Final Project Report

THE EFFECTS OF CAPTURING PREGNANT COW AND CALF MOOSE ON CALF SURVIVORSHIP, SOUTHWEST YUKON

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ABSTRACT

The effects of immobilizing pregnant moose in late winter with combinations of carfentanil, fentanyl citrate, xylazine hydrochloride, and hyaluronidase on pre and postnatal calf mortality, and the effects of capture and radio-collaring neonates on calf mortality were assessed. Prenatal calf mortality was not affected by immobilizing free ranging pregnant moose in late winter, nor was calf survivorship affected by the capture and collaring of neonates. Preliminary results suggest that postnatal calf survivorship was reduced by immobilizing the cow 2-3 months prior to parturition. We speculate that the mechanism responsible for reduced calf survivorship was either a change in the normal defence behaviour of the cow towards predators or the production of non-viable calves. Both would likely be the result of drug effects. Researchers and managers using these drugs or other chemical immobilizers to study natural mortality of moose calves should be cognizant of their potential effects on postnatal calf survivorship, especially in areas where predators are abundant.

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INTRODUCTION

Chemical immobilization is used extensively in North America to restrain free ranging moose (Alces alces), while radio-telemetry is commonly used to assess rates of natural mortality. A common assumption often made is that survival and behaviour are not affected by these activities; an assumption frequently not tested in free ranging populations due to the difficulty in establishing controls for comparative purposes.

The effects of immobilizing gravid cow moose on subsequent calf production and survival has not been well documented. Rousell and Patenaude (1975) reported no effects of immobilizing moose (N=9) with M99 (etorphine) in late pregnancy on either calf production or survival over one year. In contrast, Ballard and Tobey (1981) reported a marked decrease (approximately 50%) in calf production as a result of immobilizing pregnant moose in March with Anectine/hyaluronidase. As well, the effects of radio-collaring newborn moose calves on their survival has been rarely documented. We are aware of one study which addressed this issue (Ballard et al. 1981) and found no difference in the timing or extent of moose calf mortality between collared and uncollared calves.

A study assessing the rates and causes of moose mortality in the southwest Yukon between 1983 and 1985 (Larsen et al. 1987) documented a birth rate of 114 calves per 100 pregnant and non pregnant cows ($\geq$ 22 months) and a mortality rate of 68% on calves to 6-months of age. Pregnant moose were immobilized and radio collared and neonates radio-collared as part of this investigation. Predation by grizzly bears (Ursus arctos) and wolves (Canis lupus) caused 83% of calf deaths over 1-year. We were concerned that immobilization of cows with combinations of carfentanil/fentanyl

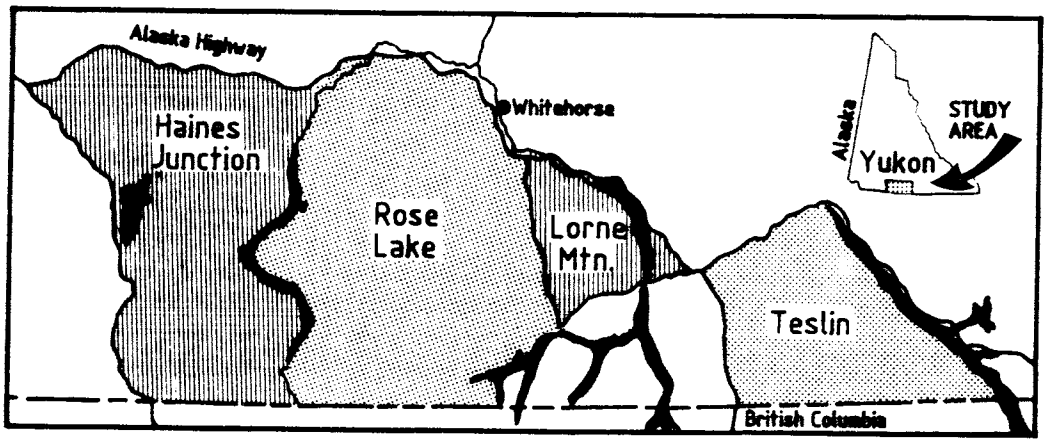
citrate/xylazine/hyaluronidase and radio-collaring newborn calves may have contributed to this high mortality rate. As well, we were concerned that the use of these drugs on cows during the last trimester of pregnancy would increase prenatal calf mortality.

