# USE OF A MESH LIVE TRAP FOR SMALL MAMMALS: ARE RESULTS FROM SHERMAN LIVE TRAPS DECEPTIVE?

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Two types of mesh live traps were better than Sherman traps for capturing rodents in high and low deserts, Mediterranean grassland and shrubland, and riparian woodland and scrub habitats ($P < 0.001$). Mesh traps took more species and more individuals within a species than did Sherman traps, resulting in substantially different estimates of density, sex ratios, age structure, and movement. Kangaroo rats frequently kicked sand into Sherman traps, but not into mesh traps. A significant difference in trap response for a variety of rodents suggests a need for reevaluation of studies on populations, behavior, and distribution conducted with Sherman and other closed, box-type traps.

Key words: trap comparison, rodents, *Dipodomys,* density, population structure, movements, distribution, behavior

Factors such as method of census, type of trapping configuration, season, type of trap, bait, phase of moon, and weather influence trapping success (Smith et al., 1975). Differences in success among various types and sizes of traps have long been recognized (Slade et al., 1993).

During translocation studies of the endangered Stephens' kangaroo rat, *Dipodomys stephensi,* we observed major differences in trap success between Sherman and custom-made, mesh live traps. In May 1991, 1,680 trap nights of saturation trapping with Sherman live traps yielded 12 captures of *D. stephensi.* Fresh scat and tracks indicated more individuals were present. During this period, vegetation was growing rapidly, which normally results in poor trap success (O'Farrell and Uptain, 1987). The area was also subjected to intense grazing by sheep. Following the grazing, areas with fresh sign were trapped for an additional 38 nights (611 trap nights) and produced a single juvenile kangaroo rat.

In July 1991, live traps custom-made of hardware cloth were placed adjacent to each Sherman trap. Over the next 7 nights (578 total trap nights; 289 trap nights with mesh traps), 14 *D. stephensi* were captured in mesh traps, and none in Sherman traps. No additional sign was found after these animals were removed.

During other salvage efforts, we trapped with both types of trap at each active burrow. All of these areas were small and had been disturbed previously. We captured few individuals of any species, but all captures were made with mesh traps. These data suggest a difference in efficacy of mesh versus Sherman live traps, particularly with reference to Stephens' kangaroo rat.

The purpose of this study was to test the effectiveness of Sherman and mesh live traps. A variety of species of rodents were trapped over a range of geographic locations and habitat types. The following questions were asked. Does a consistent, significant difference in trappability of rodents occur between the types of trap tested? If such differences exist, are they related to habitat or to the structure of populations and communities of small mammals? Do differences in trap success result in differences in estimation of species richness (Pielou, 1977) by changing the number of species captured? Do differences in trap success result in differences in density, movements, and population structure? Finally, do observed differences suggest problems with interpretation of past studies?

## MATERIALS AND METHODS

*Study sites.*—We trapped three localities: Lake Mathews, Riverside Co., California; Fernley, Lyon Co., Nevada; Edwards Air Force Base, Kern Co., California. Each site reflected local differences in vegetative conditions and, therefore, in species composition and abundance of small mammals. For experiment 1, we sampled three sites at each locality with an even mix of Sherman and mesh live traps (grids 101–103 at Fernley, 104–106 at Edwards Air Force Base, and 22, 23, and 25 at Lake Mathews). For experiment 2, we sampled two adjacent sites at Lake Mathews (grids 26 and 30), each with a different type of trap and then switched the traps and re-sampled. For experiment 3, we sampled two types of riparian habitats at Lake Mathews (southern willow riparian and mule fat scrub) with mesh traps and then with Sherman traps.

Grids used for experiments 1 and 2 at Lake Mathews represented a range of nonnative grassland types dominated by slender oat (*Avena barbata*), brome grasses (*Bromus rubens* and *B. diandrus*), filaree (*Erodium cicutarium* and *E. moschatum*), and lupines (*Lupinus polycarpus*). Sparse shrubs found on the sites included scattered Palmer's ericameria (*Haplopappus palmeri*) and California buckwheat (*Eriogonum fasciculatum*). Grids 26 and 30 also contained widely scattered brittlebush (*Encelia farinosa*).

