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Original Research

Is Livestock an Important Food Resource for Coyotes and Wolves in Central Eastern Alberta Counties with Predator Control Bounties?

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Abstract

Although bounties are known to be an ineffective management practice to address human-carnivore conflicts, they are maintained by some Alberta rural municipalities (counties) to ostensibly reduce livestock predation by coyotes (*Canis latrans*) and wolves (*Canis lupus*). However, there are no data ascertaining these municipalities' claims that livestock is an important food item in the diet of coyotes and wolves. In this study, using fecal analysis in spring and summer 2016 and 2017, we assessed the importance of cattle in the diet of coyotes and wolves in a bounty study area overlapping the Counties of Two Hills and St. Paul, and in a control area without bounties overlapping the Counties of Strathcona, Lamont and Beaver, Alberta. In 2016, in the bounty area, there was a significant difference (Fisher's test = 0.02) in the frequency of cattle remains between spring (Relative Percentage of Occurrence − RPO − 5.4%; n=69 scats) and summer (RPO 18%, n=78) coyote scats. However, there was no difference (P>0.05) between the bounty and control areas during this spring season. In 2017, the RPO of cattle remains in scats was ≤8.4% in both study areas during spring and summer; no significant difference (P>0.05) was detected between seasons and study areas. Only 22 wolf scats were collected in bounty areas, and most of them (86%) had no cattle remains. Coyote and wolf spring and summer scats with cattle remains were found in areas with carcasses of cattle that had died of natural causes; scats were likely the result of scavenging rather than predation. Based on our results, we recommend that the implementation of bounties in these counties be discontinued.

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INTRODUCTION

In Alberta, bounties to kill coyotes (*Canis latrans*) and wolves (*Canis lupus*) have been implemented in various municipal districts (also called counties) since 2007 to allegedly minimize livestock predation. Between 2010 and 2015, more than 25,000 coyotes and 1,400 wolves were killed by bounty hunters in Alberta (Proulx and Rodtka 2015). Although bounties are known to be an ineffective management practice to address human-carnivore conflicts (Theberge 1973; Melchoir *et al.* 1987; Cluff and Murray 1995), they are maintained by some Alberta counties to ostensibly reduce livestock predation by coyotes and wolves. However, there are no data ascertaining the municipalities' claims that livestock is an important food item in the diet of coyotes and wolves (Proulx and Rodtka 2015). Because coyotes and wolves may be attracted to the afterbirth, young calf manure, and deadstock, producers assume that they prey on cattle (Gililand 1995; D. Rodtka, retired Problem Wildlife Specialist, 2016, unpublished observations). In Saskatchewan, a coyote bounty was enforced in 2009-2010 (Proulx and Rodtka 2015), during which time 70,000 coyotes were killed, yet there exists no data to suggest that coyotes caused major losses to livestock producers indicating that prejudice against terrestrial predators is still trumping scientific evidence (Proulx 2018).

In Alberta, calf losses to predation are believed to be higher in March and April (Acorn and Dorrance 2010; Two Hills and St. Paul Agricultural Fieldmen Elden Kozak and Keith Kornelsen, 2016, personal communication). This period corresponds to the calving period during which time calves are most vulnerable (Acorn and Dorrance 2010). This is also the case in the United States where most calves killed by coyotes are a few weeks old (Gililand 1995; Butfiloski and Baker 2002). In contrast, coyotes rarely attack healthy adult cows, yearlings, or calves over 2 months old (Acorn and Dorrance 2010). In summer, calves are larger and can avoid coyote encounters.

Acorn and Dorrance (2010) suggested that, most often, wolves kill older calves, 7-9 months of age. However, inevitably this can vary, and wolf packs with regular exposure to livestock sporadically may cause depredations (Bangs and Shivik 2001). In Minnesota, predation by wolves occurs when livestock are released to graze unmonitored in open and wooded pastures (Fritts *et al.* 1982). As the grazing season progresses, calves of smaller size (later birthing date) or with impaired escape abilities are selected by wolves (Fritts *et al.* 1982; Oakleaf *et al.* 2003). Vulnerability to predation appeared to be correlated with spatial proximity of calves to wolf home ranges and rendezvous sites (Oakleaf *et al.* 2003).

On the basis of Acorn and Dorrance's (2010) conclusions, and Agricultural Fieldmen's opinions, we hypothesized that (H_1) cattle remains in coyote and wolf scats would be relatively more frequent in spring (April), and (H_2) relatively less frequent in summer (June). Finally, the implementation of bounties across entire counties suggests that livestock are an important food resource of wild canids across all landscapes. We therefore hypothesized (H_3) that coyote and wolf scats with cattle remains would be present throughout the bounty study area.

STUDY AREA

In Alberta, cattle are the dominant livestock (Statistics Canada 2016; Alberta Agriculture and Forestry 2018). Therefore, our investigation was conducted in 2 study areas where cattle are the main livestock: 1) a 6,000-km^2 bounty area at least 140 km northeast of Edmonton and overlapping the Counties of Two Hills and St. Paul, which represented the test site; and 2) an approximate 1,000-km^2 control area without bounty, approximately 50 km east of Edmonton and overlapping the Counties of Strathcona, Lamont and Beaver, which represented the control site (Figure 1). In the bounty area, we focused our search for scats along roads near grazing areas, wildlife reserves, and agriculture areas with woodlots. In the control area, most of the search occurred along trails and roads in or near Cooking Lake-Blackfoot Provincial Recreation Area, and agricultural roads in the Lamont and Strathcona Counties. Although the control area was markedly smaller than the bounty area, we selected it for its extensive network of roads and trails, its well established rural community, and its diversified wildlife (Alberta Forestry, Lands and Wildlife 1990). Coyotes are abundant in the region and they inhabit Elk Island National Park and Cooking Lake-Blackfoot Provincial Recreation Area where they are protected from shooting and trapping. In recent years, a wolf pack also established itself in the region (Proulx, unpublished data).

