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Field Evaluation of Radiotransmitters for Northern Pocket Gophers

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ABSTRACT -- A field study was conducted in northern Idaho from June to November 1995 to evaluate the design and functional aspects of four types of radiotransmitters for use on northern pocket gophers (*Thomomys talpoides*) as well as the effects of the transmitters on behavior of the animals. Twenty-five of 46 northern pocket gophers were fitted in the field with one of three models of radiocollars (AVM, NWRC, and Holohil), nine received Wildlife Materials abdominal implant transmitters (surgery conducted off-site), and 12 without transmitters served as controls. Study animals were relocated every second to fourth day until the end of the study. Individuals not retrieved by the end of the study were captured with live traps or kill traps. Recovery of marked animals (82.6%) and transmitters (82.4%) was high. Radiocollar shedding (35.3%) was a common phenomenon, but all implants remained intact. Transmitter malfunctions were infrequent. Physical side effects of the collars were uncommon (8.8%). No adverse effects of the implants were evident. Negative behavioral effects of transmitters included reduced spatial use and extreme length of claws on the front feet. No significant differences ($P = 0.23$) in body mass between the control and radiomarked northern pocket gophers were noted at the end of the study. Effective life of transmitters varied significantly ($P = 0.01$), with the Holohil collars having the greatest longevity (mean = 87.6, S. E. = 11.72 days). Though no single transmitter emerged as a superior choice for extended field studies, the Holohil model performed the best. It had the longest effective life, and ranked a consistent second place in size (small), mass (low), ease of attachment, and signal strength.

Key words: animal damage, northern pocket gopher, radiotelemetry, surgical implant, *Thomomys talpoides*, transmitter.

Pocket gophers cause significant damage to forest and agricultural commodities (Luce and Case 1981, Case 1989, Bonar 1995). Efforts to study and develop damage reduction methods often rely on the use of radiotelemetry as a means of monitoring the fate of test animals in natural settings. Several problems are common with the use of

current radiotelemetry methods in pocket gopher studies: radio signals from several meters underground are often difficult to detect, some animals are able to shed radiocollars, and some develop sores in the neck area or other problems that may affect subsequent movements or behavior. Zinnel and Tester (1991) demonstrated the potential for use of abdominal transmitter implants with captive pocket gophers, but not in a field setting over a lengthy time period.

The objectives of our study were to evaluate four types of radiotransmitters under field conditions for signal detection and durability and for effects on the physical welfare and behavior of northern pocket gophers (*Thomomys talpoides*). Reference to trade names does not imply U. S. government endorsement of commercial products or exclusion of a similar product with equal or better effectiveness.

STUDY AREA

The study was conducted on the University of Idaho Experimental Forest, Latah County, 9.7 km south of the town of Harvard, Idaho. The two sites (designated "upper" and "lower" units), located approximately 1.6 km apart, were similar in management history, vegetation, and soils. They were clearcut in the summer of 1984, broadcast burned in October of the same year and replanted in April 1985. Vegetation is classed as the grand fir (*Abies grandis*)-queen cup beadlily (*Clintonia uniflora*) habitat type. Soils are Santa silt loams, 20 to 35%, formed in loess over granitic residuum. The sites had 20 to 25% slopes and faced east to southeast; elevation ranged from 912 to 942 m.

METHODS

Variables calculated included: the proportion (expressed as a percent) of transmitters shed, the proportion that failed during the course of the study, the proportion of northern pocket gophers sustaining transmitter-related injuries, and mean effective life of transmitters in days. Areas of use (m^2) by gophers were determined by a simple two-dimensional calculation from cumulative radiolocations. Field personnel subjectively rated and ranked transmitters for ease of attachment and signal strength.

The study design was a one-way classification, with four treatment groups (transmitter type) and a control group without transmitters. Using ANOVA, we compared mean transmitter effective life and mean mass change of northern pocket gophers. We used Fisher's LSD test to reveal the locations of differences detected by the ANOVA. To ensure that no body mass treatment differences existed at commencement of the study, we employed a mixed linear model ANOVA with a linear

contrast test to detect differences in treatment groups.

Northern pocket gophers were live-trapped from 26 June to 6 July, 1995. Of 107 individuals captured, 46 were injected subdermally with a microchip (AVID®, Norco, California) for subsequent identification. Of these 46, 25 were radiocollared with one of three transmitter models: AVM (Livermore, California), n = 9, NWRC (Fort Collins, Colorado), n = 8, and Holohil (Ontario, Canada), n = 8. In addition, nine individuals received Wildlife Materials (Carbondale, Illinois) abdominal implant transmitters and 12 served as controls, receiving the microchip only (Table 1). Captured animals were first weighed. We did not distinguish between juvenile and adult northern pocket gophers. A minimum body mass of 60 g was arbitrarily defined for study animals in order to ensure that transmitter mass did not dramatically impact animal movements. Most captures (n = 61) did not meet this criterion and were released unmarked.

