Genetic improvement of meat production in reindeer

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ABSTRACT: Genetic variation in meat production was studied from the Kutuharju (Finland) experimental reindeer data. Calf autumn weight and growth had direct (maternal) heritability 0.17 (0.06, ns) and 0.24 (0.18), respectively. The direct-maternal genetic correlation in growth was strongly negative (-0.73). The further analysis did not support it being due to the environmental correlation between the effects. Hence, dam quality has to be included in selection criteria. Dams' lifetime production was expressed as cumulative calf production at the age of seven years. The trait was found to be heritable with estimates from 0.22 to 0.30 across analyses. Females' own calf weight and early calf production are favorably correlated with her lifetime production and therefore could be used as indicator traits for productivity. As an overall conclusion, the favorable correlations indicate that autumn weight is a good selection criterion for meat production per calf or dam in reindeer husbandry.
Keywords: reindeer; genetics; selection; growth; lifetime production

Introduction

Reindeer live in an extensive pastoral system and convert natural pastures to meat and other products. Reindeer are semi-domesticated and roam free in the environment for most of the year, being exposed to harsh natural conditions. In winters most of the animals are supplementally fed. Reindeer are gathered in autumn roundups. Most of the meat produced originates from calves born in spring and slaughtered in autumn; the best calves are left for breeding purposes.

In reindeer-herding, information on animal identity, records or pedigree is very rare. The current selection by herders is based on the phenotypes (mass selection) of half-year-old calves using calf autumn weight as the main criterion. In addition, the herders pay attention to the dam properties that affect calf growth and survival (Muuttoranta and Mäki-Tanila, (2011)). The main selection criteria are similar throughout the reindeer-herding area and related to meat production, dam properties and calf survival (Muuttoranta and Mäki-Tanila (2011; 2012)).

The meat production efficiency depends on the number and weight of calves. Dam quality can be expressed as her reproductive performance which includes number and weight of calves produced.

The studies related to the genetic variation in the meat production related traits in reindeer are rare (Varo (1972); Rönnegård and Danell (2003)). However, the information on genetic variation and correlations between the traits is needed for understanding the possibilities for selection and designing a selection scheme and choosing the selection criteria. The present article is giving an overview of the current information on the genetic variation in the traits related to meat production and of the analyzed data and methodology used for estimating the variance components of the traits.

Materials and Methods

Kutuharju data. The Reindeer Herders' Association owns and maintains the Kutuharju experimental reindeer herd which is situated in Inari, Finland (61°10´N). The Game and Fisheries Research Finland maintains the unique, very detailed data including records and pedigree information. Paternities have been confirmed with DNA markers at the Norwegian School of Veterinary Science since 1997 (Røed et al. (2002)).

The dam properties are measured in this study as cumulative weaning weight of her calves over time (here 7 years, WW7, Martinez et al. (2004)). The calf traits studied were birth weight (BW), weight in the first autumn (AW1) and growth measured as pre-weaning average daily gain (ADG).

The Kutuharju data, covering the years 1987-2011, includes 984 calves with known pedigree and records on BW, AW1 and ADG. The annual number of calves ranges from 6 to 76 with number of sires varying from 1 to 15. The variable ADG (in grams) was determined by calculating (AW1-BW) / age at weighing in days. For WW7 there were 1165 females of which 600 were aged >1 year. Her calves' AW1 values were summed up over seven years (similar to Martinez et al. (2004)). In WW7 the calves' birth year and sex were corrected. Voluntary culling and involuntary mortality were not separated due to insufficient data on mortality causes.

Maternal effects in the traits. Maternal effects are typically important for birth traits and early calf growth. In cattle and sheep, the direct-maternal genetic correlation (r_{am}) is often strongly negative. One explanation for the negative estimates is an ignored correlation between the residuals of direct and maternal effects (Koerhuis & Thompson (1997); Bijma (2006); Eaglen and Bijma (2009)). Hence, a special attention was given to finding out various correlations.

Statistical analyses. The models for BW, AW1 and ADG included birth year, sex, dam parity and sire age. In WW7, only birth year was included in the model. Animal models were set to each trait. The random effects for BW, AW1 and ADG were 1) additive (direct) genetic effect of the calf, 2) direct and maternal (dam) additive genetic effects and 3) direct and maternal additive genetic effects

and maternal permanent effect (dam). In addition, a sire-maternal grandsire (S-MGS) model was used to test the existence of correlation between residuals of direct and maternal effects in growth traits (Eaglen and Bijma (2009)). For WW7 the model 1 was used. With conversion allowing for the limited amount of data, a two-trait analysis (including maternal effects) was used to estimate heritability and genetic correlations. (Co)variance components were obtained with statistical software AS-Reml 3.0 (Gilmour et al. (2009)).

