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SELECTIVE PREDATION BY COUGAR WITHIN THE JUNCTION WILDLIFE MANAGEMENT AREA

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Abstract: Cougar (Felis concolor) on the Junction Wildlife Management Area (W.M.A.) were fitted with radio collars and located by ground and aerial telemetry. General site reconnaissance and telemetry relocation work from 1986 to 1988 revealed 116 prey species remains on which 40 were confirmed as recent cougar kills. Bighorn rams (Ovis canadensis californiana) comprised 55.2% and 40.0% of the respective totals. Analysis indicated that cougars were selecting rams in greater proportion than would be expected based on their availability. Selection of rams appeared to be seasonal and linked to poor ram condition following the rigors of the rut.

The Junction W.M.A. of central British Columbia has supported a large population of approximately 150 California bighorn rams for the past two decades (Ministry of Environment [MOE] unpubl.). Population censuses and compulsory inspection harvest data from the early 1980's, however, indicated that the demographics of the ram component had shifted from the age structure seen during the previous decade. Older, full curl rams were less prevalent and comprised a lower proportion of the population (MOE unpubl.). Annual harvest was restricted with only 2-4 rams harvested through 5 limited entry permits from 1976-1982 and 4-6 rams harvested under 9 permits from 1983-1988. The discovery of 19 ram heads during a summer of general site reconnaissance disputed the notion that illegal harvest was solely responsible for the observed age structure of rams. Further reconnaissance revealed that a number of cougars were utilizing the Junction W.M.A.

Cougars have long been recognized as predators of bighorn sheep (Beuchner 1960, Sugden 1960, Kelly 1980), yet documentation of the occurrence and extent of this predation has been anecdotal at best. Lack of information on cougar/bighorn relationships does not reflect the potential importance of this predation for wild sheep populations but reflects the difficulties of monitoring and documenting the impact of this highly cryptic predator.

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Intensive studies of cougars have usually concentrated on home ranges and intraspecific population dynamics (Hornocker 1970, Seidensticker et al. 1973). Prey species composition has generally been gathered from hunter- killed cougar stomach samples or from incidental discovery of cougar kills during trapping efforts (Robinette et al. 1959, Spalding and Lesowski 1971, Toweill and Meslow 1977, Alberta Fish and Game Division unpubl.).

The Junction Cougar Study was undertaken to investigate the predator/prey dynamics of this system. Cougar density, distribution, and movement within the W.M.A. were assessed, and the hypothesis that selective predation by cougars was occurring on the ram component was tested. Data presented here were collected during initial field work conducted from April 1986 to January 1988.

A number of individuals have contributed to many facets of the Junction Cougar Study. In particular, M. Evans, J. Hirsch, D. Lay, T. Smith, R. Wright, E. (Slim) Shrek, T. Ardunini, and Mike, Tody, Jack, and Joe have provided valuable assistance. Financial support was provided by the B.C. Ministry of Environment Wildlife Branch (Williams Lake), Foundation for North American Big Game, Guide Outfitters Association of B.C., Foundation for North American Wild Sheep, The Williams Lake Sportsmen's Association, B.C. Conservation Foundation, and Lake City Ford in Williams Lake. Without the involvement of such individuals and organizations, quality field data from a study of this nature are difficult to obtain.

STUDY AREA

The Junction bighorn sheep range lies 35 km southwest of Williams Lake in the Chilcotin region of central British Columbia. The area is characterized by rolling plains and undulating grasslands that drop sharply from the 1070 m elevation of the Fraser Plateau to the 370 m river level. Douglas fir (*Pseudotsuga menziesii*) predominate 30-40% of the slopes leading to the Fraser River while bluebunch wheatgrass (*Agropyron spicatum*) and sagebrush (*Artemisia tridentata*) cover the sidehills and hogbacks dropping to the Chilcotin River.

The study area, which was larger than the W.M.A., was bounded by Highway 20 to the north, the Chilcotin River to the south, the Fraser River to the east, and the Wineglass Ranch road to the west (Figure 1). This bounded area represented 425 km^2, but consideration of the areas utilized by cougar, sheep, and mule deer (*Odocoileus hemionus hemionus*), resulted in a functional study area of approximately 150 km^2. An area of 6,300 km^2 was closed to the harvest of cougars. This closed area included the 425 km^2 bounded area and a 5,875 km^2 surrounding buffer zone.

