THE EFFECTS OF WOLF PREDATION ON DALL SHEEP POPULATIONS IN THE SOUTHWEST YUKON

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ABSTRACT

Dall sheep (Ovis dalli dalli) population size and lamb production were observed from 1982 to 1986 in an area where wolf numbers were reduced between October, 1983 and April, 1985, and compared to sheep population characteristics in a control area. Radio-collared wolves were tracked daily from 1 November to 13 December 1986 in the reduction area to estimate early-winter predation rates on sheep. The annual wolf predation on sheep was calculated based on the average early-winter predation rate extrapolated over 180 days (winter), and the estimated wolf density. We assumed that wolves were selectively hunting sheep only during the winter period. The estimated annual loss of sheep to wolf predation was compared to the average, annual sheep mortality, based on estimates derived from a 6-year study of a stable sheep population in the SW Yukon (Hoefs and Cowan 1979).

There was little numerical response by Dall sheep to wolf reduction. Wolves declined from 136 to 67, yet the sheep population size fluctuated very little in the experimental area (CV=7.37) and was similar to the population size in the control area (R=0.93). Also, lamb production varied independently of wolf density and was similar betweeen areas (R=0.88).

The number of rams shot and their average age in the wolf reduction area varied little from 1980 to 1986, further inferring that sheep population demography changed little and was independent of wolf numbers.

Predation rates on Dall sheep in early winter appeared to be pack-specific; some packs killed no sheep while one pack was found primarily at sheep carcasses. Over the entire wolf removal area, however, sheep were killed infrequently by wolves (57 wolf-days/sheep kill). When extrapolated over the winter wolf predation on sheep represented 1.9/100 km^2. At pre-removal wolf densities this predation rate would account for an annual loss of 3.8 sheep per 100 km^2.

Wolf predation on sheep was less than the estimated natural mortality of non-lamb sheep in the study area (4.0/100 km^2), based on an assumption of sheep population stablility and mortality rates similar to those estimated for sheep in Kluane Park (Hoefs and Cowan 1979). The one pack found consistently at sheep carcasses also consumed sheep at a rate below the natural mortality rate of sheep within it´s territory.

Sumanik (1987) found wolves preying on sheep in the Kluane Game Sanctuary, west of the study area, to be in small packs at low densities and nutritionally stressed. The wolf pack in the study area that was frequently killing sheep (23.1 wolf-days/sheep kill) was smaller than pre-removal average pack sizes, it held a very large territory and was displaced from the area in late winter, and it failed to produce young in the spring.

Although our data implied that wolf reductions resulted in a subtle increase in sheep predation rates, the overall effect on sheep population dynamics appeared to be minimal. We suggest that the prevalence of escape terrain in the SW Yukon prevented a significant numerical relationship between Dall sheep and wolves.

INTRODUCTION

The effects of wolf (Canis lupus) predation on thinhorn sheep populations, (Ovis dalli), has not been well established. In Denali Park, Alaska, Murie (1944) suggested wolves were a factor limiting the growth of a depressed Dall sheep (O. d. dalli) population in years that caribou (Rangifer tarandus) were not available. Heimer and Stephenson (1982) in a more recent study in the interior of Alaska have suggested that wolves may have been responsible for Dall sheep population declines observed in the 1970's. In British Columbia, Elliott (1984) found a correlation between increasing Stone sheep (O. d. stonei) numbers and declining wolf density.

Sumanik (1987) found wolves relying heavily on Dall sheep in the SW Yukon, and yet predation rates were low, and wolves appeared nutritionally stressed. Characteristically, wolves that preyed heavily on sheep were at low densities, in small packs, and had large territories which they frequently abandoned. Sumanik (1987) concluded that wolves on a primary diet of sheep experienced poor recruitment and he suggested that the prevalence of escape terrain impeded predation on sheep.

In 1982, biologists became aware of an apparent decline of moose (Alces alces) in the southwest Yukon, which was attributed partly to wolf predation (Larsen et al. 1989). It was suggested that predation on moose was being sustained despite low moose densities, due to the availability of Dall sheep as an alternate prey, thus producing a "predator-pit" (Haber 1977).