The riparian habitats at Lake Mathews ranged from scrub to woodland. The southern willow riparian was dominated by arroyo willow (*Salix lasiolepis*) with an understory of perennial mustard (*Brassica geniculata*) and giant nettle (*Urtica holosericea*). The mule fat scrub was dominated by mule fat (*Baccharis glutinosa*) with arroyo willow and tamarisk (*Tamarix* sp.); ground cover was dominated by brome grasses.

In Nevada, greasewood (*Sarcobatus baileyi*) was dominant. On grid 101, rubber rabbitbrush (*Chrysothamnus nauseosus*) was codominant. Codominants on grid 102 were dotted dalea (*Psorothamnus polyadenia*), smooth horsebush (*Tetradymia glabrata*), and Russian thistle (*Salsola* sp.). Grid 103 had a mix of Indian ricegrass (*Oryzopsis hymenoides*), shadscale (*Atriplex confertifolia*), and bud sage (*Artemisia spinescens*).

At Edwards Air Force Base, all plots contained shadscale. Grid 104 was dominated by allscale (*Atriplex polycarpa*), peach thorn (*Lycium cooperi*), spiny hopsage (*Grayia spinosa*), and winterfat (*Eurotia lanata*). Grid 105 was dominated by creosotebush (*Larrea tridentata*), goldenhead (*Acamptopappus sphaerocephalus*), winterfat, and Joshua tree (*Yucca brevifolia*). Grid 106 contained creosotebush, burro bush (*Ambrosia dumosa*), goldenhead, and Joshua tree.

*Trap design.*—All experiments directly compared responses of small mammals to mesh live traps and collapsible Sherman live traps (7.5 by 9 by 23 cm) with galvanized doors and treadle. Initially, an 8- by 8- by 25.5-cm trap, made entirely of 6-mm mesh hardware cloth was used; the gravity drop door and teeter-totter treadle were stainless steel plates. Later trapping used commercially-available, metal mesh traps (A thru Z Consulting and Distributing, North Hollywood, CA). Stoddard traps, based on the original hardware cloth model, were constructed of 6- by 12-mm mesh welded wire with a solid galvanized metal bottom, elongated teeter-totter treadle, and a spring-hinge drop door. The treadle and door mechanism was set at the factory with a 5-g sensitivity. The welded wire was more stable than hardware cloth, the solid bottom held bait better and could be placed more solidly on the ground, and the spring-hinged door did not open if the trap was rolled.

*Experiment 1.*—A single Sherman trap was placed at the first station, a single mesh trap at the second station, and one of each type at the third station. The sequence was repeated up the first line, down the second, and so forth so the trap sequence varied between adjoining lines. Animals, thus, had an equal opportunity to encounter and choose each trap type, and we also could examine the influence of single as opposed to paired placement.

At Lake Mathews, grids 22 (27 Sherman, 26 mesh traps), 23 (26 Sherman, 27 mesh traps), and 25 (27 traps of each kind) were four by 10 stations in size, with 15-m trap spacing. The three sites were trapped for 5 nights from 29 September through 3 October 1991. Similarly spaced grids of five by 10 stations were used to sample the Fernley locality (101, 102, and 103; 33 traps of each kind) from 12 through 14 November 1991. Hardware cloth traps were used on these sites. Stoddard traps were used on 6 by 10-station grids with 20-m spacing at Edwards Air Force Base (104, 105, and 106; 40 traps of each kind) from 5 through 8 April 1992.

The sites at Edwards Air Force Base were selected to sample a different geographical locality and to test the response of the antelope ground squirrel (*Ammospermophilus leucurus*) and Mohave ground squirrel (*Spermophilus mohavensis*). California Fish and Game Department requires the use of a shade structure to protect Mohave ground squirrels during high temperatures. T. M. O'Farrell designed and produced such a shade cover, made of two U-shaped metal rods (6 mm diameter), with sharpened ends, covered with a double layer of greenhouse shade cloth. Covers collapse flat for packing but extend to form a Quonset hut-shaped structure 43 by 21 by 24 cm. Covers also may provide protection from predators and ameliorate inclement weather for nocturnal trapping. To test the effect of covers on trap response, every other combination of single and double sets was covered.

