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PRELIMINARY OBSERVATIONS OF TIMING AND CAUSES OF MOUNTAIN GOAT KID MORTALITY IN WEST-CENTRAL ALBERTA.

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ABSTRACT: The timing and causes of mortality of 11 of 26 radio-collared mountain goat (Oreamnos americanus) kids were monitored from June 1988 to April 1992 in west-central Alberta. The annual mortality rate of radioed kid to yearling age was 42%. Most mortalities (8/11) occurred by 30 November of each year and were caused by wolves (Canis lupus) (3/8), and grizzly bears (Ursus arctos) (2/8). A cougar (Felis concolor)-caused mortality, a fall, and a suspected grizzly bear-caused mortality accounted for the other 3 autumn deaths while the cause(s) of the 3 winter deaths were unconfirmed. We suggest that predation on kids is a major cause of poor recruitment into mountain goat herds in Alberta.

"Variation in age-specific mortality rates is the primary cause of different rates of increase for ungulates (Caughley 1970, 1976). Accordingly, managers charged with regulating harvests of ungulates should have knowledge of both the magnitude and agents of mortality.

Unfortunately, age-specific mortality rates of free-ranging ungulates are difficult to obtain. Indirect estimates, based on life tables derived from hunter-killed animals, are commonly used but are jeopardized by violation of several assumptions inherent in life table construction (Caughley 1977:90-96). Direct estimates of mortality based on marked animals are superior, particularly when animals are fitted with radio transmitters that provide certain knowledge of the fate of all animals in the sample (Heisey and Fuller 1985)" (Smith 1986:743).

Indirect estimates of mortality rates for kid and yearling mountain goats have been published (Hibbs 1966, Holroyd 1967, Rideout 1978, Stevens and Driver 1978, Youds et al. 1980, Adams and Bailey 1982). Moreover, Smith (1986) provided direct estimates of age-specific mortality rates and causes of death for mountain goats 1 year of age and older and concluded that predation and other natural causes of mortality primarily affected yearlings and goats older than 8 years. Prime-aged goats (age 2 - 8 years) were relatively invulnerable to natural mortality factors, but suffered considerable hunting mortality.

One factor which may limit population growth is the poor survival of mountain goat kids. On average, only half of the kids produced each year survive to yearling age (Chadwick 1983). Chadwick (1983) speculated on possible causes of high kid mortality and concluded that winter weather was the main limiting factor.

Annual mountain goat surveys in the Willmore Wilderness Area of west-central Alberta have been conducted since 1973. Results indicated a steady increase in mountain goat herds exposed to a a limited harvest of approximately 5 percent until 1980 (Smith 1988b). This increase appeared to be largely due to relatively good productivity and survival to 1 year. However,, between 1980 and 1983, populations began to decline coincident with poor kid:adult ratios and survival of kids. This decline occurred despite a reduction in harvest and very mild winter weather. Unhunted herds used as "controls" maintained themselves or increased slightly over the same time frame. However, they too experienced reduced kid:adult ratios and survival of kids although not at the same magnitude as hunted herds.

Direct assessment of mountain goat kid mortality has been limited to monitoring radio-collared or marked nannies with kids at heel (Joslin 1986, Foster and Rahs 1983). This technique has allowed the evaluation of timing and magnitude of kid mortality but not the causes.

Our study was designed to assess the timing and proximate causes of mountain goat kid mortality using radio-marked animals from June 1988 through April 1992.

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STUDY AREA

The Caw Ridge study area (54°N,119°W) is located approximately 30 km northwest of the town of Grande Cache, Alberta (Fig. 1). Caw Ridge is a front range of the eastern slopes of the Rocky Mountains and is separated from the main range by large tracts of coniferous forest. Areas used by mountain goats (approximately 21 km^2) range in elevation from 1750 to 2170 m. The weather is characterized by long, cold winters and cool, wet summers with annual precipitation averaging 540 mm. Above treeline (about 1950 m), the alpine meadows are comprised of grass and sedge species as well as lichens, mosses and a variety of herbaceous species. Vegetation below treeline is dominated

Fig. 1. Five mountain goat survey areas in west central Alberta including the location of the Caw Ridge study area.

by white spruce (Picea glauca) and alpine fir (Abies lasiocarpa) with lodgepole pine Pinus contorta) on fire-regenerated sites.

