Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
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Maternal body condition - effect on time of calving, offspring survival and body weight in reindeer

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Credits: 30 hp
Level: Advanced
Course title: Degree project in Animal Science
Course code: EX0552
Programme/education: Agricultural Science programme - Animal Science

Place of publication: SLU, Uppsala
Year of publication: 2017
Cover picture: Caroline Korpinen
Series number: 618
Online publication: http://stud.epsilon.slu.se

Keywords: Reindeer, calf, mortality, weight, condition, nutrition, survival, predators

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Summary

The reindeer husbandry faces many challenges and one of the most crucial is the high calf mortality. As some reindeer herding districts have their calving grounds based in the forest, they are at high risk of losing a large number of the calves each season to brown bear predation as the bears also rely heavily on the forest as their natural habitat. To find a solution to the problem, the Swedish government commissioned a study in 2009 with the objective to evaluate and develop different measures to prevent predator damage on reindeer. Udtja- and Gällivare forest reindeer herding districts were chosen to be part of the project as both districts suffer from a high (40 % respectively 60 %) calf mortality where a significant part is caused by bear predation. One aspect of this study was to further investigate one of the preventive measures developed in the bigger project, keeping females enclosed during the calving period (end of April until beginning of June). However, emphasis in the present study was to highlight the importance of female nutrition (measured as body mass prior to calving) on the calf. The study focused on three main questions; 1) To what extent does the weight of the dam in spring affect the calf weight? 2) Is calving date related to the dams' body weight in spring, before calving? 3) Does the weight of the dam affect the early survival of the calf?

The study also aimed to study potential differences and similarities among the four different groups of reindeer, comparing two years in Gällivare (two groups 2015 and one group 2016), and the two herding districts, Udtja and Gällivare studied in 2016.

In this study data from two years, 2015 (two groups of reindeer in Gällivare) and 2016 (one group in Gällivare and one in Udtja) was used. The females used in the study (107-225 females per group) were weighed and tested for pregnancy in April. Only pregnant females were included in the study. They were then put inside the enclosure and were fed additional feed until the beginning of June when the majority of calves had been born. Observations of newborn/dead calves were made during daytime by one observer in each enclosure and calving date for all females during the observation period was noted. Calf marking took place in the first few days of June when all calves were marked, weighed and sexed. After this, the reindeer were let out from the fenced area to freely graze in the forest.

Results showed that female body mass (measured before calving) as well as calf weights in early June were significantly higher in the group from Udtja (2016). When comparing all four groups, Group A, from Gällivare 2015, (weighing less) and Group D, from Udtja 2016,

(weighing more) differed significantly from the others. Recorded calving date differed significantly between Gällivare 2016 and the other three groups, where the new calves were observed on average 2 days later. This, however, could be explained by the difficulty of approaching the females and find any newborn calves. Furthermore, Female body mass (BM) had a significant effect on Calf BM (BM) at calf marking in June, and male calves were significantly heavier than female calves as predicted (on average 0.7 kg difference). No effect of Female BM on calving date was found. However, Female BM had a significant effect on whether the female reared a calf at calf marking in June. The number of dead calves found ranged from 4-9 calves per group. Autopsies indicated that it was likely that most calves had died as a result of emaciation. One had died from infection and one was put down due to an injury reported as accident.

Introduction

Around 2500 people within the Sámi population in Sweden rely on reindeer (*Rangifer tarandus tarandus*) husbandry as a main source of income where reindeer are raised for meat-production (Sámi Parliament, 2016-04-08). Roughly 50 % (200 000 km^2) of the land in Sweden is devoted to reindeer husbandry (Lundqvist, 2007). The pastoral reindeer herding is an exclusive right of the indigenous Sámi people based on ancient traditions (Torp, 2013). During the last two decades, the total reindeer population has varied between 219 000 – 261 000 animals with 63-69 % of the herd being adult females (Sámi Parliament, 2016-04-08). The total area where reindeer husbandry is practiced is divided into 51 different districts, where the majority practice a migratory herding system. The reindeer graze freely in alpine vegetation in the mountains and in boreal forest, and reindeer husbandry depends heavily on the availability of natural vegetation. The herding district can further be divided into either mountain districts (which is most common in Sweden) or forest districts. Mountain districts only use the forest as their winter range whereas forest districts have their calving range and feed in the forest all year around (Moen, 2008).

One of the main problems affecting the reindeer husbandry is high calf mortality. Mortality can be caused by various reasons such as; predation, bad weather conditions and abandonment by the mother. It is not unusual that 5-20 % of the calves die just a few days after birth (Pruitt 1961; Rognmo *et al*, 1983). Studies made on both reindeer and caribou show that calf losses may be as high as 30-50 % from birth until the time of slaughter in autumn (Miller & Broughton, 1974; Skogland, 1980; Eloranta & Nieminen, 1986; Adams *et al*, 1995; Young & McCabe, 1997; Nieminen *et al*, 2013). Skogland (1984) reported calf losses up to 55 % in wild reindeer from late pregnancy until the end of lactation. However, the high number of dead calves were not only caused by predation but could also be explained by abortion, stillbirths and early mortality because of poor body condition or adverse weather conditions.

The number of reindeer lost to predation in Sweden may be in the order of 50 000 but the uncertainty is very large (SOU 2012:22). The large carnivores present within the reindeer herding area are lynx, wolverine, bear and wolf. The reindeer herders are financially compensated for losses of reindeer caused by predators. Since 1997, the compensation for damage by lynx and wolverine (the main predators) is based on an estimated number of individuals (based on inventories of family groups or dens) and an estimated kill rate for each of these predator species. Compensation for wolf predation is based on inventories of individuals. Conversely, compensation for predation by bears and eagles is only based on whether these predators are at all present within the district or not and is relative to the size of the herding district (Sámi Parliament, 2016-04-08).

As reindeer husbandry is not the only use of the boreal forest in the most northern parts of Sweden, other stakeholders with economic interests also need to be considered when it comes to land-use. Reindeer rely on the forest as winter pasture but modern forestry has a vast negative effect on the availability of ground lichens, both locally and over the entire land. As the reindeer husbandry is dependent on weather, a changing climate will also play a significant role in the future (Moen, 2008). Also, increased impact from industry, e.g. construction of wind farms is another factor that causes disturbances for the reindeer and changes the land-use and movement patterns (Skarin *et al*., 2015).

The present study, which focuses on the effects of female body condition on calving date, early calf survival and calf weight, is part of a large project with the aim to quantify the effects of brown bear predation on reindeer and to test and suggest preventive measures to reduce the losses caused by brown bears. Even though bears may be responsible for a substantial part of the total calf loss in some areas, the extent of the problem has been highly uncertain. The first part of the project however showed that substantial losses of reindeer calves can be caused by brown bears, and that the predation is concentrated within a short period around calving. In a second part of the project (the part including the present study) calving within enclosures was evaluated as a preventive measure against predation. Already published results from the project are presented separately, after the literature review below.

Literature review

Reindeer diet

The common winter diet for most pregnant reindeer is lichen which may constitute more than 70 % of the diet. Lichen has a high energy content but it is lacking in protein. It also contains high amounts of carbohydrates but is lacking in many of the macro minerals such as: calcium, phosphorous, magnesium and potassium (Garmo, 1986; Klein, 1990). Besides different types of lichens, the reindeer diet consists of leaves, fungi, dwarf shrubs and graminoids (Heiskari & Nieminen, 1988; Klein, 1990). Previous food selection experiments and analyses of rumen content in reindeer have indicated a higher preference for lichens than any other plants during winter (Skogland, 1984; Danell *et al*, 1994). However, the grazing behaviour of the reindeer is very distinctive as they graze over very large areas whereas most other domesticated animals tend to intensely graze smaller areas (Persson, 1963).

Food availability

Food intake and body stores are used by reindeer for reproduction and survival (White, 1993). The climate affects ungulates both directly and indirectly. For example, reindeer need to increase their thermoregulation during harsh winters and at the same time use more energy to move due to the increased costs of locomotion in the presence of deep snow which indirectly affects the body condition of both mother and calf (Weladji & Holand, 2003). Unfavourable weather may also reduce the availability of forage as well as the quality, leading to starvation in small and weak individuals (Gaillard et al. 1998, 2000). To be able to compensate for loss of body mass during harsh winters when food is scarce, reindeer quickly deposit body tissue in summer when they have good access to forage of high nutritional quality. This mechanism is of great importance in the most northern parts of the world and especially for breeding females as they need to cover the high energy expenses of reproduction (Chan-McLeod et al., 2000).