The reduction of wolves to enhance the moose population in the SW Yukon provided an opportunity to assess the impact of wolves on a population of sheep. The intention of this study was to (i) compare sheep population size and productivity to wolf density; (ii) estimate wolf predation rates on sheep during the early winter, and (iii) compare estimated annual wolf predation on sheep to the annual sheep mortality, based on demographic data from a neighbouring unhunted, stable sheep population.

STUDY AREA

Wolf removal took place in an 12,970 km^2 portion of the Coast Mountains of the southwest Yukon, between Whitehorse and Haines Junction, and south of the Alaska Highway to the B.C. border (Fig. 1). The area is mountainous with wide U-shaped valleys. Mean annual temperatures are approximately -5° C and annual precipitation is about 200 mm. The area is predominantly alpine, with a vegetative cover dominated by lichens, ericaceous shrubs, prostrate willows (*Salix* spp), and forbs (Oswald and Senyk 1977). Sheep densities (36/100 km^2) were relatively uniform across much of the study area (72% of the wolf-removal area).

Moose were found throughout the study area, at an average density of approximately 25/100 km^2 (Markel and Larsen, unpubl. rep.). Caribou were sparse, and occurred only in the eastern portion of removal area at an average density of less than 1/100 km^2 (YTG unpubl. data). Prior to wolf removal the density of wolves was estimated at 1.2/100 km^2 (Hayes and Baer, unpubl. rep.).