In 2011, the total combined number of cattle and calves for the bounty area was an estimated 127,646 with 46,127 (36%) calves under the age of 1 year (Alberta Agriculture and Rural Development 2014). In the control area, in 2011,

Figure 1. Location of bounty and control areas, Alberta.

there were approximately 50,484 cattle and calves; 15,622 (31%) of these were calves under 1 year of age (Alberta Agriculture and Rural Development 2014). Both study areas had similar wildlife communities rich in birds, small mammals and ungulates (Semenchuk 1993; Smith 1993).

METHODS

We searched and collected coyote and wolf scats along the same dirt roads and trails crossing agricultural-wilderness areas in mid-April (spring sample; calving period), and early June (summer sample; coyote and wolf pup rearing period) of 2016 and 2017. Although the size of each feces varies with individual animal age, as well as food habits, the differentiation of scats was based on the experience of the authors, the presence of coyote or wolf tracks near scats, and the following diameter sizes: ≥18-<25 mm for coyotes, and ≥25 mm for wolves (Weaver and Fritts 1979; Green and Flinders 1981; Reed *et al.* 2004).

Scat locations were recorded with a GPS unit (Garmin model 76S; Garmin International Inc., Olathe, Kansas, USA). Scats were dated, bagged, and kept frozen until they were autoclaved at the University of Calgary at 130ºC for 30 min, to eliminate the danger of any parasite transmission to the analyst, particularly that of the granular tapeworm (*Echinococcus* spp). Scat analyses were conducted at the Alpha Wildlife Research & Management laboratory in Sherwood Park, Alberta. Scats were soaked overnight in a mild water-bleach solution, washed through a sieve, and oven-dried at 75°C (Proulx 2016). Hairs from scats were treated with methyl salicylate (Fisher's Scientific, Fair Lawn, New Jersey, USA) and examined with a microscope to identify cuticular scales and the medulla configuration (Moore *et al.* 1974). Hairs were identified to species. Bone remnants and teeth were used to ascertain the identification based on hair examinations. Feathers were identified to family level using Chandler (1916) and Day (1966). Arthropods were identified to order level.

Food items were classified into 12 categories: small mammals (mice, voles, squirrels and shrews), beaver, porcupine, snowshoe hare, carnivores, boar, wild ungulates, bison, cattle, birds, arthropods, and vegetation (Tables 1 and 2).

Contents of scats per season and per site were presented both as percentage of occurrence (PO; percentage of total scats in which an item was found) and relative percentage of occurrence (RPO; number of times a specific item was found as percentage of all items found). Although PO indicates how common an item is in the diet, RPO provides a better indication of the relative frequency with which each item is consumed because it accounts for more than one of a given item being found in a scat (Ackerman *et al.* 1984). Percent volume of remains of each food item in scats were estimated visually to the nearest 5% (McDonald and Fuller 2005).

Frequencies of food items in scats within and between years and areas were compared with Fisher's Exact Probability test and the Chi-square test for Independent Samples (Siegel 1956). Mean volumes of cattle hair in spring and summer scats collected in the bounty area were compared with a Student-*t*-test for unequal variances (Dixon and Massey 1969). Probability values $\leq$0.05 were considered statistically significant.

RESULTS

Scat collection

In 2016, we collected 138 coyote (60 in spring and 78 in summer) and 11 wolf (10 in spring and 1 in summer) scats in the bounty study area. In the control area, we collected 66 coyote (35 in spring and 31 in summer) and 9 wolf (6 in spring and 3 in summer) scats.

In 2017, we collected 164 coyote (89 in spring and 75 in summer) and 11 wolf (5 in spring and 6 in summer) scats in the bounty study area. In the control area, we collected 99 coyote (40 in spring and 59 in summer) and 12 wolf (5 in spring and 7 in summer) scats (Tables 1 and 2).

Coyote

Bounty area

In 2016, cattle remains were found in 4 (6.7%) scats in spring, and 17 (21.8%) scats in summer (Table 1). There was a significant difference (Fisher's test, P=0.02) in the frequency of cattle remains between spring (RPO 5.4%) and summer (RPO 18%) scats (Table 1). The mean volume of cattle remains in scats was significantly higher in summer (20.5%) than in spring (5.2%) (t_{126}=2.89, $P\leq$0.005). In 2017, cattle remains were identified in 5 (5.6%) scats in spring, and 9 (8.7%) scats in summer (Table 2). There was no significant difference (Fisher's test, P=0.4) in the frequency of cattle remains between spring (RPO 4.7%) and summer (RPO 8.4%). There was no significant difference (t_{137}=1.26, P>0.05) between the mean volumes of cattle remains in spring (5.6%) and summer (11%).

The frequency of cattle remains was similar from year to year, in spring (Fisher's test, P=1.0) and in summer (Fisher's test, P=0.06) (Tables 1 and 2). The mean volume of cattle remains was similar from year to year, in spring (t_{133}=0.1, P>0.05) and in summer (t_{133}=0.29, P>0.05).