However, it is not only shortage of food that is disadvantageous. It can also be disadvantageous for the dam to be heavy during winter as it may be harder for her to walk in heavy snow and to areas where there is more food or food of better quality (Fancy & White, 1985; Bergerud, 1996).

Reproduction

The breeding season

Cyclic ovarian activity in female reindeer occurs between September until February and is dependent on short-term elevations of progesterone to initiate the oestrous cycle. The rut is, however, mainly restricted to roughly 2-3 weeks in September/October (Lenvik, 1988). Moreover, a delayed ovulation is associated with delayed calving, resulting in calves that are smaller in autumn with a lesser chance of survival during their first winter (Hogg*et al*, 1992; Langvatn *et al*, 2004). In both reindeer and caribou, pregnancy rates are generally very high. It is not unusual for a herd with animals in good condition to have a pregnancy rate above 90 % (Parker, 1981; Mossing & Rydberg, 1982).

Gestation length in reindeer is affected by several factors such as; genetics, photoperiod and maternal nutrition (Ropstad, 2000). However, gestation time has not been clearly established but has been reported to vary between 208-227 days according to McEwan & Whitehead, 1972; Dott & Utsi, 1973 and between 203-240 days according to Rowell & Shipka (2009). Calving usually commences in late April and reaches its peak in Mid-May (Espmark, 1971) and female calves are have been reported to be born earlier than male calves (Holand *et al*, 2004).

Birth synchrony

As previously mentioned, birth synchrony in ungulates is regulated by two main factors, predation and seasonality. The optimal window for giving birth is often very narrow and should occur when the environmental and energetic stress on the mother is at its lowest (Bergerud, 1974; Dauphiné & McClure, 1974). Synchronizing the birth period is crucial to minimize the risk of consuming the mother's or calf's energy stores. It also minimizes the risk of predation of the defenceless new-born's (Bergerud, 1974; Dauphine & McClure, 1974).

It is also of great importance for the calf to be born at the right time and not too early as they become more dependent on their dam for survival. As the dam is in a negative nutritional balance after giving birth to the offspring, it may be harder to take extra care of her offspring and protect herself and her young against predators (Reimers *et al*, 1983; Shipka *et al*, 2007). On the other hand, calves that are born later in the season will have less time to grow to reach a good weight during the autumn. Also, it prolongs the dams' lactation period and will therefore make it harder for her to regain the weight needed for the next breeding season (Bunnell, 1982; Festa-Bianchet, 1988).

The importance of nutrition

Effects of female condition and nutritional status

For polygynous mammals, where males do not take an active role in parenting, male reproductive success is limited by access to females during a brief rutting season, while female reproductive success is more often directly linked to resource availability. In reindeer, the female reproductive success is determined by the availability of food. However, the reproductive success of males is the determined during the brief breeding season by the access to females as the male does not play an active role in raising the calf (Emlen & Oring, 1977; Davies, 1993).

During pregnancy, maternal nutrition is thought to be of great importance for several factors such as: calf birth weight, growth rate and survival (Skjenneberg & Slagsvold, 1968; Bergerud, 1975; Espmark, 1980). Calves from undernourished mothers are generally born smaller and have a higher mortality during the neonatal period than calves from dams in good condition (Reimers *et al*, 1983; Jacobsen *et al*, 1981; Rognmo *et al*, 1983; Skogland, 1984; Eloranta & Nieminen, 1986); Lenvik & Aune ,1988). Likewise, Kojola & Eloranta (1989) reported that females weighing under 60 kg had a higher chance of giving birth to female calves whereas females weighing more than 71 kg more often gave birth to male calves.

Studies show that female weight just before calving is correlated to birth weight of the calf. In other words, maternal food intake is positively correlated with calf birth weight (Rognmo, 1983). Bergerud (1975) also supported this theory by showing a negative correlation between snow depth and birth weights in caribou. The average birth weight of reindeer calves is 5-7 kg (Eloranta & Nieminen 1986). For the newborn calf to survive the neonatal period, it generally needs to weigh at least 3.5 kg at birth which is considered the critical birth weight (Geist, 1981; Skogland, 1984).

Reimers (2002) concluded that the female body mass did not influence foetus growth up to the age of 130 days and up to 550-750 g. However, females in poor condition had poorer foetus growth during late pregnancy than those in good body condition. The main part of the foetal mass, more precisely 80 % is deposited during the last trimester of pregnancy (Robbins & Robbins, 1979). The demands for maternal investment is most crucial during this time and during the first 30 days after parturition when milk production increases (Parker *et al*, 1990).

Nutritional effects of milk

The amount of milk produced is also influenced by the maternal nutrition (White & Luick, 1984 & White, 1991). However, in the study by Rognmo et al (1983), no significant difference in milk composition during any part of the lactation was found between reindeer fed lichens (3.1% protein) in winter, before parturition, as opposed to reindeer fed an improved diet (13.6% crude protein). In contrast to this, calves with mothers fed the improved diet had higher birth weights and a faster initial growth rate than calves from mothers fed a diet consisting of lichens. Three weeks postpartum, these calves were thus significantly heavier. Then again, this weight difference was greatly reduced until July and was non-existent in September.

Effect of maternal age

Females from 1 year up to 3 years of age have been shown to have a lower pregnancy rates and calving rates than females older than 3 years of age. Maternal age also influences calf body mass as studies show that young mothers give birth to calves with a lower body mass (Eloranta and Nieminen 1986; Lenvik 1988; Skogland 1984; Weladji *et al* 2002). Rönnegård *et al* (2002) also found that maternal age was correlated with offspring body mass in the autumn. Calves with mothers that were 6 years old had higher weights than those with younger or older mothers.

The brown bear predation project

As previously mentioned, the present study is part of a much larger project, "The brown bear predation project". In 2009 the Swedish government commissioned a study of bear predation on reindeer which led to a project collaboration between the Swedish University of Agricultural Sciences (Wildlife Damage Centre and the Department of Animal Nutrition and Management), the Scandinavian bear project and Udtja- and Gällivare Forest reindeer herding district. The aim of this project was to evaluate and develop measures to prevent brown bear predation on reindeer calves.

Study of bear predation on reindeer calves 2010-2012

Studies made within the bear predation project in Gällivare during 2011-2012 and in Udtja during 2010-2012 (Karlsson *et al*, 2012; Sivertsen, 2017) used GPS-collared brown bears (*Ursus arctos*) and UNF proximity collared freely-ranged female reindeer to examine interactions and study predation. An estimated 58 (95% confidence interval: 53-75) bears resided in Gällivare and the corresponding number of bears in Udtja was 71 (95% confidence interval: 62-96). In total, 344 calf carcasses were found and 333 of them was determined to have been killed by brown bears. Predation by bears was estimated to cause 16 % and 29 % calf mortality in the two herding districts, respectively. Results also showed that all except one of the reindeer calves that were killed by bears were killed during or just after the main calving period (May 1st and the 9th of June), with a clear peak during mid- and late May, and most often during night time (6 pm – 6 am). On average, the bears killed 11 calves per year (Sivertsen, 2017). It was therefore suggested that keeping the reindeer females and their calves in an enclosure during the critical time, May until the beginning of June, would reduce the bear predation to close to zero (Karlsson *et al*, 2012).

Study of corralled calving 2013

In 2013, around 2000 female reindeer were used to test calving in enclosure as a preventive measure to reduce calf loss due to predation during calving (Wikström, 2014). The females where divided on four enclosures, one in Udtja and three in Gällivare (divided depending on owner or group of owners), with 132, 212, 416 and 953 females in each enclosure. Totally 1266 calves were recorded born in the enclosures. Of these, 937 were equipped with mortality transmitters when let out to pasture in the beginning of June. The transmitters started to send a signal whenever a calf was immobile for a certain time. In total, 97 calves were found dead in the enclosure and an additional 105 dead calves were found by the mortality transmitters until the following autumn in November (an additional 10 calves were euthanized due to Necrobacillosis infection - see below).

