Grazing Effects on Deer Mice with Implications to Human Exposure to Sin Nombre Virus

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Abstract

We examined the effects of grazing on deer mouse (*Peromyscus maniculatus*) movements into buildings using passive integrated transponder (PIT) technology and small simulated buildings located on 0.6-ha treatment (grazing) and control (no grazing) plots. Twelve experimental 9-day trials were conducted over the course of the study. During these trials, mouse movements into buildings were monitored during three time periods (each 3 days in length). In the treatment plots these time periods corresponded to pre-grazing, grazing, and post grazing by horses. The number of individual deer mice entering buildings over time decreased in both the grazed and control plots during the 9 days of each experiment. The number of entrances per/individual among the pre-grazing, grazing and post grazing periods was different between control and treated plots for both males and females. The distribution of entrances/individual among the three periods differed between males and females in both grazed and control plots. The habitat modification caused by grazing appeared to reduce deer mouse activity (entrances/individual) in buildings but does not affect the number of mice entering buildings. Reducing vegetative cover by grazing or mowing may not affect the number of mice investigating small structures but grazing creates different activity patterns in the structures for neighboring deer mice.

Key words: hantavirus, deer mouse, Sin Nombre Virus (SNV), *Peromyscus maniculatus*

Introduction

Ecological and environmental changes due to changing land use practices may provide opportunities for increased transmission of infectious diseases (Woolhouse and Gowtage-Sequeria 2005) by increasing human contact with zoonotic hosts, their ectoparasites, and the diseases they carry. Rodents, such as deer mice (*Peromyscus maniculatus*), are reservoir hosts for many infectious diseases, including hantaviruses (Morse 1995). Hantaviruses are rodent-borne pathogens that can cause serious human illnesses. In the United States, the deer mouse is the principal reservoir for Sin Nombre virus (SNV) (family Bunyaviridae, genus *Hantavirus*) (Childs et al 1994, Nichol et al. 1993). SNV causes Hantavirus pulmonary syndrome (HPS) a serious human illness with a fatality rate of 35 percent (CDC). In many HPS cases, human exposure to SNV has been linked to contact with infected rodents and/or their excreta in and around buildings (peridomestic settings) (Armstrong et al. 1995). However, the ecology of deer mice in peridomestic settings is not well understood (Kuenzi and Douglass 2009, Kuenzi et al. 2001), and little data exist on what causes deer mice to move from surrounding natural areas into peridomestic settings.

Modification of surrounding habitat is one factor that may cause mice to enter buildings. Livestock grazing is probably the most common habitat modification in Montana. Small mammal populations and communities can be directly and indirectly affected by grazing (Hayward et al. 1997). Trampling of burrows, compacting soil, and competition for food resources are direct effects of grazing, while altering vegetation structure that then influences habitat selection by small mammals is an indirect effect. Significant changes in the nutritional dynamics and physical structure of vegetation have been caused by grazing by both bison and cattle (Damhoureyeh and Hartnett 1997) and presumably horses. Such alterations could potentially cause deer mice to leave their normal habitat and enter peridomestic settings.

In an effort to improve our understanding of the relationship between anthropogenic environmental changes and human exposure to SNV, we examined the movement of deer mice into peridomestic settings in response to habitat modification (grazing). We hypothesized that grazing in areas around buildings would increase deer mice movement into those buildings. To test this hypothesis we monitored deer mouse movements into simulated buildings before, during, and after grazing by horses in the surrounding habitat. We used horses to graze the surrounding habitat because they were easier to control and move than cattle. The results from this study are necessary for the development of recommendations to help reduce the risk of human exposure to rodent borne diseases.

Methods

Study Site

This study was conducted near Gregson, Silver Bow County, Montana. The dominant vegetation at the study site consisted of antelope bitterbrush (*Purshia tridentata*), spotted knapweed (*Centaurea maculosa*), cheatgrass (*Bromus tectorum*), and big sagebrush (*Artemisia tridentata*).

