DOES RECTAL PALPATION OF PREGNANT MOOSE COWS AFFECT PRE- AND NEO-NATAL MORTALITY OF THEIR CALVES?

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ABSTRACT: Chemical immobilization and handling of animals may increase the risk of mortality and reduce reproductive output and survival of offspring born to immobilized mothers. We examined to what extent winter chemical immobilization using etorphine and subsequent handling affected the immediate risk of mortality and subsequent calving success and early calf mortality in a Norwegian moose population. Following 227 immobilizations of 136 different moose, we experienced no mortality during the capture process or any mortality in the 6 weeks following immobilization. Similarly, there were no significant differences in calving success (presence or absence of calf or calves) or summer mortality (birth – mid-September) of calves from cows drugged the preceding winter versus undrugged cows. However, splitting the material into age groups, we found significantly lower calving success among drugged cows aged 6-15-years compared to un-drugged cows of the same age group, and higher mortality of calves born to 4-year-old drugged cows compared to those from 4-year-old un-drugged cows. Cows that were rectally palpated for pregnancy determination had a higher fetal and calf loss than those that were not rectally palpated. This led us to conclude that rectal palpation, and not the immobilization process per se, was the most likely cause of reduced calving success and calf survival. The presence of a palpation effect may have been influenced by increased stress involved with the weighing process to obtain body mass, but nearly all cows were weighed after immobilization, so we were unable to determine the separate effect of this procedure.

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Providing estimates of big game population parameters is often necessary for wildlife research and sound wildlife management (Williams et al. 2002). As a consequence, animals are routinely captured and marked in order to provide information on survival and reproductive rates (Williams et al. 2002). Many capture methods depend on chemical immobilization to facilitate the capturing and handling process. Both chemical immobilization and physical handling, however, may be stressful events for the animal and, depending on the drug, handling method, and species, may have unwanted immediate or long-term effects. These effects may involve direct capture-related mortality (e.g., Valkenburg et al. 1983) or increased risk of mortality after immobilization and marking (e.g., Gasaway et al. 1978). There may also be reproductive effects following immobilization as well as increased mortality rates of newborns. For instance, chemical immobilization before the rut decreased kid production the following year in mountain goats (*Oreamnos americanus*; Côte et al. 1998), and postnatal calf mortality rates increased after winter immobilization of pregnant moose cows (*Alces alces*) in Canada (Larsen and Gauthier 1989). In other species, no negative effect of chemical immobilization has been reported on either reproduction or infant survival (e.g., wild horse, *Equus caballus*, Berger et al. 1983; caribou, *Rangifer tarandus*, Valkenburg et al. 1983; white-tailed deer, *Odocoileus virginianus*, DelGiudice et al. 1986).

Since the early 1980s, moose have been regularly captured by chemical immobilization from helicopter during winter as part of ongoing research and management projects in Norway. Recently, Arnemo et al. (2001) analyzed the outcome of 1,347 etorphine immobilizations of 1,149 free-ranging moose in Norway during the period 1984-2000. Seven animals (0.5%) died or were euthanized during the capture process. Follow-up radiotelemetry was done for at least 1,119 of the animals (97.4%), from which no mortality caused by the capture (residual drug effects, stress, myopathy, or predation) was observed.

In contrast to the short-term effects on survival, information is still lacking on the possible reproductive effects of etorphine when immobilizing pregnant moose. Chemical immobilization is previously suggested to have negative immediate and long-term impact on fetal and/or early calf survival in moose (e.g., Larsen and Gauthier 1989), and similarly, different handling procedures, such as rectal palpation for pregnancy determination, can potentially affect the reproductive outcome (Franco et al. 1987, Thurmond and Picanso 1993). Rectal palpation is one of the most commonly used procedures to diagnose pregnancy in domestic cattle (e.g., Arthur et al. 1989) and is increasingly used to determine pregnancy in immobilized moose cows (e.g., Ballard and Tobey 1981, Haigh et al. 1982, Larsen and Gauthier 1989, Gasaway et al. 1992). However, while this method is considered a safe method with respect to fetal survival in domestic cows (Arthur et al. 1989), less information is available on the possible negative effect on reproduction in moose.

