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A Comment on "Coyote Control and Taste Aversion"

RICHARD J. BURNS and GUY E. CONNOLLY
U. S. Fish and Wildlife Service, Denver Wildlife Research Center, Colorado

The application of aversive conditioning (AC) to coyote (*Canis latrans*) management was first proposed by Gustavson, Garcia, Hankins & Rusiniak (1974). This publication stimulated a flurry of research until about 1980, when most workers had abandoned the concept as ineffective or impractical. In "Coyote control and taste aversion", Forthman Quick, Gustavson & Rusiniak (1985) seek to resurrect AC, and their particular paradigm, as a practical method for reducing coyote predation on domestic animals. However, they offer no new scientific information. Instead, they argue that persons who found LiCl baiting not to deter coyote predation either misunderstood or misapplied the concept—an argument we believe inadequate to explain recent contrary results.

Lithium chloride-induced AC is one of the few innovative predation management concepts to surface in recent years, and we believe that Gustavson *et al.* (1974) deserve credit for first testing the concept. Unfortunately, many researchers subsequently were unsuccessful in using LiCl-treated baits to control coyote predation. Only part of this literature is cited by Forthman Quick *et al.* (1985). They omitted several recent papers that contradict their point of view (Conover, Francik & Miller, 1979; Conover, 1982; Bourne & Dorrance, 1982; Burns, 1980 and 1983 a, b; Horn, 1983). In spite of the assertions of Forthman Quick *et al.* (1985), both theoretical and practical questions need resolving before AC could become a practical predator management technique. Some of the more important questions are identified here.

Comments on Pen and Field Studies

Forthman Quick *et al.* (1985) criticized Burns & Connolly (1980) for failing to report the number of days required for coyotes, in a test and control group, to kill 3 jack rabbits (*Lepus californicus*) each. This was important because effective AC would have produced a difference between the groups in the number of days required to reach criterion (3 kills/coyote). In that study, test-group coyotes were averted to jack rabbit baits containing LiCl and subsequently given opportunity to kill either jack rabbits or chickens (*Gallus gallus*) presented simultaneously. Control-group coyotes were treated similarly except that their baits contained no LiCl and they were not bait-averted. Our intent was to facilitate predation aversion by offering a "safe" prey (chickens) with the illness-associated prey (jack rabbits) so that coyotes were not forced to eat jack rabbits or go without food.

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Address correspondence to: Richard J. Burns, U.S. Fish and Wildlife Service, Predator Ecology and Behavior Project, Utah State University, UMC 52, Logan, UT 84322, U.S.A.

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The data in question showed that the control group reached criterion in 5 days (Table 1); the test group required only 4 days. Thus, there was little or no difference between the test and control groups. The lack of significant difference indicated that AC to the baits did not prevent or even retard jack rabbit killing by coyotes, even with chickens available as a "safe" alternate prey.

In their discussion of field applications, Forthman Quick *et al.* (1985) did not mention the important study of Bourne & Dorrance (1982), who randomly assigned sheep ranches to bait treatments either with or without LiCl. Bait preparation was essentially the same as in Saskatchewan where other workers claimed that LiCl in sheep meat baits reduced coyote predation (Gustavson, Jowsey & Milligan, 1982). Bourne & Dorrance (1982), however, found no effect attributable to LiCl. Their work is particularly important because they employed experimental controls in the same year that LiCl was used. On procedural grounds, it may be the best field study yet conducted and merits inclusion in any review of field applications.

Further, we view these results as supporting our contention that much of the pen and field work, which reportedly supports the effectiveness of coyote predation aversion, is inconclusive and suffers from poor procedures, lack of scientific control, and less than objective reporting (Griffiths, Connolly, Burns & Sterner, 1978; Sterner & Shumake, 1978; Burns, 1980; Burns & Connolly, 1980; Burns, 1983 a, b).

TABLE 1

Predation on chickens and jack rabbits by coyotes with (treated group) and without (control group) LiCl-induced aversion to jack rabbit baits [a]

Coyote number	Time to kill 3 jack rabbits (days)	Sequence of kills to criterion[b] (3 jack rabbits killed)							
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Control group									
1	4	JC	N	JC	JC				
2	4	N	J	JC	J				
3	4	N	J	JC	J				
4	8	N	C	C	C	J	C	J	J
Average	5								
Treated group									
5	3	J	J	J					
6	4	J	C	J	JC				
7	3	CJ	CJ	JC					
8	5	C	J	J	C	J			
Average	4								

[a] Study conducted at Logan, Utah during April–July 1979. See Burns & Connolly (1980) for additional details.

[b] Each coyote could have killed 1 chicken (C), 1 jack rabbit (J), both, or neither (N) on each day. Kills occurred in sequence indicated.

Current Problems

Uncertainty Over Proper LiCl Concentrations in Baits

It is generally accepted that, for effective application of LiCl AC in coyotes, coyotes must be averted from the flavor of prey meat. However, there is no agreement about an effective concentration of LiCl in baits. In pen tests, Gustavson, Kelly, Sweeney & Garcia (1976) used 3 g LiCl in gelatin capsules in rabbit bait packages of unspecified size. For field application, Gustavson *et al.* (1982) used 6 g LiCl in 100 g ground sheep meat in 1976, and 4 g LiCl/100 g bait in subsequent years. No rationale was given for the initial 6 g dose, nor for the subsequent reduction to 4 g. Contrary to the assertion of Forthman Quick *et al.* (1985), those concentrations (40,000 to 60,000 ppm) are much higher than the NaCl content (6500 to 9000 ppm) specified for physiological saline solutions (Altman & Dittmer, 1964). If salt content of blood in bait or meat is 6500–9000 ppm, any additional salt would elevate salt content out of this "normal" range.

