USE OF NIGHT-VISION GOGGLES, LIGHT-TAGS, AND FLUORESCENT POWDER FOR MEASURING MICROHABITAT USE OF NOCTURNAL SMALL MAMMALS

ROBERTA J. FARGO, USDA Forest Service, Pacific Southwest Research Station, 2081 East Sierra Ave., Fresno, CA 93710, USA

WILLIAM F. LAUDENSLAYER, JR., USDA Forest Service, Pacific Southwest Research Station, 2081 East Sierra Ave., Fresno, CA 93710, USA

ABSTRACT: In 1993 to 1996, dusky-footed woodrats (*Neotoma fuscipes*) were tracked using night-vision goggles, light-tags (LED with battery), and fluorescent powder to better understand their microhabitat use. Tracking was conducted in 3 oak woodland study sites in the southern Sierra Nevada, 16 m northeast of Fresno, California. Night-vision goggles were not very useful for direct observation because of their limited visual range. Light-tags were highly visible and provided both temporal and spatial information on microhabitat use. Times and durations of activities could not be determined using fluorescent powder, and due to its poor adherence to thin branches, it provided limited information on the woodrats' microhabitat locations. However, combining powder tracking data with light-tag tracking data provided detailed information on the dusky-footed woodrat's 3-dimensional use of oak woodlands.

Key words: Dusky-footed woodrat, fluorescent powder, light-tag, microhabitat, *Neotoma fuscipes*, night-vision goggles, nocturnal, Sierra Nevada, small mammal.

1997 TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 33:12-17

Information on behavior and microhabitat use is essential for understanding the relationships between nocturnal small mammals and their environment. Field methods, such as mark-recapture and radio-telemetry, are often used to develop information on home range and habitat use (Ingles 1961, Bleich and Schwartz 1975, Cranford 1977, Witt 1992, Lacher and Mares 1996). Although useful, such home range estimates and habitat use inferences are limited to where traps are set or animals are captured (Hayne 1949), or where telemetry readings are taken, and may include areas of non-use, as well as exclude areas important to the animals. Schroder and Rosenzweig (1975) suggested that 2 species found (trapped) in the same area may not be using it in the same way and that perhaps each species "... forages in its own preferred habitat and merely travels through the habitat of its congener". In addition, mark-recapture and radio-telemetry usually tell relatively little about an animal's use of specific microhabitats. This is particularly apparent with arboreal or semi-arboreal species that are often studied with little awareness or consideration of their habitat use above ground level. Some animals may be less successfully captured or their arboreal behavior may go undetected if livetrapped on standard 2-dimensional grids (Carey, et al. 1991, Laudenslayer and Fargo 1997). Dusky-footed woodrats, for example, were captured more successfully when traps were set in trees and on the ground at woodrat houses than when set on ground-level trap grids (Laudenslayer and Fargo 1997; A. G. Willy, U. S. Fish and Wildl. Serv., pers. comm.).

Cranford (1977) examined home range use by dusky-footed woodrats using radio-telemetry locations of woodrats on the ground and in trees. Kelly (1989) used radio-telemetry to obtain data on habitat use by woodrats, but affixed reflective tape to the radios to more accurately locate radio-tagged animals. Both arboreal live-trapping and radio-tracking can provide some information on the 3-dimensional habitat use of some species; however, they may not provide a good understanding of specific microhabitat use and behaviors. With the advent of ecosystem management and the need for a better understanding o f the components and interactions of living systems, new approaches to gain such information are needed. Direct observation of animals in their natural surroundings may be such an approach. However, directly observing nocturnal small mammals posed a problem; that is, how to observe them at night? In this paper, we describe the procedures, benefits, and drawbacks of direct observation of dusky-footed woodrats using night-vision goggles, light-tag tracking, and fluorescent powder tracking.