About 25-30 bighorn sheep (Ovis canadensis) inhabit the ridge, which is along a migration route and staging area for at least 250 woodland caribou (Rangifer tarandus). Elk (Cervus elaphus), mule deer Odocoileus heminous) and moose (Alces alces) are also present at low densities. Potential predators include wolves, coyotes (C. latrans), grizzly bears, black bears (U. americanus), wolverines (Gulo gulo), cougars and golden eagles Aquila chrysaetos). Further descriptions can be found in these proceedings (Fournier 1992) and Smith (1988b).

METHODS

Mountain goats were trapped in self-tripping clover traps and remotely-triggered Stevenson box traps baited with salt. Adults were immobilized by IM injection of xylazine. The effect was later reversed by IM injection of Idazoxan (Jorgenson et al. 1990). Adult females were fitted with color-coded radio collars or canvas collars and ear tags. Kids were handled without drugs and radio-collared with an expandable, break away elastic collar stitched with biodegradable thread. Each transmitter contained a 4-hour mortality switch (Telonics, Inc., Mesa, Ariz.). Standard measurements and weight were recorded and each kid was tagged with small Allflex ear tags. Collared kids were monitored daily from the ground for the period July 1989 to November 1991. Monthly helicopter relocations were conducted from December 1991 to April 1992.

Survival rates were estimated by dividing the number of mountain goat kids collared at time t and still alive at time t + 1 year by the number of collared kids at time t. We determined the cause of mortality by evidence at the mortality site including the presence of predators, hair, scats, tracks, the condition of the carcass (buried, covered or scattered) and presence of prey stomach contents. Scats were identified as bear, wolf or cougar based on size and shape characteristics (Larsen et al. 1989, Pall et al. 1988). The identity of predators could not be confirmed for the 3 mortalities which occurred during winter due to continued snow fall.

The study area was censused daily whenever weather permitted, if censusing did not affect trapping operations. Mountain goats were located visually or by following signals from radio collars. Groups were observed with binoculars and spotting scopes and location (UTM coordinates), group size and composition, identity and percent molt of marked goats were recorded.

Helicopter surveys of Caw Ridge and 4 other complexes were conducted in July 1991 and again between December 1991 and February 1992 in order to determine if the same pattern of autumn kid mortality that was being observed at Caw Ridge was also occurring in other herds in west-central Alberta. During the survey, mountain complexes were flown in a counter-clockwise pattern above timberline. The navigator-principal observer was to the left of the pilot, the second observer was in the left rear seat with the recorder in the right rear seat.

Mountain goats were classified as kids, yearlings and adults based on size (Smith 1988a). The July surveys were conducted between 0600-0900 and between 1700-2200 when goats were most active. The winter surveys were conducted throughout the day and tracks in the snow were utilized to locate herds.

RESULTS

A total of 26 mountain goat kids were radio-collared between June 1988 and August 1991. Kids were captured between 2 and 17 weeks of age ($\bar{x}$ = 9.7) assuming June 1 as date of birth. The annual mortality rate from kid to yearling age was 42% (Table 1). Most losses (8/11 = 73%) occurred by 30 November of each year. Wolves and grizzly bears accounted for 3 and 2 of the summer/fall deaths, respectively. A cougar, a fall and a suspected grizzly bear contributed to the other kid losses during that time of year (Table 2). Although the cause(s) of the 3 winter deaths could not be confirmed, wolves and a cougar were implicated by the presence of tracks and scats in 2 of the 3 cases.

Table 1. Mortality rates of radio-collared mountain goat kids at Caw Ridge, Alberta, 1988-1992.

Year	Mortality Rate (N)
1988-1989	0% (2)
1989-1990	40% (10)
1990-1991	46% (11)
1991-Apr 1992	67% (3)
TOTAL	42% (26)

Table 2. Timing and causes of mortality of 11 collared mountain goat kids, west-central Alberta, July 1989-April 1992.