Calf loss was on average 7.7 % during the time spent in the enclosure. The mortality was however substantially lower in two enclosures with fewer reindeer (1.2 and 2.0 %) than in the two with more reindeer (8.8 and 10.9 %). Autopsies revealed that emaciation (44 calves) and different types of infections (25 calves) were the leading cause of death. Other causes were stillbirths, accidents and unknown causes. However, many calves died during the first month after birth, and infection by oral Necrobacillosis caused by the bacteria *Fusobacterium necrophorum*, was revealed as the main cause. During a gathering on June 29th calves were examined and 10 calves were euthanized because of infections in the mouth. Most of the calves with Necrobacillosis came from the enclosure with the most animals and it was concluded that they had been infected during their stay in the enclosure. Predators otherwise accounted for the greater part of the calves found dead after calf marking, with the exception for one group (19 calves) killed by a train accident. The study concluded that even though enclosing females during calving is an efficient way to reduce the risk of predation, it can cause several health problems as poor hygiene and high animal density increases the risk of spreading diseases (Wikström, 2014).

Purpose and aim of the present study

The present study is part of the above project. The focus was to investigate the importance of nutrition and body condition of female reindeer on body mass and survival of the calf. The objective was formulated into three main questions; 1) To what extent does the weight of the dam in spring affect the calf weight? 2) Is calving date related to the dams' body weight in spring, before calving? 3) Does the weight of the dam affect the early survival of the calf?

Materials and methods

Study area and outline of the project

The preventive measure of keeping pregnant females enclosed during late pregnancy and after calving that this study regards is part of on the greater study done between 2010 and 2012 commissioned by the Swedish government in 2009. The study was carried out during 2015 and 2016 in Gällivare and Udtja reindeer herding districts, which both suffer from a high calf mortality and are located 150 kilometres apart in the north of Sweden (Fig. 1). Both districts are so called "forest herding districts" meaning the reindeer graze and give birth in the forest and not in the mountains. Two enclosures were used in Gällivare 2015 and one of these was also used in 2016. The enclosures (Fig. 2) varied slightly in size and the studied groups included 107-225 pregnant females (Table 1), resulting in animal densities between 2 and 6 reindeer per hectare.

Table 1. Illustration of how the 670 adult females are distributed in the different groups and enclosures. "Date in" is the day the females were let into the enclosure. The last two columns displaying hectares and females/hectare clarify the animal density in each enclosure. Animal densities are slightly underestimated since the enclosures housed a few additional females that were not included in the experimental groups.

District	Year	Enclosure	Group	Date in	Females	Hectares	Females/hectare
Gällivare	2015	1	A	April 15	165	60	2.7
Gällivare	2015	2	B	April 14	107	52	2.1
Gällivare	2016	1	C	April 5	225	60	3.8
Udtja	2016	3	D	April 6	173	30	5.8
Total					**670**		

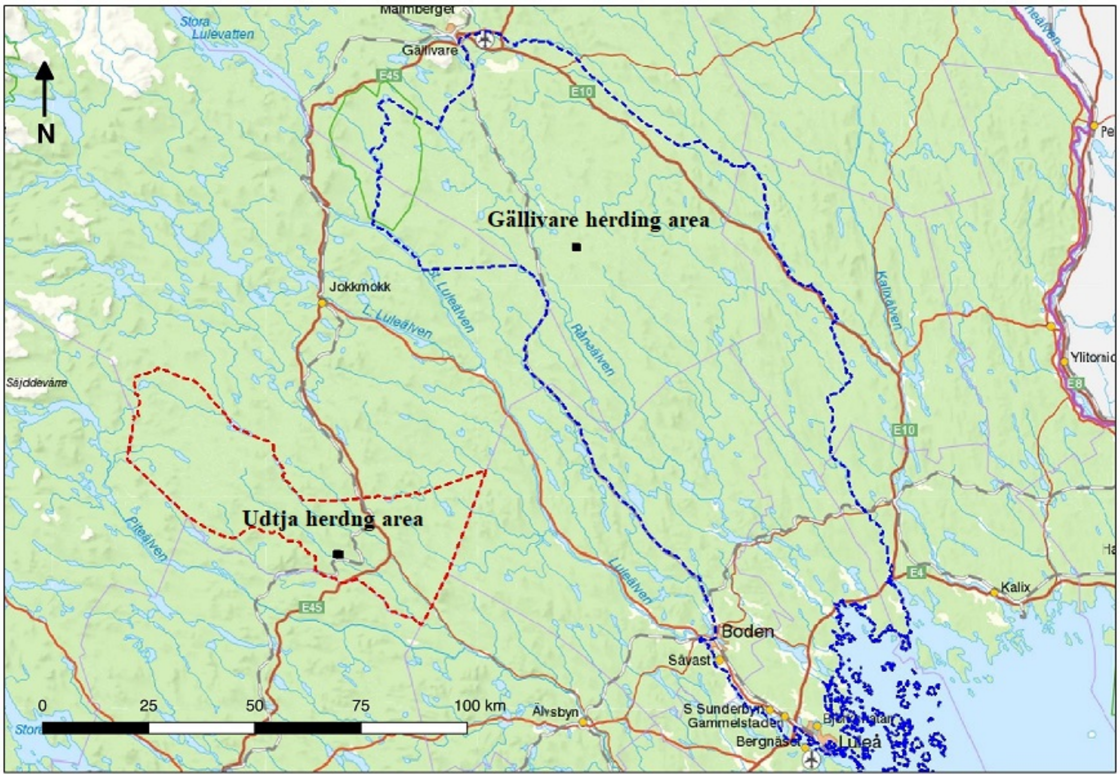

Figure 1. Map over the studied districts. Udtja reindeer community's herding district (dotted red line), and Gällivare reindeer community's herding district (dotted blue line). The black dots represent the position of the enclosures in Udtja and Gällivare, respectively. Picture: Anna Skarin & Ananai Gac Monreal

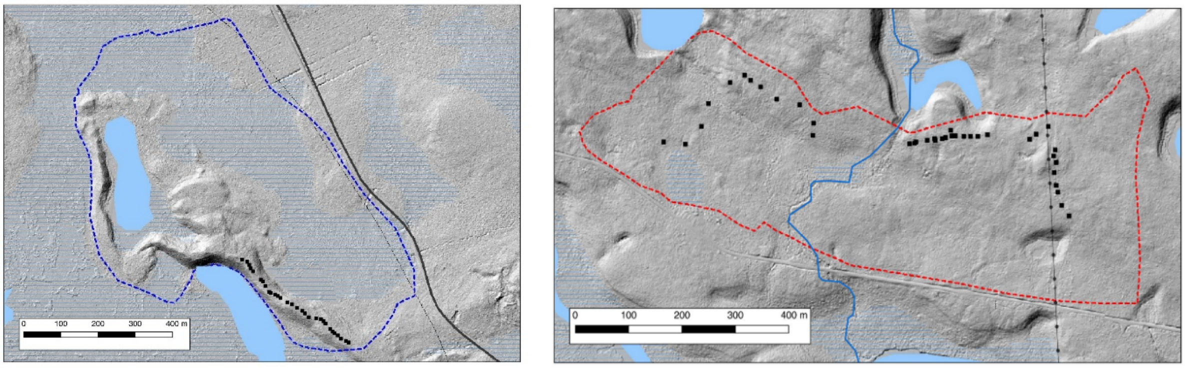

Figure 2. Outline of the enclosures used in 2016 based on GPS positions where black markings represent the location of the feed troughs. To the left enclosure 1 in Gällivare herding district (60 ha) and to the right the enclosure in Udtja herding district (30 ha). Enclosure 2 (52 ha) in Gällivare was situated just north of enclosure 1 but the outline was not investigated. Picture: Anna Skarin & Ananai Gac Monreal.

The studied females were randomly selected from larger groups of adult female reindeer from the two districts that were weighed in early April (between the 4th– 14th), and, at the same time, tested for pregnancy by a veterinarian using rectal ultrasound probe (diameter 1.5 cm, length 35 cm). The procedure was performed by enclosing the animal in a narrow crate and then inserting a plastic shaft with a transducer attached to it. A computer connected to the scanner was used to receive information about fluids in the uterus and/or foetal structures. Whether the animal was pregnant or not could then be assessed by the ultrasonographic results and by palpation of the abdomen (Savela *et al*, 2009). The overall pregnancy rates ranged between 95 – 96 % (Frank et al. 2017). All females considered pregnant were equipped with a collar marked with three digits (Figure 3a) to easily identify them during the observations and to link the calves to the individual female. From this large group of females, some were put into the experimental enclosures and some ended up as a freely ranging group studied in the other part of the "The brown bear predation project".

