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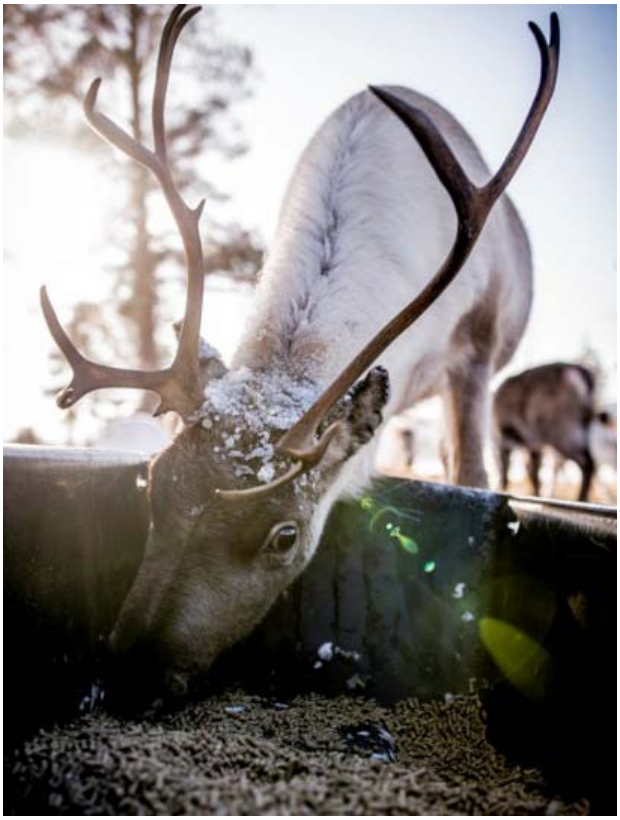
Status of supplementary feeding of reindeer in Sweden and its consequences

Status på stödutfodring av ren i Sverige och dess konsekvenser

Anna-Marja Persson



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Status of supplementary feeding of reindeer in Sweden and its consequences

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Abstract

Reindeer husbandry in Sweden is suffering from great challenges, where fragmentation of the landscape and climate change are affecting winter grazing grounds. Lichen availability is seen as the bottleneck for further existence of this livelihood, but supplementary feeding has been used to different extents to compensate for the loss of lichen pastures. The status and the level of supplementary feeding of reindeer in Sweden is little documented. I conducted a questionnaire survey addressed to all the 51 reindeer herding districts in Sweden with the objectives to document the level of feeding, the practices being used during feeding and the experiences from feeding. Based on answers from 160 herders in 40 districts, I found that feeding was frequently practiced in almost all herding districts, although to different extent and for different reasons. Herders reported benefits of feeding such as better condition and higher survival for example; and problems with feeding such as feed related diseases, infectious outbreaks, and economic challenges due to expenses for feed and negative behavioral changes of the reindeer. Statistical analyses revealed that both calving success and reindeer body condition in autumn (based on carcass weights of slaughtered calves) could be correlated with the extent of feeding. For herders that had fed regularly during several years I found that calf carcass weight had increased over the time. The proportion of the costs, the extra work load and the long-term negative effects related to feeding need to be considered in relation to the possible benefits from feeding.

Keywords: *Rangifer tarandus*, reindeer husbandry, supplementary feeding, calf survival, calf carcass weight

Introduction

Semi-domesticated reindeer (*Rangifer tarandus tarandus)* husbandry is an exclusive right connected to the indigenous people, the Sámi, and is performed on approximately half the size of Sweden (Statistics Sweden, 1999) (Fig. 1). It is a form of pastoralism where the main idea is that herders migrate with the reindeer between different grazing areas twice a year due to the seasonal changes of vegetation. Principally, during summer, reindeer graze in the mountainous area and during winter they graze mainly reindeer lichen (*Cladonia spp*.) (Kumpula, 2001) in the boreal forest towards the Baltic Sea. The reindeer is adapted to follow the seasonal fluctuations in forage and digest the feed connected to it (Eilertsen *et al.*, 2001). They are generally free-ranging all year-around and are herded a few times a year for events like calf marking in summer, slaughter in autumn and round-ups in winter. The herding area is divided into 51 reindeer herding districts which serve both as geographical and economical communities for the reindeer herders and reindeer owners. Furthermore, the herding area is divided into winter and all-year areas. Reindeer are only allowed to graze on the winter areas from the first of October until the end of April according to the Reindeer Husbandry Act (Swedish Code of Statutes (SFS), 1971:437). The districts are grouped into three types; mountain, forest and concessionary districts based on different prerequisites and migration practices. In the mountain districts (n=33), the reindeer migrate between summer and winter pastures during the year. In the forest districts (n=10) and the concessionary districts (n=8), reindeer graze in the forested area all year around i.e. they have a more stationary husbandry.

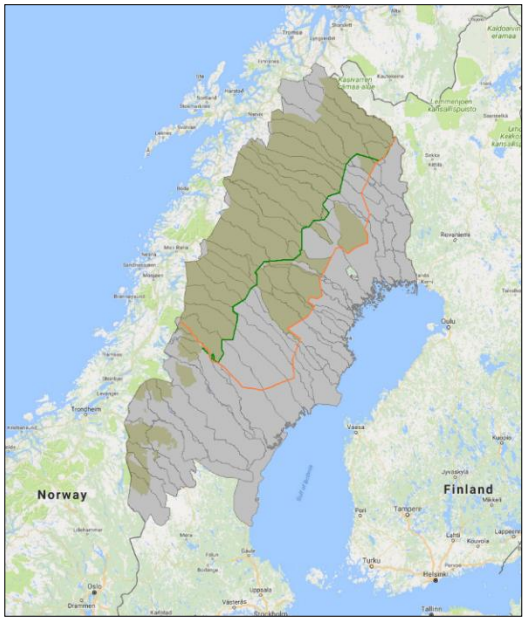

Figure 1. Map over the Swedish Reindeer Husbandry area (grey area). The green line is the cultivation border and red line is the Lapland border. Source: Sandström, P. 2015. A toolbox for co-production of knowledge and improved land use dialogues – The perspective of reindeer husbandry. Acta Universitatis Agriculturae Suecicae - Silvestra 2015:20.

Meat production i.e. harvest of adult males, calves and old females, is the main income for reindeer herders. The productivity of the reindeer herd is to a large extent a result of the reindeers' energy and nutrient budget based on the availability of forage and energetic costs, and thus their reproduction and survival (Lundqvist *et al.*, 2009). Forestry in Sweden have a high impact on reindeer lichen grounds and is seen as a major threat to reindeer husbandry (Sandström *et al.*, 2012), because of the radical changes in forest structure and management practices that have emerged during the last century (Berg *et al.*, 2008). The lichen-abundant classified forests within the reindeer herding area has during the last 60 years declined with 71% (Sandström *et al.*, 2016). The herding area is 55% of the Swedish land area and approximately 50% of the productive forest in Sweden are based here too, and thus the situation can be described as a complex common pool resource where different actors are using the same land but different resources (Sandström *et al.*, 2006). Moreover, other forms of

land use have contributed to pasture loss, e.g. development of infrastructure (Kumpula *et al.*, 2014; Nellemann *et al.*, 2003). In addition to threats from different exploitations, climate change also affects lichen grounds (Forbes *et al.*, 2016; Hansen *et al.*, 2011). In wintertime, ice formations on lichen grounds are formed from freezing events, i.e. snow thaws and freezes alternately (Bartsch *et al.*, 2010) and by rain-on-snow (ROS) events (Sokolov *et al.*, 2016). The consequence from this is inaccessible lichen that can result in reindeer starvation (Sokolov *et al.*, 2016; Reimers, 1982). For example, one major ROS-event in southern Yamal Peninsula in 2006 resulted in the death of 55 000 reindeer (Sokolov *et al.*, 2016). Winter supplementary feeding within reindeer husbandry have increased over time, and in Finland feeding is highly widespread and it became a common routine in almost every herding district in the late 1960s (Helle & Jaakkola, 2008) as a result from declining winter pastures and an increase of reindeer number (Kumpula *et al.*, 2014). Despite this, no signs of productivity losses or reproduction effects seemed evident and changing slaughtering practices towards more calf harvest and an increasingly trend of supplementary feeding seem to be the explanation of this (Helle & Kojola, 1993). Moreover, in the whole Fennoscandia, feeding dramatically increased due to the accident in Chernobyl in 1986 (Statistics Sweden, 1999). High levels of radioactive cesium were measured in especially the reindeer lichen mainly in the southern and central areas in Northern Sweden (Åhman & Åhman, 1994). To be able to sell reindeer meet, feeding of the animals prior to slaughter was a necessary measurement to reduce the cesium to acceptable levels (Åhman, 1999).

With more unstable winters due to climate change, as mentioned above, the availability of natural lichen-rich winter pastures is seen as the bottleneck for reindeer husbandry. For example, if the situation becomes critical, with absolute no lichen availability, so called emergency feeding is the only option. Turunen *et al.* (2016) mentions that reserve pastures also can be used during these situations, but it is also a matter of the timing and grade of severity of the event (Bartsch *et al.*, 2010). Traditionally, reindeer were herded to areas with arboreal lichens (e.g. *Bryoria* spp. and *Alectoria* ssp.)serving as reserve pastures, but nowadays artificial feeds are mainly used due to the large amount of reindeer that need to be fed, but also due to the lack of both arboreal and ground lichen resources (Helle & Jaakkola, 2008). The commercial feed that are being used is pelleted feeds made from grains such as wheat, oat, barley sugar-beet pulp, soybean meal, vegetal fat and vitamins and minerals (Åhman, 2002). Hay and silage is also widely used during these situations (Statistics Sweden, 1999), but need to be combined with other feed because of the reindeer disability to digest it to its fully extent (Åhman, 2002). Furthermore, in the literature, the term ‘supplementary feeding’ means that an additional extra amount of feed is given to animals. Reasons can for example be maintaining or increasing condition, or improving reproductive success (Putman & Staines, 2004) or used as means during emergency events. For the winter season 1997/98, 40% of all herding enterprises in Sweden had to emergency feed the reindeer due to bad winter conditions (Statistics Sweden, 1999). For the latest winter, 2017/18, as much as 38 out of the 51 herding districts have applied for emergency feed subsidies from the Sámi Parliament due to “locked winter pastures” (Sámi Parliament, 2018).

Supplementary feeding of reindeer has showed to have multiple positive effects on the herd, for example increased density, increased reproduction success and increased calf body mass (Ballesteros *et al.*, 2013). Similarly, improved winter conditions of female reindeer lower the costs of reproduction which increases survival rates for both females and calves (Bårdsen *et*

al., 2009). Pekkarinen *et al.* (2015) also found in their study that improved energy intake during winter resulted in better body condition and, consequently, increased both birth and carcass weights of calves. However, negative effects on reindeer health has been seen during feeding (Åhman *et al.*, 2002; Nilsson *et al.*, 2000), e.g. feed related diseases such as wet belly (Åhman *et al.*, 2002) and outbreaks of contagious *ecthyma* (orf) (Tryland *et al.*, 2001) to mention some negative effects. Also, changing behavior of fenced and fed reindeer has been showed (Nilsson *et al.*, 2004). With this thesis, I aim to examine the status of feeding practices in the reindeer herding districts of Sweden. One previous survey was conducted in 1998/99 by the Statistics Sweden, investigating for example the use of feeding practices (Statistics Sweden, 1999). Over time, with changes in climate and land use, the demand and frequency of feeding is believed to be changing rapidly, which warrants a reinvestigation of this practice, as it has both economic, social and ecological consequences. Several studies have reported both positive correlations between feeding and population dynamics (Pekkarinen *et al.*, 2015; Ballesteros *et al.*, 2013; Kumpula *et al.*, 1998; Helle & Kojola, 1993) and also negative effects such as outbreaks of diseases, feed related problems and behavioral changes from feeding. I therefore aim to investigate the likely effects that feeding may have on the body condition (through calf slaughter weights) and population dynamics (calf survival) of Swedish reindeer. My main hypothesis is that calf survival and calf carcass weights are higher in reindeer herds where regular winter feeding occurs. Also, due to negative effects from feeding (e.g. risk of diseases, changes in behavior) the experiences from herders that have been feeding reindeer will be stressed too. The aim there is to highlight the valuable information that can be received in this type of study where reindeer herders have the possibility to share their knowledge.

I will address the following questions:

- What is the extent of winter feeding in the Swedish reindeer husbandry areas and how do the feeding practices vary across different regions and herding districts?
- What are the positive and negative effects from feeding through experiences from the herders?
- Is there a correlation between carcass weights of calves and calf/cow ratio with feeding of different extents?
    - Specifically: Is there a relationship between carcass weights and calf ratio for reindeer that are being fed every year?
    - Is there an effect from feeding the subsequent year on calf carcass weights?

Material and method

Study design

To be able to scale the levels of feeding and to map the feeding practices, a questionnaire addressed to all reindeer owners/herders in Sweden was created. This approach is frequently used as a means of collecting data in ecology, where the desired data often is maintained by a specific human target population (White *et al.*, 2005). Furthermore, to test whether different levels of feeding (how often and how long) had a positive or a negative effect on calf/cow

ratio and calf carcass weights, the answers from the questionnaire were linked to census data and slaughter data received from the Sámi Parliament.

Study area

The whole reindeer herding area is included in the study. Reindeer numbers have been fluctuating between 220 000 and 260 000 the last twenty years and the number of reindeer owners has been around 4500 and number of groups responsible around 1000, in the same time. Reindeer are always counted on winter herd level during yearly round-ups (Statistics Sweden, 1999). During this event the whole herd of the district are divided into winter groups, where the herders migrate with their herd to a certain winter grazing area. For the season 2015/16 the number of reindeer was estimated to 247 466 reindeer divided into 4644 reindeer owners and 1031 group responsible (Table 1) (Sámi Parliament, 2017).

