TRAPPING MAMMALS IN A CAUTIOUS WORLD: THE EFFECT OF DISINFECTANTS ON TRAP SUCCESS

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During spring 1993, the first cases of Sin Nombre virus (hantavirus) were reported from the Four Corners region of the United States (Elliott et al. 1994, Mills et al. 1995a). Although the human mortality rate was first reported to be about 70%, it has since declined to approximately 30%–40%, despite the lack of a successful treatment or cure (Yates et al. 2002).

Since the 1993 outbreak, the origins of hantaviruses have been discovered, and a number of additional strains have been identified throughout the world (Lee et al. 1978, Mills et al. 1995a). Rodents have been identified as the primary vector for hantaviruses (Lee et al. 1985, LeDuc et al. 1986, Yanagihara and Gajdusek 1987, Childs et al. 1988, Mills et al. 1995a). In the United States, the deer mouse (Peromyscus maniculatus) has been identified as the primary reservoir host for hantavirus, including Sin Nombre (Childs et al. 1994); however, other rodents, including cotton rats (Sigmodon spp.), voles (Microtus spp.), and Old World rats (Rattus rattus and Rattus norvegicus), are also known vectors.

Humans become infected with Sin Nombre virus through exposure of their mucosal tissue to contaminated urine or feces (Peters and Khan 2002). The most common means of exposure...
comes from cleaning rodent-infested areas (i.e., houses, cabins, etc.) without proper respiratory protection; though, there have been some reports of transmission through a bite by an infected rodent (Dournon et al. 1984). Human-to-human transmission of the virus occurs rarely, if ever (Wells et al. 1997).

In 1995, the American Society of Mammalogists published protective guidelines for field mammalogists. The guidelines state that rodents should be handled outdoors and downwind of the researcher whenever possible (Mills et al. 1995b). Persons handling potentially infected rodents should wear appropriate personal protective gear: most notably, latex gloves and a respirator (Mills et al. 1995a). In addition, all rodents that come in contact with rodents should be disinfected with hospital-grade disinfectant (10% bleach or Lysol®). These guidelines were adopted to protect researchers from being infected; however, the use of disinfectants may alter rodent behaviors in ways critical to research. Specifically, residual odors of disinfectants could affect a rodent’s trappability and lead to biased population estimates. Few studies have focused on how trap odor affects trap success, with most focusing on lingering rodent odors (Mazdzer et al. 1976, Drickamer 1984, Heske 1987, Gurnell and Little 1992) and only 2 on disinfectant use (Yunger and Randa 1999, Van Horn and Douglass 2000). Odors from conspecifics of the opposite sex increased the likelihood of trapping white-footed mice (Peromyscus leucopus; Mazdzer et al. 1976). Similarly, Gurnell and Little (1992) found that more animals entered dirty traps than clean traps, and these animals were particularly attracted to traps with conspecific odors. Though natural odor seems to play an important role in trap success, neither Yunger and Randa (1999) nor Van Horn and Douglass (2000) found an effect of disinfection on trap success.

The 2 previous studies examined the effect of a single disinfectant rather than simultaneously comparing multiple disinfectants. Yunger and Randa (1999) tested traps treated with bleach or water for differences in trap success; Van Horn and Douglass (2000) used Lysol as a disinfectant treatment but did not use a standard no-treatment control. Instead they tested for differences in trap success between disinfected traps that varied in time since disinfection (≤8 hours versus ≥5 days).

This study was designed to investigate the potential effect of disinfection on trap success. We compared the 2 most common disinfectants used by researchers (bleach and Lysol) to a control treatment (water). We performed the experiment in 2 habitats: a red fir forest with high rodent abundance and a mixed conifer forest with low rodent abundance. Though there is evidence that disinfection does not reduce trap success, we predicted that use of disinfectants would decrease trap success compared to control traps. Conspecific odor has been shown to be an attractant (Mazdzer et al. 1976, Drickamer 1984, Heske 1987, Gurnell and Little 1992), and the use of disinfectant should eliminate these odors, leading to lower trap success. We also predicted a difference in trap success between bleach and Lysol, although we had no a priori reason to predict which treatment might have higher trap success.