STUDY AREA

Our study area consisted of 3, 2.25-ha oak woodland sites of varying structure and composition—Pine Flat, Camp 4 1/2, and Secata—in the foothills of the Sierra Nevada in eastern Fresno County. All 3 sites were within 2 km of the Kings River and ranged in elevation from 300 to 450 m. Pine Flat was densely vegetated, with an overstory dominated by interior live oak (*Quercus wislizenii*) and gray pine (*Pinus sabiniana*) and an understory dominated by interior live oak, ceanothus (*Ceanothus* spp.), poison oak (*Toxicodendron diversilobum*), and manzanita (*Arctostaphylos* spp.). Camp 4 1/2 had a moderate overstory of blue oak (*Q.*

douglasii), interior live oak, and California buckeye (*Aesculus californica*), with a relatively sparse understory of poison oak and ceanothus. Secata was relatively open, dominated by blue oak, with small patches of interior live oak and California buckeye. The understory was very sparse, consisting of ceanothus, chaparral hone ysuckle (*Lonicera interrupta*), redberry (*Rhamnus crocea*), and manzanita (pers. obs.).

METHODS

Observation with Night-Vision Goggles

We directly observed dusky-footed woodrats with night-vision goggles in 1993-1995 for a total of 14 nights. A 1.2 m x 1.2 m x 1.2 m blind was set up prior to dusk, approximately 2-3 m from a woodrat house. This close positioning was necessary due to the limited viewing range of the night-vision goggles (AN-PVS-5A Model 9876A - Varo, Inc., Systems Division, 2201 W. Walnut St., Garland, TX 75046) (commercial enterprises or products are mentioned solely for information. No endorsement by the U. S. Department of Agriculture is intended or implied.). From inside the blind, 1 or 2 observers recorded in field notebooks the time and nature of all animal activities observed for approximately 2-4 hours. We recorded field data without the use of artificial lighting to minimize disturbance to the woodrats. Data were later transcribed onto data forms.

Light-tag Construction

Two types of illumination, chemiluminescent tags (Buchler 1976) and light-tags (Fisher and Cross 1979), were considered for tracking animals. Both weigh less than 5% of an adult or subadult woodrat's body weight, which approximates the guidelines discussed by Cochran (1980). Chemiluminescent tags incorporate the use of 2 chemicals to produce light. Buchler (1976) mixed these chemicals in the field and put the mixture into small blown-glass spheres, which he glued to the backs of little brown bats (*Myotis lucifugus*). We considered this method too cumbersome, and were concerned the glass could break when the woodrats brushed against branches. Pre-manufactured chemiluminescent tags are also available in 4.0 cm by 0.5 cm plastic cylinders. However, the visibility of these narrow tags may be greatly reduced by the animal's fur. Hayward (1987) used betalights (cylindrical Pyrex capsules containing tritium and phosphor) packaged in acrylic rods to observe Boreal owls (*Aegolius funereus*). However, due to their small size, these too were rarely visible when placed close to the animal's body. Finally, both chemiluminescent tags and betalights produce only 1 color, which could cause identification problems when observing 2 woodrats simultaneously.

Our light-tags consisted of a lithium computer battery (number CR2032 - Whitcomm Electronics, 105 W. Dakota, # 106, Clovis, CA 93612), a T-1 3/4 (5 mm) LED, and a small piece of electrical tape. Batteries were 2 cm in diameter, weighed 3 g, and were equipped with electrical leads. We affixed the LED (0.4 g) to the battery by wrapping the wires of the LED to the appropriate leads on the battery so that the LED set on the battery's negative side. This left the battery's positive, or flat side, free for attachment to the animal. A 3 cm length of electrical tape was taped to the positive side of the battery and the excess tape edges were folded over the negative side of the battery. Attachment of the electrical tape allowed for easier removal of the light-tag from the woodrat (see below). The entire tracking light unit weighed 3.4 g, or 3.4 % of a 100 g dusky-footed woodrat's body weight.

Woodrat Capture and Application of Light-tags and Fluorescent Powder

Prior to dusk of an observation night, we randomly selected 1 active woodrat house for each observer. Two Tomahawk traps were set at each selected house and at each of up to 9 other active houses within a 30-m-diameter circular plot centered over each selected house. At each house, we set 1 trap on the ground and 1 in a nearby tree, if present. Traps were placed along woodrat runways to maximize chances of capture. We moved at least 50 m away from these observation plots to avoid disturbing trapping efforts, and after 2-3 hours, we checked the traps.

The captured woodrat was placed in a handling funnel (hardware cloth and heavy fabric), ear-tagged, body measurements taken (if not done so during a previous capture), and a tracking light unit glued to the animal's nape or upper back using contact cement. The light unit was held in place for 3-5 min, then lightly tugged to ensure the cement had set. We positioned the light unit behind the ears or between the shoulder blades so that the animal was unable to easily reach and remove the unit (Fig. 1). For any 1 observation night, tracking lights of different colors were used to aid in identifying individuals in the event the paths of the 2 woodrats overlapped.