Individuals to receive radiocollars were first anesthetized with Metofane®; once the animal was under anesthesia, we determined its sex. Collar attachment was conducted in a shaded area on a blanket. To reduce bias, the same person attached all of the collars. Collars were fit snugly around the neck so as not to preclude use of the cheek pouches and to minimize irritation in the neck area. Upon recovery, each marked individual was returned to the capture site and released into its burrow; the breached entry was then covered with soil. Individuals targeted for surgery were transported in plastic laboratory mouse cages to Washington State University, where staff of the Laboratory Animal Resources Center (including an assisting veterinarian) supervised the operations after conducting the abdominal surgery on the first animal as a training session.

Animals with transmitters were relocated every other day for the first six weeks, and subsequently, every third or fourth day until completion of the study. During each relocation effort, if movement was not detected, activity was induced in the targeted animal by stomping on the ground above the pinpointed location. If this did not result in movement, the subject was recorded as inactive. Three consecutive inactive signals served as the indicator to attempt to recover the transmitter. In some cases, just the transmitter was recovered; at other times, the transmitter was recovered on the dead animal. Any change detected in signal location while digging indicated a live animal with transmitter, in which case excavation ceased immediately. To get a crude estimate of spatial use over the course of the study, we marked each relocation point (on the lower unit only, due to uprooting of flags on the upper unit by cattle) with a colored flag. At the end of the study, for each cluster of flags representing a given animal's area of use, we measured the maximum distance (m) between flags in both east to west and north to south directions. The product (m^2) of these two measurements represented surface area used over the course of the study by a given individual. Including a third dimension (vertical depth) was not possible, given the limitations of radiotelemetry.

Recapture of marked animals at the end of the study (from 23 October to 2

Table 1. Performance of four radiotransmitter packages used in an extended field study of northern pocket gophers, Latah County, Idaho, June through November 1995.

Trans.[1] Model	n	Gopher Recovered with or without Trans. (%)	Gopher Recovered Live with Trans. (%)	Gopher Recovered Dead with Trans. (%)	Malfunctioning Trans.[2] (%)	Injuries (%) of those Recovered Live with Trans.)	Trans. Shedding (%)	Mean Trans Life (days)	Ease of Attachment[3]	Signal Strength
AVM	9	7 (77.8)	1 (11.1)	5 (55.6)	0	1 (100)	2 (22.2)	46.8	3	1
NWRC	8	8 (100)	1 (12.5)	2 (25.0)	1 (12.5)	1 (100)	5 (62.5)	35.9	1	3
Holohil	8	5 (62.5)	1 (12.5)	1 (12.5)	2 (25.0)	1 (100)	5 (62.5)	87.6	2	2
Wildlife Materials	9	8 (88.9)	6 (66.7)	2 (22.2)	0	0	0	58.4	4	4
Control	12	10 (83.3)	NA	NA	NA	NA	NA	NA	NA	NA

[1] Trans. = Transmitter
[2] Loss of a radio signal with subsequent retrieval of the unit in a nonoperative condition on or off the gopher, or failure to reacquire a nonoperative transmitter when the marked animal was recovered without it
[3] Subjective rating, 1 being the easiest to attach, 4 the most difficult
[4] Subjective rating, 1 being the strongest, 4 the weakest, signal

November, 1995) to check for long-term effects involved intensive trapping at the release site of each individual. Live-captured animals were euthanized. All retrieved animals were weighed and closely examined for internal and external signs of transmitter-related trauma.

Animals subjected to surgery were anesthetized with Metofane®. Before proceeding with surgery, we determined the sex of each animal. Using an electric clipper, we shaved a small patch of hair from the belly. The shaved area was treated three times with an alternating betadine-alcohol surgical scrub. A 1 to 1.5 cm incision was made in the abdomen and the 2.3 to 3 g (mean = 2.7 g, S. E. = 0.10) transmitter, disinfected in Nolvasan®, was inserted into the abdominal cavity. We closed the body wall and peritoneum in a single layer with 4-0 chromic gut in a simple, interrupted pattern. Using 4-0 vicryl (a synthetic suture thread), we closed the skin. A fine application of Nexaban® surgical glue was used to ensure closure of the dermal incision. A Metofane®-loaded nose cone (fashioned from a syringe case) was held over the face as needed during surgery to maintain anesthesia. Time from administration of anesthesia through completion of surgery averaged 40.6 min (S. E. = 1.86, range = 30-47 min). Following surgery, each animal was allowed to recover in a sawdust-lined cage placed on a circulating hot water heating pad, manipulated as necessary to guard against hypothermia. Ten individuals (5 males, 5 females) received implants; nine recovered completely and were returned to their burrow systems within 24 hrs of surgery. The other (a female) died during recovery.