METHODS

Collaring and Relocation with Radio Telemetry

All cougars utilizing the Junction W.M.A. were fitted with radio collars as outlined in Harrison (1987). General collaring procedures involved treeing the cougars with trained hounds, immobolizing animals

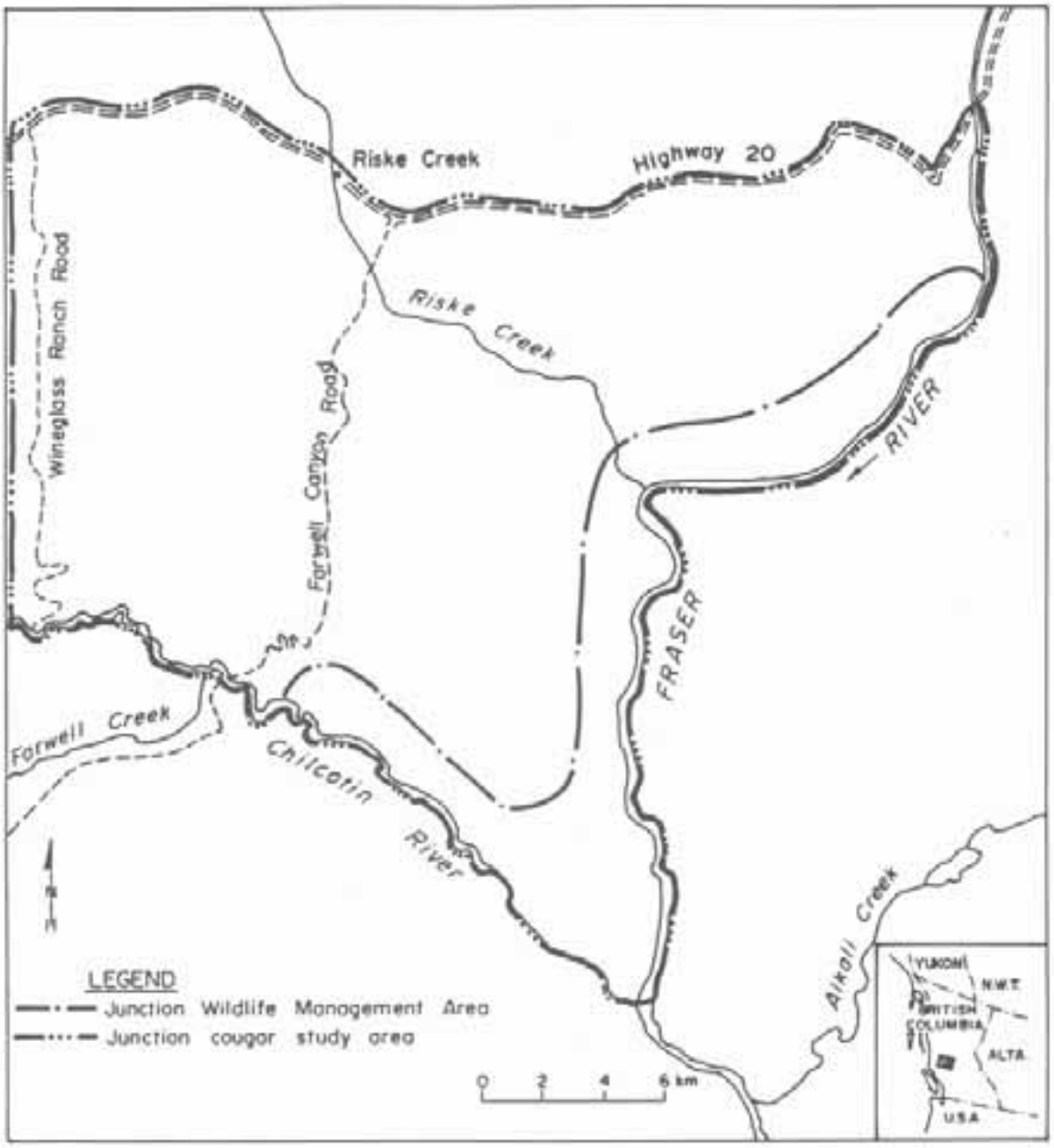

Figure 1. Junction Wildlife Management Area and Junction cougar study area in central British Columbia. All cougars entering the study area were radio collared and monitored daily while in the study area. Biweekly telemetry flights were undertaken to find cougars that moved out of the study area.

with a mixture of ketamine hydrochloride and xylazine hydrochloride (4:1 ratio) and lowering drugged cougars by rope. The first cougars were collared in November 1986 with radio relocated occuring daily during intensive field work (December-September) and a minimum of 4 times/week the rest of the year. Ground telemetry work was conducted with a single hand-held H- antenna. Initial radio relocations were made from a series of high elevation points that enabled scanning of the entire study area. Triangulation was used to pinpoint the signal to a single draw or gulley. The ground work was periodically supplemented with aerial telemetry locations to locate animals, particularly males, that had undertaken long movements beyond the study area boundaries. Telemetry relocations were utilized under 2 sampling regimes:

Direct sampling.--When cougars were relocated in the same area for 2 consecutive days or were suspected to have made a kill, the area was subject to a ground sweep. The canyon nature of the Junction made it possible to search the individual draws for kill remains. In terrain types where such sweeps were ineffective, the cougar was approached prior to departure. Approaching cougars at kill sites was of concern, not only for safety considerations but for fear of "bumping" cougars from their kills whereby they would leave and not return. This was not a problem and occured at only 1 of the 40 site examinations.