Following attachment of the light-tag, we liberally dusted the woodrat with fluorescent powder (Radiant Color, 2800 Radiant Ave., Richmond, CA 94804) by pouring the powder into the fabric end of the handling funnel and manually manipulating it under and around

Fig. 1. Dusky-footed woodrat with light-tag affixed to upper back.

the woodrat's body. Powder was not applied to the animal's head to minimize its inhalation of powder particles. Each light-tagged woodrat within a particular area was dusted with a different color to differentiate powder trails of individual woodrats.

Light-tag Observations

We tracked and observed woodrats during the summer of 1996 for 1-2 nights/ week at a different study site each night. For any 1 night, 1-2 adult (or subadult, if unable to capture adult) woodrats were visually tracked and their activities recorded by 1-2 observers (1 observer/ woodrat). One male woodrat and 1 female woodrat were observed whenever possible.

We released each light-tagged and powdered woodrat where it was captured, and observed it as it retreated into a house. While the woodrat was within the house, we retreated to a position that minimized interference with the animal's normal activities and provided an ample view of the house and the surrounding area. This was usually 7 or 8 m from the house, but in one case was 3 m away when dense cover precluded longer distances. To reduce disturbance to the woodrats, we remained in this position throughout the observation period, which was from the time of the woodrat's release through dawn. We recorded via cassette recorder: (1) time and duration of each visual and audible detection of an animal; (2) microhabitat location of the animal (e.g., tree canopy, rock outcrop, ground, woodrat house); (3) the animal's location as a "travel route" (animal continuously in motion or paused only momentarily) or a "destination" (animal in one location for $\geq$10 s); (4) position of the animal (height above ground, and azimuth and distance from observer); and (5) activity of the animal (e.g., walking, tail tapping, vocalizing).

Fluorescent Powder Tracking

The evening following light tracking, we tracked fluorescent powder trails using an ultra-violet light (model ML-49 - Willard Marking Corp.; Raytector-V - Forestry Suppliers, Inc.). We collected: (1) length of the powder trail within each microhabitat; (2) designation of each span of powder as a "travel route" (single or few trails of prints in an area; prints primarily in only 1 or 2 directions) or a "destination" (many powder prints concentrated in an area; prints faced many directions); (3) height above ground for travel routes (low and high) and destinations; and (4) azimuth and distance from the woodrat's house for destinations.

Light-tag Removal

Immediately prior to fluorescent powder tracking, we set several traps at and around the house(s) where woodrats were captured and light-tagged the previous evening. Following powder tracking, the traps were checked and the recaptured light-tagged woodrats were placed in handling funnels for light-tag removal. The battery and LED were removed by pulling the electrical tape from the battery, taking care not to pull on the woodrat's skin. If not too solidly attached to the woodrat's skin, the electrical tape was then removed by carefully peeling the glue away from the tape. If unable to remove, some glue or tape could be left on the woodrat, as it would come off as the fur grew out. If a light-tagged woodrat was not recaptured, the light unit would likely fall off as the animal groomed or brushed against limbs, or as the animal's fur grew out.

RESULTS AND DISCUSSION

Night-vision Goggles

Night-vision goggles were not very useful for documenting microhabitat use and activities of dusky-footed woodrats. The close proximity of the blind may have disturbed some animals. They sometimes hesitated on leaving their houses or immediately retreated back into the house. Few woodrats were observed leaving their houses, and when they did, they usually climbed directly up the nearest tree or shrub, often disappearing in the vegetation, out of the viewing range of the goggles, or moving too quickly to follow with the goggles. In addition, the image through the goggles was not very clear, particularly during evenings with little existing light. These factors resulted in a maximum viewing range of approximately 10 m when sufficient light and little vegetative cover were present. Very few microhabitat locations and behaviors could be identified; those that were usually were heard and not seen.

Light-tag Tracking

Our light-tags allowed the use of different colored LEDs for simultaneous observations, and their design permitted elevation of the LED above the woodrat's fur for better visibility. The battery and light combination we used also met our requirements for brightness and length of life. Despite their small size, light-tags were powerful enough to remain visible for a minimum of 12 hours (an entire evening) from at least 45 m away (the maximum distance woodrats traveled from 1 trapping night to the next).

