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# Impact of Field Border Plantings on Rodents and Food Safety Concerns

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**ABSTRACT:** This one-year study focused on the impact of hedgerows of native California plants on rodents and food safety in adjacent crops in the Sacramento Valley. Deer mice, house mice, California voles, and western harvest mice were live trapped in four different walnut orchards at zero, 10, 75, 175-m transects from hedgerows. The abundance and richness of rodents was compared to control sites with conventionally managed field edges that were mowed or sprayed for weed control. Unique rodent capture data showed two peaks in activity: 1) in the middle of the orchard regardless of field border type, and 2) in the hedgerow across all seasons with winter being the most active overall. Fewer captures were recorded in the conventional field border, likely because they lacked vegetative structure. Deer mice were the most prevalent species captured throughout the study (>96% of unique captures). House mice and California voles were almost always found in hedgerows and not in adjacent crops. Fecal samples from captured rodents showed a low prevalence of *Escherichia coli* (non-O157 STEC 1.4%,  $n = 438$ ; O157 STEC 0%,  $n = 434$ ) and *Salmonella* (0.92%,  $n = 434$ ). *Giardia* (28.6%,  $n = 210$ ) and *Cryptosporidium* (23.8%,  $n = 210$ ) were more prevalent in captured rodents, but the distribution was not affected by field-edge habitat.

**KEY WORDS:** agricultural crops, *Cryptosporidium*, disease, field-edge habitat, food safety, *Giardia*, rodents, walnuts

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## INTRODUCTION

Field border habitat plantings are gaining interest nationally as a way to enhance biodiversity and ecosystem service benefits on farms. These strips of vegetation on crop edges, often referred to as hedgerows, include native shrubs, wildflowers, and perennial bunch grasses (Williams et al. 2015). In simplified agricultural landscapes, they are well known to help protect water quality, enhance biodiversity, and provide habitat for native bees and natural enemies that enhance pollination and pest control in adjacent crops (Tate et al. 2006, Zhang et al. 2010, Fahrig et al. 2011, Morandin et al. 2016).

Despite these benefits, there is a significant concern among landholders (growers and landowners) that biodiverse field edges will provide habitat for rodents, leading to increased vertebrate pest problems on farms (Garbach and Long 2017). In particular, pocket gophers (*Thomomys* spp.), California ground squirrels (*Otospermophilus* spp.), California voles (*Microtus californicus*), and deer mice (*Peromyscus maniculatus*) are thought to build up in these border habitats leading to increased vertebrate pest problems in adjacent crops. This includes losses in crop yield and quality as well as damage to irrigation systems (especially buried drip), and potential food safety concerns (Baldwin et al. 2014). The purpose of our study was to determine the impact of hedgerows bordering walnut orchards on rodent abundance and diversity in adjacent crops.

## METHODS

### Field Site

Four walnut orchards were monitored for rodents in Yolo County, CA from 2013-2014. One side of each orchard was bordered by a 10-15-year-old hedgerow that was about seven m wide and 448 m long. Each hedgerow had one row of native perennial shrubs including California lilac (*Ceanothus* spp.), California coffeeberry (*Rhamnus californica*), coyote brush (*Baccharis pilularis*), quail bush (*Atriplex lentiformis*), blue elderberry (*Sambucus nigra*), and toyon (*Heteromeles arbutifolia*). The hedgerows also included native perennial grasses including deergrass (*Muhlenbergia rigens*) and slender wheatgrass (*Elymus trachycaulus*) (Long and Anderson 2010). The other three sides of the orchards were conventionally managed by discing, mowing, and/or herbicide sprays with some residual weeds always present. The side opposite of the hedgerow served as our control field edge.

Two of our orchard sites had mature trees characterized by canopy closure and high shading; the other two orchards were younger with less canopy closure. The orchards were between 16 and 43 ha. Average distance from any transect to water (canal or stream) was 372 m. Vegetation management in the orchards included mowing, discing, and/or herbicide treatments with some residual weeds always present. Two of the sites were sprinkler irrigated, and two sites were irrigated via subsurface drip. One orchard was organic, while the other three orchards

were conventionally managed. The walnuts were harvested late October 2013 through mechanical shaking and ground collection harvesters.