Inference.--Bighorn sheep and mule deer both inhabit the study area; however, they are segregated through differential habitat use. Moreover, rams and ewes utilize different parts of the sheep range throughout most of the year (Ashcroft 1986). Relocating cougars in certain habitat types allowed inference about prey selection based on that areas' prey availability. Data collected under this second sampling regime are not dealt with in this paper.

Confirmation of Cougar Kills

Cougar kills were readily identified by a number of criteria: dragging the kill to cover, burying the carcass, intact removal and separate burying of the rumen, and the presence of buried scat mounds in close proximity to the kill. Tracks and sightings at kill sites also confirmed cougar involvement. It was assumed that cougars made- rather than scavenged- any kills indicating cougar involvement because cougars prefer freshly killed meat (Robinette et al. 1959), and there are no other predators on the Junction W.M.A. that prey consistently on adult ungulates.

Data Analysis

The total mortality sample included all carcasses and identifiable bones found on the Junction whether a confirmed cougar kill or not. Mortalities for which no head could be found were classified as unidentified. All unidentified mortalities were sheep rather than deer based on hair colour and likely, most were rams based on their location on ram range.

Tests for differences between the prey composition of the total mortality and confirmed kill samples were conducted using the G-test of

independence at a significance level of $P<0.05$ (Sokal and Rolf 1981). For this analysis, confirmed kills and the unidentified sheep were removed from the total mortality sample.

For analysis of the confirmed kill data, the single lamb and fawn samples were added to their respective adult species and sex categories to avoid inadequate sample sizes. The coyote sample was dropped from the analysis because the coyote trapping effort (Hebert and Harrison 1988) was not constant throughout the cougar study thereby disrupting normal coyote population dynamics and complicating the estimation of coyote availability as a potential prey species.

Prey availability calculations varied for the two ungulate species. The Junction bighorn sheep are non-migratory and remain on the W.M.A. year-round. Sheep numbers were taken from triannual helicopter and ground counts. The majority of the deer population, however, is migratory and utilizes the Junction as a winter range. Deer availability was estimated from the regional deer density of 14 deer/km^2 calculated independently by the Habitat section (MOE unpubl.) and the Ministry of Forests Research section following a deer study (Ministry of Forests [MOF] unpubl.). Fourteen deer/km^2 represented the value for important wintering areas along migration corridors and may have been a high estimation for the Junction W.M.A. To correct for this, deer numbers calculated for the Junction with this density were adjusted by comparison with spotlighting indices (this study). Seasonal conversions of spotlighting indicies to population numbers followed McCullough (1982). A buck:doe ratio of 0.45 calculated from regional deer data (MOE unpubl.) was used for the analysis.

Determination of the extent of predation on bighorn sheep was made by varying deer availability as follows:

a) high deer numbers	(1,700 deer)
b) moderate deer numbers	(1,000 deer)
c) low deer numbers	(102 deer)

Making the ram component of the prey population proportionately larger by conservatively estimating deer numbers yielded results which truely tested the notion of prey selection by cougars. This occurred under scenarios (b) and (c). Utilization-availability statistics using the Bonferroni z statistic to calculate 95% confidence limits were employed to test for prey selection by cougars (Neu et al. 1974).

Only the ram and deer components were plotted in the monthly distribution of confirmed kills to show trends specifically related to these 2 prey types. The exact month in which 3 rams and 1 deer were killed could not be determined and they were excluded from the analysis.

