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ELECTRONIC FRIGHTENING DEVICES FOR REDUCING COYOTE PREDATION ON DOMESTIC SHEEP: EFFICACY UNDER RANGE CONDITIONS AND OPERATIONAL USE

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ABSTRACT: A portable 12-v battery-operated coyote frightening device was developed for reducing coyote predation on sheep and evaluated on fenced pasture farm flock operations (1979-1982). In 1986, the final experimental model consisted of a PVC case, a timer, a blinking strobe light, and a warbling type siren that was activated for 7-10 seconds at about 6-7 minute intervals throughout the night. The devices were generally suspended about 2 m above the ground and were activated at dusk by a photocell and turned off about 2 hours after dawn by a timer. Here we report tests on high mountain summer sheep ranges (1982-1987), evaluation of the devices by ADC and external cooperators (1987-1990), and efforts to make the devices commercially available.

On high mountain summer range, the devices reduced sheep losses on average about 60% with a mean dollar value savings of lambs of over $2,400 per sheep band. In the operational evaluations, 84% of our cooperators indicated that coyote predation on lambs was lowered when devices were used. Manufacture and sale of the device under the name "Electronic Guard" was begun in 1991 by the ADC Program's Pocatello Supply Depot.

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INTRODUCTION

Two to three million head of sheep, cattle, and goats are grazed annually on National Forest and National Grasslands allotments administered by the U.S. Forest Service (USFS). Predation losses on these areas can be significant; for example, 60% of all sheep deaths on National Forest ranges have been attributed to coyotes (*Canis latrans*) and other predators (Jones and Black 1983).

Options for controlling coyote predation on western high mountain summer sheep ranges are limited. Many allotments are in brush-covered or dense stands of timber in remote and rugged areas where access is usually limited to travel by foot or horseback. These conditions, along with increasing recreational use of USFS-administered lands during the summer months, make the control methods used to protect sheep in privately owned fenced pasture operations generally unsuitable for high mountain summer sheep ranges.

Bomford and O'Brien (1990) have reviewed the literature dealing with evaluation of devices using sound to control animal damage. They believed that virtually all tests reported were inconclusive because of poor experimental design; however, they clearly misinterpreted the sequential design used in our pasture tests (Linhart et al. 1984), suggesting that seasonal variations in patterns of predation could explain our results. They indicated that the few tests that did meet their criteria showed that at best frightening techniques provided only short-term damage reduction. Similarly, Koehler et al. (1990) concluded that various frightening stimuli were appropriate for situations requiring only a few days or weeks of protection. We disagree with these generalizations as they apply to coyote predation on sheep.

Our earlier field tests of electronic frightening devices for protecting farm flock sheep confined to fenced pastures showed that devices emitting light and sound stimuli can abruptly stop patterns of coyote predation for varying time periods and can substantially reduce losses (Linhart 1984, Linhart et al. 1984). We now report on subsequent tests of similar devices for protecting herded sheep on high mountain summer sheep range, their effectiveness when used operationally by ADC personnel and other cooperators, and efforts to make the devices commercially available to producers.

MATERIALS AND METHODS

Study Sites and Sheep Management Practices

We conducted field trials during summer, 1982-1987, in 3 different geographic areas: the Gunnison National Forest and an adjacent Bureau of Land Management (BLM) grazing allotment in south central Colorado (1982), the Routt and White River National Forests in northwestern Colorado (1983-1986), and the Bridger-Teton National Forest in southwestern Wyoming (1987). The 15 grazing allotments selected as test sites varied from about 1,175-3,400 ha in size and were located at 2,380-3,780 m elevation.

Our initial pilot test in the Gunnison area involved a band of about 1,000 ewes and their lambs. These sheep were grazed on a BLM allotment in the late spring and early summer and then herded to a higher USFS allotment in early July where they stayed until mid-September. The BLM site consisted of open grass, forbs, and sagebrush areas with aspens in the draws and canyons; it was accessible by 4-wheel drive vehicle. Much of the USFS allotment was above timberline and consisted of grasses, forbs, and extensive stands of 1-2m high subalpine willow. Fir and spruce were the most common tree species below timberline with some open meadows and aspens present in stream bottoms and canyons. The USFS

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area could be entered only on foot or by horseback.