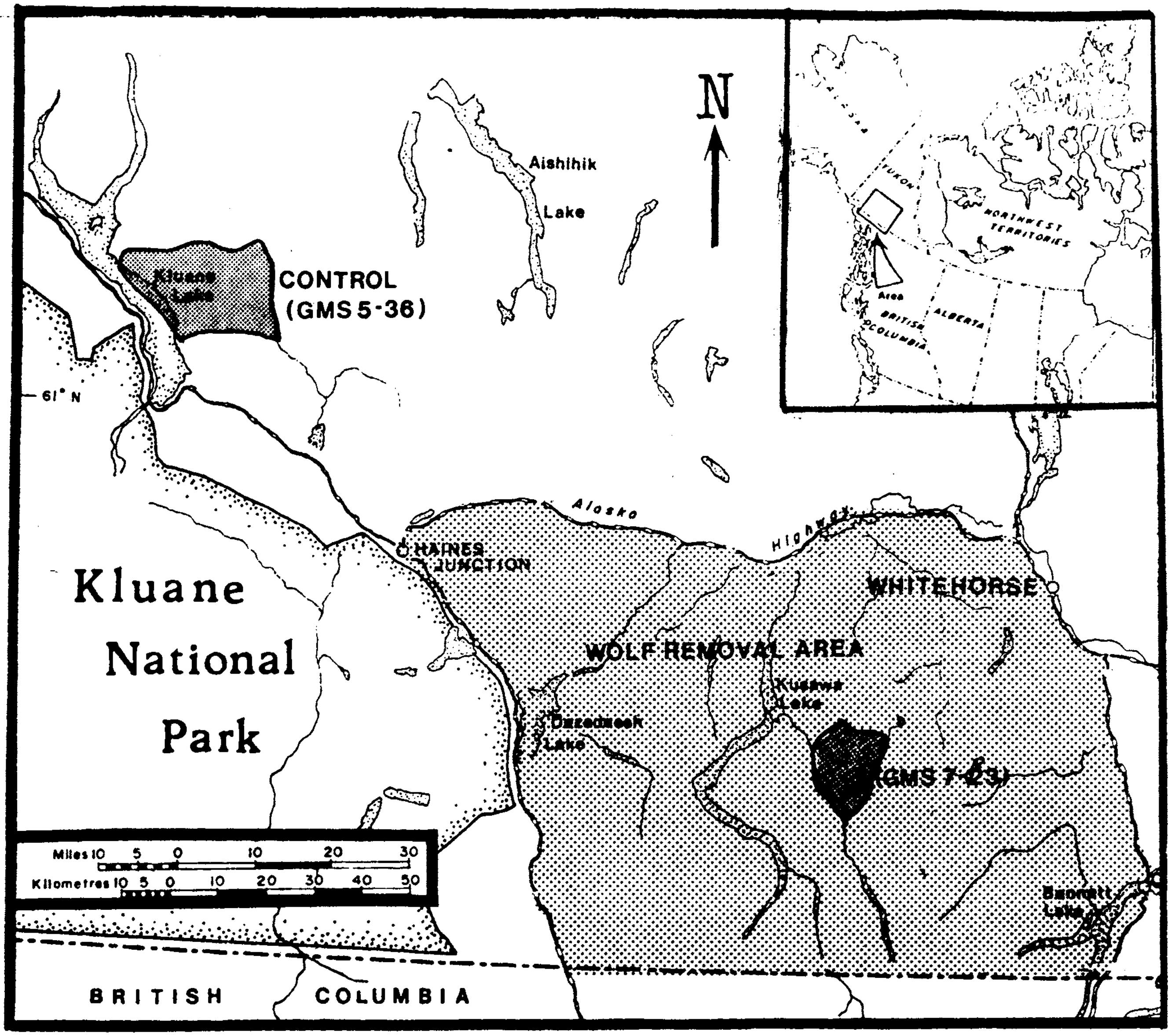

Figure 1: Study area showing sheep study area (GMS 7-23) in the wolf removal area and the control area (GMS 5-36).

METHODS

Sheep population trend

From 1982 to 1986 sheep population size and lamb production were determined in a 210 km^2 area within the wolf removal area (GMS 7-23), and in a 610 km^2 control area located 160 km northwest of the experimental area (GMS 5-36; Fig. 1). Using a helicopter carrying three observers, a complete search was made annually after lambing in July, of the entire survey blocks. The census was assumed to represent a total count. Sheep numbers on the block were assumed to vary seasonally due to migration; however, the July count was assumed to be representative of sheep population characteristics, based on assumptions of seasonal range fidelity in Dall sheep (Hoefs and Cowan 1979).

Wolf density and predation rates

Wolves were expected to have the greatest impact on sheep during the winter. This was inferred from winter predation studies in Kluane Game Sanctuary (Sumanik 1987) and the SW Yukon (YTG unpubl. data), and the examination of wolf scats around natal dens, where sheep remains were rarely found (Hayes and Baer, unpubl. rep.).

Wolf population size in early winter was compared to the sheep population data of the following July. Wolf densities were determined by intensive aircraft surveys during winter, according to Hayes and Baer (unpubl. rep.). Wolf removal occurred in late winter (March-April) of 1984 and 1985; estimated early winter wolf densities were reduced from 1.21 to 0.56 wolves/100 km^2 (Hayes and Baer, unpubl. rep.).

The number of sheep harvested in the study area and their average age were determined through compulsory submissions by resident and non-resident licensed hunters. Age of each sheep killed was determined through counting horn annuli (Hemming 1969). The Indian harvest, which was not subject to compulsory reporting, was thought to be minimal (Quock and Jingfors, unpubl. rep.). The number of days effort hunting sheep in the study area was estimated from voluntary recall surveys to all licensed sheep hunters.

During the period 1 November to 8 December 1986, radio-collared wolves from 9 packs were monitored for 38 consecutive days. Four packs were located daily (106 pack days) and 5 packs were observed intermittently (23 pack days). Observations of pack size, wolf activity, and wolf-killed ungulates (species killed, location, and site characteristics) were recorded. We assumed that one brief observation per day would provide an accurate estimate of kill rates on ungulates. Sumanik (1987) and Hayes and Baer (unpubl. rep.) found wolves to be present at sheep kill-sites for an average of 1.4 and 1.6 days, respectively.

Annual sheep losses to wolf predation were estimated based on early winter predation rates and wolf densities extrapolated over a 180 day period (winter). This yielded an estimated annual sheep loss to wolves, per 100 km^2. Summer predation on sheep was assumed to be minimal.

Sheep natural mortality rates were drawn from 6 years of detailed investigations of Dall sheep in Kluane National Park (Hoefs and Cowan 1979). These rates of loss were applied to the minimum population count of sheep in the wolf-removal area based on July helicopter surveys (unpubl. data) to yield an estimated natural sheep mortality per 100 km^2. Annual sheep mortality was compared to the estimated annual wolf predation on sheep.

