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Reindeer Calving in Enclosures – Effect on the Mother's Activity

Renkalvning i hägn

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Summary

Reindeer (*Rangifer tarandus* spp.) are a migratory species, which have a high fidelity to their calving grounds. They therefore return to calve in the same location each year. In Sweden, all reindeer (*Rangifer tarandus tarandus*) are herded within a pastoral and extensive system. There are reindeer herding communities, which herd their reindeer to the mountain region in summer and to the boreal regions in winter, and there are forest reindeer herding communities, which keep their herd in the boreal regions throughout the whole year. A larger project at the Swedish University of Agricultural Sciences presented an opportunity to observe reindeer calving in enclosures in both Udtja and Gällivare forest reindeer herding communities. The aim was to observe reindeer behaviour around calving and investigate whether or not calving in enclosure affects reindeer behaviour and movements around calving. To track the movements of the reindeer, 25 reindeer in total were equipped with GPS-collars in both Udtja and Gällivare enclosure and in addition in a freely ranging herd in Udtja. Specifically, female residence time (RT) and step length (distance between adjacent GPS-positions) were calculated as an indication of reindeer movement around calving and overall movement during the period 5 May to 30 May. RT was used to define a calving event and quantify the amount of time spent by the reindeer cow and her calf in close proximity of the calving place, after calving. The mean RT was significantly greater in the freely ranging herd than the pooled data from the two enclosures, but no significant difference was found between the freely ranging herd and the reindeer in the Udtja enclosure. There was no significant difference of mean RT between the two enclosures either. Gällivare enclosure also had a significantly greater mean step length value than the freely ranging herd, and the difference seemed to be greatest around feeding in the morning. In conclusion, reindeer calving in enclosure seem to have the potential to affect reindeer behaviour in a negative way by decreasing their residence time and increasing step length. However, an enclosure with more flat grounds and less wetlands and mires seem to be preferable if calving in enclosure is necessary, as it seems to let reindeer activity be more in harmony with their activity patterns in their natural habitat.

Contents

Introduction

Reindeer (*Rangifer tarandus* spp.) are a herd-living and migratory species with long-term fidelity to their calving grounds, meaning that they return to the same calving location every year (Gunn & Miller, 1986; Baskin, 1990). This behaviour is thought to be a partly or fully learnt behaviour (Gunn & Miller, 1986; Baskin, 1990). In caribou, home-range fidelity was observed to be higher during calving and summer than during autumn and winter (Faille et al., 2010). Caribou displayed a more negative response on home-range fidelity towards natural disturbances, such as insect outbreak and windfall, during calving, than anthropogenic disturbances, e.g. clear-cuts, roads, infrastructure and power lines. Nevertheless, the caribou still showed an overall tendency to continue to use their ordinary calving area during disturbances, they did however seem to increase the size of their home-range (Faille et al., 2010).

In Sweden, all reindeer (*Rangifer tarandus tarandus*) are domesticated and herded within the Sámi reindeer herding communities. In total, there are 51 reindeer herding communities in Sweden, of these 33 communities migrate with their reindeer between mountain regions in the summer and in boreal forest in the winter (mountain reindeer herding community), 10 herding communities keep their reindeer in the forest all year round (forest reindeer herding community), and then there are 8 concession reindeer herding communities situated towards the border of Finland (Jernsletten and Klokov, 2002).

Calving takes place in spring and is mainly concentrated to the month of May (Espmark, 1971a; Eloranta & Nieminen, 1986). The reindeer calf is likely more at risk from predation during the first part of life (Espmark, 1971a). In an ongoing study of brown bear predation on reindeer calves in the forest region in the County of Norrbotten, Sweden, preliminary results indicate that 99.7 % of the calves killed by brown bears in the study, were killed between 1 May and 9 June (Karlsson et al., 2012). The number of calves killed by one bear seem to be associated with the amount of time the bear is in proximity of the reindeer calving areas, rather than individual preferences for killing reindeer calves (Karlsson et al., 2012).

This thesis is part of a larger ongoing project at the Swedish University of Agricultural Sciences. The Swedish Government decided in 2012 to give the Swedish University of Agricultural Sciences together with the Scandinavian Brown Bear project a mission to investigate how calving in enclosures as well as harvesting of bears within the reindeer calving ranges would affect survival of the calves in the reindeer herd (dnr L2012/2817/JFS). The project is expected

to deliver a final report by the end of 2017. The investigation of calving in enclosures was performed between 2013 and 2016 in Udtja and Gällivare forest reindeer herding communities. It is not common practice for reindeer herders in Sweden to let the reindeer calve in enclosures, as reindeer husbandry is mainly a pastoral system making use of the natural forage resources (Skarin & Åhman, 2014). The project therefore presented a rare opportunity to observe reindeer behaviour around calving in this type of controlled environment.

The reindeer cow and her calf

Calving

During calving, the female reindeer split up in two groups, one consisting of mothers and their new-born calves and one consisting of the other cows and yearlings (Espmark, 1971a). It has been suggested that it is the pregnant cow that initiate this separation, as she removes herself from the group prior to calving (Espmark, 1971a). Among forest reindeer there is a clear tendency for the mothers to separate themselves from the rest of the group during the calving event, normally in a secluded place free from snow (Espmark, 1971a). It has been observed that one-two days before parturition the mother displays behaviours, such as nervous walking and trotting, these behaviours seem to be disharmonised with the rest of the group's activity pattern (Espmark, 1971a). There is also a decline in foraging activity. Reindeer most commonly give birth lying down, but before parturition the cow alternates between standing up and lying down (Espmark, 1971a). The calf is licked continuously for half an hour instantly after being born, and occasionally during the hours that follow. Body care directed towards the calf after its first day has been seen to be mainly associated with nursing (Espmark, 1971a). It is common that all of the afterbirth is consumed by the female, and in some cases even the vegetation covering the birthplace is ingested (Espmark, 1971a). After giving birth, the mother's attentiveness is increased and the acceptance level for disturbances is lowered (Espmark, 1971a; Skarin & Åhman, 2014). The female often rise and chase off or threaten reindeer that come too close to her calf. When other reindeer approach the calving site, the female often rise from a lying position and makes more frequent contact with her calf as well as vocalize more in grunts (Espmark, 1971a). The female and her newly born calf later join the group, consisting of other mothers and calves. The time the mother and her new born calf stay together before returning to the rest of the group varies a lot between individuals but has been observed to generally be within 24 hours after parturition (Espmark, 1971a).

Bonding

It is believed that the bonding between the mother and the calf starts immediately after birth and continues until the pair joins the rest of the group. The intense licking of the calf as well as grooming during nursing allows them to recognize each other through olfactory queues (Espmark, 1971b; Källquist & Mossing, 1982). A while after giving birth, the mother starts grazing in the close vicinity of her calf and then successively starts grazing further and further away. The calf follows the mother but obviously moves slower, when the calf has fallen behind a couple of metres the mother usually stops, looks back, grunts at the calf and waits for it to catch up or returns to the calf, both smelling and licking it (Espmark, 1971a). This is repeated several times before successfully leaving the birthplace. During the first week of the calf Espmark (1971a) observed that a following response from the calf was continuously conditioned by the mother in a similar fashion as when exiting the birthplace. The mother moved away from the calf, stopped and looked at it and then waited for it to catch up and then they made naso-nasal olfactory contact followed by a short suckling bout (Espmark, 1971a).

