INTRODUCTION

Despite their secretive nature, small mammals have provided and continue to provide field and theoretical biologists numerous opportunities for research. Hundreds of papers have been published describing the natural history, behavior, and population ecology of small mammals (Nowak and Paradiso, 1983). Additionally, many theoreticians have used small mammal populations in theoretical studies of population cycling and cost-benefit analyses of mating strategies (e.g., Greenwood, 1980; Tamarin and Sheridan, 1987).

Small mammals also make good subjects for undergraduate laboratory exercises. There are greater than 180 small mammal species representing nine families and two orders inhabiting North America north of Mexico (Hall, 1981). Rodents are the most abundant species, are found in virtually all North American habitats, and are relatively easy to capture. Additionally, an abundant literature is available and nearly every state has a handbook of mammals. Handbooks (e.g., Mammals in Kansas) generally provide distribution maps and detailed descriptions of each species and often include photographs. A non-mammalogist can, with little effort, learn to identify the few species likely to be captured in a potential trapping area. Additionally, I have found that students enjoy getting into the field and trapping small rodents. Most have not seen representative members of the local small mammal community and few, if any, have handled live wild animals. Rodents are relatively easy and safe to handle and are generally active at night, as are many college students.

This paper describes an easy-to-use, inexpensive field trip/laboratory exercise designed to delineate home ranges of small mammals. The objective of this exercise is to have students participate in the design of the exercise, collection of data, analysis of data, interpretation of data, and presentation of results.

HOME RANGE

Burt (1943:351) described the home range of an animal as "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young." The simplicity and clarity of that definition belies the difficulty encountered in its application. For many years mammalogists delineated home ranges through analysis of trapping records obtained from geometric grids; the capture coordinates being subjected to various estimating methods (Jennrich and Turner, 1969). In addition to having several inherent sources of error, trapping yields few data concerning the manner in which animals actually use the area defined as home range (Sanderson, 1966). Attempts to provide more accurate data on both size and utilization of home range by using alternative techniques such as radiisotope tagging (see Ambrose, 1960; Godfrey, 1953), paper tracking (Sheppe, 1965; Justice, 1961), and sand tracking (e.g., Siniiff and Tester, 1965) have met with varying degrees of success. Cochran and Lord (1963) introduced the technique of radiotelemetry as a more precise method of estimating home range and activity periods. Unfortunately, radiotelemetry is an expensive technique and requires a level of expertise beyond what can be reasonably expected after a few hours of practice (per-
sonal experience). Fisher and Cross (1979) used a battery-light tracking technique for studying movements of nocturnal small mammals and reported precise home range maps and activity periods. Although relatively inexpensive, this technique is limited by the extent of ground cover. Mammals can be observed in open areas but disappear in forested, shrub, or grassland habitats.

Recently, an inexpensive easy-to-use technique of home range determination has been reported. Powdertracking consists of dusting live-trapped small mammals with fluorescent powder by gently placing them in a plastic bag containing the powder (Lemen and Freeman, 1985). Animals covered with the pigment leave a trail that can be followed at night with a portable long-wave ultraviolet light. Powdertracking has been used in reports of social interactions among deer mice (Kauffman, 1989), horizontal and vertical movements of white-ankled mice (Mullican and Baccus, 1990), and home ranges of prairie voles (Jike, Batzli, and Getz, 1988). The technique also allows identification of manipulated objects, burrows entered, and foods consumed. Powdertracking has a minimal impact upon the activity of mice (Mikesic and Drickamer, 1992) and fluorescent trails persist for long periods of time (Halpenny, 1992).

MATERIALS AND METHODS

The expense of this laboratory exercise depends upon the equipment available. I prefer folding traps constructed of galvanized steel because they are easy to store and transport, and are more durable than lighter weight aluminum. A 3 X 3.5 X 9" folding trap constructed of 30 ga. galvanized steel weighs 0.8 lb and costs approximately $10.00 (H. B. Sherman Traps, Inc., P.O. Box 20267, Tallahassee, FL 32316, 904-562-5566). This size trap is suitable for small mammals ranging from 15 g to 350 g. Currently, nine colors of fluorescent pigments are available: chartreuse, deep green, orange-yellow, sunset orange, orange-red, red, cerise, pink, and magenta (Radiant Color, 2800 Radiant Ave., P.O. Box 4019, Richmond, CA 94804-0019, 800-777-2968). I have successfully used green, magenta, pink, and orange pigments; other investigators have used different colors and combinations of colors (Kauffman, 1989; Lemen and Freeman, 1985). Each color is packaged in a one-pound container and costs $12.00

(one pound is enough powder to dust one elephant or 100,000 mice).

