EFFECTS OF BLACK BEAR PREDATION ON CARIBOU--A REVIEW

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ABSTRACT: I reviewed available literature concerning black bear (*Ursus americanus*) predation on caribou (*Rangifer tarandus*) in an effort to gain insight on the possible impacts of black bear predation on a potential re-introduction of woodland caribou (*Rangifer tarandus caribou*) to north-central Minnesota. Several case histories were reviewed and inferences were drawn from several black bear-moose (*Alces alces*) studies. I concluded that black bear predation on woodland caribou in the proposed re-introduction area would likely be a secondary source of caribou mortality and that between 6-30% of the calves and 0-5% adults might be killed annually by black bears.

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Predation has been identified as a major limiting factor in many populations of ungulates. The majority of these losses generally occur among juvenile age classes. Because predation can limit ungulate populations, it can potentially impact re-introductions of ungulate species into areas from which they have been extirpated. The North Central Caribou Corporation is in the process of completing plans for a potential re-introduction of woodland caribou (*Rangifer tarandus caribou*) into north-central Minnesota. Predation, particularly by wolves (*Canis lupus*) (Bergerud and Elliot 1986), has been identified as a potential factor which could result in the failure of this re-introduction. However, other predator species also occur in the area.

Black bears (*Ursus americanus*) have recently been identified as important predators of juvenile ungulates in several areas of North America (Schlegel 1976, Franzmann *et al.* 1980, Adams *et al.* 1988). Black bears are moderately abundant within the proposed re-introduction area (i.e., 159 to 244/1,000 km^2 [Rogers 1987]), and predation by them could be a significant factor in the success or failure of the re-introduction. Because of the above concerns the North Central Caribou Corporation desired additional information concerning the potential of black bears to impact the woodland caribou re-introduction to Minnesota. The purpose of this report is to review information concerning black bear predation on caribou in general, and on woodland caribou in particular.

METHODS

I reviewed literature concerning black bear predation on ungulates in North America and relied heavily on the review papers by Truett *et al.* (1989) and Ballard (1992), and on the bibliography on *Rangifer tarandus* compiled by Kreeger and Fleming (1991). I contacted a number of individuals seeking unpublished information on the subject; however, this report is not an exhaustive review of black bear predation on caribou. I may have omitted some studies concerning woodland caribou; however, I believe the information presented is representative of the state of knowledge concerning woodland caribou-black bear relationships.

CASE HISTORY STUDIES

Most studies on bear-caribou relationships concern barren ground caribou and grizzly bears (*Ursus arctos*) in tundra ecosystems (Page 1976, Garner and Reynolds 1986, Bergerud and Page 1987, Adams *et al.* 1988, Whitten *et al.* 1992). In all cases, predation by wolves and grizzly bears was found to be a significant cause of calf caribou mortality.

Although these studies did not involve black bears, some inferences can be drawn concerning the timing of mortality and the potential significance of black bear predation on woodland caribou. Also, there have been several studies which have concerned black bear predation on woodland caribou.

Newfoundland

Mahoney *et al.* (1990) provides the largest data set concerning the impacts of black bears on woodland caribou. Between 1979 and 1984 they determined causes of mortality of 220 radio-collared newborn caribou calves within three woodland caribou populations in Newfoundland. Twenty-three percent of the calves died during their first year of life with predation accounting for 78% of the deaths. Predation by lynx (*Lynx canadensis*) and black bears was each responsible for 35% of the mortalities. Of 52 mortalities, 23 (44%) occurred within 2 weeks and 62% occurred within 4 weeks of birth (Mahoney *et al.* 1990). There were no differences in vulnerability of calves by sex or weight. Wolf predation was not a factor because they no longer occur in Newfoundland (Mahoney *et al.* 1990). No estimates of black bear density were provided and the three caribou populations totaled 17,713 $\pm$ 15% individuals (Mahoney et al. 1990). The observed total mortality rate of 23% for calves aged $\leq$12 months was not sufficient to limit population growth during the study period.