In this paper, we examine the possible effects that etorphine immobilization and rectal palpation has on moose cows, subsequent calving success, and early calf mortality in a Norwegian moose population. Based on the assumption that chemical immobilization and handling only affect reproduction the following spring, we examined to what extent fetal and neonatal mortality differed between years of immobilization and other years. We hypothesized that neither chemical immobilization nor rectal palpation of moose cows increase the probability of fetal or neonatal loss.

STUDY AREA

The study area was the island of Vega (Fig. 1) located off the coast of Nordland county (65°40‘N, 11°55‘E) in Northern-Norway. The island was colonized by moose in 1985 when two yearling cows and one yearling bull swam over from the nearby mainland (4-8 km) (Sæther et al. 2001). Since then, the population has increased in number both due to immigration and reproduction, peaking at 43 animals during the winter 1993/1994 (Sæther et al. 2001). Since 1995, harvesting has maintained the winter population size at about 30-35 animals (0.25-0.30 moose/km^2). The climate on Vega is highly oceanic, with mild winters (Fig. 2) and only short periods of continuous snow cover during most winters. One exception occurred in 1994, when relatively deep snow covered the island during the period January-March (Fig. 2). Large carnivores are absent from the island.

METHODS

In 1992, we started a study on the island of Vega to study the dynamics in a moose

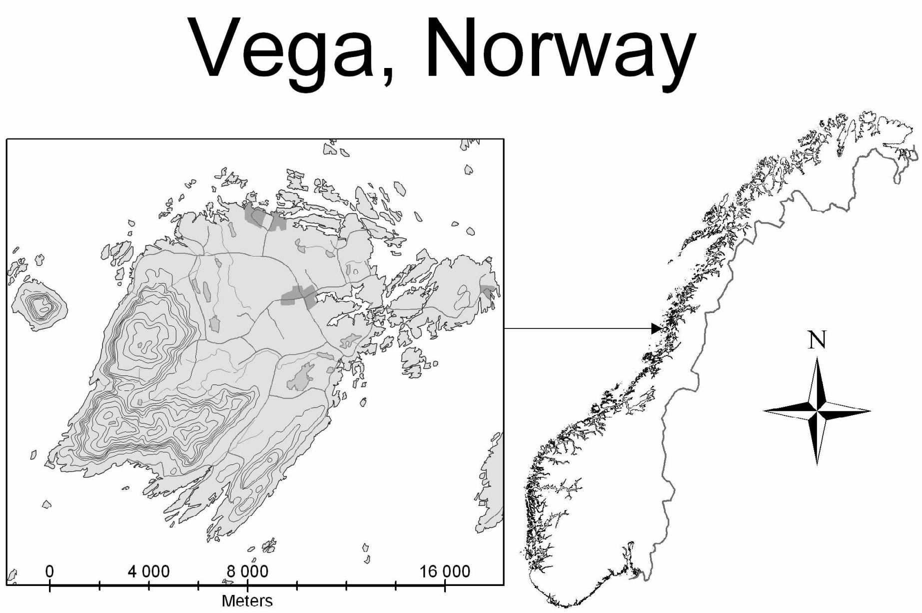

Fig. 1. The location of the study area, the island of Vega (65° 40' N, map based on ©Statens kartverk. MAD12002-R123230).