### Rodent Trapping and Fecal Sampling

Each of the four walnut orchards was monitored seasonally using 7.6×8.9×22.9-cm Sherman live traps. Trap transects were set at zero, 10, 75, and 175 m from the control and hedgerow field edge borders into the orchard. Two transects were established per distance category (i.e., zero, 10, 75, and 175 m) from each treatment edge with a 30-m minimum buffer between each transect within the same distance category. Each transect contained 10 baited (peanut butter with rolled oats) traps spaced every 10 m in a straight line totaling 90 m from the first to the last trap. Traps were typically placed between the walnut trees, out of mowing lanes, and when possible, along irrigation lines or rodent runways. Traps were baited and opened each evening and checked and closed the following morning. Upon initial capture, rodents were ear tagged, identified to species, sexed, and weighed. Recaptures were noted through ear tag identification. Fecal samples were taken directly from most rodents in microcentrifuge tubes and from the cotton bedding, to test for food pathogens. These were labeled with the date, ear tag number, trap location, and sex before being placed in a cooler; samples were delivered to the Western Center for Food Safety in Davis, CA for processing and analysis.

### Habitat Sampling

Eight habitat variables were measured to determine their impact on mammal activity in each orchard. Habitat assessments were conducted in the fall of 2013 and spring of 2014 at each site. We randomly established five plots of one square meter each, within all transects at the zero- and 10-m distances. We only established plots within one transect for the 75- and 175-m distances, given that walnuts are a monoculture with very little variability within orchard interiors.

Within each plot, percent ground cover was estimated in 5% increments for forbs, grasses, woody plants, bare ground, and thatch (dead vegetation and leaf litter). Canopy cover was measured four times per plot facing each cardinal direction using a spherical densitometer (Lemmon 1956). The four readings were combined into a plot-average percent canopy cover. Vertical cover was measured four times from each cardinal direction facing a Robel pole at a four-m distance with a one-m vantage point (Robel et al. 1970). The four readings were combined into a plot average percent vertical cover. Two measurements of vertical cover were documented: low vertical cover (0-50 cm) and total vertical cover (0-150 cm). All measurements of vertical cover for the five sample plots were averaged to represent the transect.

### Data Analysis

Index values for rodent abundance were first calculated by identifying the number of unique captures for each trap. These values were then divided by the number of nights the surveys were conducted for each trap to provide a general index value to calculate transect averages (Engeman 2005). Unique capture values for small rodents

[i.e., deer mice, house mice (*Mus musculus*), western harvest mice (*Reithrodontomys megalotis*), and California voles] were analyzed as a three-factor repeated measure for analysis of variance (ANOVA) with site as the blocking effect that received all combinations of season, treatment (hedgerows versus controls), and distance from field edge (zero, 10, 75, 175 m). We only used unique capture data for analyses with all rodents. Habitat variables were compared to capture data using Spearman's ranked correlation analysis (Zar 1999) to determine how habitat factors influenced mammal activity. Data were analyzed by season to determine any seasonal differences in habitat impacts.

### RESULTS

A total of 775 mice and voles were captured in 12,789 trap nights resulting in a 6% trap success rate. Deer mice were most abundant ( $n = 746$ ,  $\bar{x}$  mass = 15.7 g), although house mice ( $n = 20$ ,  $\bar{x}$  mass = 16.0 g), California voles ( $n = 7$ ,  $\bar{x}$  mass = 41.9 g), and western harvest mice ( $n = 2$ , mass of single adult = 14.0 g) were also captured. It bears noting that all house mice were captured in the hedgerow. Additionally, six of the California voles were captured in the hedgerow, with one additional vole trapped 75 m from the control field edge. One western harvest mouse was captured in the hedgerow, and one additional individual was captured 10 m from the hedgerow.

Capture rates of unique individuals of all rodents were not equivalent throughout the study area and seasons as evidenced by a season ( $F = 3.99$ ,  $P = 0.046$ ) and a treatment × distance interaction ( $F = 4.13$ ,  $P = 0.043$ ). Most rodent captures occurred during winter ( $\bar{x} = 0.06$  rodents per trap night versus summer  $\bar{x} = 0.03$ , fall  $\bar{x} = 0.02$ , and spring  $\bar{x} = 0.02$ ; Figure 1). Capture rates also exhibited different trends in hedgerow and control portions of the walnut orchards; rodent activity was five times greater within the hedgerow ( $\bar{x} = 0.05$ ) than in the control border ( $\bar{x} = 0.01$ ). Little difference in capture rate was observed at any other distance from field borders (Figure 2).

