EVALUATING THE GAS CARTRIDGE FOR COYOTES IN CONTROLLING BADGERS

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ABSTRACT: Efficacy investigations were conducted in Pampa, TX to evaluate the use of the "GAS CARTRIDGE FOR COYOTES: (Canis latrans) for controlling problem badgers (Taxidea taxus) in burrows. This coyote cartridge with two active ingredients (sodium nitrate and charcoal), produces high concentrations of carbon monoxide when burned and is effective in controlling coyotes in dens. Badgers were live-trapped, immobilized, and equipped with mortality-indicating radio transmitters prior to their release. Movements were monitored for a minimum of 12 days prior to each initial efficacy test and for at least 3 days in follow up tests for survivors. Only occupied burrows, unplugged and previously utilized by the badger during the study, were selected for gassing. The coyote cartridge was used according to label directions, and survival or mortality were recorded for each test. The mortality rate was 25% (1/4 attempts) using one gas cartridge and 50% (1/2) using two. Survivors resurfaced between 5-72 hrs after the gassing and relocated a least 2 km away from the test burrow. Because the overall 33% mortality was well below the 70% minimum efficacy standard recommended by the EPA, the study was discontinued. Results suggested that amending this registration for badgers should not be pursued. Factors possibly contributing to badger survival are discussed including a tolerance for low oxygen, behavior associated with burrow entrance disturbance, soil porosity and moisture content, and badger body weight.

Key words: badger, efficacy test, gas cartridge, movements, radiotelemetry, Taxidea taxus, Texas.

Proc. East. Wildl. Damage Control Conf. 6:79-84. 1995.

Badger (Taxidea taxus) conflicts with humans occur mainly in agricultural areas where their fossorial niche (Lindzey 1982) creates mounds and deep burrows that may be hazardous to livestock (Burt and Grossenheider 1964, Long and Khillingly 1983) and may damage rangeland (USDA 1990), farm equipment or water systems (Minta and Marsh 1988). Although badgers are economically a minor vertebrate pest to agricultural interests, they may cause serious losses to individual farmers or ranches (Minta and Marsh 1988). The Animal Damage Control (ADC) program of the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) has identified the badger in their Draft Environmental Impact Statement (USDA 1990) as one of 17 species that it takes in substantial numbers. In a national survey of ADC State Directors conducted in 1991, nine respondents requested an additional control tool for this species.

Savarie et al. (1980) stated that a two-ingredient gas cartridge (sodium nitrate and charcoal) produces high concentrations of carbon monoxide gas when burned, and he suggested it would be an effective pyrotechnic fumigant for vertebrate pests that live in burrows or dens. Its development and testing has been reported by Savarie et al. (1980) Savarie and Blom (1993) and Elias et al. (1983). As a mammalian predacide, undergoing the final phase of reregistration (Ramey et al. 1992), it is effective against the coyote (Canis latrans) (Savarie et al. 1980), striped skunk (Mephitis mephitis) (Ramey 1992a), and red fox (Vulpes vulpes) (Ramey 1992b) in dens. Efficacy of similar formulations with various sizes of gas cartridges have been reported for rodents (Fagerstone et al. 1981, Matshcke and Fagerstone 1984, Dolbeer et al. 1991). In 1991, the ADC program requested the Denver Wildlife Research Center (DWRC) to submit the necessary efficacy data to the Environmental Protection Agency (EPA) to support the proposed use of APHIS's GAS CARTRIDGE FOR COYOTES (coyote cartridge) EPA Registration No. 56228-21) to control pest badgers.

I wish to thank K.A. Fagerstone, P. J. Savarie, and S. A Shumake for reviewing the manuscript and providing useful comments, and P. A. Burk for assisting with various aspects of the manuscript's preparation. I appreciated the support of M. Graham, G. Dasch, P. Hedgal of DWRC and G. Nunley, R. Gilliland, R. Smith, and B. Byron of the Texas ADC in conducting the study. A special thanks to Mr. Studebacker and Mr. Darsey for graciously allowing us access to their ranches.