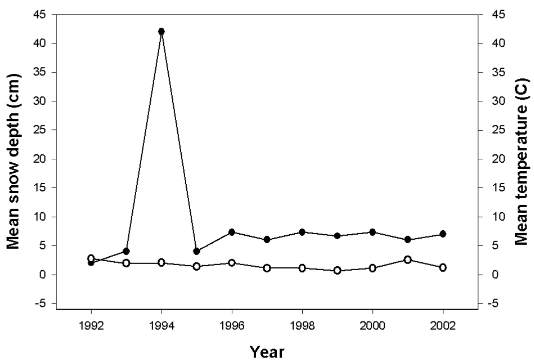

Fig. 2. Mean snow depth (closed circles) and temperature (open circles) at Vega during January-March in the study period 1992-2002.

population subject to different hunting regimes (Sæther et al. 2001). That included radio-collaring all animals present on the island as well as all calves and immigrating animals in subsequent years. As part of the study, we manipulated the adult sex and age structure to examine to what extent a low proportion of males and/or low male age influenced the reproductive performance of the cows. The results indicated that biased adult sex ratio during the rutting season led to delayed parturition the following spring, whereas no effects were observed on calving success (Sæther et al. 2003). Thus, we have no reason to believe that this manipulation confounded the results of the present study.

Moose were captured by the use of a helicopter and a remote drug delivery system (Dan-Inject, Børkop, Denmark) during winter from January to March. An initial dose of 7.5-9.0 mg etorphine per adult was used for immobilization (Kreeger et al. 2002). In animals not recumbent within 15-20 minutes, another full dose of etorphine was administered. Diprenorphine at 12 mg per 9 mg etorphine was used for reversal.

After immobilization, all moose were radio-collared and ear-tagged, and a number of morphological measurements, such as leg-length and shoulder-hoof-length, were taken. Body mass was measured using net and helicopter in 98% of the cases. In addition, 67 % of the moose cows were rectally palpated on one or several occasions by one of two experienced veterinarians (coauthors Jon Martin Arnemo and Øystein Os) to detect pregnancy (Haigh et al. 1982, Arthur et al. 1989). Pregnancy was determined by slipping fetal membranes (the main method employed in the first trimester) or by palpation of the uterine artery or the fetus itself (in the second trimester). Other field procedures included sampling of blood, feces, and skin biopsy. During the study period a total of 44 immobilizations were carried out on 31 different cows.

Age of each individual was determined by the time elapsed since radio-collared as calf or yearling, or post mortem by the tooth replacement pattern (yearlings) or number of cementum annulli of the incisors (Haagenrud 1978). Three cows radio-collared as adults were not aged, either because they emigrated before they died or because their jaws were not collected. These animals were given a minimum age based on body size, tooth wear, and reproductive status when first handled.

The number of calves was determined by locating and approaching the radio-collared moose cows on foot every 3-4 days throughout the calving season (May 15 to the end of June) (Sæther et al. 1996), and more infrequently during July and August to follow up the non-calving cows. In the summer of 2002, we did not check any cows for calving after July15, assuming that the 2 individuals not observed with calves were barren this year. Occasionally moose may give birth late in the summer, following late conception during the previous rutting season (see Schwartz 1998 for a review), but in the present study no cow was found with calf/calves after the 8th of July. Calving success was defined as the proportion of cows that were observed with a calf or calves in the spring and twinning rate was the proportion of calving cows that produced twins.

We also located and approached radio-collared cows on foot in the autumn just prior to the hunting season (hunting starts between 25 September and 10 October) to determine calf survival. Seven calves that disappeared during summer (3 and 4 calves from drugged and un-drugged mothers, respectively) were excluded from the sample because their deaths were probably caused by human interference.

Data Analyses and Predictions

To determine the effect of immobilization and handling on reproductive performance, we compared the outcome of calving for immobilized cows (treatment group) to that of non-immobilized cows (control group). If immobilization has a negative effect, we expected lower calving success and fewer calves born per cow in years of immobilization compared to other years.

