosm approach has proven effective when attempting to evaluate pesticide effects under natural field conditions (e.g., Barrett 1988). This approach simulates a naturally functioning ecological system, yet permits treatment and control replications.

Besides possible pesticide hazards, small mammals in agroecosystems are also exposed to lack of cover at the time of planting. Vegetative cover provides small mammals with protection against predators and may also serve as a food source (e.g., Birney et al. 1976). The deer mouse, *Peromyscus maniculatus bairdii*, is commonly found in agricultural fields in the midwestern United States (Gottschang 1981) and uses corn and other grains for food and protection from predators. However, the response of *P. maniculatus* to cover removal within agroecosystems needs to be examined more extensively. The purpose of this study was to evaluate simultaneously the effects of COUNTER® 15-G insecticide and lack of cover at the time of planting on the population dynamics of *Peromyscus maniculatus* under replicated experimental field conditions.

MATERIALS AND METHODS

STUDY SITE: This study was conducted at the Miami University Ecology Research Center located near Oxford, OH. Eight 0.1-ha (0.25-ac) enclosures served as the study site. Enclosure walls constructed of 20-gauge galvanized sheet metal, extending 60 cm above ground and 45 cm below ground, were used to restrict small mammal populations. Enclosures of this type have been previously described (Suttman and Barrett 1979, Maly and Barrett 1984).

EXPERIMENTAL DESIGN: The selection of insecticide-treated and control enclosures (hereafter termed grids) was based on a systematic design (Hurlbert 1984). This design was used to minimize possible effects resulting from change in slope, soil type, moisture, or nutritive content between treatments.

All eight grids were tilled on 29-30 May 1986. A one-meter strip of vegetation was left for cover around the edge of each grid. One-quarter of a bale of straw was placed along each enclosure wall to provide additional cover for the mice. Grids were treated with a commercial liquid fertilizer (10-34-0, N-P-K) at 114 kg/ha (100 lb/ac). All grids were planted in corn (Lynx #4355) on 31 May 1986. COUNTER® 15-G was applied banded during planting to four of the grids. The insecticide was applied in a 17.8 cm (7 in) band on top of each furrow at rates recommended for field corn (i.e., 227 g per 305 m of row or 8 oz per 1000 ft of row) with rows approximately 76 cm (30 in) apart. This resulted in a granular application rate of 5.3 kg/ha (4.7 lb/ac) or 1.4 kg active ingredient/ha (1.2 lb a.i./ac). Alachlor (2-chloro-2′6′-diethyl-N-(methozymethyl) acetanilide) plus Atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine) herbicides were then applied to all grids at the rates of 300 g/l

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(2.5 lb/gal) and 180 g/l (1.5 lb/gal), respectively. Weeds were hoed within each grid to maintain a monoculture corn community.

Four 0.25-m^2 samples of edge vegetation (one/grid wall) were collected from each grid on 8-9 July using the harvest method (Odum 1960). Plants were dried at 80° C for 48 hours and weighed to the nearest 0.1 g to estimate mean plant biomass per species.

Census procedures: Thirty-seven Sherman live traps were stationed in each grid. Twenty-five traps were arranged in 5 x 5 grid pattern with traps spaced 6.4 m apart in the crop area and 12 traps (three per wall) placed in the vegetative cover near the enclosure walls. Four pair of adult (>12 g) *P. maniculatus* were marked and released into each grid on 1 June (i.e., less than 24 hours after the time of COUNTER® application). Trapping was conducted three times weekly for the first two weeks when COUNTER® is most toxic and twice weekly for the following three weeks. Traps were baited with peanut butter and contained cotton for bedding. Traps were set between 1900-2000 hours and checked the following morning between 0700-0800 hours. Captured mice were weighed to the nearest gram, examined for reproductive status, and released at the site of capture. Population densities were estimated by the calendar-of-catches method (Petrusewicz and Adrzejewski 1962). Removal trapping was conducted from 3-8 July 1986 to remove any remaining individuals. The following population parameters were determined: population density (number of individuals per 0.1-ha per week), weight change, survivorship (percent survival per 0.1-ha per week from time of initial release), sex ratios, trapping efficiency (number of animals captured on any trapping day divided by the number known to be present at the time of trapping based on the calendar-of-catches method), and habitat use based on site of capture.

Feeding study: Mice were observed to feed on kernels of seed corn during the initial few weeks of the study. Since the planted corn seed had a mercury-based fungicide (Captan®) coating, a feeding study was conducted to determine any toxic effect the corn seed might have when ingested. Sixteen new adult (>12 g) *P. maniculatus* from the same breeding colony were used in a two-week study from 23 September through 7 October 1986. Eight mice were fed Lynx #4355 corn coated with the fungicide; eight were fed uncoated whole shelled corn. Four grams of either treated or untreated corn was made available to each mouse each day. Mice were weighed daily to determine body weight changes and to observe any toxic effects during the feeding experiment.