Rodent Trapping and Processing

We conducted 12 experimental trials (9 days each) from April through June 2005; October through November 2005; February 2006; June through August 2007; and May through July 2008. Deer mice were trapped and marked 3 days prior to each trial. In each plot we attempted to saturate the plot with traps set in grids containing (see experimental design below), five rows of 25 traps (Sherman non-folding, aluminum life traps (8 x 9 x 23 cm, H.B. Sherman Trap Co., Tallahassee, Florida, USA), with 10-m spacing between traps, were set with the experimental buildings in the center of the grid, and checked each day for 3 consecutive days. Traps were baited with peanut butter and oatmeal and contained polyester bedding. All captured animals were transported to a central location for processing. Species, body mass, sex, age, and reproductive condition of captured animals were recorded. Deer mice were ear-tagged with monel #1005-1 tags (National Band and Tag Co., Newport, Kentucky). PIT tags (Passive integrated transponder tags, BioMark, Inc; Boise, Idaho) were adhered directly to the skin between the shoulders of each deer mouse. A small patch of fur was shaved away to secure the PIT tag closer to the animal. The adhesive was then used to coat over the PIT tag and glue the surrounding fur over the tag to help with tag retention. Based on modifications to methods used in previous work, (Kuenzi et al 2005) we assumed pit tag retention was nearly 100 percent for the duration of each trial. A hand held reader was used to verify that the PIT tags functioned after attachment. PIT tag numbers were then recorded and individuals were released at the point of capture.

Experimental Design

The effects of habitat modification (by grazing) on mouse entries into buildings and availability of food resources (rolled oats) within buildings were examined using a series of 12 experimental trials. For each trial, one treatment (grazing) plot and one control (no grazing) plot (0.6 ha) were used. Two small simulated buildings were placed in the center of each plot. Each simulated building was 2.44 m x 1.22 m x 1.22 m with a 5-cm diameter opening in one end. Our simulated buildings do not represent all features that actual outbuildings would present to mice; however, we feel the initial response by mice to simulated buildings would be similar to that of actual buildings. Further experimentation would be required to determine what would allow deer mice to establish residency in buildings. One building in each plot contained ~ 1 kg of rolled oats. An electrical fence was constructed around treatment pastures to control horses.

We equipped each building with a passive integrated transponder (PIT) tag transceiver (Model 2001F, Biomark Inc, Boise, Idaho) linked to an antenna located around the building opening. The antenna detected pit-tagged deer mice that entered/exited the building. The pit tag number, date and time of the entrance/exit were recorded in the transceiver. Transceivers in each building were activated in the evening and turned off every morning to conserve electricity. Each transceiver was powered by a 12-volt deep cycle battery charged by a solar panel. Transceivers were retrieved from the field in the morning and data from the previous night were downloaded onto a desktop computer. Movement into these buildings was monitored for 9 nights during each experimental trial.

Buildings in both the treatment and control plots were monitored 3 days prior to introducing the horses (pre-grazing). Both plots were monitored for 3 days with the horses in the treatment plot (grazing) and then monitored again for 3 days after the horses were moved out (post grazing). Six horses were used to graze each experimental plot. The horses basically removed all herbaceous vegetation (to within 2 cm of the soil) within the three days they were present in the treatment plots. All plots had an entire winter and growing season between trials.

Data Analysis

To determine if habitat modification by grazing would affect deer mouse entrances into our simulated buildings, we used Chi-square analyses (Zar 1984) to compare the numbers of individuals entering buildings (a numeric response) and the number of entrances/individual (a behavioral response) during the pre-grazing, grazing and post grazing periods between the control and grazed pastures summed across all trials. A *P*-value of 0.05 was used for all analyses.