On all sites, traps were opened and baited in late afternoon with a mixture of crimped oats, wild-bird seed, and peanut butter. Traps were checked 2–3 h after sunset and again at sunrise. On grids 104–106, traps were left open through the day and checked at noon and late afternoon. Each animal caught was identified to species, marked, assessed for gender, reproductive condition, and relative age, and weighed. Grid coordinate, type of trap, and type of trap station were recorded. Each animal was released at point of capture. *D. stephensi* was marked with fingerling eartags or subcutaneous, passive-integrated transponders. The remaining species were marked by toe-clipping or by clipping a small patch of hair on the left flank to indicate recapture status.

*Experiment 2.*—Experiment 2 tested the magnitude of differences in populational estimates, sex ratios, and movement using one type of trap at a time. Grid 26 was used for this experiment because it contained the highest estimates of density encountered for *D. stephensi* in western Riverside Co. (28.2 individuals/ha—M. J. O'Farrell, pers. obser.). Grid 30 was established in visually similar habitat, ca. 180 m southeast of grid 26. Each site contained a four- by 10-station grid with four assessment lines. Assessment lines were equally positioned along each long side and extended 10 stations beyond the edge of the grid. Stations on all lines were at 15-m intervals. Each grid was trapped for 4 consecutive nights, and then assessment lines were trapped for an additional 2 consecutive nights (O'Farrell et al., 1977).

Trapping was conducted from 20 to 25 November 1991 with two Sherman traps per station on grid 30 and two hardware cloth traps per station on grid 26. Traps then were switched between grids, and trapping done from 2 to 7 December 1991. The first trapping set occurred through the full moon, which introduced an additional, unwanted variable. The trapping protocol was identical to that given for experiment 1.

*Experiment 3.*—The third experiment tested responses of species in habitats more mesic than those tested in experiments 1 and 2. The riparian and riparian-scrub habitats were immediately south of Lake Mathews. Because these habitats were linear, 100 traps were placed in an irregular line at 5-m intervals. Stoddard traps were used from 2 to 4 June 1992 and Sherman traps from 29 to 30 June and 2 July 1992. Other work in progress prevented our conducting 3 consecutive nights of trapping during the last effort. Trapping protocol conformed to that previously described.

## RESULTS

*Experiment 1.*—For most species with sufficient captures, the proportion of captures in mesh traps was significantly greater than in Sherman traps (chi-square goodness-of-fit test for binomial distribution; Table 1). Results were the same for all three localities. Therefore, all captures for a species were summed for evaluation. Heteromyid rodents demonstrated choice for mesh traps. *Peromyscus maniculatus* showed no clear choice in type of trap, and *Onychomys torridus* followed the heteromyid pattern. Nine species trapped had too few captures for analysis, but 29 of 33 captures were in mesh traps.

Little difference in selection of mesh traps was evident between single mesh traps and those paired with a Sherman trap (Table 1). About 40% of captures in Sher-

TABLE 1.—*Summary of captures in Sherman and custom-made mesh or Stoddard wire live traps in experiment 1. Number of individuals captured* = n. *Captures are presented as total per each type of trap and by the distribution, either as a single trap or both traps at a station.*

