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The livestock protection collar (LP Collar) i: one of the few technical innovation: developed over the past 20 years fog managing coyote depredation on livestock Invented by Roy McBride in 1970, the LF Collar was researched at length by the Denver Wildlife Research Center (DWRC; and several cooperators before being approved for use with Compound 1080 by the U. S. Environmental Protection Agency (EPA) in 1985 (Burns et al. 1988, 1991; Connolly et al. 1978; Connolly 1980, 1985, 1990; Connolly and Burns 1990; Littauer 1984; Scrivner 1983; Scrivner and Wade 1986; TAMU 1983).

The original Compound 1080 LP Collar registration was obtained by the U.S. Department of the Interior, Fish and Wildlife Service (FWS), in July 1985. Later that year, Congress transferred the Animal Damage Control (ADC) program from FWS to the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). With this transfer, the LP collar registration passed to APHIS along with other vertebratd pesticide registrations. APHIS has continued to support the collar registration (#56228-22) as well as a related, manufacturing-use registration (#56228-26) for the technical Compound 1080 needed to make LP Collars.

LP Collars have not been used under the APHIS registration, which made no provision for training and certification of collar users. However, the APHIS registration makes it possible for individual states to establish applicator training and certification programs, and to authorize certified applicators to obtain and use collars. Five states (Texas, New Mexico, Montana, Wyoming, and South Dakota) have established such programs.

Collar use by state-certified, rancher applicators began in April 1988 in Texas and soon thereafter in Montana and New Mexico. Wyoming has trained a few applicators, but collars have not been used in that state except in a research project in 1990. Collars have not been used in South Dakota.

Texas Animal Damage Control (ADC) personnel began using LP Collars in 1990. These workers were trained and certified by the Texas Department of Agriculture, just like other LP Collar applicators in Texas.

Now that the LP Collar has been available for 5 years, it is appropriate to assess progress toward the implementation of this new technique in coyote depredation management. In this paper, I attempt such an assessment by summarizing and analyzing collar use from 1988 through 1992.

Use of livestock Protection Collars

Description of the LP Collar

The Compound 1080 LP Collar consists of a 2 x 6-inch, inflatable rubber bladder with

velcro neck straps to hold the bladder in place under the throat of a sheep or goat. Each collar contains 30 ml of 1080 solution (10 mg sodium fluoroacetate/ml), 15 ml in each of two toxicant compartments. All collars used to date have been manufactured by Ranchers Supply, Alpine, Texas. For detailed instructions on the collar and its use, see the EPA-approved technical bulletin (Connolly 1985).

Collar Use by Rancher Applicators

Approximately 3,000 LP Collars were distributed to state-certified, rancher applicators in 4 states from 1988 through 1991 (Table 1). Collars were placed on 2,753 sheep or goats for a total of approximately 111,700 collar use nights (1 use night = 1 collar on a sheep or goat for 1 night). Eighty-five percent of all collar use to date by state-certified rancher applicators occurred in Texas, and about 8 percent took place in New Mexico. Collars were used very little in Wyoming and Montana, and not at all in South Dakota.

Of the 2,753 collars put on livestock by rancher applicators, 133 collars (5 percent) were reported as punctured by coyotes. An additional 136 collars (5 percent) were accidentally punctured by vegetation, wire, or other objects, and 124 collars (5 percent) were missing (Table 1). The remaining 2,360 collars, about 85 percent of all collars placed on livestock, were removed with contents intact when collar use was terminated.

Coyotes attacked collared livestock and punctured 1 or more collars in approximately 39 percent of the cases where Texas ranchers applied LP Collars. applications resulted in no coyote punctures (Walton 1992b).

Rancher applicators in all 4 states recovered a total of 37 carcasses of coyotes thought to have been killed by LP Collars (Table 1). However, it is likely that many more than 37 coyotes were killed. Research experience has shown that virtually every coyote that punctures a collar succumbs to the toxicant, and that most wild coyotes killed by 1080 collars are not recovered (Connolly 1980). Therefore, I believe that the number of collars punctured by coyotes is the best index to the number of depredating coyotes killed by LP Collars. The large number of coyotes found in New Mexico, relative to number of collars punctured, probably reflects the relatively flat terrain and sparse vegetation in most New Mexico pastures where collars were used.

Rancher applicators reported no suspected *poisoning of* nontarget animals other than 1 collared lamb with a collar ruptured from an unknown cause (Walton 1992a). In addition, coyotes killed a number of collared sheep and goats without puncturing the collars. Such events occur frequently. They cannot be prevented because coyotes do not invariably attack sheep and goats with throat bites and, even when collared animals are attacked at the throat, the collars are sometimes missed (Connolly 1980, 1990; Connolly and Burns 1990; DWRC 1983; TAMU 1983; Littauer 1984).

