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THE USE OF BONE OIL (RENARDINE) AS A COYOTE REPELLENT ON SHEEP FARMS IN ONTARIO

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ABSTRACT: As no control methods, apart from shooting and leghold traps, are legal in Southern Ontario, field trials of lithium chloride and bone oil ("Renardine") were carried out between 1991 and 1998. No effect could be demonstrated with lithium chloride. Between 1994 and 1998 bone oil was used as a repellent on seven different flocks, either directly onto the sheep or as a perimeter barrier round pastures. As long as the treatment was maintained, repulsion was achieved. The coyotes continued to kill in the surrounding area. If the odor level was not maintained, the coyotes would return to kill in the trial flocks. A slow release method for perimeter treatment was tried.

KEY WORDS: coyotes, repulsion, bone oil

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INTRODUCTION

In the last decade coyote predation on Ontario farm livestock has increased by 400%. Producers' losses have been compensated under the Livestock, Poultry and Honey Bee Protection Act. Payments in 1999 were almost \$500,000, less than in previous years. The coyotes killed 1,927 sheep and lambs, and 736 cattle. The actual losses will be much higher as a carcass must be found and identified as a coyote kill before payment is made.

A few attempts have been made to control predation with limited success as methods of control apart from leghold traps and shooting are illegal in southern Ontario. Since 1991, field trials have been carried by staff of Livestock Technology to find an effective aversion agent or repellent. The initial work from 1991 to 1993 used lithium chloride in suitable baits as an aversion agent. The method used followed the published method from Manitoba (Manitoba Agriculture 1984). At the end of the period it was obvious that aversion was not achieved.

A reference to the use of "fox oil" to protect lambs from foxes was found in a clinical note in the "Veterinary Record" (Harwood and Malone 1992). Fox oil was traced to a commercial product containing bone oil, "Renardine,"[™] manufactured by Roebuck-Eyot. The appropriate research license was obtained from Agriculture Canada and a supply of bone oil purchased.

MATERIALS AND METHOD

Human Interactions

Before field trials were started, the effect of bone oil on humans and the meat were tested by skin reactions, smell and taste tests.

- To test for any skin reaction, three areas, about 1 cm in diameter on the inside of the forearm of a volunteer, were painted with bone oil.
- Several human volunteers were asked to cautiously smell a sample of bone oil and record the effect on them.

- A lamb was treated daily for seven days with a small amount of bone oil on the shoulder. The lamb was then slaughtered, jointed, and frozen in a commercial freezer. Loin chops from this lamb were grilled at the same way as similar chops from an untreated lamb. Sixteen volunteers undertook a blind taste test of the two samples.

Application

Two methods of application were used:

- Applying oil directly to the fleece. Sheep received a small amount of the oil each time they passed under a cattle oiler ("Stockmop Oiler," Ketchum Manufacturing, Ottawa). A water trough was surrounded on three sides by panels and the oiler hung over the entrance on the fourth.
- Perimeter treatment. The perimeters of pastures were treated originally by a continuous band of oil, sprayed from a backpack sprayer, or by a drag soaked in the oil. Later, perimeters were protected by applying a small amount, 4 to 5 ml, by sprayer or paintbrush to each fence post, about 12 to 16 inches from the ground. A slow release system was tried using "pop cans" full of the oil attached to the fence posts with a wick allowing a slow drip of the oil.

Trial Sites

The criteria for the trial sites were that they had a documented history of predation, were easily accessed, and the owners were willing to cooperate in the trial. All producers were asked not to change any other predation control methods, record bone oil treatments, kills, and any observation of sheep or coyote reaction to the oil.

In 1994 and 1995 Amherst Island was selected. Amherst Island is in eastern Lake Ontario. It is approximately 16 km (10 miles) long and 8 km (5 miles) wide and separated from the mainland by a 4 km (2.5 mile) channel. From January to the end of March there

is an ice bridge across the channel. Coyotes are seen crossing this bridge in most winters. Once the ice thaws in late March, coyotes cannot reach or leave the island until the following winter. There were three sheep farms on the island. One flock, A, B, of 850 ewes is usually run as two groups on the west end. At the east end there are two flocks, C of 200 ewes and D of 750 ewes grazing the full width of the island. These flocks share a common boundary at the back of both farms. The fencing of all three flocks was to keep coyotes out.