Results and Discussion

Genetic variability in the traits. The total heritability (T^2) indicating the variance available for selection was computed from the variance of the sum of direct and maternal effects (cf. Bijma (2006)). The T^2 estimate (Table 1) in ADG was similar to the one for autumn weight estimated by Rönnegård and Danell (2003) but smaller than Varo's (1972) estimates obtained from small data. The T^2 of birth weight (0.61) was larger than in red deer (0.14 – 0.46) (McManus (1993); Clements et al. (2011)). In farmed red deer, the weaning weight h^2 values obtained among various farmed populations were mostly larger varying from 0.36 to 0.89 (McManus (1993)).

Table 1. Genetic parameters* for birth weight (BW), autumn weight (AW1) and average daily gain before weaning (ADG) of reindeer calves.

Trait	T^2	h^2_d	h^2_m	r_{am}
BW	0.61	0.23 (0.08)	0.24 (0.06)	ns
AW1	0.57	0.17 (0.12)	0.06 (0.07)	ns
ADG	0.20	0.24 (0.09)	0.18 (0.06)	-0.73 (0.17)

* T^2 = total heritability, h^2_d = direct heritability, h^2_m = maternal heritability, r_{am} = direct-maternal genetic correlation. Standard errors are given in parentheses.

The evolvability (CV_A) is expressed as the available total additive genetic variation in relation to the mean (Houle (1992); Bijma (2006)) and it quantifies the potential change by selection. The CV_A varies from 5% to 10% for AW1, ADG and BW and 87% for WW7. Results suggest that there is potential for selection in all the traits. Excluding the non-producing females from the analysis of WW7 would perhaps decrease the CV_A value.

The direct and maternal heritability values show a significant maternal heritable effect in BW and in ADG (Table 1). The genetic and phenotypic correlations (standard errors in brackets) between AW1 and ADG are 0.35(0.24) and 0.61(0.03), respectively. In ordinary reindeer herds there are no records on birth date and birth weight to have accurate measures on ADG.

The heritabilities in WW7 ranged from 0.22 to 0.30 in the bivariate analyses carried out together with dams' own AW1 and with ADG and AW1 of her first calf. Hence, dam properties can be improved with selection.

Correlations. Strongly negative direct-maternal genetic correlation is common in livestock (Bijma (2006)) and in ADG it was -0.73 ($\pm$0.17). As suggested by Eaglen and Bijma (2009), we included S-MGS model in the study and it resulted in similar variance component estimates (results not shown). Hence, the ignored correlation between residuals of direct and maternal effects does not explain the strongly negative estimate. Negative correlation indicates decrease in maternal ability if selection is only for growth traits. Maternal ability needs to be included in selection criteria (Holand (2007)) and the herders are paying attention to dam properties in the empirical selection (Muuttoranta and Mäki-Tanila (2011; 2012)).

The genetic correlation between dam's autumn weight when she was a calf (DAW1) and her lifetime production traits was 0.63 (Fig. 1). High genetic correlation implies genetic gain in dam's lifetime production when selecting for calf autumn weight (Fig. 1).

Improvement of selection efficiency. In practice, calf's autumn weight is a very sound selection criterion. In the hectic round-ups, calf size is fairly easy to measure. It is even possible to compare the size of contemporary animals that have shared similar environment. In reindeer, calf autumn weight varies between years; therefore the contemporary comparison is vital. Moreover, when using calf autumn weight in selection, no information on birth weight or date is needed. Even in this trait, the selection efficiency could be improved with recording the weights objectively, using scales instead of eye-balling the animals.

Identity information is needed for efficient selection. In ordinary reindeer herds, about half of the breeding animals have individual ear tags (Muuttoranta and Mäki-Tanila (2011)), which is a promising starting point for recording and book keeping. Creating a simple system for these might encourage the herders to adopt individual weight recording.

Information on relatives would improve the selection accuracy. The information could be obtained in freely mating reindeer using DNA-samples. After the large data is collected, large-scale genome based pedigrees could be introduced in reindeer husbandry. The large data would also facilitate studying the genetic variation in calf survival and meat quality traits.