We ran an additional 11 tests in or adjacent to the Routt and White River National Forests on the White and Williams Fork River drainages. All allotments were located below timberline (2,440-3,050 m) where the topography and vegetation were generally comprised of timbered mountainous terrain having deeply cut drainages in which aspen, spruce, and fir were the major tree species. Open parks of varying size were scattered throughout the grazing allotments. Horses were usually required to reach herders' camps and sheep bedgrounds. One of the 11 test allotments in this area was located on lower, privately leased land adjacent to the National Forest where the predominant vegetation was grasses, forbs, serviceberry, and scrub oak. In 1987, we attempted an additional 3 tests on allotments in southwestern Wyoming in the Bridger-Teton National Forest where the topography and vegetation were similar to that described for northwestern Colorado. For reasons later discussed, these last 3 tests were not completed and we terminated the study with 12 rather than the 15 test sites initially envisioned.

Sheep management was generally similar on all test sites. Adult ewes and lambs (generally 1,000 ewes and their lambs) were moved to grazing allotments in early July and removed from mid- to late September. Herders (usually 1) stayed in camp wagons when sheep were grazed and bedded close to secondary roads. Otherwise, they lived in tents and all supplies were carried into camps by pack horse. Sheep producers or their camp tenders visited herders at least weekly, gave them instructions, provided them with supplies and salt for the sheep, and checked on problems such as lost sheep and mortality due to predation, poisonous plants, or other causes. Sheep locations within the allotments were changed every few days, or more often, depending upon local conditions and USFS requirements. Herder camps were usually located 0.75-3.0 km from sheep bedgrounds and infrequently as close as 200-500 m. Each band of sheep was herded daily from its bedground to a preselected grazing area where it remained until late afternoon when the herder returned and gathered and moved the band to its bedground. All herders placed salt on bedgrounds to concentrate sheep within the area, normally about 200 m in diameter or 200-400 m along a ridgetop. All herders had extensive experience herding sheep and all generally followed our instructions on the use and placement of frightening devices. Without exception, herders were able to determine if their sheep had died from non-predator related causes or from predation, and if predator kills were by coyotes or black bears (lion predation was not a problem on our test sites). The principal sources of variation we noted among herders related to interest in testing the devices, familiarity with the allotments in which they worked, attentiveness to their sheep, and practices of establishing small, discrete bedground sites or allowing sheep to bed over larger areas.

To ensure that we used only active predation situations as test sites, we set a criterion of at least 5 coyote kills during the 2 weeks immediately prior to device deployment. We asked cooperating sheep producers to suspend all routine coyote control efforts throughout the test period, except the use of our frightening devices. We considered this a necessary procedure so that any changes in predation rates could be attributed to our frightening devices and not to conventional control methods. Producer and herder efforts to reduce coyote numbers on their allotments were minimal. USFS restrictions on the types of control methods that could be used and the rugged, generally inaccessible allotments selected as test sites precluded any intensive depredation control efforts by ADC specialists on or adjacent to allotments. These conditions resulted in the removal of only a few coyotes on or adjacent to our test allotments either prior to or during the test period. Since varying levels of coyote predation or coyote sign or vocalizations were always present during the time devices were in use, we believe that routine predator control activities did not greatly influence either sheep mortality rates or the results of our field trials. Because frightening devices were experimental and of unknown effectiveness under range conditions, we agreed to reimburse cooperating sheep producers for confirmed coyote kills, as recorded by their herders, at fair market price.

In summer 1987, we attempted to conduct 3 additional tests on summer sheep range in the Bridger-Teton National Forest in Wyoming. These 3 tests were intended to complete a planned series of 15 field trials on summer open range situations to complement our earlier fenced pasture studies. However, we were unable to complete these last 3 tests. On 1 of the 3 allotments, 4 frightening devices were reportedly used for the first 25 nights of the approximately 10-week grazing period. However, our biweekly measurements of battery discharge showed that they had been only used 15 nights, at which time the herder decided that the devices were attracting rather than frightening coyotes and turned them off. The herder on the second allotment reported that the devices had been used for 4 weeks, but our measurement of battery discharge rates indicated that they had been turned off after the first 2 weeks of use. The herder on the third area apparently used the devices during the entire 10-week period; however, it became evident that all 3 herders had discussed device use and were convinced that they were responsible for higher than "normal" losses. Furthermore, we were unable to obtain data from herders and other sources that we felt were necessary for a valid assessment of their effectiveness. For the above reasons we excluded the 1987 field trials from our analysis of results.