A combination of oilers and perimeter dragging was used in A and B. In flock C the sheep passed under the oiler to reach the water trough. Flock D used a perimeter drag to protect the lambing pasture. Once the lambs were three weeks old, the perimeter was no longer protected. No treatments were used on the island in 1996.

Between 1995 and 1998, three flocks were selected in the Guelph area:

Farm 1: 1995 and 1996. This flock of 85 ewes ran outside all year on a 24 hectares (60 acres) pasture and adjacent barn. On two and part of the third boundary, the fencing was 1 meter (40 in) high pagewire with 15 by 40 cms (6 by 16 in) openings, a common fencing in Ontario. The remainder was cedar rail fencing, about 1 meter (40 in) high. The winter yard was enclosed with a similar cedar rail fence. There were no electric fences used. From May 1995 to May 1996, perimeter protection was used; from May 1996 to May 1997, an oiler was used as a comparison of the two methods. All the perimeter treatment and oiler maintenance on this farm was carried out by one of the authors (SJM).

Farm 2: 1996 to 1998. This flock of 350 Shetland sheep were kept in a 16 hectares (40 acres) pasture adjoining a local wildlife safari park. The northern and western boundaries were a 2.5 meter (8 feet) high interwoven wire fence under which coyotes, in places, could pass. The remaining fence was a 1.3 meter (50 in) conventional pagewire fence. There was an additional pasture outside the treated area. There was no electric fencing used. Guard donkeys were run with the sheep but had not prevented predation. Perimeter protection was used as the sheep, being kept for their wool, could not pass under an oiler. The perimeter was treated every seven days. In 1998, the slow delivery method was used to protect a deer compound adjoining the sheep.

Farm 3: 1997 to 1998. This was a 165 commercial ewe flock east of Toronto. The ewes grazed 13 acres of pasture enclosed by a four-strand electric fence and could be put into three yards within this area. Coyotes killed in the enclosed area despite the use of donkeys.

Also between August and October 1995, bone oil dispensed by an oiler, was used to protect 102 ewes grazing a 32 acre woodlot. The grazing was surrounded by a low 75 cm (30 in) high three-strand electric fence. The oiler enclosure surrounded the one water trough at the bottom of a shallow ravine. Coyotes were active in the area, and there was a den outside the northern boundary.

The results were compared to the previous predation history on the farm, the local township and the county, using the claims record of the Farm Assistance Branch, OMAFRA. These records document all claims for compensation for livestock losses to wolf/coyote predation

by number of animals killed or injured, by owner, by township and by county across the province.

RESULTS

Human Interactions

1. Skin reaction. At each site there was erythematous reaction in each area. There was no irritation and all reaction had disappeared within 12 hours.
2. Human impact. The human reaction to smelling a sample was of a sharp pain in the nasal cavity and in the frontal area of the brain.
3. Meat residues. There was no detectable odor from the loin chops at cooking. The 16 volunteers in the blind taste test could not detect any difference between the two samples.

Application

- a. Using the oilers. The design of the water trough enclosures was modified several times. It started as a solid sided chute and ended as wire mesh enclosure. The final design allowed the sheep to exhibit normal sight behavior (Lynch et al. 1992). The base of the mop fronds could not be more than 1 meter (39 in) from the ground to ensure adequate oiling of the sheep and agitation of the oiler to maintain a flow of oil to the fronds. Lambs were not oiled, but they appeared to rub enough from the ewes to be protected.

One problem with the oiler was the evaporation of the carrier in the summer months with the resultant tarring of the mop fronds. After one season, a number of the oilers had to be replaced because of excessive tarring and subsequent plugging.