Conclusion

Results suggest that there is genetic potential in the traits affecting meat production efficiency. In practice, calf's autumn weight is a satisfactory selection criterion. It is easy to measure and favorably correlated with pre-weaning growth and dams' lifetime production. However, due to highly negative direct-maternal correlation in growth, also dam properties have to be taken into account in selection. Heavy calves from females with good maternal properties are the best breeding animals in reindeer herd.

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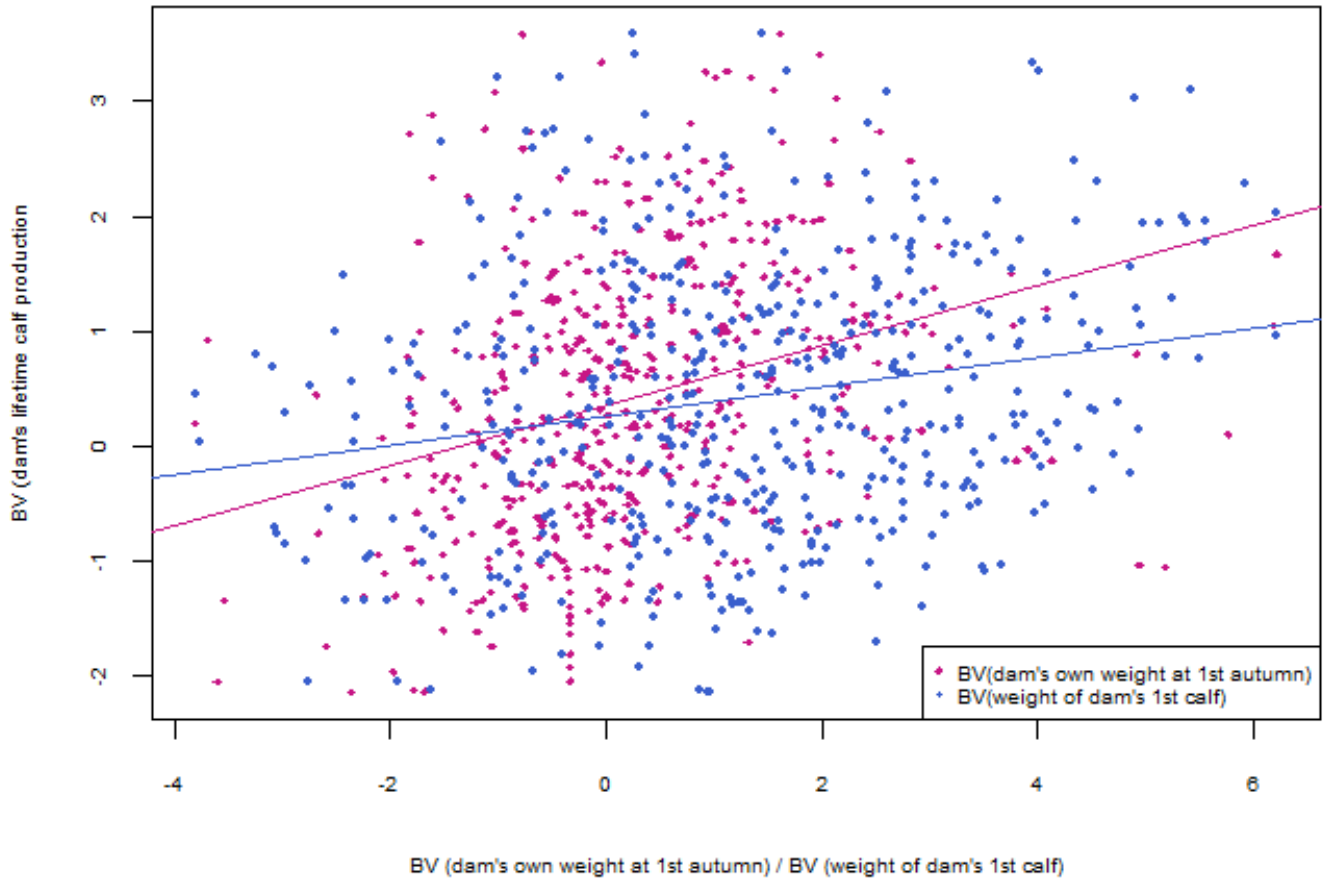

Figure 1. The breeding values of dam's lifetime production versus her own weight at 1st autumn and her 1st calf's weight at autumn. The values are standardized by mean and standard deviation.