MANAGING COYOTE DAMAGE PROBLEMS WITH NONLETHAL TECHNIQUES: RECENT ADVANCES IN RESEARCH [1]

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OVERVIEW

In 1972 President Nixon issued Executive Order 11643 prohibiting further federal use of toxicants for controlling predators; EPA subsequently withdrew all chemical registrations for this purpose. These actions stimulated research efforts to develop alternate nonlethal means of reducing livestock losses to coyotes and other predators. Some of these studies, focused primarily on barrier fencing, guarding dogs, chemical repellents and aversive agents, "frightening" devices, and modification of leg-hold traps, have resulted in new ways to alleviate the problem.

U.S. investigators have assessed electric fencing equipment and technology developed in New Zealand and Australia. Results of these studies showed that when fences were properly constructed or when several offset electric wires were added to existing woven-wire sheep fences, coyotes could be excluded. Ranchers who have tried electric fencing have generally been satisfied with its performance, but its use has not been widely adopted by the sheep industry. The major reason for its poor acceptance is most likely the initial cost of fencing materials and installation.

Livestock guarding dogs have been used for centuries in the old world to protect domestic animals from wolves, bears, and other large carnivores. Recent studies show that they can reduce coyote predation on sheep and goats. Surveys have indicated that producers who used dogs were generally satisfied. Breed and behavior of individual dogs, proper training, type of livestock management, and terrain are primary factors influencing their effectiveness.

In the mid-1970s, studies were aimed at finding chemicals that could be placed on sheep to elicit coyote olfactory repellency or taste avoidance. Although some pen tests showed promise, in no instance were investigators able to demonstrate conclusive efficacy under field conditions. Lithium chloride (LiCl), an aversive compound, was placed in sheep carcasses or in wool-covered sheep-meat baits to induce illness in coyotes and subsequent avoidance of live sheep. This approach produced varied results: the controversy over test procedures employed and the validity of resultant data were never resolved. Use of LiCl has not been adopted by livestock producers as a viable option for reducing their losses to predators.

Propane or acetylene exploders have frequently been used to scare coyotes away from livestock for limited periods of time. The recent development and evaluation of battery-operated strobe light/siren devices, timed to present these stimuli at irregular intervals throughout the night, indicate that protection can be provided for extended periods. Their effectiveness for reducing predation losses of range sheep is currently being assessed.

Opposition to the use of steel leg-hold traps for taking coyotes and other predators has increased in recent years, as evidenced by state referendums against trapping and legislation introduced at state and federal levels. Trap pan tension devices have been evaluated to reduce the number of nontarget animals taken accidentally, and traps with padded jaws show promise as a means of reducing foot injury of captured animals. These developments may reduce objections to the steel trap as a predator damage control tool.

A combination of various nonlethal and lethal techniques is necessary to effectively reduce predation on livestock in central and western United States.

FENCING

Experiments to exclude coyotes from sheep pastures with barrier fences were documented as early as 1908 by Jardine (1908), who conducted field tests over several years using various configurations of wire fencing. Years ago woven or "net" wire fences with buried wire aprons were commonly installed around large pastures in parts of Texas and elsewhere to exclude coyotes. Because costs of materials and labor to install this type of fencing are now prohibitive, its use is limited to small areas or situations in which farm flock damage is extremely high. The types of barrier fences evaluated by Thompson (1976, 1979) and deCalesta and Cropsey (1978) now appear to be of only limited value to livestock producers, except when used around nighttime corrals or for confinement and feed lot operations.

Electric fencing has been used for many years to manage livestock but I am aware of only two publications before 1978 (Larson et al. 1975, Wallace 1975) that described its application for excluding coyotes. Interest in this approach was stimulated by the cancellation of predacide registrations in 1972 subsequent to Executive Order 11643 (Nixon 1972) and by the importation into this country of new types of fence chargers and electric fencing techniques from

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Australia and New Zealand in about 1976. Several papers describing tests with imported equipment and techniques have now been published (Shelton 1977, Gates 1978, Gates et al. 1978, Henderson 1978, Dorrance and Bourne 1980, Linhart et al. 1981, deCalesta 1983). One obstacle to more widespread use of electric fencing is the high initial costs of equipment, materials, and labor. Even though a favorable amortization of these costs over the life of a fence may be shown where coyote losses are consistently moderate to high over a period of years, ranchers are still reluctant or unable to make the initial investment. Such fences require a moderate amount of maintenance, and some producers prefer not to spend their time making inspections or repairs. Thus, though the results of tests to determine efficacy have been generally favorable, electric fencing has not been widely adopted by the industry and, except for southeastern New Mexico, use has generally been restricted to farm flock operations (Linhart et al. 1981).