RESULTS

Forty-six northern pocket gophers (19 males, 27 females) were marked and monitored during our study. Recovery of previously-marked (live and dead) animals (including controls) by the end of the study averaged 82.6% across treatments. Collar shedding among the three radiocollar treatments was highest with the NWRC and Holohil collars (each 5 of 8 = 62.5%); the AVM collars were shed least often (2 of 9 = 22.2%) (Table 1). Eight of nine Wildlife Materials abdominal implants remained intact (Table 1). Carcasses and transmitters were retrieved at an average depth of 23 cm (S. E. = 3.98) underground.

Harmful side effects, occurring in just three cases of collar attachment, were uncommon (one case each for the AVM, NWRC, and Holohil collar typs) (Table 1). We could not determine when injuries began to develop, as the three surviving individuals were not recovered until the end of the study and animals recovered dead were partially decomposed. Clinical signs varied in severity and included impaction of soil under the collar below the chin, hair loss in the underlying area of the neck, often extending down the dorsal aspect of the forelimbs, and formation of small scabs in the affected areas. No focal subdural hemorrhaging was noted in any cases. None

of the recovered individuals implanted with the Wildlife Materials transmitters showed any external or internal clinical manifestations of injury. Healing of the incisions was complete, with no signs of surgery visible at recapture (up to four months later). Extreme length of the claws on the forelimbs in two cases (an NWRC-collared individual and a Holohil-collared individual) suggested that the collars impacted normal burrowing operations by reducing activity, and permitting the claws to grow disproportionately long from lack of use. Indeed, the areas of use were largest for those individuals fitted with the least externally obtrusive Wildlife Materials implants (mean = 20.5 m^2, S. E. = 4.43), almost twice as large as those fitted with the NWRC collars (mean = 10.9 m^2 ,S. E. = 0.83), the largest and heaviest of the four transmitter types (Table 2). Areas of use for individuals wearing the AVM and Holohil collars (mean = 12.3 m^2, S. E. = 3.03 and mean = 15.3 m^2, S. E. = 4.16, respectively) were intermediate in size, and perhaps reflected the smaller size and mass of these transmitters (Table 2). The spatial use of the controls could not be determined.

The AVID® microchips used to identify each individual appeared to have no adverse behavioral or physical effects on the animals. Ten of 12 control animals (83.3%) were recaptured and showed no evidence of physical abnormality. The negligible mass (mean = 0.104 g, S. E. = 6.64 x 10^{-6}) and small size (1.45 x 0.18 cm) of these markers made them virtually unobtrusive.

Over the course of the study, body mass tended to decline. This was a common occurrence even with the unmarked (control) animals. However, no significant changes in mass between the control individuals (mean = -7.83 g, S. E. = 2.33) and those with transmitters (mean = -8.56, S. E. = 1.53) were noted (F = 0.74, df = 1, 55, P=0.39). No differences in body mass loss treatment means (F = 0.63, df = 4, 55, P = 0.64) or in the interaction of treatment and time effects (F = 1.80, df = 4, 55, P = 0.14) indicated that pre-study body mass was comparable across treatments. This pre-study comparison ensured that no mass loss differences were masked in the analysis.

Mean radiotransmitter effective life ranged from 35.9 days (S. E. = 11.18) for the NWRC collars to 87.6 days (S. E. = 12.52) for the Holohil collars (Table 1). Three collars (1 NWRC and 2 Holohils) and two abdominal implants were still intact and functional at the end of the study (100+ days). Life of transmitters varied significantly (F = 4.20, df = 3, P = 0.01), with the Holohil collars having a significantly greater effective life than either the AVM (mean = 46.8 days, S. E. = 4.45) or NWRC collars, but not the Wildlife Materials implants (mean = 58.4 days, S. E. = 12.58).

Signal strength was subjectively rated during the course of the study from numerous relocations by three field personnel. The AVM transmitters gave the most audible signal, followed by the Holohil, NWRC, and Wildlife Materials models in descending order (Table 1). The most noteworthy dropoff in signal strength occurred with the Wildlife Materials transmitters.