There was a significant difference (χ^2= 19.6, df: 6, P<0.01) between the spring and summer diets of coyotes in 2016 (Table 1). There were significantly more remains of small mammals (Fisher's test, P=0.004) in spring; there were more cervid (Fisher's test, P=0.05) and arthropods (Fisher's test, P=0.05) remains in summer (Table 1). There was also a difference (χ^2=47.9, df: 6, P<0.001) between the spring and summer diets of coyotes in 2017 (Table 2). Remains of small mammals (Fisher's test, P=0.0003), and larger rodents (i.e., beaver and porcupine) and snowshoe hares (Fisher's test, P=0.0007) were more frequent in spring than in summer; scats with arthropod remains were more frequent in summer (Fisher's test, P<0.001) (Table 2).

Control area

Cattle remains were found in 1 scat collected in spring 2017 (Table 2). There was no significant difference ($\chi^2\leq$6.1, df: 2-3, P>0.05) between the seasonal diets of coyotes within and between years (Tables 1 and 2).

Bounty vs. control areas

In spring 2016, although there was no difference (χ^2=1.02, df: 3, P>0.05) between the diets of coyotes from the bounty and control areas, and no difference in the frequencies of cattle remains in scats (Fisher's test, P=0.26), it is important to note that there were no cattle remains in the coyote scats of the control area (Table 1). In summer, there was a difference (χ^2 = 10.7, df: 3, P<0.02) between study areas. There were no cattle remains in the coyote scats of the control area, thus resulting in a significant difference with the bounty area (Fisher's test, P=0.003) (Table 1).

In spring 2017, there was no difference between the diets of coyotes from the bounty and control areas (χ^2=0.86, df: 4, P>0.05). In summer, there was a significant difference between study areas (χ^2 = 18.8, df: 3, P<0.001). There were no cattle remains in the coyote scats of the control area (Fisher's test, P=0.01) (Table 2). Arthropod and vegetation remains (Fisher's test, P<0.001) were less frequent, but small mammal (Fisher's test, P=0.001) and bird (Fisher's test, P=0.007) remains more frequent, in the control area than in the bounty area (Table 2).

Wolf

Bounty area

In 2016, cattle remains were found in 3 scats in spring (Table 1). No cattle remains were found in the 2017 scats. Wild food items included small mammals, snowshoe hares, small carnivores, and cervids (Tables 1 and 2).

Control area

During both years, we found no scats with cattle remains. Small mammals were commonly found in scats of both years (Tables 1 and 2).

Bounty vs. control areas

In spring 2016 and 2017, although there was no significant difference between the frequencies of cattle remains in wolf scats from the bounty and control areas (Fisher's test, P=0.21), it is noteworthy to mention that there were no cattle remains in scats collected in the control area (Tables 1 and 2). In summer 2016 and 2017, no scats with cattle remains were found in both study areas.

Distribution of scats with cattle remains in the bounty area

Coyote and wolf scats were not found throughout the bounty study area (Figure 2). We were particularly successful in collecting scats near wilderness areas (Locations 1 and 6), wildlife reserves (Location 3), grazing leases (Locations 2 and 5), and areas with cattle carcasses in the field (Locations 1, 2 and 4). Scats with cattle remains came from the same localized areas (Table 3, Figure 2).

DISCUSSION

H_1− Cattle remains in coyote and wolf scats will be relatively more frequent in spring

Coyotes

Contrary to Acorn and Dorrance's (2010) statement, cattle was not an important food resource for coyotes in spring. We therefore reject H_1. We do not believe that the low frequency of scats with cattle hair in the bounty area is due to the implementation of bounties. In the control area where no bounties are being paid to kill coyotes and wolves, there were no scats with cattle remains in 2016, and only 1 scat with cattle hair in 2017.

We observed a major difference between producers' practices in the bounty and the control areas. In the bounty area, dead animals and piles of carcasses were common across the landscape (Figures 3 and 4). These carcasses and dead animals are a source of food for wild canids. In the control area, however, we did not see dead animals or carcasses in fields. This difference in scavenging opportunity likely explains the slightly greater frequency of scats with cattle hair in the bounty area.

Nevertheless, coyotes inhabiting the bounty area fed mainly on wild prey, as was the case in the control area. Coyotes are opportunistic, generalist predators and they eat a variety of food items in relation to changes in availability (Bekoff and Gese 2003). In spring, small mammals were the major prey item for coyotes, as it was observed elsewhere (Bowyer *et al.* 1983; Bartel and Knowlton 2005; Lukasik and Alexander 2012; and others).

Wolves

Wolf scats with cattle hair were found only in spring 2016, and the RPO of cattle remains was 27.3%. Because all wolf scats with cattle hair were collected in locations where cattle carcasses had been left in the fields (personal communication with producers), we believe that wolf predation on livestock is being overestimated. Considering the small number of scats, and the likelihood that wolves scavenged on carcasses, it is unlikely that livestock is an important food item of wolves in the spring. Our conclusion that livestock is not an important food item for wolves inhabiting the bounty study area is in agreement with Morehouse *et al.* (2018) who reported a very low number of claims from the wolf compensation program in this region.