Vocalization

The reindeer mother and her calf do not only communicate through olfactory queues but also through vocalization (Espmark, 1971a; Espmark, 1971b; Espmark, 1975). The vocal repertoire consists of both bleats and grunts. In situations where the mother and calf have been separated grunts and bleats have been heard from both calves and mothers (Espmark, 1975). Vocal recognition between mother and calf was investigated in two reports, one used a playback technique and observed the reactions of both mothers and calves (Espmark, 1971b). In the other study Espmark (1975) analysed the characteristics and the individuality of the calves' bleats. The average length of a calf's bleat is longer when it is stressed compared to when it is undisturbed (Espmark, 1975). In the analysis of different variables and features of the calf's bleat, Espmark (1975) found that there was significant variance both within as well as between individuals. They found evidence of individual characteristics in all of the investigated calves' bleats and it was concluded that the characteristics of a calf's call is made up by the combination of several features as opposed to a specific feature. The results from the study also suggest that the mother can distinguish a filial calf's call from a non-filial calf's call (Espmark, 1975).

Mother and calf distance

Espmark (1971a) found that when both mother and calf were lying resting, the maximum distance between them was estimated to be one meter, up until the calf reached 2 months of age. When one or both the mother and the calf were active the distance and time spent apart

differed amongst pairs and also depended on the age of the calf. The mean duration that the mother was separated from her calf was 15 minutes, however, the longest separation observed was one hour. The mother paid less attention to her calf when performing more concentrated grazing, and during these occasions the calf was generally resting. When the mother had distanced herself between 10 to 15 meters from the calf, it got up and ran to the mother and laid down again when it had reached her. When the calf initiated the separation the mother generally followed the calf if the distance between them were longer than 10 meter (Espmark, 1971a).

Environmental factors such as the herd's group size and terrain structure also affect the distance between the mother and her calf. A larger group size often results in larger mother-calf distances (Mathisen et al., 2003). The mother's social rank can also affect the distance between the mother and the calf, high rank seems to be associated with a shorter mother-calf distance (Kojola, 1989). The distance between mother and calf increases with the calf's increasing age, there seems to be no difference in the rate of the increasing distance between male and female calves (Mathisen et al., 2003). Espmark (1971a) found that at times, the calf or mother were not as attentive to the separation initiated by either the calf or the mother, and consequently, the calf was temporarily deserted. When the calf discovered that the mother was missing it ran around grunting, listening and looking for a couple of minutes before returning to wait in the area where the mother and calf last had contact. After being separated for a while the mother came back, often running and occasionally grunting and the calf met up with her replicating the same behaviour (Espmark, 1971a).

Nursing and Grooming

The calf commonly makes several suckling attempts towards the wrong body parts on the mother before the first successful suckling solicitation is made (Espmark, 1971a). During the calf's first week the mother seeks contact by nose-nudging, intense licking or giving it a gentle push with the hoof, which encourages the calf to initiate suckling (Espmark, 1971a).

Olfactory contact is very common between the mother and her calf (Källquist & Mossing, 1982). The olfactory contact is more frequently initiated by the mother, in the form of sniffing around the calf's nose, tail or anogenital region (Källquist & Mossing, 1982). The calf's olfactory initiation is more frequently through naso-nasal contact (Källquist & Mossing, 1982).

Mean duration of the suckling bout as well as successful suckling solicitations per week and hour are greatest during the calf's first week and decreases with age and increased grazing (Espmark, 1971a; Lavigueur & Barette, 1992). Suckling solicitations with no initiated olfactory

contact are significantly less successful than suckling solicitations initiated with olfactory contact (Källquist & Mossing, 1982). After the calf's first day of life, body care from the mother has been observed to be closely associated with nursing, e.g. sniffing or licking around the anogenital region (Espmark, 1971a; Källquist & Mossing, 1982). Also in woodland caribou (*Rangifer tarandus caribou*), grooming from the mother has been directed mostly towards the calf's anogenital region (Lavigueur & Barette, 1992). When the calf is suckling, the mother stands still, she stops her activity and normally smells or licks the calf throughout the nursing period, mainly around the genital area for a short time (Espmark, 1971a; Källquist & Mossing, 1982). This grooming is performed again when the calf has ended a suckling bout and the mother wants to stimulate it to resume suckling (Espmark, 1971a). The highest frequency of nursing accompanied with licks has been seen during the calves first 20 days of life (Lavigueur & Barette, 1992). During that period the licking was most probable to accompany suckling when the mother had initiated the suckling (Lavigueur & Barette, 1992). During the calf's first month, grooming from the mother during nursing has been seen to result in longer suckles than those without grooming (Lavigueur & Barette, 1992). It seems like the licking is completely eradicated when the calf is two months old, and is replaced with increased nose contact (Espmark, 1971a). The same behavioural change has been observed in woodland caribou (Lavigueur & Barette, 1992). Throughout the nursing period, the calf is the one who on average initiates most suckles. The mothers' initiation of suckles decreases with the calf's increasing age (Lavigueur & Barette, 1992).

Four different types of postures have been recorded in suckling reindeer calves (Espmark, 1971a; Källquist & Mossing, 1982; Engelhardt et al., 2014). The most frequent position observed was where the calf was nursing antiparallel to the mother, which enables the mother to reach the calf's anogenital region as the rear end is angled towards the mother's head (Espmark, 1971a; Källquist & Mossing, 1982; Engelhardt et al., 2014). The calf has also been observed standing in the opposite direction with the rear end angled diagonally away from the head of the mother (Engelhardt et al., 2014). Another possibility is to suckle the mother from under her rear end, standing parallel to the mother but behind her (Espmark, 1971a; Engelhardt et al., 2014). There are also observations of calves suckling from the mother when she is lying down (Espmark, 1971a).

Allosuckling

There is evidence of allosuckling amongst both reindeer and caribou (Espmark, 1971a; Källquist & Mossing, 1982; Lavigueur & Barette, 1992; Engelhardt et al., 2014). In a study

with 25 reindeer calves, almost a fourth of all the suckling solicitations were made by non-filial calves, and slightly less than half of them were successful allobouts (Engelhardt et al., 2014). In another study with fewer calves, all but one calf attempted allosuckling (Espmark, 1971a). There is however a difference between the non-filial and the filial calf's suckling bout even if both types have been successful. The filial calf's suckling bout is more than two times longer than that of a non-filial (Espmark, 1971a; Engelhardt et al., 2014) and the reindeer cows reject the non-filial calves' solicitations more frequently than the filial calves' (Espmark, 1971a; Engelhardt et al., 2014). Several factors have an impact on the rate of success of the allobout, e.g. the female calf seem to have greater odds of success than the male calf (Engelhardt et al., 2014). The non-filial calf arriving second also has an increased success rate compared to the one coming first, third or fourth (Engelhardt et al., 2014). The position adopted during the solicitation was not found to influence the success rate but filial calves adopted the parallel position almost every time (89.3%), which was about twice more often than the non-filial calves (Engelhardt et al., 2014).