STUDY AREA AND METHODS

The study area (14,800 km^2) consisted of four subareas located in the southwest Yukon, between Whitehorse and the British Columbia - Yukon border (Fig. 1). Topography, vegetation, climate, and other characteristics have been described elsewhere (Larsen et al. 1987).

One hundred and twenty six cow moose ($\geq$ 22 months of age) were immobilized and radio-collared during March-April of 1983 and 1984 (Table 1). Moose were immobilized with various combinations of carfentanil (Janssen Pharmaceutical, Mississauga, Ontario), fentanyl citrate (Janssen Pharmaceutical), xylazine hydrochloride (Rompun: Cutter Laboratories) and hyaluronidase, hereafter referred to as the CFXH mixture. Dosages of carfentanil varied from 2.0 to 3.2 mg/cow. Fentanyl and hyaluronidase when used were administered at a constant level of 30 mg and 150 mg/cow, respectively. Xylazine levels were either 40 or 50 mg/cow. The immobilizing drugs were administered from a Cap Chur dart gun (Palmer Chemical and Equipment Co., Doulgassville, Georgia) fired from a helicopter. Zero to 220 mg of naloxone (E.I. duPont de Nemoirs, Glenolden Pennsylvania) and 1 to 14 mg of diprenorphine/cow (M50:50; Cyanamid, Montreal, Quebec) were used as the narcotic antagonists. In most cases one half the antagonist mixture was injected intravenously and one half subcutaneously. For more information on induction and recovery times by the various drug combinations see Glover and Larsen (1988).

Fig. 1 Southwest Yukon Territory study subareas 1983-1986



Pregnancy diagnosis was determined in 123 moose using rectal palpation (Arthur 1964, Haigh et al. 1982) and birth rates by the number of newborn calves observed with radio-collared females on reconnaissance flights throughout the calving period (Table 1). Calving flights were more frequent (daily) in 1983 and 1985 then in 1984 (weekly). Population composition was estimated in November using a stratified aerial survey technique described by Gasaway et al. (1986), and modified for Yukon terrain and climatic conditions by Larsen (1982).

One hundred and thirty five neonates were radio-collared in 1983 and 1985 in the Rose Lake and Teslin subareas. (Table 1). Calves were located between May 15 - June 10 through daily helicopter searches of the calving areas and monitoring of radio-collared cows. Calf age at collaring was estimated as <1-day, 1-day, 2-days, 3 to 7-days or 7-days old (Larsen et al. 1987). Calves were live-captured and collared after the cow had been separated from its calf

using the helicopter. During collaring the transfer of human scent to the calf was minimized by wearing disposable rubber gloves and plastic overalls. Collars were washed in biodegradible soap, disinfected with rubbing alcohol and air-dried for up to one month prior to collaring. Expandable collars (Schlegel 1976) were used on transmitters equipped with 2-hour mortality switches (Telonics, Mesa, Arizona).

We tested 2 hypotheses regarding the effects of immobilizing, handling and collaring pregnant cows on calf mortality, and 1 hypothesis on the effects of handling and collaring neonates on calf mortality (Table 2). Three types of calf and cow groups, based on collar status, were used for these tests: 1) collared calf with collared cow; 2) uncollared calf with collared cow; and 3) collared calf with uncollared cow. These groupings allowed us to compare survival rates of control animals (noncaptured) to the survival rates of test animals (captured).

Mortality rates were calculated as the number of calves that died between birth and 1 November, divided by the total number of calves born. The majority of the annual calf deaths (90%) occurred prior to November (Larsen et al., 1987). Radio-collared calves were visually monitored within 24 hours of collaring to determine if the calf had been abandoned. For the remainder of the study radio-collared calves were electronically monitored and uncollared calves were visually monitored between 4 times daily and once per month. All monitoring was done from either a helicopter or fixed-wing aircraft.

Statistical differences between means were determined by t-test analysis and differences in proportions by log-likelihood ratio and contingency table analysis. Hypotheses were tested at a 0.05 significance level.

Table 1. Years and subareas of collaring and data collection on reproduction, mortality and population status within the southwest Yukon 1983-1986. (Values in parenthesis indicate n.)