Date	Cause	Sex of kid	Habitat[a]	Time between last live signal and discovery of carcass
16 Sep 1989	Wolves	Male	Subalpine	25 hr.
3 Oct 1989	Grizzly Bear	Female	Subalpine	6 hr.
28 Nov 1989	Wolves	Male	Krumholz	22 hr.
11 Feb 1990	?	Male	Subalpine	22 hr.
19 Aug 1990	Fall	Female	Krumholz	6 hr.
10 Sep 1990	Wolves	Male	Subalpine	20 hr.
21 Oct 1990	Grizzly Bear	Female	Subalpine	2 days
23-28 Oct 1990	?Grizzly Bear	Male	Krumholz	2 days
25-30 Jan 1991	?Cougar	Male	Subalpine	5 days
14 Sep 1991	Cougar	Female	Krumholz	3 days
14 Feb-31 Mar 1992	?Wolves	Female	Subalpine	45 days

[a]Subalpine = forested area below timberline, Krumholz = timberline

Aerial survey results indicated that the pattern of kid mortality observed on Caw Ridge in the fall of 1989 and 1990, did not occur on Caw Ridge in 1991 nor in any of 4 other mountain complexes (Fig. 2).

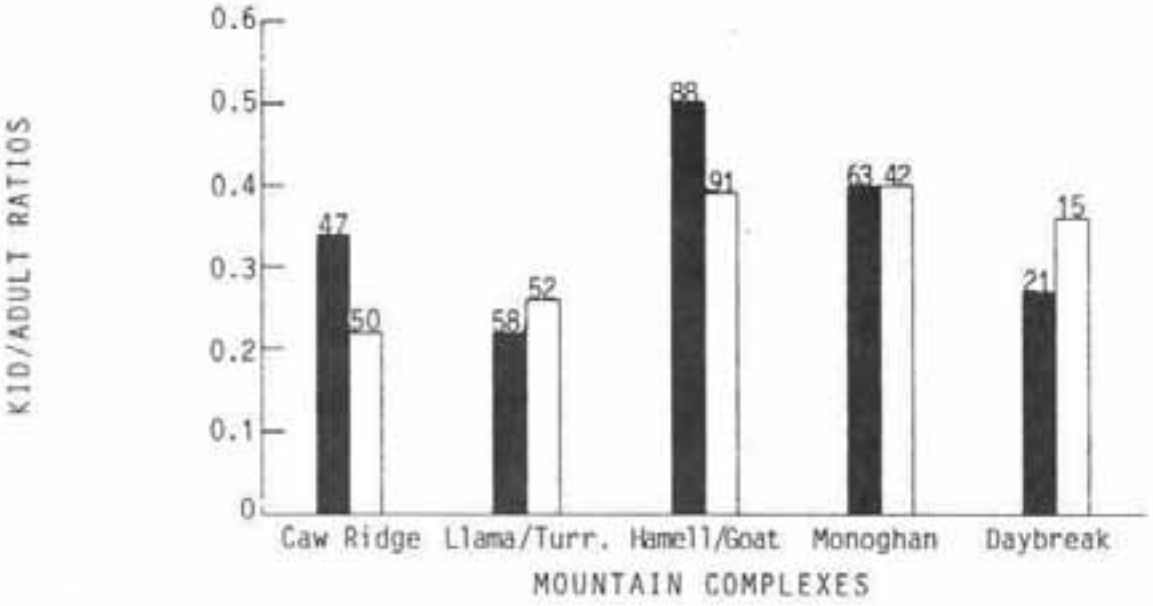

Fig. 2. Mountain goat aerial survey results for 5 mountain complexes in west central Alberta during July 1991 (solid bars) and December 1991, January and February, 1992 (open bars). (Numbers above bars are sample size).

DISCUSSION

Our original hypothesis was that the majority of mountain goat kid mortality at Caw Ridge would occur during winter (1 Dec-30 Apr) when deep snow and cold temperatures would reduce the availability of forage (that had already declined in food value) thereby placing the smallest members of the herd in a negative energy balance (Hobbs 1989). Moreover, snow would also restrict movements of mountain goats and increase the likelihood of predation. Because the majority of the kid mortality occurred by 30 November in 1989 and 1990 (when the sample size was 10 and 11, respectively) we reject this hypothesis.