Feeding

The reindeer were fed daily during their stay in the enclosures. Feeding took place at approximately 8:00 am and the feed was delivered by a snowmobile or a four-wheeler by the herders. The feed consisted of commercial pellets made especially for reindeer and the reindeer had access to natural water sources in the form of a lake or river. The feed was offered in feeding troughs (Figure 3a). In Gällivare, the number of troughs varied from 31 to 35 (4.0-5.3 females/trough) and in Udtja from 10 to 30 (4.7-4.9 females/trough) during the observation period in 2016. No information of the number of feeding troughs used during 2015 was available. As the reindeer appeared more stressed by the human activity as the calving progressed, the troughs were moved further away from the entrance of the enclosures. The reindeer also tended to prefer some troughs more than others and the herders therefore decided to increase the number of troughs to reduce any aggressive behaviors and make sure everyone got fed. Also, it was a preventive measure to reduce the risk of spreading any potential disease.

Figure 3a. Female reindeer at a feeding trough with pellets. Photo: Caroline Korpinen

Figure 3b. Ole-Gunnar and Veronica from the Scandinavian bear predation project weighing one of the calves during calf marking in Gällivare the 4th of June. Photo: Birgitta Åhman

Field observations

In 2016, there were two observers, one performing the observations in Udtja and one in Gällivare from May 5th until 4th of June. The observations noted in the journal from the study made in 2015 from the Gällivare enclosures (also done between May 5th and 4th of June) were also used as material in this study and made by only one observer. All observations were made by using binoculars. Weather conditions, potential predators inside the enclosure, disturbances and any unusual behaviour of the reindeer were noted in the journal each day. The enclosures were checked daily for dead calves and in case one was found, it was sent to the Swedish National Veterinary Institute for autopsy where the dead calves were checked for underlying diseases, possible injuries from predators, body condition and overall health status.

All observations were made during daytime Monday to Friday (and during weekends in mid-May when calving peaked) from approximately 8-12 am until 4 pm depending on weather conditions and other chores that needed to be done in the enclosures. In the morning, observations took place at the feed troughs as it was a great approach of studying the females with their calves and they did not seem to be bothered as much of the company. As they later left the feed troughs to rest or graze the enclosures were checked for any dead reindeer (both calves and adult females) by walking around the entire enclosure.

The enclosures were also checked daily for newborn calves and the date of the first time a calf was seen with its mother was put in the protocol (referred as calving date). In 2016, calves that were unsteady or unable to walk without falling it was noted as “newborn”. The same applied if the mothers had the placenta still attached to her or the calf still had a fresh umbilical cord. The definition used in 2015 was however not as clearly stated but basically meant that the observer (who had much previous experience working with reindeer) with certainty could see that the calf had just been born or could not stand by itself. The method of noting new calves was changed as the calving progressed. In the beginning of the observation period, all newborn calves were noted but when the predominant part of calves had been born it was easier to focus on a list with females who had not yet been seen with a calf.

Weighing of calves

The marking and weighing of calves took place during the first days of June (Table 3). The reindeer herds were gathered into a smaller enclosure in late evening and the procedure continued into night-time. Calves were then linked to their mothers by fitting a temporary numbered neck collar on the calf and then noting which calf followed each of the females. All calves were then marked with both a traditional owner mark in the ear and a numbered ear tag. The calves were weighed by a person standing on a scale and holding the calf (Figure 3b). At the same time, the sex of the calf was noted. If a female that had previously been observed with calf did not have a calf at calf marking the calf vas recorded as dead. To ensure that the calves of females that were still pregnant during marking did not end up in the same category as the dead ones, females without calf were inspected by palpation of the abdomen to see if they were still pregnant.

Statistical analyses

Female body mass (hereinafter referred to as "Female BM"), Calf body mass (hereinafter referred to as "Calf BM"), Calving date (first date when a female was observed with calf), District, Age and Sex of the calf were used for statistical analyses. The analyses were carried out using the statistical software program JMP® provided by SAS.

Mean and standard deviation is presented for each of the variables, respectively, and t-test was used to test if the average body weights of females and calves differed between the groups. ANOVA was used to test the combined effect of Group, Female BM, interaction between Group and Female BM, and Sex on Calving Date and Calf BM, respectively. The interaction between Female BM and Group showed no significant effect ($P=0.31$) so I removed it from the model and used only Group, Female BM and Sex in the final model. A separate model was also used to test the effect of Age (days from first observation of the calf until the time of weighing) on Calf BM. In the model I included Age, Group, interaction between Age and Group, Sex and Female BM. In addition, I used Chi-2 to test if Female BM and Group had effect on whether the female reared a calf at calf marking in June or not (as a measure of calf survival until calf marking in June).

Results

Female BM

Results from the t-test showed that females in group D were significantly heavier than females in the other groups with an average weight of 79.6±7.9 kg. Group A on the other hand were significantly lighter (72.4±8.0 kg). However, no significant difference was found between group B (75.4 ±8.7) and group C (76.11±8.5).

Calving date

The overall rate of females observed with a calf in the enclosure ranged from 82.1 – 91.6 % with Group D having the lowest and Group B the highest rate. All groups show a peak in calving during Mid-May and the dates ranged from May 1st to May 31st (Table 2 & Appendix 2). The ANOVA indicated that Group C differed significantly (F-Ratio=8.14, $P<0.0001$) from the others, with the median calving date being May 17th, compared to May 14th-16th in the other groups. The median calving occurred at May 16th. Calving date was however not correlated to Female BM before calving ($P=0.1431$) (Figure 4), nor did the sex of the calf have a significant effect on calving date.

Table 2. Recorded calving date (median and interval) in each group, and proportion of calves registered as "newborn" at first observation. The first time a female was seen together with her calf was noted as the calving date. Note that calving day 32 represents June 1st.

Group	Calves observed	Median calving date	Calving interval	Calves noted as newborn
Group A	154	14 May	1-31 May	~ 2.8 %
Group B	105	15 May	4 -31 May	~ 15.5 %
Group C	204	17 May	3-31 May	~ 3.1 %
Group D	162	16 May	1-27 May	~ 29.3 %

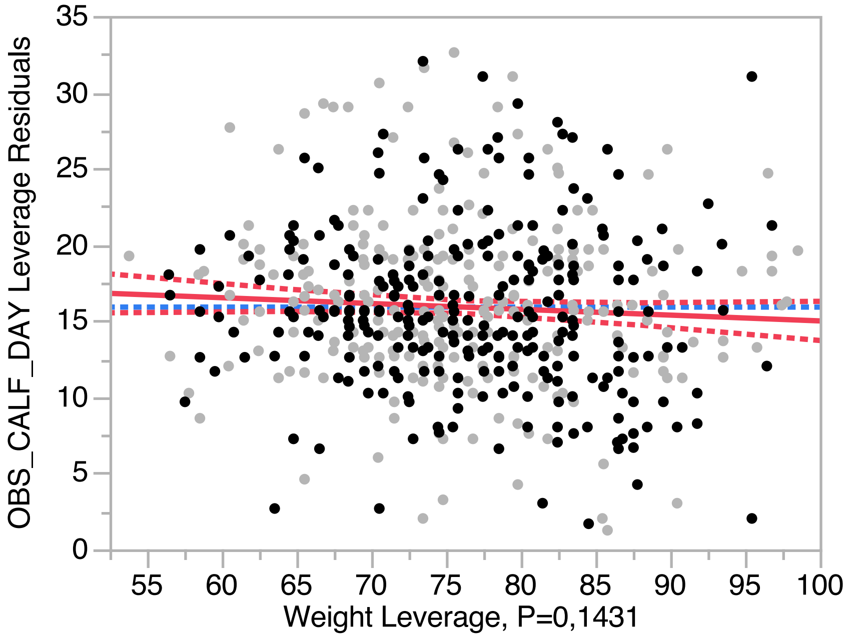

Figure 4. The effect of Female BM on calving date based on combined data from all groups (P=0.1431), from ANOVA including Female BM, Group and Sex of the calf. Regression line (bold red line), mean weights (blue dashed line) and standard error of the fit (dashed red lines). Black dots represent female calves and grey dots represent male calves.