RESULTS

A total of 116 prey mortalities were discovered from April 1986 to January 1988 (Figure 2). Of this total, 40 were confirmed as recent cougar kills (Figure 3). The confirmed sample represents kill data collected from 2 adult females each with 2 kittens. The number of

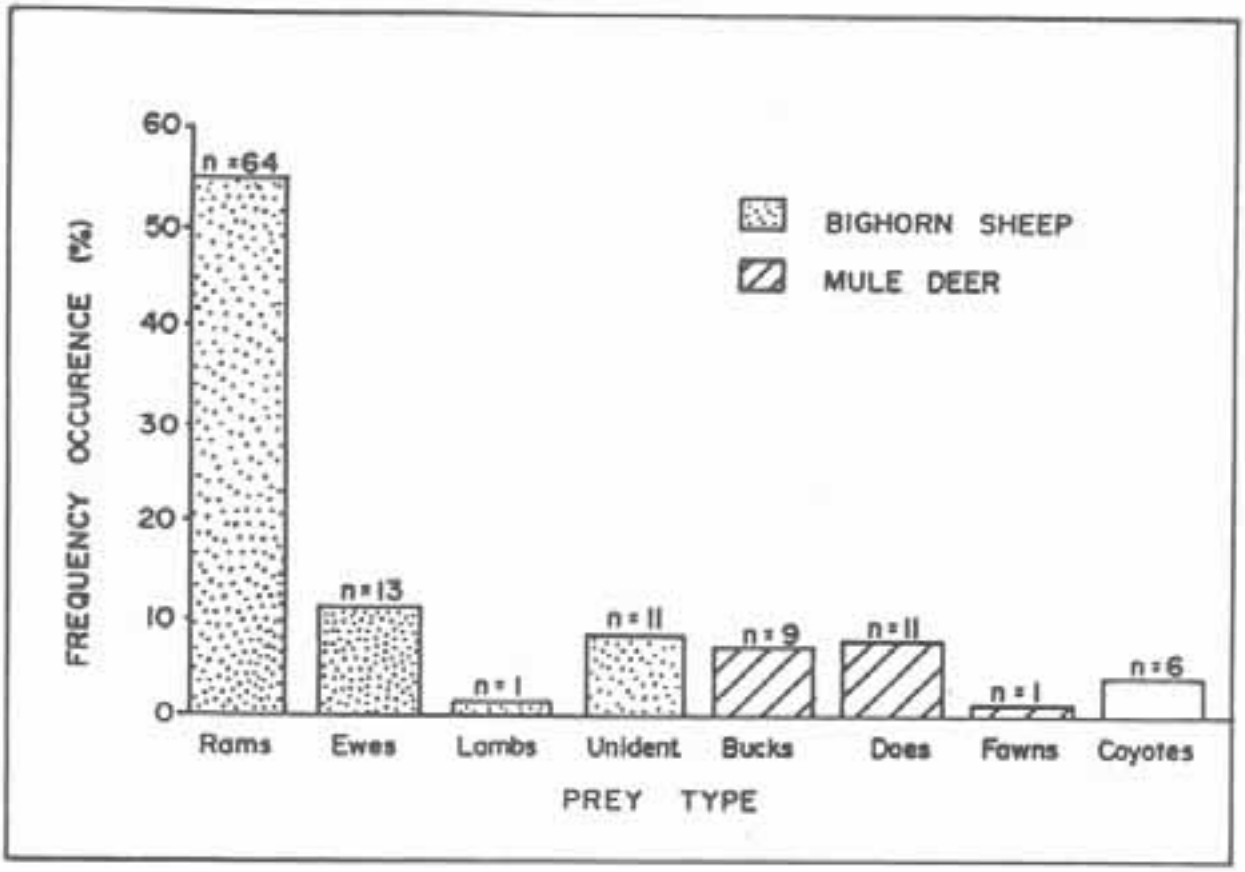

Figure 2. Total mortalities found in the Junction Wildlife Management Area, British Columbia. (April 1986 - January 1988)

confirmed kills represents a conservative figure since the majority of the total mortality sample was found prior to collaring and intensive monitoring of cougars. Moreover, many of the mortalities were discovered in areas indicative of cougar kills such as covered gullies or beneath trees in more open areas.

Tests for sample differences between the total mortality and confirmed kill samples indicated that proportions were not similar ($G = 13.53; P<0.01$). The prey species composition of both samples, however, reflected the general proportion of prey species occurrence and the predominance of rams.

Analysis of the confirmed kill data revealed that prey species were not utilized equally for either moderate ($X^2 = 48.17; P<0.001$) or low ($X^2 = 35.26; P<0.001$) estimations of prey numbers. Utilization-availability statistics showed that cougars were preying on bighorn rams in greater proportion than would be expected based on their availability in the potential prey population (Tables 1 and 2).