Collar Use by Texas ADC Applicators

The Texas ADC program bought 925 LP Collars during Fiscal Years 1990 through 1992 (Table 2). ADC personnel put collars on 2,348 sheep or goats for a total of approximately 55,500 collar nights in 67

collar projects. The number of collars used in specific projects varied between 7 and 121, with an average of 35 collars per project (personal communication, J. Dorsett).

Of the 2,348 collars put on livestock by Texas ADC personnel, 46 collars (2 percent) were reported as punctured by coyotes, and 105 (4 percent) were punctured by vegetation, wire, or other objects. Thirty-six collars (2 percent) were missing (Table 2). The remaining 2,161 collars, about 92 percent of all collars placed on livestock, were removed with contents intact at the end of collar projects.

Coyotes attacked collared livestock and punctured 1 or more collars in 31 (46 percent) of the 67 LP Collar projects completed by Texas ADC personnel. Fifty-four percent of the projects resulted in no coyote punctures, usually because problem coyotes were removed by other methods that were used concurrently with collars or predation ceased when collars were applied (personal communication, J. Dorsett).

Six coyotes killed by LP Collars were recovered from Texas ADC collar use projects (Table 2). As discussed previously, however, it is likely that the number of coyotes actually killed was much higher. No nontarget poisonings were detected, other than 2 bobcats that appeared to have killed by attacking collared livestock and puncturing the collars. These depredating bobcats were target animals in the context of the damage situation, but were reported as nontargets because the bobcat is not listed as a target species on the EPA-approved LP

Total Collar Use Since Registration

As explained earlier in this paper, the Compound 1080 LP Collar was registered by EPA in 1985, but collars were not actually used under EPA-approved registrations until 1988. Most of the collar use activity that has occurred to date under these registrations is documented in Tables 1 and 2. These data indicate that, in total, about 4,000 LP Collars were distributed in the United States to rancher applicators through 1991 and ADC personnel through Fiscal Year 1992. Approximately 81 percent of these collars were purchased by users in Texas.

Similarly, the total amount of LP Collar use in the U. S. through 1991 (by ranchers) and Fiscal Year 1992 (by ADC personnel) was approximately 167,000 collar nights (Tables 1 and 2). Nearly 90 percent of this use

Amounts of Toxicant Used in LP Collars

LP Collars were placed on 5,101 sheep and goats in the U. S. through 1991 by ranchers and through Fiscal Year 1992 by ADC personnel (Tables 1 and 2). These collars contained a total of 1.53 kilograms (3.4 pounds) of sodium fluoroacetate (active ingredient). However, most of this toxicant was not released into the environment. Only 580 collars, 11 percent of the total number put on livestock, were punctured or missing. Concern for environmental impacts, including hazards to man and other nontarget animals, focuses on the toxicant in punctured and missing collars.

The 580 punctured and missing collars contained 174 grams (0.4 pounds) of sodium fluoroacetate (Table 3). This is an extremely small amount of toxicant, compared to the

quantities of other hazardous chemicals such as methyl bromide (10.7 million pounds) or aldicarb (2.3 million pounds) used annually in the U. S. (Gianessi 1986).

In these computations (Table 3), I assumed that the total contents of each punctured or missing collar were released into the environment. Such an assumption overstates the actual amount of toxicant released because many collars have only I of the 2 toxicant reservoirs punctured. When only 1 reservoir is punctured, only half of the total collar contents are released. Collar users usually do not record the amount of toxicant lost from each punctured collar. Therefore, the most expedient approach for estimating total amounts of toxicant used is to assume that the entire contents of each punctured or missing collar were released. The actual amounts of toxicant released from LP Collars were somewhat lower than the estimates reported in Table 3.

Risks of Operational Use vs. Research Use of LP Collars

An important risk assessment question for the LP Collar is whether or not the conclusions from research studies are adequate to assess the risks of practical, operational use of this technique. The answer to this question could be negative if rates of, collar loss or accidental puncture were substantially higher in operational use. I have addressed this issue by comparing rates of collar puncture, collar loss, and toxicant use recorded by ranchers and ADC specialists to similar rates from earlier research studies (Table 4).

This analysis indicates that the amounts of toxicant released or lost as a result of LP Collar use by ranchers or ADC personnel do not differ materially from the amounts recorded in research studies. There were apparent differences among some rates; in particular, researchers recorded a higher frequency of missing collars from Angora goats in Texas than from sheep in Idaho and Montana. In the bottom line, however, the overall rate of toxicant release was virtually constant for all kinds of collar applications. The lowest rate (0.9 grams of active ingredient per 1000 collar nights) was seen in research trials on sheep in Montana and Idaho, whereas the highest rate (1.1 grams per 1000 collar nights) was recorded for state-certified rancher applicators (all states; both sheep and goats). From a statistical standpoint, the small, observed difference between these rates probably is not significant.

Such comparisons are valuable and relevant because the research studies were conducted under controlled field *conditions with* more intensive *monitoring than* would be reasonably expected in practical applications by ranchers or ADC specialists. Experience to date, as summarized in Table 4, does not show the potential risks of operational LP Collar use to differ materially from the risks of controlled, research use.