Field tests conducted in North Dakota and Kansas in 1977 and 1978 showed that wild, unconfined depredating coyotes could be excluded by 12-wire all-electric fences, 5-½ ft high, or by 4 or 5 electric wires offset from existing woven-wire fences, and that sheep producers were generally pleased with electric fencing as a means of coyote damage control (Linhart et al. 1981). However, V.W. Howard (pers. commun.), New Mexico State University, who is currently conducting field tests of electric fencing on pinon-juniper rangelands, has apparently had little success in excluding coyotes from sheep pastures having a 7-strand electric fence or a conventional woven-wire sheep fence with 2 barbed wires and 2 electric wires on outriggers. Wade (1982) presented an excellent summary on the use of fences for predator damage control and included an extensive list of pertinent references. He concluded that fences are most useful for protecting small areas where producers use intense livestock production methods and may be helpful for directing predator travel to sites where other control techniques can be applied. He listed such factors as construction and maintenance costs, terrain and vegetation, and inability to exclude some predators or to remove them from fenced areas, as major problems associated with exclusion fencing.

Controlled tests and assessments by producers have so far indicated that under certain conditions electric fencing can be a useful technique for reducing coyote predation on livestock. However, additional studies would be helpful to determine minimum height and maximum wire spacing needed to exclude coyotes, cost/benefit studies under varied sheep management regimes, the possible use of electric fencing to exclude coyotes from large areas, long-term monitoring of electric fences installed by producers to assess efficacy and maintenance problems, and field measurement of the capacity of low versus high output impedance chargers for maintaining adequate line voltages under adverse weather and vegetative conditions.

GUARDING DOGS

Several breeds of large dogs have been used for centuries by rural societies in the Old World to guard livestock from predators. Sheep and goat producers in the United States have occasionally used assorted and mixed breeds of dogs to protect their livestock from coyotes, but only within the past few years has interest in guarding dogs sparked research efforts to evaluate their potential. A substantial number of producers raising livestock in fenced pastures now use guarding dogs to reduce their losses to coyotes and efforts are underway to assess their effectiveness on rangelands.

Individuals who have recently completed or are presently conducting dog research include J. Greene and his coworkers at the USDA's DuBois, Idaho, Sheep Experiment Station; P. Lehner and J. McGrew at Colorado State University; R. Coppinger and his associates at Hampshire College, Amherst, Massachusetts; and H. Black at Brigham Young University. While many of the earlier guarding dog publications were of a popular and anecdotal nature, studies using quantitative methodology are now appearing in print and are providing valuable insight as to the dogs' behavioral traits, methods of training and utilization, and producer assessment of their effectiveness. For example, Coppinger and Lorenz (in press) and Coppinger and Torop (1981) discussed various aspects of introducing guarding dogs to livestock producers and certain behavioral characteristics of the dogs. Coppinger et al. (1983) presented quantitative data on what they term the "attentiveness" of guarding dogs; i.e., as assessment of their physical proximity to sheep in relation to reducing predation. Lorenz and Coppinger (1981) discussed the field evaluation of guarding dogs and their effectiveness while Green and Woodruff (1980) and Pfeiffer and Goos (1982) surveyed ranchers to obtain data on losses before and after dogs were used, the degree of rancher satisfaction, and other pertinent information. Green et al. (1980) and Green et al. (in press) discussed cost/benefit factors and practicality relative to dog use. Green et al. (in press) presented data on field trials with four breeds of dogs, the percent of time they were successfully integrated into livestock operations, and problems encountered when using them for guarding sheep, while McGrew and Blakesley (1982) observed how Komondor dogs guarded sheep in large enclosures. Green and Woodruff (in press) discussed the use of three dog breeds to protect range sheep. Coppinger and Coppinger (1981) and Green and Woodruff (1983) have compiled visual and written information designed to instruct livestock producers on how to best train and use guarding dogs to protect their livestock. Black (1981) observed the use of mixed breed dogs to protect sheep and goats by the Navajo Indians in Arizona and raised the question of why mixed breeds couldn't perform the same guarding function as the Old World dogs being imported into the United States.