STUDY AREA

Field investigations were conducted 40 km SSE of Pampa, Texas, in Gray County. This area was selected because of the documented agricultural damage caused by badgers (R. Gilliland, pers. commun.) and the willingness of ADC operational personnel to participate in this study. The study site was along McClellan Creek (N 35° 17', W 100° 45') which flows from west to east at approximately 850m (2800 ft) above sea level. The gentle hills, sandy loam soil, and arid conditions made it suitable for alfalfa production using overhead sprinklers or for use as rangeland for livestock. Temperature and precipitation were measured daily by the National Weather Service's station located at Pampa, TX.

MATERIALS AND METHODS

The coyote cartridge is a multi-component pyrotechnic fumigant that is manufactured at the Pocatello Supply Depot, 238 E. Dillon Street, Pocatello, ID 83201. It consists of 1) a cartridge tube and end caps fabricated from paper, 2) a firework safety fuse, and 3) a chemical formulation inside the cartridge weighing 240 g and consisting of two active ingredients, 65% sodium nitrate (Nominal) and 35% charcoal/carbon (Nominal). Savarie and Blom (1993) have discussed suppliers and other details about a similar gas cartridge for rodents.

A standard shipment of 100 coyote cartridges (Lot No. 136-1) was obtained from the Pocatello Supply Depot. Ten cartridges were randomly selected for sodium nitrate and charcoal content analysis according to DWRC Method No. 40A by the Analytical Chemistry Section (ACS) at DWRC. All others were randomly assigned to the efficacy test.

The study was initiated February 7, 1992. Three badgers were captured using Woodstream Softcatch[1] No. 3 Traps, and anesthetized with ketamine (15 mg/kg) and acepromazine (2 mg/kg) using a jab pole. Demographic data were obtained for each badger prior to instrumentation with a mortality-indicating radio transmitter (Advanced Telemetry Systems[1]). Each transmitter operated on one of 12 assigned channels (164 MHz band) and averaged 114 g in weight. Pulse-interval timers (AVM Instrument Co.[1]) were used to identify transmitter pulse rates. All radiotracking was done with portable telemetry receivers (Model CD-12, AVM Instruments Co.[1]) and 3 element hand-held yagi antennas. Badgers were released at the point of capture and monitored both day and night, with their movements plotted on aerial photographs.

Following at least twelve days of movement data, coyote cartridges were used in individually located badger burrows according to the following label directions:

> "Select den, make sure cartridge will enter freely and obtain material to plug entrance. With 1/8" nail, puncture cap at end of cartridge at points marked. Insert fuse in one of center holes. Insure there is a minimum of 3 inches of exposed fuse. Hold cartridge away from face and body, then light fuse. Place cartridge, fuse-end first, into burrow as far as possible. Plug burrow immediately. (If burrow is steep, contents of cartridge may flow out of the lighted end. If so, place cartridge as deep in burrow as possible with fuse-end up, light, then close burrow.)"

About 6 hours after a badger died, the transmitter's pulse rate was programmed to double, indicating mortality; about 18 hours later, the burrow was excavated to recover the badgers, and survival or mortality was recorded. Searches of the burrow sites were made for nontarget mortality.

RESULTS AND DISCUSSION

Radiotelemetry provided a powerful technique for investigating this fossorial species. Telemetry greatly assisted in determinations of their wide-ranging nocturnal movements, subterranean burrow use patterns, movements during burrow entrance disturbance, badger reactions and relocations following gassing, the effectiveness of treatment, and excavation of carcasses. Similar benefits from using radiotelemetry to determine badger movement behavior (Sargeant and Warner 1964) in efficacy testing have been reported (Dodge 1967, Fagerstone et al. 1981).