Calf BM

Calf BM in June varied between 4.8 and 20.1 kg, and male calves in all groups had on average higher weights than female calves (Table 3, also illustrated by graphs in Appendix 3. We also observed that there were slightly more female calves (52.3 %) compared to male calves (47.7 %) at the weighing in June. ANOVA revealed significant effects of Group as well as Sex and Female BM (Table 4 & Table 5). Overall, Calf BM in June was positively correlated with Female BM before calving (Table 4, Figure 5). Although calves in Group A were on average lighter compared to those in Group B and D (Table 3), this difference between groups changed, when taking Female BM into consideration, including also Sex and Group, in an ANOVA. Least square mean (LSM) for Calf BM was significantly higher in Group B, while Group C had the lowest LSM (Table 4). Male calves were significantly heavier than female calves (12.6 ± 0.1 kg BM for males compared to 11.9 ± 0.1 kg for females (Table 5). Age (explained as the number of days since birth) was correlated to Calf BM ($t=14.40$, $P<0.0001$), and the effect corresponded to an average calf growth rate at 211 ± 15 gram/day. A significant effect was found for the interaction between Age and Group on Calf BM ($P<0.0001$), which could be explained by a different effect of Age on Calf BM for Group C ($t= - 4.4$, $P<0.0001$) compared to the other groups (see also Appendix 4).

Table 3. Calf body mass (BM) in June Mean ± Standard deviation (SD) of female and male calves in the different groups. The date of calf marking in June is the day BM was recorded and the sex determined. Means with different subscripts differ significantly from each other when using a t-test ($p < 0.05$).

Group	Calf marking	Female calves (N)	BM (Mean ± SD)	Male calves (N)	BM (Mean ± SD)
Group A	June 3	76	11.1 ± 2.2^{a}	66	11.7 ± 2.6^{a}
Group B	June 2	49	12.3 ± 2.2^{bc}	49	13.5 ± 2.9^{b}
Group C	June 4	97	11.7 ± 1.8^{ac}	102	12.4 ± 2.4^{ac}
Group D	June 2	82	12.3 ± 2.1^{b}	60	12.7 ± 2.3^{bc}

Table 4. Parameter estimates showing the effect of Female body mass (BM), Sex and Group on Calf BM tested in an ANOVA. Group D and Male were set as reference for group and sex, respectively.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.32	0.83	4.0	<0.0001*
Female BM (kg)	0,12	0.01	10.76	<0.0001*
Sex[Fem]	- 0.35	0.09	- 3.98	<0.0001*
Group [A]	- 0.45	0.16	- 2.89	0.0040*
Group [B]	0.74	0.17	4.26	<0.0001*
Group [C]	- 0.18	0.14	- 1.30	0.1958

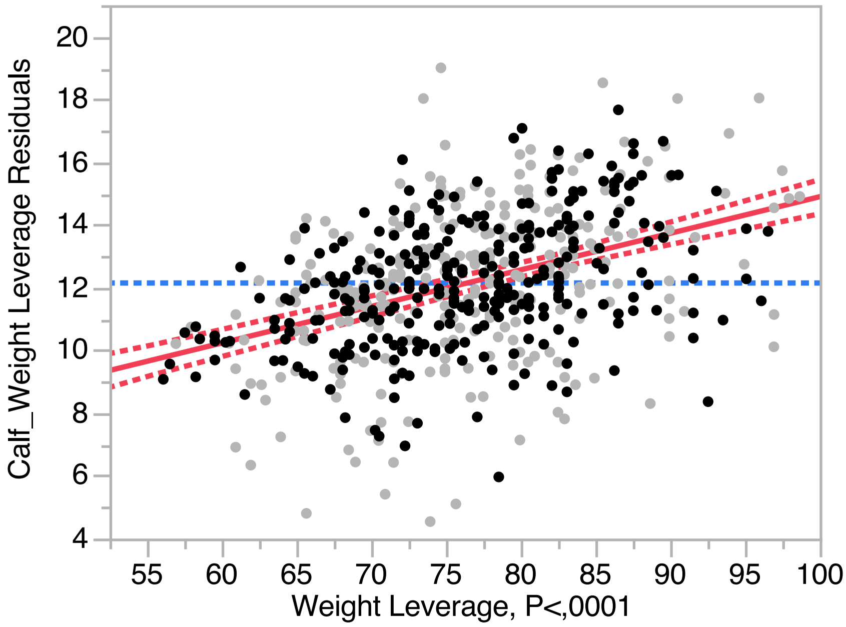

Figure 5. Effect of Female body mass (BM) on Calf BM (P<0.0001). Regression line (bold red line), mean weights (blue dashed line) and standard error of the fit (dashed red lines). Black dots represent female calves and grey dots represent male calves.

Table 5. Least square means (LSM) ± with standard error (SE) for Calf body mass (BM) when including Female BM, group and sex in the model. LSM with different subscripts differ significantly from each other (p <0.05).

Term	**LSM**	**SE**
Group		
Group A	11.78^{a}	0.18
Group B	12.97^{b}	0.21
Group C	12.05^{a}	0.15
Group D	12.13^{a}	0.19
Sex		
Male	12.58^{a}	0.13
Female	11.88^{b}	0.12

Calf survival

From the total number of females kept in the enclosures, 83 – 93 % reared a calf in June. The corresponding number for the females that had an observed calving date during the observation period and was seen with a calf at foot at calf marking in June was 87 - 94 % (Table 6). One female in Group A and one in group B were still pregnant at the time of calf marking. Both Group (Chi-2= 10.78, p=0.0130) and Female BM (Chi-2= 12.38, p=0.004) had significant effect on whether the female reared a calf or not in June. A number of the previously observed calves were missing in June (Table 6), varying between 6 and 21 in the four groups. Group C had the highest number of females with calf in June (14) that had not been observed with calf previously (no recorded calving date).

Table 6. Total number of females, and females with a noted calving date until calf marking, and the number and percentage of total females and females previously observed with calf that had a calf at calf marking in June.

Group	Total number of females	Fem with calf in June	% of fem with calf in June	Fem with obs calving date	Fem with obs calving date + calf in June	Fem with obs calving date + calf in June
Group A	165	142	87 %	154	141	92 %
Group B	107	99	93 %	105	99	94 %
Group C	225	199	88 %	204	185	91 %
Group D	173	143	83 %	162	141	87 %
Total	**670**	**583**	**88 %**	**625**	**566**	**91 %**

Results from "The brown bear predation project" showed that from the time when the reindeer were let out of the enclosures until July 1st, the calf mortality ranged from 0-5.1 % where the leading cause of death was emaciation. The overall calf mortality was higher for the test groups compared to the free ranged groups from July – September. However, this difference was not statistically significant. Calf BM on the other hand, was correlated to calf survival in both situations and was higher in Gällivare than in Udtja (Frank *et al*, 2017).

Causes of mortality

In total, 4 dead calves were found in Group A in 2015 and 9 were found in group B. In Group A, 3 calves showed signs of emaciation and the cause of death could not be determined for the fourth calf. Emaciation were also the cause of death for 5 calves in Group B and one calf had most likely died due to pleuritis caused by pneumonia. The cause of death for 3 of the calves could however not be determined.

Furthermore, 4 dead calves were found in Gällivare in 2016 (group C). All calves showed signs of emaciation and were believed to be between two and three days of age. Weather the calves were born weak, left alone over a longer period or completely abandoned by the mother is impossible to tell. Two of the calves were female (2 & 3.3 kg) and the third calf was so small (850 g) that the sex could not be determined. All that remained of the fourth calf was the legs, and the sex or cause of death could not be determined based on the remains alone. There were no signs of any kind of abnormalities or disease for any of the calves. However, all calves had been eaten by scavengers such as birds and smaller mammals.

In Udtja, 7 dead calves were found. One female calf roughly one week old was found dead but in good condition (6.7 kg), but had still most likely died as a result of starvation. Milk and fractions of moss was found inside the stomachs, indicating it nursed and ate when it was already emaciated. Additionally, one male calf (4.3 kg) was found alive but had been put down due to emaciation. Likewise, one male calf (2.9 kg) was found dead and one female calf (2.3 kg) had to be put down, both were emaciated and had probably been born dead or abandoned. Also, one calf was found dead hanging with one leg stuck in the fence and another calf had to be put down after it broke its leg during calf marking (both reported as accidents). It was not possible to connect the dead calves to their respective mother due to the large number of females included in the study.

Discussion

The present study was conducted in two different forest reindeer herding districts located in northern Sweden and included a large data sample of pregnant reindeer females with recorded body mass before calving, and data on calving date and calf weight.