Statistical analysis: Mann-Whitney U tests were used to compare mean weekly population density differences between treatments in the field and animal weight treatment differences in the feeding study. Student's *t*-tests were used to compare mean weekly survivorship and trapping efficiencies between treatments in the field study and to compare treatment differences regarding the amount of corn ingested in the feeding study. Chi-square analysis was used to compare sex ratios. A contingency Chi-square analysis was performed to determine treatment differences in habitat use (edge vs. field) by male and female mice. Significant differences were determined at the $P<0.05$ level for all analyses.

RESULTS

No significant differences ($P>0.05$) in mean population densities were found between control and insecticide treatments (Fig. 1). Similar patterns of population decrease were exhibited in the two treatments with the greatest population decline occurring during week two for both sexes (Table 1). Survivorship rates were similar between treatments with no significant differences during any week. Survivorship declined to below 20% by week three in both treatments. Seven deer mouse carcasses (four from control and three from insecticide-treated grids) were found during week two. Only partial body remains prohibited insecticide residue analysis.

Sex ratios (M:F) were not significantly different ($P>0.05$) between treatments throughout the study (Table 1). Trapping efficiencies were also not significantly different ($P>0.05$) between treatments. Mean body weight of mice in control and insecticide grids decreased 16.0 and 11.9%, respectively, by the end of the study.

Mice in control grids were captured 39 times in the edge habitat and 51 times in the field habitat. Mice in insecticide grids were captured 52 times in the edge habitat and 42 times in the field habitat. No significant differences were found between habitat use (edge vs. field) by male and female mice (Table 2).

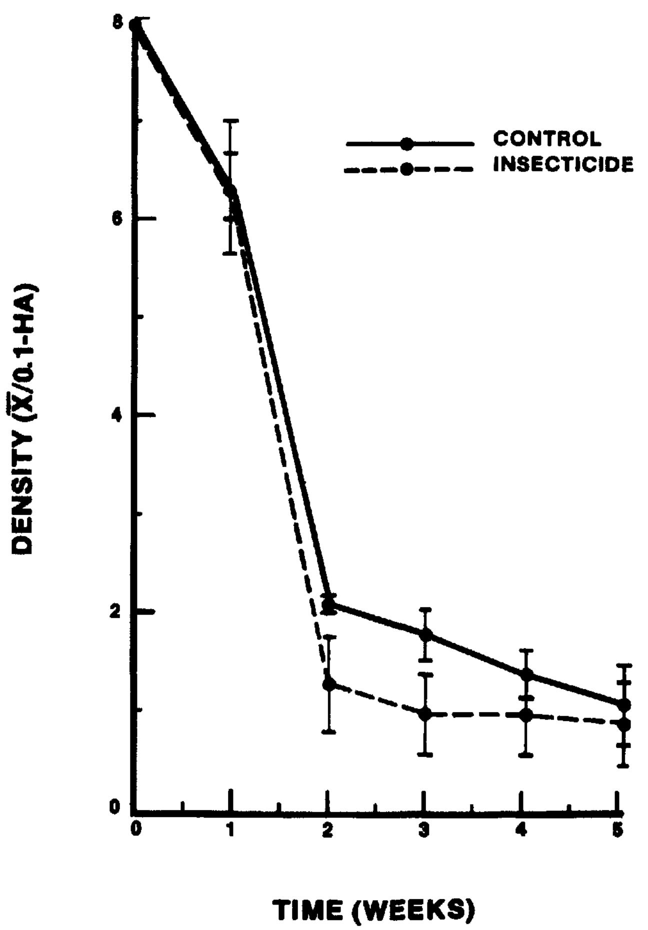

Figure 1. Population density ($\bar{x}$/0.1-ha ± SE) of *Peromyscus maniculatus* in control and insecticide grids.

TABLE 1

Weekly sex ratios (M:F) for Peromyscus maniculatus *in control and insecticide-treated grids.*

TREATMENT	WEEK	MALES	FEMALES	RATIO	X^2	P
Control	1	13	12	1.08	0.04	0.84
	2	4	4	1.00	0.00	0.99
	3	4	3	1.33	0.14	0.71
	4	3	3	1.00	0.00	0.99
	5	3	1	3.00	1.00	0.32
Insecticide	1	13	12	1.08	0.04	0.84
	2	2	3	0.67	0.06	0.75
	3	2	2	1.00	0.00	0.99
	4	2	2	1.00	0.00	0.99
	5	2	2	1.00	0.00	0.99

TABLE 2

Habitat use by male and female Peromyscus maniculatus *in control and insecticide-treated grids.*

TREATMENT	HABITAT	MALE	FEMALE	X^2	P
Control	Edge	22	17	1.66	0.70
	Field	30	21		
Insecticide	Edge	27	25	1.09	0.80
	Field	23	19		

Vegetation composition of the edge habitat in control and insecticide grids was determined to identify those species with >5.0 g dry wt/m^2. Grasses (Family Gramineae) dominated above-ground standing crop biomass in control and insecticide grids with values of 207 ± 63 and 248 ± 110 $\bar{x}$ g dry wt/m^2 ± SD, respectively. A biennial (*Dacus carota*), perennials (*Solidago canadensis* and *Potentilla norvegica*), and a winter annual (*Erigeron annuus*) were also abundant in the edge habitat of both treatments.

