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Ecology and Surveillance of the Deer Mouse *Peromyscus maniculatus* in San Diego County, California

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ABSTRACT: Sin Nombre virus is the etiologic pathogen of hantavirus pulmonary syndrome. In the U.S., this pathogen is carried by the deer mouse. The deer mouse is more prevalent than any other mammal in North America. The biology and behavior of the deer mouse is described. Disease surveillance is critical and is conducted by monitoring reservoir populations; early detection can help prevent the possible spread of disease to human populations. In San Diego County, annual surveillance has been conducted since 1994, with the percentage of positive deer mice ranging from 0% to 5.3%, with an average of 2.6% positive. Preventive measures to reduce human – hantavirus contact are recommended.

KEY WORDS: deer mice, disease, hantavirus, *Peromyscus* spp., prevention, public health, Sin Nombre virus, surveillance

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INTRODUCTION

Sin Nombre virus is the etiologic pathogen of hantavirus pulmonary syndrome (HPS) (Mills et al. 1995). In the United States, this pathogen is carried by the deer mouse, *Peromyscus maniculatus*, a species of rodent that is more widespread than any other mammal in the North America. There are more than 60 subspecies of deer mice, each with slight deviations in diagnostic characteristics. Early detection of the occurrence of hantavirus in rodent populations can help prevent the possible spread of disease to humans. Thus, disease surveillance is critical and is conducted by monitoring reservoir populations.

ECOLOGY OF THE DEER MOUSE

Occurrence

The term “deer mouse” is derived from this rodent’s resemblance in color to white-tailed deer (*Odocoileus virginianus*). Deer mice can be recognized by their bi-colored tail, which is generally shorter than its head and body. Their body is white underneath, including their feet. Their dorsum can be various shades of brown and often include black flecks.

Because of their diverse diet, deer mice are able to prevail in a variety of habitats from the coast to deserts, and they flourish in San Diego County. There are two subspecies of deer mice in San Diego County: *P. m. sonoriensis*, found in the deserts, and *P. m. gambelii*, which can be found from the coast to edge of desert habitats.

Diet

Deer mice are omnivorous. They are nocturnal and will spend most of their waking hours foraging for food. They will feed on seeds, fruits, berries fungi, insects, worms, and caterpillars. Frequently, they will gather, accumulate, and store food. This cache is consumed at a later date, when food supplies might not be readily available. Deer mice may enter a state of torpor when food sources are not available. During torpor, their

metabolic rate can decrease as much as 75%. This preservation of energy increases their chance of survival during inclement weather (Nestler et al. 1996).

Habitat

Deer mice inhabit most of the ecological regions throughout San Diego County: herbaceous, scrublands, woodlands, forest, desert transition zones, and areas that have recently succumbed to fires (Bonds 1977). They adapt to each of these environments differently. They are often attracted to terrain that has been recently burned. Foraging becomes effortless, when fire has cleared the ground cover that would normally camouflage seeds (Glennis et al. 1988). In rain-prone environments, deer mice are likely to cache food supplies atop an accumulation of minute materials (McCabe and Blanchard 1950). The purpose of this understructure is to supply drainage, consequently keeping food supplies dry.

Reproduction

Like many other rodents, deer mice are polyestrous. Females reach reproductive maturity at about 7 weeks. Males are reproductively mature shortly thereafter. The time of gestation is about 22 - 25 days. The offspring are born blind, deaf, and hairless, with the average litter containing 3 - 6 pups that weigh 1 - 2 g. Young are fully weaned in about 3 - 5 weeks.

Deer mice are able to breed year-round. In San Diego County, breeding season is generally at its peak from spring through fall. They may produce 3 - 4 litters per year. Factors that can influence reproduction can include weather conditions, food availability and predators. Wild deer mice have a very short life span; in their natural environment, it would be unlikely for them to survive more than a year.

Behavior

Deer mice prefer to travel across the ground surface, electing to travel underneath vegetation rather than flee over or through shrubs and branches. Although they

prefer not to, deer mice are able to swim well (King 1968).

Juveniles can be very vocal, uttering high-pitched squeaks, when under duress, that can be heard at human auditory levels. Adult vocalizations are louder but very infrequent, and can be heard when they are annoyed or harmed. During breeding season, when androgen levels are elevated, males become more aggressive towards one another. A female deer mouse in estrous will become very aggressive while protecting her nest.

Deer mice have a very acute sense of smell. They can use their sensitive olfactory system to detect the gender, age, and species of other rodents.