Gas Cartridge Ingredient Assays

Nominal concentrations of ingredients in the formulation for the gas cartridges as indicated on

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[1]Reference to commercial products or entities does not imply endorsement by the U.S. Government

the Confidential Statement of Formula (CSF) are: sodium nitrate, 65.0% and charcoal, 35.0%. Assay results were 63.0% (SD=1.8, n=10) sodium nitrate (w/w) and 34.7% (SD=1.7, n=10) charcoal (w/w). A comparison of the observed and theoretical percentage of formulation, based on percent recovery by the Analytical Method 40A, was also determined. The corrected estimates using the Quality Control (QC) assay data (mean percent recovery) for sodium nitrate (65.2%) and charcoal (34.9%) were very close to the values listed on the label and CFS (65.0% and 35.0%).

Efficacy Test

One adult (male, 8.2 kg) and two juveniles (male, 4.6 kg; female, 4.4 kg) were included in the study, and their movements were monitored for an average of 486.8 hours. Each badger was monitored for a minimum of 288 hours ($\bar{x}=333.5$) to establish normal movement behavior and burrow use prior to the efficacy tests (Table 1). When follow up efficacy tests were conducted on survivors in different unplugged burrows, a minimum of 75 hours ($\bar{x}=115$) were used between each test. Two badgers were declared dead by mortality collar activation and lack of movement for 3 consecutive days (one of these was confirmed dead by excavation) and one badger survived three separate gassings.

The 70% minimum efficacy standard recommended by the EPA for amending the registration of the GAS CARTRIDGE FOR COYOTES (Reg. Nos. 56226-21)

Table 1. Gas cartridge efficacy for badgers in burrows. All cartridges except #52 underwent a complete burn; this cartridge was excluded from the study because < 10% of it burned. Pampa, Texas in 1992.

Badger No.	Cartridge(s)	Hrs Monitored*	Gassed	Out come
Test One - One Gas Cartridge and First Attempt				
1	One - #52	288.1	2-25-92	Survived
3	One - #1	288.3	2-28-92	Survived
2	One - #75	424.1	3-02-92	Survived
Test Two - One Gas Cartridge and Second Attempt				
1	One - #77	93.7**	2-29-92	Dead 3-1-92
3	One - #97	139.7**	3-05-92	Survived
Test Three - Two Gas Cartridges and Third Attempt				
2	Two- 43 & 95	151.5**	3-08-92	Dead 3-9-92
3	Two- 82 & 56	75.0**	3-08-92	Survived

* Badgers were instrumented with mortality-indicating biotelemetry collars
**Hours monitored since the previous attempt to gas

to include badgers, was not attained. The overall efficacy was 33% (2/6) based on 25% (1/4) mortality (juvenile male No. 1) using one gas cartridge, and 50% (1/2) mortality (adult male No. 2) using two. The latter efficacy tests were based on the recommendation of Dolbeer et al. (1991) that more than one cartridge should be used in larger burrow systems; however, the use of two gas cartridges that were simultaneously ignited, only slightly increased the efficacy (1/2 or 50%). Although the sample size was very small, the study was discontinued because of the low mortality.

Field efficacy tests determining mortality have been previously reported for this gas cartridge: 96% coyotes (Savarie et al. 1980), 100% skunks (Ramey 1992a), 100% red fox (Ramey 1992b), and 77% Norway Rats (Rattus norvegicus) (Savarie et al. 1980). Mortality has also been reported for similar gas cartridges with efficacy demonstrated to be 84% for ground squirrels (Spermophilus spp.) (Matschke and Fagerstone, 1984) and 80% for woodchucks (Marmota monax) (Dolbeer et al. 1991).