Categorizing the confirmed kills the confirmed kills by month revealed that the majority of rams were taken during the late fall and

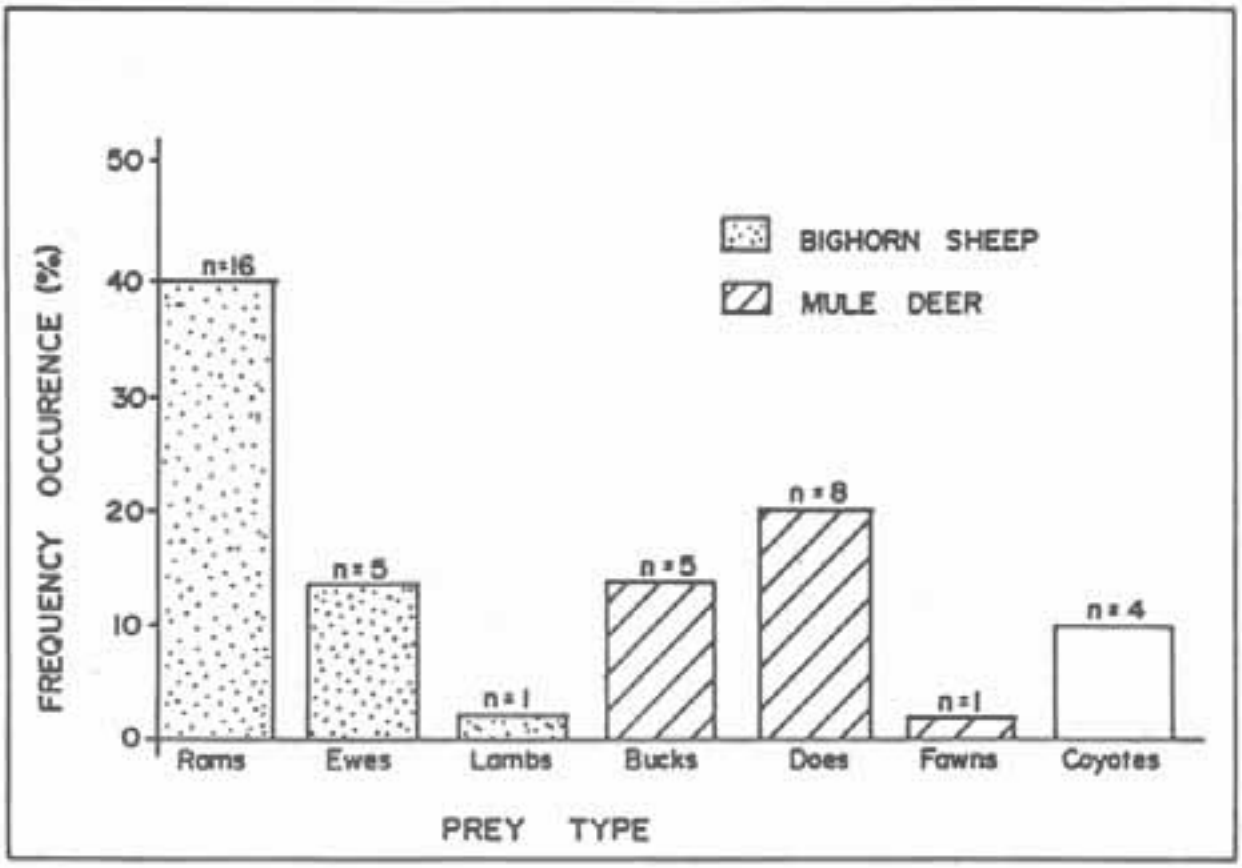

Figure 3. Confirmed kills from 2 radio-collared female cougars in the Junction Wildlife Management Area, British Columbia. (December 1986 - January 1988)

early winter months ($X^2 = 30.48; P < 0.01$) while deer were selected during the midwinter and spring months ($X^2 = 21.21; P < 0.05$) (Figure 4). The lack of samples recorded during August and September reflected a decreased efficiency finding kills due to changes in cougar movements and distribution resulting from intraspecific interactions in May 1987. These changes affected the discovery of summer sheep and deer mortalities equally.

DISCUSSION

The high proportion of rams found in the total mortality sample indicated that rams were dying of natural causes, and although some illegal harvest probably did occur, it was not the major cause of the decline in the number of large rams at the Junction. The 11 unidentified sheep carcasses represented animals that may have been poached; however, legal harvest would have accounted for some of this sample because hunters are required to remove only 1 hindquarter under B.C. hunting regulations for bighorn sheep. Other unidentified sheep would have died due to natural causes, including predation, with the heads being removed by hikers or previous researchers.

Table 1. Proportion of prey species in confirmed cougar kill sample found on the Junction Wildlife Management Area (December 1986 - January 1988) calculated for moderate deer numbers.