RESULTS

DALL SHEEP DEMOGRAPHY

In the wolf-reduction area there was little change in the size of the sheep population following a substantial reduction in wolves (Fig. 2). Wolves experienced a 2-fold decline in numbers (CV=25.65, n=5), while the sheep population in a portion of the study area (GMS 7-23) varied between 189 and 230 (CV=7.37, n=5). There was a tendency for sheep numbers to increase slightly with increasing wolf density (r^2=0.43, n=5). However, similar changes in sheep population size were observed in the control area (R=0.93; Fig. 3a). Also, sheep population size in the experimental area was less variable than population size in the control area (C=4.34, p=0.01, n=5).

The trend in the number of lambs observed and the ratio of lambs to nursery sheep in the wolf-removal area was similar to the trends in lamb production in the control area (R=0.88, n=5, and R=0.78, respectively; Fig. 3b). Lamb production was more variable in the control area than in the experimental area (C=4.46, p=0.01, n=5). No relationship between lamb production and wolf density was observed in the experimental area (R=0.20, n=5; see Fig. 2).

Sheep harvest

Sheep hunting effort by licensed hunters was similar between years, from 1982 to 1986. An average of 679 days were spent

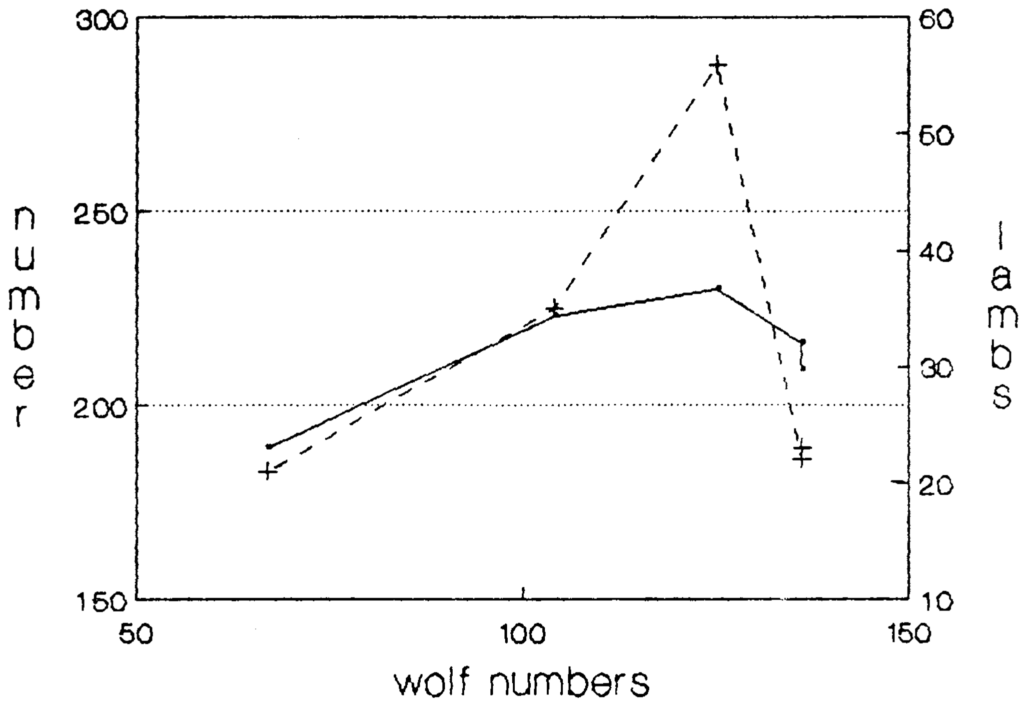

Figure 2. Sheep population size (·———·) and lamb production (+-----+) in subzone 7-23, against the number of wolves in Zone 7.