Table 1. Reindeer statistic winter 2015/16. Source: Sámi Parliament

Region	Number of districts	Group responsible	Reindeer owners	Number of reindeer
Norrbotten County	24	774	3136	139122
Västerbotten County	7	108	337	48945
Jämtland County	12	118	376	49241
Concessionary Districts	8	31	795	10158
Total	**51**	**1031**	**4644**	**247466**

Questionnaire

An initial letter with an invitation for participation in my study was sent to all chairmen in each herding district. Later, all chairmen were contacted again for receiving contacts of the herders that wanted to participate. An account in the web survey tool LimeSurvey™ was created and the questionnaire (see Appendix 1) was constructed within the frame. Four themes of questions were asked; background, time and range, feeding practices and experiences, with the possibility to comment to each question. An agreement was submitted too whether the participants agreed or not to give access to personal data (reindeer census statistics and slaughter statistics provided by the Sámi Parliament). The districts were grouped into abbreviations for the region or type they belonged to; NM = Norrbotten Mountain, VM = Västerbotten Mountain, C = Concessionary, F = Forest; and J = Jämtland and Dalarna; and assigned a random number (1-51). Direct invitations to the questionnaire was sent to the herders that I had received contacts from, and a direct link for self-register was also sent out to all chairmen for further distribution. The questionnaire was open for a total of 2.5 months. The answers from the questionnaire was first processed in Microsoft Excel® (version 2013) and then imported to the statistical software program R (version 3.3.2) for graphing. Respondents that answered question A1 with either ‘occasionally’ or ‘never’ were treated as “non-feeding” and were asked to answer only question A2 and the D-questions. Similarly, respondents that answered question A1 with either ‘every year’, ‘often’ or ‘some years’ were treated as “feeding” and thus, asked to answer questions A3, all questions B, C and D. All comments that was received were thoroughly grouped into primary and secondary effects from feeding, and then grouped into positive or negative. The questions regarding the amount of feed given, date of migration from/to winter pastures and weeks of feeding were excluded

from the analyses due to lack of sufficient data received and structural problems in LimeSurvey.

Slaughter statistics and census data
Slaughter statistics and census data for the period 1997-2017 were used and linked to the relevant questionnaire responses. Calf ratio was calculated for each herder and year, based on the number of calves and females before slaughter as follows:

$$\frac{slaughtered\ calves + counted\ live\ calves}{(slaughtered\ females + counted\ live\ females) * 0.9} = calf\ ratio$$

The category "females" includes all female reindeer >1 years old. I used a factor 0.9 to estimate the number of females over 2 years, since reindeer are not expected to give birth until this age (Rönnegård *et al*., 2002). Calf carcass weight during October to December was used as an index of overall reindeer body condition in the autumn (Olofsson, 2011). Individual weights for each slaughtered calf were used in the statistical analyses. The herders that only fed reindeer during gathering or migration were excluded from further analyses due the small amount of feeding time during these events. Those that only fed reindeer prior to slaughter were also excluded. For the remaining herders the levels of feeding were numerically assigned; 'every year'=1; 'often'=2; 'some years'=3; 'occasionally'=4 and; 'never'=5. Depending on question, different filters were used for extracting the relevant data. For the question regarding long-term effects of feeding on calf ratio and calf carcass weights, herders that had slaughtered ≥30 calves for at least 10 years were used. The amount of data varied among herders regarding calf ratio and slaughter data, which affected the total number of herders used for these analyses. To answer the question about the effect the year after feeding; data from herders that had specified what years they had been feeding were used. The data used for this was grouped into 'before' and 'after' feeding.

Statistical analysis
A simple linear regression model was used with year versus mean weights and calf ratio, respectively to test how the linear trend, either positive (+) or negative (-), looked like in the districts for each herder. To test for differences between the herders either t-test or one-way Analysis of variance (ANOVA) with the post hoc comparison test Tukeys HSD were used. For calf ratio, comparisons between the individual herder and the whole district was made due to same format of data (yearly means). Analyses of weights were performed on the detailed data (each calf) for the herders and thus, no comparison between the weights for the district was made due to lack of detailed data on district level. The consistent assumption for my analyses was that the level of feeding had been practiced throughout all years (1997-2017), except for the years when other information was given as for the comparison between before and after feeding. Calf ratios (scale 0-1) and carcass weights (kg) were reported with mean and standard error (SE) and p-values of linear trends. Significant letters (A, B, C etc.) indicates whether herders or districts were statistically significantly different or not. Sample size (n) was years. The significance level was set to α=0.05 and all statistical analysis were performed in the statistical software JMP® 13.2.1 (©2016 SAS Institute Inc.).

Data limitations

Due to varying success in contacting the chairmen of the herding districts, all herders did not get the possibility to participate in the questionnaire and this have of course influenced the response frequency. This can for example be explained by the fact that the sample period occurred during round-ups, known as a busy time for herders. Since both active herders and reindeer owners in general were addressed, answers from the same herding group may have occurred. The census data from round-ups sometimes seemed to be incorrect, since equal numbers of reindeer were listed multiple years for some herders. Hence, calf ratio sometimes exceeded 1.0 and therefore this data was excluded from analyses. Calf carcass weights >30 kilos were also excluded, based on previous studies on calf carcass weights and therefore higher weights indicate that the carcasses have been incorrectly classified as calves (Åhman, 2012).

Results

Use of supplementary feeding

General overview

The general view given from the chairmen after the first contact revealed basically three groups of feeding levels; no feeding, yearly feeding, and; feeding during emergency years, i.e. ice cover on reindeer lichen. Exceptions within single communities did however occur, e.g. different feeding experiments had occurred. In Jämtland County, only the southernmost districts seem to be unaffected from emergency feeding, whereas all the other districts have been feeding reindeer at least during some emergency years.

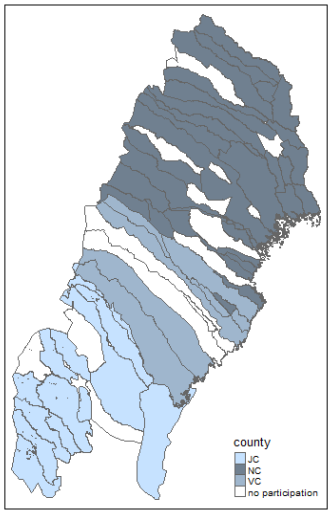

Figure 2. District participation of the questionnaire allocated into the counties of Norrbotten, Västerbotten and Jämtland.

Overview of the questionnaire

Totally 160 respondents from 40 districts (Fig. 2) answered the questionnaire. The frequency of answers did not differ much between regions, neither with respect to proportion of herding districts or herders per district (Table 2).

Table 2. Response frequency of the questionnaire, divided into number of district and respondents' participation within the different regions.

Region	No. of districts within region	No. of districts participating	Respondents (n)	Answer frequency/ district 1-5	Answer frequency/ district 6-15
Norrbotten Mountain (NM)	15	13	52	10	3
Västerbotten Mountain (VM)	6	4	14	4	0
Forest (F)	10	6	23	4	2
Concessionary (C)	8	7	25	6	1
Jämtland (J)	12	10	46	7	1
Total	**51**	**40**	**160**	**31**	**9**

Questionnaire responses

A. Background information

Question A1. "*Is supplementary feeding a part of your reindeer herding?*"

Most of the herders answered that they were feeding reindeer every year, whereas the other answering alternatives received far less with "never feeding" as the least alternative (Fig. 3). In the comments, some of these herders mentioned that it was due to the high expenses, the risk of diseases and that feeding is not natural.

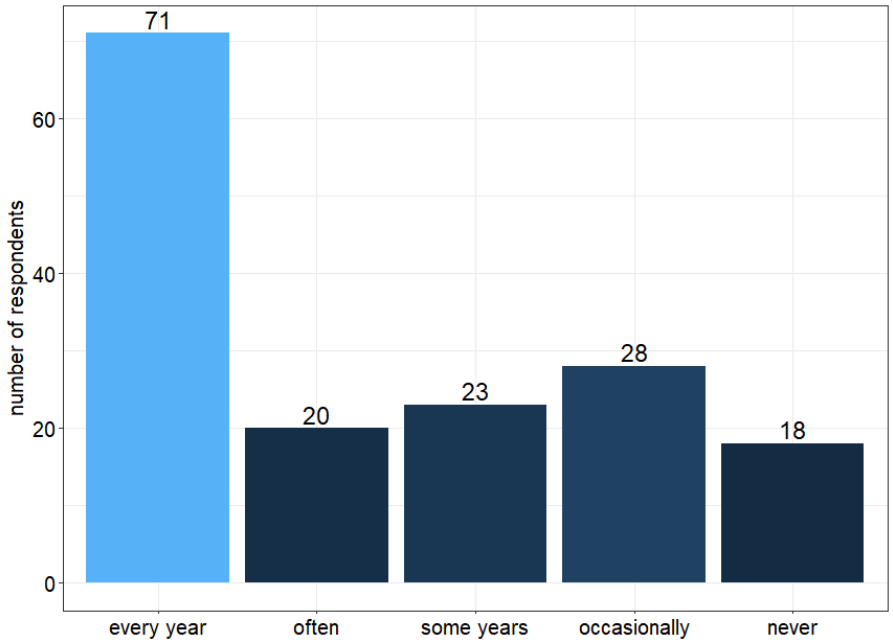

Figure 3. Distribution of the answers from the question regarding how often the herders were feeding the reindeer.

The frequency of answers regarding "every year" of feeding did not differ much in extent between the regions (Table 3). It was mainly in Jämtland that "never" feeding occurred in contrary to Västerbotten Mountain and forest districts where all respondents fed or had been feeding reindeer at some point.

Table 3. Response frequency distribution on regional level regarding to what extent herders were feeding reindeer.

	Norrbotten Mountain (NM)	Västerbotten Mountain (VM)	Forest (F)	Concessionary (C)	Jämtland (J)	**Total**
Every year	19	10	11	18	13	**71**
Often	8	2	3	2	5	**20**
Some years	8	1	6	2	6	**23**
Occasionally	11	1	3	2	11	**28**
Never	6	0	0	1	11	**18**
Total	**52**	**14**	**23**	**25**	**46**	**160**

Question A2. "*If you do not feed the reindeer, what are the reason(s) for that?*"

The main reason for the herders for not feeding the reindeer were because it had not been necessary, whereas the other reasons were less frequently given (Fig. 4). It was mainly herders from Jämtland and Norrbotten mountain districts that answered that they did not need to feed, and the other reasons did not differ much between the regions (Table 4).

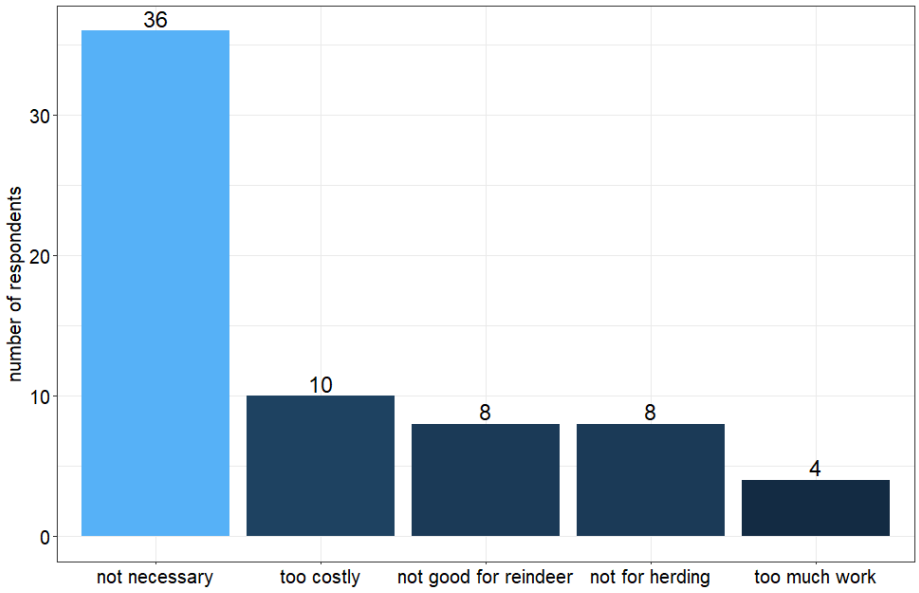

Figure 4. Distribution of the answers regarding the reasons why herders do not feed the reindeer.

For the comments connected to these answers, many herders pointed out their fear of what will happen to reindeer that are being fed. One herder stated: "In a long-term feeding situation, it is possible that the reindeer will get used to feeding and will stop grazing as they are used to. The consequence of this will be that the season when reindeer are naturally gaining weight will change". Further, herders stated, that feeding is too expensive, it changes the behavior of the reindeer, and it also changes the herder and their traditional knowledge.

Table 4. Regional distribution of the respondents regarding the reasons for herders that are not feeding the reindeer.

Reason not to feed	NM	VM	F	C	J	**Total**
Not necessary	13	1	1	0	21	**36**
Too much work	0	0	1	2	1	**4**
Too costly	5	0	1	2	2	**10**
Not good for reindeer	3	0	3	2	0	**8**
Not a part of reindeer herding	3	0	2	2	1	**8**
Total	**24**	**1**	**8**	**8**	**25**	**66**

Question A3. "*If you have been feeding the reindeer, what were the reason(s)*?"