H_2 − Cattle remains in coyote and wolf scats will be relatively less frequent in summer

Coyotes

According to Acorn and Dorrance (2010), and the Agricultural Fieldmen of Two Hills and St. Paul Counties, cattle predation would be less frequent in summer than in spring. However, in the bounty area in 2016, cattle remains were more frequent in coyote scats collected in June than in April when calves are larger and can avoid coyote encounters, and complications with calving are over. In 2017, there was no significant difference between the frequency of cattle remains in spring and summer. Cattle remains were not

Table 1. Frequencies and volumes of food items by season in coyote and wolf scats in bounty and control areas, Alberta, Canada, 2016 (PO: percentage of occurrence; RPO: relative percentage of occurrence; PV: percent volume; SD: standard deviation).

FOOD ITEM	COYOTE												WOLF											
	Bounty area						Control area						Bounty area						Control area					
	Spring			Summer			Spring			Summer			Spring			Summer			Spring			Summer		
	PO (*n*) *n* = 60	RPO (*n*) *n* = 74	Mean PV (SD)	PO (*n*) *n* = 78	RPO (*n*) *n* = 94	Mean PV (SD)	PO (*n*) *n* = 35	RPO (*n*) *n* = 45	Mean PV (SD)	PO (*n*) *n* = 31	RPO (n) *n* = 38	Mean PV (SD)	PO (*n*) *n* = 10	RPO (*n*) *n* = 11	Mean PV (SD)	PO (*n*) *n*= 1	RPO (*n*) *n* = 1	Mean PV (SD)	PO (*n*) *n* = 6	RPO (*n*) *n* = 10	Mean PV (SD)	PO (*n*) *n* = 3	RPO (n) *n* = 5	Mean PV (SD)
Small mammals (insectivores & rodents)[a]	60 (36)	48.7 (36)	50.5 (45.8)	32.1 (25)	26.6 (25)	23 (38.7)	71.4 (25)	55.6 (25)	61.1 (44.4)	54.8 (17)	44.7 (17)	42.7 (45.1	10 (1)	9.1 (1)	10 (-)	-	-	-	50 (3)	30 (3)	27.5 (40.5)	66.7 (2)	40 (2)	18.3 (-)
Beaver	-	-	-	-	-	-	2.9 (1)	2.2 (1)	2.3 (-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowshoe hare	15 (9)	12.2 (9)	12.8 (31.9)	5.1 (4)	4.3 (4)	5.1 (22.2)	8.6 (3)	6.7 (3)	4.9 (18.8)	9.7 (3)	7.9 (3)	9.7 (30.1)	20 (2)	18.2 (2)	20 (-)	-	-	-	-	-	-	-	-	-
Carnivores[b]	8.3 (5)	6.8 (5)	5.7 (20.4)	6.4 (5)	5.3 (5)	4.7 (19.2)	11.4 (4)	8.9 (4)	2.9 (9.8)	16.1 (5)	13.2 (5)	14.2 (34.3)	40 (4)	36.4 (4)	39 (50.4)	100 (1)	100 (1)	100 (-)	33.3 (2)	20 (2)	21.7 (-)	-	-	-
Cervids[c]	10 (6)	8.1 (6)	9.5 (29)	23.1 (18)	19.2 (18)	19.8 (38.4)	20 (7)	15.6 (7)	18.6 (38.5)	16.1 (5)	13.2 (5)	14.7 (34.3)	10 (1)	9.1 (1)	1 (-)	-	-	-	50 (3)	30 (3)	32.5 40.7)	33.3 (1)	20 (1)	23.3 (-)
Cattle	6.7 (4)	5.4 (4)	5.2 (22)	21.8 (17)	18 (17)	20.5 (39.6)	-	-	-	-	-	-	30 (3)	27.3 (3)	30 (48.3)	-	-	-	-	-	-	-	-	-
Birds[d]	8.3 (5)	6.8 (5)	4.7 (19.2)	7.7 (6)	6.4 (6)	7.1 (25.1)	5.7 (2)	4.4 (2)	4.6 (6)	16.1 (5)	13.2 (5)	13.5 (32.5)	-	-	-	-	-	-	16.7 (1)	10 (1)	16.7 (-)	66.7 (2)	40 (2)	58.3 (-)
Arthropods[e]	1.7 (1)	1.4 (1)	0.3 (-)	16.7 (13)	13.8 (13)	12.9 (32.4)	-	-	-	3.3 (1)	2.6 (1)	0.6 (-)	-	-	-	-	-	-	-	-	-	-	-	-
Vegetation	13.3 (8)	10.8 (8)	9.3 (27.1)	7.7 (6)	6.4 (6)	5.6 (20.1)	8.6 (3)	6.7 (3)	5.7 (20.2)	6.5 (2)	5.3 (2)	4.5 (-)	-	-	-	-	-	-	16.7 (1)	10 (1)	1.7 (-)	-	-	-
Total		**100 (74)**	**100**		**100 (94)**	**100**		**100 (45)**	**100**		**100 (38)**	**100**		**100 (11)**	**100**		**100 (1)**	**100**		**100 (10)**	**100**		**100 (5)**	**100**

[a]Masked shrew (*Sorex cinereus*); deer mouse (*Peromyscus maniculatus*); heather vole (*Phenacomys intermedius*); meadow vole (*Microtus pennsylvanicus*); prairie vole (*Microtus ochrogaster*); red-backed vole (*Myodes gapperi*); northern pocket gopher (*Thomomys talpoides*); house mouse (*Mus musculus*); least chipmunk (*Tamias minimus*); northern flying squirrel (*Glaucomys sabrinus*); red squirrel (*Tamiasciurus hudsonicus*); Richardson's ground squirrel (*Urocitelus spermophilii*). [b]Weasels (*Mustela* spp.); striped skunk (*Mephitis mephitis*); black bear (*Ursus americanus)*; coyote (*Canis latrans*); red fox (*Vulpes vulpes*). [c]Deer (*Odocoileus* spp.); moose (*Alces alces*); elk (*Cervus canadensis*). [d]Anatidae, Passeridae, Phasianidae, Rallidae. [e]Coleoptera, Odonata.