Speculations about the badgers' survival ability in this study include: (1) a tolerance for lowered oxygen levels, (2) plugging behavior during burrow entrance disturbance, (3) soil porosity and moisture content, and (4) body weight. Minta and Marsh (1988) reported that burrows occupied by a badger may have a dirt plug that is positioned near the entrance of the burrow when the badger has decided to stay in a burrow or has been disturbed. The badgers in this study utilized multiple burrows, with the entrance to smaller occupied burrows were most often complete plugged or partially plugged with an air hole, and the entrances to larger occupied burrows were most often left open. Although microenvironmental conditions in the badger burrows including gas concentrations were not investigated, badgers may have a tolerance for lowered oxygen levels. Kennerly (1964) and Studier and Procter (1971) have reported that burrows occupied by fossorial rodents generally exhibit lower levels of oxygen and higher levels of carbon dioxide than surface air.

The badgers in this study seemed to demonstrate a sensitivity to den entrance disturbance, as monitored by telemetric movements. Noise at the burrow entrance seemed to disturb the badgers, and they generally moved slowly (meters/hour) away from the entrance. Minta and Marsh (1988) suggested that badgers have extremely acute auditory and olfactory senses, capable of hearing and smelling through considerable depths of soil, and that they plug their burrow when disturbed. Based on movement observations, we speculate that the surviving badgers may have plugged the burrow upon the insertion of the gas cartridge and slowly dug away from the cartridge while back-filling the burrow behind themselves. Survivors resurfaced between a minimum of 5-13 and a maximum of 45-72 hours after the cartridge was burned, and they then relocated to another area at least 2 km away from the gassed burrow.

Highly porous soils such as dry, sandy soils have a high gas diffusion rate, whereas heavy clay soils have a low diffusion rate (Matschke and Fagerstone 1984). In addition, dry soils increase diffusion by gases, in contrast to wet soils that decrease gas diffusion (McClean 1981). The burrows gassed in this study were dug in dry, sandy loam soils that may have facilitated a lowered carbon monoxide equilibrium after gassing.

Another factor that may have contributed to survival was badger body weight. Although the sample was very small, the use of one gas cartridge produced death of one juvenile male weighing 4.6 kg, and use of two gas cartridges produced death of one adult male weighing 8.2 kg. However, one juvenile female survived two trials with one cartridge and one trial with two (Table 1). Matschke and Fagerstone (1984) reported that ground squirrel body weight may have contributed to the survival of heavier squirrels. Factors such as these may have provided the badgers in this study with the ability to survive the use of the gas cartridge designed for lethal control of coyotes in dens.

Wildlife Hazards

The use directions for this gas cartridge state that it is to be used "only in the underground burrows or dens of target animals." Under these conditions it should have minimal impact or nontarget animals and the environment. In the current study, radio-monitored badgers were located and gassed in their burrows and nontarget mortality was not observed. Dolbeer et al. (1991) emphasized that in the operational use of gas cartridges, nontarget mortality should be minimized by only treating burrows with signs of active use by the species of concern rather than indiscriminately treating all burrows in an area.

Carbon monoxide is highly toxic when inhaled because it has a much higher affinity to combine with hemoglobin (240 times) than oxygen and quickly leads to tissue hypoxia (Swinyard 1975). The American Veterinary Medicine Associations's (1993) Panel on Euthanasia has stated that the main advantage of using carbon monoxide for euthanatizing animals is that it quickly induces unconsciousness without pain and with minimal discernible discomfort; concentrations of 4-6% result in rapid death. As one would expect based on this mode of action, signs of secondary toxicity have not been observed. Savarie et al. (1980) reported that secondary toxicity was not observed in bobcats (Lynx rufus) fed rats killed by carbon monoxide fumes from burning sodium nitrate and charcoal.

MANAGEMENT IMPLICATIONS

Research to add the badger to the label for coyote control should not be continued because of the poor efficacy observed for this proposed control tool. Efficacy in the use of the coyote cartridge may be increased through a better understanding of the survival mechanisms that contributed to the results observed in this study. Other control strategies like habitat modifications to reduce the badger's prey base may be useful in population control; however, this approach is generally considered too slow to resolve immediate or individual problems. Thus, trapping and shooting will probably continue to be the most effective methods available for pest badger control (Minta and Marsh 1988).

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