Methods

We conducted this study in 2 study areas in the Plumas National Forest surrounding Quincy, California. One area was in a red fir forest and the other was in a mixed conifer forest. Red fir (Abies magnifica) dominated the red fir forest, and western white pine (Pinus monticola) and lodgepole pine (Pinus contorta) were distributed throughout the area. The understory was composed of a thick layer of prostrate mazanita (Arctostaphylos puzilus) with numerous fallen logs, coarse woody debris, and large granite rocks and boulders. Mixed conifer sites were composed of ponderosa pine (Pinus ponderosa), sugar pine (Pinus lambertiana), Douglas-fir (Pseudostuga menziesii), and white fir (Abies concolor). Results from a California Department of Health investigation showed that the study areas were known to contain deer mice (Peromyscus maniculatus), approximately 50% of which were seropositive for hantavirus. All work was performed under an approved Institutional Animal Care and Use Committee (IACUC) protocol and followed guidelines of the American Society of Mammalogists.

We established a set of triplicate trap grids in each of the 2 forest types; each grid consisted of a 6 x 6 array of XLK Sherman live-traps (H.B. Sherman, Tallahassee, FL) with 10-m spacing. A single trap was placed at the intersection points of the grid, for a total of 36 traps per grid. Traps were given 1 of 3
TABLE 1. Results of Program MARK analysis for disinfection effects. Apparent survival was held constant (.) while capture probability (p) and probability of movement between disinfection types (phi) were changed. Models included habitat (red fir, mixed conifer), time (month), or disinfection (Lysol®, bleach). Best-fit models are shown for each species. Akaike’s corrected information coefficient (AICc), adjusted for overdispersion, and the model weight relative to other less-fit models are given.

<table>
<thead>
<tr>
<th>Model</th>
<th>AICc</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Φ(c)p(habitat*t)(phi(.))</td>
<td>278.9</td>
<td>0.53</td>
</tr>
<tr>
<td>Φ(c)p(t)(phi(.))</td>
<td>280.7</td>
<td>0.21</td>
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<tr>
<td>Φ(c)p(habitat*t)(phi(dis))</td>
<td>291.8</td>
<td>0.12</td>
</tr>
</tbody>
</table>

We analyzed the data using logistic regression models with treatment (control, Lysol, bleach) as the main factor of interest and the proportion of traps on each grid that captured an individual of each species as the dependent variable. However, because of suspected differences in the number of individuals of each species captured between habitats, years, and occasions, we performed logistic regressions within a number of stratified analyses. In the red fir habitat, we performed a full-model logistic regression for each species that included treatment, year (2004, or 2005), occasion (trap day), and a 3-way interaction term. Mixed conifer sites were only trapped in 2005, so we could not perform a full model on 2004 analyses. In addition, for each habitat (red fir and mixed conifer) and species, we performed a logistic regression by year with treatment, occasion, and their interaction as the terms. We used PBOC LOGISTIC in SAS (SAS Institute, Inc. 2002) to perform the analyses. Our a priori criterion for significance was $P \leq 0.05$. All means are presented with standard errors.

**Results**

Program MARK identified 3 models with support (Table 1). The model with the greatest support was the null model (no effect of disinfection), which had more than twice the support of the next highest model, a model containing only disinfectant effects on capture probability. Probability of capture within the null model was 0.80 (SE = 0.08) for any trap, independent of disinfection treatment. The last model with support included only disinfectant effects on movement probability. Effects of disinfectant type on capture probability (as indicated by model 2) showed a reduction in capture probability from disinfection (0.76, SE = 0.11) compared to control traps (0.87, SE = 0.15).
Similarly, movement was affected somewhat by which trap an individual visited first. Individuals visiting a control trap first were less likely to move to a disinfected trap ($Y = 0.23, \ SE = 0.05$) compared to individuals moving from a disinfected trap to a control trap ($Y = 0.28, \ SE = 0.07$). Probability of movement between disinfected traps (Lysol to bleach, or bleach to Lysol) was greatest ($0.32, \ SE = 0.07$).

Trap success differed temporally and spatially with the red fir forest grids having much greater success (72%, 2004; 38%, 2005) than grids in mixed conifer sites (9%, 2005). We trapped in red fir forest sites during both years; a yearly difference was observed in the population of all rodent species, but the difference was especially large for *Peromyscus maniculatus* (Fig. 1). In red fir forests, *P. maniculatus* was more abundant in 2004 (102 individuals) than in 2005 (16 individuals). We captured 26 individuals of *Peromyscus* in the mixed conifer forest during 2005 trapping. In contrast, fewer *Spermophilus*...
individuals were captured in 2004 (2 individuals) than in 2005 (28 individuals). Capture rates of Neotamias remained relatively constant across both years. We trapped in mixed conifer sites only in 2005, and our trapping there represented an attempt to sample a low density area. Capture rates were lowest in the mixed conifer sites, with 26 and 3 unique individuals of Peromyscus and Neotamias captured. In addition to the above species, we also captured montane voles (Microtus montanus), long-tailed voles (Microtus longicaudus), shrews (Sorex spp.), and one long-tailed weasel (Mustela frenata).