Table 2. Frequencies and volumes of food items by season in coyote and wolf scats in bounty and control areas, Alberta, Canada, 2017 (PO: percentage of occurrence; RPO: relative percentage of occurrence; PV: percent volume; SD: standard deviation).

FOOD ITEM	COYOTE											
	Bounty area						Control area					
	Spring			Summer			Spring			Summer		
	PO (*n*) *n* = 89	RPO (*n*) *n* = 107	Mean PV (SD)	PO (*n*) *n* = 75	RPO (*n*) *n* = 107	Mean PV (SD)	PO (*n*) *n* = 40	RPO (*n*) *n* = 45	Mean PV (SD)	PO (*n*) *n* = 59	RPO (n) *n* = 73	Mean PV (SD)
Small mammals (insectivores & rodents)[a]	65.2 (58)	54.2 (58)	59.3 (46.8)	41.3 (31)	29 (31)	29.4 (39.9)	67.5 (27)	60 (27)	60.8 (46.2)	67.8 (40)	54.8 (40)	58.1 (45.3)
Beaver[b]	3.4 (3)	2.8 (3)	1.9 (10.3)	1.3 (1)	0.9 (1)	1.3 (11.5)	2.5 (1)	2.2 (1)	2.5 (15.8)	-	-	-
Porcupine[c]	1.1 (1)	0.9 (1)	0.2 (2.1)	-	-	-	-	-	-	-	-	-
Snowshoe hare[d]	20.2 (18)	16.8 (18)	17.6 (37.3)	6.7 (5)	4.7 (5)	5.3 (20.8)	17.5 (7)	15.5 (7)	17.5 (38.5)	11.9 (7)	9.6 (7)	11.8 (32.5)
Carnivores[e]	4.5 (4)	3.7 (4)	3.7 (18.3)	9.3 (7)	6.5 (7)	8.2 (27.3)	-	-	-	3.4 (2)	2.7 (2)	2.5 (14.5)
Wild boar[f]	1.1 (1)	0.9 (1)	1.1 (10.6)	-	-	-	-	-	-	-	-	-
Cervids[g]	9 (8)	7.5 (8)	5.3 (19.8)	18.7 (14)	13.1 (14)	13.7 (31.4)	10 (4)	8.9 (4)	6.5 (20.8)	8.5 (5)	6.8 (5)	8.5 (28.1)
Bison[h]	-	-	-	-	-	-	2.5 (1)	2.2 (1)	1.5 (9.5)	-	-	-
Cattle	5.6 (5)	4.7 (5)	5.6 (23.2)	12 (9)	8.4 (9)	11 (31.1)	2.5 (1)	2.2 (1)	2.5 (15.8)	-	-	-
Birds[i]	7.9 (7)	6.5 (7)	5.7 (21)	10.7 (8)	7.5 (8)	5.3 (18..6)	10 (4)	8.9 (4)	8.8 (27.5)	27.1 (16)	21.9 (16)	18.1 (32.9)
Arthropods[j]	1.1 (1)	0.9 (1)	0.01 -	26.7 (20)	18.7 (20)	18.7 (36.8)	-	-	-	1.7 (1)	1.4 (1)	0.03 -
Vegetation	1.1 (1)	0.9 (1)	0.06 -	16 (12)	11.2 (12)	7 (19.2)	-	-	-	3.4 (2)	2.7 (2)	0.8 (4.7)
Total		**100 (107)**	**100**		**100 (107)**	**100**		**100 (45)**	**100**		**100 (73)**	**100**

FOOD ITEM	WOLF											
	Bounty area						Control area					
	Spring			Summer			Spring			Summer		
	PO (*n*) *n* = 5	RPO (*n*) *n* = 6	Mean PV (SD)	PO (*n*) *n*= 6	RPO (*n*) *n* = 6	Mean PV (SD)	PO (*n*) *n*= 5	RPO (*n*) *n* = 6	Mean PV (SD)	PO (*n*) *n* = 7	RPO (n) *n* = 7	Mean PV (SD)
Small mammals (insectivores & rodents)[a]	60 (3)	50 (3)	60 (54.8)	33.3 (2)	33.3 (2)	33.3 (51.6)	40 (2)	33.3 (2)	39 (53.4)	28.6 (2)	28.6 (2)	28.6 (48.4)
Beaver[b]	-	-	-	-	-	-	-	-	-	-	-	-
Porcupine[c]	-	-	-	-	-	-	-	-	-	-	-	-
Snowshoe hare[d]	40 (2)	33.3 (2)	36 (46.5)	-	-	-	40 (2)	33.3 (2)	40 (54.8)	42.9 (3)	42.9 (3)	42.9 (53.5)
Carnivores[e]	-	-	-	-	-	-	20 (1)	16.7 (1)	20 (44.7)	14.3 (1)	14.3 (1)	14.3 (37.8)
Wild boar[f]	-	-	-	-	-	-	-	-	-	-	-	-
Cervids[g]	20 (1)	16.7 (1)	4 (8.2)	33.3 (2)	33.3 (2)	33.3 (51.6)	-	-	-	14.3 (1)	14.3 (1)	14.3 (37.8)
Bison[h]	-	-	-	-	-	-	-	-	-	-	-	-
Cattle	-	-	-	-	-	-	-	-	-	-	-	-
Birds[i]	-	-	-	-	-	-	-	-	-	-	-	-
Arthropods[j]	-	-	-	33.3 (2)	33.3 (2)	33.3 (51.6)	-	-	-	-	-	-
Vegetation	-	-	-	-	-	-	20 (1)	16.7 (1)	1 (2)	-	-	-
Total		**100 (6)**	**100**		**100 (6)**	**100**		**100 (6)**	**100**		**100 (7)**	**100**