Difference in calf behaviour

The behaviour of male reindeer calves differs to the behaviour of female calves (Mathisen et al., 2003). The differences have been seen in the mean distance to their mother, some locomotive behaviour and predator vulnerability. On average, male calves have been found to keep a significantly longer distance to their mother than do female calves (Mathisen et al., 2003). However, there seem to not be a difference in the distance between male and female calf to their mothers when the calves are lying down (Mathisen et al., 2003). Both walking and play behaviour is performed significantly more by male calves, whereas behaviours such as lying, grazing and suckling have no significant sex-specific difference (Mathisen et al., 2003). Mothers of male calves showed a tendency to walk more and graze less than mothers of female calves (Mathisen et al., 2003). In the study performed by Mathisen et al. (2003), male calves had a constantly higher mortality rate than female calves, the main cause of death for both groups was predation.

Aggression and mother-yearling

There is a higher association between the mother and her calf and her yearling during the rut, compared to mother and other non-related females (Hirotani, 1989). A study investigating aggression and nearest neighbour distance in the female reindeer during the rut found a sex-specific difference in the mother's tolerance towards her yearling offspring (Kojola & Nieminen, 1988). There was a higher tolerance towards the female yearling, which also stayed

closer to the mother during a longer time period compared to the male yearling (Kojola & Nieminen, 1988). A suggestion for the higher association between the cow and her female calf is partly that the male calf has a higher motivation for exploratory behaviour (Kojola & Nieminen, 1988). The association between mother and daughter decreases with age (Kojola, 1990; Mathisen et al., 2003). There is no direct association between daughters of the same mother unless the mother is present (Kojola, 1990). This is similar to another study, where non-related females, female siblings and mothers and their two-year old female offspring had the same level of association (Hirotani, 1989).

There seems to be no or very little maternal aggression towards calves (Espmark, 1971a; Kojola & Nieminen, 1988; Kojola, 1989). However, in a study where the mothers had been separated from their calves, the mothers repeatedly chased the calves off when they approached after reintroduction to the group (Kojola, 1990). Källquist & Mossing (1982), also showed evidence of agonistic interactions between cows and non-filial calves. The agonistic interactions were often preceded by olfactory contact between the non-filial calf and the cow. More than half of the olfactory contacts between a cow and non-filial cow resulted in agonistic behaviour toward the calf (Källquist & Mossing, 1982). The calf initiated olfactory contact with its own mother directly after the agonistic interaction in approximately a fourth of the cases (Källquist & Mossing, 1982).

Feeding and foraging

A study on supplementary fed reindeer, showed that they were commonly dispersed around the feeding site in smaller non-permanent groups compared to when they were not being fed (Holand et al., 2004; Holand et al., 2012). Using permanent artificial feeding sites, which concentrates food resources can create and intensify interference competition between animals (Holand et al., 2004; Milner et al., 2014). Feeding can also increase the stress and aggression levels in the ungulate herd (Milner et al., 2014). Moreover, when providing reindeer with supplementary feed, the risk of spreading infection increases as a response of having many animals in a concentrated area (Åhman, 2002; Milner et al., 2014). Reindeer are also sensitive to changes in their diets so they need an adaptation period of two to three weeks to prevent them from developing diseases associated with impaired digestion, e.g. wet belly and rumenitis (Åhman, 2002; Nilsson et al., 2004).

Mother's social status – effect on calf

There is evidence of post-weaning maternal effort in reindeer (Holand et al., 2012). Non-orphaned calves have been found to loose less body mass during their first winter than orphaned calves, this seems to be a result of the mothers sharing space at craters and feeding troughs with their calf as well as protecting them from harassment (Kojola, 1989; Holand et al., 2012). In the same study it was also evident that calves stayed closer to their own mother than orphaned calves did to mothers in the herd (Holand et al., 2012).

The social rank of the mother can affect the calf by influencing both pre-parturition maternal effort and early pre-weaning period (Holand et al., 2004). The calf's daily body-mass gain is positively correlated to the rank of the mother during the early pre-weaning period, and higher ranked females also calve earlier than lower ranked females (Holand et al., 2004). Calves of more dominant mothers have also been observed to feed more than three times longer in their mother's crater than those of less dominant mothers (Kojola, 1989).

The calf's foraging behaviour

Grazing attempts of the calves is often sporadically performed during the calf's first day of life. After the first day, more time is spent on grazing and it takes up to three days for the calf to perform the behaviour properly, including ingesting food (Espmark, 1971a). During the first two weeks in life, the calf is observed to graze in the same patch as the mother close to the mother's head. Moreover, during the first month the calf grazes closer to the mother than any other herd-member. It seems like the calf almost routinely starts grazing on whatever is in their close proximity after having performed some grooming preceded by a resting period (Espmark, 1971a).

Pawing and digging are essential behaviours in reindeer to access vegetation during winter when pasture is covered by snow. This behaviour has also been observed to occur during the calf's first day of life (Espmark, 1971a). Calves have performed the digging gesture without actually touching the snow with their hoof during its first day of life. There also seems to be a strong connection between digging and grazing in young calves, even when patches have been free from snow, pawing at the ground has often been seen to precede the calves' grazing attempts (Espmark, 1971a). Nevertheless, during the first days of life it is common for a calf to successfully clear a patch from snow and then skip the grazing (Espmark, 1971a). Calves have also often been seen to paw at the ground and then graze to the side of the patch instead of on

the patch (Espmark, 1971a). When calves are at feeding sites, which are not shared with their mothers, they have been observed to paw more frequently (Kojola, 1989).

Aim

The overall aim of this thesis was to observe reindeer behaviour around calving and investigate if calving in enclosure affects reindeer behaviour and movements. The following questions were answered: i) Is there any difference in step length between reindeer in enclosures and freely ranging reindeer? ii) Is there a difference in residence time, i.e. the amount of time that the reindeer cow and her calf spend in close proximity of where she has calved after calving, between reindeer in enclosures and freely ranging reindeer? The null hypothesis was that there were no differences in step length nor residence time between reindeer in enclosures and a freely ranging herd.

Materials and methods

Study area

The study was performed in Udtja and Gällivare forest reindeer herding communities located in the county of Norrbotten, Sweden. In total, three herds were involved in the study; one freely ranging herd in Udtja reindeer herding community and two herds in enclosures, one in each of the two reindeer communities, respectively.

Gällivare enclosure

The enclosure in Gällivare reindeer herding community was situated near Nattavaara, Gällivare (Fig. 1). The enclosure was 50 ha in size, 46 ha excluding the lake in the enclosure, and kept 232 female reindeer. The reindeer had free access to natural sources of water, as well as free access to pasture growing within the enclosure. They were fed pelleted feed, adapted for reindeer (from Lantmännen), loaded onto feed troughs every morning. On a few occasions they were also fed in the afternoon. The feed troughs were placed on a ridge, and then moved further down on the ridge every week.