Fetal and/or early calf mortality may depend on the developmental stage of the fetus at the time of immobilization (24 January – 30 March) and whether rectal palpation was conducted (e.g., Franco et al. 1987, Thurmond and Picanso 1993). To test the importance of rectal palpation and immobilization date on fetal and neonatal mortality, we compared the calving success and calf mortality for those palpated with those not, and before and after the median immobilization date (23 February), respectively. Because the rectal palpated cows were immobilized 13 days after the non-palpated cows (21 February versus 6 March) we also examined to what extent there was a relationship between palpation date and fetal and neonatal mortality. We further examined to what extent variation in body mass, as an index of body condition, influenced calving success and calf mortality in the year the cows were immobilized and weighed. To control for the higher probability of maturity with increasing body mass among primiparous cows (e.g., Sæther and Haagenrud 1983, 1985), we split the data set into low and high body mass within age classes; i.e., we examined if small cows were more affected by immobilization and handling than large cows of the same age. Moreover, based on data from 15 palpated cows from which we also collected blood samples, we examined to what extent calf loss was associated with low serum progesterone levels (Franco et al. 1987).

Because reproductive rates and calf mortality were recorded earlier in the study period for palpated (in the years 1992-95, 2000, and 2001) than non-palpated cows (1992, 1999, and 2002), annual variation in living conditions may have caused spurious differences in fetal and neonatal mortality between palpated and non-palpated cows. For instance, both abortion rate and early calf mortality may depend on the severity of the winter. We therefore checked whether higher fetal or calf loss occurred in 1994 when the average snow depth was higher than normal at Vega (Fig. 2). Similarly, we tested for any trends in fetal and neonatal mortality over years as the effect of palpation may depend on the experience of the examiners. The two veterinarians involved in pregnancy determination had 8 and 17 years experience, respectively, as dairy cattle veterinarians prior to the start of the project. This regularly involved palpation of dairy cows to determine pregnancy. However, they had no previous experience in palpating moose.

We analyzed the effect of immobilization on the response variables by fitting logistic models (Proc GENMOD, SAS Institute 1996) to the data by maximum likelihood estimation. The factor 'immobilization' (yes = 1, no = 0), rectal palpation (yes, no), immobilization date (before, after median date), and body mass (high, low) were included as independent variables. Because the response variables calving success (calves/calf = 1, no calf = 0), twinning rate (twins = 1, single calf = 0), and calf mortality (alive = 1, dead = 0) were assumed to follow a binomial distribution, the models were run with a logit link function (SAS Institute 1996).

To control for the lack of independence among observations in cases where the same individual contributed several observations to the same age and study group (treatment/control), we randomly drew one observation for each individual cow. Thus, for cows immobilized or checked for calving and calf mortality several times, only one observation was used in the treatment group (immobilization) and one in the control group. A possible alternative method using mean values for cows that contributed several observations within age- and study group and testing for differences in a contingency table analysis (e.g., G-test, Sokal and Rohlf 1981) was not employed because of the many cells with low frequencies (i.e., zero). However, for comparison, we have shown the percentage calving success, twinning rate, and calf mortality based on mean values from the different moose cows in Tables 1 and 2.

RESULTS

During the study period, 1992- 2002, we immobilized and handled 62 moose bulls, 45 moose cows, and 120 calves distributed over 136 different individuals. No individual died during the capturing or handling process. Similarly, no captured individuals were found dead during the following 6 weeks after capturing or were observed to have any problems that could be related to the capturing process. Indeed, for moose found dead after 6 weeks, we found no indications that this was related to immobilization.

In general, calving success and twinning rate was high (Table 1), and based on the total data set there were no significant differences in reproductive rates between cows in the year they were drugged and in years they were not immobilized. However, splitting the data set into age-groups showed that older-aged cows (6-15 year-olds) had lower calving success after immobilization than in other years (*P* = 0.006, Table 1). No such effect was present in the twinning rate (Table 1).

The variation in calving success or twinning rate was not related to the body mass of the cows (mean = 352 kg and range = 249-438 kg) in the winter of immobilization, or to immobilization date (Table 2). In

Table 1. Differences in calving success (% with calves), twin-production (% with twins), and calf mortality (% calf mortality) between drugged and un-drugged moose cows at Vega in the period 1992-2002. Samples in pooled age-groups are based on randomly selecting one observation from those cows that contribute more than one observation to the study group (drugged or un-drugged). For comparison, calving success, twinning rate, and calf mortality (%) based on mean values from each cow are shown in the Table (mean %). Statistics in bold indicate significant differences.