[a]Shrew (*Sorex* spp.); deer mouse (*Peromyscus maniculatus*); meadow vole (*Microtus pennsylvanicus*); prairie vole (*Microtus ochrogaster*; red-backed vole (*Myodes gapperi*); northern pocket gopher (*Thomomys talpoides*); house mouse (*Mus musculus*); least chipmunk (*Tamias minimus*); northern flying squirrel (*Glaucomys sabrinus*); red squirrel (*Tamiasciurus hudsonicus*); Richardson's ground squirrel (*Urocitellus spermophilii*). [b] Beaver (*Castor canadensis*); [c]Porcupine (*Erethizon dorsatum*); [d]Snowshoe hare (*Lepus americanus*). [e]Weasels (*Mustela* spp.); striped skunk (*Mephitis mephitis*); black bear (*Ursus americanus*); coyote (*Canis latrans*); red fox (*Vulpes vulpes*); cougar (*Puma concolor*). [f]Wild boar (*Sus scrofa*); [g]Deer (*Odocoileus* spp.); moose (*Alces alces*); elk (*Cervus canadensis*); [h]Bison (*Bison bison*). [i]Anatidae, Columbidae, Passeridae, Phasianidae, Rallidae. [j]Coleoptera.

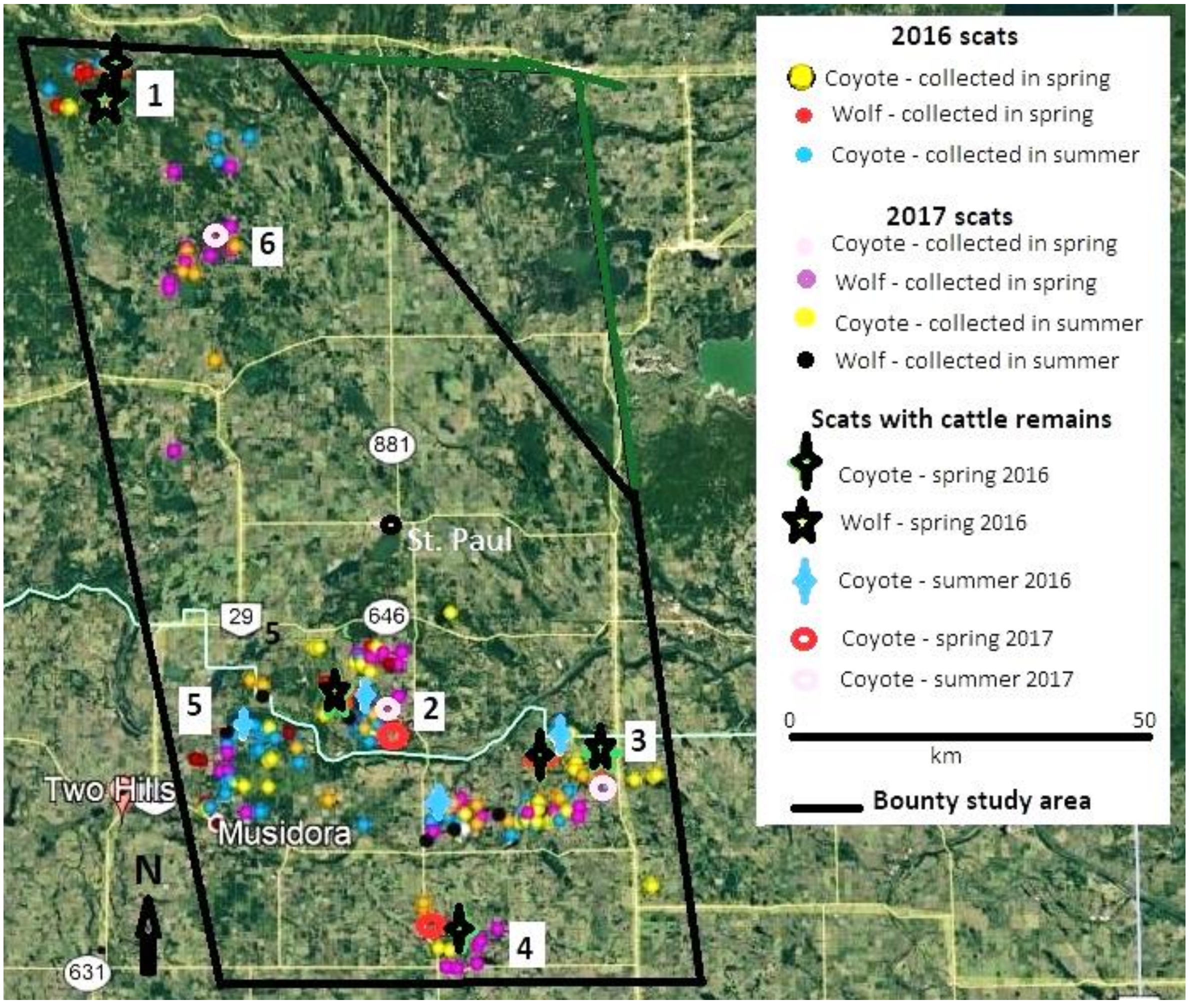

Figure 2. Distribution of coyote and wolf scats in the bounty study area, and location of scats with cattle remains. Numbers represent locations where coyote and wolf scats with cattle remains were found (see Table 3 for description of the locations). Dots may represent ≥ 1 scat. Only 1 wolf scat was collected in summer 2016 and it is not included here.