Gaspesie Park, Québec

Crête and Desrosiers (1994) reported on the status of the Gaspesie Park caribou herd which was declining due to low recruitment. Twelve of 13 calves born to radio-collared caribou during 1988 were lost during the summer (majority in July); predation by black bears and/or coyotes (*Canis latrans*) was suspected as the cause of these deaths. Newborn calves were also radio-tagged in 1989 and 1990 with 16 of 25 calves dying during the first summer of life. Indices on the cause of death were found for 11 cases; coyotes, black bears, and golden eagles were thought to be responsible for 11, 3, and 1 mortalities, respectively. Yearling and adult female caribou experienced high annual survival between 1987 and 1992 (>90%) and no cases of predation were observed during 11,915 caribou-days of monitoring. Black bear feeding stations were in operation during 1989 and Crête *et al.* (1991) concluded that the stations could have reduced bear predation rates.

Grand-Jardins Park, Québec

Efforts have been underway to restore caribou to Grand-Jardins Park since 1969 when 41 fawn and yearling caribou were released into the Park (H. Jolicoeur, unpubl. data). However, only 12 of the animals survived or stayed in the area. No caribou were released in 1970 but an additional 25 fawns and yearlings were released in 1971. The latter animals remained in the area apparently because they formed an association with the 12 surviving adult animals from the 1970 release. An additional 12 adults were released in 1972. This herd has increased at an average rate of 5% since 1970 (Cantin 1991) and currently numbers 125 animals (H. Jolicoeur, unpubl. data).

Wolf densities within this area were reduced during 1979 and 1980 and are currently 10 wolves per 1000 km^2 (H. Jolicoeur, unpubl. data). Black bear density was estimated at 220 per 1000 km^2. The meningeal worm (*Parelaphostrongylus tenuis*) was not present in this area (H. Jolicoeur, pers. commun.). Crête (pers. commun.) suggested that the existence of escape habitats (open landscapes) such as alpine tundra or large bogs could play a key role in allowing introduced caribou to increase where bears and wolves exist.

Southeastern British Columbia

Seip (1992) reported on the status of two woodland caribou herds in southeastern British Columbia and sought to identify limiting factors. Woodland caribou populations de-

clined or disappeared from this area during the 1900's. Over-hunting was blamed in many cases, but other populations without hunting exhibited similar declines. In a non-migratory caribou population the distribution of wolves, grizzly and black bears, and caribou overlapped while in a migratory population wolf and moose (*Alces alces*) distribution did not overlap that of caribou during summer. No mention was made of bear distributions but I assume they probably overlapped. Within the non-migratory Quesnel Lake caribou population wolves and bears (both grizzly and black bears) accounted for 55 and 15%, respectively, of the adult mortality. About half of the calves died of unknown causes during the calving period. Seip (1992) suggested that calf survival was related to wolf abundance during summer and that wolf predation was driving the caribou population towards extinction.

Within the migratory Wells Gray Park caribou population, Seip (1992) estimated that the adult caribou mortality rate was 8% with most of the mortality being attributed to bear predation (apparently both species). Approximately 40% of the adult female caribou had surviving calves and the population was stable or slowly increasing. Seip (1992) concluded that the differences between the two populations were due to differences in wolf predation and overlaps in distribution of alternate prey (i.e., moose) and wolves.

Seip (1991) concluded that forest-dwelling caribou in Ontario, Saskatchewan, Alberta, and the non-mountainous regions of British Columbia had declined or were eliminated due to wolf predation and human harvest. Increased wolf densities following the range expansion of ungulates such as moose, elk and deer has resulted in greater predation pressure on resident caribou. Caribou persist in large numbers in northern or high elevation areas where predation and hunting pressures are reduced. In southern areas they continue to persist in low numbers where they can avoid predators by calving or living on islands (D. R. Seip, B. C. Ministry of Forests, Burnaby, pers. commun.).

Baxter State Park, Maine

During 1989, 12 woodland caribou were released in Baxter State Park, Maine (McCollough and Connery 1990). Within 6 months of the release 10 of the 12 died; at least five died or "were predisposed" to meningeal worm, one died from abomasal ulcers, one from either a fatal accident or black bear predation, and 3 died apparently from black bear predation. Black bear density was estimated at about 232/1,000 km^2, coyote density at 183/1,000 km^2, and no wolves were present. The authors pointed out that two major factors (i.e., disease and predation) suggested by Bergerud and Mercer (1989) as being responsible for both the decline of caribou in North America and failure of recent reintroductions were also responsible for the reintroduction failure in Maine.

