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Hantavirus in Montana Deer Mouse Populations: Preliminary Results

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ABSTRACT: Dynamics of small mammal populations and the prevalence of antibodies for hantavirus were determined in six locations in central and western Montana (USA). Eighteen live-trapping grids were trapped monthly from June through September 1994. Deer mouse (*Peromyscus maniculatus*) populations ranged from 0 to over 90 on one-hectare grids. Our bleeding technique had no apparent effect on survival of deer mice. Deer mice, meadow voles (*Microtus pennsylvanicus*), and sagebrush voles (*Lagurus curtatus*) were seropositive. Thirty-eight (8%) (range, 0% to 30%) of 471 deer mice were seropositive for hantavirus antibodies. Seropositive mice were older and had lower monthly survival rates than seronegative deer mice. We found no relationship between prevalence of hantavirus antibodies and population density.

Key words: Hantavirus, *Peromyscus maniculatus*, populations, *Lagurus curtatus*.

The infection of humans by rodent borne hantavirus in the southwestern United States (Childs et al., 1994) during 1993 stimulated us to study the disease in rodents in Montana (USA). We present preliminary results of the first year of a continuing study.

In June 1994, we initiated a study of the incidence of hantavirus and population dynamics of rodents, primarily deer mice (*Peromyscus maniculatus*), in various locations in central and western Montana. Our objectives were to compare the changes in densities survival, and recruitment rates of seropositive mouse populations, to populations seronegative for exposure to hantavirus antibodies.

We attempted to provide replicated data for rodent populations selected from a broad geographic area. Because deer mice seem to be the major host of the hantavirus transmitted to humans (Childs et al., 1994), we selected an array of habitats suitable for deer mice and which represented common land uses not in reserves, such as grazing, logging, and recreation. We replicated our sampling over 18 sites for four continuous months.

Nine live-trapping grids were located in western (45°40′ to 47°46′N, 113°00′ to 113°46′) and nine in central (46°31′ to 48°58′N, 108°35′ to 112°31′W) sites in Montana. Elevations ranged from 738 m to 1957 m. Habitats in western Montana included four lodgepole pine (*Pinus contorta*), one Douglas-fir (*Psuedotsuga menziesii*), two sagebrush (*Artemisia spp.*), one subalpine fir (*Abies lasiocarpa*), and one grassland community. Habitats in central Montana included six grassland, two sagebrush, and one mixed pine (*Pinus ponderosa*) and Douglas-fir community. Habitat names were derived from the dominant plants. Most areas were subject to livestock grazing. Three of the grids were located within a few hundred meters of human dwellings. Ten by ten grids consisted of 100 Sherman (H.B. Sherman Traps, Tallahassee, Florida, USA) live-traps spaced at approximately 10-m intervals in 1 ha. Traps were baited with peanut butter and oatmeal, provided with cotton bedding and set for three nights per month for 4 mo. Three grids were trapped concurrently at each of the six locations. On one grid at each location, all animals were marked and released. On the other two grids, a blood sample was taken from each individual before it was released. The non-bleed grid served as a control to allow the determination of the effect of bleeding on rodent populations.

With the exception that we did not anesthetize animals, animal handling, blood collection, data collection techniques and safety precautions used in this study are the same as described in Mills et al. (1995). Age was inferred from weight

TABLE 1. Species of small mammals sampled on 18 live-trapping grids over 20,592 trap-nights in Montana during 1994.

Common name[a]	Scientific name	Individuals/100 trap-nights	Number tested	Number seropositive	Prevalence of antibodies (%)
Deer mouse	*Peromyscus maniculatus*	7.4	471	38	8.0
Meadow vole	*Microtus pennsylvanicus*	0.6	83	6	7.2
Montane vole	*Microtus montanus*	<0.1	1	0	0
Boreal redback vole	*Clethrionomys gapperi*	0.3	23	0	0
Sagebrush vole	*Lagurus curtatus*	0.1	10	2	20
Western jumping mouse	*Zapus princeps*	0.1	5	0	0
Wyoming pocket mouse	*Perognathus fasciatus*	<0.1	2	0	0
Yellow pine chipmunk	*Tamias amoenus*	0.3	39	0	0

[a] Infrequently captured animals included bushy-tailed woodrat (*Neotoma cinerea*) (n = 2), golden-mantled ground squirrel (*Spermophilus lateralis*) (n = 1), Richardson's ground squirrel (*Spermophilus richardsonii*) (n = 1), shortail weasel (*Mustela erminia*) (n = 1) and several species of shrews (*Sorex* spp) (n = 15). These animals were not bled.

for deer mice: <14 g were considered juveniles, 14 to 17 g were subadults, >17 g were adults (Fairbairn, 1977). Animals were bled once per month. Blood samples were immediately stored on dry ice until delivered to the Montana Department of Health and Environmental Sciences (MDA), Helena, Montana.

Whole rodent blood was tested at the MDA using the enzyme immunoassay method (Feldman et al., 1993). Titers greater than or equal to 400 were classified as positive (Childs et al., 1995). Specimens were classified as equivocal if the titers were 100, or if the two measures of interpretation were discordant. Titer less than 100 were classified as negative. In this paper, we only discuss those classified as positive.

