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USE OF LIVESTOCK PROTECTION COLLARS TO PROTECT SHEEP AND GOATS

Murray T. Walton
Texas Department of Agriculture

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MURRAY T. WALTON, Texas Department of Agriculture, Box 12847, Austin, TX 78711

Abstract: The sodium monofluoroacetate (Compound 1080) Livestock Protection Collar is selective for individual predators attacking the throat of sheep or goats and is especially useful in taking coyotes (*Canis latrans*). However, fears of secondary and nontarget poisonings have resulted in restrictions on their use. They are registered for use in the United States only to kill coyotes. To satisfy U.S. Environmental Protection Agency requirements, the Texas Department of Agriculture provides training and testing for certifying collar applicators, and has monitored collar use from 1988 through 1990. During this period, 59 licensed applicators, 6 collar pools, and the Texas Animal Damage Control Service obtained collars. Information on effectiveness in taking coyotes and the fate of collars was collected through applicator reporting, inspections, surveys, and discussions with applicators. Sixty-two applicators used collars during the 3-year period for a total of 89,649 collar use-days. The number of coyotes killed by collars has been conservatively estimated to be 92. The only reported incident of suspected nontarget poisoning involved a lamb wearing a collar that was ruptured by an undetermined cause. Also described in the paper are targeting strategies, organization of collar pools, steps taken to reduce controversy, and the suitability of collars for combatting coyote predation on farm flocks in the eastern United States.

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The Livestock Protection Collar (LPC) is a rubber bladder containing a toxicant that is attached to the neck of sheep or goats with straps (Rancher's Supply, Inc.). Coyotes attacking sheep or goats at the throat are poisoned when collars are punctured. The collar's outstanding advantage is its selectivity for individual coyotes that actually cause damage (Connolly 1980).

In the early 1970s, a successful collar containing Compound 1080 was developed by R. McBride of Alpine, Texas. However in 1972, use of Compound 1080 for predator control was banned because of instances of misuse and fears of secondary poisoning (Ruckelshaus 1972). The U. S. Fish and Wildlife Service, Denver Wildlife Research Center (DWRC), tested collars using three toxicants—sodium cyanide in 1975, diphacinone in 1976, and Compound 1080 in 1978-1980 (Connolly 1980). The Texas Agricultural Experiment Station, Texas A&M University, under contract to the DWRC, performed additional field tests of Compound 1080 collars in Texas during 1980-1983. Potential hazard to nontarget carnivores and scavengers from collar use was found to be small (Connolly 1980, Eastland and Beasom 1986, and Tex. Agric. Exp. Stn. 1983). A registration for use of the LPC by Texas Animal Damage Control Service (TADC) personnel was subsequently obtained by the U. S. Department of Agriculture, and in December 1987 the U. S. Environmental Protection Agency (EPA) granted a conditional registration for LPCs to Rancher's Supply, Inc. for use of collars in Texas. To date, registration has been granted only for small collars containing 30 ml of 1% Compound 1080 solution.

Most methods of predator control, and especially those using toxicants to kill predators, are highly controversial. Arthur et al. (1977) found that 23% of respondents indicated a farmer should not be allowed to kill an animal that killed livestock. However, of those who approved of killing such predators, only 43% approved of killing other animals of the same species to prevent further predation. Trapping and slow-acting poisons were judged least humane. Kellert (1979) found that both informed and uninformed members of the general public disapprove of poison uses as the cheapest means of coyote control, if nontarget species would be killed. There was very little regional difference in response rates, varying from a low of 83.1% disapproving in the South to 93% disapproving in the Pacific region.

Registration of Compound 1080 for predator control has been the subject of organized opposition by leading conservation groups. In *The Case Against Poisoning Our Wildlife*, the Defenders of Wildlife (1982) singles out Compound 1080 with reference to nontarget take and secondary poisoning and raises the question of Compound 1080 use in the east for coyote control.