EFFECTS OF BEAR PREDATION ON CARIBOU

Prior to the use of radio telemetry on neonates, bears were largely thought of as scavengers of ungulates (Jonkel 1978). Since Schlegel's (1976) study of elk (*Cervus elaphus*) calves, black bears have been identified as significant predators of neonatal elk (Schlegel 1976), moose (Franzmann *et al.* 1980, Ballard 1992), deer (*Odocoileus* sp.) (Wilton 1983, Conger and Giusti 1992), and caribou (Mahoney *et al.* 1990). Wilton (1983) summarized observations of black bears preying on ungulates in North America and concluded that they should be considered effective predators of ungulates throughout their range. Black bears are not considered effective predators on adult moose (Ballard 1992), but Mercer (1986, cited in McCollough and Connery 1990) and Seip (1991) suggest that black bears may account for the majority of adult caribou mortality. Also, V. Crichton (Manitoba Dep. of Nat. Resources, Winni-

peg, pers. commun.) reports an increasing incidence of anecdotal reports of black bears preying on adult moose in Manitoba and Ontario (Austin *et al.* 1994). In other areas scattered anecdotal accounts of black bears preying on adult caribou exist, but black bears are not considered significant predators of adult caribou (V. Crichton, pers. commun; L. G. Adams, U. S. National Park Service, Anchorage, Alas., pers. commun.). Regardless, black bear predation is a significant source of mortality to neonates in many ungulate populations.

Predation has been reported in many studies to be the most significant mortality factor affecting caribou populations (Miller and Broughton 1974, Bergerud 1980). Most mortality of caribou neonates due to predation occurs during the first month of life (Bergerud 1971, 1980; Miller and Broughton 1974; Jakimchuck 1979; Miller 1987; Adams *et al.* 1988, Mahoney *et al.* 1990, Whitten *et al.* 1992;). Generally the most abundant predator species constitutes the largest source of mortality (Truett *et al.* 1989). However, this is not always true, particularly with regard to black bear predation. Ballard *et al.* (1990) examined the causes of mortality to neonate moose in southcentral Alaska where black bears outnumbered grizzly bears and wolves by factors of 3.2 and 32, respectively. Grizzly bears killed 52% of the calves followed by 9% for black bears and 7% by wolves. Thus occurrence of predator species, their relative predation efficiency and density, and prey density probably affect which predator species are the most significant cause of mortality.

Neonatal moose are most vulnerable to bear predation during their first 6 weeks of life (Ballard *et al.* 1981). Subsequently their increased mobility appears to make them increasingly less vulnerable to bear predation (Ballard *et al.* 1980). Newborn caribou calves also suffer their highest mortality during the first 1-2 months of life and become less vulnerable to at least bear predation with increasing age and mobility (Truett *et al.* 1989, Adams *et al.* 1993).

Predation by black bears has accounted for the deaths of from 2 to 50% of radio-collared moose calves in various areas of North America (Table 1). Ballard (1992) concluded that black bears were a significant source of mortality to moose calves when they out number grizzly bears and wolves by factors of 10 and 30, respectively, or their densities were >200/1,000 km^2. Although only based on two studies from the Kenai Peninsula, Alaska, Ballard (1992) also concluded that black bear kill rates (functional response) appeared to be dependent upon the densities of moose calves while the percent of the moose population killed (functional and numerical response) was not dependent on moose densities. Based upon the aforementioned studies the importance of black bear predation as an ungulate limiting factor is dependent upon the density of black bears in relation to the number and density of other predator and prey species. It is not known whether black bear predation is a learned phenomena, or whether it has occurred all along. It may not have been detected earlier because many food habits studies have relied on scat analyses which would underestimate the importance of ungulates (Ballard and Larsen 1987).