relatively less frequent in summer scats, and we therefore reject H_2. We believe that the presence of cattle remains in coyote scats in summer may be the result of scavenging deadstock rather than predation, as explained above.

According to rancher Joe Englehart (personal communication, 2017), losses due to cattle feeding on toxic plants (e.g., tall larkspur, *Delphinium glaucum*) are significant from mid-May to late-July, and thus predator scavenging on carcasses increases in summer. One farmer in our bounty study area (near Location 4; Figure 2) indicated that in 2015, he lost 4 calves to water-hemlock (*Cicuta maculata*).

Location 2 (Figure 2) was particularly rich in coyote scats with cattle hair, even though no losses to predation were reported by the operator of the grazing lease (V. Robinson, personal communication, April 2016 and 2017). However, local producers are known to use the surrounding forested areas and the local gravel pit to dump cattle carcasses. Not far from Location 2, we found the carcass of a young calf that had died of natural causes still in the field with livestock (Figure 5). The producer told us that he usually hauled deadstock into the bush, on his own property. We find it disconcerting that the producer was indifferent to leaving a dead calf in the field or in a nearby woodlot, and therefore baiting and feeding coyotes and other natural predators with deadstock. We believe that discarding cattle carcasses in

Figure 3. This cow died from natural causes and was dumped in a woodlot within the bounty area (Location 4 in Figure 2). Note the presence of 2 coyotes that were neck-snared near the carcass; 1 of their paws were amputated for bounty compensation (insert), Tow Hills County, April 2016.

Figure 4. Carcasses of animals that died of natural causes (personal communication with producers) were commonly encountered in the bounty study area – note the presence of cattle in the background – St. Paul and Two Hills Counties, 2016.

woodlots is the rule rather than the exception in this agricultural region, and this largely explains the high frequency of scats with cattle remains in summer. When farmers allow coyotes and wolves to access cattle carcasses or any part thereof, they are likely conditioning predators to feed on livestock (Fritts 1982; Knowlton *et al.* 1999; Shivik 2004). In summer, coyotes fed mainly on small mammals, cervids and arthropods, as it was also found in other regions (Johnson and Hansen 1979; Elliott and Guetig 1990; Cypher *et al.* 1993; Lukasik and Alexander 2012; and others).

Wolves

The small number of wolf scats collected in the summer of both years and the absence of cattle remains in these scats suggest that wolves are not abundant and their impact on livestock is likely minimal.

H_3 − Coyote and wolf scats with cattle remains will be present throughout the bounty area

Although we traveled extensively across the bounty area in 2016 and 2017, the distribution of coyote and wolf scats with cattle remains corresponded to specific areas characterized by the presence of carcasses (Figure 2, Table 3). We therefore reject H_3 suggesting that the presence of coyote and wolf scats would occur throughout the bounty area.

The bounty area was a mosaic of lightly managed wilderness areas interspersed with agricultural fields and pastures. Location 5 (Figure 2) is an example of such a mosaic. Newly created fields were surrounded by forests, and coyote scats collected in this area contained cattle hair. When producers establish their fields within a wilderness area, more feeding on cattle (either predation or scavenging) may occur, particularly if these producers do not spend much time with their herd (Bangs and Shivik 2001). Cows retire to a secluded spot in the brush to give birth, or to seek food or cover (Figure 6). Under these circumstances, when calves are either stillborn, or sick or weak, they are more vulnerable to predation or other hazards (Pastuck 1974).

Scat analyses and scavenging

Depredation of cattle and other domestic animals is often more common when human activities have decreased natural prey abundance, which may be one factor that could cause coyotes and wolves to turn to livestock for sustenance (Sidorovich *et al.* 2003; Fox and Papouchis 2005). On the basis of our field observations, the bounty area encompassed many habitats rich in natural prey, and coyotes and wolves fed mainly on small mammals, snowshoe hares, wild ungulates and arthropods. A switch in the diet of these animals could occur if there was a shortage of natural prey. However, due to the actual mosaic of agricultural fields and forests, wild canids can access a diversity of habitats and we doubt that a shortage of natural prey would occur in the near future.

There are several biases associated with scat analysis that could affect our findings such as the amount of diagnostic material a prey species contributes to a scat, and the effect of prey and meal size. We acknowledge such biases, and mistakes likely occur when assessing the importance of ≥ 2 small mammal species present in the same scat. However, our main objective was to detect the presence of cattle remains in the scats; recognizing the presence of cattle hair was fairly simple. Nevertheless, fecal analysis did not enable us to distinguish between predation events and scavenging of animal remains. Thus, the actual risk to livestock may be overestimated using fecal sampling alone when scavenging of carcasses occurs and is not indicative of actual coyote and wolf predation (Chavez and Gese 2005).