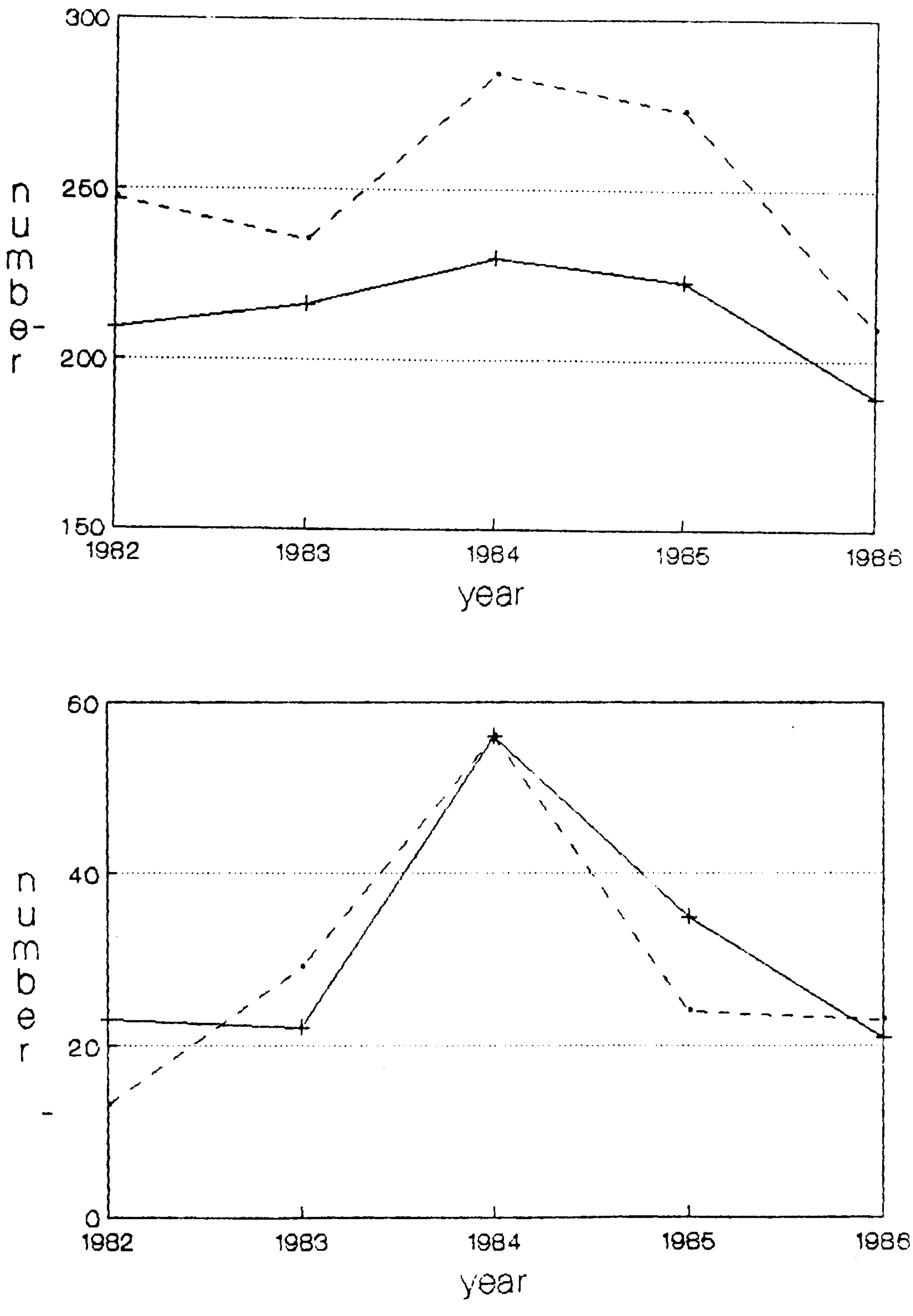

Figure 3(a). Sheep population size and (b) lamb production in a portion of the wolf removal area (+————+) and in the control area (•---------•), against year.

hunting sheep in the study area (CV=7.88), and the number of rams killed was correlated to days effort (R=0.70). Therefore, we assumed that sheep harvest would provide an indication of sheep population stability. The harvest of rams in the experimental area was very consistent from 1980 to 1986, both in numbers shot (mean=54.71, n=7 years, CV=6.48) and average age (mean=8.39, n=7, p=0.94, CV=1.67; Fig. 4).

