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Abstract. Lethal control techniques for controlling coyotes (*Canis latrans*) are often maligned as a means for resolving coyote depredations on domestic livestock. With the exception of theh Livestock Protection Collar (LPC), lethal control methods (e.g., foot-hold traps and neck snares) lack the ability to specifically remove those coyotes actually preying upon livestock. The LPC capitalizes on attack behavior of coyotes to remove offending individuals. Although currently registered for use in 5 states, LPCs have been used routinely only in Texas. Success with LPCs involves an understanding of coyote behavior and proper targeting of collared livestock. LPCs have been used in Texas to successfully remove problem coyotes that have learned to evade other forms of control, and this may be their niche in an arsenal of lethal and nonlethal control alternatives. Herein, I review the development and testing of LPCs and current use in Texas.

Arguments surrounding coyotes often involve the control methods available for resolving damage incidents. Over the last 20 years, public concerns over the use of toxicants and other forms of lethal control have increased greatly. Proponents of lethal techniques such as foothold traps or neck snares criticize these methods as nonselective, i e , as likely to take nontarget animals as coyotes.

The ideal control method is one that would combine effectiveness, safety, selectivity, cost-effectiveness, social acceptability and ease of use (Sterner and Shumake 1978). Given the range of habitats and damage situations that characterize coyotes, these criteria will likely never be achieved However, the Livestock Protection Collar (LPC) may come as close as any technique currently available.

History of LPC

The LPC was invented by Roy McBride in the early 1970s and is currently registered for use with the U S. Enivornmental Protection Agency under McBride's company (Rancher's Supply, Inc , Alpine, TX) EPA registration was preceded by intensive research by the Denver Wildlife Research Center to assess the efficacy of LPCs as a predator management tool (Burns et al 1984, Connolly 1985).

McBride's orginal prototype of the LPC stemmed from his observations that most coyotes attack sheep and goats at the throat, just behind the mandible In its current form ("small size"), the LPC consists of of 2 rubber bladders each of which contains 15 ml of a 1% solution of sodium fluoroacetate (Compound 1080). A "large size" version contains 30 ml in each bladder of a 0.5% solution of 1080 Only the small version is registered currently for use in the U.S., but registration is being sought for the larger version as well. A pink (Rhodomine B) [early versions] or yellow (Tartrazine) dye is contained in the solution as a contamination indicator. The LPC is held in place with Velcro straps for attachment beneath the throat and just behind the jaw of a lamb or kid goat (USDA-APHIS 1990) (Fig. 1)

The LPC capitalizes on the killing behavior of coyotes attacking sheep and goats Coyotes typically attack sheep-sized animals by biting them under the neck and crushing the trachea, causing suffocation (Connolly et al. 1976). Coyotes that exhibit such attack behavior ruptured one or both bladders of the LPC in at least 75% of their attacks on sheep under pen-monitored trials (Connolly 1985) In doing so, the attacking coyote receives a lethal oral dose of 1080 Dosed coyotes die from 2 to 7 hours later (average about 4 hours)

Figure 1 Diagram of Livestock Protection Collars in use on sheep (left) and goat (from TDA 1994)

As of 1989, LPCs were registered for use by state-certified applicators in Texas, Montana, Wyoming, South Dakota and New Mexico. Of these, most of the field use has been conducted in Texas (Walton 1990). Training materials for certification to use LP Collars are available that address user certifcation, application and hazard information (Wade 1985, TAEX 1990, TDA 1994). Use of LPCs is restricted in extreme south Texas due to the possible presence of 2 species of end-angered felines.

Although users and agencies have been slow to adopt the LPC and use it widely, LPCs have gained immediate and widespread use in several foreign countries in Central and South America and Africa (R. McBride, Rancher's Supply, Inc., pers. commun.).

Advantages of LPCs

The LPC is the most selective control method available for removing those coyotes that are actually attacking sheep and goats This latter ability illustrates the LPC's specificity, a characteristic unaddressed by other techniques but important in determining public acceptance of control alternatives (Cain et al 1972, USFWS 1978).