The main drivers for feeding were due to ice cover and during herding and migration (Fig. 5). As many as 79 herders were feeding because of ice cover and most them were in Norrbotten Mountain districts (Table 5). Feeding due to ice cover every year had the highest response rate in all regions. The answer frequency regarding the extent of feeding because of ice seem to differ between and within the regions (Fig. 6), where it clearly can be seen that there are herders within districts that have different practices.

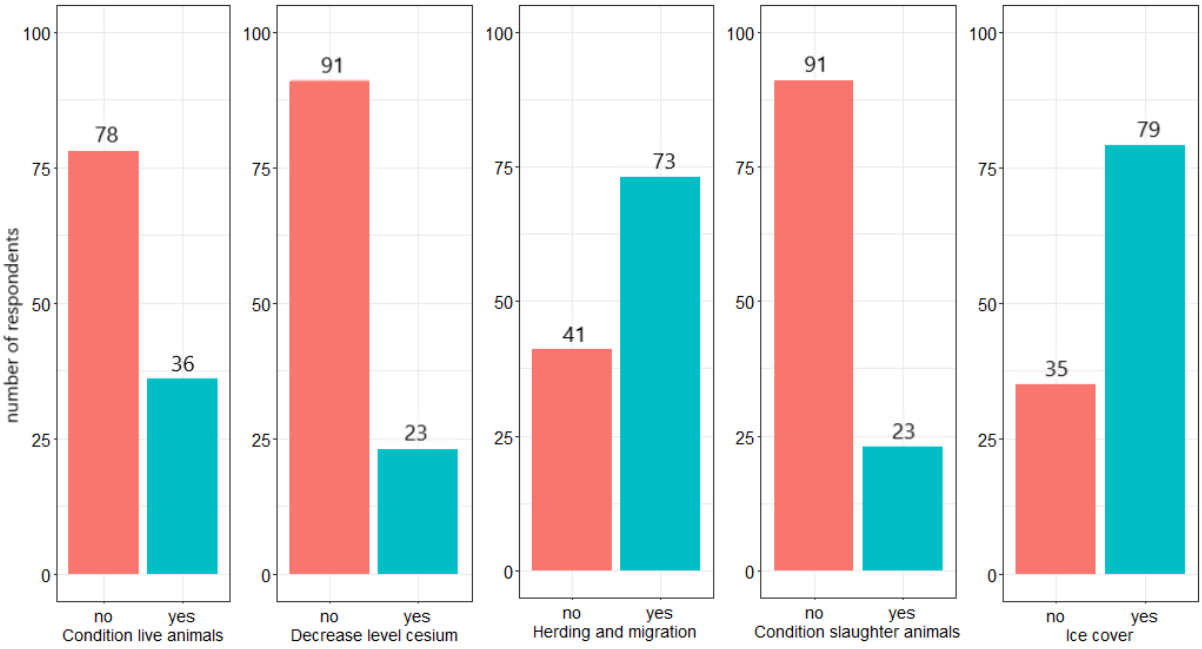

Figure 5. Distribution of the respondents that answered either 'yes' or 'no' to each reason for feeding.

Table 5. Regional distribution of the respondents regarding the reason of feeding in different extent due to ice cover on winter pastures.

Feeding due to ice cover	NM	VM	F	C	J	**Total**
Every year	17	8	10	14	3	**52**
Often	7	1	2	2	2	**14**
Some years	4	1	6	1	1	**13**
Total	**28**	**10**	**18**	**17**	**6**	**79**

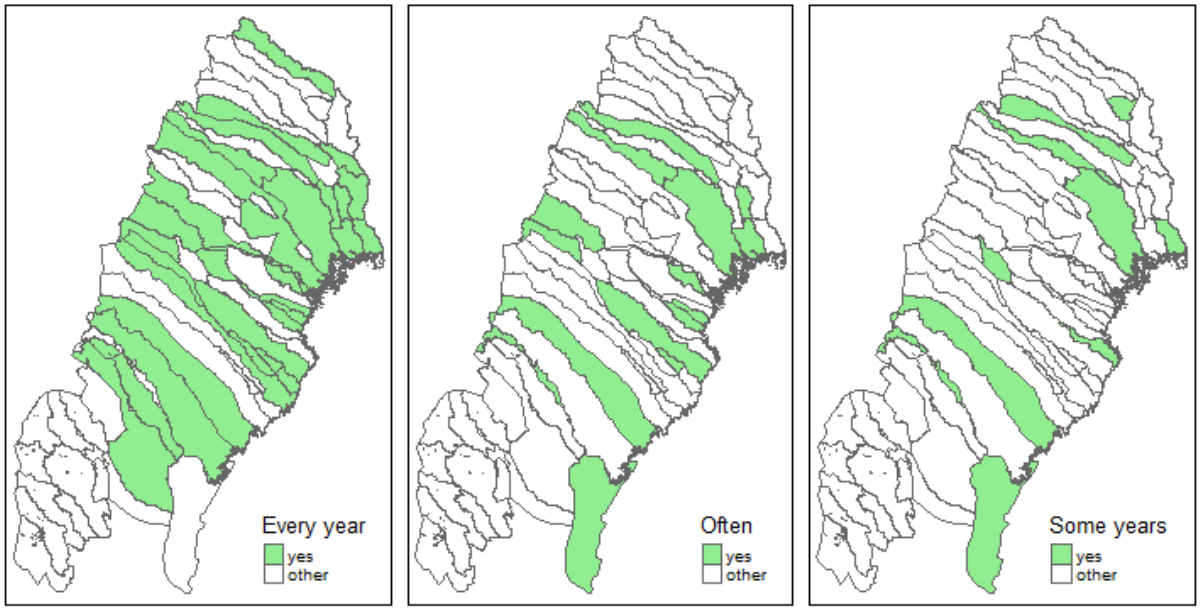

Figure 6. The green colored districts represent at least one respondent that have answered that they are feeding due to ice cover on winter pastures. From the left respondents that are feeding every year due to this. In the middle often and to the right some years.

For 23 respondents one reason for feeding was because of high cesium levels in reindeer where the majority were doing this every year (Table 6). There were only respondents from Jämtland, mountain districts in Västerbotten and forest districts that were feeding to reduce cesium levels before slaughter. The concessionary districts and mountain districts in Norrbotten were unaffected (Table 6). One respondent from Jämtland clarified that their district was free from cesium since the last 10-15 years. One herder in Västerbotten mountain wrote that they have fed due to high levels, but that it has decreased during the years and that sometimes was not even necessary to feed. Furthermore, one herder in the same region answered that they have been feeding every year since the Chernobyl accident in 1986.

Table 6. Regional distribution of respondents regarding the reason of feeding in different extent due to cesium levels in reindeer.

Feeding due to cesium	NM	VM	F	C	J	**Total**
Every year	0	5	5	0	6	**16**
Often	0	2	1	0	2	**5**
Some years	0	1	1	0	0	**2**
Total	**0**	**7**	**7**	**0**	**8**	**23**

B. Questions regarding time and range

Question B1. "*Have you been feeding the reindeer in the same way previous years?*"

Out of the respondents that were feeding reindeer, most of the respondents answered that they have been feeding the reindeer in the same way previous years (Table 7). 14 herders clarified in the comments that it was depending on the winter situation with lichen pastures. For example, one herder said that they were forced to feed every year for last 4 years due to ice cover, whereas another herder said that they had been feeding every year since 2011. For some herders that were feeding during herding and migration too, the reasons for in what extent and time of feeding, depended on the occurring winter situation.

Table 7. Regional distribution of respondents regarding if they have fed the reindeer in the same way previous years.

Same feeding practices	NM	VM	F	C	J	**Total**
Yes	28	11	15	20	21	**95**
No	5	1	4	1	2	**13**
Do not know	2	0	0	0	0	**2**
Total	**35**	**12**	**19**	**21**	**23**	**110**

Question B2. "*What proportion of the herd are being fed?"*

Regarding this question, 44 of the respondents that fed their reindeer said that they were feeding all animals (Fig. 7). It was clarified in some comments that the ambition is to feed all animals, but that the circumstances set the outcome of how well the gathering goes that year and thus, the proportion of animals being fed. It was also mentioned in the comments that during round-ups, all reindeer were fed while they were waiting for transportation to winter pastures, or during migration between pastures. 7 herders estimated that they were feeding between 25-50% of the winter herd. For those that answered around 50-70% or >75% of the herd, some respondents clarified in the comments that they fed all reindeer that they gathered, but that this seldom includes 100% of the winter herd.

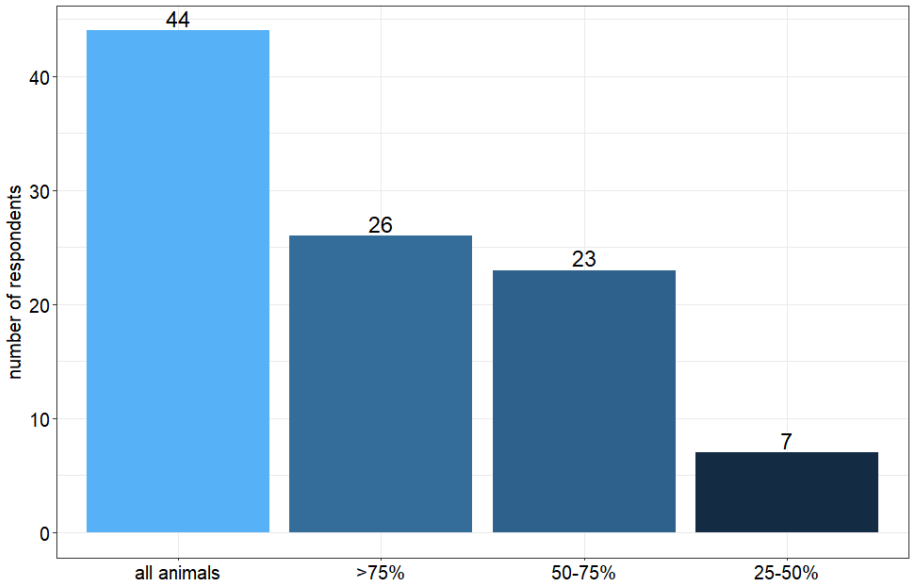

Figure 7. Distribution of the respondents regarding what proportion of the herd that are being fed during winter.

Question B3. *"Which animals are you feeding?"*

84 respondents answered that they were feeding all categories (calves, females and males). Some herders (n=4) clarified in the comments that during emergency winters with locked pastures, all animals were fed. For those herders that answered, 'calves and females' (n=15), 'only calves' (n=4) and 'other' (n=9, e.g. tame bulls) gave different comments to why. For example, 4 herders said that they were only feeding calves (mainly male calves) and bulls, but only prior to slaughter. Moreover, one herder said that the ratio of animals that are being fed should be around 80% calves and 20% females because it is necessary to have females that learn calves to eat pellets. One herder also mentioned that they were feeding mainly adult reindeer because the younger ones have not learned to eat pellets.

C. Questions regarding feed and practices

Question C1. "*What type of feed have you been using?*"

Pellets was the main feed used during feeding, closely followed by silage and lichen (Fig. 8). Dry hay was also used by some herders and other feed that was used were arboreal lichen, dry leaves, horsetail and potatoes, or a combination of these. One herder commented that there could be an enormous difference in the quality of silage from year to year, and that it was difficult to get farmers to understand the need of good quality silage for reindeer that have sensitive rumens.

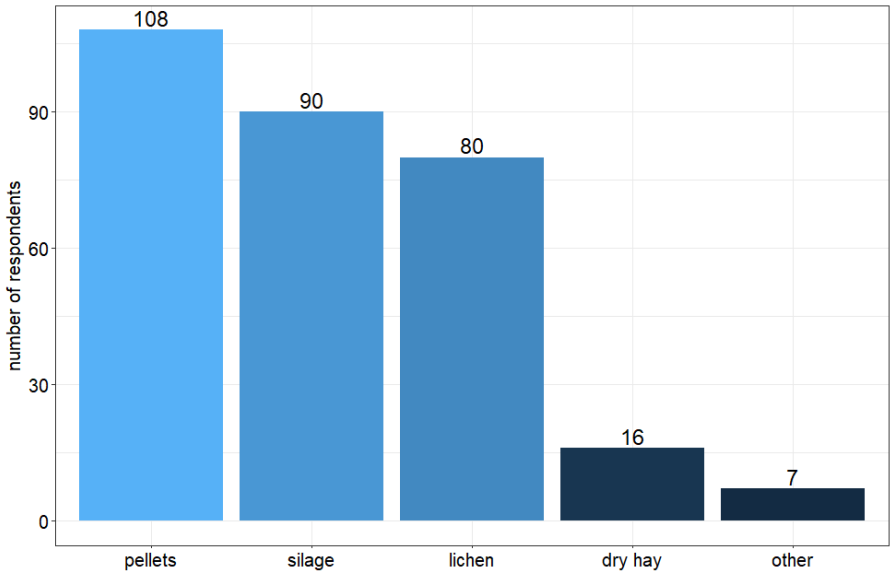

Figure 8. Distribution of respondents regarding the type of feed that are being used during feeding of reindeer.

Question C3. "*How is the feeding practiced?"*

Feeding the reindeer in a combination of using both pens and on free-range was the most frequently used method (Fig. 9). According to the comments, there were different measures used, for example one herder said that first the reindeer were given silage when free-ranging and later they were put in pens where they were given pellets and silage. 3 herders that used a combination also clarified that it was mainly the weak reindeer that were fed in pens whereas the rest of the herd was fed on free-range. It also seemed to depend on whether there was an emergency year or not which practice that was used.