Texas leads the nation in sheep and Angora goat production with 2.0 and 1.6 million head respectively (Texas Agric. Statistics Serv. 1991*a*). Texas also has approximately 330,000 Spanish goats and smaller numbers of dairy and cashmere goats. Much of the range used for sheep and goat production is gently rolling to rugged limestone hills with moderate to dense brush that provides good habitat to a variety of avian and mammalian predators. Sheep and Angora goat predation losses during 1990 totaled 177,000 head valued at $7.5 million, with coyotes accounting for more than half of the damage (Texas Agric. Statistical Serv. 1991*b*).

LPCs offer ranchers another tool for protecting livestock from predation. Because of the mode of action, collars can be especially useful in killing coyotes that have learned to evade conventional control methods such as traps, snares, calling and shooting, and M-44 sodium cyanide devices. The small LPC that fits lambs or kids from 15 to 50 pounds, is registered for use by specially trained and certified applicators in the states of Montana, New Mexico, South Dakota, Texas, and Wyoming.

During 1988-1990, approximately 73% (n = 2,436 collars) of all collars sold in the United States have been to Texas ranchers, collar pools in Texas, and the TADC. Collar use in Texas during 1988-1990 occurred primarily in the central counties (Fig. 1).

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METHODS

In developing a program to certify LPC applicators, the Texas Department of Agriculture (TDA) sought input from conservation, environmental, and animal welfare organizations, as well as the ranching industry. A series of field trips and meetings for representatives of various parties were held in 1986 and 1987 to familiarize them with predation problems and control methods. Public notice of intent to register collars in Texas and amend the Texas Pesticide Regulations to allow applicator certification was published in the 11 November 1986 and 19 May 1987 editions of the *Texas Register* (TDA 1986, 1987). Public hearings were held in Austin and San Angelo,