It was logistically difficult to spatially replicate this experiment due to the large area necessary, a limited supply of horses, and the home range size of deer mice. Therefore, this experiment was replicated by performing multiple ($N = 12$) experimental trials. The location of treatment and control plots were randomized among a set of pastures within a single ranch. Accordingly, the 12 experimental trials were conducted over a relatively long period (Apr 2005 to Jul 2008) to enhance the independence of observations, i.e., reduce the probability that individual mice would become habituated to the experiment.

Results

Of the 174 deer mice fitted with PIT tags, 69 (39.7%) entered buildings at least once. Out of these 69 individuals, only four individuals entered buildings on all 9 days of a given trial. Across all trials and plots, 63 of the 69 individual mice entered buildings during the pre-grazing period, 42 during grazing period and 32 during the post grazing period. Some individual mice were recorded during multiple periods and were included in the number of individuals/period.

Across all trials in the treatment plots, we recorded a total of 26 individual mice entering buildings with 24 individuals entering during the pre-grazing period, 18 during the grazing period, and 14 during the post grazing period (Fig. 1). In the control plots across all trials, 43 individuals entered buildings with 39 mice entering the buildings during the pre-grazing period, 24 during the grazing period, and 18 during the post grazing period. Regardless of treatment, the number of mice entering the buildings was greatest during the first 3 days of the trial (pre-grazing period) and smallest during the last 3 days of each trial (post grazing period; Fig. 1). The number of individuals entering buildings among periods was similar between control and treated pastures ($\chi^2 = 0.017$, $P > 0.05$) (Fig. 1) with the number of individuals entering buildings declining in both control and treatment plots over the 9 days of a trial. In control plots 18 individual deer mice accounted for 87 percent of movements into buildings whereas nine individuals accounted for 70

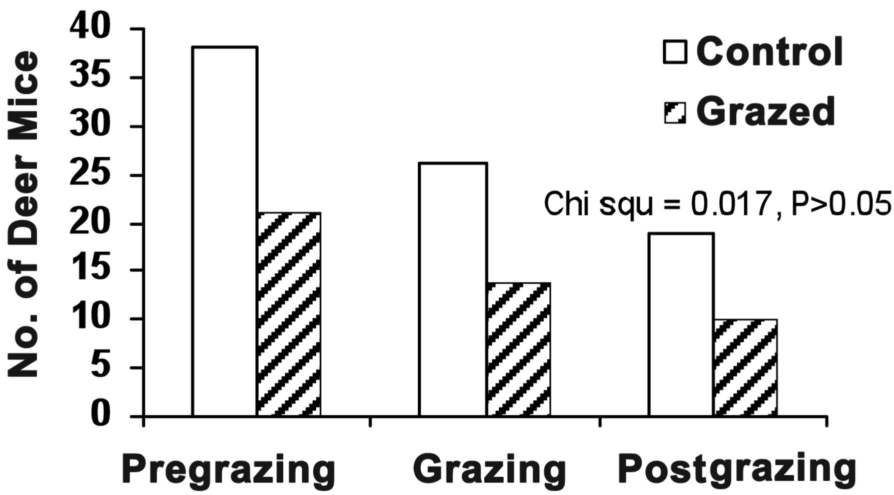

Figure 1. The number of deer mice entering simulated buildings in grazed versus control (non-grazed) plots in Southwestern Montana from 2005 through 2008.

percent of the movements into buildings.

The behavioral response (number of entrances/individual) was significantly different between control and grazed plots for both females ($\chi^2 = 7.68$, $P < 0.05$) and males ($\chi^2 = 95.68$, $P < 0.001$; Fig. 2). The number of female entrances into buildings in grazed plots decreased over 9 days but remained fairly constant in the control plots. Male entrances also decreased in the grazed plots but increased in the control plots from one period to the next.

Males and females responded differently in terms of numbers of entrances per individual through the duration of a trial in both the grazed plots ($\chi^2 = 12.38$, $P < 0.05$) and the control plots ($\chi^2 = 26.36$, $P < 0.001$; Fig. 3). However, overall responses differed in the grazed plots compared to the control plots. Both female and male entrances decreased over the nine days in the grazed plots with males decreasing more than females. In the control plots, male entrances/individual increased during the nine days while female entrances remained relatively constant. Most animals in the experiments were adults thus sample sizes were insufficient to test age related responses and sample sizes were insufficient for seasonal comparisons.