	Cow drugged the previous year							
	Yes			No				
Cow age	Calves /no calves (mean %)	Twins / single (mean %)	Calves alive /calves dead (mean %)	Calves /no calves (mean %)	Twins / single (mean %)	Calves alive /calves dead (mean %)	χ^2	*P*
2	6/5			9/10			0.14	0.70
2		2/4			3/6		0.00	1.00
2			8/0			10/1	1.22	0.27
3	4/0			16/3			1.24	0.27
3		2/2			8/8		0.00	1.00
3			4/0			20/2	0.70	0.40
4	5/0			16/0			0.00	1.00
4		4/1			12/4		0.05	0.82
4			**6/3**			**28/0**	**9.37**	**0.002**
5	9/0			10/0			0.00	1.00
5		7/2			9/1		0.54	0.46
5			16/0			19/0	0.00	1.00
6-15	**7/4 (64)**			**14/0 (100)**			**7.56**	**0.006**
6-15		7/0 (100)			12/2 (76)		1.73	0.19
6-15			13/1 (7)			24/2 (10)	0.00	0.94
2-15	24/7 (78)			20/10 (81)			0.88	0.35
2-15		16/8 (71)			11/9 (62)		0.63	0.43
2-15			38/4 (8)			38/2 (4)	0.63	0.43

Table 2. Variation in calving success, twinning rate, and summer calf mortality in relation to: (A) immobilization date (before and after median date); (B) cow body mass (above and below average); and (C) between cows checked for pregnancy by rectal palpation or not when immobilized in winter at Vega during the period 1992-2002. Samples are based on randomly selecting one observation from those cows that contribute more than one observation to the study groups. For comparison, calving success, twinning rate, and calf mortality (in %) based on mean values from each cow are shown in the Table (mean %). Statistics in bold indicate significant differences.

A	Immobilization in relation to median immobilization date							
	Before			After				
Cow age	Calves /no calves (mean %)	Twins / single (mean %)	Calves alive /calves dead (mean %)	Calves /no calves (mean %)	Twins / single (mean %)	Calves alive /calves dead (mean %)	χ^2	*P*
2-15	18/7			11/1 (92)			2.10	0.15
2-15	(70)	12/6 (69)			9/2 (77)		0.82	0.37
2-15			23/3 (9)			19/1 (5)	0.77	0.38
B	Above or below age-specific mean body mass							
	Below			Above				
2-15	16/4			14/2 (84)			0.92	0.34
2-15	(75)	13/3 (78)			9/5 (68)		0.90	0.34
2-15			25/1 (3)			19/1 (4)	0.08	0.77
C	Cow handled by rectal palpation							
	Yes			No				
2-15	14/6 (67)			14/1 (97)			3.25	0.07
2-15		11/3 (77)			9/5 (70)		0.52	0.47
2-15			**19/4 (15)**			**25/0 (0)**	**10.40**	**0.001**

contrast, calving rate, but not twinning rate, was lower in cows in which we had determined pregnancy by rectal palpation compared to those without palpation ($P = 0.072$, Table 2C). Indeed, of all observations of cows not recorded with calf/calves in the spring following immobilization (10 of 43 observations), 9 were of previously palpated cows and only one was from a non-palpated cow. Three of 26 cows palpated (6 handled twice) were not found pregnant, and accordingly, none of them was seen in company with calf/calves in the spring. Of the remaining 23 cow observations, all were diagnosed pregnant, but only 17 (74%, SD = 44.9) were observed with calf/calves in the spring. One of the cows not observed with calves was diagnosed to have a poorly developed fetus, possibly because of late conception, or because the fetus was dead and in the process of being reabsorbed.

