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Calving traits in Norwegian Red x Beef crosses: First genetic analysis

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Introduction

The global dairy industry has undergone a major shift in breeding strategies over the past decade. The strategic utilization of beef cattle genetics in dairy herds, frequently called the "beef-on-dairy" (BoD) approach, has seen a remarkable surge in adoption both internationally (Berry, 2021) and nationally in Norway. This has primarily been driven by the economic incentive to increase the value of surplus calves not needed for dairy herd replacements (Berry *et al*., 2019). Improvements in dairy cow fertility and reproductive performance have reduced replacement requirements, a trend further accelerated by the widespread use of sex-sorted semen (Berry, 2021; Hockett, 2024). A technology that enables the production of sufficiently high-quality dairy replacements from a smaller, genetically superior subset of cows, leaving a substantial proportion of the herd available for mating with beef sires (Berry, 2021; Hockett, 2024). Consequently, a large proportion of the cow population, often those with lower genetic value, is available to be mated with beef sires to produce crossbred calves. While a vast body of international research in this field has focused on Holstein populations, the main dairy breed in Norway is Norwegian Red (NRF). A breed characterized by decades of selection for a balanced breeding goal, that in addition to milk production emphasizes fertility, health, and moderate body size. Consequently, the phenotypic expression of calving traits in NRF x beef crosses may differ from the results observed in Holstein-based systems. While BoD aims to improve the carcass merit, it entails risk to the dam. Calving traits, including stillbirths, calving ease, and calf size, represent key biological constraints, directly influencing dam welfare and calf survival (Tsiligianni *et al*., 2024; Eriksson *et al*., 2020). Difficult calvings are not only an animal welfare concern, but this can also result in loss of the calf and, for the cow, lead to reduced milk production in the subsequent lactation, increased veterinary costs, and higher culling rates (Ahmed *et al*., 2024; Fouz *et al*., 2013). Therefore, identifying sires that produce moderately sized, easily born calves is essential for maintaining biological and economic efficiency in dairy systems (Berry and McCarthy, 2025).
The aim of this study was to estimate genetic parameters for calving traits, including stillbirth, calving ease, calf size, and gestation length, in purebred and crossbred Norwegian Red calves, to provide insight that could support selection strategies aimed at improving calf survival, calving ease, and overall herd productivity.

Materials & Methods

This study was based on calving data from the Norwegian Dairy Herd Recording System between 2016 to 2024. The final dataset included a total of 44,365 crossbred calves from 594 Aberdeen Angus, 328 Charolais, and 321 Limousin sires. More specifically, 23,468 Aberdeen Angus, 11,871 Charolais and 9,026 Limousin crossbred calves. An additional 205,486 purebred NRF calves sired by 3,058 NRF sires from the same 2,702 herds were included. The

data was restricted to herds with a minimum of 5 crossbred calves in the given year. The sire had to have sired at least 50 calves to be included. The pedigree file used for the genetic analysis contained a total of 601,869 animals.
Four calving traits were analyzed: stillbirth, calving ease, calf size, and gestation length. Stillbirths are defined as calves that are dead at birth or within 24 hours. Table 1 summarizes the number of recorded stillbirths by calf sire breed, ranging from 3.3% to 4.5%.

Table 1. The total number and the proportion of stillbirths within each sire breed; Norwegian Red (NRF), Charolais, Aberdeen Angus and Limousin, all with NRF dams.

Sire breed	NRF	Charolais	Aberdeen Angus	Limousin
Stillbirths	7475 (3.6%)	540 (4.5%)	1064 (4.5%)	301 (3.3%)

The trait calving ease is evaluated on a three-point scale, where 1 is no difficulty, 2 is moderate, and 3 is severe difficulty, while calf size is evaluated as small, medium, or large. Calving ease and calf size were recorded at calving, and the distribution of records over categories are summarized in Table 2.

Table 2. Distribution of records in each category[1] of calf size and calving ease in total for purebred Norwegian Red and crossbred calves included in the data analysis.

Size\Calving ease	1	2	3	Total
1	26,456 (10.6%)	1,211 (0.5%)	506 (0.2%)	28,173 (11%)
2	171,611 (68.7%)	6,544 (2.6%)	2,326 (0.9%)	180,481 (72%)
3	34,131 (13.6%)	4,736 (1.9%)	2.330 (0.9%)	41,197 (17%)
Total	232,198 (93%)	12,491 (5%)	5,162 (2%)	249,851

[1] Calf size: 1=small, 2=medium, 3=large. Calving ease: 1=no difficulty, 2=moderate 3=severe difficult

Gestation length was calculated as the number of days between the successful insemination or mating date and the calving date, Figure 1 visualizes the distribution by sire breed.