The enumeration technique (Chitty and Phipps, 1966) was used to determine the minimum number alive, survival, and recruitment. We analyzed data with computer programs provided by C. J. Krebs of the University of British Columbia, Vancouver, British Columbia, Canada. The programs produced standard population summaries used in small mammal population biology (Krebs, 1966). Enumeration was used to calculate the minimum number alive which is within 10% of the actual number if trapability is above 50% (Hilborn et al., 1976). Trapability for deer mice exceeded 50% for all grids for all trapping periods.

For a preliminary analysis, we combined data from all grids for general population dynamics and from 12 grids from which blood samples were collected for comparisons between seropositive and seronegative populations. The results were based on 20,592 trap-nights of effort.

Eleven species of rodents, one mustelid species, and several species of shrews were captured (Table 1). Deer mice were the most commonly captured species, followed by meadow voles (*Microtus pennsylvanicus*) and red backed voles (*Clethrionomys gapperi*). Antibodies reacting with SNV were detected in deer mice, meadow voles, and sagebrush voles (*Lagurus curtatus*).

The minimum number alive ranged from zero on a forested grid to 98 in sage habitat. The same forested grid had a minimum number alive of 10 during August 1992 (Coffin, 1994). The mean (±SD) minimum number alive increased from 13.8 ± 11.8/grid (range, 0 to 39) in June to 27.3 ± 26.4 (range, 1 to 95) in September. The minimum number alive fell within the ranges of densities previously found for this species (Petticrew and Sadlier, 1974; Sullivan, 1977; Fairbairn, 1978; Douglass, 1989).

We collected 706 blood samples from

471 deer mice. Based on combined data from all grids, monthly survival was higher for bled mice: 79 (54%) of 146 mice survived June to July, 155 (66%) of 235 mice survived July to August, and 210 (77%) of 273 mice survived August to September. In contrast for non-bled mice, 24 (39%) of 61 mice survived June to July, 75 (51%) of 148 mice survived July to August, and 115 (55%) of 210 mice survived August to September. This was true for both sexes and all age classes except that male non-bled deer mice had a higher survival rate than bled deer mice from June to July: 19 (51%) of 37 non-bled mice survived, compared to three of seven bled mice. The differences in survival were small and we believe that our bleeding did not affect survival.

The percent of deer mice seropositive for hantavirus ranged from 0% to 30%/grid/mo and averaged between 8% and 10%/mo for all grids. Seropositive mice were identified on all grids except two and these were located in a forested area where we captured only five deer mice. In a plot of antibody prevalence for each grid against the minimum number alive for each grid, there was no correlation between population density and antibody prevalence ($r = -0.03$, $P = 0.08$, $n = 37$) (Zar, 1974). The prevalences reported herein are similar to those recently reported by others (Kaufman et al., 1994; Burek et al., 1994). Our maximum of 30% was equal to that found in the Four Corners area during 1993 (Childs et al., 1995).

Lee et al. (1981) and Childs et al. (1987a) suggested that hantavirus in species other than deer mice was unlikely to directly cause mortality. However, the seropositive population of deer mice in our study consistently had lower survival rates than the seronegative mice. Based on data from all grids, seropositive deer mice had survival rates of 36% (four of 11 mice) from June to July, 33% (six of 17 mice) from July to August and 41% (seven of 17 mice) from August to September. Seronegative mice had survival rates of 44% (48 of 108 mice) from June to July, 64% (110 of 172 mice) from July to August, and 51% (108 of 212 mice) from August to September. Also, most seropositive deer mice trapped in June and July did not survive to the following month and none trapped in June or July survived to the third month. However, there were only 38 seropositive deer mice for which we could determine survival rates. Many seronegative mice lived through all four months.

TABLE 2. Age distribution for deer mice seropositive (+) for hantavirus antibodies compared to that of mice without antibodies (−). Data are from 12 grids in Montana sampled during 1994.

	June		July		August		September	
	+	−	+	−	+	−	+	−
Adults	9	42	12	54	11	58	12	83
Sub-adults	2	37	3	64	3	96	6	120
Juveniles	0	29	2	54	3	58	0	83
Totals	11	108	17	172	17	212	18	286

Verhagen et al. (1986) found that the hantavirus antibody prevalence in bank voles (*Clethrionomys glareolus*) increased with age and sexual maturity. Childs et al. (1987a,b) found the same for Norway rats (*Rattus norvegicus*). During all months the seropositive population of deer mice was skewed towards adults when compared to the seronegative population (Table 2). Except for September (Chi-square = 5.87, $P = 0.053$, 2df) (Zar, 1974) there was always a statistically smaller percentage of juveniles and subadults in the seropositive population than in the seronegative population (June, Chi-square = 8.03, $P = 0.01$, 2df; July, Chi-square = 9.99, $P < 0.01$, 2df; August, Chi-square = 10.11, $P < 0.01$, 2df). Also the percent of seropositive population that was adult was always higher than that of the seronegative population. Because we found no juveniles and very few sub-adult mice based on our weight classification that were sexually mature, our findings that antibody prevalence is higher in older and sexually mature animals is consistent with the findings of others (Verhagen et al., 1986, Childs et al., 1987a).

After one summer season of a long-term

study of hantavirus in deer mice, we report that population densities over a broad area of Montana are in the range of previous studies and that the prevalence of infection and types of animals infected were similar to those reported by other studies. We found no correlation between population density and prevalence of infection. Seropositive deer mice appeared to survive less well than seronegative deer mice.

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