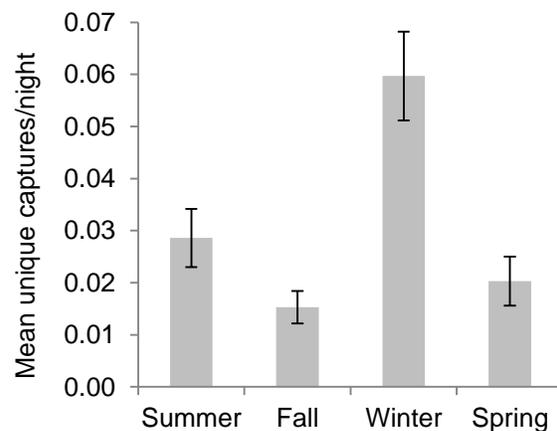
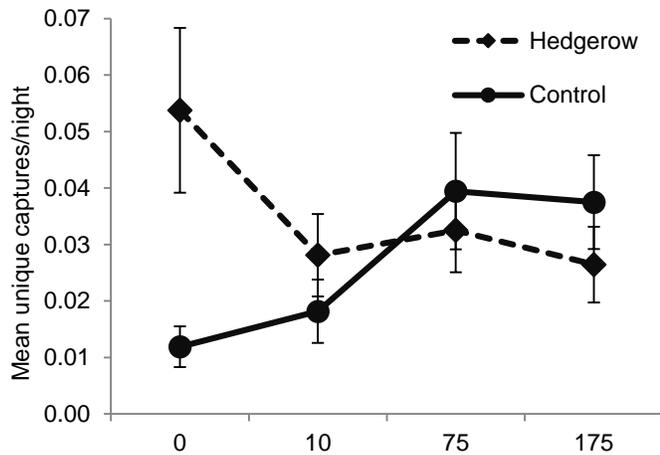


Figure 1. Mean ( $\pm$  SE) number of unique rodents captured per trap night across seasons in walnut orchards from 2013-2014.



**Figure 2.** Mean ( $\pm$  SE) number of unique rodents captured per trap night at set distance intervals (m) from hedgerow and control edges of walnut orchards from 2013-2014.

**Table 1.** Spearman rank correlation of habitat factors and their seasonal influence on rodents in walnut orchards.

Season	Habitat variable <sup>a</sup>	$r_s$	P-value
Fall	Thatch	-0.43	<0.001
	Forb	0.22	0.076
Winter	Canopy cover	0.25	0.051
Spring	Total vertical cover	0.23	0.062
	Canopy cover	0.25	0.048

<sup>a</sup> Habitat variables included: canopy cover = percent canopy closure, forb = percent ground cover of forbs, thatch = percent ground cover of thatch, and total vertical cover = percent obstruction of vertical cover from ground level to 150 cm above ground.

Rodent activity was negatively correlated with thatch cover during fall. However, activity was positively correlated with canopy cover during spring and winter, total vertical cover during spring, and forb ground cover during fall (Table 1). No other habitat variables were strongly correlated with rodent captures during any season ( $r_s \leq |0.20|$ ,  $n = 64$ ,  $P \geq 0.110$ ).

Fecal samples from captured rodents showed a low prevalence of *Escherichia coli* (non-O157 STEC 1.4%,  $n = 438$ ; O157 STEC 0%,  $n = 434$ ) and *Salmonella* (0.92%,  $n = 434$ ). *Giardia* (28.6%,  $n = 210$ ) and *Cryptosporidium* (23.8%,  $n = 210$ ) were more prevalent in captured rodents, but the distribution was not affected by field-edge habitat.

## DISCUSSION

Deer mice were most abundant in our study sites, accounting for 96% of unique captures. These mice are common across a variety of landscapes and often pioneer vacated or disturbed areas regardless of the presence or absence of surrounding habitat (Baker 1983). House mice were far less abundant, perhaps due to a preference for heavily vegetated habitats (Geier and Best 1980, Lorenz and Barrett 1990, Wolf 2016) that were absent from all areas except hedgerows in our investigation. Likewise,

California voles prefer perennial grass areas where they can forage using runways (Batzli and Pitelka 1971), while western harvest mice tend to use areas that provide consistent vertical cover (Shump 1974). This preference for cover by many of the rodent species in our study area led to a slightly higher diversity of rodents in the hedgerow, with activity peaking during the wintertime.