| | | Total captures[a] | | Capture by distribution | | |
|---|---|---|---|---|---|---|
| Species plot | *n* | Sherman | Wire | Sherman | Wire | Sherman/Wire |
| *Dipodomys stephensi* | | | | | | |
| Lake Mathews | 61 | 9 | 150** | 7 | 62 | 2/88 |
| *Dipodomys merriami* | | | | | | |
| Fernley | 29 | 4 | 46** | 3 | 25 | 1/21 |
| Edwards Air Force Base | 253 | 74 | 470** | 43 | 243 | 31/227 |
| *Perognathus longimembris* | | | | | | |
| Edwards Air Force Base | 99 | 30 | 91** | 18 | 42 | 12/49 |
| *Ammospermophilus leucurus* | | | | | | |
| Edwards Air Force Base | 22 | 7 | 31** | 3 | 17 | 4/14 |
| *Peromyscus maniculatus* | | | | | | |
| Lake Mathews | 13 | 7 | 12 | 3 | 5 | 4/7 |
| Edwards Air Force Base | 12 | 11 | 4 | 6 | 3 | 4/2 |
| *Dipodomys microps* | | | | | | |
| Fernley | 3 | 2 | 10* | 2 | 2 | 0/8 |

[a] Chi-square goodness-of-fit test for binomial distribution was used to determine if number of captures in mesh traps was significantly greater than that in Sherman traps.
* $P \leq 0.05$.
** $P \leq 0.01$.

man traps occurred at paired stations where the mesh trap also was occupied.

The presence of shade cloths appeared to have little effect on selection of mesh traps (chi-square goodness-of-fit test for binomial distribution; Table 2). Except for *D. merriami,* there was no significant difference between covered and uncovered Sherman traps. Significantly more *Perognathus longimembris* were captured in uncovered Stoddard traps than in covered ones (31 versus eight; $P < 0.001$) on plot 104. The combined data for *P. longimembris* do not show this choice.

*Experiment 2.*—The first sampling period occurred during the full moon, introducing a potential bias in trap response. However, the discrepancy between Sherman and mesh traps on grid 30 still reflects choice of mesh traps (Table 3). The null hypothesis ($H_o$: proportion of trap responses = 0.5) is

TABLE 2.—*Summary of the number of captures in covered and uncovered live traps at Edwards Air Force Base, Kern Co., California (Sherman live traps and Stoddard wire mesh live traps).*

| | Uncovered | | Covered | |
|---|---|---|---|---|
| Species | Sherman | Wire | Sherman | Wire |
| *Perognathus longimembris* | 4 | 31 | 4 | 8 |
| *Dipodomys merriami* | 4 | 18 | 5 | 9 |
| *Ammospermophilus leucurus* | 10 | 12 | 3 | 13 |

TABLE 3.—*Number of individuals captured per species by Sherman and mesh live traps during experiment 2 (M = Full-moon conditions).*

| | Plot 30 | | Plot 26 | |
|---|---|---|---|---|
| Species | Sherman | Mesh | Sherman | Mesh |
| *Dipodomys stephensi* | 68 (M) | 203 | 91 | 113 (M) |
| *Chaetodipus fallax* | 20 (M) | 54 | 15 | 48 (M) |
| *Peromyscus maniculatus* | 40 (M) | 70 | 35 | 63 (M) |

TABLE 4.—*A comparison of species collected with Stoddard versus Sherman live traps in riparian and riparian-scrub habitats at Lake Mathews, Riverside Co., California (June 1992).*

| Species | Stoddard | Sherman |
|---|---|---|
| Mule fat scrub | | |
| *Chaetodipus fallax* | 17 | 12 |
| *Dipodomys stephensi* | | 1 |
| *Microtus californicus* | 31 | 19 |
| *Neotoma fuscipes* | 5 | 6 |
| *Neotoma lepida* | 14 | 10 |
| *Peromyscus maniculatus* | 111 | 75 |
| *Reithrodontomys megalotis* | 23 | |
| *Mus musculus* | 9 | 1 |
| *Rattus rattus* | 2 | |
| Total | 212 | 125 |
| Southern willow riparian | | |
| *Chaetodipus fallax* | 12 | 7 |
| *Microtus californicus* | 23 | 10 |
| *Neotoma fuscipes* | 29 | 30 |
| *Peromyscus eremicus* | 1 | |
| *Peromyscus maniculatus* | 75 | 52 |
| *Reithrodontomys megalotis* | 9 | 1 |
| *Mus musculus* | 4 | 5 |
| *Rattus rattus* | | 1 |
| Total | 153 | 106 |

rejected for combined sites and all species captured (chi-square goodness-of-fit test for binomial distribution; $P < 0.01$). In addition, 55 of the 68 original individual *D. stephensi* on grid 30 were recaptured in mesh traps. In contrast, only 44 of the 113 individuals initially captured with mesh traps were recaptured with Sherman traps. Similar differences were observed for the other two species.