A full model with treatment, year, occasion, and a 3-way interaction term was utilized to identify what factors, if any, were important to each rodent species. Because mixed conifer sites were only trapped in 2005, they were not included in the full-model logistic regression. In the red fir forest, a yearly difference in the proportion of captures of *P. maniculatus* was observed ($\chi^2 = 125.6$, df = 1, $P < 0.001$), with capture numbers in 2004 being substantially greater than in 2005 (Fig. 1a). Although an annual difference was detected for Peromyscus, no effect of trap treatment was observed for any of the 3 species (P. maniculatus: $\chi^2 = 5.29$, df = 6, $P = 0.5$; Neotamias spp.: $\chi^2 = 5.95$, df = 6, $P = 0.4$; S. lateralis: $\chi^2 = 4.68$, df = 6, $P = 0.6$).

To investigate variation within each site, logistic regressions were run independently for each species, year, and habitat to determine if treatment affected trap success on any of the grids sampled (Table 2). Within mixed conifer sites, *P. maniculatus* was the only species with enough captures to perform an analysis. We did not observe a treatment effect for any of the species or within either habitat type (Table 2). The only significant differences observed were in red fir sites and occurred between individual trap days (occasion) for *Peromyscus* in 2004 ($\chi^2 = 19.04$, df = 2, $P < 0.0001$) and *Neotamias* in 2005 ($\chi^2 = 13.29$, df = 2, $P = 0.6$; Table 2).

**DISCUSSION**

During 2004, we trapped the red fir forest site with high trap success (72%) on all grids. Because we only checked traps in the morning, we were unable to determine in what pattern rodents occupied the traps (i.e., were control traps used first, then disinfected traps, or were traps used randomly). We felt that the high proportion of captures might wash out any patterns of capture that occurred in response

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**Table 2.** Results of logistic regression by year for 3 species of rodents captured in red fir or mixed conifer forests in the northern Sierra Nevada. Species captured are *Peromyscus maniculatus* (PEMA), *Neotamias* sp. (NESP), and *Spermophilus lateralis* (SPLA). Mixed conifer sites were only trapped in 2005 and contained no SPLA. Treatment (control, Lysol®, bleach) and day of trapping (occasion) were used for model factors (effect).

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Species</th>
<th>Year</th>
<th>Effect</th>
<th>df</th>
<th>$\chi^2$</th>
<th>$P$</th>
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<tr>
<td>Red fir</td>
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to the disinfectant treatment. Therefore, we repeated the experiment the following year and added a low density site—the mixed conifer forest. Rodent abundance was lower the second year in red fir sites; mixed conifer sites had an even lower abundance. Results from both years and habitats showed no effect when traps were disinfected with either Lysol or bleach. These results are consistent over a wide range of population densities. Our results agree with previous studies that tested the effects of residual disinfectant odors on trap success (Yunger and Randa 1999, Van Horn and Douglass 2000). Our results provide further evidence that even daily disinfection of traps does not affect the trappability of rodents, suggesting that safety and data collection are not necessarily antagonistic.

Results from Program MARK showed the model with no disinfectant effects to have more than twice as much support as those including disinfectant effects. In our opinion, this result shows that trap disinfection with bleach or Lysol, has no effect on live-trapping efforts. However, there was some support for a minimal reduction in trap success due to disinfectants. Results from the MARK analysis showed that the use of disinfected traps lowered capture probability by 7.5%. However, this effect is only observed when rodents have a choice between both disinfected and control traps. During normal, hantavirus-safe trapping, only disinfected traps would be available to rodents. Therefore, we feel that such a small reduction in capture success would be functionally insignificant. In addition, our results show that once an individual visits a disinfected trap, it is more likely to visit another disinfected trap over a control trap. This result indicates that, upon visiting a disinfected trap, individuals may lose any sensitivity they may have had to anthropogenic smells.

The guidelines and suggestions provided by Mills et al. (1995b) are sufficient to protect scientists that perform live-trapping field studies involving potentially infected rodents; however, these guidelines may be overly cautious and restrict potential data collection or studies because of the dangers associated with wearing protective gear, especially at high altitudes and during excessively hot weather. A consensus of what constitutes appropriate safety equipment and procedures needs to be determined so field mammalogists can perform valid studies while still protecting their health. Regardless of what safety measures become the standard for field mammalogists, disinfection will surely be among the procedures used in any study of rodents. Our study provides further evidence that trap disinfection can be used without biasing live-capture data.

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Literature Cited


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