In almost all instances, grizzly bear and wolf predation occurred at or below timberline. In 2 of the 3 years (1990 and 1991), mountain goats at Caw Ridge increased the amount of time spent foraging at timberline during the fall (Fig. 3). In the year when this habitat shift did not occur (1989), summer rainfall (Jun-Aug) was almost double that observed during the 2 subsequent years (Fig. 4). This might suggest that high precipitation during the summer months may have maintained green-up for a longer period which encouraged mountain goats to remain in alpine habitats later into the fall. Conversely, snow accumulation in the fall might be expected to drive mountain goats out

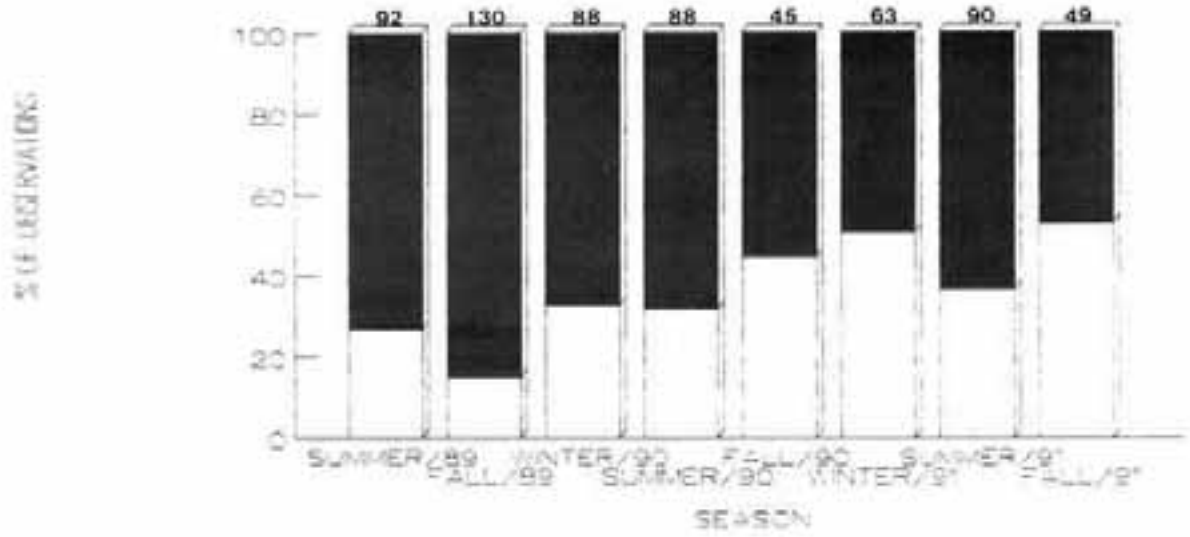

Fig. 3. Seasonal habitat use by mountain goats on Caw Ridge, Alberta, June 1989-November 1991. (Summer = Jun-Aug; Fall = Sep-Nov; Winter = Dec-May; solid bars = alpine habitat; open bars = treed habitat; numbers at top of bars are sample size).

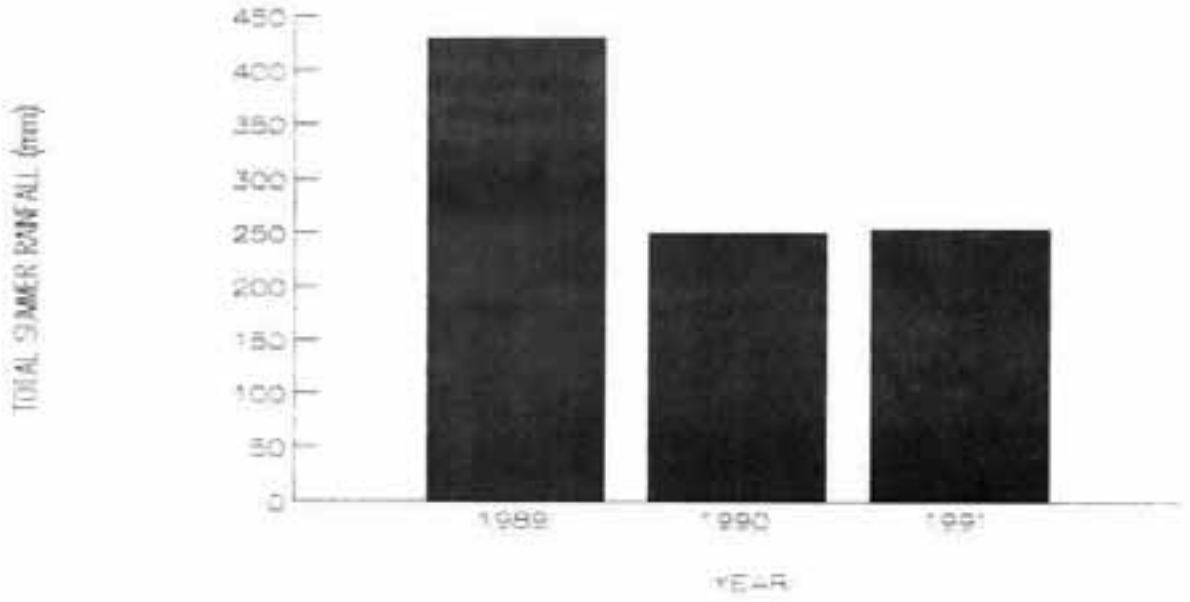

Fig. 4. Comparative summer rainfall (Jun-Aug) for 1989-91, Grande Cache, Alberta.

