

Note

Behavioural reactions of bighorn sheep (*Ovis canadensis*) to cougar (*Puma concolor*) attacks

Comportement du mouflon d'Amérique (*Ovis canadensis*) lors d'attaques par le cougar (*Puma concolor*)

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Where large predators persist, predation is a strong determinant of ungulate population dynamics (Larsen et al. 1989; Lingle 2002; Robinson et al. 2002). Bighorn sheep (*Ovis canadensis*) and cougars (*Puma concolor*) are both commonly found in the Canadian Rocky Mountains (Krausman and Bowyer 2003; Pierce and Bleich 2003). Bighorn sheep use several antipredator tactics such as gregariousness, traditional trails and traditional seasonal range-use patterns (Festa-Bianchet 1991a). Moreover, they select habitats close to cliffs and steep rocky areas where they can escape from predator attacks (Geist 1971; Berger 1991). These antipredator tactics are likely more efficient against coursing predators such as wolves (*Canis lupus*) than against ambush predators such as cougars (Festa-Bianchet 1991a).

In the last decade, several studies on bighorn sheep have reported that predation by one or more specialist cougars can strongly and unpredictably influence population trajectories (Wehausen 1996; Ross et al. 1997; Festa-Bianchet and Apollonio 2003, Festa-Bianchet et al. 2006). Ross et al. (1997) reported that over one winter, two cougars were responsible for 55% of all sheep mortality (16 known cougar kills of 29 mortalities) leading to a 13% population decline in a bighorn population of 126 individuals, while Wehausen (1996) recorded survival of 62.5% for nine radiotracked adult ewes during a period with cougar predation.

Because bighorn sheep reactions to cougar attacks are rarely witnessed, the reasons why bighorn sheep appear highly sensitive to cougar predation are poorly

understood. Here, we present observations of cougar attacks on bighorn sheep and examine their behavioural response to this natural predator.

We observed bighorn sheep and cougar interactions in the Sheep River Provincial Park (50°39' N, 114°38' W), southwestern Alberta, during a long-term study of a marked bighorn population (Festa-Bianchet 1986; Loison et al. 1999). Research on marked cougars in the same location lasted from 1983 to 1996 (Ross et al. 1997). Over the last 20 years, there were two episodes of intense cougar predation, one from 1993 to 1995 and one in 2000–2003. In both cases, predation led to population declines (Figure 1). The decrease observed between 1985 and 1988 was due to a pneumonia epizootic occurring in 1985–1986, and subsequent poor lamb survival (Festa-Bianchet 1988). Encounters between sheep and cougars were observed from September 2000 to December 2003. Each time an attack was observed, we recorded the date, time, size of the group, location and a narration on the behaviour of the sheep and the cougar. Distance from escape terrain and flight distance of the sheep were estimated using an enlarged topographic map with scale 1:50,000. Escape terrain included cliffs and a steep canyon (Frid 1999). Flight distance was the displacement in meters of the group of sheep after an attack. We measured flight distance as the distance moved by sheep from the first sight of the cougar to when they stopped their displacement (when they reached escape terrain or stopped running and 50% of the group went back in foraging). More details on the Sheep River study population and sheep census are reported elsewhere (Festa-Bianchet 1991b; Hogg and Forbes 1997; Loison et al. 1999).

We recorded eight encounters between bighorn sheep and cougars (Table 1). When attacks occurred, the distance of the sheep groups from the escape terrain (group size ranging between 3 to 27 individuals) was on average 122.5 m (range 0–400 m) and the average flight distance was over 2 km. On five occasions the cougar was spotted low to the ground or running towards the group of sheep by observers. On one occasion, a group of three sheep was observed until sunset. No attack was witnessed, but the next day we found the carcass of one ewe that had been killed by a cougar at the bottom of the cliff, and the two other individuals had moved to a cliff approximately 6 km away. Bighorn sheep are usually not active at night (Sayre and Seabloom 1994); therefore, we assume that this displacement was related to the attack. For six of the encounters we were able to follow

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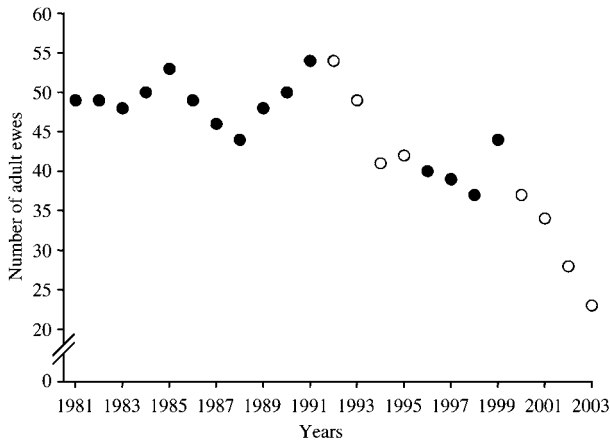


Figure 1 Number of adult ewes in March in the Sheep River population, Alberta, from 1981 to 2003. Open circles correspond to years with cougar predation. Solid circles correspond to years without cougar predation.

the sheep groups during their displacements. For one encounter the sheep group was not followed because the attack occurred very late in the day. In that case, the location of the sheep groups the next morning was used to estimate flight distance. Finally, in two cases the cougar approached the group by crawling, but it did not attack. Interestingly, in those two cases, the sheep were in escape terrain and saw the cougar, but they did not run away. They moved a short distance (20 and 70 m) onto the cliff while the cougar was there, but after the predator had left, they stayed in the same location (Table 1).