Activity	Subareas and years															
	Haines Junction				Rose Lake				Lorne Mtn.				Teslin			
	1983	1984	1985	1986	1983	1984	1985	1986	1983	1984	1985	1986	1983	1984	1985	1986
cows (pregnant and nonpregnant) immobilized and collared	-	(26)	-	-	(39)	(5)	-	-	-	(20)	-	-	(27)	(9)	-	-
calves collared	-	-	-	-	(60)	-	(59)	-	-	-	-	-	(16)	-	-	-
cows (pregnant and nonpregnant) palpated	-	(26)	-	-	(38)	(5)	-	-	-	(20)	-	-	(25)	(9)	-	-
birth rates determined	no	yes	no	no	yes	yes	yes	no	no	yes	no	no	yes	yes	no	no
calf mortality rates determined	no	yes	no	no	yes	yes	yes	no	no	yes	no	no	yes	yes	no	no
fall aerial surveys conducted	yes	yes	no	no	yes	no	no	yes	yes	no	no	no	yes	yes	no	no

RESULTS AND DISCUSSION

Effects of Cow Immobilization

We reject the hypothesis that restraining free ranging moose with the CFXH mixture, in late pregnancy, had any measurable effects on prenatal calf mortality. The mean number of calves predicted to be born through pregnancy diagnosis in the year the cow was immobilized, (1.18 calves/pregnant cow, N=86) was similar to the mean number of calves observed at birth (1.19 calves/cow) for the same cows (Table 2). Nor was the mean number of calves born to immobilized cows in the year the cow was drugged (1.19 calves/pregnant cow, N=86) significantly different from that of nonimmobilized cows (1.27/pregnant cow, N=77). The birth rate (calves born/pregnant and nonpregnant cow) in the year the cow was immobilized (1.07 calves/cow) was not significantly different from the birth rate in subsequent years (1.13 calves/cow) when these same cows were not immobilized. The latter test was limited to cows for which we had a minimum of 2-years of consecutive data on birth rates (Table 1).

To date 3 studies have shown that xylazine, in combination with other drugs, had no effect on fetal survival of caribou (Rangifer tarandus), white-tailed deer (Odocoileus virginianus), and moose (Valkenberg et al. 1983, DelGiudice et al. 1986, this study; respectively) Knight (1980), however, recommended that xylazine should not be used in ruminants in late pregnancy because it may cause abortion. The above studies do not support this conclusion. No increase ($P > 0.05$) in abortions, reabsorptions and still births occurred in the present study as a result of immobilizing pregnant cows in their last trimester.

A study by Ballard and Tobey (1981) is the only reference that we are aware of, which reported an adverse effect of a chemical immobilizer on moose

productivity. The drug used was succinylcholine chloride, a depolarizing muscle relaxant that paralyzes the skeletal muscles while the animal remains conscious. Ballard and Tobey (1981) speculated that the low productivity measured in their study was due to high levels of stress. The drugs used in this study (carfentanil, fentanyl citrate, and xylazine) act on the central nervous system (CNS) causing unconsciousness and, therefore, presumably less stress.

Our results suggest that immobilizing free ranging moose in late pregnancy with the CFXH mixture may have lowered postnatal calf survivorship. The results of three tests show calves with cows immobilized when pregnant consistently had a higher mortality rate compared to calves with nonimmobilized cows; however the differences were significant in only 2 of the 3 tests (Table 2). In the first test postnatal calf mortality to 1 November was greater for calves with cows that had been immobilized (88%) compared to calves with nonimmobilized cows (74%) during the same year; however this difference was not significant (P=0.06). This analysis was based on data from the subareas and year when both cows were immobilized and calves were collared (uncollared cows) (Table 1). Similar results were found in a recent study in Alaska, using etorphine hydrochloride (M99, Cyanamid, Montreal, Quebec), on pregnant moose in March. Mortality rates of calves (N=18) with immobilized cows (78%) was nearly identical to mortality rates of calves (N=15) with nonimmobilized cows (80%) (W.C. Gasaway, pers. commun.).

A second test showed a significant difference between the November calf/cow ratio of collared cows in the year the cow was immobilized (13 calves/100 cows) compared to the general population (27 calves/100 cows), as determined from aerial surveys (Table 2). Data for this test was based on the subareas

Table 2. Summary of hypotheses, predictions, observations and conclusions on the effects of capturing pregnant cow and calf moose on calf survivorship in the southwest Yukon, 1983-86

H_1: Immobilization of pregnant cows in late winter with the CFXH mixture in combination with the antagonists naloxone and diprenophine caused increased prenatal calf mortality.