of the alpine. However, the snowfall accumulation in 1990 (Sep-Nov) was more than double that experienced in the year previous or the year following (Fig. 5) without any noticeable effect in habitat selection in the fall of 1990 (Fig. 3). Sample size is small and no conclusions can be made.

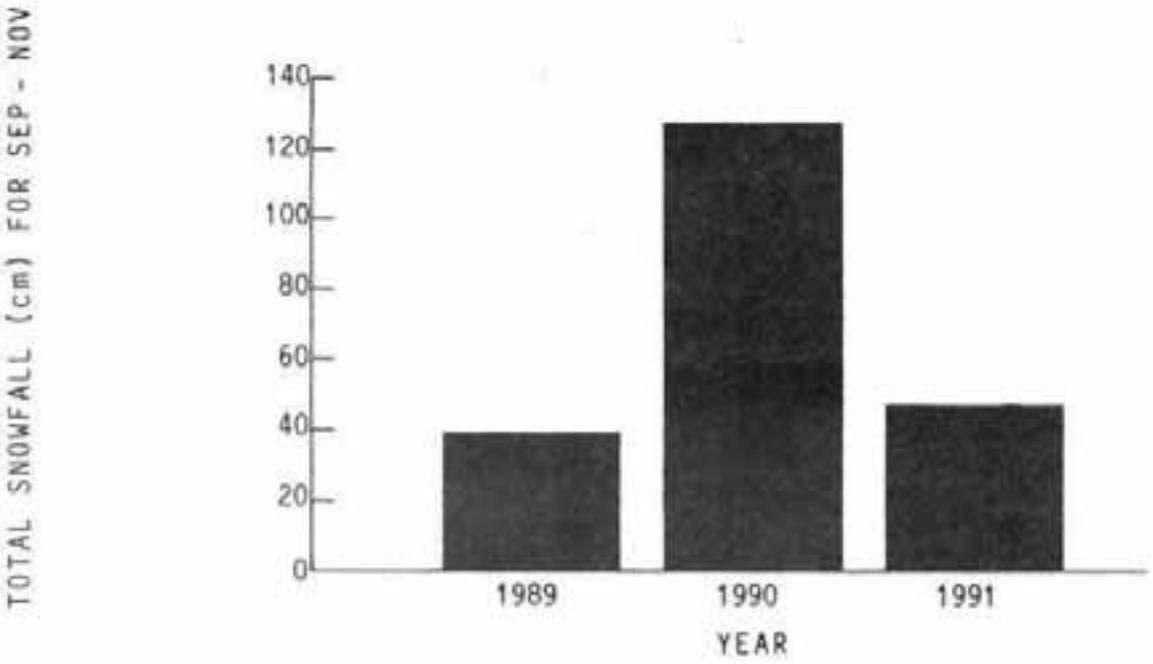

Fig. 5. Comparative autumn (Sep-Nov) snowfall for 1989-91, Grande Cache, Alberta.

If the search for green forage results in mountain goats shifting to timberline habitats in autumn it should reduce their ability to visually detect predators and might take them further from escape terrain. This coincides with the period when grizzly bears may also be feeding on mast crops in the same vegetation zone (Mundy and Flook 1973, Russell et al. 1979, Hamer and Herrero 1983). In addition, we suspect that the number of wolves on the study area may increase in the fall as they follow up to 250 woodland caribou which are migrating out of the mountains to winter in the boreal forest foothills. (Caw Ridge provides the major staging area for woodland caribou in west central Alberta and has also provided winter range for up to 50 woodland caribou in 1990/91). Cougar predation is a recent development and occurs throughout the year. Increased use of treed habitats might be expected to result in increased predator caused mortality of kids; however, there wasn't a detectable difference in the mortality rate of radio-collared kids between 1989 and 1990 despite a much greater use of treed habitat in the latter year (Fig. 3). (The 1989 and 1991 radio-collared samples were insufficient to detect a pattern).