An Eveready Indoor/Outdoor Commander Fluorescent Lantern (model no. 5209, Union Carbide Corporation, Danbury, CT 06817) equipped with a 6-W ultraviolet tube (General Electric, F6T5-BL) or a Blakray fluorescent lantern (model ML-49, Ultra-Violet Products Inc., San Gabriel, CA 91778) is used to follow trails. The price of these portable lanterns varies, but I have purchased the Eveready Lantern and a 6" bulb that fits a UV bug zapper for under $40.00. Most rodents, shrews, and moles can be captured with bait consisting of mixed grains. Peanut butter works well, but it is messy and attracts ants. Trap sites are marked with wooden garden stakes for permanent grids or surveyor’s tape for temporary grids.

This exercise can be performed as part of a laboratory course if suitable areas are reasonably close, or during an overnight field trip. I have used both methods with success. The first method involves establishment of a trapping grid (I generally use a 49-trap grid with 7-m intertrap distances in a geometric design that fits the topography) and repeated trapping sessions. Traps are baited before dusk and checked 2-3 hours later. Animals are removed from traps by shaking them into cotton muslin bags that just fit over the door of the trap (one yard of muslin is sufficient to make 4 20 X 38 cm trap bags). A string tied around the top of the bag allows the animal to be weighed in the bag (alternatively, bags can be manufactured with pull strings). Inspection of the animal is achieved by rolling the excess bag, forcing the animal to one side, grasping the bag with the animals loose neck skin between your thumb and first finger, and peeling the bag from around the animal to determine sex, age, and identity. If further studies are to be conducted the animal can be marked by toe-clipping. Headlamps are preferable, but hand-held flashlights suffice to conduct these activities.
in the dark. The animal is then placed into a plastic bag containing powder and allowed to move around until it is covered with the powder. Trails are followed and marked with surveyor's tape the following night. Approximately two hours are required for two individuals to follow and mark each trail. Detailed maps can be constructed when convenient.

The second method can be accomplished during an overnight field trip. Traps are set in a grid formation or along lines before dusk and checked 2-3 hours later. Animals are dusted, released, and tracked 1-2 hours after release. Detailed maps are constructed the following morning.

Both methods provide sufficient data for interpretation, however, the grid method allows for repeated tracking of the same individuals and comparison of home ranges observed. Observation as appropriate experimental method. After realization that most small mammals are nocturnal and secretive, trapping becomes the logical method of choice. At this point I provide a few papers from the literature cited section of this paper. During the next class meeting we discuss specific designs for grids or trap-lines, trapping and powdertracking schedules (trapping schedules may bias results because some animals become trap-shy and others become trap-happy), and methods of analyses. This procedure insures that students have first-hand involvement with the design of a scientific study and ownership of the investigation.

Conducting the experiment appears to generate the most enthusiasm. Many students willingly participate in trapping during unscheduled laboratory times, either at regular intervals or on overnight field trips. Additionally, most students are partly nocturnal and powdertracking small mammals on field trips provides them with structured activity after dark.

Data analysis, report preparation, and presentation of results can be an individual or a group effort. I prefer small groups of 3-4 students who divide up the tasks of data analysis, literature research, and final preparation. This is the manner in which most research scientists function and students should be encouraged to do the same. The obvious problems with this approach are that some students may contribute very little and some students may not understand certain aspects of the process.

**Home-range size of each animal, as determined by grid trapping or by powdertracking, can be estimated by the smallest possible convex polygon that encompasses all points of the home range (the convex-polygon method of Jennrich and Turner, 1969).**

determined by mark-recapture methods and powdertracking.

Grid coordinates derived from repeated captures can be easily analyzed by one of the mathematical methods reported by Jennrich and Turner (1969). Home-range size determined by powdertracking is easily analyzed by the methods described by Jike, Batzli and Getz (1988). Their methods involve tracing home ranges onto translucent paper, cutting out the designs, weighing the paper designs, and comparing paper weights to the weight of paper representing a known area.

**RESULTS AND DISCUSSION**

This exercise begins with discussions of the concept of home range and how it can be measured. Once a definition of home range is accepted, students invariably suggest

**CONCLUSIONS**

**Powdertracking small mammals is an illuminating experience for undergraduate students. They learn the difficulties of conducting field investigations that support such simple ideas as home range. They design and conduct field research in an effort to define the actual home range of a small mammal. Both students and faculty get an opportunity to get into the field. And finally, powdertracking represents a worthwhile after dark activity for overnight field trips.**

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