- b. Perimeter Treatment. Laying a continuous band of oil around the perimeter of a pasture by sprayer was discontinued. To spray a thin band round 26 hectares (65 acres) required 40 liters of oil. Using a drag or treating fenceposts proved to be as effective and economical in the use of oil. The "paint brush" method was preferable to the sprayer as the oil corroded some of the plastic components to the pump and plugged the spray nozzle.
- c. Slow release cans. The slow release cans were effective. Both woven and string wicks gave a slow drip of oil to the ground. Once these were in place the coyotes ceased killing deer. The cans needed to be refilled once every 3 weeks.

Kills

Amherst Island (Table 1). All the 100 lambs killed in Flock AB were either before a pasture was treated or in an untreated adjacent area. If coyotes killed and then the area was treated, they moved to another area to continue to kill. This flock grazed 29 different areas in the course of the summer of 1994.

In Flock C, there was one ewe killed in December 1994 after treatment ceased. There were two ewes bitten in the hind leg in September of 1995, most probably by pups learning to hunt. Treatment was discontinued in 1996, when 20 sheep were killed.

Flock D only protected the lambing area until the lambs were about 3 weeks old. The kills in 1994 were after this time.

The small number of kills in 1995 across the island could be related to hunters killing coyotes in the spring after the island was isolated. By 1996, coyotes were once more established on the island and continued to kill sheep. Flock AB, and D now use guard dogs to control predation.

Table 1. Amherst Island.

Flock	Kills		
	1994	1995	1996
AB	100	0	31
C	0	2	20
D	31	1	48

Farm 1 (Table 2). The perimeter was treated, on average, every nine days from May 1995 to May 1996. Four ewes were killed before treatment started, one was killed in June. The coyotes passed under the perimeter barrier to kill through an untreated culvert; once this was treated as part of the perimeter there were no further kills on the property until November. Then, an early snow fall covered the bone oil on the posts; a lamb was killed within a day. Four ewes were killed in another farm, 50 yards outside the treatment area. Twice, once by tracking and once by observation, coyotes were known to have avoided the treated area even though sheep were in easy reach. The number killed in 1996 reflects the problems with the oiler delivering insufficient oil for protection.

Table 2. Farm 1.

Year	Kills		
	Farm 1	Township	County
1992	1	21	70
1993	13	43	97
1994	9	61	116
1995	2(9)	N/A	99
1996	12	16	76

Farm 2 (Table 3). Once perimeter treatment was started there was no further killing inside. The perimeter was treated every seven days. However, in August 1996 sheep had to be moved to an adjacent pasture outside the perimeter. Within a few days 19 lambs had been killed. Similarly, the four ewes killed in 1997 were in the same unprotected pasture. The slow release method repelled the coyotes from the deer area.

Table 3. Farm 2.

Year	Kills		
	Farm 2	Township	County
1994	8	17	190
1995	47	55	95
1996	0(19)	N/A	103
1997	0(4)		

Farm 3 (Table 4). In January 1997, three ewes were killed before the trial began. One ewe was killed on July 16 within the treatment area, but treatment had lapsed for several weeks. Once treatment was restarted there were no further kills until the end of September when two ewes escaped the area and were killed outside on different days. In 1998, bone oil continued to be used. The only kills inside the perimeter were four lambs on one night in July. Outside six sheep and lambs were killed in the remainder of the year. In 1999 it was not used. There were no kills, but there had been a severe mange outbreak in the local coyote population. This year there is already evidence of renewed coyote activity on the property but to date no problems have been reported.

Table 4. Farm 3.

Year	Kills		
	Farm 3	Township	County
1994	1	16	29
1995	0	18	33
1996	6	28	50
1997	0(7)	28	52
1998	4(6)		

Woodlot. In the trial period, two ewes died by accident, but there were no coyote kills. In the immediate area from April 1 until December 31 of that year, coyotes are known to have killed six calves, one cow and ten lambs. As the oiler was at the bottom of shallow ravine, the smell of the oil was more pronounced than at the other sites.

Analysis

Statistical analysis of the results showed no significant difference in the pretests and trial years in the counties. Comparing the trial farms to the counties in the pretest years, predation on the trial farms was significantly higher, but in the trial period there was only a borderline significance. There was a significant difference between the test and non-test years on the trial farms.