Identification of commercial products and companies does not constitute endorsement by the U.S. Government.

Thus, since the initial limited and preliminary evaluation of Komondor dogs by Linhart et al. in 1979, a great volume of data and information have been generated and published in a short period of time. For the most part, these data have shown that guarding dogs can significantly reduce predation losses in many situations. While some factors limit their use or practicality, this is also true of all other available predator control techniques. Guarding dogs thus appear to be another method that livestock producers can use to minimize their losses to predators.

CHEMICAL REPELLENTS AND AVERSIVE AGENTS

The concept of applying a nontoxic chemical repellent to sheep by dips, sprays, collars, eartags, or other means received a great deal of attention, starting in the mid-1970's after restrictions were placed on the use of predacides. Two approaches were taken: the first was based on chemicals that might have olfactory repellency while the second involved testing compounds that might elicit gustatory or taste avoidance. One of the first attempts at that time to use an olfactory repellent involved affixing plastic disks containing mercaptan compounds to the ears of sheep or to an expandable collar placed around their necks. Field tests of this device, patented by a Canadian inventor, were conducted in several western states but results were negative or equivocal (Swanson and Scott 1973; unpublished reports, DWRC files). Work on candidate olfactory and gustatory repellents was later undertaken by Colorado State University (Swanson et al. 1974, 1975, 1976; Lehner et al. 1976); Texas A&M University at San Angelo; the University of Wyoming (Botkin 1977); the U.S. Department of Agriculture (USDA) Sheep Experiment Station in Dubois, Idaho; and the U.S. Fish and Wildlife Service (FWS) in Denver (Linhart et al. 1977). Much of this work, except that conducted by FWS, was funded by the USDA's Economics and Statistics Service. Although some pen tests with captive coyotes showed that certain compounds elicited repellency, in no instance did field trials indicate significant efficacy or practicality for producer use. The discouraging results obtained, despite intensive research, caused investigators to seek alternate nonlethal approaches. To my knowledge, no one is aggressively pursuing research on coyote repellents at the present time. Although the reason or reasons for the poor success attained are speculative, one likely factor may be that coyotes rely heavily on visual cues to locate and attack their prey (Wells and Lehner 1978). Thus, though chemicals having repellent odors or tastes may reduce coyote feeding on treated dead prey or other food sources, it appears that they have little deterrent effect on the coyotes' prey-killing behavior. As judged by research conducted so far, further work on chemical repellents appears to offer little potential for resolving coyote damage problems.

Investigations of chemical aversive agents, specifically lithium chloride (LiCl), to avert coyotes from attacking sheep first appeared in the literature in the mid 1970s (Gustavson 1974, Gustavson et al. 1974, 1975). The concept, well documented for averting rodents from food sources, was based on the idea that, after coyotes consume LiCl-treated wool-covered sheep meat baits or treated sheep carcasses, they would become ill and associate the illness with sheep and thereafter avoid killing live sheep. The technique appeared particularly attractive in that, unlike many nonlethal techniques, it would be useful for open range damage situations and could be applied over large geographic areas. A number of researchers have conducted tests with confined coyotes (Gustavson 1974; Gustavson et al. 1974, 1975; Horn and Lehner 1977, 1981; Olsen 1975; Olsen and Lehner 1978; Griffiths, Connolly and Burns 1978; Burns 1980, 1983, in press; Burns and Connolly 1980; Conover et al. 1977; Fagre 1981) or have carried out short or long-term field trials (Bourne and Dorrance 1982, Cornell and Cornely 1979, Ellins and Catalano 1980, Ellins et al. 1977, Gustavson et al. 1982). Some field tests have suffered from poor experimental design, thus further complicating an objective evaluation of the technique. FWS investigators are not convinced that lithium chloride is a viable coyote damage control method nor has this approach been widely adopted by the livestock industry. The most recent review of the subject was by Burns (1983). One major problem appears to be that coyotes are intelligent enough to distinguish between treated sheep baits or carcasses and live, untreated sheep.