Although cattle was not an important food item for wolves and coyotes in the bounty area, we believe that the presence of cattle remains in the scats was largely the result of scavenging events rather than predation. The location of these scats, as determined by GPS, allowed us to establish a link with the presence of deadstock. Such a relationship was reported by previous researchers (Fritts 1982). Kamler *et al.* (2004) found that locations with deadstock can influence coyotes over large areas and may concentrate both resident and transient coyotes in relatively small quarters, at least for short periods. They found that resident coyotes traveled as far as 12.2 km from the center of their home ranges, suggesting that carcass locations influenced residents over a 468-km^2 area. Transient coyotes traveled from as far as 20.5 km away, suggesting that carcass locations influenced transients over a 1320-km^2 area. Danner and Smith (1980) also reported that a continual supply of livestock carrion from a feed yard influenced coyote movements over a 380- to 700-km^2 area, as radio-collared coyotes traveled from as far as 15.3 km. In that study, immature coyotes, which are often transients, visited the carrion site 5 times more often than adults, which are often residents. We believe that the presence of accessible deadstock in the fields explains the localized distribution of spring and summer coyote and wolf scats in our study area.

MANAGEMENT IMPLICATIONS

Should bounties be maintained?

While bounties are an ineffective wildlife management practice to address livestock predation by wild canids (Proulx and Rodtka 2015), a few wolves and more than 2,600 coyotes are killed every year in the combined area of St. Paul and Two Hills Counties, and annual bounty payments amount to $20,000–25,000 (Two Hills Agricultural Fieldman Elden Kozak and St. Paul Agricultural Fieldman Keith Kornelsen, 2016, personal communications). On the basis of

Figure 5. This calf died of natural causes and was left in the field for scavengers (including the producer's dogs). Note the proximity of other cows and calves – St. Paul County, June 2016.

Figure 6. A cow and its young calf at the edge of a woodlot in our bounty study area, St. Paul County, spring 2016.

this study, there is little evidence that livestock is an important food item for coyotes or wolves in the bounty area.

The maintenance of bounties may be counter-productive. Indeed, previous research has shown that removing resident wild canids may actually result in an increase in conflicts with livestock due to subdivision of existing territories, and an increase in canid densities through compensatory reproduction and colonization (Ballard and Stephenson 1982; Brainerd *et al.* 2008; Wielgus and Peebles 2014) in areas where lethal interventions occurred and in neighboring farms (Santiago-Avila *et al.* 2018). For wolves, socially fractured packs that have lost members to bounties may be less capable of effectively hunting wild prey, and thus forced to survive on whatever can be obtained. Also, coyote and wolf immigrants and dispersers could become accustomed to cattle meat as part of their diet because producers leave carcasses where they can be accessed by scavengers.

Ethics aside, the implementation of bounties in these counties appears unjustified and should be discontinued. Economically, the money invested in bounty programs could be put to a better use to reduce predator-livestock conflicts by setting up carcass removal programs, providing educational workshops to ranchers on how to prevent conflicts, investing in community range rider programs, building birthing corrals, etc.

Mitigation measures to minimize coyote and wolf predation on livestock

Although municipal governments traditionally support lethal methods and control (bounty) programs to allegedly minimize predation of livestock, pre-emptive and non-selective methods and programs have been found ineffective in the past (Proulx and Rodtka 2015; Treves *et al.* 2016). In fact, there is a growing body of scientific evidence that demonstrates lethal management of wild canids can be counterproductive when addressing predator-livestock conflicts (Wielgus and Peebles 2014; Treves *et al.* 2016; Santiago-Avila *et al.* 2018).

When lethal control is judged necessary to resolve specific predation problems, the selective removal of problem animals is more effective than any bounty program (Jaeger *et al.* 2001; Bradley *et al.* 2015). However, producers can use non-lethal methods to help prevent or minimize predation problems. Although the efficacy of some techniques is questionable, and no one method will always work in all situations (Bangs and Shivik 2001), livestock-guarding dogs are usually effective in preventing predation by wild canids in pastures (Treves *et al.* 2016; van Eeden *et al.* 2017).

We believe that leaving dead animals in fields and woodlots is a major concern when dealing with predation by wild canids. Any dead, diseased or dying animal left unguarded is an attractant for scavengers and easily identified as vulnerable prey by predators. Hauling away, burying or burning livestock carcasses rather than leaving them in the field to decay reduces the chances of attracting coyotes and wolves (Defenders of Wildlife 2016; Wolf Awareness Inc. 2017). The afterbirth from calving can also be a powerful attractant for coyotes and wolves; this should be taken into account when planning the timing and location of calving activities. Finally, hiring range riders specifically for the calving and grazing seasons to patrol the areas frequently, particularly at dawn and dusk, can minimize considerably conflicts with wild canids (Wolf Awareness Inc. 2017; V. Robinson, personal communication, April 2016 and 2017). Riders can closely monitor livestock while providing other advantages such as finding dead cattle and identifying cause of death, and providing early detection and doctoring of injuries, illness or stress in the herd. Riders can also assist with preventing livestock from overgrazing sensitive meadows and streambeds, detecting the presence of plants toxic to livestock, and reducing the chances of livestock theft. Adding this kind of personnel increases production costs for the livestock operation but may be worth the cost if losses to predators and other threats are minimized (Defenders of Wildlife 2016).

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