Frightening Devices and Deployment

We modified the design of our frightening device several times during the 5-year test period to improve their effectiveness and packaging. In 1982, we used the devices and electronic circuitry previously described in detail by Linhart et al. (1984). The second-generation (1983) and third-generation frightening devices (1984-85) were smaller, more portable, and were contained in surplus military boxes. Light entering a plexiglass port or window energized a photocell that activated the timer, switching the devices on at dusk and off in early morning. Two different types of devices were used. The first held a 110-dB warbling-type siren drawing 750 mA. The second contained both a 70,000 CP strobe light drawing 200 mA and a high frequency (HF) 123-dB electronic alarm drawing 170 mA. The HF alarm was added in 1984 because earlier observations suggested that coyote kills were found more frequently near strobe light units. The addition of the HF sound alarm, it was reasoned, would cause coyotes to more readily detect the strobe light, particularly in timbered areas. Timers activated the devices for about 7-10 seconds at 6-7 minute intervals. Four devices (2 of each type) were used on or adjacent to each bedground. Four devices per

bedground were also used in 1986; however, 2 were packaged in ammunition boxes as described, the other 2 were packaged in a cylindrical section of white PVC pipe capped at both ends (designated as fifth-generation). The PVC-housed device contained both a 123-db warbling siren recessed into 1 cap and a strobe light affixed to the other cap with a combined power requirement of about 950 mA. A Duracell[2] 12-vDC industrial-type battery with screw-type terminals (Model No. 109260) in the PVC package ran the device for at least 60 days before battery replacement was needed. This battery was also used to power the other device configurations used after 1983. We used the PVC configuration exclusively for the 1987 field trials and for the 3-year period (1987-89) when ADC personnel and other cooperators evaluated the devices. The PVC device measured 16.5 x 47.0 cm and weighed 4.8kg. This design was subsequently used for commercial production (Fig. 1).

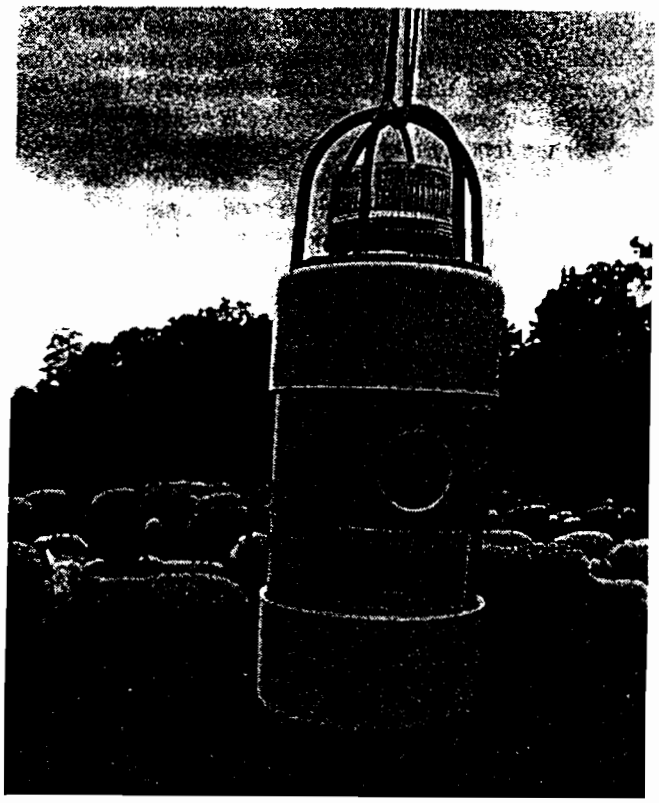

Figure 1. Portable electronic frightening device evaluated for protecting sheep from coyote predation.