The fungicide coating on the seed corn appeared to have no acute toxic effect on *Peromyscus*. There were also no significant differences (P>0.05) in the mean daily weight of mice fed treated corn compared to those fed untreated corn.

DISCUSSION

The present study illustrates the importance of a replicated, mesocosm research design when evaluating the effects of a pesticide stress on the population dynamics of small mammals within agroecosystems. For example, without replicated control plots available, it might appear that deer mouse population densities in insecticide-treated plots were affected by pesticide treatment. Our research design, accompanied by both field and laboratory population measurements, indicates, however, that COUNTER® application did not contribute to the rapid deer mouse population decline observed in both control and insecticide-treated plots. Rather, it was predation, elicited by *Peromyscus* feeding behavior in the recently tilled and planted corn plots, that likely caused the observed population decline.

COUNTER® insecticide appeared to have no acute toxic effect on *Peromyscus maniculatus*. COUNTER® has a half-life of 14 days and is most toxic immediately following application (American Cyanamid 1985). Dingledine (1985) found COUNTER® to be potentially harmful to both avian and mammalian populations. He points out, however, that harmful effects on small mammal populations (e.g., carcasses) were found only following aerial application; no carcasses were found following treatment at the recommended ground application rate. Dingledine (1985) attributed small mammal mortality to greater availability of COUNTER® caused by aerial application. Labisky (1973) found COUNTER® to have minimal effect on wildlife when applied at the recommended agricultural levels employed in this study. He found one carcass, a common grackle (*Ouiscalus quiscula*), which contained high levels of COUNTER® residue and attributed its death to COUNTER® poisoning. Three of 23 other captured animals, including two *P. maniculatus*, contained residues of COUNTER® and its metabolites, but concentrations were low (<0.22 ppm) and the animals survived. Our results indicate no significant effect of COUNTER® treatment on deer mouse population densities.

Predation, however, appeared to affect population densities in both treatments, especially during week two, following planting. Both avian and large mammalian predators were able to enter the grids and capture the mice, particularly those venturing into the open field area. Blair (1940) studied the behavior of *P. maniculatus* in open sandy areas in southern Michigan and observed that individuals entering the open area immediately moved to clumps of vegetation or ran into holes for cover. If no suitable refuge was found, the mouse quickly ran across the open area seeking cover. Our recently tilled plots lacked such clumps of vegetation or holes for cover, thus increasing the risk of predation. Three predators, a feral house cat (*Felis domesticus*), a Barred owl (*Strix varia*), and a Great-horned owl (*Bubo virginianus*), were frequently observed and/or heard in the area at the time of the present study. During week two, four partial mouse carcasses were found in control grids and three in insecticide grids, providing direct evidence of predation. Predation has also been reported to reduce *Peromyscus* population densities in similar experimental plots at this site following vegetation removal by burning (Crowner and Barrett 1979).

Differences in food availability between the edge habitat and the recently planted corn plots likely affected *Peromyscus* feeding behavior. Deer mice utilize a variety of seeds, including those of cultivated crops (e.g., Jameson 1952). Hamilton (1941) and Whitaker (1966) found insects, earthworms, corn, and plant seeds to comprise a substantial portion of the diet of *P. maniculatus*, especially in plowed fields. These food items were especially abundant in the recently tilled and planted corn plots. The seed bank in the planted areas also provided an abundant food source (Froud-Williams et al. 1983). *P. maniculatus* readily consume both natural and planted agricultural seeds (Cogshall 1928). During weeks one and two, partially eaten kernels of the planted corn were frequently found in traps in both treatments. However, the decrease in population densities was not attributed to toxicity since *Peromyscus* fed fungicide-treated corn exhibited no toxic effects and maintained their body weight.

Since the biennial, perennial, and winter annual plant species present in the edge habitat had yet to produce their annual seed crop, the deer mice likely ventured into the planted area in search of food and were, therefore, exposed to increased predation. Indeed, mice were trapped as frequently in the open habitat as in the edge habitat, although cover was minimal in these recently planted plots. Thus, it appears that predation-reduced population densities can be attributed to lack of cover at the time of planting. It is suggested that an adequate edge habitat, such as habitat provided by uncultivated corridors within agroecosystems (Kemp and Barrett 1989), must accompany recently tilled or planted habitat in order for granivorous small mammal species to survive within the agricultural landscape mosaic.

Further investigations are needed to determine the effects of perturbations on *P. maniculatus* within a variety of replicated agricultural crop communities. Such studies must integrate small mammal bioenergetics, feeding behavior, the effects of cultivation techniques, and measures of predation if the effects of simultaneous perturbations, such as pesticide treatment and habitat disturbance, are to be understood.

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