We were concerned that the light-tags might hinder or otherwise affect woodrat activities. A few of the woodrats, upon release, shook or turned to examine the light-tag. Otherwise, all light-tagged woodrats appeared to move about normally throughout the evening. In addition, our presence in the area did not seem to disturb them either. This may be due in part to having previously captured and recaptured many of them. We often observed that most woodrats, when repeatedly captured, became much less agitated upon our approach and during handling (pers. obs.).

There was also the potential for increased predation on woodrats equipped with light-tags, especially if we were unable to recapture them and remove the tags following light tracking. However, no predators were detected in close proximity of a light-tagged woodrat, nor was there any indication of a predator being drawn nearer to the area. This may have been due to our presence in the area or, perhaps woodrats were light-tagged for too short a duration for predators to recognize them as prey. In all 3 study sites, California spotted owls (*Strix occidentalis occidentalis*), that have been acclimated to human presence, nest in the area, however, were never detected in the immediate vicinity of a light-tagged woodrat. No woodrats died or were injured during the time they carried the light-tag following an observation night. This includes 1 woodrat, which potentially carried the light-tag for 3-4 weeks before it was finally recaptured. All others were recaptured the evening following light tracking. The light-tag was successfully removed from approximately half the woodrats. The others had already lost or removed the light-tag (only 2 of these woodrats potentially lost their light-tags during the previous night's observation period, as all others were visible until dawn). Even if the light-tags had remained on the animals, the LEDs would dull substantially after 10-12 hours, and would emit only a dull glow after 30 hours. In the summer of 1997, during a second season of light-tag observations, one woodrat which was light-tagged in 1996 was recaptured with no evidence of having been adversely affected by the light-tag (pers. obs.).

Light tracking provided detailed information on 3-dimensional habitat use, including identification of some woodrat activities, the time and duration of each activity, microhabitat location, and the position of the woodrat relative to its house. Fisher and Cross (1979), using light-tags on nocturnal rodents, obtained accurate spatial and temporal information on microhabitat selection, use, and dimensions. The light source they used allowed them to track animals on dark nights without additional visual aids. The LED light we used was also highly visible. Woodrats were readily tracked and were visible almost continuously as they moved along travel routes. View of animals was disrupted only momentarily as they moved through the vegetation. If an animal stopped behind vegetation or other objects, it was usually relocated soon after it resumed travel. The light from the LED was very confined and did not illuminate the woodrat. This limited our identification of activities to movement-related or audibly-identifiable activities, such as walking, freezing, running, vocalizing, tail or foot tapping, and sometimes foraging or eating.

Despite some limitations with light tracking, we were able to determine the time and duration of particular activities, whether an animal was traveling or stationary, what types of microhabitats and travel routes were used and the extent, and the exact position (distance, azimuth, and height above ground) of woodrats relative to their houses.

Fluorescent Powder Tracking

Fluorescent powder tracking required relatively little time and resources, and provided some information on woodrat locations and microhabitat associations, particularly on the ground. Barnum et al. (1992) and Steketee and Robinson (1995) used fluorescent powder on white-footed mice (*Peromyscus leucopus*) and American woodcock (*Scolopax minor*) chicks, respectively, and successfully determined habitats used and distances traveled. In contrast, Lemen and Freeman (1985) found that rodents left poor ground trails in areas with no grass or forb cover. We also found some powder trails to be discontinuous and widely spaced; however, this was primarily in trees and shrubs. In many cases, these trails were so discontinuous that tracking was often impossible. In addition, trails in the higher branches of trees and shrubs could not be reached without the aid of tree climbing, which would be arduous and time consuming at night. We were also unable to use powder tracking for identifying woodrat activities or indicating when or for how long activities occurred.

Fluorescent powder has some potential side effects. When inhaled, it can cause pneumonia in some animals (Stapp et al. 1994). Our method of dusting animals greatly reduced inhalation of the powder; however, we did not test them for contraction of any associated diseases. Fluorescent powder has also been shown to persist in the environment up to 2 years after application (Halfpenny 1992). The environmental effects of this persistence are unknown.

Conducting fluorescent powder tracking in conjunction with light tracking provided more accurate and detailed information than night-vision goggles or either method alone. Powder tracking helped confirm where the woodrat was observed during light tracking, and provided additional data, such as microhabitat location and position of the woodrat relative to its house, for those times the animal was barely or not at all visible during observation.