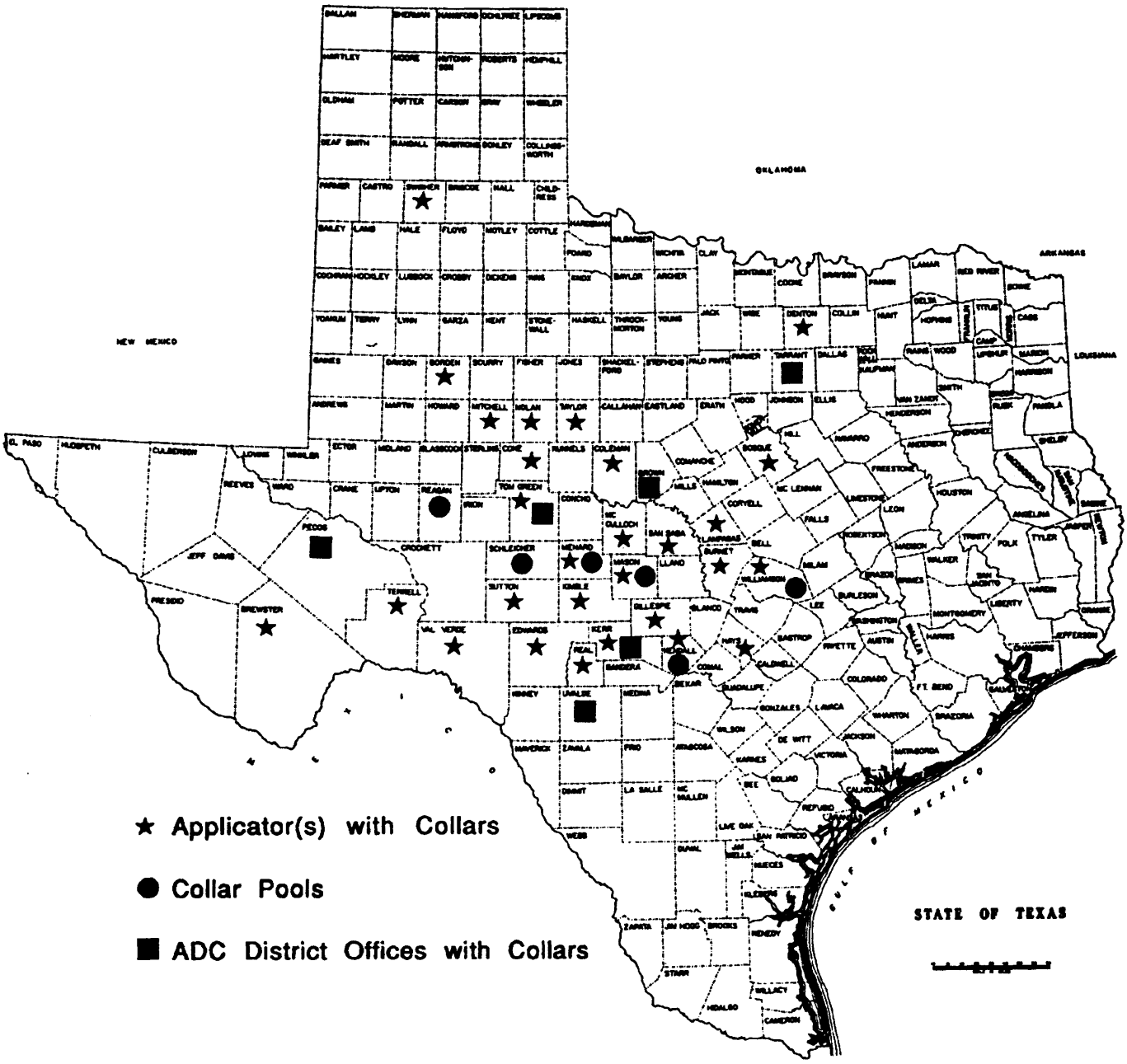

Fig. 1. Distribution of Livestock Protection Collars in Texas by county, 1990.

Texas to allow for additional public input. A press conference announcing collar applicator training was held in January 1988, at which use of livestock guarding animals was emphasized as part of TDA's comprehensive predator management program (Mulder 1988). Regulations have subsequently been changed on 2 occasions, with the appropriate hearings and opportunity for public comment provided.

A training program patterned after Wade and Bowns (1985), that includes identification of predation and alternative methods of control, was developed for M-44 sodium cyanide and LPC applicator certification. The training program also draws heavily from *Applicator Manual for Compound 1080 in Livestock Protection Collars* (Wade 1985). Walton (1989) describes this program in greater detail. Agency personnel involved in applicator training and inspections were selected with consideration for ability to address technical and sociological aspects of predator management issues. A Predator Management Advisory Committee was formed with representation from various interest groups. TDA kept the committee abreast of program activities.

To satisfy EPA requirements, TDA must report annually on all LPC use and status of each collar by serial number. Before acquiring collars, certified applicators completed a site review and sales data form. This form includes questions on predation losses, pasture sizes, methods of predator control being used, and location of ranches where collars were to be placed on livestock. Also, applicators having collars must report quarterly to the TDA on all collar use, the fate of all collars, any punctures by coyotes, collar-induced mortality of nontarget species, and any accidents involving collars. Maximum, minimum, and estimated collar use-days were calculated from quarterly reports. Maximum use-days were determined by counting the number of days from the date of collar attachment until a collar was found to be punctured, ruptured, missing, etc. Minimum use-days were determined by counting the number of days from attachment until the last day on which a collar was found to be in satisfactory condition. An estimate for collar use-days was then calculated by averaging the maximum and minimum numbers.

Surveys were sent to 42 applicators in December 1988 to collect information on LPC use. Additional questionnaires were sent to 50 applicators during December 1989 to collect information on use of various predator management methods. Surveys were also mailed to 17 collar applicators in June 1989 to gather information on livestock guard donkey use and husbandry practices (Walton and Feild 1989), and sent to 123 licensed applicators in January 1990 to solicit opinions on applicator recertification and program changes. Data gathered during annual applicator inspections and discussions with applicators have provided additional information on collar use.