Prey species	Total prey numbers	Proportion of total prey population (availability)	Confirmed # of cougar kills	Expected # of cougar kills	Proportion of confirmed kills (p_i) (utilization)	Confidence Intervals (95%)
Rams	150	0.097	17	4	0.472	$0.230 < p_1 < 0.714$
Ewes	400	0.258	5	9	0.139	$(-0.028) < p_2 < 0.306$
Bucks	310	0.200	6	7	0.167	$(-0.013) < p_3 < 0.347$
Does	690	0.445	8	16	0.222	$0.021 < p_4 < 0.423$
Totals	1550	1.000	36	36	1.000	

$X^2 = 48.17$; $P < 0.001$

Table 2. Proportion of prey species in confirmed cougar kill sample found on the Junction Wildlife Management Area (December 1986 - January 1988) calculated for low deer numbers.

Prey species	Total prey numbers	Proportion of total prey population (availability)	Confirmed # of cougar kills	Expected # of cougar kills	Proportion of confirmed kills (p_i) (utilization)	Confidence Intervals (95%)
Rams	150	0.230	17	8	0.472	$0.230 < p_1 < 0.714$
Ewes	400	0.614	5	22	0.139	$(-0.028) < p_2 < 0.306$
Bucks	32	0.049	6	2	0.167	$(-0.013) < p_3 < 0.347$
Does	70	0.107	8	4	0.222	$0.021 < p_4 < 0.423$
Totals	652	1.000	36	36	1.000	

$X^2 = 35.26$; $P < 0.001$

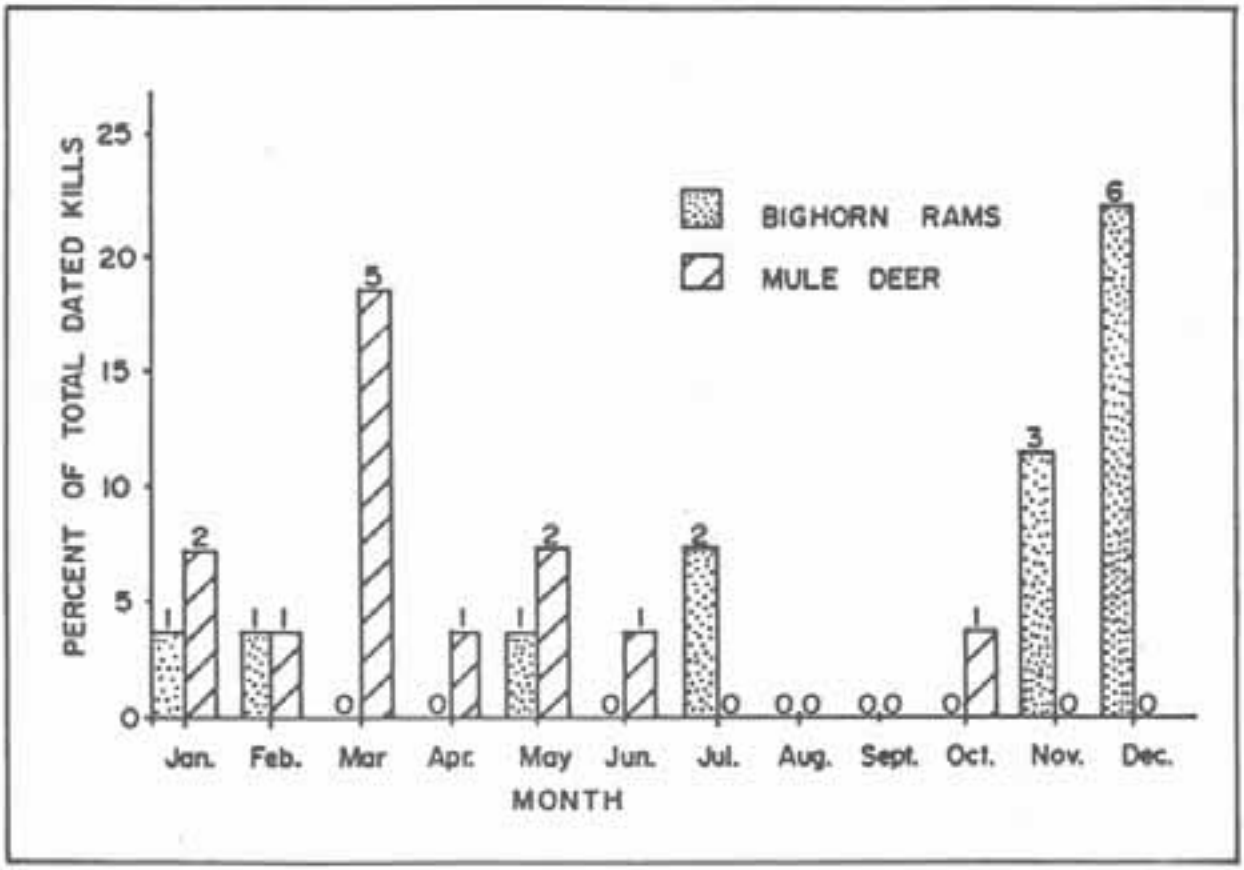

Figure 4. Monthly distribustion of bighorn rams and mule deer killed by radio-collared cougars in the Junction Wildlife Management Area, British Columbia.(December 1986-January 1988). Sample sizes shown above.