Summer mortality of calves was analyzed based on 204 calves from 120 cow-observations. Eleven (5.4%) of the calves disappeared during summer, 4 (7.5%) from cows that were immobilized and 7 (4.7%) from cows that were not. After randomly selecting 1 observation per cow and study group, no significant difference in calf mortality existed within the complete sample between calves produced by mothers immobilized the preceding winter and calves from mothers not immobilized (Table 1). However, after splitting by age, there was significantly higher mortality among calves produced by drugged 4-year-old mothers compared to those that were not drugged (Table 1). In this case, 2 cows lost 3 out of 4 calves. No difference was found in any other age group (Table 1).

No effect of body mass or immobilization date was found on calf mortality (Table 2). However, as for calving success, there was a significant association between rectal palpation and calf mortality ($P = 0.001$, Table 2), as all 4 calves that died were from palpated mothers. Thus, of 26 palpations of 20 cows, 3 cows were not found pregnant, 6 (26%) lost their calf/calves during pregnancy or just after calving, while another 3 cows (18%) lost 4 out of 6 calves during summer. This contrasts with 17 observations of 15 cows that were not palpated, of which all but one were found with 1 (5) or 2 calves (11) in the spring and none lost their calves during summer. Hence, despite the low sample size, the pattern of higher fetal/calf loss after palpation appears quite consistent. Indeed, excluding the cows that were palpated from the sample, calving success ($\chi^2 = 4.51$, $P = 0.034$), but not calf survival ($\chi^2 = 2.35$, $P = 0.12$) was significantly higher in drugged compared to undrugged cows.

Three yearling cows that were immobilized in the winter of 1994 were all found pregnant by palpation, but none of them was observed with calves in the spring. In contrast, 10 cows (9 adults, 1 yearling) not drugged that year were all seen with calf/calves in the spring, although one lost a calf during summer. Hence, immobilization and/or palpation, and not winter severity (Fig. 2), appear to be the most likely reason for fetus loss in immobilized cows this year.

When we examined the 23 observations from 18 cows found pregnant by rectal palpation, no significant relationship existed between fetus/calf loss and year of immobilization (B = -0.442, $\chi^2 = 1.069$, $P = 0.30$). Similarly, no significant relationship existed between fetus/calf loss and immobilization date (B = -0.014, $\chi^2 = 0.41$, $P = 0.52$), but there was a tendency for cows palpated early in the winter to experience higher calf loss than those palpated later. This was particularly apparent for the 4 individual cows palpated in January, as all lost their fetus, whereas only 5 of 19 palpations (26%) from 16 cows immobilized in February and March were associated with fetal/calf loss ($\chi^2 = 4.51$, $P = 0.034$). No relationship existed between fetus/calf loss of palpated cows and cow age (B = -0.065, $\chi^2 = 0.13$, $P = 0.72$) or cow body mass (B = -0.000, $\chi^2 = 0.00$, $P = 0.99$).

Based on progesterone levels in blood serum from 15 cows (mean = 16 nmol/L, range = 7-24) that were found pregnant by rectal palpation (2 cows contributed twice), 3 cows that were not observed with calf/calves had values at average or below (mean = 12 nmol/L), but this association was not significant ($\chi^2 = 1.74$, $P = 0.19$).

DISCUSSION

Although a large number of immobilizations ($n = 227$) were carried out, no capture-related mortalities occurred in the present study. This contrasts with several studies from North America, where the reported mortality rates following chemical immobilization of moose typically range from 6 to 19% (Roffe et al. 2001). The lack of immobilization-related mortality at Vega may be due in part to the exceptionally good condition of moose on the island, following the low moose density and mild winters (Sæther et al. 2001, Fig. 2). Carcass mass of harvested moose on the island is higher than what is normally observed on mainland populations and accordingly, both calving success and the twinning rate is high (e.g., calving success/percent with twins: 52/33% and 94/75% for 2-year olds and older cows, respectively; Sæther et al. 2001, unpublished data) compared to most Norwegian (Sæther et al. 1992) and North American (e.g., Gasaway et al. 1992, Schwartz 1998) moose populations. However, even in other, presumably more food-constrained populations in Norway, capture-related mortality following chemical immobilization by etorphine during winter has been found very low (i.e., below 0.5 %; Arnemo et al. 2001).