Udtja enclosure

The enclosure in Udtja reindeer herding community was located near Tellejaure, Jokkmokk (Fig. 2). The enclosure was 30 ha in size and kept 189 female reindeer. The reindeer had free access to natural sources of water from a creek running through the enclosure separating it into two parts, as well as free access to pasture growing within the enclosure. Pelleted feed for reindeer (from Lantmännen) was given in feed troughs every morning. The feed troughs were

situated on the eastern side of the creek during the first half of the month and were later moved to the western side, four feed troughs were however left on the eastern side.

Freely ranging

The reindeer in the freely ranging herd in Udtja were located within Udjta calving area (Fig. 3). Udtja reindeer herding district's all-year land is 80 km long and 30 km wide and stretches from Tjavelkjaure to Tellejaure. A large part of the area is also used by the Swedish Defence Materiel's missile test range called Vidsel Test Range; therefore the area is partly surrounded by a fence in three directions. The reindeer in this herd had free access natural sources of water as well as pasture and in addition they were supplementary fed with the same pelleted feed used in the enclosures.

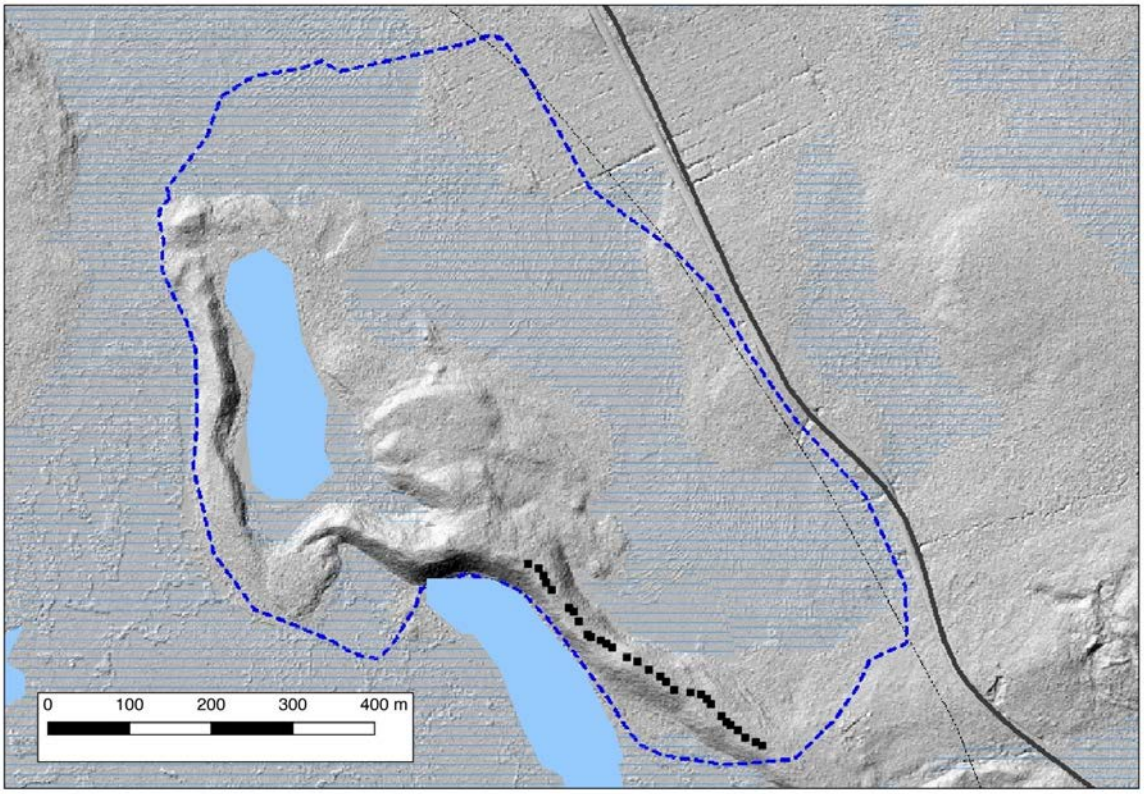


Figure 1. Gällivare enclosure, 50 ha. Black squares represent the location of the food troughs, the long black line outside of the enclosure is a road and the striped blue patches are wetlands. Scale (1:5000).

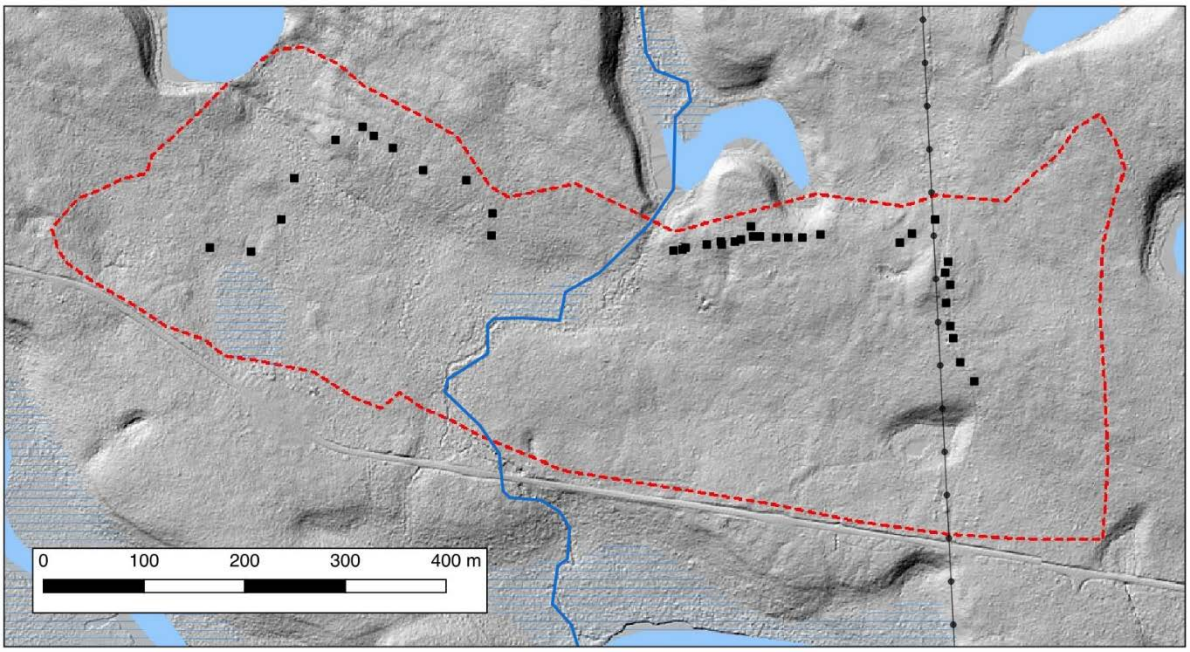


Figure 2. Udtja enclosure, 30 ha. Black squares represents the location of the food troughs, the long dotted black line represents a powerline, the striped blue patches are wetlands and the solid blue line going across the enclosure is a water stream. Scale (1:5000).