HANTAVIRUS IN DEER MICE

Surveillance Objectives

The objectives of the County's Environmental Health disease surveillance program are to:

- Measure the distribution of a specific pathogen.
- Identify prominent reservoir species, and determine their density and distribution.
- Identify the risk factors associated with reservoir populations and human activity.
- Curtail the spread of the disease to human populations by means of early detection, education, and outreach.

Incidence

In San Diego County, annual surveillance has been conducted by the Department of Environmental Health since 1994. The number of deer mice tested in any single year has varied between 13 and 271, while the number of hantavirus-positive mice has ranged from 0 to 7 in any given year. Based on the number sampled within a year, the percentage of positive deer mice has ranged from 0% to 5.3%, with an average of 2.6% mice found to be positive (Figure 1). This compares with data collected by Bennett et al. (1999) that found 9.1% of deer mice collected in Orange and San Diego counties, California, to be positive for Sin Nombre virus antibodies.

Figure 1. Number of deer mice sampled in San Diego County from 1994 through 2008, indicating the number that were positive for hantavirus (maximum percentage positive was 5.3%, or 3 of 57, in 1996).

Disease Transmission

Transmission of hantavirus from infected deer mice to humans can occur when minute particles containing the virus become aerosolized and inhaled. These particles are emitted from feces, saliva, and urine of infected mice. Direct transfer can also occur by transporting particles to the eyes, mouth, or nose after touching the excrement of diseased mice. Open sores are also an avenue of disease introduction. More rarely, but also a possibility, is the introduction of the virus through the bite of an infected deer mouse.

Symptoms

In humans, the incubation period can range from 1 - 6 weeks following the initial exposure. The onset of HPS is characterized by flu-like symptoms: fever, myalgia, headache, and cough. Acute cases can include respiratory distress, followed by respiratory failure. In the United States, the fatality rate for HPS cases is 35% (CDC 2007).

Prevention

Preventing risk of hantavirus infection in humans primarily involves reducing the incidence of deer mice in and around human habitation. Thus, many of the recommendations are similar to those for keeping commensal rodents, such as house mice (*Mus musculus*), out of homes, garages, mountain cabins, tool sheds, and other such locations:

- Remove clutter (such as trash, debris, building materials, old vehicles) from areas near structures.
- Stack woodpiles 18 inches above the ground and 1 ft from walls or fences.
- Do not allow pet food to remain in dishes available to mice, and store pet food and seeds in rodent-proof containers.
- Keep all vegetation within 100 ft of structures well-manicured and trimmed sufficiently to be inspected for rodent activity.
- Seal all structural openings greater than ¼ inch.
- Act quickly! Trap mice at the first sign of rodent activity.

Decontamination

It is not unusual for deer mice to come into and inhabit structures, particularly buildings that are used only infrequently or seasonally (e.g., mountain cabins, storage sheds, pump houses). Over time, such structures can become heavily contaminated with rodent urine, feces, and hair, as well as dust. Unless proper procedures are used, cleaning up such structures after mouse occupation can pose significant risk to individuals conducting the clean-up. The following basic guidelines should always be followed:

- Disinfect all surfaces and contaminated materials with a mixture of 1½ cups of household bleach per gallon of water (1 part bleach to 9 parts water), sprayed onto contaminated areas and objects until wet.
- Always wear rubber or latex gloves, and goggles. Use of a disposable high-efficiency particulate air (HEPA) mask is recommended.

Figure 2. Personnel of the San Diego County Department of Environmental Health conducting field rodent surveillance to detect the presence of hantavirus. Note that appropriate personal protective gear is required when handling rodent and when working in contaminated areas.

- Air out potentially contaminated buildings for at least 1 hr before entry.
- Trap and remove rodents; disinfect and remove their nests.
- After spraying surfaces with the disinfectant solution, wipe down surfaces with wet cloths, paper towels, mops, or other cleaning tools using a bleach solution or a similarly appropriate disinfectant solution. **Do not** vacuum, sweep, or dust potentially contaminated areas.
- Double bag and discard all waste, including the mop head and other cleaning materials, in tightly sealed plastic bags.
- After decontamination, thoroughly wash your gloved hands with disinfectant or soap and hot water, and remove the gloves and dispose of them. Then, thoroughly wash your bare hands with soap and warm water.

In situations of heavy rodent contamination, persons conducting cleanup efforts may be required to wear fit-tested respirators with N-100 (HEPA) cartridges, goggles, solvent-resistant gloves, coveralls, and boots (see Figure 2). In such situations, seek guidance and assistance from your local county health department.

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