RESULTS

Public Relations Effects

Considerable initial opposition to LPC registration was experienced. More than 450 letters in opposition to collar use were received in response to the 1986 public notice, outnumbering letters of support by nearly a 2:1 ratio. The Humane Society of the United States orchestrated the largest block of opposition. More reasoned opposition along with suggestions for safe-guards came from the Lone Star Chapter of the Sierra Club, Defenders of Wildlife, and the National Audubon Society.

Since implementation of the program, no organized opposition has surfaced. The conservation and environmental group representatives on TDA's Predator Management Advisory Committee have offered constructive suggestions within the forum provided. Only one letter was received opposing regulation changes proposed in 1990 to abolish applicator reporting and to make licensing less costly. There have been some complaints from pro-collar forces concerning departmental attention to nonlethal alternatives. However, efforts to promote nonlethal management methods, particularly guard donkeys, have resulted in excellent publicity and allowed continuation of a balanced program.

Texas Rancher Use

Characteristics of collar applicators and their predator control efforts are discussed in Walton (1989, 1990). More than half of the LPC applicators raise both sheep and goats, and suffered approximately a 10% loss to predation prior to acquiring collars. Applicators owned from fewer than 100 head to more than 5,000 animals, and used collars in pastures ranging from 24 ha to 688 ha. More than half of all reported sheep and goat losses were attributed to coyotes, with domestic dogs ranked second in frequency of predation on livestock. Respondents to the surveys used a variety of predator management practices. Predators reported as killed by collar applicators by various means included coyotes, dogs, bobcats (*Felis rufus*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), mountain lion (*Felis concolor*), and raccoons (*Procyon lotor*). Most ranchers received assistance from TADC.

Thirty-one of the 54 licensed Texas ranchers using collars reported 1 or more collar punctures attributed to coyote attacks. Eight collar users suspected coyotes were killed by collars in 2 of the years of collar use, and 2 applicators suspected coyote kills in 1988, 1989, and 1990. Thirty-seven confirmed or suspected LPC-induced coyote kills were reported in 1988; 23 kills were reported in 1989; and 24 kills were reported in 1990 (excluding suspected kills from missing collars when a dead coyote was not found). A minimum of 7 poisoned coyotes were located by applicators in 1988, including 2 coyotes that had punctured the same collar. One poisoned coyote was reported found in 1989, and 6 dead coyotes, including another double kill from a single collar, were reported found in 1990.

An estimate of 25,694 collar use-days was calculated for 1988, 26,986 collar use-days were calculated for 1989, and 22,383 use-days in 1990, for a total of 75,063 collar use-days. An average of 894 collar use-days was recorded per suspected

coyote kill. Kills were recorded with 2 to 40 collared sheep or goats in a pasture and in 1 to 104 days maximum time from application. For 85 collar punctures attributed to coyotes, 21 (25%) occurred within 7 days of collar attachment, 50 (59%) within 14 days, and 66 (78%) within 21 days. Average number of collars deployed in a pasture during suspected punctures by coyotes was 13, but 52% of all reported punctures occurred with 10 or fewer collars in use. Punctures were recorded for all months except January. Fifty-six applications of LPCs resulted in 1 or more coyote punctures of collars, while 83 applications resulted in no reported punctures. One-hundred-six collars were reported as lost along with the collared animals, and only 3 collars were reported as lost from animals. Seventy-four collars were reported as torn or pierced by vegetation, with cactus (*Opuntia* spp.) thorns being a leading cause of damage. Twelve collars were ruptured by unknown causes, and 1 collar was torn during removal. Average collar-life calculated during the 1988-89 period from all causes of collar loss or destruction was approximately 300 use-days (Walton 1990).

Applicators who first correctly identified coyote attacks at the throat of sheep or goats and then collared all kids or lambs placed with a larger number of adult animals as recommended in the *Applicator Manual for Compound 1080 in Livestock Protection Collar* (Wade 1985) were usually successful in taking coyotes with collars in less than 3 weeks. The common targeting practice used by ranchers who were successful in taking coyotes with LPCs was to place a few collared lambs or kids with their mothers, and a larger number of dry ewes or nannies, in a pasture where coyotes were attacking at the throat. If young animals in excess of the number of collars were on hand, they were penned or moved (with their mothers, if not weaned) to a pasture some distance from the area of coyote attacks. Collar applicators with small pastures in areas of relatively high human activity, and isolated from other sheep and goat producers, have been especially successful.