SCARE DEVICES

Various types of frightening devices such as electric lights, portable radios and propane exploders are used by ranchers to reduce livestock losses to predators. However, evaluation of their efficacy is almost completely lacking (Meduna 1977, Pfeifer and Goos 1982, Rock 1978, Schaefer 1978). The Denver Wildlife Research Center recently completed field tests that assessed the effectiveness of FWS-fabricated portable, battery-operated strobe-light and siren devices to reduce coyote predation on pastured sheep. Both the original prototype device and the second-generation, smaller, less expensive model ($100-125 ea) consisted of an electric timer wired to a commercial strobe light, a warbling-type siren and a 12 vDC rechargeable battery. Unlike the commonly used propane exploders that produce a repetitive explosion at regular intervals, several of the DWRC devices, deployed around a pasture or bedground, emitted a varying and irregular sequence of light and sound stimuli originating from different locations. We believe this technique minimized habituation to the stimuli by depredating coyotes and prolonged the period of repellency.

From 1979-1982, 15 field trials of these devices were conducted on pastured sheep located on ranches in Colorado, Idaho, South Dakota and Oregon. Results were encouraging; following a 2-3-week pretest period to document baseline kill rates (i.e., controls), the original prototype device (10 trials) provided a mean of 53 nights of protection (2 or less losses), whereas the

newer model (5 trials) protected sheep for a mean period of 91 nights (Linhart et al. in press). In no instance did the devices frighten the sheep being protected, even when sirens and lights were located directly on the bedground.

The reduction of coyote predation on sheep grazed on open range is frequently difficult to achieve because of terrain or vegetation, the large number of sheep vulnerable to predation, the size of the land areas, and limited access to these areas. Coyote damage control on U.S. Forest Service (FS) allotments where sheep are herded from about July 1 to September 15 may be particularly difficult because vehicular access to many allotments is impossible or prohibited and only a small number of FWS-supervised predator control specialists are available to respond to depredations problems. Because of high recreational use of some allotments, FS supervisors frequently limit the types of control methods that can be used, thus further reducing the effectiveness of damage suppression efforts. Calling and shooting coyotes is sometimes the only technique permitted on many allotments.

A pilot field test in 1982 on a band of range sheep located on adjacent Bureau of Land Management (BLM) and FS allotments in the Gunnison National Forest in western Colorado provided encouraging results. Four devices deployed on or around the sheep bedgrounds resulted in an 80 percent reduction in lamb losses as compared to the previous year. Additional field trials are now being conducted on open range to determine the extent FWS frightening devices can reduce losses to depredating coyotes.

A concern sometimes expressed by both sheep producers and ADC specialists is that nonlethal control techniques merely displace coyotes from the immediate area of impact and that displaced individuals will subsequently begin preying upon adjacent unprotected livestock. This viewpoint may have merit, although earlier tests of our devices in fenced pastures provided no clear evidence that such is a common occurrence. Periodic checks of these test areas indicated that coyotes remained on or near test sites as determined by the presence of coyote sign and vocalizations. Radio telemetry studies of coyote movement and home range by Andelt (1982) and a number of other investigators indicate long-lasting fidelity to established home ranges by resident coyotes; however, none of these studies were conducted with nonlethal control techniques in effect. Because numerous sheep bands are frequently grazed in close proximity to one another on summer range, we believe it is important to determine whether coyotes are displaced from their home ranges by frightening devices and if kill-rates increase on nearby sheep bands. Radio telemetry studies would be one way to collect displacement-type data, as well as to establish coyote movement and activity patterns relative to the location and deployment of devices.

Another frequently expressed concern is that frightening devices will provide only temporary relief and that coyotes will habituate to their presence and quickly resume killing sheep. We have no direct evidence to dispel this concern, but do believe that the 6-19 weeks of protection afforded by our devices on 11 of our 15 test ranches was of significant duration to be helpful to producers. More tests in open range situations are needed but so far we are encouraged by the preliminary results of our 1983 tests on FS grazing allotments in the western Colorado mountains.