DISCUSSION

Bone oil, in original form, was tried with a mixture with a capsaicin and crude wool fat and was considered to show some promise (Thompson 1975). "Renardine"[™] is a more refined bone oil with other additives to enhance the smell.

Griffiths states that, to test the effectiveness of any technique, the investigator "must not only demonstrate that predation would have occurred in the absence of treatment, but also, that any observed reduction resulted from the experimental treatment and not from other causes." In these trials, the producers were asked not to change their flock management or other techniques they had used to control predation. In each case the only experimental treatment was bone oil. Comparing the trial farms' records before and during the trial, with the records of the township and county for the same period, any reduction in predation would be demonstrated. As no bone oil was used to control predation except on the trial sites, this trial fits with Griffiths' test of effectiveness.

Predation by coyotes can vary considerably; availability of alternate food supply, competition from other predators, concurrent disease (especially mange), migration in and out of the area, hunting or trapping will change the predation pattern in a particular county. The increase in coyote predation on livestock in the same period maybe a result of this competition. On Amherst Island, the predation on the sheep flocks has varied with the vole population (Kennedy, pers. comm.). There were few voles in 1994, but the population had rebounded in 1995. Whether this will continue as the coyotes become more attuned to the advantages of shecp over voles as a food source is open to conjecture.

For a mammalian repellent to be effective "it must affect you as well as the target species" and also "all repellents work through the receptors of the trigeminal nerve" (Mason 1998). As smells stimulate the olfactory, sensory, receptors of the nasal cavity, and thus by the trigeminal nerve to the olfactory bulbs in the frontal areas of the cerebrum, any reaction to the repellent would occur in the nasal cavity and the frontal area of the brain. The reaction to the odor by the human volunteers, pain in the nasal cavity and a developing "headache" in the olfactory area is similar to others reported to severe nasal irritation (Guyton 1986) and fulfills this premise. A coyote's olfactory power, far more acute than humans, is believed to be one of its most important senses (Bekoff 1978), while that of the sheep is less sensitive and only used in conjunction with the recognition of food and social behavior (Lynch et al. 1992). If the odor of bone oil can cause pain in humans, lower concentrations may cause similar pain to the highly developed olfactory system of the canid. With a less sensitive system, sheep were not affected by the odor and did not change their behavior.

The coyote's natural reaction to a painful olfactory stimulus is to move away. But with the visual stimulus of sheep, and easy food across the "smell boundary," it will return to probe and to cross the boundary where the odor is minimal. Coyotes circumvented the "smell boundary" through a culvert to kill inside the treated perimeter (Farm 1). They also crossed the boundary to

kill when the odor was reduced; a snow fall on Farm 1 and lapsed treatment on Farm 3.

Mason also stated that "repellents condition avoidance, they do not stop the killing elsewhere." The behavior of coyotes to a bone oil boundary, only killing sheep outside the treated area, Farm 2 and 3 in two successive years, or moving to unprotected sheep, Flock AB, Flock D versus Flock C in 1994, follows this statement. Once sheep were unprotected, Flock C in 1996, the coyotes return to kill on that farm. On Farm 1 and the woodlot the perimeter fencing was inadequate as a coyote deterrent, the only protection for the sheep was the bone oil. As long as it was reinforced regularly, there was repulsion.

But if other food sources were not available, the need for food will overcome the repulsion of bone oil as is seen in the reported repellent effect of bone oil in a captive coyote population (Mason, pers. comm.).

Which of the delivery methods was the most successful? The use of an oiler ensures a constant level on the fleece to give continuous protection. However, the oiler must be maintained to achieve this. Perimeter treatment appears to be the preferred method provided it is reinforced every seven days, and at shorter intervals if dictated by weather conditions, snow or very hot dry conditions. The slow delivery system with a suitable wick could lengthen the maintenance interval and still provide protection. The drawback to perimeter treatment in extensive management systems is the time constraints for maintenance. Back oiling will work, but a different design of oiler for sheep is required. On Farm 1, the difference in the kills between 1995 and 1996 was due to problems with the oiler.

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