The differences between the total mortality and confirmed kill samples were the result of the higher proportion of rams in the total sample which, to some degree, reflected differential species and sex skull perishability of the ungulate species involved (Murphy and Whitten 1976). The confirmed kill data, however, were the result of the intensive radio relocation and sampling regime and not reflective of the perishability differences.

The direct sampling method was particularly effective for locating kills of females with young, collared kittens. The kittens would remain at the kill site while the female moved off to hunt. As the kittens became older, however, the rate at which kills were located declined despite the fact that the utilization rate and likely the kill rate were increasing. An increase in mobility around kills made it more difficult to rely solely on the kittens' location to mark the site. The central area of kitten activity could be approached using ravens (Corvus corax), bald eagles (Haliaeetus leucocephalus), and golden eagles (Aquila chrysaetos) as distant markers (100-200 m radius) and magpies (Pica pica) as more exacting markers (5-10 m radius) of the kill site.

The difficulty finding summer kills resulted from a series of intraspecific interactions among the cougars of the area. In May 1987, tracks of an uncollared cougar were found in the vicinity of both collared family groups (two adult females each with 2 kittens). Within 1 week, the 2 kittens of 1 family had been killed by a cougar (Provincial Vet Lab necropsy rep.) and the other family had vacated the study area by crossing the Chilcotin River despite full freshet conditions and a river width of 15 m. The result was a single collared female in the area for most of the summer although the other family group did return.

Evidence of Selective Predation

Documentation of a predator's prey species composition is useful for addressing a number of aspects of predator/prey interactions especially the selection of specific prey types. Selection of mule deer bucks by cougars has been reported in a number of studies (Robinette et al. 1959, Hornocker 1970, Shaw 1975, Russell 1978); however, after analyzing prey species composition of 6 such cougar studies, Anderson (1983) concluded "the assertion of puma selectively killing certain sex and age classes of mule deer remains an untested hypothesis".

Inherent in the examination of prey selectivity is the need for an understanding of prey availability. Difficulties in determining the availability and the population structure of the prey base has precluded definitive statements on cougar prey selection. This is particularly true when examining the intraspecific selection of deer. Deer availability and population structure are difficult to document particularly in forested habitats. Although a number of deer censusing techniques have been developed (Lewis and Farrar 1968, Floyd et al. 1979, McCullough 1982), they are often prohibitively expensive or ineffective in the terrain types of most cougar study sites. Indices of relative deer abundance, however, are readily obtained through seasonal spotlight counts and can provide valuable information in the examination of cougar prey selection under two conditions:

1) inter rather than intraspecific prey selection is being examined, and

2) good population composition data are available for the alternative prey species.

In this study, bighorns represented the alternative prey for which population data were available (Ashcroft 1986, MOE unpubl.). Relative abundance of deer became important only in determining the extent of selective predation by cougars on sheep with respect to deer.

Moderate prey numbers (Table 1) represented the conservative estimation of the prey base wintering on the study site from late October to April. Under this scenario, rams were clearly utilized by a significantly greater proportion (47.2%) than they were available (9.7%) in the total prey population.

To further examine the extent of cougar prey selectivity, the estimated deer population was reduced to a level where the proportional

availability of rams equalled the lower limit of the 95% ram utilization confidence limit (Table 2); that is, the deer numbers were lowered to the point where selection of rams was, statistically, no longer occurring given a significant level of $P<0.05$. To achieve this, the deer population had to be reduced to 102 animals: an unrealistic winter figure given that 131 deer have been counted in a single 5 km^2 field during fall spotlight counts (this study).

The breakdown of the confirmed kills by month (Figure 3) revealed that utilization of both deer and rams peeked during the fall to spring period suggesting that wintering deer numbers (Table 1) were more appropriate for the analysis. This revealed that strong selection of rams by cougars was occurring on the Junction W.M.A.