Conclusions

Early experience with the Compound 1080 LP Collar indicated that this technique was a welcome addition to existing technology for protecting sheep and goats from coyote predation. Compared to other methods of coyote removal, the collar was demonstrably selective for depredating individuals and could take some depredating coyotes that seemed to elude other capture techniques. Moreover, the collar appeared not to pose unmanageable risks to humans, nontarget

wildlife, or the environment (Connolly 1980).

These findings formed the basis for the original, September 1981 application for EPA registration of the 1080 collar. Subsequent research sustained early findings (DWRC 1983, TAMU 1983, Littauer 1984), and the collar ultimately was registered for use by specially certified LP Collar applicators. The EPA registration mandated detailed record keeping and monitoring, which continued to verify that the collar was a useful and safe technique for coyote depredation control (Walton 1990, 1992a). EPA-imposed record keeping, monitoring, and other registration requirements currently are the major obstacles to wider acceptance and use of the LP Collar. Given the positive record to date, it would be appropriate now for EPA, APHIS and other interested parties to increase their efforts to reduce the regulatory burden.

APHIS is continuing to support this registration, increase its utility, and expand its use by ADC personnel in states other than Texas. In October 1992, EPA issued a data call-in for 14 studies to be completed by October 1993 to support reregistration of the technical product (Compound 1080) used in LP Collars. APHI$ will complete these studies on schedule.

In addition, the DWRC has completed efficacy testing of a large collar for use on sheep and goats above 50 pounds in weight, and APHIS has recently asked EPA to approve revised labelling that will provide for the use of this large collar. ADC personnel in New Mexico are preparing to use LP Collars this year, and are exploring the use of this technique with regulatory agencies in several other states including Ohio, Utah, and California.

I believe that there will continue to be a need for lethal methods in coyote damage control, and that these methods must be as selective as possible. The LP Collar offers the ultimate in selectivity. Therefore, in the next 5 to 10 years I hope to see the collar become established as an integral part of private and governmental predator management programs.

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Table 1. Livestock protection collar use by state-certified applicators, 1988-1991'.

	Wyoming	Montana	New Mexico	Texas	Total
Collars distributed	122	185	424	2,231	2,962
Collars put on livestock	122	206	356	2,069	2,753
Collar use nights (1000s)	4.4	4.1	8.4	94.8	111.7
Collars punctured or missing	12	15	29	337	393
(Punctured by coyotes)	(0)	(7)	(24)	(102)	(133)
(Punctured other)	(9)	(2)	(1)	(124)	(136)
(Missing)	(3)	(6)	(4)	(111)	(124)
Coyotes found	0	0	23	14	37

'Unpublished data recorded by State Department of Agriculture personnel in each state. Statistics for 1992 were not available from all states.

Table 2. Texas Animal Damage Control (ADC) use of livestock protection collars, Fiscal Years 1990-1992.

	FY90	FY91	FY92	Total
Collars bought	300	625	0	925
Collars put on livestock	466	906	976	2,348
Collar use nights (1000s)	8.9	23.1	23.5	55.5
Collars punctured or missing	26	75	86	187
(Punctured by coyotes)	(7)	(25)	(14)	(46)
(Punctured other)	(12)	(33)	(60)	(105)
(Missing)	(7)	(17)	(12)	(36)
Coyotes found	2	3	1	6

Table 3. Amounts of Compound 1080 (active ingredient) used in livestock protection collars'.

_	Collars Used (Number)	Collarb Contents (Liters)	1080b (AI) (Grams)
Wyoming, 1988-91	12	0.36	3.6
Montana, 1988-91	15	0.45	4.5
New Mexico, 1988-91	29	0.87	8.7
Texas, Private Applicators, 1988-91	337	10.11	101.1
Texas, ADC Program, 1990-92	187	5.61	56.1
Totals	580	17.40	174.0

'"Amounts used" are defined as amounts contained in collars that were punctured or missing.

beach collar contained 30 milliliters of 1% (10 mg/ml) toxicant solution. "AI" means active ingredient.

Table 4. Comparison of livestock protection collar use by ranchers, Texas ADC, and research personnel.

	Ranchers 1988-91'	Texas ADC 1990-92b	Research 1978-83 Goats (TX)`(ID/MT)d	Sheep
Collar use nights (1000s)	111.7	55.5	23.4	14.3
Number/1000 collar nights:				
Coyote punctures	1.2	0.8	1.7	2.2
Other punctures	1.2	1.9	0.5	0.6
Missing collars	1 1	0.6	1.2	0.1
Toxicant used/1000 collar nights (grams A.I.)`	1.1	1.0	1.0	0.9

'This report, Tables I and 3.

bThis report, Table 2 and 3.

'DWRC (1983:Tablpe 12).

dConnolly & Burns (1990:Table 5).

'"Toxicant used" includes contents of all punctured and missing collars. Each collar contained 0.3g of sodium fluoroacetate (active ingredient).