The difference in Female BM found between Group A and Group B was surprising as they were randomly sampled from the same herd. Most likely, it was a coincidence that heavy, and possibly older, individuals were placed in Group B (Appendix 1). Higher body mass in Group D (Udtja) was less surprising, since these females came from a different herding district. Rönnegård (2003) suggests that differences in Female BM can be partly due to different breeding strategies between different districts or by different herders within the same district. For example, Udtja may have decided to save calves from mothers who consistently had given birth to a heavy offspring. Also, the importance of access to good quality pasture is evidently another important factor affecting the female body mass (Skogland, 1985). The average pregnancy rate of 95.5 %, when including both females older than 3 years of age and those younger than 3 years of age (Frank et al. 2017) is in good agreement with previously reported pregnancy rates above 90 % for both reindeer and caribou (Parker, 1981; Mossing & Rydberg, 1982). Furthermore, the overall calving rate ranged from 82.1 – 91.6 % (87 % on average) indicating that most females considered pregnant in April later gave birth to a viable calf.

Calving date ranged from May 1st to May 31st with a clear peak in Mid-May. The overall result from all groups agrees with the studies done by Espmark (1971) where calving also peaked in Mid-May and were all calves had been born in a period of three weeks. Eloranta & Nieminen (1986) also reported a calving period between May 10 and May 29th in a study made in northern

Finland during 1970-1985. The number of calves noted as newborn (Table 2) show some variation between the different groups and could in theory be interpreted as a measure of how exact the calving dates are. However, the inter observer reliability may affect the recorded calving dates as the observations was made by one observer in 2015 and two different observers in 2016. According to the journals that were kept by the observers, the observers in Gällivare (both years) found difficulties in detecting new calves which could explain the lower percentage of newborn calves in Gällivare (especially in enclosure 1, i.e. Group A and C) compared to Udtja. The two-day difference in calving date between Group C and the other three enclosures is most likely a result of the difficulty of getting close enough to see the number on the collar and register a new calf. The low number of newborn calves in this group supports this theory, and also the higher number of females with calves in June that had not been previously recorded with a calf.

Previous studies show that maternal age and undernutrition in the last part of gestation could affect gestation length in free-ranging reindeer (Skogland, 1984; Reimers 2002). Females in poor condition may also result in poorer foetus growth during late pregnancy than for those in good body condition (Reimers, 2002). Yet, in this study there was no correlation between Female BM and Calving date which was unexpected.

Furthermore, Age (first observation of calf) had a significant effect on Calf BM but when examining the distribution of calving dates (Appendix 2) it becomes rather clear that the noted calving dates differ from the actual calving day as there are some days (especially in Mid-May) when no calves are noted. This can be a result of harsh weather conditions or days when the observers spent time in the other enclosure. The calves may therefore have been registered 1-2 days later, which explains the large number of new calves that appear days after no calves were registered. Larger difficulty to detect new-born calves in Group C may explain the later apparent peak in calving in this group. Keep in mind that apparent growth rates (Appendix 4) are also based on these calving dates, and the results may therefore give an incorrect impression of a higher birth weight and a slower apparent growth rate for Group C compared to the other groups.

All factors tested in the ANOVA model (Female BM, Group and Sex) had significant effect on Calf BM. The study provides additional evidence that the female weight in spring is positively correlated to calf weight. This is in good agreement with previous studies where a positive correlation between maternal food intake during pregnancy and calf weight was found (Espmark, 1980). Also, birth weight has been correlated with maternal body mass in several other studies in reindeer (Eloranta & Nieminen, 1986; Kojola 1993; Rognmo 1983; Lenvik & Aune 1998 & Weladji *et al*, 2002) and caribou (Taillon et al, 2012). Additionally, male calves had a higher mean weight compared to the female calves. The higher birth weight of male calves has previously been established in several studies such as Eloranta & Nieminen (1986) and Mysterud *et al*. (2009) and was therefore hypothesized before the study started.

Previous studies report that young mothers give birth to calves with lower birth weights (Rönnegård *et al*, 2002). Age was known for some of the females, however not for all. Had the age of each female been known it would have been interesting to test the correlation between maternal age and calf weight at birth. For example, the calves found dead in 2016 may have had young mothers (with lower BM) which may have resulted in a low birth weights and a lesser chance of survival.

Both Group and Female BM had an effect on whether the female reared a calf or not at calf marking, and on average 91 % of all calves that had been noted as born survived until June. However, there were more calves missing at calf marking in June than the number of calves found dead in the enclosures, showing that not all dead calves were found.

The main cause of death for the totally 24 calves that were found was emaciation, and other deaths were reported as accidents or miscarriage. When Wikström (2014) studied calving in enclosure in 2013 emaciation was also the main cause of death. However, as reported above, many calves died due to different types of infections, e.g. Necrobacillosis, during their first month. One explanation may be the substantially higher animal density in 2013. In the present study, few signs of infections were found (one calf had probably died from lung infection in 2015). The overall calf mortality is considered within a normal range, as it is common that 5-20 % of reindeer calves die just a few days after birth (Pruitt 1961; Rognmo *et al*, 1983) and calf loss can reach up to 30-50 % until autumn in both reindeer and caribou (Miller & Broughton, 1974; Skogland, 1980; Eloranta & Nieminen, 1986; Adams *et al*, 1995; Young & McCabe, 1997; Nieminen *et al*, 2013). This however includes also predation. According to Eloranta & Nieminen (1986) a low calf body weight is correlated to a low weight in autumn and lesser chance of survival. Not only, most of the dead calves found in 2016 weighed less than the average birth weight of 5-7 kg (Eloranta & Nieminen 1986), they also weighed less than the critical birth weight of 3.5 kg reported by Rognmo et al. (1983), which may indicate they had very little chance of survival.

Conclusions

The present study provides further evidence that maternal body condition is correlated to calf weight in spring, proposing that increasing female body mass is a good way to ensure viable calves. Suggestions for future research within the subject would be to investigate other important factors affecting female body mass such as age and previous pregnancies. In this study, calving date was however not affected by Female BM. Calf survival rates is greatly improved when keeping females enclosed before, during and shortly after calving as the risk of predation is heavily reduced. However, this method is very costly and increases the risk of spreading potential diseases. Access to high quality pasture, good hygiene and a low animal density is therefore crucial if this method is to be successful but is still not a long-term solution to the high calf mortality within the reindeer husbandry.

Populärvetenskaplig sammanfattning

Effekt av vajans kroppsvikt på tidpunkten för kalvning, kalvöverlevnad och kalvens levande vikt vid kalvmärkning

Renskötseln står inför många utmaningar och en av de mest avgörande är den höga kalvdödligheten. Eftersom många samebyar har sina kalvningsmarker i skogen (som även utgör björnens naturliga habitat) löper de hög risk att förlora ett stort antal kalvar varje säsong till björnpredation. För att finna en lösning på problemet beställde den svenska regeringen 2009 en studie med målet att utvärdera och utveckla olika åtgärder för att förhindra rovdjursskador på renar. Udtja- och Gällivare sameby valdes ut som en del av projektet eftersom båda årligen drabbas av en hög (40% respektive 60%) kalvdödlighet där en betydande del orsakas av just björnpredation. En aspekt av denna studie var att ytterligare undersöka en av de förebyggande åtgärderna som utvecklats i det större projektet, att hålla vajorna i hägn under kalvningsperioden (slutet av april till början av juni). Fokus i denna studien var dock att lyfta fram vikten av vajans kondition (mätt som kroppsvikt före kalvning) på kalven. Studien fokuserade på tre huvudfrågor; 1) I vilken utsträckning påverkar vajans vikt under våren kalvvikten? 2) Är kalvningsdatum relaterat till vajans kroppsvikt på våren före kalvning? 3) Påverkar vajans vikt kalvens tidiga överlevnad?

Studien syftade också till att studera potentiella skillnader och likheter mellan de fyra olika rengrupperna, jämförande två år i Gällivare (två grupper 2015 och en grupp 2016), och de två samebyarna Udtja och Gällivare som studerats under 2016. I den här studien användes data från två år, 2015 (två grupper av renar i Gällivare) och 2016 (en grupp i Gällivare och en i Udtja). De vajor som användes i studien (107–225 vajor per grupp) dräktighetstestades och vägdes i april och endast dräktiga vajor ingick sedan i studien. Vajorna fördes sedan in i respektive hägn där de tillskottsutfodrades till början av juni när majoriteten av kalvarna hade fötts. Observationer av nyfödda/döda kalvar gjordes under dagtid av en observatör i varje hägn och kalvningsdatum för alla vajor under observationstiden noterades. Kalvmärkning skedde under de första dagarna i juni där alla kalvar märktes, vägdes och könsbestämdes. Därefter släpptes renarna ut från hägnen för att få beta fritt i skogen.