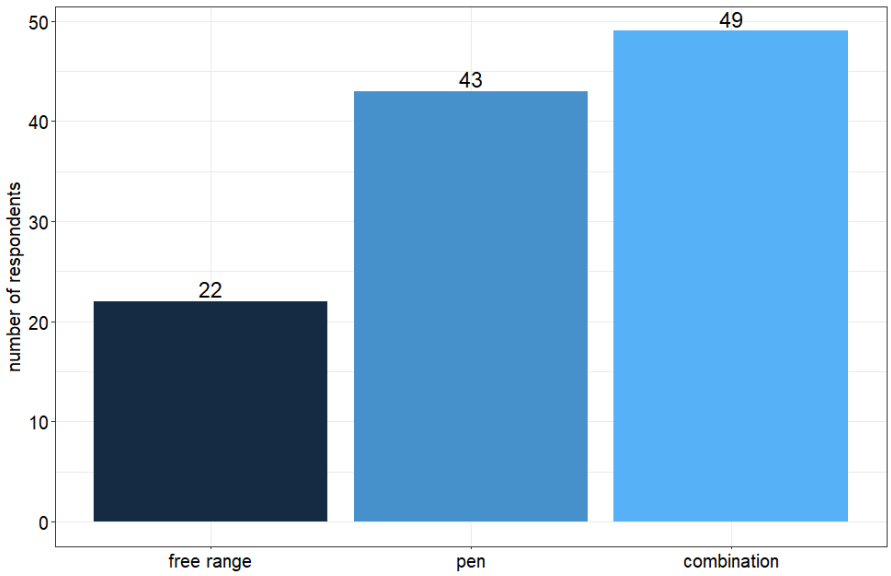

Figure 9. Distribution of respondents regarding the way reindeer are kept when they are being fed.

Question C4. *"How was the feed given?"*

Most of feeding means was to give feed in cribs (Fig. 10). It was stated in the comments that most of the pellets was given in cribs and the silage and lichen on the ground. Two herders, however said that sometimes even pellets were given on the ground, but that it was always on free-range. One herder described that the process of habituation of pellets was done by giving pellets on the ground so that they could not overeat before they were used to it. After habituation, pellets were given in cribs. Furthermore, one herder reflected that 3 weeks seemed to be a "magical line" until the reindeer were used to eat pellets. Also, one herder pointed out that the time of habituation only referred to one type of pellets. If they had to switch distributer they had to go through the process of habituation one again. It was also mentioned by a few herders that the combination of pellets and/or silage and lichen was given especially during the habituation period.

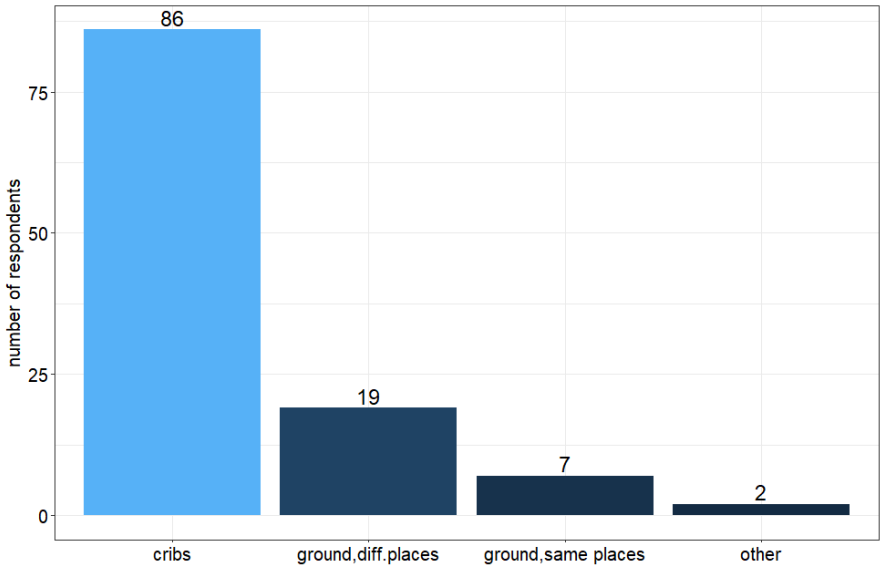

Figure 10. Distribution of respondents regarding how the feed were given to the reindeer during feeding.

D. Questions regarding experiences from feeding

Question D1. "*Is the herding work affected by feeding?*"

In addition to the usually routines in reindeer herding, most of the herders answered that the extra work with feeding practices were affecting the regular routines (Fig. 11). In the comments (see Appendix 3 for more comments), it was revealed that 28 herders experienced positive effects from this in the way that it was easier to plan and perform herding work. 8 herders specific mentioned that the herd was more gathered when they were being fed on free-range and that it facilitated to keep the herd under easier surveillance. 3 herders also mentioned that the reindeer were attracted to the feeding place as a consequence from feeding.

"It is possible to keep the winter herd gathered
when the lichen grounds are locked by ice"

The negative aspects from feeding were described by 61 herders in the comments. 32 herders specific stated that it was time consuming, it required extra staff/people, other work that needed to be done was usually postponed and it was an obligation every day due to feeding. Moreover, the physiological and psychological aspects with feeding were identified by 10 respondents, e.g. heavy lifts during daily feeding, stress and concern over bad winter conditions. For the economically side of feeding, 19 herders meant that there were large and even huge challenges due to the expenses for feed. This was also stated to affect the psychological well-being by some herders.

"*I am forced to decrease my herding work and work with other things to be able to get income for my reindeer husbandry so I can continue with it*"

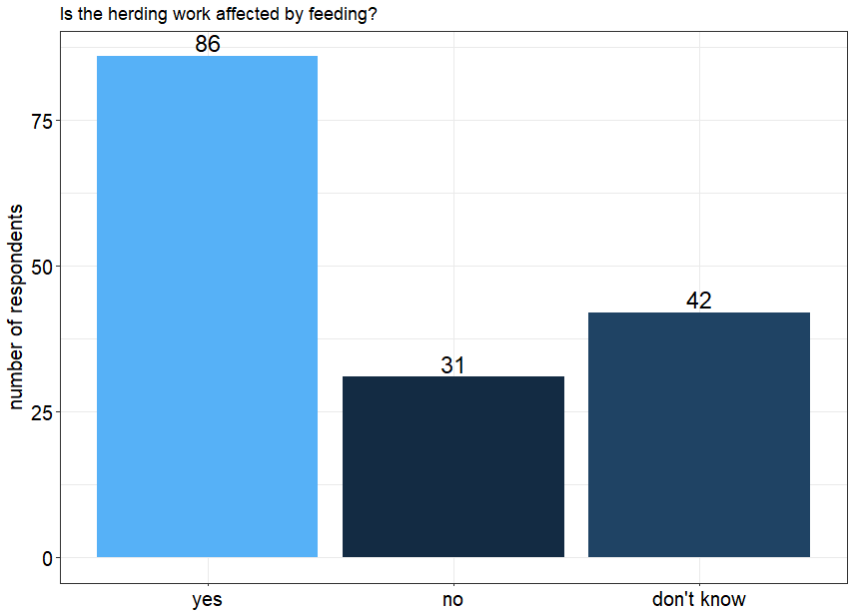

Figure 11. Distribution of responses regarding if the usual herding work is affected by feeding (when it is required or done).

Question D2. "*Is the behavior of the reindeer affected by feeding?*"

As many as 98 herders answered that they thought that the behavior of reindeer was changed due to feeding, whereas 15 herders did not believe so (Fig. 12). The primary effect from feeding was mentioned that the reindeer become tame, unafraid and calmer, which 135 respondents were reporting in the comments. Consequently, from that many positive and negative secondary effects were derived. For the positive aspects, 16 herders mentioned that the reindeer were easier to handle during different herding practices. In contrast to the easier handle of reindeer due to tameness, 6 respondents mentioned that tame reindeer sometimes was harder to handle and to herd. Overall, more negative effects were mentioned, e.g. 41 respondents said that the reindeer went lacier and comfortable, and stopped grazing by themselves and instead waited for food to get served.

> *"Reindeer that are being fed every year becomes lacy; they stop digging for food and are attracted to the feeding places when snow comes"*

Furthermore, 23 respondents described that the reindeer were attracted to them as herders, to other snowmobiles, to other people, to societies etc. because of the previous effect (tamer). Also, 14 respondents specific described that they thought reindeer also got more unafraid of dogs and predators due to the increased tameness. They mentioned that the natural flight instinct seemed to disappear.

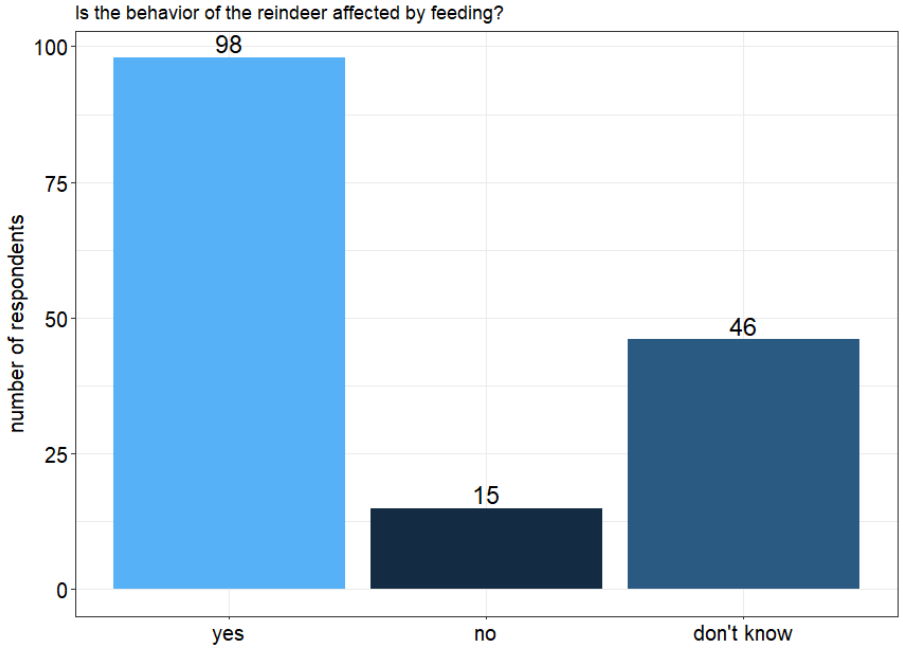

Figure 12. Distribution of responses regarding if the behavior of the reindeer is affected by feeding.

Question D3. "*Is the health of the reindeer affected by feeding?*"

The health of the reindeer was affected by feeding according to 100 respondents whereas 13 thought it was not (Fig. 13). Also, there were a division of both positive and negative effects from feeding described in the comments. For the negative effects, diseases and risk of infections were mentioned as a risk by 22 respondents and experiences from, and a fear of, specific eye infections were mentioned by 10 herders. The comments were mostly connected to when reindeer were fed within pens, due to the amount of space, the need of clean pens, fresh snow/water etc. Some herders also thought that the dust from pellets were irritating both eyes and lungs of the reindeer. Feed related effects such as diarrhea, constipation, vitamin and mineral shortage, digestive problems, bad condition of the reindeer etc. were effects that were mentioned by 48 respondents.

"It is important to keep the cribs clean and enough in number,
as well as access to clean snow. Change pens in between to avoid diseases".

For the positive effects from feeding, better condition of the reindeer was mentioned by 46 respondents. As another consequence from feeding, better herd survival was stated by 10 persons, and specific better calf survival were also mentioned by 10 respondents.

"*They can get a lot of diseases such as wet belly etc.*
But if they don't get sick they have better condition from feeding"

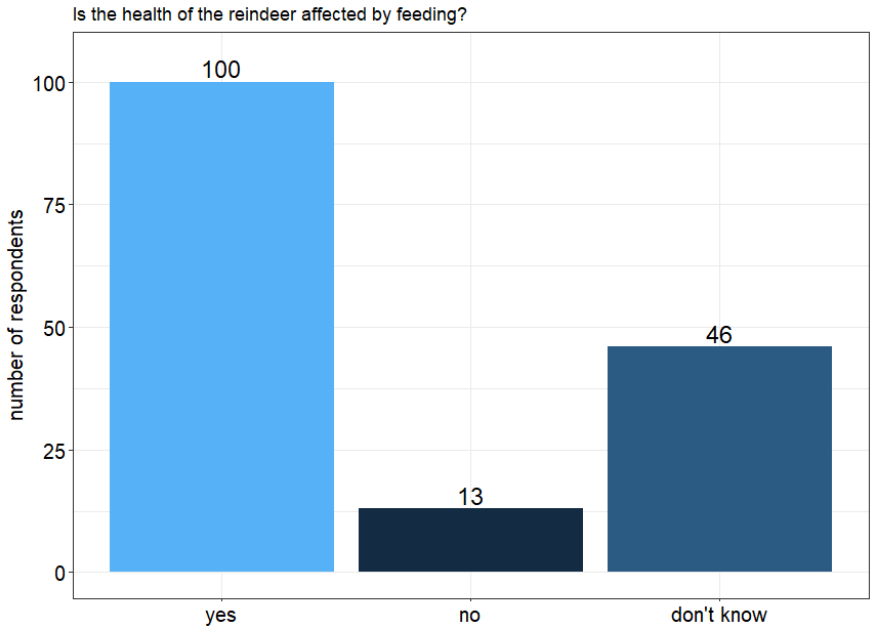

Figure 13. Distribution of responses regarding if the health of the reindeer is affected by feeding.