One collar applicator successfully used night penning and a guard donkey with livestock in an adjacent pasture to direct coyote attacks to collared kids (H. Hitzfelder, pers. commun.). This applicator recorded 5 collar punctures in fewer than 30 days using only 8 collared kids. An applicator who had a guard dog bonded to goats was successful in using collars on lambs in the same pasture with the dog and goats (E. Haydon, pers. commun.). The dog protected goats from attack on the bedding grounds at night, but the sheep were bedding in another area. A few applicators have used collars in a prophylactic manner on small target flocks of adult goats. The collared animals were placed in pastures with a history of predation to remove predators prior to moving in larger herds to graze. This strategy has been successful for several ranchers, but has resulted in many collar use-days per suspected coyote puncture.

Several other targeting strategies have proven successful. In areas having a history of coyote predation, small herds of collared lambs or kids with or without adult animals have been placed in pastures before moving larger herds into the area. Two to 3 weeks is allowed for attacks on the collared animals before introducing the additional uncollared animals. In pastures where no small lambs or kids were in the herd and coyotes were attacking large and adult animals, smaller animals of proper size for use of small collars have been acquired from elsewhere and added to the herd. This management practice has been used in advance of lambing or kidding, especially if numbers of newborns were expected to be too high to collar. In some instances, coyotes that attacked large animals at the flank or rear were enticed to attack at the throat by adding a few small collared animals. Also, the addition of a few smaller animals with shorter hair has helped in instances where long wool or mohair was discouraging attacks at the throat (L. C. Howard, Jr., pers. commun.).

Cessation of coyote attacks after collars were placed on animals and a resumption of attacks after collars were removed in 2 to 4 weeks have been reported (K. Schneider, R. L. Kneuper, pers. commun.). One instance was reported of coyotes switching from killing kids to killing nannies after the kids were collared (H. Hitzfelder, pers. commun.). The applicator was successful in diverting the attacks to the throat of collared kids by placing black inner-tube bands around the necks of nannies in the herd.

The only reported incident of suspected nontarget Compound 1080 poisoning involved a lamb with a collar ruptured from an unknown cause. Additional mortality of collared animals (other than animals killed during attacks that resulted in collar punctures) included 1 animal destroyed due to Compound 1080 contamination from a ruptured collar, 1 collared animal that broke a leg after being caught in a leg-hold trap, 7 that died of unknown causes, and 30 that were killed by predators in attacks not resulting in collar puncture. Twenty of the animals killed by predators without puncturing collars were all in the same pasture.

Though only 85 collar punctures attributed to coyotes were recorded by ranchers, among the coyotes taken were several that had escaped all other control measures for more than a year, and were believed to be responsible for killing more than 100 head of livestock (F. Beaver, pers. commun.). Also, some applicators experienced a reduction of predation losses after collared animals were found to be missing.

Several applicators possessing collars did not use collars because they did not have predation from coyotes attacking at the throat of sheep or goats. Other reasons for not using collars included too many kids or lambs to collar, collar use not feasible because of pasture characteristics, predation was more easily controlled by other means, the cost of using collars, and record keeping. Two applicators, including one who was succesful on the first night of use, have reported destroying their collars to avoid the reporting and record-keeping chores.