Resultaten visade att vajvikter (mätt före kalvning) samt kalvvikter i början av juni var signifikant högre i gruppen från Udtja (2016). När man jämförde alla fyra grupperna skilde sig både grupp A, från Gällivare 2015 (vägde mindre) och Grupp D, från Udtja 2016 (vägde mer) signifikant från de andra grupperna. Vidare skilde det observerade kalvningsdatumet signifikant mellan Gällivare 2016 och de övriga tre grupperna, där kalvarna observerades i genomsnitt 2 dagar senare. Detta kan dock förklaras av svårigheten att närma sig vajorna och hitta några nyfödda kalvar. Vidare hade vajans vikt hade en signifikant effekt på kalvens vikt vid kalvmärkning i juni. Tjurkalvarna var signifikant tyngre än kvigkalvarna (i genomsnitt 0,7 kg skillnad) och hade förutspåtts redan innan studien påbörjats. Ingen effekt av vajans vikt på kalvningsdatum påträffades. Vajans vikt hade dock en signifikant effekt på huruvida vajan hade en kalv vid sin sida vid kalvmärkning i juni. Antalet döda kalvar som hittades varierade mellan 4–9 kalvar per grupp. Obduktionerna indikerade att de flesta kalvar troligen dött till följd av utmärgling. Vidare hade en kalv dött av infektion och en avlivats på grund av en skada, som sedan klassificerades som en olycka.

Acknowledgements

I would first like to thank my supervisor Birgitta Åhman for expertise in the subject and help with the statistical analysis. To my assistant supervisor Anna Skarin for all the help during the observation period and to Anna-Marja Persson for assembling and analysing the data in 2015. Also, I would like to thank all people involved in the Bear Predation Project for making the trip to Gällivare and Udtja possible and of course Gällivare and Udtja Sami districts for welcoming me. To family and friends who kept me motivated and Ananai Gac Monreal for sharing this fantastic experience with me.

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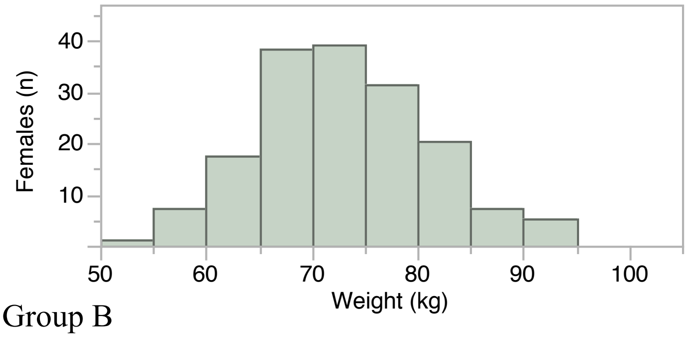
Appendices

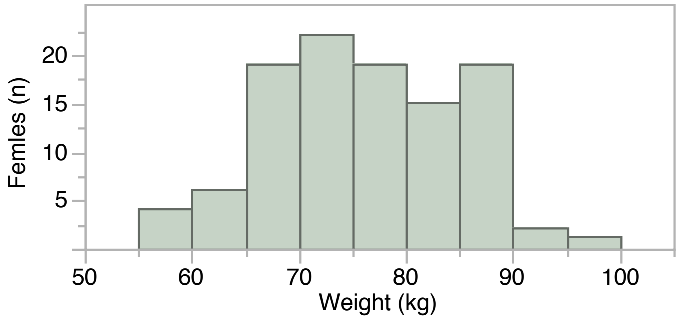
Appendix 1.

Female body mass (kg) before calving.

Group A



Group B



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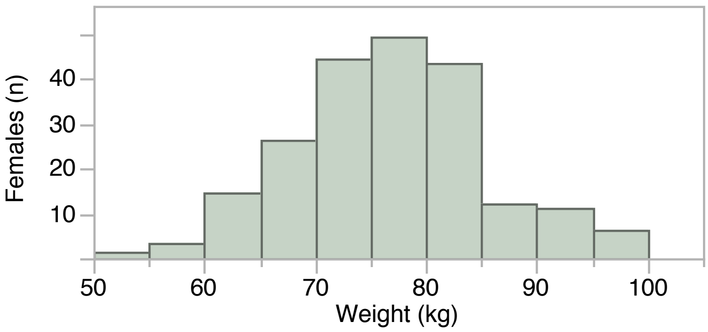

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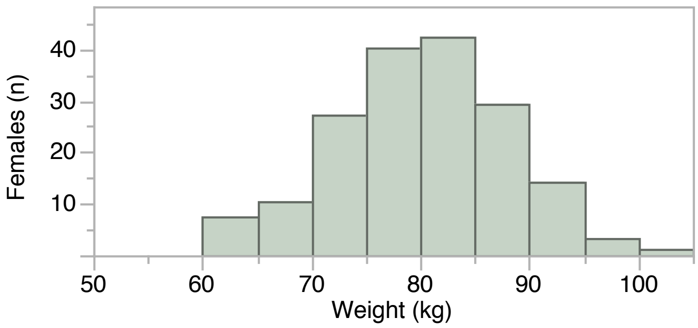
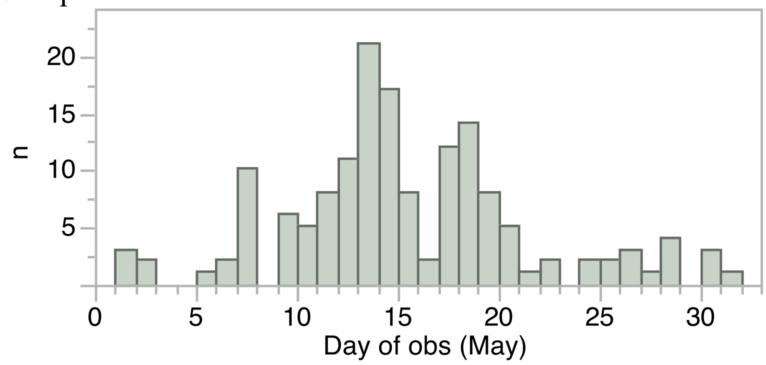


Appendix 2.

Distribution of calving dates (first observation of calf). Note that even though most calves were born in May, some were born in the beginning of June. The x-axis therefore have a span between day 1 to 35 where 1 represents May 1st and day 35 represents June 4th.

Group A



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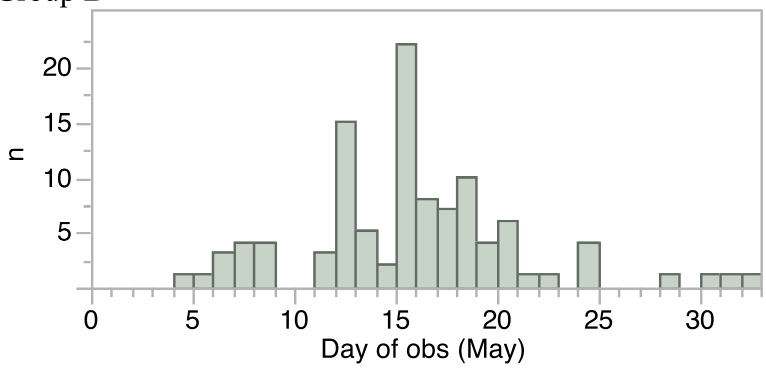

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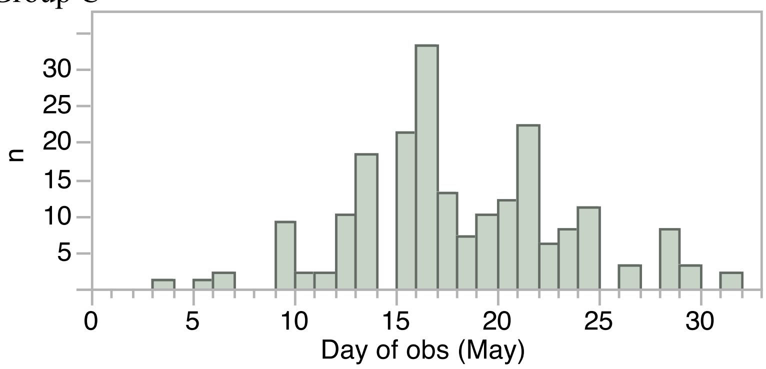