High Mountain Summer Range Tests

We developed a routine procedure for placing devices on bedgrounds and for instructing herders on their use. Devices were suspended from tree limbs or tripods approximately 2.0-2.5 m above ground level. Generally, 1 device was placed in the middle of the bedground and the other 3 at the edges or 50-150 m distant. Devices were deployed on hills or ridge tops, where possible, or at the edge of clearings toward the direction from which coyotes were likely to approach the bedground. We routinely visited each test site every 2 weeks, usually on horseback, talked with the herder, checked devices to ensure that they were located and functioning properly, and made any necessary repairs. We also completed a data sheet on which we recorded information about the herders' sheep management practices, the location and status of devices, evidence of predators and predator signs, weather, and whether the herder was recording events on the calendar provided.

Operational Use Of Devices

In winter 1987, we began contacting ADC personnel and state or university wildlife extension biologists to determine interest in evaluating frightening devices. Interested cooperators were sent information on the devices, results of our prior tests, 4-page instructions on how to use the devices, and a 2-page questionnaire to be completed for each damage situation where the devices were tried. The questionnaire asked for information about site location, numbers of sheep and type of operation, sheep predation before device use, dates of device use, how placed, when checked, faulty operation of devices, and predation losses during the time devices were deployed. We usually provided devices to cooperating personnel in early spring so that field tests could be conducted when coyote depredations were most severe, generally from April-May through September. We provided 24, 40, and 44 devices during 1987, 1988, and 1989, respectively, to cooperators in 10 widely scattered areas of the country (CA, CO, GA, KS, ID, NH, NY, OH, WA, WY). Several cooperators used the devices during only 1 season; others conducted seasonal tests during all 3 years.

Data Analysis

High mountain summer sheep range tests were evaluated by comparing producer-estimated lamb losses to coyotes on allotments the summer prior to device use with losses to coyotes that occurred on the same allotments the following summer when devices were used. For baseline data we used producer records, their sheep counts obtained prior to entering the allotments, lamb counts at the time of their shipment to market, the producer's personal knowledge, and dead sheep found and reported to producers by their herders. At our direction, each herder maintained a daily calendar at camp on which was recorded the number of lambs and ewes he found dead and whether death was due to coyote or bear predation or non-predator related causes such as sickness or poisonous plants. We also took digital voltage readings from all batteries every 2 weeks to determine the rate of discharge under field use. These data enabled us to determine whether devices were used by herders continuously, intermittently, or not at all. We used only lamb losses as a measure of device effectiveness because loss of adult ewes was normally too low to be indicative of differing predation levels. Satisfactory tests were conducted on 8 different allotments; replicate tests of the devices were again run on 4 of the same areas on alternate years resulting in a total of 12 tests during the period 1982-1986. We determined device effectiveness in 2 ways: (1) by calculating the percent differences in losses with and without devices in use, and (2) by calculating the dollar value of lambs lost or saved by devices using the average $55 lamb market price paid producers in 1983 and 1984.

We were unable to quantify the effectiveness of the devices when used operationally, either by percent reduction in lamb losses or by dollars saved or lost during tests. This

[2]The use of trade names for identification does not imply government endorsement

problem resulted from the different time periods or seasons during which devices were used, differing sheep management practices, varying levels of coyote damage control prior to or concurrent with device use, and cooperators that reported sheep losses in different ways (i.e., as a percent of total sheep, or actual numbers of sheep lost). We therefore elected to use cooperator response as to whether or not losses were lower, the same, or higher when devices were deployed. A similar type of analysis of nonlethal damage control methods has been previously used to evaluate the effectiveness of electric fencing (Linhart et al. 1982, Nass and Theade 1988) and livestock guarding dogs (Coppinger et al. 1983, Green et al. 1984).