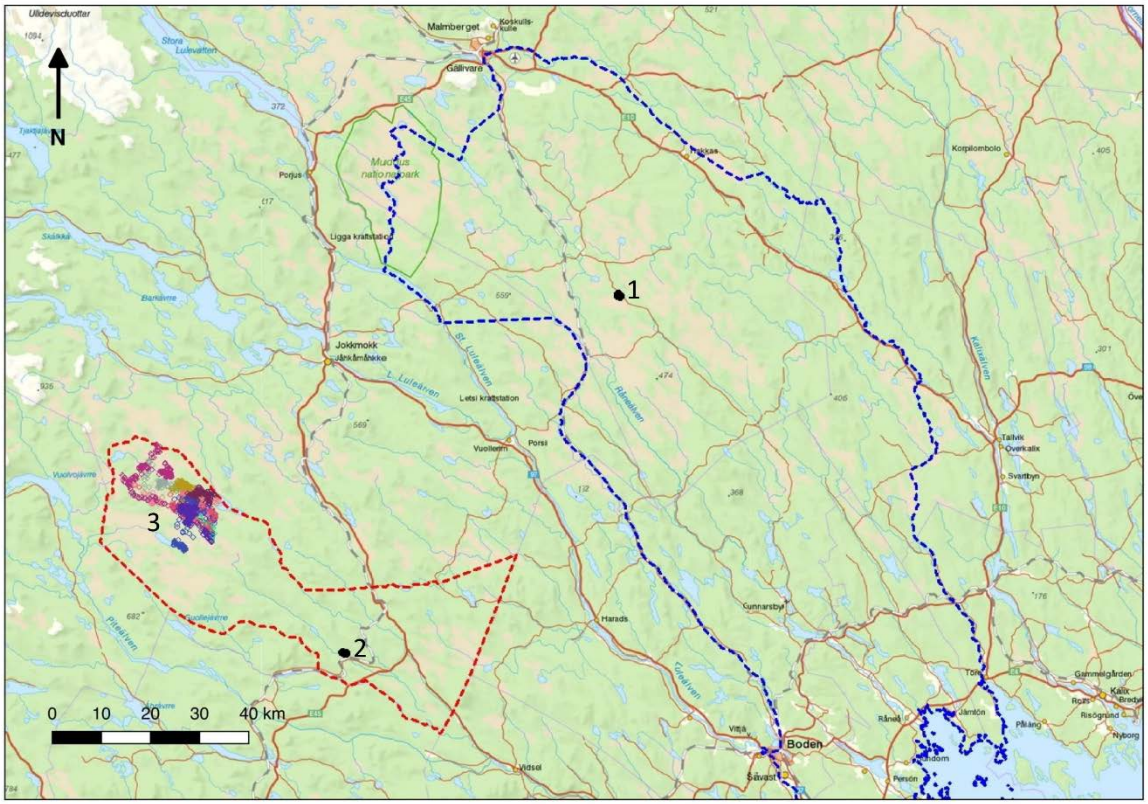


Figure 3. Map over the study areas; Gällivare reindeer herding community's herding area (dotted blue line), and Udtja reindeer community's herding area (dotted red line), including (1) Gällivare enclosure (50 ha) and (2) Udtja enclosure (30 ha). The coloured circles in Udtja (3) represents individual

positions from GPS-marked reindeer in the freely ranging herd, to indicate their location and the size of the area they visited during the timespan included in this thesis.

The study area and the reindeer individuals included in the study were selected previous to this study, as they were part of the larger project, described in the introduction. A pregnancy test was performed in beginning of April, to make it possible to only include females showing signs of pregnancy in the enclosures. All reindeer in the enclosures were individually marked with numbered collars.

GPS

To follow the reindeer movements', seven reindeer in Gällivare enclosure, six reindeer in Udtja enclosure and 12 reindeer in the freely ranging herd in Udtja were equipped with GPS collars (Telespor, www.telespor.no) collecting the reindeer locations from 5 May to 30 May 2017. The GPS-collars on the reindeer in the enclosures collected locational data every 30 minutes and in the freely ranging herd every second hour, for battery saving purposes.

To define the border of the enclosures as well as the location of the feed troughs a handheld Garmin GPS-device was used.

Calving observations

In Udtja enclosure, each day from 1 May to 27 May, new calves observed in the enclosures were recorded together with the mothers' ID, and the dates were categorized as calving dates. However, they might not be the true calving dates as the calves might have been born before the day of the first sighting of the calf. The same procedure followed in Gällivare enclosure from 1 May to 31 May. The calving dates in the enclosures were recorded by both the observers as well as the reindeer herders.

Residence time

To identify the individual calving date of the GPS-marked females the GPS-data was analysed in R (R Development Core Team, 2015) using the "Residence Time" (RT) function (Barraquand & Benhamou, 2008). The time between successive locations was set to 2 hours, as this was the minimum time difference for the GPS on the freely ranging reindeer. With this function the site that was used intensively for a short time could be identified, i.e. the number of GPS-locations within a patch of a given radius was quantified and the time spent at the calving site could be defined. The radius of the patch was set to 50, 100 and 200 meters, similar to Colman et al. (2015), and maximum time allowed outside of the patch was set to 2 hours. A radius of 100 meters gave the most consistent change in RT values. Residence time peak periods

together with the field observations were used to identify the calving events. In the cases where there were no field observations, the first peak, which was evidently larger than the average peak was assumed to be a calving event, similar to Colman et al. (2015). In cases where no peak could be considered clearly larger than the average peak and there were no field observations, the reindeer was considered to not have calved during the given time-period or the calving event could not be identified.

Welch two sided t-test was used to compare the residence time of the three herds: Gällivare enclosure, Udtja enclosure, freely ranging. The two enclosures' data were also pooled to be compared with the freely ranging herd. The null hypothesis was that there was no significant difference between the enclosures and no difference between the enclosures and the freely ranging herd. A t-test can be used when the population variances are unknown. It is used to compare the mean values of two independent samples and tests whether or not there is a significant difference between the values.

Step length

To investigate if there were any differences between the two enclosures in overall distance moved throughout the observation period, as well as between the three herds in the distance moved after calving, step length (i.e. length between two locations) was calculated for individual reindeer within each herd.

Step length was calculated by using the GPS-data, which was sent every 2 hours in all herds, and also using the signals sent every 30 minutes from the GPS-reindeer in the enclosures. However, the use of 2 hours interval in the enclosures poses a risk of underestimating the step length, as the fence hinders the reindeer from moving. The animal may walk up to the fence, and then has to turn to where it came from and then end up close to the starting point. This risk increases with decreasing size of the enclosure and with increasing time interval between positions. To counteract the fence effect, the step length for reindeer in the enclosures was calculated using the 30 minutes intervals, which were then multiplied by 4 to make it more comparable with the freely ranging reindeer, which only had locational data every second hour. Although, the normal procedure is to compare distances from data with equal time interval between positions due to the longer distance travelled than measured between two positions (Pepin et al., 2004).

The mean step lengths for the whole study period, 5 May to 30 May, in both enclosures were compared using Welch two sided t-test. Step length after calving, within the different time

periods and groups was evaluated fitting a multiple regression model with time period × group treatment as fixed effect, and in addition by fitting a mixed linear model with step length as response variable and time period × group treatment as fixed effect and reindeer individual as random effect. The log-likelihoods of the fitted models was used to compare the two models and the model with the highest log-likelihoods was considered as the most parsimonious model and used in further interpretation of results. In both models nRT of the freely ranging herd was set as the reference level.