Etorphine has no major clinical side effects in moose and has a wide safety margin; i.e., the same dose can be used in all adults irrespective of body mass (Arnemo et al. 2001, Kreeger et al. 2002). In addition, a skilled and experienced capture team will significantly reduce the risk of anesthetic mortality by use of proper remote drug-delivery systems and well-established capturing methods. Thus, immobilization of moose from helicopter with etorphine in winter can be considered a safe procedure in this species (Arnemo et al. 2001).

Despite the lack of immediate mortality following moose immobilization, we found significantly lower calving success and calf survival within some age groups in years of immobilization (Table 1). This supports several other studies reporting that immobilization and handling can increase fetal loss or early calf mortality in different large herbivores (e.g., mountain goats, Côté et al. 1998; black rhino, *Diceros bicornis*, Alibhai et al. 2002), including moose (e.g., Ballard and Tobey 1981, Larsen and Gauthier 1989), although following the use of other drugs than etorphine. For instance, Côté et al. (1998) found significant immobilization effects on kid production among young primiparous mountain goats, but not among older animals. This contrasts with the present study where the effect of drugging on calving success was only apparent in older cows. Young animals may be particularly vulnerable to various types of stress because of lower than average body mass and condition, but so may older, senescent individuals (e.g., Loison et al. 1999). In moose, senescence in mortality and reproduction have been reported to occur in cows, particularly after 10-12 years of age (e.g., Ericsson and Wallin 2001, Ericsson et al. 2001), possibly because of increasing tooth wear and subsequent decreasing body condition with age (Ericsson and Wallin 2001). Among the cows that were observed without calves in our study, however, neither were older than 9 years or had lower body mass than cows that were observed with calf/calves, and none of the older cows were immobilized during the winter of 1994 (Fig. 2), when a temporary decrease in the accessibility of food may have occurred.

As an alternative explanation, we suggest that the lower calving success and survival of calves born from drugged cows were due to rectal palpation. All cows that experienced calf loss were previously rectally palpated in winter, whereas only 1 of 15 cows (17 observations) immobilized, but not palpated, were observed without calf/calves or lost 1 or 2 calves during summer (Table 2). The use of palpation in domestic cows is usually regarded as a safe method with respect to embryonic or fetal mortality (Arthur et al. 1989), and quite aggressive handling has been assumed necessary to cause abortion (Paisley et al. 1978). More recent studies, however, indicate that rectal palpation may affect the abortion rate in cattle (Franco et al 1987, Thurmond and Picanso 1993, but see Alexander et al. 1995), although at a relatively modest level. Franco et al. (1987) found about 10% higher abortion rate in dairy cows that were palpated compared to those that were not. This contrasts with the 26% of palpated moose cows that experienced calf loss in the present study.

Although the cause of increasing calf loss after palpation is unknown, we speculate that palpation conducted under field conditions may increase the chance of damaging the fetus, which increases the risk of abortion or early calf mortality. In cattle, rectal palpation is carried out with the cow standing and physically restrained, whereas in moose, rectal palpation has to be performed during chemical immobilization with the cow in sternal or lateral recumbency. These differences in handling conditions may increase the possibility of trauma to the fetal membranes or the fetus. The weighing of the pregnant cows in a net beneath the helicopter may have contributed to this effect, but as nearly all cows (98%) were weighed immediately following immobilization, we were unable to determine the separate effect of this procedure. Accordingly, we cannot exclude the possibility that the additional stress caused by weighing decreased the threshold for rectal palpation to have an effect.