No apparent difference in trap response was found between adults and juveniles. Differences between male and female response to type of trap resulted in different sex ratios, depending on type of trap. Ratios of male to female *D. stephensi* using Sherman traps were 1.72:1 and 1.22:1 for grids 30 and 26, respectively (reject $H_o$: male to female ratio 1:1; chi-square goodness-of-fit test for binomial distribution; $P < 0.05$). Ratios obtained with mesh traps were 0.88:1 (do not reject the null hypothesis) on both plots.

Assessment line movements, used for calculating the area of effect (O'Farrell et al., 1977) for estimation of density, varied by type of trap and phase of moon. Linear movements of *D. stephensi* determined by mesh traps (37.5–52.5 m) were greater than those determined by Sherman traps (7.5–22.5 m). Estimates of density using mesh traps were similar (65.0/ha and 63.8/ha) on grids 26 and 30, respectively. Estimates of density were lower and more variable using results from Sherman traps (40.9/ha and 54.4/ha, respectively). The same trends were evident for the other two species present.

Another indicator of the behavioral response of kangaroo rats to different types of traps was the presence of dirt kicked into the interior of the trap. Sherman traps consistently elicited this behavior (412 instances as opposed to 14 for mesh traps). The quantity of dirt in Sherman traps sometimes exceeded 25% of the trap volume, disabling the treadle mechanism.

*Experiment 3.*—Inventories of species in riparian and riparian-scrub habitats were substantially different between Stoddard and Sherman traps (Table 4). In mule fat scrub, *Reithrodontomys megalotis* and *Rattus rattus* were not sampled by Sherman traps and *R. megalotis* was relatively abundant. The lack of *D. stephensi* in Stoddard traps may be due to the high percentage of traps occupied each night (92, 93, and 98%). In contrast, nightly trap success with Sherman traps was 58, 60, and 73%.

Differences were more subtle within the southern-willow-riparian habit. *P. eremicus* was not captured in Sherman traps, and *R. rattus* was not captured in Stoddard traps. Nightly trap success differed between types of traps as in the mule-fat-scrub habitat. Percentage of occupied traps for the 3 nights of trapping with Stoddard traps was 72, 79, and 87%, and with Sherman traps 56, 55, and 62%. There were fewer unoccupied Stoddard traps than Sherman traps on any given night.

## Discussion

Sampling small mammals has long been fraught with problems. The literature is replete with studies comparing responses of species to various types of traps (Beacham and Krebs, 1980; Boonstra and Krebs, 1978; Chitty and Kempson, 1949; Cockrum, 1947; Holdenried, 1954; Weiner and Smith, 1972; Williams and Braun, 1983).

Sherman traps have been in common use for ca. 40 years. Sherman traps of several sizes performed equally well (see Kisiel, 1972, for review), but a variety of sizes of small mammals was not examined. Slade et al. (1993) found that the long model of Sherman trap was more effective than the standard model for nine of 10 species of small mammals captured.

Two studies have compared Sherman traps with custom-made traps, and both concluded that Sherman traps were less effective (Brant, 1951, cited in Kisiel, 1972; Holdenried, 1954). Brant (1951) presumably used large can traps as proposed by Burt (1927). Holdenried (1954) used a large trap made of hardware cloth that yielded 72% success versus 58% for Sherman traps.

Direct comparison with Sherman traps here indicates a significant preference for mesh traps, regardless of habitat sampled (Table 1; experiment 1). Apparently, an open trap that can be seen through is preferred to an enclosed box. Number of individuals captured in mesh traps generally range from two to three times those of Sherman traps on the same study plots (Table 3; experiment 2). Total captures show the same pattern.