Question D4. *"Is predation loss affected when reindeer are being fed?"*

Most of the respondents (n=67) did not knew if the predation rate was affected when reindeer were fed whereas almost the same number of respondents thought it was (Fig. 14).
Many herders (n=42) answered in the comments that the reindeer were protected from predators when they were fed within fences because the herder had a higher surveillance of the herd then. In contrary, 19 herders answered that reindeer that were fed, in fence or on free range, were attracting predators. 7 respondents specific answered that they did not thought there was any difference on the predation rate.

"*The reindeer are gathered in the same area and the predators know that. Reindeer have their feeding places and so do predators*"

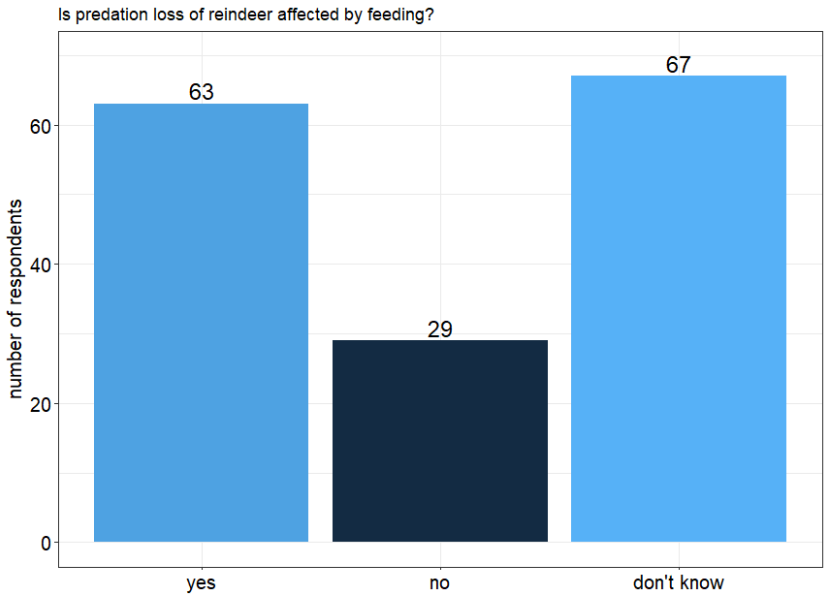

Figure 14. Distribution of responses regarding if the predation loss is affected when reindeer are being fed.

Question D5. "*Are the reindeer in same winter pastures when they are being fed?*"

Out of all respondents, 53 answered that the reindeer are in the same winter pastures when they are being fed (either in pens or on free range). 56 respondents answered that they are not, and only 5 did not know (Fig. 15). However, the answers to this question seemed to depend on whether the reindeer were being fed in pens or on free-range. According to the comments connected to this question there were at least 4 herders that clearly stated that they do not have other pastures to utilize so they need to feed on the same winter grazing areas. Moreover, a few herders (n=3) mentioned that they were trying to feed on pastures that are less lichen rich, so they do not litter the ground with hay, and to prevent that the reindeer are trampling the existing lichen. Among herders that were feeding on free range, 8 of them mentioned that they preferred to give supplementary feed on winter pastures that are good enough for the reindeer to find natural feed too on. A few herders mention that if the reindeer were fed in pens, these pens were often connected to roads or constituted their round-up/slaughter facilities.

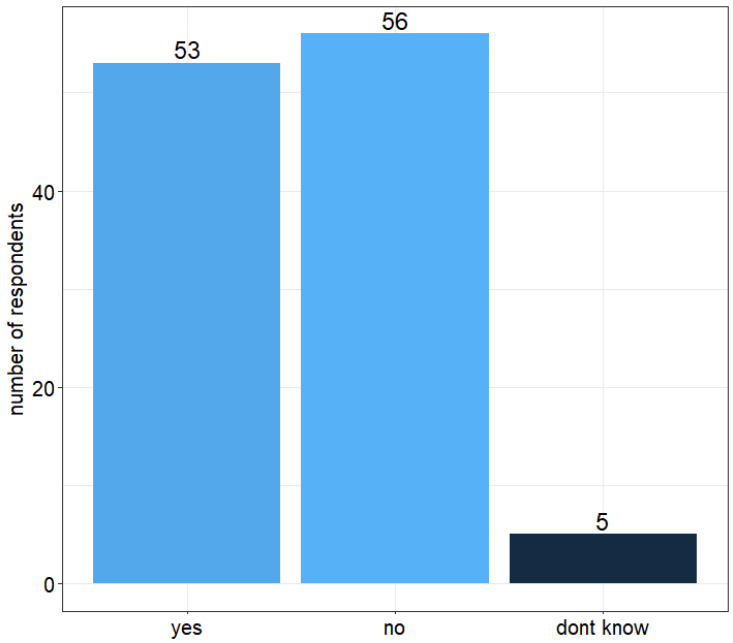

Figure 15. Distribution of responses if the reindeer are on the same pastures as they used to if they were grazing natural, when they are being fed.

"Our winter pastures are so small, so we have to utilize every single spot for the herd"

Effects of level of feeding on calf ratio and calf carcass weight

Calf ratio

Data from a total number of 17 herders in 8 districts (Appendix 2a) were used to analyze the possible effect of feeding on calf ratio. There were significant differences between each of the three levels of feeding ('every year'=1,'often'=2 and 'occasionally'=4) when data from all herders within each of these three levels were grouped and compared (Fig. 16). Herder feeding occasionally had higher calf ratio than herders feeding either every year or often, and feeding reindeer often had the lowest calf ratio of them all (Fig. 16).

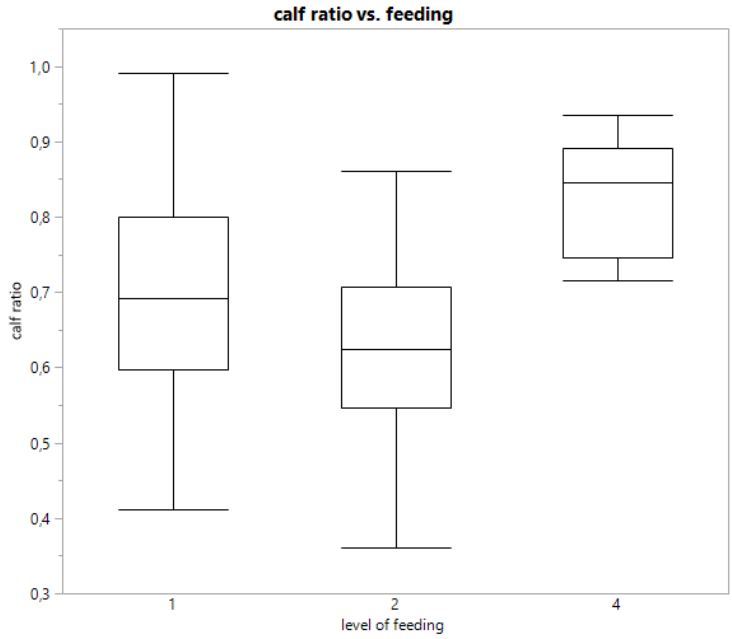

Figure 16. Comparison of calf ratio between all herders for all years with data for each herder within the levels of feeding; 'every year'=1, 'often'=2 and 'occasionally'=4. Significant differences were found between each of the levels; calf ratio for level 4 (0.83±0.019) was higher than level 2 (0.63±0.016) (P<.0001) and level 1 (0.70±0.012) (P=0.0015). Level 1 was higher than level 2 (P=0.0023).

Differences in mean calf ratio between herders (or between herder and the rest of the district) were found in five of the districts (Table 8), whereas no differences were found in the other three. Positive time trends were found for 3 herders, all in different districts. Positive trends were also found for two whole districts (D2 and D4). For two herders in district D7, the time trends were negative, and there was also a negative trend for the district as a whole. Within districts D1, D3, D5 and D8, none of the herders showed any significant linear trend for calf ratio with time.

All herders from district D1 and D2 were feeding every year but still showed significant differences in mean calf ratio within district. There were also no significant trends with time for the individual herders in these two districts. Significant differences in mean calf ratio between herders with different feeding level were only observed in district D5 and D7, but with opposite effect in the two districts (higher calf ratio with lower feeding level in D5, and the opposite in D7). The three herders that showed positive time trends in calf ratio had been feeding every year (1) or often (2), and these trends showed to be strong (see example in Appendix 4a). One of these herders (D6005 that fed every year) also had the highest mean calf ratio within the district.

Table 8. Mean calf ratio and trend over years for herders with known level of feeding and enough data over at least a 10-year period. For the districts the level of feeding is unknown. Herders (and the whole district with the herders included in that data in parentheses) with level of feeding; ('every year'=1, 'often'=2, 'some years'=3, 'occasionally'=4, 'never'=5); mean calf ratio (scale 0-1, ±SE); letters indicating significant differences within districts; p-Values for time trends with (+) for positive trend and (-) for negative trend; and years of data (n) with number in parentheses refer to the initial numbers of years before years in the data containing errors were excluded.

District	Herder	Level of feeding	Mean calf ratio (SE)	Sign. *	p-Value (trend)	n (years)
D1	D1010	1	0.88 (±0.045)	A	0.5177 (-)	8(11)
	D1008	1	0.76 (±0.025)	AB	0.6042 (-)	17(18)
	D1009	1	0.66 (±0.027)	BC	0.0513 (+)	15
	D1000 (district)	-	0.63 (±0.025)	C	0.7936 (+)	20
D2	D2020	1	0.70 (±0.023)	A	0.4202 (+)	12
	D2000 (district)	-	0.61 (±0.033)	AB	<.0001 (+)	20
	D2013	1	0.50 (±0.037)	B	0.1493 (-)	10(14)
D3	D3010	1	0.73 (±0.036)	A	0.4620 (-)	11
	D3000 (district)	-	0.56 (±0.027)	B	0.7488 (+)	20
D4	D4000 (district)	-	0.56 (±0.018)	A	0.0315 (+)	20
	D4001	2	0.62 (±0.024)	A	0.0541 (+)	13
	D4002	2	0.64 (±0.051)	A	0.0146 (+)	11(12)
D5	D5006	4	0.83 (±0.020)	A	0.1979 (-)	13(16)
	D5000 (district)	-	0.78 (±0.019)	A	0.4556 (-)	20
	D5003	1	0.58 (±0.022)	B	0.5299 (+)	13
D6	D6000 (district)	-	0.71 (±0.011)	A	0.4094 (+)	20
	D6001	2	0.73 (±0.022)	A	0.4212 (-)	17
	D6005	1	0.77 (±0.026)	A	<.0001 (+)	17
	D6006	1	0.70 (±0.027)	A	0.1050 (+)	18
D7	D7000 (district)	-	0.78 (±0.028)	A	0.0048 (-)	19
	D7002	1	0.68 (±0.033)	AB	0.0095 (-)	14
	D7004	2	0.57 (±0.031)	C	0.0202 (-)	16
	D7006	2	0.58 (±0.041)	BC	0.0011 (+)	9
D8	D8000 (district)	-	0.55(±0.019)	A	0.4467 (+)	19
	D8001	5	0.55(±0.022)	A	0.1349 (-)	14

*herders not connected by same letter are significantly different

Calf carcass weight

Data from a total number of 19 herders in 8 districts (Appendix 2a), were used to analyze the possible effect of feeding on calf carcass weight. Herders feeding reindeer often (level 2) had significant lower calf weights than herders feeding either often (level 1) or occasionally (level 4) (Fig. 17). No difference for weights were found for level 1 and level 4 (Fig. 17).

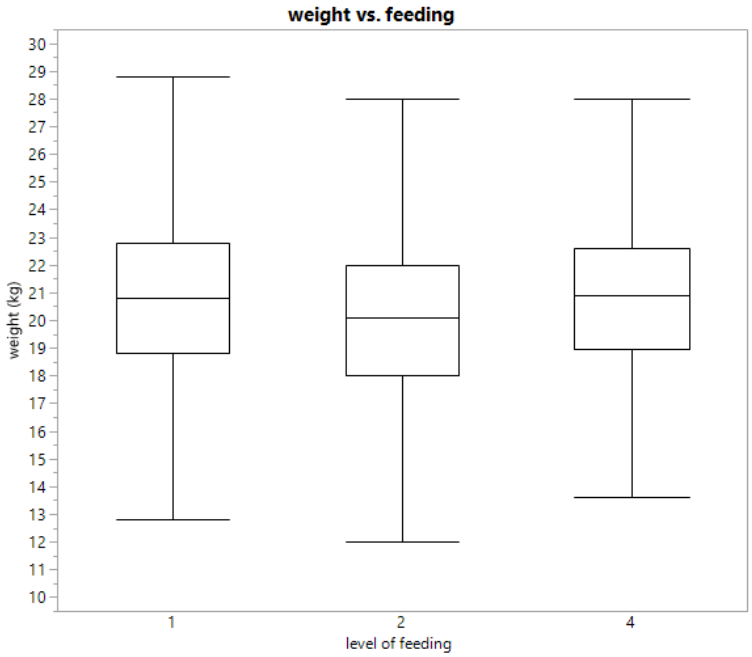

Figure 17. Comparison of calf carcass weight between all herders for all years with data for each herder within the levels of feeding; 'every year'=1, 'often'=2 and 'occasionally'=4. Strong significant difference was found between level 1(20.73kg ±0.024) and level 4(20.74kg±0.063) altogether and level 2(20.01kg±0.039) which was lower (P<.0001). Calf carcass weight for herders in level 1 and level 4 were almost the same (P=0.99).