The notion that a coyote population contains both "killer" and "nonkiller" coyotes (relative to livestock) has been espoused and has at least some empirical support (Connolly et al. 1976, USFWS 1978). Eight of 11 captive-reared coyotes killed sheep (Connolly et al. 1976), and 18 of 19 pen-reared coyotes killed sheep in another study (USFWS 1978·74). However 16 of 54 wild-caught coyotes did not kill sheep when confined in a 2 5 acre observation area, even after being deprived of food for several days. However, these authors caution about extrapolating results of pen trials to field situations. A consensus seems to be that, while all coyotes do not kill sheep, most coyotes that are exposed to sheep, especially lambs, will probably learn to kill sheep eventually (USFWS 1978)

The niche that LPCs currently occupy in Texas' predator control scheme has been primarily one as a measure of "last resort". LPCs have been used

successfully by users and the Texas Animal Damage Control Service (TADCS) to remove problem coyotes that have learned to avoid more traditional control methods (e g , traps) (Walton 1989, Dorsett 1995a, b) Additional field studies need to be conducted to address the LPC's effectiveness as the primary corrective control.

Use in Texas, 1988-94

EPA granted a conditional registration to Rancher's Supply, Inc for use of small LPCs in December 1987, and certification of applicators began in April 1988 (Walton 1990) A total of 51 licensed LPC applicators obtained LPCs, and 40 applicators used LPCs during this period. Use by TADCS employees began on a pilot basis in 1990 (Dorsett 1991) LPC use by TADCS personnel increased from 12 projects in FY90 to 44 in FY94 Success rates (i e., coyotes were taken by LPC use) have averaged just under 50% over the 4 years of use by TADCS (Dorsett 1995). This success rate should be viewed in the context that the coyotes removed had already evaded other ongoing control efforts, including M-44 devices, traps, snares and aerial gunning. Dorsett (1995) acknowledged that the LPC has become a very useful tool to TADCS for removing problem coyotes.

One of the disadvantages of using LPCs is the expense of purchasing enough LPCs to collar a sufficiently large target flock (e.g., 100 head). Collars cost $20 each and could present a sizeable investment for the individual rancher. A collaborative effort of the TDA, Rancher's Supply, Inc. and the Texas Agricultural Extension Service (TAEX) allowed for the formation of "county collar pools" (TDA 1991) Restrictions concerning collar pools are found in TDA's (1994) certification training handbook Although the agreement allowed a maximum of 15 participating counties, only 6 counties actually formed collar pools (TDA 1991), and these have been used infrequently Most of the LPC use in Texas currently is under the auspices of TADCS personnel

Using LPCs effectively

McBride (in TAEX 1991) lists the following reasons when citing failures in LPC use:

(a) using collars where killing frequency is erratic and infrequent;

(b) users try to manipulate coyote behavior by placing collared animals in pastures where attacks had not been occurring, or by using collared animals unlike those being attacked;

(c) using insufficient collars to ensure that a coyote will prey upon a collared individual; and

(d) improperly targeting the coyote's attack to the collared animals.

A 14-minute instructional video "*Using Livestock Protection Collars*" is available from TAEX (write to author at address listed on this paper) and provides management tips for increasing success with LPCs.

LPCs are most effective in areas with a high frequency of attacks and where other control measures have failed. Success will be highest when proper "targeting" methods are used to focus coyote attacks on collared livestock (Wade 1985). A "target flock" consisting of a small number (e.g., 20) of collared lambs or kid goats are accompanied by 100 or more adult animals. McBride (pers. commun.) recommends target flocks consisting of 100 or more collared lambs/goats with several hundred adult animals, in a ratio of about 1 collared young per 10 adult animals If given a preference, coyotes will almost always attack the younger animals (Guthery 1977). Other uncollared livestock on the site should be moved to a safe area or penned until offending coyote(s) are removed or predation ceases.

Conclusions

The invention, testing, registration and subsequent field use of LPCs has been a drawn out, political process. Users certified by TDA complain that record-keeping requirements and use restrictions are cumbersome, and user acceptance of LPCs in Texas has been slow to date. However, these political constraints should not overshadow that the LPC has proven to be a selective, effective and indeed specific tool for removing coyotes that actually kill sheep and goats.

The LPC is the only control alternative currently

available for delivering "perfect justice" to coyotes guilty of killing livestock, i.e., its specificity rarely affects non-offending animals (coyote or nontarget). The fact that it involves a relatively slow-acting and highly politicized toxicant (Compound 1080) hinders its acceptance among animal welfare groups However, such groups generally oppose the use of all lethal control alternatives, regardless of their selectivity, specificity or perceived humaneness.

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