RESULTS

Frightening Device Performance

We were generally satisfied with the performance of frightening devices during field trials but made several modifications in response to mechanical or electronic problems. For example, the devices used in summer 1982 had the light and siren fastened to the exterior of the ammunition box and could be broken or cracked when knocked over or transported by herders. We recessed the siren horn into the box and used a lower profile strobelight to resolve this problem. Rain entering an upturned siren caused it to malfunction, and tripods used to suspend devices were occasionally knocked over by sheep. In 1983, the 12-v battery model we used discharged rapidly and devices would not operate over the time period we desired. Changing to a different model industrial battery (Duracell No. 109260) that powered the devices for at least 60 days resolved the problem. In 1982-83, half of the devices triggered at 7min and half at 13 min. The 1984 devices were modified so that all timers triggered at approximately 7-min intervals. Other modifications after 1984 included an exterior on-off switch, a wire guard for the strobe light, foam padding for internal components, interchangeable timers with electronic components embedded in potting material, and more weather-resistant seals to prevent entry of rainwater. The use of PVC-packaged devices starting in 1986 also improved device performance, as did placing both a siren and strobe on all units. Three instances of malfunctioning timers and 2 occasions of herder misuse resulting in rain entering devices were noted in 1985-86. During the first 2 years (1987-1988) when cooperators tested the devices, we received several reports (9 of 91) of malfunctions. However, none were reported during the last year (1989), suggesting that nearly all defects associated with experimental models had been corrected.

High Mountain Summer Range Tests

The percent of all lambs lost to coyotes on all 12 areas the summer prior to device use, based on a mean loss of 74.8 lambs per band, was 6.6%. This was compared with a 2.7% loss (30.2 lambs per band) during the summer when devices

Table 1. Lamb numbers and estimated lamb losses to coyotes the summer prior to test compared to the summer of frightening device use on U.S. Forest Service grazing allotments in western Colorado, 1982-1987.

	Estimated losses to coyotes summer prior to test		Estimated losses to coyotes summer of test		% reduction in
Allotment	No. lambs	% loss	No. lambs	% loss[a]	lamb losses
A. Deer Lakes	455	5.7	1005	2.3	59.6
B. Rough Creek	1105	10.7	1062	6.0	43.9
C. Dunckley Flat Tops	1102	10.3	1406	1.8	82.5
D. Indian Run	1380	4.4	1218	2.3	47.7
E. Moon Lease	1400	0.9	1941	0.05	94.5
F. Saw Mill	1310	5.6	533	1.9	66.1
G. Sleepy Cat	1200	5.2	900	1.3	75.0
H. Wet Park	1350	6.8	862	0.5	92.6
I. Rough Creek 2[d]	799	3.8	1033	4.9	0[b]
J. Indian Run 2[d]	1072	3.5	1277	8.7	0[c]
K. Saw Mill 2[d]	850	7.1	718	2.4	66.2
L. Sleepy Cat 2[d]	1490	14.1	1630	0.9	93.6
TOTAL	13,513		13,585		
MEAN		6.6		2.7	59.6

[a]Percent losses were calculated using only kills that occurred after devices were deployed.
[b]Lamb losses increased 22.4% summer of test.
[c]Lamb losses increased 59.8% summer of test.
[d]Replicated test

Table 2. Calculated dollar savings or loss associated with 12 frightening device tests based on estimated lamb losses to coyotes the summer prior to test compared to summer frightening devices were used, Western Colorado 1982-1987.

	Summer prior to test		Summer of test		Difference		
Allotment	No. of lambs	Percent lost	No. of lambs	Percent lost	Percent difference	No. lambs	Value of lambs ($)[a]
A	455	5.7	1005	2.3	3.4	34	1870
B	1105	10.7	1062	6.0	4.7	50	2750
C	1102	10.3	1406	1.8	8.5	120	6600
D	1380	4.4	1218	2.3	2.1	26	1430
E	1400	0.9	1941	0.05	0.8	16	880
F	1310	5.6	533	1.9	3.7	20	1100
G	1200	5.2	900	1.3	3.9	35	1925
H	1350	6.8	862	0.5	6.3	54	2970
I	799	3.8	1033	4.9	1.1[b]	11	-605
J	1072	3.5	1277	8.7	5.2[c]	66	-3630
K	850	7.1	718	2.4	4.7	34	1870
L	1490	14.1	1630	0.9	13.2	215	11825
TOTAL	13,513		13,585				
MEAN		6.6		2.7	3.9	44	2415

[a]At $55/lamb based on average 1983 and 1984 market prices.
[b]11 more lambs lost summer devices were used.
[c]60 more lambs lost summer devices were used.

were used. In 10 of the 12 tests, losses were an average of 73.2% less when devices were used; losses were an average of 46.0% higher the summer of device deployment for the remaining 2 tests. The 59.6% reduction in lamb losses with devices in use on all 12 areas resulted in a mean savings of 44.6 lambs per band valued at over $2,400 (Tables 1 and 2).