POTENTIAL EFFECTS OF BLACK BEARS ON WOODLAND CARIBOU RE-INTRODUCTIONS IN THE BOUNDARY WATERS CANOE AREA WILDERNESS

Bergerud and Mercer (1989) have suggested that even in the absence of deer (the source for *P. tenuis*) when wolf densities exceed 10/1,000 km^2, caribou re-introductions will fail. Bergerud and Elliot (1986) indicated that in general, caribou populations can not maintain their numbers when wolf densities are $\geq$6.5/1,000 km^2 in the absence of

escape habitat. The increasing caribou population at Grand-Jardins Park, Québec appear to fit their prediction in that the caribou herd has been increasing at 5% annually (Cantin 1991), wolf and black bear densities have been estimated at 10 and 220/1,000 km^2, respectively (H. Jolicoeur, unpubl. data), and adequate escape cover exists (M. Crête, pers. commun.). Wolf densities within the proposed Minnesota caribou reintroduction area have been estimated at 16 to 20/1,000 km^2 (Nelson and Mech 1992). Nelson and Mech (1992) acknowledged that their reported wolf densities were well above the threshold reported by Bergerud and Elliot (1986) and Bergerud and Mercer (1989), but that caribou coexisted in other areas with higher wolf densities: Spatsizi Provincial Park, British Columbia (16 wolves/1,000 km^2), Lake Nipigon, Ontario (10-14 wolves/1,000 km^2), and Pukaskwa Park, Ontario (14 wolves/1,000 km^2). None of the aforementioned authors mentioned bear predation.

Bergerud *et al.* (1983) mentioned that the caribou population at Pukaskwa Park numbered 20-30 animals and that wolves seldom preyed upon them. Black bears also occur in the area, but their densities are unknown (G. Eason, Ontario Ministry of Natural Resources, Wawa, pers. commun.). The caribou in this area have apparently declined, and only a few remained in the area by 1992 (G. Eason, pers. commun.). Causes for this apparent reintroduction failure are unknown.

Bergerud *et al.* (1990) suggested that caribou successfully calved on islands to escape predation by wolves. Nelson and Mech (1992) also suggested that islands at Lake Nipigon, Ontario provided escape habitat for caribou from wolf predation. V. Crichton (pers. comm.) indicates that woodland caribou on the east side of Lake Winnipeg, Manitoba traditionally calve on islands in large lakes and on occasion within bogs. These herds are composed of 40-100 individuals. Prior to 1978 few black bears were observed on the islands, but since 1978 numerous black bears have been observed, and the caribou population has apparently remained stable. It is unknown whether black bears are preying on caribou calves, but the recent occurrence of bears on the islands suggests that they may be preying on caribou calves. Hair from adult caribou has been found in bear feces during July, but it is not known whether these observations represent carrion feeding or actual predation.

Caribou persist at low densities (about 0.02/km^2) where wolf density is high (16/1,000 km^2) at Spatsizi Provincial Park, British Columbia (A. T. Bergerud, Univ. of Victoria, British Columbia, pers. comm.). Both black and grizzly bears occur in the area, but their importance as predators has not been studied. However, if they prey on caribou the magnitude of such predation would be secondary to that by wolves.

Pitt and Jordan (1992) examined the use of islands by black bears within the Boundary Waters Canoe Area by examining usage of bait stations at islands with and without human camp sites. They found that black bears appeared to be more abundant on islands with camp sites than those without camp sites. Although their study results were limited because they could only place bait stations within 1 km of camp sites (this limited the size of the island which could be studied--W. Pitt, Utah State Univ., Logan, pers. commun.) their results have a direct bearing on bear usage of island sites. Islands with camp sites appeared to be occupied less frequently by wolves but more frequently by bears (W. Pitt, pers. commun.). Apparently bears were attracted to the islands because of the presence of food associated with humans. Because woodland caribou use islands as escape habitat during calving, the attraction of bears to island sites occupied by campers will increase the frequency of bear-caribou interactions. This may result in increased bear predation because of the presence of human camp sites.

Table 1.Causes of mortality and survival rates of radio collared moose calves to November in relation to observed kill rates and predator densities in North America (modified from Ballard 1992).