STEEL TRAPS

Steel leghold traps are an important tool for capturing carnivores and other mammals that cause economic losses to livestock producers, damage agricultural crops, or transmit diseases such as rabies. They are frequently the only means of effectively dealing with these problems and the Fish and Wildlife Service relies heavily on their use, both for conducting animal damage control activities and for carrying out research. In FY-1980, 36 percent of all coyotes taken by the FWS Animal Damage Control (ADC) program were taken by traps (Connolly 1982).

Concern about the use of traps by both individuals and organized groups has increased in recent years. Restrictive trap legislation is proposed or introduced each year into many state legislatures, and state referendums aimed at prohibiting their use are becoming increasingly popular.

Interest in traps and trapping was stimulated by the 1981 final report of the Canadian Federal Provincial Committee for Humane Trapping and the recommendations contained in this report (Neave 1981). The Committee's work dealt primarily with the effects of various kill-type traps on captive furbearers and its report recommended specific capture devices for each of the major species taken for fur in Canada. This Committee stated that most traps presently in use in Canada will need to be modified or replaced as new capture devices are developed and proven effective. They also recommended that jurisdictions regulating uses of traps accept their criteria for kill-type traps such as the Conibear, and made recommendations for future development and research on trapping systems.

The Canadian report and the proposed trap legislation mentioned earlier have gained the interest of the International Association of Fish and Wildlife Agencies. At their recent annual meetings, the Association's Fur Resources Committee noted that the recommendations in the Canadian report for specific trapping devices were premature. The Fur Resources Committee supported and recommended that high priority be given to establishing minimum standards for evaluating traps. It also assigned high priorities to research on trap design, performance of commercial traps, and evaluation of experimental traps, particularly the padded jaw trap and the powered foot snare. The Committee stated that after new traps have been proven efficient, selective, less damaging, and economically feasible, their use should be encouraged through public communication and education. It also

recommended that traps now in general use should not be prohibited simply because new or modified designs appear to duplicate the performance of existing devices. Most recently, the American National Standards Institute has agreed to participate in the International Organization for Standardization's project on animal traps. A technical advisory group is being organized by F.F. Gilbert of Washington State University. Obviously, the interest and concern over the use of trapping devices merit our attention.

Opposition to leghold traps is based primarily on two objections: (1) a lack of selectivity for target species and (2) foot injury sustained by captured animals. More selective use of steel traps is being achieved in part by the addition of pan tension devices to traps (Day 1934, Linhart et al. 1981, Turkowski et al. in press). Briefly, Turkowski and his coworkers evaluated three different types of tension devices (shear pin, leaf spring, and steel tape) in four western states and recorded the number of coyotes and nontarget species that stepped on unmodified and pan tension device-equipped Victor 3N-M long spring traps and were captured or excluded. Nontarget species designated for this study were kit *(Vulpes macrotis)*, swift *(V. velox)*, and gray *(Urocyon cinereoargenteus)* foxes, striped skunk *(Mephitis mephitis)*, opossums *(Didelphis marsupialis)*, and jack rabbits *(Lepus californicus)*. Exclusion rates (animals stepping on pan but not captured) in wet clay or alkali soil conditions for all nontarget species combined were 92, 100, 95, and 6 percent for improved shear pin, improved leaf spring, steel tape, and unmodified traps, respectively. Coyote capture rates in wet areas were 87, 92, 84, and 98 percent, respectively. While use of the devices slightly reduced the rate at which coyotes were captured, the reduction in the numbers of nontarget species taken resulted in more traps remaining set for coyotes.

The Denver Center began field evaluation of padded jaw traps in fall 1980. To date, a total of 17 field tests of unpadded and padded traps have been completed. With one exception (Idaho), all tests were conducted in Texas under moderate temperatures and generally dry conditions. In no instance have padded traps been evaluated in either extremely wet and muddy conditions or in cold environments. A total of 214 coyotes have been taken, with samples of 20-21 coyotes per test when the padded traps under evaluation appeared to show some promise for reducing foot damage without hindering efficacy. When test pads were obviously ineffective, tests were stopped after a sample of 5 coyotes were obtained. All tests were conducted in areas where coyotes were numerous and all traps were set in locations so as to maximize the possibility for capturing this animal. Too few numbers of other species were taken during any one test to permit assessment of foot damage (or lack thereof) to such carnivores as raccoon, skunk, bobcats, badger, or fox.