Prediction:

1) mean number of calves in utero/pregnant immobilized cow > the mean number of calves at birth/pregnant immobilized cow ($P < 0.05$, paired comparison t-test)

2) mean birth rates of pregnant cows in the year immobilized < the mean birth rates of pregnant non immobilized cows ($P < 0.05$, two tailed t-test)

3) mean birth rate of pregnant and nonpregnant cows in the year immobilized < the mean birth rate of these same cows in non immobilized years ($P < 0.05$, two tailed t-test)

Observed Outcome:

1) mean fecundity rate (n=86) = 1.18
mean birth rate (n=86) = 1.19
(P=0.85)

2) mean birth rate of immobilized cows (n=86) = 1.19.
mean birth rate of non immobilized cows (n=77) = 1.27 (P=0.26)

3) mean birth rate of cows in year immobilized (n=60) = 1.07
mean birth rate of cows in nonimmobilized years (n=86) = 1.13 (P=0.53)

Conclusion: results from 1, 2 and 3 support rejection of the hypothesis.

H_2: Immobilization of pregnant cows in late winter with the CFXH mixture in combination with the antagonists naloxone and diprehophine caused increased postnatal calf mortality.

Prediction:

1) ratio of alive to dead calves with collared cows in November of the year the cow was immobilized < ratio of alive to dead calves with non-immobilized (uncollared) cows in November of the same year ($P < 0.05$, log-likelihood ratio analysis)

2) November calf/cow ratio of collared cows in the year the cow was immobilized < November calf/cow ratio of the general population in the same year ($P < 0.05$, contingency table analysis)

3) ratio of alive to dead calves with collared cows in November of the year the cow was immobilized < ratio of alive to dead calves with these same cows in November of nonimmobilized years ($P < 0.05$, log-likelihood ratio analysis)

Observed Outcome:

1) immobilized cows = 7 alive/51 dead.
nonimmobilized cows = 12 alive/34 dead.
($P=0.06$)

2) immobilized cows = 10 calves/78 cows.
population = 236 calves/865 cows.
($P < 0.05$, $x^2 = 5.07$, 1df)

3) immobilized cows = 3 alive/38 dead.
nonimmobilized cows = 27 alive/44 dead.
($P < 0.001$)

Conclusion: results from 1 support rejection and results from 2 and 3 support acceptance of the hypothesis.

H_3: Radio collaring and handling newborn calves increased calf mortality.

Prediction:

1) ratio of alive to dead collared calves with non-immobilized cows in November < ratio of alive to dead uncollared calves with nonimmobilized cows in the same years ($P < 0.05$, log-likelihood ratio analysis)

Observed Outcome (N):

1) collared calves = 22 alive/34 dead.
uncollared calves = 6 alive/12 dead.
($P = 0.65$)

Conclusion: results support rejection of the hypothesis.

and years when both aerial surveys were conducted and > 10 cows were immobilized (Table 1). The corollary of the above test showed no significant difference ($P > 0.05$) between the November calf/cow ratio of nonimmobilized cows (26 calves/100 cows) and the rest of the population.

A third test showed a significant difference between mortality rates of calves with cows which had been immobilized when pregnant (93%), compared to the mortality rate of calves with the same cows in subsequent years (62%) (Table 2). This test was based on data collected from subareas and years when cows were immobilized and calf mortality rates were determined, followed by 1 or 2 consecutive years of data on calf mortality rates (Table 1).

The effect of the CFXH drug mixtures on postnatal calf survivorship was limited to the year in which the cow was immobilized, as evident from the above test which showed differences occuring between the year of immobilization and the year(s) immediately following immobilization. This conclusion is further supported by a non significant difference in mortality rates of calves in the two subsequent years (69% and 72%, $P=0.81$) after immobilization in the Rose Lake subarea; and the non significant ($P=0.07$) difference in calf/cow ratios in Rose Lake (1986) between cows immobilized 2 to 3 years earlier (28 calves/100 cows) and the general population (31 calves/100 cows).