The presence of a full moon during the first sampling period in experiment 2 introduces a potential bias. Exposure to light from a full moon may negatively affect the surface activity and reduce movements of many small mammals, particularly kangaroo rats (O'Farrell, 1974; Kaufman and Kaufman, 1982). Reduced movements presumably lessen the opportunity to encounter traps and result in low values of abundance. Sherman traps were used on grid 30 during the full moon, and mesh traps in the new moon phase. The number of individuals captured regardless of species was greater during the new moon. However, the number of individuals captured in mesh traps during full moon, on grid 26, was higher than the numbers captured in Sherman traps during new moon (Table 3).

Animals would be expected to give a range of responses to the introduction of novel items, such as traps (see Sealander et al., 1958, for a review). Initial reaction may be negative but may become positive with prolonged exploration and familiarity. Sealander et al. (1958) found that ca. 50% of approaches by house mice to Sherman traps resulted in captures. Differences in perception of transparent as opposed to enclosed traps may be illustrated by the behavior of kangaroo rats. Kicking sand is associated with agonistic encounters in kangaroo rats (Blaustein and Risser, 1976; Eisenberg, 1963). Kangaroo rats routinely kick soil into traps. It follows that soil kicked at a trap represents an animal's perception of the trap as a threat. In experiment 2, longer exposure of kangaroo rats to live traps of either type resulted in greater sand-kicking response.

Biased trap success may yield erroneous information on population characteristics, such as sex ratio and age structure, as well as behavioral aspects, such as movements and temporal and spatial use. Virtually all aspects of small-mammal community structure and function inferred from live trapping are subject to the accuracy of trap success. Experiment 2 provides insight into differences in density estimates and population structure. Recorded linear movements from the grid are greater using mesh traps, even during full moon. Estimates of density using mesh traps are 15–37% higher than estimates obtained with Sherman traps. Sex ratios tend to be different with the use of different types of traps, significantly for *D. stephensi* on grid 30. Sherman traps captured twice as many males as females ($n = 68$) while mesh traps captured slightly more females than males ($n = 203$). The trapping periods were 4 days apart to minimize the potential that movement patterns or other behaviors changed appreciably. The larger sample size provides a more robust estimate of sex ratio.

The composition of communities of small mammals may be inaccurately represented based on the type of trap used (Table 4; experiment 3). Effectiveness of traps is critical when providing distributional status of sensitive species where presence or absence and the limits of area occupied are determined by trapping. It is known that some species are difficult to trap (Martin and Matocha, 1991; O'Farrell and Uptain, 1987). If the presence of an endangered species is not found by trapping, destructive activities may be allowed to progress, the local population can be extirpated, and the environmental sensitivity of the species is exacerbated.

We trapped in weather ranging from cold with light snowfall of early winter (Fernley), moderate to cool temperatures with periodic fog and rain (Lake Mathews), to intense summer heat (Edwards Air Force Base). Mesh traps provide better circulation of air than box traps, and animals are less likely to suffer stress from heat or cold. In winter, condensation occurs in Sherman traps and results in wet pelage with some mortality. No such mortality or sign of distress is observed in mesh traps. In either type of trap, condensation on metal surfaces rapidly wets a trapped animal and hypothermia ensues in periods of fog and rain.

Diurnal trapping with a ventilated cover in summer can prevent heat-related mortality. Presence of trap covers does not significantly alter the number of captures in mesh traps (Table 2). Merriam's kangaroo rats show a significant increase in total captures in covered versus uncovered Sherman traps. The cover may provide sufficient shelter to allow a less cryptic species more time at a trap to become familiar enough to enter.

Our results suggest the need for comprehensive studies in various types of habitat and assemblages of small mammals with both open mesh and closed types of traps to determine the magnitude of ecological differences and to ascertain if predictive relationships exist. These types of studies are particularly important in areas that have been studied intensively in the past and have shaped current hypotheses in the biology of small mammals.

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