There may also exist individual differences among cows in their tolerance of palpation due to variation in age or hormonal imbalances (Arthur et al. 1989). Franco et al. (1987) found in dairy cows that later experienced embryonic or fetal death had lower than average milk progesterone, possibly making them less fit to maintain pregnancy following a stressful event. In the present study, no significant relationship existed between fetal mortality and blood serum progesterone concentration, although there was a trend for lower concentrations to be associated with cows experiencing fetal loss. Moreover, of 11 cows that were immobilized twice, 4 experienced fetal/calf loss, of which 3 lost fetus/calves on both occasions. All these cows were palpated. Thus, certain individuals seem to be more prone to fetal or calf loss than others following immobilization and palpation.

Another factor that may affect the reproductive outcome is the timing of palpation in relation to conception date. Domestic cows are often palpated before fetal attachment (45 days after conception) to allow pregnancy diagnosis following insemination (Thurmond and Picanso 1993). At this stage the embryo may be particularly vulnerable to trauma following palpation and consequently it has been proposed that palpation before day 45 may increase the risk of abortion (Franco et al. 1987, but see Thurmond and Picanso 1993). In our study, palpation occurred after placental attachment, as all immobilizations occurred between day 116 and 181 (assuming conception at October 1) at a stage where the fetus is relatively well developed (Schwartz and Hundertmark 1993) and presumably more resistant to fetal trauma following palpation. Because of the smaller size of the fetus in the early pregnancy, however, pregnancy at this stage is often determined by the slipping fetal membrane method (Arthur et al. 1989), which in our opinion is more difficult and invasive than palpation of the fetus or uterine artery as is usually done at a later stage of pregnancy. This may explain the higher incidence of fetal/calf loss among those cows that were palpated in early winter.

Few other studies have directly tested to what extent rectal palpation induces fetal loss in moose. Ballard and Tobey (1981) found that moose cows immobilized and palpated in March experienced significantly lower calving success than cows immobilized, but not palpated, in October. This could be due to an effect of palpation, but as the probability of abortion due to chemical immobilization could also vary with the age of the embryo or fetus, this is impossible to determine. In contrast, Smith and Franzmann (1979) were cited in Ballard and

Tobey (1981) to find no effect of palpation on reproduction after immobilization by the use of M99 and Rompun. Whether this was based on extensive data is unknown as we have not been able to retrieve this technical report. In other studies, rectal palpation has often been conducted on all, or the majority of cows immobilized, making it impossible to determine whether the drug or the handling method is the main cause of fetal or calf loss (e.g., Larsen and Gauthier 1989).

We conclude that rectal palpation was the main reason for the fetal/calf loss observed in the present study, possibly in combination with the weighing procedure to obtain body mass. We find it unlikely that the effect was due to improper palpation by the examiners as, to our experience, palpating moose does not differ extensively from palpating dairy cows (except for the position). The lack of any experience effect was also supported by the non-significant relationship between fetal/calf loss and palpation-year. Moreover, we did not find it more difficult to palpate and determine pregnancy in older compared to younger cows, which could possibly have explained the age class disparity in the observed fetal and calf loss; i.e., by erroneously classifying non-pregnant old cows as pregnant. Indeed, of all 4-15 year-old cows (17) palpated, 94% (16) were found pregnant, which is about the pregnancy rate to expect for this age class (Schwartz 1998).

Based on the present results, we encourage other studies to evaluate the potential effect of rectal palpation on fetal/calf loss before uncritical use of this method for pregnancy determination in moose. This may not be a great loss as alternative noninvasive methods are available, such as pregnancy diagnosis based on progesterone levels in blood serum and fecal samples (e.g., Haigh et al. 1982, Monfort et al. 1993, Schwartz 1998, Arnemo et al. unpublished data) or by using serum pregnancy tests based on radioimmunoassays (RIA) specific for moose pregnancy-specific protein B (PSPB; Huang et al. 2000). The former two methods cannot be used to determine the number of fetuses, but neither can, in our opinion, rectal palpation (but see Haigh et al. 1982, Larsen and Gauthier 1989). By the use of RIA and PSPB in sera, however, Huang et al. (2000) found that both pregnancy and the number of fetuses could be determined with high accuracy in immobilized free-ranging moose.

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