In addition, the mean residence time of the freely ranging herd was hypothesised to represent reindeer natural residence time (nRT) at the calving site and was set as a reference value. This was the time from the calf's birth up until the reindeer mother and calf start moving away from the calving area in their natural habitat. Thus the step lengths within nRT of the freely ranging females were compared with the step lengths within nRT of the females in enclosures. This comparison was repeated for the following time period. Specifically, the first period included the start date and time of the initiation of the calving event up until nRT, i.e. the first 38h since initiation of calving. The second period was set to start at nRT hours after calving initiation and to last until 2*nRT hours, i.e. from 38 hours until 76 hours after initiation of the individual calving event.

Results

Calving dates

The majority of new calves observed in Udtja enclosure were within 9 May and 19 May (Fig. 4), and in Gällivare enclosure the dates were within 9 May and 24 May (Fig. 5).

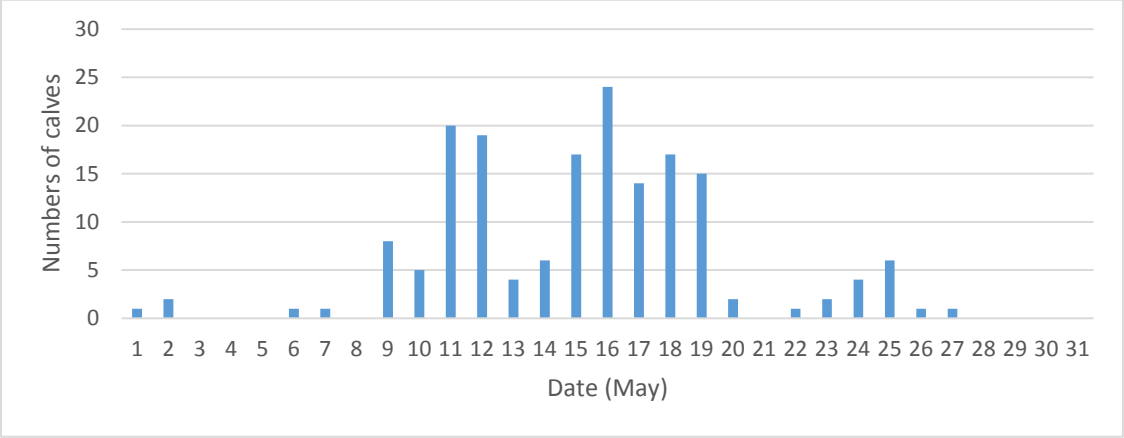


Figure 4. Figure over dates that new calves were observed in Udtja enclosure.

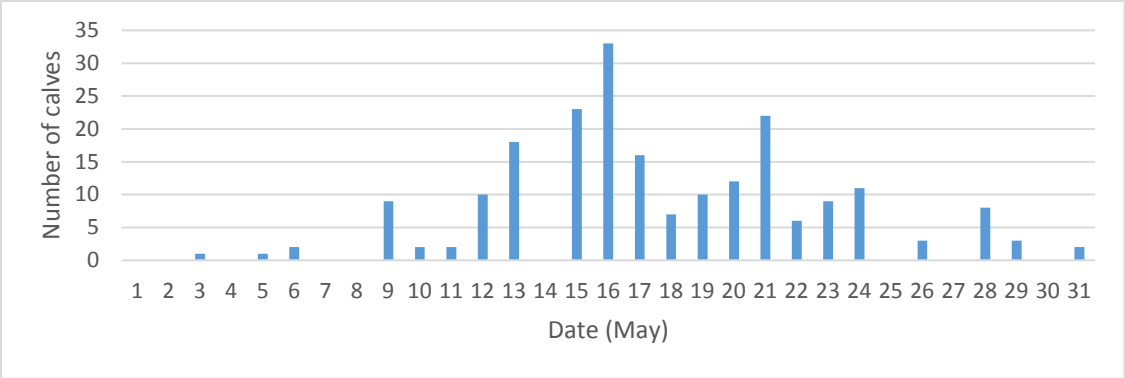
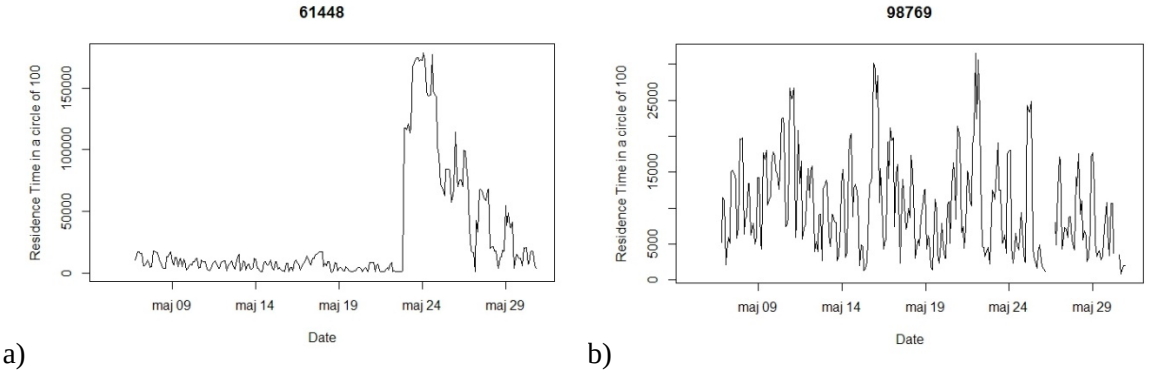


Figure 5. Figure over dates that new calves were observed in Gällivare enclosure.

Comparison of residence time

The residence time for one reindeer in Udtja and two reindeer in the freely ranging herd did not have clear calving peaks and were therefore excluded (Fig. 6b). In total, the RT for 22 reindeer could be calculated.



a) b)

Figure 6. Example of a) a clear RT peak and b) unclear RT peak.

There was a significant difference of the mean residence time between the enclosures and the freely ranging herd (Table 1). The reindeer in the Udtja enclosure had a significantly longer residence time compared to reindeer in the Gällivare enclosure. Furthermore, reindeer in the freely ranging herd had a significantly longer residence time than the reindeer in Gällivare. No significant difference was found between the freely ranging herd and the reindeer in the Udtja enclosure. The null hypothesis that there was no significant difference in the mean value of residence time between the enclosures could thus be rejected. The null hypothesis for no difference between the reindeer calving in enclosure and the freely ranging reindeer could also be rejected, however it seemed like this difference was mostly due to the difference between reindeer in the Gällivare enclosure and the freely ranging reindeer. The reindeer for which no detection of calving event was possible, were not included in the analysis.