Collar Pools

During much of the year, the number of kids or lambs produced on many Texas ranches preclude successful targeting with a small number of collars. The expense of purchasing a

large number of collars, which may be needed only occasionally (every two or more years), is prohibitive to some livestock users. Pooling of collars by several ranchers provides a cost-effective method to make an adequate number of collars available on an "as needed" basis. To address this problem, licensed applicators have established several collar pools patterned after LPC clubs organized in South Africa to combat black-backed jackal (*Canis mesomelas*) predation (McBride 1990). All applicators who participate (as collar applicators) in a pool are first required to complete the TDA training course for LPC applicators, pass the required test, and possess a commercial, noncommercial, or private applicator license; or a private applicator certificate. The collar pools are managed by agents designated by Rancher's Supply, Inc. and approved by TDA. The agents must obtain a pesticide applicator license with certification in the LPC category and a pesticide dealer license. Up to 15 agents are allowed under current regulations. The agents do not directly supervise collar application and are not paid to apply collars. Collars for operation of a pool can be acquired by: (1) participating certified or licensed LPC applicators who complete a site review and sales data report form and purchase the required number of collars for transfer to the the pool for storage under the management of the agent, or (2) the agent purchasing collars directly for the pool from the pool account. While collars are in storage with the agent, pool members are not required to file quarterly use reports. A site review and sales data form must be completed and a copy sent to TDA whenever collars are transferred to an applicator. Records for all collar transfers to and from the pool must be maintained by the agents. The agents manage the pools and resolve any conflicting needs for collars according to guidelines agreed upon by pool participants. The individual LPC applicators remain responsible for compliance with all label requirements, laws, and regulations governing collar use for all periods during which collars are in the applicators' possession. This includes quarterly reports and accident reports (if necessary), as well as disposal of punctured or torn collars, for any period when collars are in use or in possession of the applicator. When use by a pool member is terminated, collars are transferred back to the pool and replacement made for any collars lost, destroyed, or damaged enough to become unusable. Agents reporting to TDA on the receipt of collars back to the pool and/or quarterly applicator reports, allow TDA to know which applicators need to file quarterly reports or need an annual inspection.

The first collar pools in Texas were organized in Reagan and Menard Counties in late 1989. Pools were subsequently organized in Kendall, Mason, Schleicher, and Williamson counties. In all but Williamson County, the pool agent is the Texas Agricultural Extension Service County Agent. The pools have acquired from 20-250 collars. Typically, pool members spend $200 each for purchasing 10 collars. The Menard Collar Pool also requires membership in the county trapping club, and several club members not using collars have also contributed for purchase of collars (Campbell 1990). Only 10 applications of pool collars were made in 1990, and 5 collar punctures were recorded in 6,655 collar use-days (included in rancher use figures).

Texas Animal Damage Control Service

TADC made 17 collar applications in 12 counties during 1990. Collars were used on ranches under agreement to help with herd management and an obligation to reimburse TADC for any lost, torn, or punctured collars. Seven of the applications resulted in 1 or more punctures attributed to coyotes. An estimated 14,586 collar-use days resulted in a suspected kill of 7 - 10 coyotes. In addition to the 10 collars punctured by coyotes, 11 were lost along with the collared animal, 7 were punctured or torn by vegetation (primarily cactus thorns), and 8 were ruptured from unknown causes. Number of collars used per application varied from 7 to 85 and averaged 36 collars per application.

DISCUSSION

Opposition in Texas to Compound 1080 use in LPCs has been subdued since the start of the TDA program. Several factors, including TDA's interest in public input and oversight, contribute to this public trust. Also, the selectivity of collars for only offending animals meets with general approval. Survey results showing public opposition to use of toxicants for predator control may be biased due to the wording of questions that imply posions will indiscriminately kill nontarget species. This has not been the case with collars, as no nontarget wildlife kills have been documented or even suspected. Problems from lost collars, as predicted by Defenders of Wildlife (1982), have not materialized. However, if future collar use results in any significant nontarget poisonings, or if applicators misuse Compound 1080, opponents of predator control with poisons will become active.

Training applicators to identify coyote attacks to the throat, and to differentiate between coyote attacks and attacks from other predators is essential to properly using collars, because collars are registered in the United States only for taking coyotes. Red fox, grey fox, domestic dogs, bobcat, and cougar also may kill prey by a bite at the throat (Wade and Bowns 1985) and could be accidently taken with collars. Species other than coyotes, including black-backed jackal and leopard (*Panthera pardus*) in South Africa and Pategonian red fox (*Dusicyon culpaeus*) in Argentina, have been taken with collars placed on sheep (R. McBride, pers. commun.).