Cougars move quietly and low to the ground when stalking prey. They approach as close as possible, and then rush on the prey and attempt to grab it by the neck (I. Ross, personal communication). Of eight attacks, five were recorded within escape terrain and one while the sheep were walking uphill towards the escape terrain (approximately 100 m from the cliff) on a traditional trail. The cougar chased them downhill. Cougars did not appear to choose a specific individual prior to the attack, but rather seemed to chase the closest sheep. In six cases, the cougar approached from uphill, walking from the top of the cliff across the escape terrain. On those occasions the sheep ran downhill and away from escape terrain, in the forest or in open grassland, depending on the location of the attack, and then split into two or more subgroups.

Usually, pursuit of prey by cougars is relatively short compared to the long chases of coursing predators such as wolves (Pierce and Bleich 2003). None of the attacks we witnessed was successful, and the cougar gave up after a burst of high-speed chasing over a distance of <200 m. In one case, the cougar ran after a group of three ewes for over 2 km. This attack happened on a large cliff and the sheep broke into two subgroups (initially $n=21$). We followed a subgroup of three ewes that ran on the road to escape the cougar, while the other group ($n=18$) disappeared into the forest. The cougar came out of the forest between the sheep and observers, after which we lost sight of it. Tracks in the snow revealed that the cougar followed the sheep for almost 2 km. The two subgroups rejoined approximately 1 h later in another escape terrain located 6 km away from the site where the attack occurred (Table 1). Although none of the attacks witnessed were successful, cougars can be really successful in killing bighorn sheep (Wehausen 1996; Ross et al. 1997). No data, however, are available to quantify the success rate of attacks for this species.

Bighorn sheep appear to be highly vulnerable to cougar predation. The cryptic nature of cougar behaviour allows it to approach very close to sheep in escape terrain, without being located. Then the cougar ambushes the sheep forcing them to run away from the escape terrain, where they become very vulnerable. Bighorns have climbing skills that allow them to utilise cliff and rocky slopes to escape predators (Geist 1971; Festa-Bianchet 1987), but specialist cougars hunt bighorn sheep by stalking them in escape terrain. It is possible that the antipredator tactics of bighorn sheep evolved under selective pressure from coursing predators, and may be less effective for stalking predators. Bighorn sheep may abandon seasonal migrations and seasonal home ranges where they face high predation by specialist cougars (Wehausen 1996). Results from the long-term monitoring of the Sheep River population (1981–2003) also suggest that ewes stopped using their traditional winter range. Cougar predation events occurred in 1993–1995 and 2000–2003. In 1981–1999, the proportion of ewes wintering at Sheep River was 100% (Festa-Bianchet 1986 and M. Festa-Bianchet personal communication). In 2000, it appeared that the ewes at Sheep River stopped using their traditional winter range following intense cougar predation pressure (percentage of ewes in the winter range: 2000, 91%; 2001, 94%; 2002, 44%; 2003, 33%).

Table 1 Observations of cougar attacks on bighorn sheep at Sheep River Provincial Park, Alberta from 2000 to 2003.

Date	Time (h)	Distance from escape terrain (m)	Estimated flight distance (m)	Group size	Attack	Group composition
3 Dec 2000	07:40	<15	6000	3	Yes	♀ ♂
12 Dec 2000	09:03	0	6000	3	Yes	♀
12 Dec 2000	09:03	0	6000	19	Yes	♀ with lambs and ♂
5 Aug 2002	14:14	400	500	10	Yes	♂
5 Aug 2002	14:16	400	500	15	Yes	♂
25 Oct 2003	09:12	0	70	27	No	♀ with lambs and ♂
5 Nov 2003	17:08	100	>500	18	Yes	♀ with lambs
17 Nov 2003	14:00	0	20	21	No	♀ with lambs

Attack “Yes” means that the cougar actively tried to kill a sheep, while “No” means that the cougar was seen crawling toward the sheep, but did not rush at a sheep. ♀, female 1 year and older; ♂, male 1 year and older.

Many populations of bighorn sheep overlap with cougar home ranges, but most are not strongly affected by cougar predation. Ross et al. (1997) radiocollared 60 cougars in the Sheep River area and they remarked that only some cougars specialised on sheep. For 10 years, the monitoring of bighorns and cougars overlapped and only two cougars specialised on sheep. This suggests that only a few cougars systematically prey on sheep, while others prefer to hunt alternative prey, such as white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), moose (*Alces alces*) and elk (*Cervus elaphus*), which are also abundant in this area (Ross et al. 1997). It is likely that the hunting skills required to pursue bighorn sheep may be very different to those needed to hunt cervids. The only documented case of a cougar specialist was a female radio-collared for more than 10 years. This female hunted mainly deer for most of her life and in old age started to exclusively kill sheep. Even though the home range of this cougar overlapped with the sheep wintering range during the 10 years of monitoring, when she started to specialise on sheep, her home range shrunk and her movement was exclusively confined to the sheep range (Ross et al. 1997). In a small sheep population facing a specialised cougar, up to 16 individual sheep have been killed in only one winter, accounting for 55% of over-winter losses (Ross and Jalkotzy 1996; Ross et al. 1997). Gaillard et al. (1998) reviewed ungulate population dynamics and concluded that although adult survival is usually much less variable than juvenile survival, a small change in adult survival would have a very strong effect on a population's growth rate. Therefore, predation by a specialised individual may have strong effects on the population trajectory for small isolated populations and could even lead to extinction (Sweitzer et al. 1997, Festa-Bianchet et al. 2006).

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