Reasons for Selective Predation

Cougars are capable of killing a wide range of prey species (Anderson 1983) under a wide range of conditions. Reports of a 43 kg female cougar killing 6-point bull elk (Hornocker 1976) and observations of cougars stalking and killing prey on open grasslands (this study) attest to the cougar's predatory abilities. Despite this prowess as a top predator, cougars must still acquire prey within the constraints of predator/prey dynamics. The functional responses of predators to varying prey densities have been demonstrated in foraging experiments (Holling 1965). Prey palatability was an important component determining the predator's prey selection in the systems studied; however, Holling also recognized that behavioural and physiological characteristics of the prey may be important in determining prey choice in other systems.

The solitary nature of male mule deer combined with their preference for rugged, dense habitat have been cited as behavioural factors that increase buck vulnerability to the stalking attack of cougar (Robinette et al. 1959, Hornocker 1970, Spalding and Lesowski 1971). Work done on sexual segregation and group size in the Junction bighorn herd, however, showed that ram group size and habitat use were stable year-round outside of the October rut (Ashcroft 1986). Moreover, the annual concentration of cougar-killed rams suggested that while both prey group size and habitat selection were undoubtedly important parameters in determining prey vulnerability and cougar hunting success, these factors alone did not adequately explain the observed pattern of cougar predation observed at the Junction. The selection of rams occurred during November and December when poor condition following the October rut would have been an important factor underlying ram vulnerability to predation.

The rut represents a time of high energy demands for rams. Despite the long, intense battles throughout the rut, rams do little or no foraging (Geist 1971) resulting in extremely poor body condition. The inattentiveness of rams resulting from poor post-rut condition likely predisposed them to the observed cougar predation. It has been suggested that bucks' pre-occupation with the activity of the rut increases their vulnerability to cougar predation (Robinette et al. 1959). This was not the case observed here as no cougar-killed rams were found during the rut.

Another series of factors potentially important in determining cougar selection of rams relate to horn size. Social dominance in bighorn sheep is related to horn size with the larger, dominant rams involved in most of the active rutting (Geist 1971). Large rams likely enter the post-rut period in particularly poor condition although, as Festa-Bianchet (1987) pointed out, this remains an untested bypothesis as younger rams may expend energy attempting to gain access to estrous ewes (Hogg 1984). Even if all rams enter the post-rut period in equally poor condition however, the larger horned rams would be more vulnerable to cougar predation due to the nature of the attack. Cougars stalk prey to within some critical distance (Hornocker 1970) and then pounce on the back of the prey and biting at the base of the neck (Robinette et al. 1959). Large, full curl rams would be particularly vulnerable to this form of attack because of inhabited rear and peripheral vision.

Horn structure may have also been responsible for the low cougar utilization of ewes. The short, relatively straight horns of the ewes may represent greater injury potential for a cougar biting at the base of the neck. By throwing her head back, even if an uncontrolled response, a ewe's horns are more likely to strike the cougar.

Implications of Selective Predation

Cougars were found to be selecting rams at the Junction W.M.A. following the rut as cougars keyed on the exhausted and less wary rams. The relationship demonstrated here between reproductive effort--the rut, and the associated costs--an increased vulnerability to predation, have implications for the ecological fitness of rams. If this pattern of predation is a regular component of the Junction predator/prey system, it may pay rams to expend less energy during any one rut. The cost of such a strategy would be a decrease in short-term breeding success while the benefit would be increased survival resulting in long term breeding success and overall fitness.

Cougar predation may, conversely, be a relatively new component of the Junction system as provincial cougar numbers recover from the combination of predator control and disease epidemics that are believed to have reduced cougar numbers significantly during the 1950's and 1960's (MOE 1980). If the observed pattern of cougar predation has only recently become a part of the Junction system, the resulting trends in the sheep population may serve as a natural test of a hypothesis linking lower production in sheep populations to breeding by immature rams (Heimer and Watson 1986).

Another implication of this study relates to predator/prey systems and the perception of predation in a more general sense. Wild sheep biology involves the examination of the factors affecting sheep population dynamics. Discussions of escape terrain and predator avoidance behaviour are common place in this examination (Buechner 1960, Sugden 1961, Demarchi and Mitchell 1973, Gionfriddo and Krausman 1986, Festa-Bianchet 1988); yet, actual predation on sheep is rarely documented. This often lead to the conclusion that predation is a minor or nonexistent component of even the most intensively studied sheep populations.

Predators, particularly the act of predation, are extremly difficult to observe, quantify, and document. To accomplish this requires a different approach to field work. Dead sheep are found in markedly different places than live ones. The discovery of these mortalities requires reconnaissance of the thickets and gulley bottoms: places sheep biologists rarely venture. Regular, systematic searches of this sort are required to find mortalities within the 1 or 2 days of death that enables a realistic assessment of the cause of death. The time and physical constraints of such searches are obviously high; however, without them little can or should be concluded about the extent of predation on wild sheep popupations.

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