Other workers using similar concentrations found that coyotes averted to salty-tasting material but continued to kill and eat live prey (Griffiths *et al.*, 1978; Burns, 1980; Burns & Connolly, 1980; Conover, 1982). These results led us to test baits containing different amounts of LiCl to determine if there was an optimum amount. Stronger bait aversions were formed with 1 g LiCl/500 g bait than with 2 or 4 g/500 g bait (Burns & Connolly, 1980). When LiCl was microencapsulated in beeswax in an attempt to further reduce taste and odor cues, stronger bait aversions were formed with 1·08 g LiCl/500 g bait than with 0·27, 0·54, or 2·16 g/500 g bait (Burns, 1983 b). These "strongest" LiCl concentrations in baits were then tested in an AC paradigm and produced no aversion to live prey (Burns & Connolly, 1980; Burns, 1983 b).

Ellins & Martin (1981) found that coyotes detected LiCl by olfaction and avoided baits containing very low concentrations. Canned dog-food patties (50 or 100 g) containing only 50 mg LiCl were rejected 75 per cent of the time. Coyotes apparently can detect and learn to avoid LiCl at lower concentrations than those commonly used in experiments and field tests to deter coyote predation.

We believe that the best concentration to produce AC from baits in coyotes is about 1 g LiCl per 500 g flesh. At this concentration coyotes do not vomit the lithium, but instead retain the lithium, thereby suffering a more severe illness (Burns & Connolly, 1980; Burns, 1983 b). However, we believe that bait-averted coyotes do not necessarily desist from killing the kind of prey from which the baits were made, irrespective of the LiCl concentration in the baits.

Lack of Transfer of Bait Aversion to Live Prey

The key question is whether coyotes, once averted to prey baits, will transfer or generalize the aversion to live prey. In several studies with captive coyotes, no generalization occurred (Conover, Francik & Miller, 1977; Burns, 1980; Burns & Connolly, 1980; Conover, 1982; Burns, 1983 b); in others, if generalization occurred, it was short-lived (Lehner & Horn, Note 1; Horn, 1983).

The lack of generalization from LiCl-treated baits to live prey suggests that coyotes might not have evolved a prey-killing aversion mechanism similar to flavor aversion in rats (Burns & Connolly, 1980), or that, if the mechanism is present, lithium chloride cannot activate it; i.e. LiCl baits strong enough to produce generalization from bait

aversion to prey-killing aversion can be distinguished from freshly-killed prey by taste and odor, and LiCl baits that are indistinguishable from prey flesh contain insufficient lithium to produce a generalization (Burns, 1983 b). Also, a captive coyote apparently associated bait and sickness with the observer or his truck (Burns, 1983 b). However, irrespective of the reason, since many investigators have failed to obtain a generalization under controlled conditions with captive coyotes, we think it unlikely to occur in the field.

Extrapolating from Other Species to Coyotes

We feel that misunderstandings about LiCl bait-induced aversion, as applied to the management of coyote predation, result from some workers extrapolating from AC in other species to coyote predation. Gustavson & Gustavson (1982) compared the reinforcing effects of illness, chemical repellents, and mechanical deterrents and confirmed that a flavor-illness procedure was the most effective method to suppress *feeding in rats.* Citation of this reference in relation to coyote predatory suppression is questionable. Results of studies about rat feeding behavior might be properly used to generate hypotheses for testing on coyotes, but predation aversion involves much more than simple flavor aversion, and we urge caution in extrapolating from rat feeding to coyote predation.

Lithium Chloride is not Registered

In the United States, chemical aversive agents must be registered by the Environmental Protection Agency (EPA) before they can be legally used in coyote management. Applicants for registration are required to submit data on efficacy, chemistry, and hazards (Quarles, 1975). In general, registrations are approved when applicants demonstrate that products will perform their intended functions without causing unreasonable adverse effects on man or the environment.

No one, to our knowledge, has applied for EPA registration of LiCl to protect sheep. However, AC was formally evaluated by EPA in 1982 during reregistration hearings on Compound 1080. At the conclusion of these hearings, the presiding administrative law judge (Nissen, 1982) and reviewing EPA Assistant Administrator (Thomas, 1984) concluded that the effectiveness of AC as a method of predator control had not been established.

Additionally, non-target hazards of LiCl in baits have received little investigation. Forthman Quick *et al.* (1985) apparently ignored possible non-target hazards in recommending the use of LiCl baiting, rather than lethal coyote control methods, in California condor (*Gymnogyps californianus*) ranges. Rogers (1974) showed that some blackbirds (*Agelaius phoeniceus*) voluntarily ingest lethal amounts of LiCl-treated corn, demonstrating that LiCl can be toxic to wildlife under some circumstances. Even if LiCl is not toxic to condors, the use of LiCl in livestock carcasses or baits might well avert condors from carrion. Such an aversion could be detrimental since livestock carcasses furnish about 75 per cent of the condors' food (Wilbur, 1978). Note that the possible effectiveness of LiCl in this situation would not involve prey killing.

Conclusion

We conclude that convincing evidence that coyotes will generalize bait aversion to live prey is still lacking. In the unlikely event that AC proved effective in deterring coyote predation, investigation of nontarget impacts would be needed before LiCl could be registered.

Forthman Quick *et al.* (1985) lamented that the studies not showing LiCl baits to stop predation have had a "disproportionate effect on attitudes toward applied taste aversion research". However, we feel that the preponderance of results from the most recent and most procedurally sound studies indicate AC to prey baits does not stop coyotes from killing that prey. We join Forthman Quick *et al.* (1985) in wishing that LiCl baiting was effective, but, unlike them, we cannot ignore or rationalize away the large body of contrary evidence.

Reference Note

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