Direct observation with the aid of light-tags and fluorescent powder tracking can provide useful and, often, otherwise unobtainable information on the temporal and 3-dimensional habitat use and activities of woodrats or other nocturnal animals.

ACKNOWLEDGMENTS

We thank P. Kelly and D. Chesemore for the loan of ultra-violet lights for powder tracking. We are grateful to T. Whitlock and W. Auernheimer for their assistance in developing an adequate battery and light combination for our needs. We also appreciate the constructive comments by B. Boroski, M. North, L. Hall, M. Morrison, and an anonymous reviewer, which greatly improved this manuscript.

LITERATURE CITED

Barnum, S. A., C. J. Manville, J. R. Tester, and W. J. Carmen. 1992. Path selection by *Peromyscus leucopus* in the presence and absence of vegetative cover. Journal of Mammalogy 73:797-801.

Bleich, V. C., and O. A. Schwartz. 1975. Observations on the home range of the desert woodrat, *Neotoma lepida intermedia*. Journal of Mammalogy 56:518-519.

Buchler, E. R. 1976. A chemiluminescent tag for tracking bats and other small nocturnal animals. Journal of Mammalogy 57:173-176.

Carey, A. B., B. L. Biswell, and J. W. Witt. 1991. Wildlife habitat relationships: sampling procedures for Pacific Northwest vertebrates. U.S. Department of Agriculture Forest Service Pacific Northwest Research Station General Technical Report. Portland, Oregon 24pp.

Cochran, W. W. 1980. Wildlife telemetry. Pages 507-520 *in* S. D. Schemnitz (ed.). Wildlife Management Techniques Manual. Fourth ed. The Wildlife Society, Inc., Bethesda, Maryland

Cranford, J. A. 1977. Home range and habitat utilization by *Neotoma fuscipes* as determined by radiotelemetry. Journal of Mammalogy 58:165-172.

Fisher, J. L., and S. P. Cross. 1979. Battery-light tracking as a technique for studying small nocturnal mammal movements. Northwest Science 53:90-93.

Halfpenny, J. C. 1992. Environmental impacts of powdertracking using fluorescent pigments. Journal of Mammalogy 73:680-682.

Hayne, D. W. 1949. Calculation of size of home range. Journal of Mammalogy 30:1-18.

Hayward, G. D. 1987. Betalights: an aid in the nocturnal study of owl foraging habitat and behavior. Journal of Raptor Research 21:98-102.

Ingles, L. G. 1961. Home range and habitats of the wandering shrew. Journal of Mammalogy 42:455-462.

Kelly, P. A. 1989. Population ecology and social organization of dusky-footed woodrats, *Neotoma fuscipes*. Ph.D. Dissertation. University of California, Berkeley. 191pp.

Lacher, T. E., Jr. and M. A. Mares. 1996. Availability of resources and use of space in eastern chipmunks, *Tamias striatus*. Journal of Mammalogy 77:833-849.

Laudenslayer, W. F., Jr., and R. J. Fargo. 1997. Small nocturnal mammals in oak woodlands: some considerations for assessing presence and abundance. Proceedings of Oak Woodlands Ecology, Management, and Urban Interface Issues Symposium. General Technical Report 160, USDA Forest Service, PSW, Albany, California. In Press.

Lemen, C. A., and P. W. Freeman. 1985. Tracking mammals with fluorescent pigments: a new technique. Journal of Mammalogy 66:134-136.

Schroder, G. D., and M. L. Rosenzweig. 1975. Perturbation analysis of competition and overlap in habitat utilization between *Dipodomys ordii* and *Dipodomys merriami*. Oecologia 19:9-28.

Stapp, P., J. K. Young, S. VandeWoude, and B. Van Horne. 1994. An evaluation of the pathological effects of fluorescent powder on deer mice (*Peromyscus maniculatus*). Journal of Mammalogy 75:704-709.

Steketee, A. K. and W. L. Robinson. 1995. Use of fluorescent powder for tracking American woodcock broods. Auk 112:1043-1045.

Witt, J. W. 1992. Home range and density estimates for the northern flying squirrel, *Glaucomys sabrinus*, in western Oregon. Journal of Mammalogy 73:921-929.