All coyotes were left in traps approximately 48 hours, i.e., traps were checked daily and when a coyote was captured it was left in the trap until the following day when it was killed, the leg in the trap removed to be later stored in a freezer, and the extent of foot damage noted. All feet were subsequently examined in the laboratory and the extent of damage was verified. The damage category [none; swollen foot; slight, moderate or severe cut(s); broken bone(s)], was then changed if required. Captured coyotes that for some reason were dead at the time traps were checked (e.g., shot by ranch hand, etc.), were excluded from all samples. Traps used for tests were either Victor 3N-M, Victor 3N-R, or Victor No. 3 double coil spring.

While additional tests must be run, results so far have been encouraging. The percent of foot damage reduction achieved has been about the same as that obtained with tranquilizer trap tabs (Balser 1965; Linhart et al. 1981), or about 10-15 percent little or no damage for unmodified traps as compared to 80-85 percent of coyotes taken in traps affixed with pads. The best results achieved to date were with a padded-jaw Victor No. 3 double coil spring trap provided by the Woodstream Corporation, Lititz, PA 17543. Woodstream will begin selling padded traps in Canada in fall 1983 (H. Robertson, Woodstream Corp., pers. commun.). Controlled testing of the most promising traps and pads is needed under extremes of moisture, heat, and cold to determine if results vary significantly. The extent to which the FWS will evaluate the effects of unpadded and padded coyote traps on nontarget species has not yet been determined. However, tests of padded traps for taking smaller carnivores have been conducted by investigators in Georgia, New York and Alberta, Canada.

Denver Wildlife Research Center studies of steel traps are restricted to the needs and objectives of the FWS. Fur industry and private fur trapper views on the desirability of and need for changes in steel trap technology will obviously differ because of the commercial and practical aspects of furbearer harvest.

LIVESTOCK HUSBANDRY PRACTICES

Livestock husbandry practices can also significantly reduce losses to predators. Such practices may include keeping stock close to occupied buildings, confinement at night, daily inspection, shed lambing, use of electric lights, pasture rotation, belled sheep, disposal or removal of dead animals, clearing natural cover for predators or avoiding such areas, and keeping dogs in proximity to livestock (Nass, in press). Some of the above are practical means of dealing with predation problems; others are prohibitively expensive or are not compatible with some types of livestock operations. Efforts to assess the relative merits of different husbandry practices are difficult because producers normally use a combination of lethal, nonlethal and husbandry techniques and experimental manipulation of such practices is usually prohibitively expensive for the researcher. A few individuals have attempted to assess their efficacy by surveying or interviewing livestock producers (Meduna 1974, Robel et al. 1981).

SUMMARY

Nonlethal management techniques can be used along or in combination with lethal control and husbandry practices. Their advantages include use by livestock producers following minimal instruction rather than the need for professional ADC field agents, and better acceptance by government regulatory agencies and the general public. Another advantage (in theory) is that resident coyotes can be "taught" to avoid livestock and will continue to maintain and defend territorial areas in the vicinity of livestock. In such situations, predation rates should be lower than if depredating coyotes were killed, thus creating space for immigrating, potential killers to enter the area and cause damage. This hypothesis obviously requires further study.

Most reasonably informed and rational people now recognize that the coyote is an extremely adaptable species, capable of successfully surviving and even thriving in the presence of man. Not only behavioral adaptations, but compensatory mechanisms such as increased productivity, survival rates, and immigration in response to intensive man-induced population reduction by lethal techniques, give this species a resiliency that is admired by some and the cause of extreme frustration to others. Considering the above factors and the variety of livestock management practices used throughout the range of the coyote, along with the wide range of human idiosyncrasies—moral, social and legally imposed—it is obvious that differing coyote damage control methods are needed and must be available for resolving man-livestock-coyote conflicts.

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