Differences in weights between herders were found in four of the districts (Table 9), whereas no differences were found in the other two districts that were compared. Positive time trends were found for a total number of 14 herders in seven of the district (see Appendix 4b for example). In the last district the time trend was strongly negative for the herder which was the only herder with this result. Moreover, positive trends were also found for 5 whole districts (D1, D4, D5, D6 and D7). The two herders within district D4 were both feeding often but still showed significant differences. For the two herders in district D4, the feeding level were 1 (every year) and 4 (occasionally) and the weights were significant different, but the herder that fed occasionally had the highest mean weight. This was also found between two of the herders in district D6 that had different levels of feeding. For district D7, three herders that were feeding either every year or often, were not different by mean weights, but they were significant different from the other two herders (feeding level 1 and 2) in the district.

Table 9. Calf carcass mean weights and trend over years for herders with known level of feeding and enough data over at least a 10-year period. Herders and the whole district (in italic) with the herders included in that data with level of feeding; ('every year'=1, 'often'=2, 'some years'=3, 'occasionally'=4, 'never'=5); calf carcass mean weight (kg ±SE); letters indicating significant differences within districts; p-Values for time trends with (+) for positive trend and (-) for negative trend; and years (n) of data.

District	Herder	Level of feeding	Mean weight (SE)	Sign. *	p-Value (trend)	n (years)
D1	D1010	1	20.19 (±0.096)	A	0.0003 (+)	21
	D1009	1	20.15 (±0.067)	A	0.3804 (+)	21
	D1008	1	19.96 (±0.073)	A	<.0001 (+)	21
	D1000 (district)	-	*19.88 (±0.202)*	-	*0.0269 (+)*	-
D2	D2013	1	22.37 (±0.127)	A	0.4708 (-)	11
	D2020	1	22.21 (±0.107)	A	<.0001 (+)	21
	D2000 (district)	-	*21.94 (±0.330)*	-	*0.1029 (+)*	-
D3	D3010	1	19.95 (±0.090)	-	0.1087 (+)	19
	D3000 (district)	-	*21.01 (±0.256)*	-	*0.0103 (+)*	-
D4	D4002	2	19.88 (±0.082)	A	<.0001 (+)	20
	D4001	2	19.57 (±0.077)	B	<.0001 (+)	20
	D4000 (district)	-	*19.82 (±0.218)*	-	*0.0065 (+)*	-
D5	D5006	4	20.74 (±0.067)	A	<.0001 (+)	21
	D5003	1	19.83 (±0.086)	B	0.0008 (+)	21
	D5000 (district)	-	*20.16 (±0.206)*	-	*0.0093 (+)*	-
D6	D6005	1	21.65 (±0.064)	A	<.0001 (+)	21
	D6006	1	21.09 (±0.097)	B	<.0001 (+)	21
	D6001	2	20.34 (±0.094)	C	<.0001 (+)	18
	D6000 (district)	-	*20.37 (±0.218)*	-	*0.0038 (+)*	-
D7	D7001	1	20.43 (±0.126)	A	<.0001 (+)	14
	D7006	2	20.31 (±0.091)	A	0.0614 (+)	18
	D7003	1	20.18 (±0.064)	A	<.0001 (+)	20
	D7004	2	19.84 (±0.101)	B	0.0008 (+)	21
	D7002	1	19.74 (±0.083)	B	<.0001 (+)	21
	D7000 (district)	-	*19.78 (±0.237)*	-	*0.0019 (+)*	-
D8	D8001	5	21.66 (±0.089)	-	<.0001 (-)	18
	D8000 (district)	-	*21.55 (±0.454)*	-	*0.0872 (-)*	-

*herders not connected by same letter are significantly different

Calf carcass weight the year after feeding

Data from a total number of 4 herders in 4 districts (Appendix 2b) were used to analyze the calf carcass weight before and after annual feeding started. Significant strong differences were found for herder A and B (Fig. 18 and 19), were the weights the year after feeding started were higher than before. Herder A: before feeding (21.06±0.14 kg, n_{years}=8) and after feeding (22.57±0.14 kg, n_{years}=3). Herder B: before feeding (19.93±0.11 kg, n_{years}=8) and after feeding (21.07±0.11 kg, n_{years}=5). For herder D, the result was the opposite than for herder A and B, were the weights before feeding (21.02±0.28 kg, in 2013) were significant higher than after feeding (18.78±0.27 kg, in 2015) (Fig. 20). No difference for weights before feeding and after feeding were found for herder C (P=0.44).

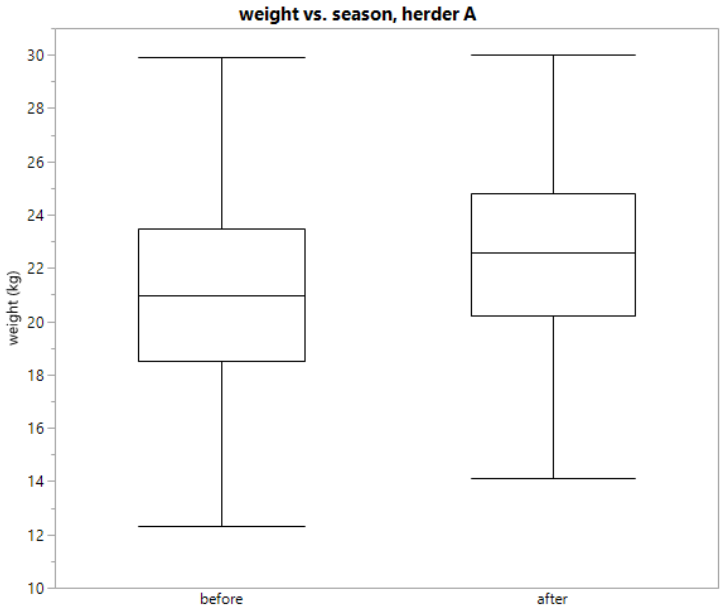

Figure 18. Comparison between calf carcass weights before feeding (slaughter season 1999-2006) and after feeding (slaughter season 2007-2009) for a herder in a forest district. The difference was strongly significant between weights (P<.0001).

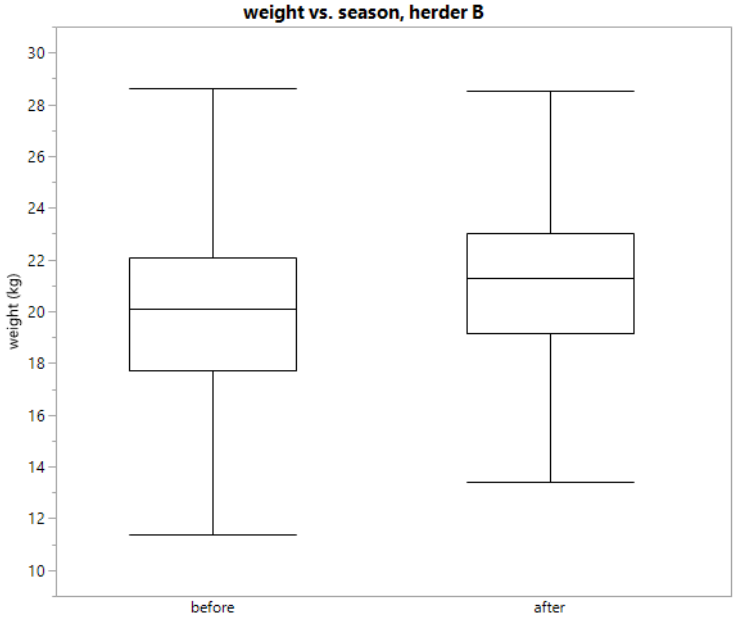

Figure 19. Comparison between calf carcass weights before feeding (slaughter season 2004-2011) and after feeding (slaughter season 2012-2016) for a herder in a mountain district in Norrbotten County. The difference was strongly significant between weights (P<.0001).

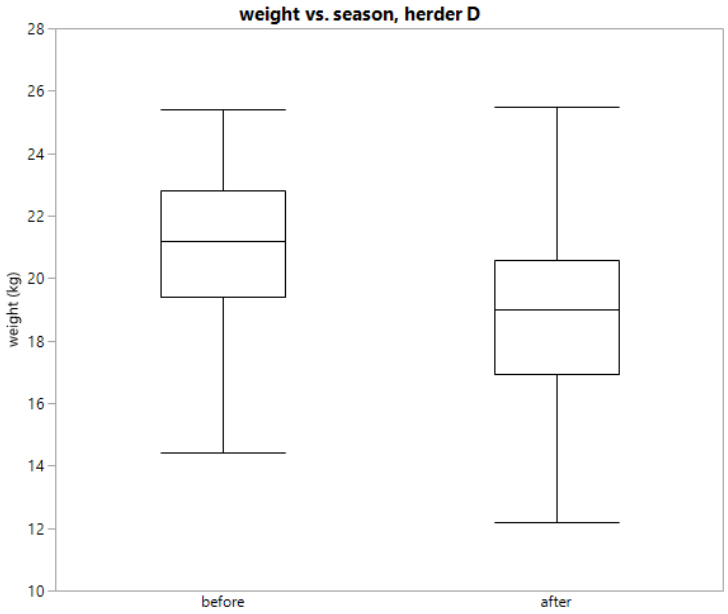

Figure 20. Comparison between calf carcass weights before feeding (slaughter season 2013) and after feeding (slaughter season 2015) for one herder in a district in Jämtland County. The difference was strongly significant between weights (P<.0001).

Discussion

Use of supplementary feeding

The responses from the questionnaire showed that supplementary feeding was frequently used in almost all districts although to different extent. The variety of comments based on experiences from the herders gives a broad picture of experiences from feeding, covering positive and negative primary and secondary effects including reindeer health-related issues, changing behavior and predation risk.

The main driver for feeding were during herding/migration and because of ice cover. For the latter one, 79 herders reported this and as many as 52 fed every year because of this. The likelihood of ice-crust formations and other environmental characteristics have been studied and resulted in a zone division of the herding area (Lundqvist *et al.*, 2007). Feeding seems to be more prominent in areas with a higher likelihood of ice cover, e.g. the coastal area of Västerbotten and Norrbotten, and in contrary, less frequent in Jämtland (low ice-crust probability). Feeding for reduction of cesium levels were only done by 16 herders in districts of Jämtland, mountain districts of Västerbotten and forest districts. In a study by Åhman (1999) where the levels of cesium was measured in slaughtered reindeer between 1986-1996 it was found that the first slaughter season after the Chernobyl accident, almost 73 000 of the slaughtered reindeer were condemned. In addition, this year only 1% of the reindeer were fed and as the proportion of reindeer were fed prior to slaughter, throughout the years, the proportion of condemned reindeer also decreased. Cesium levels in reindeer decreases over time which seems to reflect the response frequency in this question.

It is also mentioned by some herders that they are being forced to feed during springtime, before the melting of snow, due to the lack of old forest and thus arboreal lichen, because of

forestry. Also, arboreal lichen is used as “emergency feed” when the ground lichen is locked by ice, and in districts without arboreal lichen, the only option is to supplementary feed. This is also stated by Finnish herders, that the main reason for feeding there is due to the lack of arboreal lichen and old forest (Helle & Jaakkola, 2008). This scenario was supported by the findings from a study in Finland, where the need for supplementary feeding decreased with increasing arboreal lichen in areas with low ground lichen biomass (Pekkarinen *et al.*, 2015).

The responses from the question where I aimed to receive estimated number of weeks that the herders were feeding could not be used. Even if the question was correctly asked, the answer option had structural problems in the web survey tool, so no data could be extracted for this question. Since the design of a questionnaire and the formulation of the questions are of great importance when the aim is to detecting trends (Jones *et al.*, 2008), this was an unfortunate outcome. Moreover, the questions B2 and B3, where I asked for the proportion of the herd that were fed, and which animals that were being fed seemed to cause some confusion for the respondents. For example, the answer option ‘all animals’ for the question of what proportion are being fed can be interpreted as the whole herd. Further, the other question is asking to specify what type of animals are being fed, were ‘all categories’ includes the whole herd too. The confusion of these questions is a consequence of the questionnaire design.

The final questions regarding experiences from feeding were answered by all respondents but one, and the responses was valued high. It is however crucial to interpret these answers with caution due to the risk of biased answers because the lack of experience from feeding for all participants in the questionnaire. Also, for sensitive questions there is always a risk that the answers can be biased, if for example there seem to be a “risk” connected to the participation of the study, which can be the case when research is addressed to a certain community of members (Sheil & Wunder, 2002), as for this study. Therefore, parts of the results from this questionnaire need to be interpreted cautiously. Nevertheless, regarding the comments connected to the final questions, the homogeneity of them (except the last one of predation risk) somehow reveals the overall experiences. Behavioral changes of reindeer were verified by the respondents. Many reported the increase of tameness with consequences. E.g. becoming less afraid of people and dogs, ‘lazy’ in the context of waiting for food to be served (and save energy). The latter one can be supported by the study by Mesteig *et al.* (2000), where the resting time of fenced and pellet fed reindeer was 50% in contrary to 35% resting time for free-ranging reindeer (Collins, 1989).

Regarding disease and risk of infections when reindeer are fed, several studies have shown different outbreaks (Åhman *et al.*, 2002; Tryland *et al.*, 2001). For example *echtyma* (orf) in reindeer may be stressed by keeping reindeer in pens for a longer period in combination with bad nutritional status (Tryland *et al.*, 2001). During emergency years when herders are forced to feed the reindeer, the risk of diseases increases, and this was also mentioned by many herders. It is generally known that ruminants need 3 weeks to adapt to a new diet and a rapid change to a new diet can lead to feed related diseases such as wet fur (Nilsson *et al.*, 2000). Moreover, many herders reported health benefits from feeding with e.g. better condition of the reindeer, which has been found on fed reindeer (Nilsson *et al.*, 2006). High and almost equal response frequency for pellets, silage and lichen usage during feeding were reported which meant that herders are combining the feed. In contrary, almost all herders’ answers that

the feed is given in cribs which is the common way to give pellets, and altogether this seem a bit contradictive.