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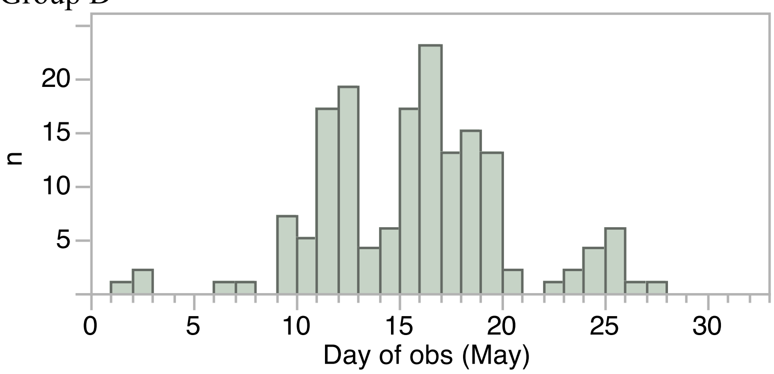
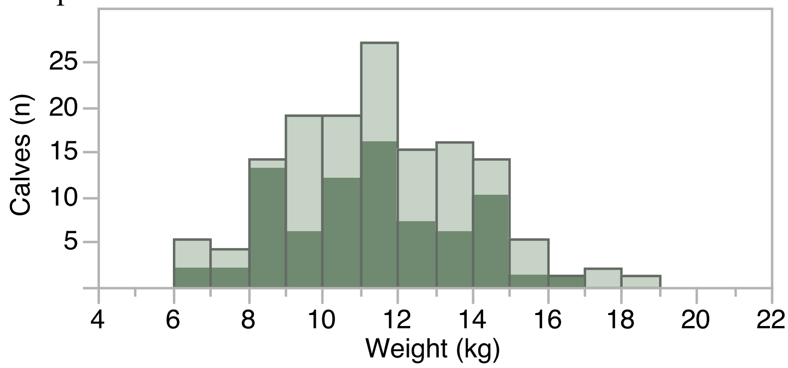


Appendix 3.

Calf body mass (kg) recorded at calf marking. The female calves are highlighted.

Group A



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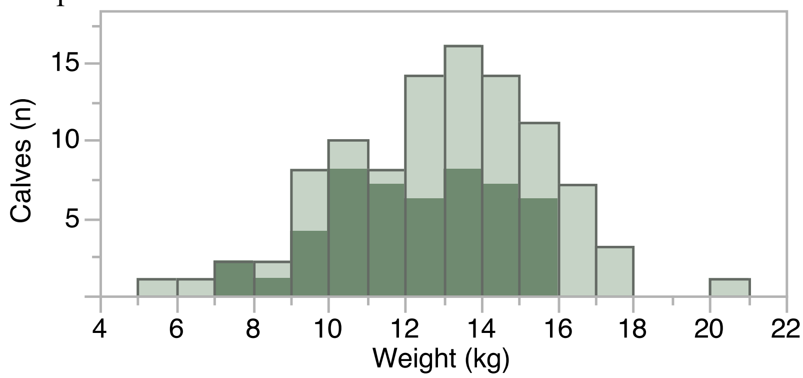

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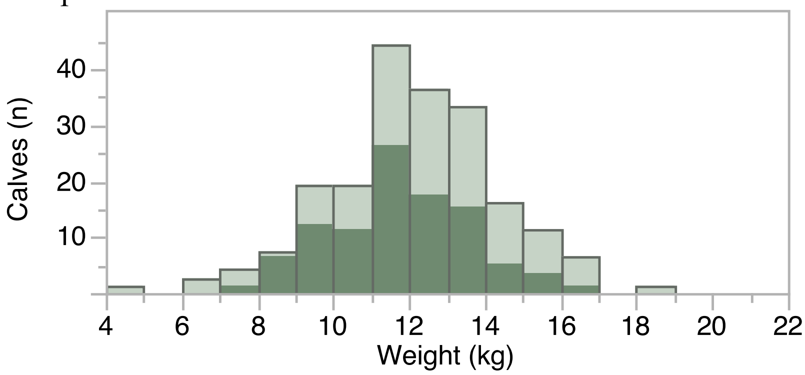

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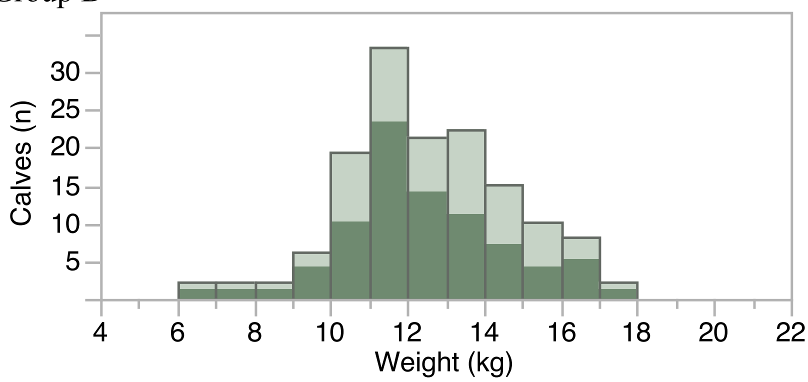
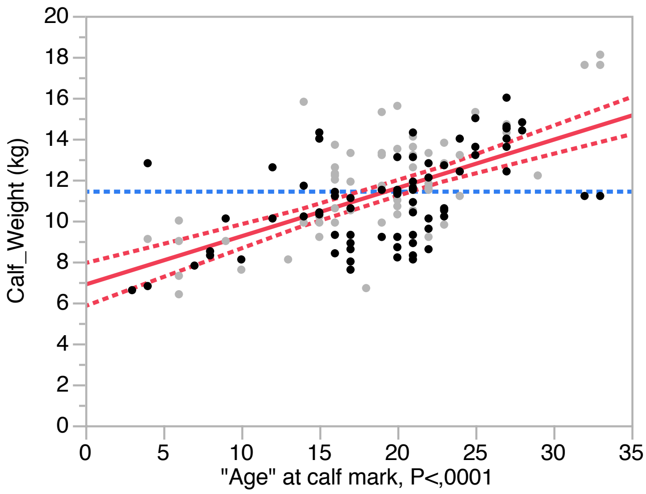


Appendix 4.

Correlation between estimated calf age at calf marking and calf body mass (Apparent growth rate)

Group A



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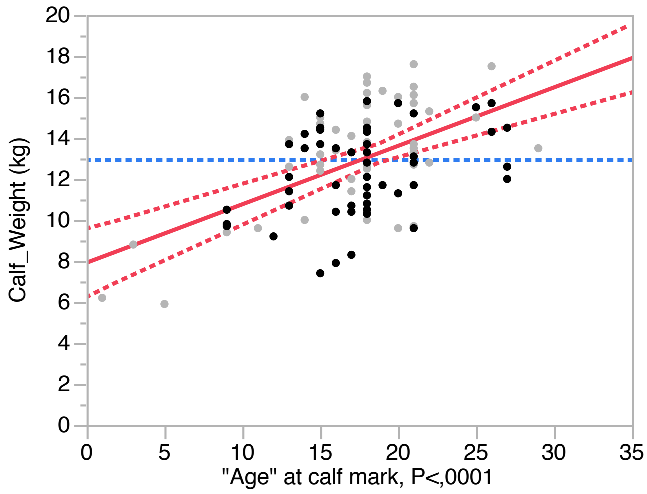
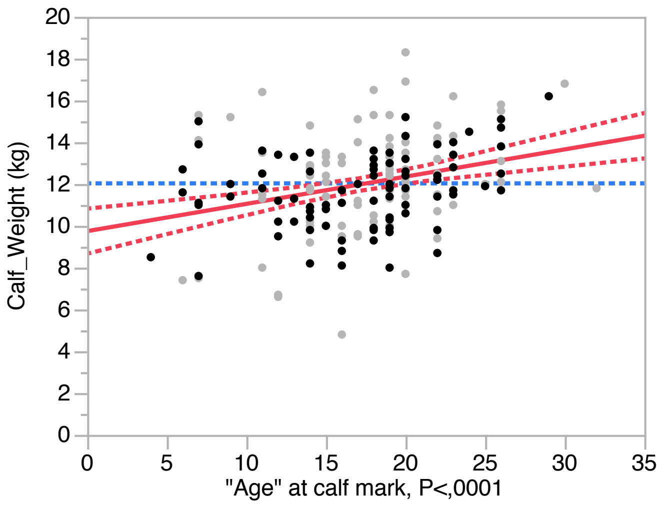


Group C



Group D