Physical design of the transmitters determined the amount of difficulty encountered in fitting them to animals. NWRC collars were the simplest to attach,

Table 2. Descriptive features of four radiotransmitter packages used in an extended field telemetry study of northern pocket gophers, Latah County, Idaho, June through November 1995.

Transmitter Manufacturer	Model	Type	Mean Mass (g) (SE)	Life (weeks)	Antenna Type	Dimensions (mm)
AVM Livermore, CA	BR	Collar (flat)	4.7 (0.13)	24	External loop	18x14x10
NWRC Fort Collins, CO	None	Collar (round, beaded)	6.3 (0.08)	12	Curved whip	24x16x12
Holohil Ontario, Canada	PD-2C	Collar (round, smooth)	3.8 (0.04)	14-26	Whip	20x10x5
Wildlife Materials Carbondale, IL	SOPI-1070-LD	Implant	2.7 (0.10)	8	Internal loop	20x8x5

followed by the Holohil collars, and then the AVM collars (Table 1). Because of the surgery required, the Wildlife Materials implant transmitters were the most time consuming and most labor intensive to fit to the animals.

DISCUSSION

The identification of a satisfactory transmitter for extended field studies with pocket gophers involves meeting a number of criteria. These include design and functional aspects of the transmitters themselves, as well as physiological and behavioral effects on the animals (Samuel and Fuller 1994).

Signal strength was a critical concern for relocation success. Typical pocket gopher behavior during the hot summers involves movement into the deeper burrows accompanied by reduced activity levels. These burrows may be over 100 cm deep (Witmer et al. 1996). The average depth at which shed transmitters from our study were recovered was 22 cm (range = 0 to 57 cm). Hence, a transmitter with a strong signal is necessary for consistently locating well-entrenched individuals. Signal strength is typically greater in transmitters with whip antennae, such as the Holohil and NWRC models. We found the greatest signal strength, however, with the AVM collar, which has a loop antenna encircling the animal's neck. The Wildlife Materials transmitter gave the weakest signal, probably because of the internally-located antenna system and the fact that the transmitter was completely enclosed within the animal's body cavity.

Transmitter mass and configuration are also important selection criteria. Ideally, a transmitter should be no more than 3 to 5% of the animal's body mass and be as compact as possible so as not to inhibit behavior and normal movement (Hegdal and Colvin 1986). Thus, the ideal transmitter would be one that is small, lightweight, easy to attach, and emits a strong signal. Of the radiotransmitters we investigated, the Holohil model, ranking a consistent second place in desired size and mass, ease of attachment, and signal strength, comes closest in these categories (Tables 1 and 2).

Transmitter effective life was defined as the time from which a transmitter was activated (commencing from the time a northern pocket gopher was equipped) until its failure to emit a signal or recovery with or without the animal. Transmitters still functioning upon recovery were not left activated through the duration of the study. Hence, these values are minimum figures. Holohil collars had the longest effective life- somewhat surprising for one of the lighter mass transmitters. Typically, larger-capacity batteries are needed to extend transmitter life, but at the expense of increased mass.

Malfunctioning transmitters were uncommon. Transmitter malfunction was defined as the loss of a radio signal with subsequent retrieval of the unit in a nonoperative condition on or off the northern pocket gopher, or failure to reacquire a

nonoperative transmitter when the marked animal was recovered without the unit. Failure to reacquire both the marked animal and the transmitter did not qualify as a malfunction because of the possibility of movement of the unit out of signal range via predation or dispersal. Although predation was not documented during our study, it probably occurred. Marked northern pocket gophers probably did not emigrate from the study site, since only animals greater than or equal to 60 g (subadults and adults, which are the older component of the population with well-established burrow systems) were selected for marking. Because functional transmitters recovered from northern pocket gophers prior to the end of the study were not maintained in an active mode through the duration, malfunction should not be considered as a true time duration comparison of transmitters. Failure of transmitters was related to components of the unit itself (battery or electronics). The Holohil had the highest malfunction rate (2 of 8) (Table 1). The only other model with any malfunctions was the NWRC with a single malfunction (Table 1). None of the AVM or Wildlife Materials transmitters malfunctioned.

Ease of transmitter attachment is not extremely important in evaluating transmitter performance, unless large numbers of experimental animals are to be used. The NWRC collar had the advantage of being the easiest to attach, but its large size and mass conferred no advantage on collar life (rank = fourth) and signal strength (rank = third) (Table 1). Conversely, the Wildlife Materials implant transmitter was the most time consuming to fit. It also gave the weakest signal, probably because none of the components protruded from the animal's body.