Effects of level of feeding on calf ratio
Based on the results from the comparison between all herders in the different feeding levels, the level of feeding does not seem to have an effect on calf ratio. The herder feeding occasionally had higher calf ratio than those herders feeding every year or often. However, the dispersion of data for calf ratio differs between the levels with regard on the only herder that belong to level 4, occasionally, compared to the other two levels. Yearly feeding was expected to give higher calf ratio than the other levels based on findings from Bårdsen *et al.* (2008) where long-term fed females had an estimated higher calf ratio than females on natural pasture.

For the detailed analyses between and within districts, the results do not reveal any clear patterns either. It was only 3 herders in total, which were feeding either every year or often, that had an increasing trend of calf ratio with time. This is partly in line with the findings that supplementary fed females have a higher reproductive success than females on natural grazing ground (Ballesteros *et al.*, 2013), e.g. have an increased chance to have higher calf survival thus higher calf ratio. Furthermore, in the district where the herder that fed occasionally, this herder had a higher calf ratio than the herder that fed on a yearly basis, which is contrary to what would be expected. Also, for some districts there were no differences between calf ratio and in some districts, there were. Therefore, it does not seem possible to explain a certain calf ratio by the level of supplementary feeding. Other factors such as reindeer density and pasture quality for example have been shown to affect calf ratio too (Kumpula *et al.*, 1998). Poorer winter pastures seem to cause a greater instability of calf ratio and the higher density of reindeer, in combination with slaughter strategy, the lower calf ratio was seen (Kumpula *et al*., 1998).

Moreover, age structure of the females also influences calf survival (Rönnegård *et al*., 2002) which was unknown for the females in this study. The assumption was that an average of 90% (10% expected to be <2 years old and thus non-fertile) of all females that were counted and slaughtered every year were fertile. This number varies of course among the years. Even if females are expected to be fertile at the age of 2 year, not all of them rear a calf from that age and every following year. Female mass can increase until the age of 7-8 year which was found in the study of Rönnegård *et al*. (2002) and that calf survival is positively correlated with female mass. Since neither female age nor female mass is known in this study, the accuracy of calf ratio is uncertain. In addition, the assumption that all females were fed during feeding may also influence the results from the analyses. As for the answer frequency of the question regarding what proportion of the herd are being fed it was revealed that not 100% of the herd are being fed.

Effects of level of feeding on calf carcass weight
For the overall comparison between all herders in the different levels, the result show that the calf carcass weight was similar for the herder feeding occasionally and the herders feeding every year. Regarding the analyses between the herders, it was found that in contrary to the calf ratio, the linear trends were significant positive for almost all herders which can be supported by earlier finding where feeding positively affect calf carcass weights (Pekkarinen

et al., 2015; Bårdsen *et al.*, 2009). Also, the only herder that never fed had a negative trend. The increased amount of feed given per reindeer is shown to have a direct response on the productivity of calf carcass mass (Kumpula *et al.*, 2002). This supports the results from my analyses, where almost all herders that feed regularly seem to have an increased trend of calf carcass weights. It also supports the idea that if you do not feed your reindeer regularly there will be a decrease of weight, as for one of the herders in my result. Still, in contrary to this, the herder that occasionally fed the reindeer still had a positive linear trend of the weights and additionally, the highest mean weight in that district compared to the other herder that fed every year. Despite the strongly significant declining trend for the herder that never feed, this herder had one of the highest mean weight compared to the rest. These two finding were not in line with previous findings.

When the results from the calf ratio and weights were compared, a few similarities between the results was found. For 5 herders it was seen that they had both the highest calf ratio and the highest weights within their districts. All the trends for mean weights were significantly positive whereas for two herders also the calf ratio trend. As mentioned earlier, feeding may have a direct effect on reproductive success and on calf body mass according to the study of Ballesteros *et al.* (2013) which support that these 5 herders that regularly feed (4 out of 5) have both high calf ratio and high calf carcass weights. The findings from these results only indicate in what direction the trend points. For example, if the trend is positive with a constant positive line (which the linear trend visualizes), it must be considered that the calf ratio cannot exceed 1.0 (1 calf per female) or that the weight cannot continue to increase indefinitely.

Moreover, high calf ratio and calf carcass weights can be seen as a good indicator of reindeer productivity based on a multitude of factors. Lundqvist *et al.* (2007) includes other driving factors for productivity, for example climate, topographical characteristics, latitude and weather variation. In addition to these environmental factors, herding practices and slaughter practices play an important role too for the outcome of calf survival and slaughter weights. It is therefore impossible to compare this between and within the herding districts without more detailed data since the requisites and practices varies amongst the districts.

Effect from feeding the subsequent year

For the two herders, A and B that had been feeding their reindeer on a yearly basis since 2007 and 2012 respectively, it was found that the mean weights before the annual feeding started, were significant smaller than after feeding. Since feeding affects calf carcass weight (Pekkarinen *et al.*, 2015) this supports the findings, even if there probably are other factors affecting this too. For herder C this was not significant even if this herder also had been feeding for a long time (since 2009). The feeding history before the annual feeding started is however uncertain in these three cases (although treated as 0 years of feeding in the analyses), and therefore one cannot conclude too much here. The result for herder D showed however the opposite, with lower weights the year after feeding. Whether the actual feeding in this case affected the weights is difficult to fully explain and more analyses are needed.

Data limitation

Regarding the questionnaire responses, it is not possible to apply the feeding practices from one or a few herders within a district on the whole district. The method I used to receive responses may be biased since all members within all districts did not participate. This can be

explained by either methodical, financial limitations or lack of interest from some herders. Regarding the first question, it may also be possible that some respondents were making a calculation of how often they have been feeding. If a herder for example, have been a herder for 30 years, but only have been feeding the last 10 years, the answer could either be every year or occasionally depending on the interpretation of the question. This was a common effect observed in another interview study made by Jones *et al.* (2014) where respondents were estimating their answers, and of course need to be taken into consideration when interpreting the results from the questionnaire. The census data and amount of data for some herders may have influenced the outcome of the calculated calf ratio, e.g. calf ratio exceeded 1.0 in some cases and calf weights were sometimes reported over 30 kilos. The lack of other data such as female age structure, female body mass and the exact knowledge of which females that have been fed, which could contribute to the certainty of calf ratio, were missing and therefore the results must be cautiously interpreted.

Conclusion

Based on the responses and comments from the questionnaire, it can be concluded that the level of feeding in the Swedish reindeer herding area varies in and between the districts. The opinion regarding feeding seems to be a mix of both benefits and problems, with most of negative experiences from it. It can also be concluded that within the districts, many of the herders had a positive trend of calf carcass weights whereas only a few had the same for calf ratio. If these trends are correlated with the level of feeding is difficult to conclude here. This also applies for the overall comparison between all herders and the different levels of feeding. When analyzing data for a few herders with known feeding status for some years, a direct effect from feeding on the following year seemed to be prominent. Nevertheless, possible benefits from using feeding as a measure during winter cannot be evaluated only based on for example the increased carcass mass attained. The proportion of the costs, the extra work load and the long-term negative effects related to feeding need to be considered in relation to the increased carcass weight. Rennert *et al.* (2009) predicts that the frequency of ROS events will increase in the Arctic area due to climate change and the fragmentation of both summer and winter pastures, are forcing herders to adapt to new routines, where supplementary feeding is one (Turunen *et al.*, 2016).

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Appendices

Appendix 1. Questionnaire template (Swedish and English)

A. Bakgrundsinformation
Background information

A1. Är utfodring en del i din renskötsel? (foder=pellets/ensilage/hö/renlav/annat)
Is feeding a part of you reindeer herding? (feed=pellets/silage/hay/lichen/other)

☐ Ja, varje år ☐Ja, ofta ☐Ja vissa år, men oftast inte
Yes, every year *Yes, often* *Yes, some years, but often not*
☐ Nej, men det har hänt ☐ Nej, aldrig (besvara A2, och hoppa sen till fråga D)
No, but it has happened *No, never (answer A2, then jump to question D)*
Kommentarer *(comments)*:
……...

A2. Om du väljer att inte utfodra (ibland eller alltid), varför inte?
If you don´t feed (sometimes or always), why not?

☐ Har inte varit nödvändigt ☐ För kostsamt ☐ För mycket arbete
Not been neccessary *Too coostly* *Too much work*
☐ Inte bra för renarna ☐ Utfodring och renskötsel hör inte ihop
Not good for reindeer *Feeding and reindeer husbandry doesn't match*
☐ Annat *(other)* :……
Kommentarer *(comments)*:
……...

A3. Om du har utfodrat, av vilken anledning? (flera anledningar kan kryssas i)
If you have been feeding, for what reason? (More options can be mentioned)

☐ I samband med flytt och samling
During herding and migration
☐ Låst bete (istäcke över renlaven) ☐ För att förbättra konditionen på livdjuren
Locked pastures (ice cover) *Increase condition on live animals*
☐ För att öka vikten på slaktdjur ☐ För att sänka cesiumhalter före slakt
Increase weight on slaughter animals *Decrease level of cesium prior to slaughter*
☐ Annat *(other)* :……
Kommentarer *(comments)*:
……...

B. Tid och omfattning
Time and extension

B1. När utfodrade du dina renar vintern 2015/2016? Kryssa i veckor nedan. Varje månad har 4 veckor.

When did you feed your reindeer during season 2015/2016? Tick weeks below. Every month have 4 weeks.

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Oktober November December Januari Februari Mars April Maj
October November December January February March April May

Har du utfodrat på ungefär samma sätt tidigare år?: …….
Have you been feeding on approximately the same way previous years?

När flyttade du till och från vintermarkerna vintern 2015/2016? ……
When did you migrate back and forth to winter pastures 2015/2016?

Kommentarer *(comments)*:

……...

B2. Hur stor andel av renarna i vinterhjorden utfodras?
What proportion of the reindeer in winter herd are being fed?

☐ Alla *(all)* ☐ minst *(at least)* 75% ☐ 50-75% ☐ 25-50% ☐ <25%

Kommentarer *(comments)*:

……...
……...

B3. Vilka renar brukar du utfodra?
What animal do you use to feed?

☐ Alla kategorier ☐ Vajor och kalvar ☐ Bara vajor ☐ Bara kalvar
All categories Females and calves Only females Only calves

☐ Annat, i så fall vilka:……
Other, what?

Kommentarer *(comments)*:

……...

<u>C. Frågor gällande foder och utfodringssätt</u>
Questions regarding feed and feeding practices

C1. Vad har du utfodrat med? (flera fodermedel kan kryssas i)
What feed have you been using? (More options can be mentioned)

☐ Pellets ☐ Ensilage ☐ Torrhö ☐ Renlav
Pellet Silage Dry hay Reindeer lichen

☐ Annat *(other)* :……

Kommentarer *(comments)*:

……...

C2. Uppskatta mängden foder vintern 2015/16
Estimate the amount of feed during winter 2015/2016

Pellets *(pellet)* : ..... kg *(kilos)*

Ensilage *(silage)* : .....balar *(bales)*

Ange om du använder mindre balar än vanlig storbal: .....
Specify if you are using smaller bales than usual big bale

Lav *(lichen)*: .....säckar *(sacks)* Ange storlek på säckarna: ..... liter
Specify the size of the sacks (litres)
Kommentarer *(comments)*:
……...

C3. Hur har utfodringen gått till?
Where have you been giving the feed?
☐ fritt i fält (dvs inget stängsel som håller renarna) *Open field, i.e. no fence*
☐ i hage *Within fences*
☐ kombination hage/fritt fält *Combination fence/open field*
Kommentarer *(comments)*:
……...

C4. Hur har du gett fodret?
How have you been giving the feed?
☐ I krubbor *In cribs*
☐ Utspritt på marken, olika platser varje gång *Spread out on the ground, different places each time*
☐ Utspritt på marken, samma plats *Spread out on the ground, same places*
☐ Annat *(other)*:……
Kommentarer *(comments)*:
……...

<u>D. Hur upplever du att utfodring påverkar renarna och renskötseln?</u>
Questions regarding experiences from feeding.

D1. Påverkas renskötselarbetet av utfodring (förutom själva arbetet med utfodringen)?
Is the herding work affected by feeding (except the actual work with the feeding)?
☐ Nej ☐ Vet ej ☐ Ja I så fall hur: …….
No I don't know Yes If, how:
.....

D2. Påverkas renarnas beteende?
Is the behavior of the reindeer affected?
☐ Nej ☐ Vet ej ☐ Ja I så fall hur: ……
No I don't know Yes If, how:
.....

D3. Påverkas renarnas hälsa?
Is the health of the reindeer affected?

☐ Nej ☐ Vet ej ☐ Ja I så fall hur: ……
No *I don't know* *Yes* *If, how:*

.....

D4. Påverkas rovdjursförlusterna av att renarna utfodras?
Is the predation rate affected by the fact that the reindeer are being fed?

☐ Nej ☐ Vet ej ☐ Ja I så fall hur: ……
No *I don't know* *Yes* *If, how:*

.....

D5. Är renarna på samma marker när de utfodras som de skulle ha varit på om de inte hade utfodrats?
Are the reindeer on same pastures when they are being fed, as if they would not have been fed?

☐ Nej ☐ Vet ej ☐ Ja I så fall hur: ……
No *I don't know* *Yes* *If, how:*

.....