Wolf predation on Dall sheep

In the study area, wolves killed a sheep, on average, every 57.3 wolf-days (Table 1). There was, however, considerable variation between packs in the predation rates on sheep (Table 2).

Sheep mortality and wolf predation

When the estimated predation rate is applied to the 1986 wolf density (at the time of the predation rate study) and over a winter period of 180 days, only 1.9 sheep were killed per 100 km^2. Applied to the pre-removal wolf density an estimated 3.8 sheep would be killed by wolves per 100 km^2. These estimates, based on 1983 (pre-removal) and 1986 (post-removal) wolf densities, represent 5.3 to 10.6% of the minimum sheep population and 6.6 to 13.1% of the minimum non-lamb population in the study area.

Wolves in one pack regularly hunted sheep and when their estimated rate of predation is applied over 180 days they would remove 28.8 sheep annually. However, they held a very large territory (3005

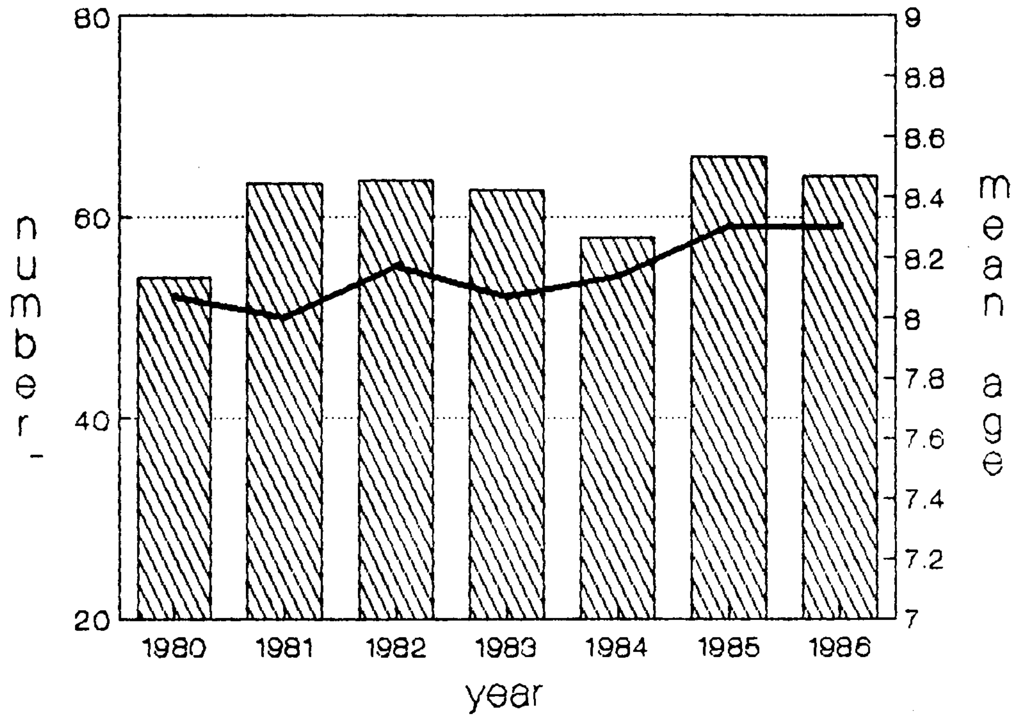

FIgure 4. The number of rams shot in Zone 7 (•——•) and their average ([hatched bar]), against year.

Table 1: Wolf predation in the study area, from November 1 to December 8, 1986, by pack

Pack	Mean pack size	Dates observed	Pack days	Wolf days	No. killed shp	mse	unk
CL	1.4	Dec. 4 - Dec. 16	5	7	0	3	0
HS	3.7	Nov. 3 - Dec. 8	25	92.5	4	1	3
MH	5.3	Nov. 3 - Dec. 8	27	143.1	1	8	1
RC	3.1	Nov. 3 - Dec. 8	26	80.1	0	1	3
PC	2.5	Nov. 19 - Dec. 2	6	15.0	1	1	0
PM	1.1	Nov. 1 - Dec. 8	28	30.8	1	1	1
T1	4.5	Dec. 2 - Dec. 13	3	13.5	0	0	1
T2	1.8	Nov. 18 - Dec. 8	7	12.6	0	2	0
TS	3.1	Nov. 18 - Dec. 2	2	6.2	0	1	0
TOTAL	**2.9**	**Nov. 3 - Dec. 16**	**129**	**401.3**	**7**	**18**	**9**