Transmitter shedding was a key concern that made evaluating transmitter performance and physical effects on the animals more difficult (Table 1). The implant transmitters had the highest recovery rate (none shed) and margin of safety (no adverse health effects), but at the expense of highly compromised signal strength and increased time (surgery) required to fit the implants to the subjects. Zinnel and Tester (1991) concluded that peritoneal implantation is a satisfactory method of equipping plains pocket gophers (*Geomys bursarius*) with transmitters. A higher proportion of collar transmitters (AVM, NWRC, and Holohil models) were shed, perhaps because the whip antenna made digging and movement within burrows difficult and irritating (Table 1).

Transmitter-induced injuries were not as prevalent as expected, but the number of animals available to evaluate this (those recovered with collars) was very small (Table 1), and individuals recaptured at the end of the study that had slipped collars early had time for injuries to heal. This may have been an indication that the collars were not attached as tightly as they could have been. Just three animals recovered alive showed evidence of external injuries. However, the large number of individuals in these three groups that were recovered dead (8 of 25) or that had shed collars (12 of 25) might explain the low incidence of external injuries. The effect of radiocollars on the well-being of the animals was difficult to evaluate because of the low recovery of live, radiocollared animals at the end of the study. This was in large part due to the

infrequency with which relocations were obtained (every second to fourth day). Potentially, an individual could have been dead for more than a week before it was recovered; body condition in such cases made evaluating impacts of the transmitters nearly impossible.

Northern pocket gopher recovery was high (38 of 46 individuals). This indicated low mortality (aside from study-related mortality factors) and low emigration. However, the short duration of our study minimized the chances of documenting dramatic population changes.

Over the course of our study, loss of body mass, although not significant, was the general rule, both for control and transmittered gophers. In contrast, Zinnel and Tester (1991) noted long-term mass gains in captive plains pocket gophers with peritoneal transmitter implants. However, the mass of pocket gophers in the wild can fluctuate widely, depending on the season (Bonar 1995).

Areas of use calculated for northern pocket gophers in our study are not representative indicators of home range size, and consequently, were not interpreted as such. They better approximate what Hayne (1949) terms the "geometric center of activity", defined as the geographic center of all points of capture, a two-dimensional average of a group of points. In our study, the geometric center of activity across treatments averaged 15.29 m^2 (S. E. = 2.07). The geometric center of activity generally occurs within 3 m of the den, and gophers spend approximately 50% of their time in 4% of the home range area (Kuck 1969). Indeed, we routinely noted that flags marking the locations of a given individual were typically clustered in a confined area. However, this observation can in part be attributed to the effect that presence of field personnel has on behavior of the animals. Pocket gophers located away from the nest typically retreat rapidly to the nest (Kuck 1969, pers. obser.). Hence, by default, some bias exists in defining true locations of study individuals.

Because the geometric center of activity is actually a segment of the true home range, it is substantially smaller than the home range estimates of 750, 998, and 2373 m^2 from three different calculation methods for the same data set, for northern pocket gophers in Idaho (Kuck 1969) and 185.8 m^2 for northern pocket gophers on the Black Mesa of southeastern Colorado (Turner et al. 1973). The variability of methods used to calculate and define home range make it difficult to compare home range values across studies (Kuck 1969). In addition, factors such as year-round food availability and population density are paramount factors in determining size and shape of the home range (Marsh and Steele 1992). At low population densities, pocket gophers create larger and irregularly clustered burrow systems with much space between neighbors; at high population densities, pocket gophers have smaller and more regularly distributed territories (Bonar 1995). We did not quantify population density on our study site, but based on our extensive trapping experience, we estimated the population at a moderate density.

Consideration of the criteria we evaluated must take into account the species of

pocket gopher. Interspecific variation in body size and behavior will play an important role in selection of the best transmitter for a given species. The best overall performance of the transmitters we tested was with the Holohil model, which had the longest lifespan, and ranked a consistent second place in size (small) and mass (low), ease of attachment, and signal strength. Fidelity was low (5 of 8 collars were shed), and adverse effects on health and behavior were documented, though they were no more severe than with either of the other two neck collar models (AVM, NWRC). Fitting the collars more tightly might reduce shedding, but may increase the incidence of injury or death of collared animals. We recommend additional research to address variables, which may influence transmitter performance and northern pocket gopher behavior, including age and reproductive status of the animal, season of the year, and site characteristics (soil conditions, vegetation).

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