TACK SÅ MYCKET FÖR DITT DELTAGANDE!
Har du övriga kommentarer kan du skriva dem här.
Thank you so much for your participation! If you have other comments please write them here.

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Appendix 2a. List of districts were linear trend analyses and comparisons of group means of calf ratio and calf carcass weights were done.

District	Herder	Level of feeding	Region
D1	D1010	1	Västerbotten Mountain (VM)
	D1009	1	
	D1008	1	
	D1000 (district)	-	
D2	D2013	1	Norrbotten Mountain (NM)
	D2020	1	
	D2000 (district)	-	
D3	D3010	1	Forest (F)
	D3000 (district)	-	
D4	D4002	2	Västerbotten Mountain (VM)
	D4001	2	
	D4000 (district)	-	
D5	D5006	4	Västerbotten Mountain (VM)
	D5003	1	
	D5000 (district)	-	
D6	D6005	1	Forest (F)
	D6006	1	
	D6001	2	
	D6000 (district)	-	
D7	D7001*	1	Norrbotten Mountain (NM)
	D7006	2	
	D7003*	1	
	D7004	2	
	D7002	1	
	D7000 (district)	-	
D8	D8001	5	Jämtland (J)
	D8000 (district)	-	

*extra herder for calf carcass weight analyses

Appendix 2b. List of herders were the effect from feeding the subsequent year were analyzed.

Herder	Region	Yearly feeding
A	Forest (F)	since 2007
B	Norrbotten Mountain (NM)	since 2012
C	Västerbotten Mountain (VM)	since 2009
D	Jämtland (J)	only feeding 2015/2016

Appendix 3. Some of the comments from the herders in the questionnaire.

Om man börjar utfodra så måste man nog fortsätta. Men det är olika i Sverige, vi behöver inte utfodra ännu. Vi har fortfarande gamla skogar kvar.

Renen är kort och gott inte gjord för att stå i hägn och utfodras. En hel vinter i hage är för mig en absolut sista utväg. En grupp i området fodrar mycket i hägn. Därifrån har jag sett många effekter som fodringen ger.

Man märker att vintrarna har blivit förändrade bara sedan jag var liten, man är jätte beroende av mera folk för att klara utfodringen hela vintern.

Renarna är fina så länge som dom utfodras. Efter utfodring så lever dom en hårdare vinter än renarna som varit på naturbete. Utfodring av ren verkar vara en kortsiktig lösning. vill man bli kvitt sin renhjord, då ska man helutfodra hjorden.

Kalvarna blir större när vajan har bra med mjölk

Vi har matat som stöd vissa vintrar. En del vintrar har vi haft full utfodring av både hö och foder som börjat tidigt under vintern, ibland har vi valt att börja mata lite senare för att stärka vajorna innan flytten upp till fjälls och kalvningen.

Vi har även använt oss av mineralhinkar som vi satt ut i skogen, något som våra renar uppskattat mycket, helst kalvarna och vajorna som jag ofta sett slicka i mineralhinkarna. Mineralhinkarna köper vi från Granngården och vi använder den som innehåller koppar eftersom att renarna tycker om den.

Jag utfodrar dels för att få bättre slakt och dels för att vajor och kalvar ska få ha lite lugn och ro. Det känns bra att veta att dom inte riskerar att ätas upp av rovdjur eller bli påkörda av lastbilar. Jag upplever mina renar som rätt nöjda över att vara i hage under vinterhalvåret. Dom får liksom lite "semester" och förutom allt detta tycker jag dessutom att det är väldigt roligt att hålla på med renarna.

Bedrev under en tid utfodring i hägn under kalvning och konstaterade att kostnaden aldrig täcks av den förhöjda överlevnaden. Sedan så tittade vi på överlevnad och viktökning i samband med utfodring och kom fram till att det inte skiljde mellan de som fodrats och de som inte fodrats. Så har börjat titta på en återgång till enbart ensilage eftersom det är en naturlig föda för renen.

Jag har märkt att renar som vi utfodrar på hösten för att få ner cesiumhalterna inte lagt på sig lika mycket fett som två senaste höstarna som tidigare år och min teori är att det är för att man tagit bort palmoljan ur fodret. Misstolka mig inte jag tycker inte man ska handla palmolja men det är bara en iakttagelse, kanske man borde leta efter en ingrediens mer lik palmoljan.

Kräver att man utfodrar exakt varje dag, med täta mellanrum. Förändrar själva arbetssättet inom renskötsel. Bunden på ett helt annat sätt. Annan typ av djurhållning idag, mer jordbruk,

på ett negativt sätt. Andra faktorer här i Norrbotten vilka som har renar, inte traditionellt sett att den som har mest renar är den som jobbat mest, utan den som tjänar mest (har ett vanligt jobb på sidan av) som har råd att ha renar, har råd att utfodra sina renar. Man får ju mer renar av foder och bättre kalvöverlevnad, så den som har råd att fodra får automatiskt mer ren. Mer legitimt att helutfodra nu än vad det var förr.

Från våran by, vi har hård press från i synnerhet vindkraft. Många parker överallt. Exploatörer är inne på att vi ska fodra. Att man ska få foder. Foder är lösningen enligt dem. Men renen är inte ägnad åt att fodras, mår bäst på fritt fält. Ser som en fara att använda foder! det är inte lösningen för renskötseln. Farlig väg att gå. En foderhage på 2 km räcker enligt dom. Inget som vår by förordar! Vi tvingas att fodra i kortare perioder och det är bra då, men aldrig under långa perioder. Tror ej på lönsamheten att utfodra långa perioder.

Utfodrar allt kommer inte ge någon ekonomi. Om det blir katastrof kanske man måste, men måste få in renarna innan katastrofen så att de hinner vänja sig vid fodret. Ingen ekonomi i utfodring.

Håller i princip med en äldre renskötare i södra Jämtland att alla borde hålla så lågt renantal så att det inte blir utbetat och därigenom fryser lättare, men i en del fall har kanske föregående generationer haft för mycket renar och betat bort det mesta av laven så att man måste slita med lite lav som fort fryser. Då kanske man måste utfodra tills laven får växa till. Viktigt är nog hur som helst att hålla renantalet på en låg nivå så att det inte blir utbetat och därigenom lättare fryser. Kanske det är bättre att utfodra med lav och lite hö om man måste i stället för pellets.

Renskötsel ska bygga på naturbetande renar där maten är anpassat till årstiden. Utfodring av ren blir en slags farmrenskötsel som inte är bra för renskötseln eller för ekonomin. Ska man utfodra djur så ska man skaffa andra djur än renar att hålla på med. Undantag kan göras för körrenar eller ledarrenar där man önskar andra egenskaper än de som ska finnas hos majoriteten av renarna som hålls för köttproduktion.

En hållbar renskötsel är anpassad till betesresurserna och då behövs ingen utfodring Stödutfodring mer vanlig då markerna krymper och höglänta marker blir kvar

Man skall skilja på utfodring i samband med att betet är låst inom hela samebyn där alternativen inte finns , och en regelmässig utfodring som syftar till att förändra djurets beteende till att mer likna lantbrukets djur som är färdigdomisticerade för det ändamålet.

Renens enda skyddsmekanism är flyktbeteendet bygger man bort den med regelmässig utfodring kommer ett antal andra problem bli synliga som exempelvis mer exponerade för rovdjur m.m.

Upphör rennäringen med det nomadistiska verksamhetsformen kommer försvar av renens betesmarker att än mer ifrågasättas och andra verksamheter som kommer att ha fritt tillträde till de traditionella betesmarkerna.

Man må nyttja den teknik som finns i renskötselarbetet men lämnar man de som av tradition har varit renskötselns signum att renskötaren anpassar sig till renens traditionella betesmönster med olika typer av natur för olika årstider och därmed är nomadiserande , till att få renen att anpassa sig till renskötaren eller att bli mer stationär finns tyvärr för många frågetecken som hopar sig i ett sånt scenario.

Utfodring av kalv är troligen företagsekonomiskt bra.

Ökad överlevnad, lättare tillvänjning nästa år, högre vikter är exempel på positiva saker.

Mera jobb för renskötarna. Pellets orsakar ibland diarré och förstoppning hos vissa renar. Ej naturligt bete.

Stödutfodring har kommit för att stanna.

Stödutfodring med hö borde upphöra. Förstör renbetesland och skräpar ned.

Ser en stadig trend av utfodring, ser ett behov av att lära sig mer av utfodring, lära sig olika tekniker. För att förstå skillnader mellan ensilage t.ex. Angående torrfoder, skulle vilja ha en dialog med fodertillverkare. Vill ha mer kunskap om foder för att undvika sjukdomar.

Få ut forskningen som har gjorts. Det funkar inte nå mer med dagens skogsbruk för renbetet i skogslandet tar bara slut. Det är bara att beklaga. Jag kan inte rekommendera min son att fortsätta med renskötsel. Det är tråkigt.

Utfodringen håller på att knäcka renskötseln på grund av att det är så kostsamt, men vad ska man göra? Renägaren gör allt för att renen ska leva.

Staten borde upprätta en klimatfond för renskötseln så kostnaderna för fodring täcks. Klimatförändringen och bristen på betesland har vi inte bidragit till i någon större grad och det borde kompenseras. Om det här är framtiden så kommer många att slås ut pga höga foderkostnader. Inte hållbart och en fråga "våra" sk politiker ska prioritera!

Det positiva kommer med vårsolen. Man har klarat av vintern. Inför kommande vinter börjar man fundera hur mycket pellets som ska köpas in, hur många balar ensilage som ska köpas. Hur ska man planera för fodring kommande vinter?

Renskötsel är en ekonomisk katastrof.

Ekonomin styr hela renskötseln idag, som ej förr.

Tiden sätter stopp för "gammaldags" renskötsel, utfodring tar all tid.

Kroppsligt och psykiskt påfrestande idag.

Renskötare gör vad vi kan för att renarna ska överleva.

Problemet är att få beslutsfattande organ att förstå situationen för rennäringen!

På längre sikt kommer renskötseln att förändras av utfodringen. Dels renarna men framförallt renskötarna och deras kunskap kommer att gå förlorad.

Merarbete, arbetsmiljön blir sämre med tunga lyft, ekonomiskt, socialt, en annan typ av renskötsel som inte bygger på fritt bete

Kan i en långvarig utfodring förändra renens betesmönster så att renen vänjer sig vid utfodring som innebär att renen som djur inte längre betar på samma sätt som tidigare dvs att den inte lägger på hull under den tid som renen traditionellt gör det.

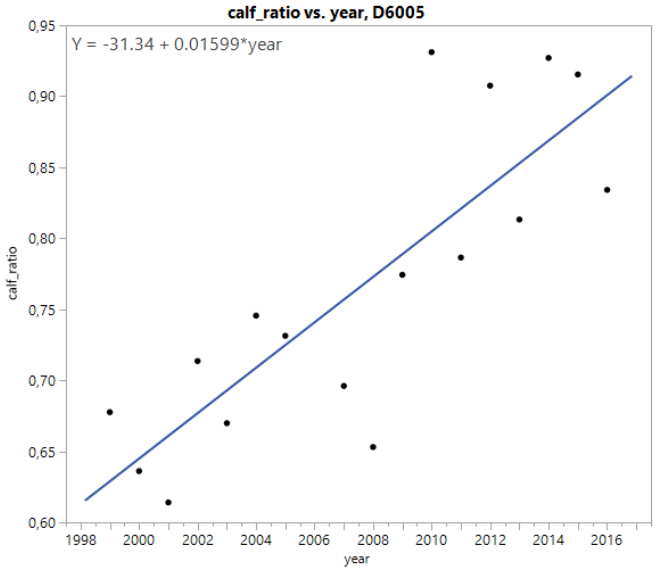
Allt förändras. Det är ju en helt annan metod än naturbetande renar.

Stödutfodring i yttersta nödfall.

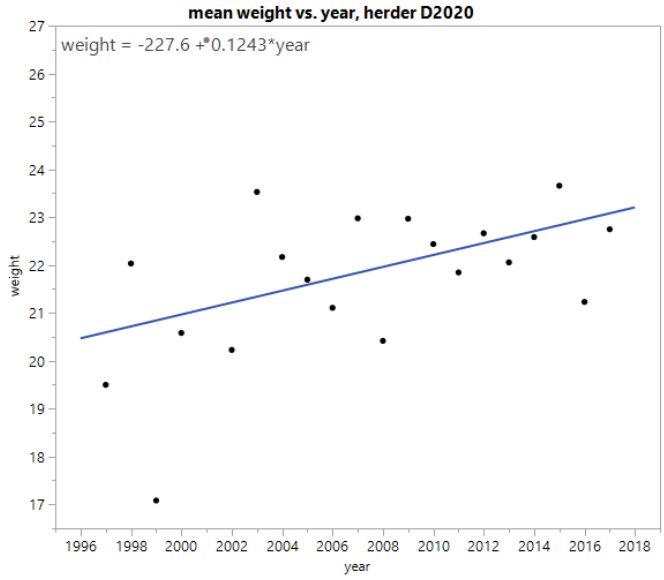
Har bara positiv bild av trots merjobbet. Men kommentarerna att vi behövde mindre mark och att vi alltid skulle utfodra var jobbigt att höra.

En hållbar renskötsel är anpassad till betesresurserna och då behövs ingen utfodring.

Appendix 4a. Positive linear trend of calf ratio for herder D6005, feeding level 1, 1999-2016 (P<.0001).



Appendix 4b. Positive linear trend of mean calf carcass weight for herder D2020, feeding level 1, 1997-2017 (P<.0001).



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