Consistent with our observations in pasture tests, frightening devices did not appear to adversely affect or alter the behavior of domestic sheep. We never observed sheep that were frightened or displayed unusual or obvious avoidance behavior, even when devices were placed in the center of bedgrounds. Similarly, cooperating herders never indicated to us that sheep behavior was adversely affected. All the allotments on which we conducted tests contained both elk and mule deer, and researchers and cooperating herders frequently saw both species or their signs (tracks, pellets) or heard elk vocalizations near devices or in the vicinity of bedgrounds. These observations suggested that both species accommodated to the devices and that their geographic displacement did not occur.

Operational Use of Devices

A total of 47 completed questionnaires were received from cooperators over the 3-year period of external evaluation (1987-89). Of these, 42 provided us with useful information on device use to protect sheep from coyote predation. Cooperators used the devices on areas that varied widely in size (0.4-810 ha). Excluding a few extremely large areas (4/42), the mean size of areas was about 28 ha. Eighty-one percent of the reports (34/42) involved sheep in fenced pastures; 59% (19/32) of the tests were aimed at protecting bedgrounds within fenced pastures. All use to protect range sheep (8/42) was restricted to bedground sites. Thirty-six percent (15/42) of the reports were from states east of the Mississippi River.

From 1 to 4 devices were used for each test. Our written instructions recommended that at least 2 devices per site be used; however, 66% of the test situations involved only 1 device per test site. This pattern of usage was probably a result of field personnel accustomed to previous use of single propane exploders for depredation control. As explained in our earlier reports (Linhart 1984, Linhart et al. 1984), we believe these devices function to delay coyote habituation to disturbance stimuli (i.e., sound and light). Their advantage over singly used repetitive devices such as exploders is only achieved when multiple devices are used. Variations in activation of photocells and cycling of timers produce light and sound stimuli in a varying, irregular pattern that coyotes appear to avoid. This effect is lost if single devices are used.

We reviewed the comments of ADC field personnel and other cooperators as to whether the devices stopped or reduced sheep losses. Ten of 42 respondents either didn't comment (3) or were unable to determine if they were effective (7). Twenty-seven of the remaining 32 (84%) stated that losses were reduced for a sustained period of time, 3 said that loss reduction was for only a short period of time, 1 that it remained unchanged, and 1 that it increased. We were unable to determine any relationships between the use of frightening devices or alternate predation control methods and extent of sheep losses because of wide variation in the information available from test sites.

DISCUSSION

A number of our colleagues have speculated that use of nonlethal methods will cause coyotes to shift their activity patterns and to begin preying upon nearby unprotected sheep. However, strong evidence exists in the technical literature that coyotes have a long lasting fidelity to established home ranges. Each time we visited a test site we asked the herder if, since our last visit, he had heard coyotes howling, or had seen coyotes or coyote tracks or droppings. In all instances, herders told us that coyotes were present on their areas. These observations, as well as ongoing coyote predation on our test areas, strongly suggest that use of frightening devices will not result in higher levels of predation on adjacent bands of sheep. We believe that coyotes merely avoided the immediate vicinity of devices but continued to frequent the general area. However, particularly if use of such devices becomes common, the question of how coyote activity and predation patterns are affected might be a subject for future research.

Our field trials showed that, on average, producers lost far fewer lambs to coyotes when devices were used and that the dollar savings were substantial. However, our observations of coyote sign, herders' comments, and their records of sheep losses suggested that coyote activity continued in the presence of the devices and that predation continued, but at a substantially lower rate. Observations of the locations of sheep kills suggested that at least some of this continuing predation occurred during the daytime in areas where sheep were dispersed and grazing near brushy edges or bottoms. We believe coyotes were simply wary of approaching bedgrounds where devices were in use and that this behavior modification resulted in lowered predation. In earlier pasture tests (Linhart et al. 1984), more discrete patterns of cessation of predation were evident because sheep were better protected and less vulnerable to coyote predation during daylight hours.