The presence of food had no effect on entrances/individual in the grazed plots (food vs. no food, $\chi^2 = 1.68$ $P > 0.05$). However in the control, entrances/individual increased continuously in the building with food and remained fairly constant in the building with no food over the nine days ($\chi^2 = 17.67$, $P < 0.001$; Fig. 4).

Discussion

Research on the effects of livestock grazing on deer mouse ecology has yielded various results for different vegetation types (Douglass and Frisina 1993, Clary and Medin 1992, Medin and Clary 1989, Oldemeyer and Allen-Johnson 1988). In this study we found no difference in the number of individuals entering buildings in grazed versus ungrazed plots. Our movement data are consistent with Oldemeyer and Allen-Johnson (1988), who found little or no difference in deer mice abundance between grazed and ungrazed sites with dominant vegetation types of spotted knapweed, antelope bitterbrush, and cheatgrass.

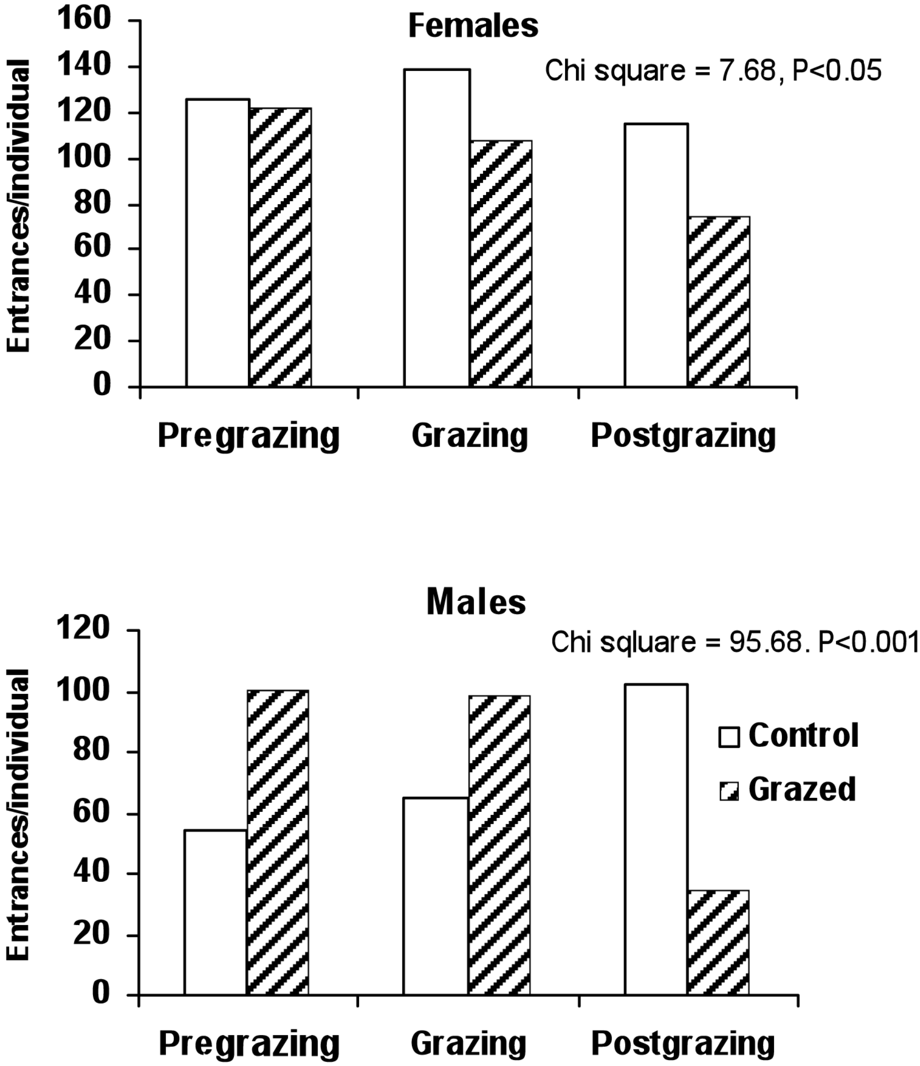

Figure 2. The number of entrances/individual mice into simulated buildings located in control (non-grazed) versus grazed plots in Southwest Montana from 2005 through 2008.

In our study, the number of mice entering simulated buildings declined over the 9-day period of each experimental trial. This reduction in numbers over time was most evident in the control plots of the study in the absence grazing, suggesting that the longer mice had access to buildings, the less the mice were "inclined" to enter them. Fewer mice may have entered over the duration of the study possibly because after initial investigations, they found the simulated buildings unsuitable or they may have left the area entirely.

However, we detected activity to differ between control and grazed plots for both males and female deer mice, as represented by number of entrances into buildings per individual. Activity decreased over the 9-day duration of experimental trials in the grazed plots but in the control plots it remained fairly constant for females and increased for males (Fig. 3). In grazed plots deer mice may possibly have been using a new resource, e.g., seed in horse manure, instead of entering buildings or the mice hesitated to move across open areas to access the