	South central Alaska				Kenai Peninsula, AK						
Areas	Area 1-3	Area 1	Area 4	Areas Pooled	1947 Burn	1969 Burn	Southwest Yukon[a/]	Eastcentral Alaska	Saskat-chewan	New Brunswick	New-foundland
Years	1977,1978	1979	1984	1977-84	1977,1978	1981,1982	1983,1985	1984	1982	1983,1985	1983-88
No.calves	124	28	46	198	47	74	117	33	12	11	88
Causes of mortality (%)											
Grizzly bear	41.9	42.9	52.2	44.0	6.4	2.7	41.9	51.5			
Black bear			8.7	2.0	34.0	35.1	3.4	3.0	50.0	9.1	30.0
Grizzly & black								2.7			
Wolf	1.6		6.5	2.5	6.4	1.4	17.9	15.2			
Unknown predation	2.4			1.5	4.3	2.7	2.6				
Misc.	4.8	14.3	13.1	8.1		5.5	6.0	12.1		9.1	
Unknown causes	3.2		2.2	2.5	1.3	1.4	9.4				
Surviving (%)	46.0	42.9	17.4	39.4	44.6	48.5	18.8	18.2	50.0	81.8	70.0
Density (no./1000km^2)											
Grizzly bear	24	10	28	24-28	12-28	12-28	16	16	0	0	0
Black bear	0	0	90	0-90	205	258	16[b/]	8-11	200-400	mod.?	570

Table 1. continued...

Density (No./1000km^2)											
Wolf	1.8-3.6	2.3	2.8	1.8-3.6	11	11	4.1[c/]	4.0	Low?	0?	0
Moose	650	700	892	65	01,000	3,700	220	175	450	?	3,000
Kill rates											
Grizzly bear											
calves/ bear/day				0.097			0.085[d/]	0.143			
adults/ bear/day				0.023			0.022				
Black bear											
calves/ bear/ day			0.025		0.019[d/]	0.103[d/]					
Source[e/]	1	2	3	3,4	10,12	9,12	11	7,8,15	5,13	6	14

[a/] Causes of mortality and survival rates are annual estimates.

[b/] Black bear densities were not estimated but were thought to be similar to grizzly bear densities (D.G. Larsen, pers. comm.).

[c/] Average late winter density for 1983 and 1985.

However, if wolves are more abundant on islands not occupied by humans, then caribou may be subjected to high levels of wolf predation on islands without human camp sites.

Using the wolf densities reported by Nelson and Mech (1992), it appears that the area considered for caribou reintroduction exceeds the threshold level of wolf densities that Bergerud and Mercer (1989) indicated were necessary for caribou to survive. Assuming that black bear densities are similar to those reported by Rogers (1987) for the Superior National Forest (159 to 244 bears/1,000 km^2), bear densities approach the level suggested by Ballard (1992) for black bears to be a significant source of mortality. Based upon both the reported bear, wolf, and deer (i.e., <386/1,000 km^2, Pitt and Jordan 1991) densities within the proposed reintroduction area and reviewed literature, black bears might kill between 16 to 30% of the calves produced by adult woodland caribou, and may kill 0-5% of the adults annually. The accuracy of these estimates would depend upon the magnitude of wolf predation. In any case, the evidence suggests that in the presence of wolves, black bear predation will be a secondary source of mortality which could be additive to other sources of mortality.

The success or failure of the caribou reintroduction may depend on the timing and numbers of caribou released during the initial reintroduction. If black bear predation is, in part, a learned phenomenon then it would appear that introduction of large numbers of caribou at the initial stages of the project may allow caribou to establish a foot-hold before bears and wolves learn of their presence. It may also be advisable to establish diversionary feeding stations as was done by Crête *et al.* (1991) and Boertje *et al.* (1992) which may reduce black bear kill rates. At low caribou numbers the increased survival of just a few individuals can make the difference between success and failure of a caribou transplant. Although my analysis is based upon reviewed literature, I point out that the interactions between caribou and black bears, particularly woodland caribou, are poorly understood as suggested by the paucity of studies cited in this review.

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