Collar use by Texas ranchers and TADC has demonstrated success with no unexpected nontarget losses. In contrast, Tomsa and Forbes (1990) reported a nontarget:target ratio of 10.8:1 in New York using leg-hold traps to catch coyotes. Beasom (1974) also experienced a large nontarget catch using steel traps without a pan-tension device in south Texas. TADC killed 18,573 coyotes, including 2,885 in steel traps, during fiscal year 1990. Nontarget take was only a fraction of this number (Hobbs 1991). In this period, TADC took more coyotes (n = 6,474) with M-44s than with any other method, and had

a very low nontarget take with this toxicant device (Hobbs 1991). Data presented by Beasom (1974) also indicates that the M-44 can be used as a highly specific control measure for coyotes. M-44s provide a quick-killing poison, but not the selection for only individual predators killing livestock. LPCs should take only predators actually preying on sheep and goats. However, LPCs are effective only in limited situations.

The average of 894 collar-use-days/puncture attributed to coyotes achieved by Texas ranchers and the 1,459 use-days/puncture for TADC use compare favorably with approximately 832 use-days/puncture on an "intensive" site and 1,367 use-days/puncture on a "rancher-use" site recorded by the Texas Agricultural Experiment Station (1983). TADC had approximately the same success rate as rancher applicators in obtaining coyote induced punctures, but the larger average number of animals collared per application resulted in more use-days/puncture. In 1989, New Mexico rancher-applicators reported a much better success rate in recording 9 coyote punctures in 4,129 collar-use days, an average of only 459 use-days/puncture (J. Elrod, N. M. Dep. Agric., unpubl. data). Four collar-use trials in Wyoming during 1990, totalling 1,939 use-days, resulted in no collar punctures. However, predation stopped in 3 of the pastures after collared lambs were found to be missing (Wyo. Dep. Agric. 1991).

Actual success in taking coyotes with LPCs is probably being underestimated by attributing kills primarily on the basis of collar punctures. Several collared animals reported lost or missing probably involved collar punctures by coyotes. Compound 1080 typically requires 1 - 2 hours to produce symptoms of intoxication in coyotes, 4 - 8 hours or even longer to cause death, and therefore permits coyotes to travel long distances before succumbing to the toxicant (Wade and Connolly 1980). Before dying, coyotes can easily drag off small kids and lambs. Vegetative cover and rough terrain on many Texas sheep and goat ranches further hampers the location of kills. The relatively low incidence of collared animals found dead from unknown causes, and the low incidence of collared animals recorded as being killed without collar punctures, further supports an assumption that many of the missing collared animals would have punctured collars. Of the animals found killed by predators without collar punctures, 20 of 30 were killed in a single pasture in an area known to have severe dog predation problems.

Targeting is the process by which a depredating coyote is brought together with a sheep or goat wearing a collar. With only the small collar available, the animal of choice is a lamb or kid between 15 and 50 pounds because: (1) the small collar fits properly over the jaw area of animals in this size range, and (2) given the choice, most (not all) coyotes will select for a smaller animal. After first determining that a coyote is attacking at the throat of sheep or goats, greatest success is achieved by collaring all target-type animals. If only 50 of 100 lambs are collared, there is a 50:50 chance that the next attack will be on a lamb with a collar. It is important therefore to collar all probable target animals remaining in the area subject to predation. Targeting may be complicated by: (1) more target animals in a pasture than there are collars available, (2) more target animals in a pasture than the LPC-use restrictions will allow to be collared, (3) labor requirements to collar a large number of animals, (4) coyote attacks on all sizes of sheep and goats, and (5) an abundance of target-type animals in adjacent pastures. In some instances it will be necessary to remove livestock from adjacent pastures to avoid a coyote simply shifting predation to the other herd.