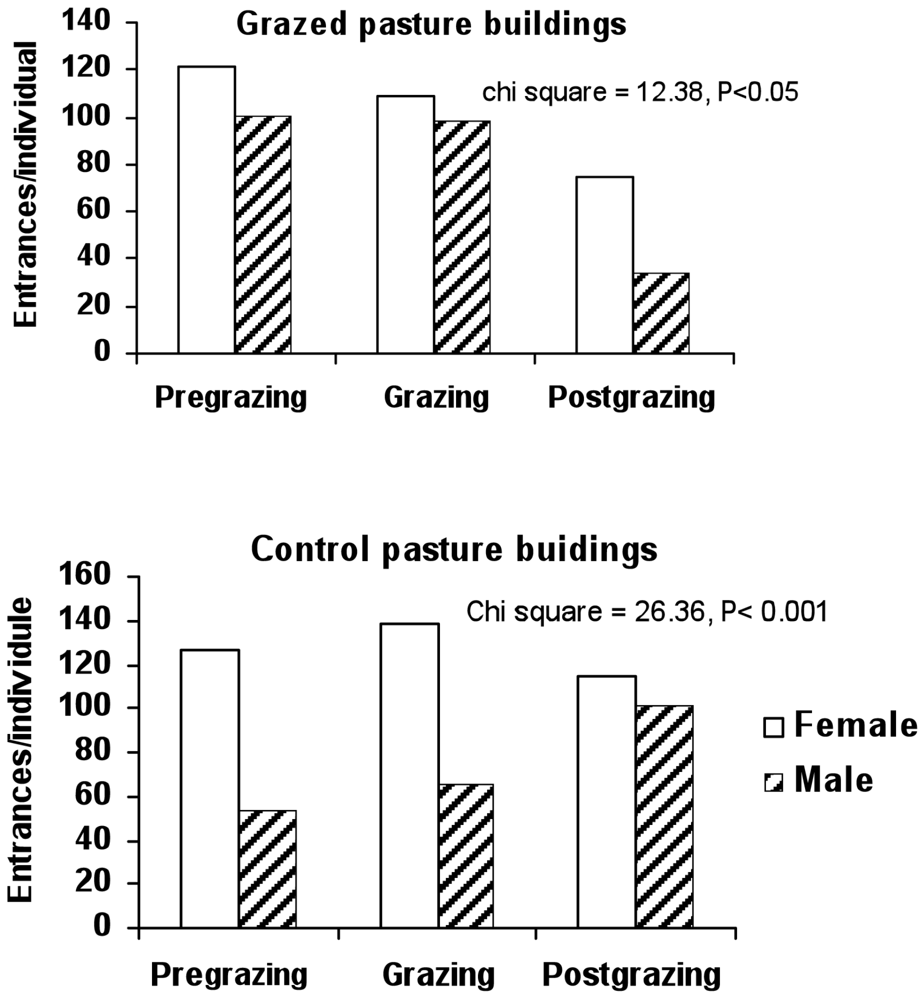

Figure 3. Response of female versus male deer mice to grazing expressed as the number of entrances/individual mice into simulated buildings located in control (non-grazed) versus grazed plots in Southwest Montana from 2005 through 2008

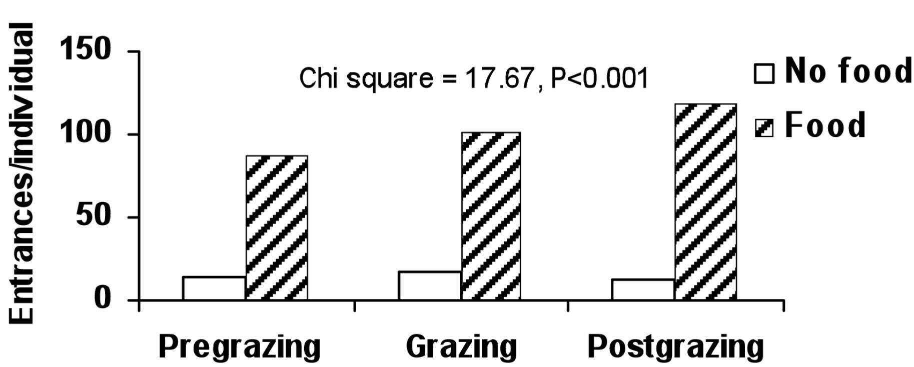

Figure 4. Effects of food in simulated buildings on the distribution of entrances/ individual deer mouse in non-grazed pastures in Southwest Montana from 2005 through 2008. Animals responded to food and non-food buildings equally in grazed pastures.

buildings. The increase in activity by males in the control plots may have been due to the presence of food in one of the buildings. In a previous study, presence of food significantly increased activity represented by entrances into buildings (Kuenzi and Douglass 2009). However, the effect of food only occurred in the control plots and not in grazed plots. Why male activity would increase and female activity did not is unclear. Perhaps males could shift activity to the new food resource more easily than females that may have had litters in nests some distance from the buildings.

Previous research has shown that adult males are the most likely to become infected with SNV (Douglass et al. 2007) as well as to disperse (Lonner et al. 2008). If males are more likely to enter or are more active in peridomestic systems upon sylvan disturbance (grazing in this instance) than females, grazing could increase chances for human exposure to SNV. However, grazing did not increase the number of either males or females entering buildings but did modify the behavioral response (number of entrances/individual). The males increased activity in buildings located in the control plots during the duration of the trials but decreased activity into buildings located in the grazed plots. This may indicate that grazing in small areas around buildings may reduce human exposure to SNV in buildings.

The simulated buildings do not replicate all resources presented to deer mice in normal houses, barns and sheds. Normal buildings are much more complex, larger and provide places for nesting, hiding and caching food. The resources provided by normal buildings would affect how deer mice used the buildings once the outside environment was modified differently than our simulated buildings did. However, the simulated buildings do provide insight into the initial response (entering) of deer mice to habitat modification surrounding buildings.

Information on factors that draw mice into buildings is necessary to better understand the relationship between peridomestic and sylvan settings. This understanding is necessary to design proper health measures to protect humans from SNV. More research, perhaps with more severe and expansive habitat modification than was created by a few days of grazing and more complex buildings is necessary to clarify the influences of habitat modification on deer mice entering buildings. However, our preliminary results suggested that grazing may reduce activity of male mice in buildings.

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