The number of rodent captures was greater in the hedgerows compared with the control field edges. However, there were no differences in trap catches in the interior of the crop between the different distances (10, 75, and 175 m) or treatments (control versus hedgerow) indicating that rodents are present in crops regardless of field edge habitat. This suggests that hedgerows may be too narrow to support a buildup of rodents that then disperse into neighboring crops. Instead, rodents likely move from nearby crops that are disced after harvest. The low prevalence of food-borne pathogens in the rodents we trapped also indicates a low risk of hedgerows to food safety in crop production. These data support Karp et al. (2015), who also showed no impact of habitat on the prevalence of food pathogens in crop production. More large-scale studies in simplified agricultural landscapes are needed to determine how rodents are moving on larger landscape scales in crop production to help manage these vertebrate pests.

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## LITERATURE CITED

- Baker, R. H. 1983. Michigan Mammals. Wayne State University, Detroit, MI. 642 pp.
- Baldwin, R. A., T. P. Salmon, R. H. Schmidt, and R. M. Timm. 2014. Perceived damage and areas of needed research for wildlife pests of California agriculture. *Integr. Zool.* 9:265-279.
- Batzli, G. O., and F. A. Pitelka. 1971. Condition and diet of cycling populations of the California vole, *Microtus californicus*. *J. Mammal.* 52:141-163.
- Engeman, R. M. 2005. Indexing principles and a widely applicable paradigm for indexing animal populations. *Wildlife Res.* 32:203-210.
- Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O. Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena, and J. L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. *Ecol. Lett.* 14:101-112.
- Garbach, K., and R. F. Long. 2017. Determinants of field edge habitat restoration on farms in California's Sacramento Valley. *J. Environ. Manage.* 189:134-141.
- Geier, A. R., and L. B. Best. 1980. Habitat selection by small mammals of riparian communities: evaluating effects of habitat alterations. *J. Wildl. Manage.* 44:16-24.

- Lemmon, P. E. 1956. A spherical densiometer for estimating forest overstory density. *For. Sci.* 2:314-320.
- Long, R. F., and J. Anderson. 2010. Establishing hedgerows on farms in California. Publ. 8390, Agriculture and Natural Resources, University of California, Richmond, CA. 7 pp. <http://anrcatalog.ucanr.edu/pdf/8390.pdf>
- Lorenz, G. C., and G. W. Barrett. 1990. Influence of simulated landscape corridors on house mouse (*Mus musculus*) dispersal. *Amer. Midl. Nat.* 123:348-356.
- Karp, D. S., S. Gennet, C. Kilonzo, M. Partyka, N. Chaumont, E. R. Atwill, and C. Kremen. 2015. Comanaging fresh produce for nature conservation and food safety. *Proc. Nat. Acad. Sci.* 112:11126-11131.
- Morandin, L. A., R. F. Long, and C. Kremen. 2016. Pest control and pollination cost benefit analysis of hedgerow restoration in a simplified agricultural landscape. *J. Econ. Entomol.* doi: 10.1093/jee/tow086
- Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. *J. Range Manage.* 23:295-297.
- Shump, K. A., Jr. 1974. Nest construction by the western harvest mouse. *Trans. Kans. Acad. Sci.* 77:87-92.
- Tate, K. W., E. R. Atwill, J. W. Bartolome, and G. Nader. 2006. Significant *Escherichia coli* attenuation by vegetative buffers on annual grasslands. *J. Environ. Qual.* 35:795-805.
- Williams, N. M., K. L. Ward, N. Pope, R. Isaacs, J. Wilson, E. A. May, J. Ellis, J. Daniels, A. Pence, K. Ullmann, and J. Peters. 2015. Native wildflower plantings support wild bee abundance and diversity in agricultural landscapes across the United States. *Ecol. Appl.* 25:2119-2131.
- Wolf, K. M. 2016. Examinations of the ecology, management, and restoration of rangeland ecosystems. Ph.D. dissert., University of California-Davis, Davis, CA. 215 pp.
- Zar, J. H. 1999. *Biostatistical Analysis*, 2<sup>nd</sup> Ed. Prentice Hall, Upper Saddle River, NJ. 718 pp.
- Zhang X, X. Liu, M. Zhang, R. A. Dahlgren, M. Eitzel. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. *J. Environ. Qual.* 39:76-84.