Joslin (1986) monitored the reproductive histories of 11 marked female mountain goats from 1979-86 along Montana's Rocky Mountain

Front. In 4 cases, the earliest dates where the absence of a kid at heel was reported were 28 July, 31 July, 10 October and 13 October. In a fifth instance, the kid was missing sometime between 11 August and 25 February (G. Joslin, unpubl. data). The timing of mortality at Caw Ridge appears to be similar to that reported in Montana. Mortality of the radio-collared sample at Caw Ridge was not significantly different from the unmarked kids (Table 3; $\underline{x}^2 = 0.00$; 1 df; $\underline{P} < 0.0001$).

Table 3. Mortality of radio-collared vs unmarked mountain goat kids at Caw Ridge, Alberta, 1989-91[a]

Kid I.D.	Died	Survived	Total
Radio-collared	9	12	21
Unmarded	8	11	19

[a]Data are not available for unmarked kids in 1988 or 1992.

We are not able to provide a direct estimate of post-natal mortality since kids were not radio-collared immediately following birth. However, results from daily censusing efforts indicated that total kid numbers on 1 June of 1990 and 1991 did not decline any more by the end of the trapping season (mid Oct) than would have been expected based on the radio-collared sample.

We believe that predators and/or predator sign found at kid mortality sites within 72 hours indicate that predation was the cause of death. Ballard et al. (1981) suggests that large carnivores do not find moose calf carcasses until $\geq$30 hours after death. Similarly, Franzmann et al. (1980) found that moose calves were not scavenged by wolves and bears up to 8-10 days following death. Any of the Caw Ridge mortality sites that weren't visited by the observers within 72 hours were considered unconfirmed (Table 1).

In only 1 instance was the separation of the kid from the female thought to have contributed to the mortality of the radio-collared kid (the mortality resulting from a fall). In all 25 other cases, the female and kid were observed together following capture and abandonment was not considered a factor in subsequent mortality (see Livezey 1990).

We are not aware of any significant disease agents or parasites that have limited other mountain goat populations (Cooley 1976, Hebert et al. 1977, Kerr and Holmes 1966, Samuel et al. 1975). Forage availability appears to be exceptional at Caw Ridge and nutritional stress is not considered a limiting factor predisposing kids to predation; particularly during the period when the majority of mortality was detected. With the exception of the mortality caused by the fall, there was insufficient material at any of the mortality sites to provide samples for the determination of body condition.

Eight of the 9 known-age nannies whose kids died were 5 or 6 years of age. Although we have documented reproduction by nannies at Caw

Ridge at 4 years of age, the majority do not conceive until age 5. Therefore, it would appear that the majority of kids which died in their first year were offspring of first or, at most, second time mothers. In addition, none of the 4 members of the 2 sets of twins observed during the course of the study, survived to their first birthday.

The aerial survey data (Fig. 2) supports the rationale of being able to extrapolate kid mortality rates and timing from Caw Ridge to other herds in west-central Alberta. However, the pattern of mortality observed in 1989 and 1990 (73% by 30 Nov) was not detectable in either the radio-collared sample (only 3) or the aerial survey sample for 1991. It would be desirable to obtain aerial survey information in a year with a greater fall mortality of kids as documented in the 2 previous years.

In summary, preliminary evidence indicates that the majority of mountain goat kid mortality on Caw Ridge occurs before November 30 of each year and it is a result of predation by wolves, grizzly bears and cougar. Summer precipitation may influence mountain goat distribution; however, the increased seasonal density of large predators at or near timberline would appear to be the single, most important factor influencing the timing and amount of mortality. On a provincial basis, all of these predators would not influence all mountain goat herds (wolves decrease in density in a north-south gradient while cougars increase). However, kid mortality rates are comparable throughout the Province of Alberta and, in fact, may be similar to many herds in North America (Rideout 1978, Chadwick 1983). Management objectives for grizzly bears and cougars in Alberta are to increase the number of both of these species while only site-specific, temporary reductions in wolves have been targeted in exceptional circumstances (Alberta Fish and Wildlife 1990, 1991, 1992). Consequently, a predator reduction program to enhance mountain goat kid survival will not be implemented in Alberta and further work will be required before mortality rates can be accurately predicted.

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