Too few data were available to determine if the devices were a deterrent to black bears that prey upon sheep. Mountain lions were not a problem on our study areas; however, limited use of the devices and observations by an ADC District Supervisor in Nevada (M. Anderson, pers. commun.) suggested that activity patterns of lions were only minimally affected by the devices.

The data from this study, as well as that we previously reported (Linhart et al. 1984, Linhart 1984), indicated that frightening devices can help to reduce sheep losses to coyotes. However, as with all other damage control techniques, some situations occur where they are not effective. In most depredations control problems, management specialists or producers are in the best position to determine the most practical and efficacious control methods because of their local experience. Effective action frequently involves integrated use of a variety of control tools best suited for local livestock management practices and situations. Our research suggests that frightening devices should be included in the array of damage control techniques available.

PRODUCT DEVELOPMENT

Upon completion of the cooperator evaluation of the devices, we attempted to find a commercial manufacturer to produce them for sale to ADC, other wildlife damage control specialists, and sheep producers. The DWRC sent out more than 30 information packets to all known manufacturers and vendors of predator-related ADC products. The packet consisted of technical publications and reports, instructions to users, and a list of components and their cost. Also, a notice of the availability of this material was prepared and published in the Commerce Business Daily (U.S. Department of Commerce). However, these efforts were not successful in attracting a commercial manufacturer to make and sell the devices. The design, manufacture, and marketing of a new product is associated with many risks. Prospects for mass production, reliability of component sources, manufacturing processes, and market information were all unknown. The reluctance of the private sector to develop this product was understandable.

An effort was then begun by the ADC Program to arrange manufacture and marketing through the Pocatello Supply Depot (PSD). After a delay of nearly a year, a commercial engineering firm accepted a contract to develop a prototype, but their minimum required order (500 units) and proposed price ($500) was prohibitive. Furthermore, the prototype produced did not meet standards. The PSD decided to seek suppliers and subcontractors for the components, to assemble the devices at PSD to ensure acceptable quality, and to fabricate them only on a demand basis. Under such an arrangement, the device could be manufactured and sold at cost, lowering the price per unit to $225.

PSD used the specifications for the research prototypes to identify suppliers for the components. An international distributor of irrigation pipe located in Preston, Idaho, agreed to manufacture the PVC bodies and mount the strobe light in the caps. They also helped in mass production designs for the PVC materials, O-rings, and sealing problems associated with this component. An electronics engineering/manufacturing firm in Salt Lake City, Utah, developed a mass production timer prototype and is now producing that component. The other components of the device were available from normal suppliers of standard parts and materials.

The PSD also attempted to determine potential users of the device and the probable market size with the help of the ADC Operational Support Staff in Hyattsville, Maryland, and the USDA Extension Service in Washington, DC. It was no surprise that only about 65 commitments to purchase the initial units were received. PSD began building the first 100 devices in March 1991. Production was limited initially to identify any problems with the first models. In these first units, the cap-to-body seal was too tight making access to the battery compartment difficult. The strobes, sirens, and timers initially obtained from commercial sources performed inconsistently. These problems were corrected and the PSD has now produced 100 improved models, of which about half have been sold nationwide under the name "Electronic Guard."

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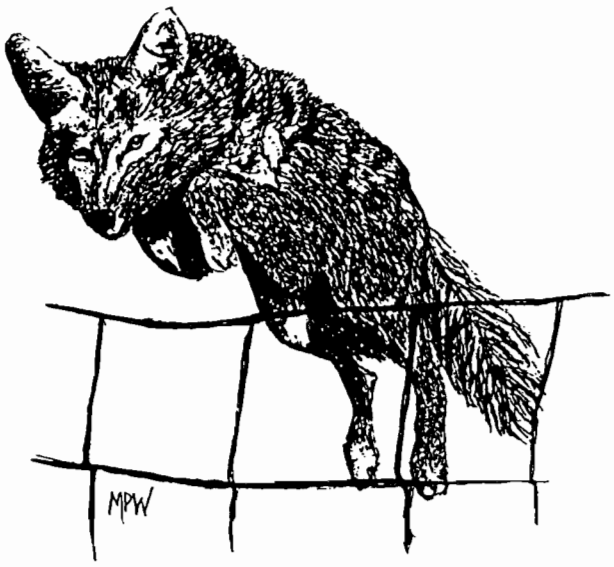
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