If a coyote is consistantly attacking at the throat in a pasture, a collar puncture is likely to occur in 3 weeks. Large numbers of collars are not needed in many situations where coyote attacks can be directed at a few collared animals. Some coyotes (especially those in more remote areas) may be driven away by human activities, and changes in herd size may cause coyotes to go where prey is more abundant. Patience may be required to allow a coyote to accept disturbance resulting from collar use. Also, collars should be left on target animals for several days after experiencing a puncture to assure that all problem coyotes have been killed. In some instances, young or inexperienced coyotes foraging on kills made by the coyote taken with a collar will begin attacks on livestock at other areas of the body. Other means of control must then be used. Some of the most successful collar applications were in areas with a high rural human population near major roads, and in semi-urban areas. Probably coyotes in such areas are not disturbed by the added activity associated with collar applications, inspections, and adjustments. Using collars in a prophylactic manner resulted in a high number of collar-use-days/suspected coyote kill, and is generally not recommended.

Some failures with collars can be attributed to the target coyotes being taken by the collar applicator or adjacent landowners with other techniques. Inadequate numbers of collared kids or lambs in the presence of large numbers of "target-size" animals contributed to several failures to take coyotes in instances when predation continued. Improper identification of the predator causing losses is also suspected as a cause of failure to take coyotes with collars. Considerable opportunity exists for improving targeting practices.

Several factors contribute to the reluctance of ranchers to use collars. Ranchers suffer livestock losses to a wide variety of predators, and collars are normally limited in their effectiveness to coyotes attacking at the throat of sheep and goats. With only the small collar registered for use, effectiveness is further limited to use mostly on small lambs and kids. Many ranchers are satisfied with their current coyote-control methods, or the protection afforded by TADC. The husbandry and management requirements for effective collar utilization are frequently in excess of the common practices or capabilities on extensive range livestock operations. Large rough pastures and heavy brush make checks on collared animals difficult. Cost and availability of labor are also primary considerations of many ranchers interested in using collars. Initial investment

including licensing, a minimum of 10 collars at $20 each, and incidental equipment costs total about $300. The Texas Agricultural Experiment Station (1983), using data from LPC use on 12 ranches, calculated an average total cost of $1,055 during an average 30-week period, and estimated a cost of $1,828 for a 52-week period. Labor accounted for more than half of the total cost. Though current costs may be higher, collar use under proper circumstances should compare favorably with the overall cost of $2,086/coyote trapped by the New York State Cooperative Coyote Damage Control Program (Tomsa and Forbes 1990).

MANAGEMENT IMPLICATIONS

LPCs can be used effectively in conjunction with other predator control methods to protect sheep and goats from coyote predation. Also, LPC's are more selective for individual predators causing damage than other control devices and provide greater relative safety to nontarget species than steel traps. However, there is considerable public concern over use of mammalian pesticides, particularly Compound 1080. Involvement of conservation and environmental interests at all stages of program development, along with updates on results, can greatly reduce controversy and opposition.

Collars are especially valuable in taking coyotes that have learned to avoid other control methods such as traps, M-44s, or calling and shooting. All programs for collar use should be integrated with other lethal and nonlethal methods of predator management, as collars are only a partial solution for reducing livestock losses.

Reducting costs to applicators through collar pools makes collaring large numbers of animals feasible, and thereby increases ability to take coyotes when large numbers of lambs and kids are on the range. Collar pools also reduce applicator reporting and agency regulatory burden as well.

Highly successful use of collars in areas of Texas with small ownerships, isolated herds of sheep or goats, and semi-urban characteristics indicates that LPCs could be useful for combating coyote predation on farm flocks in the eastern United States. The problem of collar damage from thorny shrubs and cactus thorns should be greatly reduced or nonexistent in eastern pastures. Furthermore, nontarget take should be virtually nonexistent in comparison with trapping coyotes. Perhaps the greatest drawback and liability regarding collar use in the eastern United States is the fate of lost collars. Neighbor landowners should be advised of collar use.

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