For all GPS-collared reindeer in the two enclosures, using the 30 min GPS intervals, the mean step length in Gällivare enclosure was significantly faster than in Udtja enclosure, 84m/30min compared to 76m/30min (t=-3.90, p-value<0.001). There seemed to be a greater difference in the morning, between 8-11 am (Fig. 7). Step length after calving was calculated for all reindeer for which RT could be calculated in all three herds. Using the 30 min data, the mean step length in Udtja enclosure within nRT was 41 (± 4.7) m/30min, and in Gällivare enclosure it was 45 (± 3.8) m/30min. Within nRT*2, the mean step length in Udtja enclosure was 40 (± 3.1) m/30min and in Gällivare enclosure it was 55 (± 3.7) m/30min. The freely ranging herd's mean step length, using the 2 hour GPS interval, was 134 (± 13.9) m/2h within nRT, and when using the 30 min data recalculated to 2 hour positions (to counteract the fence effect) the mean step length in Udtja enclosure was 165 (± 18.9) m/2h and 179 (± 15.0) m/2h in Gällivare enclosure. Within nRT*2, the mean step length in the freely ranging herd was 197 (± 21.5) m/2h, and when using the recalculated 30 min data it was 159 (± 12.4) m/2h in Udtja enclosure and 221 (± 14.9) m/2h in Gällivare enclosure. Comparing the step length between the three groups and between time periods in the linear mixed model it was shown that the step length within nRT in the freely ranging herd was significantly shorter than step length in Gällivare enclosure in the same time period, as well as significantly shorter than the step length in Gällivare enclosure and the freely ranging herd within nRT*2 (Table 2). Step length in the freely ranging herd within nRT did not differ significantly from the step length in Udtja enclosure, in neither periods (nRT and nRT*2).

Table 1. Welch two sample t-test results comparing residence time (in hours) between enclosures, and enclosures with the freely ranging herd

Herd	Mean RT (h)	SE	N	t-value	p-value
Udtja enclosure	28.40	5.64	5	3.22	P=0.047
Gällivare Enclosure	12.57	1.29	7		
Both enclosures	19.17	3.30	12	3.58	P=0.002
Freely ranging	37.80	4.10	10		
Udtja Enclosure	28.40	5.64	5	7.05	P=0.213
Freely ranging	37.80	4.10	10		
Gällivare enclosure	12.57	1.29	7	4.98	P<0.001
Freely ranging	37.80	4.10	10		

Table 2. Mixed linear model estimates of step lengths with the reference level set to the nRT of the freely ranging herd, and the 95% confidence intervals

	Estimates	SE	2.5%	97.5%
Intercept (Freely ranging nRT)	78.78	31.34	19.66	138.04
Udtja enclosure nRT	70.82	58.11	-38.76	180.33
Udtja enclosure nRT*2	80.59	54.06	-21.28	182.65
Gällivare enclosure nRT	94.04	49.14	1.39	186.71
Gällivare enclosure nRT*2	142.63	47.72	52.69	232.71
Freely ranging nRT*2	119.59	25.37	68.48	168.28

Both enclosures had their peak in mean step length between 8am and 10am (Fig. 7), however, Gällivare enclosure had a higher peak than Udtja enclosure. Gällivare enclosure also had a higher mean step length peak around 3 am.

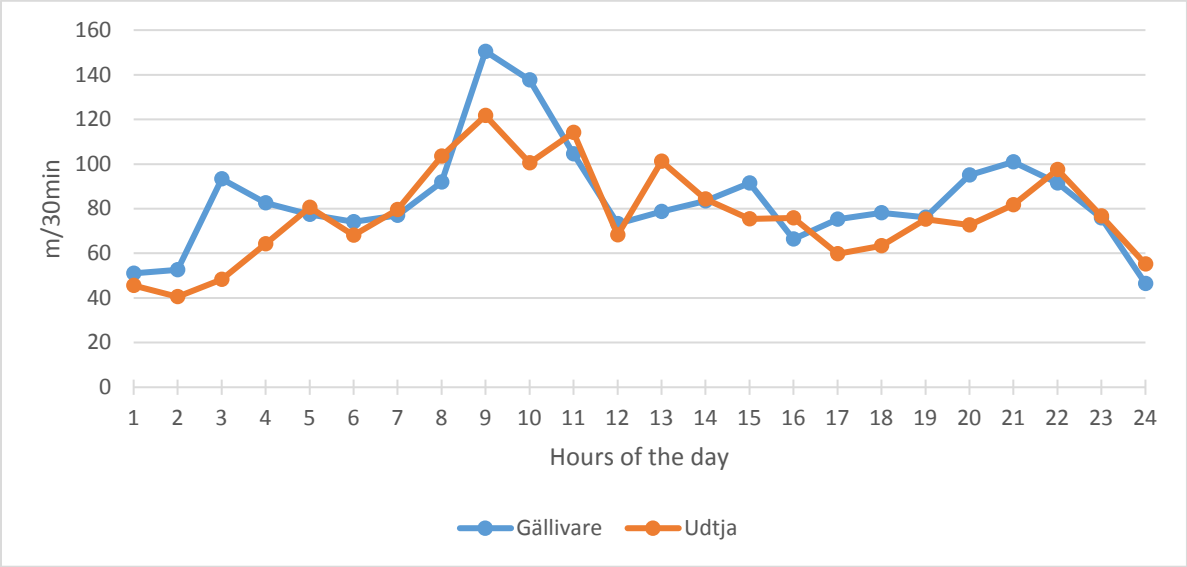


Figure 7. Mean step length throughout 24 hours, in Udtja enclosure and Gällivare enclosure, over the study period 5 May to 30 May.

Discussion

Reindeer show a noticeable increased attentiveness after the calf is born and have a lower acceptance towards disturbances (Espmark, 1971a, Skarin & Åhman, 2014). Espmark (1971a) argue that the function of an intensified attentiveness after parturition is to make sure that the bonding process between mother and calf is not disturbed, as this is a very sensitive process, and also to decrease the risk of predation of the calf. As reindeer are herd-living animals, even

females without calves might be affected by reactions from females with calves in relation to disturbance from humans or predators, e.g. if one reindeer starts running the others follow. Although it wasn't possible to quantify the behaviours observed, the observers nonetheless perceived the herds to be more easily disturbed after the calving had started in the enclosures, not only the female with calves. This perceived change in behaviour could therefore partly be explained by a heightened attentiveness after parturition.

There are clear differences in flight responses and sensitivity to e.g. approaching humans in wild reindeer populations and semi-domesticated reindeer populations in Fennoscandia (Nieminen, 2013). Nieminen (2013) observed that semi-domesticated reindeer have almost three times shorter flight distance (68m), compared to wild reindeer (192m). Moreover, Nieminen (2013) also observed a difference in flight distance within the semi-domesticated reindeer, between non-fed reindeer and reindeer which had been artificially fed. Reindeer with no supplement feeding had a longer flight distance (115m) than the reindeer with access to supplement feeding. Thus, it seems like reindeer can be subject to habituation (Nieminen, 2013). Reindeer herders in Udtja spent more time in the enclosure before the calving started, compared to reindeer herders in Gällivare. The difference in the time spent being still with the calf during the calving event, and particularly step length, between the two enclosures could indicate that the reindeer in Gällivare enclosure were more disturbed by the observer and reindeer herders or even the snow mobile, moving in the enclosure during feeding, than reindeer in Udtja enclosure. The difference could therefore partly be due to a stronger habituation or acceptance level to human activities in Udtja.