Table 2: Wolf predation in the SW Yukon, 1984-1986

Area	Year	Months	Wolf-days	Wolf-days/ Sheep kill	Sheep kills no.	Sheep kills %
Study area	1986	Nov.-Dec.	401.3	57.3	7	28
Study area	1986[1]	Mar.-April	593.0	83.0	7	--
Study area	1984[1]	Mar.-April	657.0	109.5	6	32
HS Pack	1986	Nov.-Dec.	92.5	23.1	4	80
PR Pack	1984[1]	Mar.-April	265.0	44.2	6	55
KGS[2]	1985	Mar.-April	533.0	53.3	10	--

[1] From Hayes and Baer (unpubl. rep.)
[2] Kluane Game Sanctuary (KGS); from Sumanik (1987)

km^2), much larger than the average wolf territory size (Hayes and Baer, unpubl. rep.). Therefore, their rate of predation over the winter would be only 1 sheep/100 km^2.

In an unhunted sheep population in the southwest Yukon, which was considered stable during 6 years of study, an estimated 18.3% of the population disappeared from one year to the next (Hoefs and Cowan 1979). Of the non-lamb population, an estimated 14.4% disappeared from natural causes from one year to the next. Applied to the study area, this rate of loss represents 4 non-lambs per 100 km^2. The average annual hunter-kill was approximately 0.6 rams per 100 km^2.

Therefore, the estimated loss of sheep to wolf predation, based on either pre-removal or post-removal wolf densities, was less than the estimated natural mortality of sheep in the study area.

DISCUSSION

There was no apparent population response of Dall sheep to wolf reduction: (a) wolf density and mid-summer sheep population size were only weakly and positively correlated, (b) sheep population size in a portion of the wolf-removal area and in the control area were closely correlated, and, (c) the number and average age of the sheep harvest was stable. These patterns were apparent despite a two-fold reduction in wolf numbers in the experimental area.

The high correlation in sheep population size between the experimental and control areas suggest that similar factors, possibly general climatic conditions, are regulating sheep numbers. Sheep population and harvest trends, Yukon-wide, have also been generally stable since 1980 (CV=6.71; Yukon Government, unpubl. data). It is noteworthy that the annual variation in population size was significantly higher in the control area where wolf numbers were presumably stable, than in the experimental area.

Lamb production was also apparently unaffected by wolf numbers. The absolute and rate of lamb production in the experimental area closely tracked that in the control area, but with less annual variation. Lamb production tends to be variable in the Yukon (Yukon Government unpubl. data) and has been linked to climatic conditions during the winter (Burles and Hoefs 1984, Barichello and Carey 1988).

Predation rates on Dall sheep in the early winter appeared to be pack-specific. Some packs apparently ignored sheep despite high sheep densities, while others appeared to concentrate their hunting efforts on sheep. Averaged over the study area, wolves appeared to prey on sheep infrequently (57.3 wolf-days/sheep kill). The predation rate was similar to that observed in the northern portion of the wolf-removal area during the late winter of 1984 (64.5 wolf-days/sheep kill; Hayes and Baer, unpubl. rep.), and in the Kluane Game Sanctuary in late winter of 1985 (53.3 wolf-days/sheep kill; Sumanik 1987).

We may have underestimated the predation rate on sheep. The calculation of predation rate is based on one daily observation which determines the presence or absence of a kill on each "wolf-day." Small ungulates may be entirely consumed in a portion of the day. Sumanik (1987) found wolves to be at sheep kill sites for an average of 1.4 days, but indicated that lamb mortality sites may be over-looked. However, Hayes (unpubl. data) found no difference in wolf predation on barren-ground caribou (similar weight to Dall sheep rams) between estimates based on one or two daily monitoring flights. Intuitively, the time on the carcass should depend on carcass weight, pack size, and wolf condition. Without numerous daily observations, the time spent on sheep kills and the relationship between pack size and consumption rate will remain unknown. Nevertheless, Heimer and Stephenson (1982), Sumanik (1987) and Hayes and Baer (unpubl. rep.) from intensive wolf studies have inferred that wolves prey primarily on adult sheep.