We speculate that the mechanism responsible for lowered postnatal calf survivorship was either a change in the cows normal defensive behaviour towards predators, as a result of long term drug effects, or the production of non-viable calves, as a result of short term drug effects. We found no reference to the long term effects of immobilization with CNS depressant drugs

such as carfentanil on ungulate behaviour. We speculate, however, that animals may suffer some long lasting drug effects based on the short term effects and the properties of these drugs. Xylazine is a commonly used sedative analgesic to capture wild ungulates and has been considered relatively safe when used alone or in combination with other tranquilizers and anesthetics (Knight 1980). It does, however, cause hypertension, high blood pressure, hyperglycemia, and temporary loss of appetite in ungulates (Knight 1980, Warren et al. 1984, Van Der Eems and Brown 1986). Carfentanil is an ultrapotent morphine-like agent which is estimated to be 8,000 times more potent than morphine and two to three times more potent than M99 in rats and dogs (Meuleman et al. 1984). In large doses this drug decreases heart and respiratory rates (Meuleman et al. 1984), increases body temperature (Franzmann et al. 1984, Meuleman et al. 1984, Bailey et al. 1985), causes loss of appetite for several days and loss of body weight within the first week (Franzmann et al. 1984), abnormal behaviour (Seal et al. 1985) and occasionally death from several days to months after drugging (Franzmann et al. 1984). The latter authors reported narcotic recycling with carfentanil/diprenorphine and speculated that it could affect survival if the animal was in rough terrain or in areas with abundant predators. Acute capture-related mortalities (< 1 week after drugging) in that study were thought to be related to a combination of drug dosage/absorption, narcotic recycling or inadequate antagonist effect. Recycling was not observed in moose given 100 - 150 mg naloxone/mg carfentanil instead of diprenorphine as the antagonist (Franzmann, pers. comm.). In our study moose were given lower levels of naloxone (0 - 80 mg/1 mg carfentanil) and thus potentially increased the chance of narcotic recycling.

If drugging affected the normal behavior of the cow, it may not be as successful in defending its calf from predators as a nonimmobilized cow. Or,

the combined affects of immobilization and the stress of being separated from her calf during collaring may have influenced the cow's behaviour towards predators.

Calf survivorship would also potentially be affected if calf viability was decreased as a result of immobilizing the cow. Anorexia in pregnant cows for an extended period following immobilization could potentially inhibit fetal growth rates, resulting in the birth of smaller claves. These calves may have a lower survival rate than calves of normal birth weight.

Effects of capturing and radio-collaring calves

We reject the hypothesis that radio-collaring and handling newborn calves increased calf mortality. Mortality rates of collared calves associated with non immobilized cows (61%) was not significantly different (P=0.65) from that of uncollared calves (67%) with cows that were not immobilized when pregnant (Table 2). These results support the findings of Ballard et al. (1981) and Garrott et al. (1985) who found that mortality rates of moose and mule deer calves (Odocoileus hemionus), respectively, were not increased as a result of collaring.

As well, the capture of neonates caused minimal abandonment and thus supports rejection of the above hypothesis. Of 135 radio-collared calves two (1.4%) were rejected by their dams. One calf was killed by the cow within 24 hours after capture, and a second calf was abandoned. The abandoned calf was transported to the birth site of another calf of similar age and was successfully adopted. We attribute the low rate of rejection and abandonment to the sterile precautions taken with equipment and while handling the calves, and the limited time ($\bar{x}$=3 min) that calves were separated from the cow

(Ballard et al. 1979). Another contributing factor to our low abandonment rate may have been the young age of the calves when collared ($\bar{x}$=2 days, ± .17).

In summary, our results suggest that the use of the CFXH mixture on pregnant moose in late winter had no effect on prenatal calf survivorship but may have reduced postnatal calf survivorship. Due to inconsistency of our results, we suggest that further studies are required, but that in the meantime managers and researchers should be cognizant of the potential effects of these drugs on postnatal calf survivorship. If the mechanism responsible for lower calf survival was a change in maternal defence behaviour, we recommend that researchers studying natural mortality of calves in areas where predators are abundant either immobilize cows with these drugs well in advance of parturition (pre-rut or one full year prior to calf mortality studies) or not at all. The effects of other immobilizing drugs on postnatal moose calf survivorship have not been documented and should be closely scrutinized.

We encourage the continued use of radio telemetry to study the causes and rates of calf mortality as collaring the calf does not appear to increase its vulnerability to predation. Abandonment of newborn calves can be minimized using the techniques described in this page.

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