There was a large variation in residence time between individuals in all three herds, a large individual variation was also observed by Espmark (1971a). Nonetheless, the enclosures as a whole had a significantly shorter residence time than the freely ranging herd, i.e. the reindeer spent less time being still with the calves after calving. Step length of both the reindeer in Gällivare and the freely ranging herd increased from the assumed calving event to the period after the calving event. This is not surprising as the first period (the time around assumed calving event) includes the start and end of residence time, which already indicates that the reindeer are moving less. The freely ranging herd had the shortest step length in the hours following the calving event, which was expected as the freely ranging herd's mean residence time was set as the nRT (natural residence time), to decide the length of the periods. Also, during the second period (the period after the calving event), the calf can follow the mother

more easily as it is older, opening up the opportunity for the mother-calf pair to move longer distances together.

Results from residence time seem to be in accordance with step length to a certain degree. The shorter residence time and longer step length within the second period in Gällivare enclosure is also supported by the perception of the observers that reindeer in Gällivare enclosure were more easily disturbed and moving away from disturbances (e.g. the observer, loud and/or sudden noises, and movement outside of the enclosure such as cars driving by) more than the reindeer in Udtja enclosure. This is also reflected in the overall step length being longer in Gällivare enclosure than in Udtja enclosure. The largest difference in mean step length between Udtja enclosure and Gällivare enclosure was during the morning, around feeding. This could indicate that the reindeer in Gällivare enclosure either had to move longer distances to get to the feed troughs from where they were resting before feeding, or also move longer distances after feeding if they preferred to rest in another location of the enclosure.

Furthermore, if the area around the feeding site does not meet other habitat requirements (e.g. thermal condition), artificial feeding can lead to an increase in animal movement compared to animals which are not supplementary fed (Milner et al., 2014). There were many differences in the enclosures' contents and designs, which could therefore also have affected the difference in step length between the enclosures. In Gällivare enclosure, the feed troughs were placed on an elevated ridge and a large part of the surroundings were wetlands and mires, whereas Udtja enclosure was more flat with less wetlands and mires. As the enclosure in Udtja was smaller it could also have had a higher rate of encounter probability, i.e. encounter between reindeer and human was more frequent, this could also have affected habituation or increased the acceptance level through an increased exposure to humans. Reindeer in Gällivare could move longer distances within their enclosure, as it was larger (46 ha) than the enclosure in Udtja (30 ha), they could also remove themselves further away from the feeding area, which could also have contributed to the differences between the two enclosures.

The results indicate that calving in enclosure affects the reindeer's residence time during calving, and have the potential to also affect the activity of the reindeer. Reindeer calving in enclosure can lead to a shorter residence time, and potentially an increased step length, during the calf's first day or two. Thus, it could affect the recovery of both the female and the calf after parturition negatively, as they are moving longer distances earlier, which could result in the pair spending less time resting, grazing or suckling. Further implications could be that the bonding between females and calves in enclosures could become weaker compared to reindeer

in the freely ranging herd which have a longer residence time, i.e. longer time to bond without interruption after parturition. A strong bond is of importance to the calf's survival, as it is taught to follow the mother as well as allowing the mother-calf pair to recognise each other, which is used e.g. when the calf initiates suckling or upon reunion when the pair has been separated (Espmark, 1971a; 1971b; Källquist & Mossing, 1982).

As reindeer are animals with high fidelity to their calving grounds (Gunn & Miller, 1986; Baskin, 1990), using a system where part of the herd or the whole herd calve in enclosures far away from their original calving grounds could disrupt the herd's willingness to stick together and have a geographically synchronised calving in the subsequent years after calving in enclosures. Additionally, long-term feeding has the potential to lead to a disturbance in the migration behaviour (Milner et al., 2014). The implication of this could well be that the reindeer herders will have to spend more time, and require more herders, to herd the reindeer to the wanted calving grounds. The reindeer herders would also have to spend more time trying to keep the reindeer inside the calving grounds once they have reached the area. Another possible scenario is that there would be two calving grounds instead of one, which would have the same implications, more time and herders would be needed to manage and supervise the herd.

Furthermore, implementing a system where the reindeer calve in enclosures can also give the herder a greater possibility to manage the herd and help weak calves or reindeer, by e.g. providing them with extra nutrition or bottle-feeding calves with milk replacement. However, if these weaker individuals, who could have otherwise been eliminated from the herd through natural selection, are allowed to procreate, it could lead to a selection for individuals with a lower chance of survival in the next generation (Milner et al., 2014). It may also lead to a selection of individuals not adapted to natural pasture. Especially in herds where breeding selection is low, non-existent or there is no controlled breeding. As an example, in Finland, the calf's muscularity, body size and health were among the most important selection criteria for reindeer herders (Muuttoranta & Mäki-Tanila, 2011). As traits associated with nutrition can have a reduced selection pressure when ungulates are artificially fed, selecting on e.g. reproductive success, calf weight and overwinter mortality could therefore be misleading as those are traits that can be affected by nutrition (Milner et al., 2014).

Forest reindeer commonly segregate themselves from the herd before calving and after calving the females with calves form their own group (Espmark, 1971a). Segregation from the rest of the herd could explain observations made in this study during the time when majority of the new calves were observed (Fig. 4 & 5). Between the 11 May and 19 May, a decline in reindeer

visiting the feed troughs during feeding was observed in Udtja enclosure, and in Gällivare a decline was observed from 9 May to 19 May. Hence the decline of reindeer visiting the feed troughs in the morning during feeding, observed in this study, could therefore be interpreted as an indication of many females calving during that particular night, just before or shortly after. Another possible explanation could be that the females and their calves avoided the feeding area in the morning during feeding to avoid interference competition between females when the calves were young.

Mother and calf distance has been observed to be short at the start of the calf's life and then increase with the age of the calf (Espmark, 1971a; Mathisen et al., 2003). A bonding process and the conditioning of a following response starts already when the calf is born (Espmark, 1971a; Källquist & Mossing, 1982). It is therefore not surprising that the calves in this study were observed to follow their mothers to the feed troughs. However, it was not possible to observe at what age the calf starts following the mother to the feeding area and how long after calving the mother visits the feeding area. There was a possibility that the female had temporarily left her calf (hidden) to feed at the feed troughs before the calf could start following and be observed. As higher rank females have been associated with a closer mother and calf distance (Kojola, 1989), it would be interesting to know if only high ranking females come to the feed troughs with their calves, or if low ranking females have a higher tendency to leave their calves alone and go to the feed troughs. Calves that followed their mothers to the feed troughs were observed to graze around the feed troughs, and during the latter part of the study, also eat out of the feed troughs. This could possibly be a health concern as there could be a higher contamination risk around this frequently visited area by many individuals (Åhman, 2002; Milner et al., 2014), calves could arguably be more susceptible as they are not fully developed.

In conclusion, reindeer calving in enclosure seem to have the potential to affect reindeer behaviour in a negative way by decreasing their residence time and increasing step length. However, an enclosure with more flat grounds and less wetlands and mires seem to be preferable if calving in enclosure is necessary, as it seems to let reindeer activity be more in harmony with their activity patterns in their natural habitat.

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