The extrapolation of predation rates in early winter over the entire winter may inflate the estimate of annual wolf predation on sheep. Comparisons of wolf predation on sheep in early and late winter in the study area (1984, 1986) suggests that wolves are more successful early in the season (see Table 2). This view is consistent with the rate of disappearance of radio-collared rams in the Northern Richardson Mountains, most of which were lost from November to January, coinciding with rut activities (Barichello et. al. unpubl. rep.). We suggest that rams may be more vulnerable in the rut period, as a result of increased movements and less wariness as a consequence of hormonal levels.

When we applied the estimated predation rate to the estimated wolf density in the study area we estimated that wolves would remove 1.9 sheep per 100 km^2. Even extrapolating to the pre-removal wolf density, sheep predation represented only 3.8 sheep per 100 km^2. However, this implies a rate of sheep predation that is independent of wolf density.

Sumanik (1987) found wolves on a diet of sheep to be at low densities in small packs and with large territories, to have low predation and consumption rates, and to have high adult dispersal rates. The one pack we observed with the highest predation rate on sheep (HS pack) was smaller than the average pre-removal pack size (3.7 compared to 8.0, respectively). Also, the pack had a very large territory, it was displaced in the late winter of 1986-87, and failed to produce young in the spring of 1987 (Hayes pers. comm.). Hunting over such a vast area, it´s overall impact on sheep was small; approximately 1 sheep killed annually per 100 km^2. Sumanik (1987) implied that there was a functional dietary response to reduced wolf densities; the sheep-kill/wolf increases with decreasing wolf density. The same pattern was apparent in the study area in 1986.

Nevertheless, even comparing what may be an overestimated average predation rate to an underestimated sheep population, the rate of sheep predation (1.9 to 3.8/100 km^2) was less than the estimated natural mortality of the total (6.5/100 km^2), or the non-lamb sheep population (4.0/100 km^2).

The potential effect of wolves on sheep is probably closely linked to the prevalence or accessibility of topographic breaks (escape terrain). Mountain sheep are rarely found away from escape terrain which undoubtedly serves as protection from predators. Wolves probably reinforce the relationship between escape terrain and sheep; with adequate escape terrain, high densities of sheep may be maintained despite an abundance of wolves. Equally plausible, in the absence of wolves, sheep numbers may increase and expand onto range with a limited amount of escape terrain.

The interrelationship among sheep, escape terrain, and wolves, however, is undoubtedly more complicated. Forage conditions, sheep density, and health and experience of individuals will influence the distribution of sheep with respect to escape terrain. We suspect snow conditions and the quality of the pasture will force sheep to range further from escape terrain.

Density of sheep will influence forage quality and may result in competition for limited escape terrain. The animal's health and experience will influence its ability to safely reach escape terrain when surprised and pursued by predators. Sheep may be immune to wolves under appropriate conditions but highly susceptible at other times. Snow conditions are probably a primary factor in facilitating predator-caused mortality, due to its influence on the quality and accessibility of escape terrain. Deep snow will retard access to forage and escape terrain, predisposing sheep to reduced physical condition and predator attack. Also, heavy accumulations of snow may yield marginal escape terrain inadequate as predator refugia.

Wolf removal, then, may substantially enhance sheep populations where escape terrain is limited or reduce the influence of predation during some winters. In the southwest Yukon where sheep habitat is excellent (dry, alpine pastures, and escape terrain are abundant), wolf removal appeared to have a limited, if any, effect on sheep demography during the study period. Wolf predation on sheep was found to be relatively infrequent and below the average, annual, mortality of sheep, based on population dynamics of a neighbouring sheep population. The demographic similarities with a sheep population in an area where wolf numbers were unperturbed, and the relatively stable nature of the sheep harvest since 1980 substantiate the view that wolves in the southwest Yukon have minimal short-term effects on Dall sheep population dynamics. However, wolves have likely been a major evolutionary factor in determining the distribution, density and behaviour of thinhorn sheep.

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