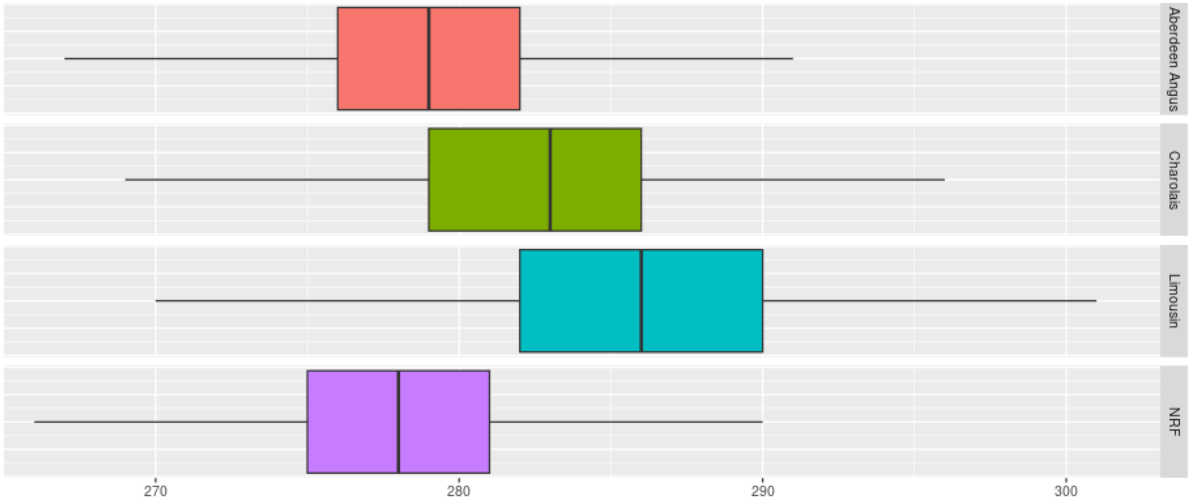

Figure 1. Boxplot showing the distribution of phenotypic gestation length for Norwegian Red (NRF) dams inseminated or mated with NRF, Charolais, Aberdeen Angus, or Limousin bulls. The boxplot display the median (line), the interquartile range (box), and the range of non-outlier values (whiskers).

The variance components were estimated with linear single-trait animal models in the DMU software package (Madsen and Jensen, 2008). The statistical models accounted for fixed effects of sire breed, twinning, calf sex, month of birth, and contemporary group (herd-year). Additionally, the model included a fixed regression on the age of the dam within each calf sex by sire breed combination to account for the physical maturity of the cow. Variance components and heritabilities were estimated to determine the proportion of phenotypic variation attributable to additive genetic effects.

Results

The genetic analysis uncovered genetic variation in all calving-related traits. Table 3 summarizes the estimated variances together with heritabilities for calf size, calving ease, gestation length, and stillbirths. These parameters provide insight into the relative contributions of genetic and environmental factors to the observed variation.
Calving ease exhibited a relatively low heritability of 0.13 ± 0.007, indicating that environmental influences contribute more to variation in calving difficulty and the trait having little variation with 93% experiencing no calving difficulty, as shown in table 2. Calf size showed a higher heritability of 0.34 ± 0.007. The highest heritability was observed for gestation length (0.65 ± 0.006), highlighting a strong genetic contribution. Stillbirth showed very low heritability (0.0013 ± 0.00023).

Table 3. Estimated additive genetic (σ_a^2) and phenotypic (σ_P^2) variance with standard error in parentheses and the corresponding heritabilities (h^2) for the traits, calf size, calving ease, gestation length, and stillbirth.

	σ_a^2	σ_P^2	h^2
Calf size	0.087 (0.002)	0.26 (0.001)	0.34 (0.007)
Calving ease	0.015 (0.0009)	0.12 (0.001)	0.13 (0.007)
Gestation length	17.7 (0.237)	27.1 (0.278)	0.65 (0.006)
Stillbirth	$3.98x10^{-4}(7.04x10^{-5})$	$0.03\ (8.3x10^{-5})$	0.0013 (0.00023)

Breed differences were observed for both gestation length and calf size. The largest difference was observed between NRF and Limousin sires, with Limousin x NRF calves having approximately five days longer gestation on average than NRF calves. Aberdeen Angus sired calves were expected to have shorter gestations than Charolais and Limousin calves, but longer than purebred NRF calves.

Discussion

The findings in this study highlights the genetic variation available for selection and demonstrates how sire breed choice can influence calving outcomes in a BoD system utilizing NRF dams.
The genetic analysis revealed that gestation length is highly heritable in this population (h^2 = 0.65), which is at the higher end of the range reported for international cattle populations, where estimates typically vary between 0.42 and 0.57 (Splittorff *et al*., 2023; Hansen *et al*., 2004).
In contrast, stillbirth exhibits heritability close to 0 (h^2=0.0013), lower than estimates from Danish Holstein (h^2=0.10) (Hansen *et al*., 2004). The overall stillbirth rates for NRF x Beef crosses (3.3% to 4.5%) were similar to purebred NRF (3.6%).

Calving ease showed a heritability of 0.13, which is consistent with other populations (Hansen *et al.,* 2004). The high percentage of unassisted births (93%) in this study likely reflects the decades of selection in NRF for a balanced breeding goal emphasizing health and functional traits alongside milk production.

Clear breed differences were observed, particularly the trade-off between growth potential and calving ease. Limousin-sired calves had the longest average gestation – approximately five days longer than purebred NRF. This aligns with international data where Limousin and other "heavy" breeds (Charolais, Simmental) are consistently associated with longer gestations and a higher risk of dystocia compared to other breeds like Aberdeen Angus (Ahmed *et al*., 2024; Fouz *et al*., 2013). In the NRF population, Angus-sired calves were found to have shorter gestations than Charolais and Limousin.

The moderate heritability for calf size (h^2=0.34) suggests that producers can effectively use sire selection to control birth weights. Larger calves are a primary driver of dystocia, which in turn leads to significant economic penalties like increased veterinary costs (Ahmed *et al*., 2024; Fouz *et al*., 2013; Tsiliganni *et al*., 2024)

Conclusions

In conclusion, this study demonstrates that sire selection is a powerful tool for optimizing calving outcomes in NRF x Beef crosses. The high heritability for gestation length and moderate heritability for calf size indicate that these traits are useful targets for breeding decisions, including mating plans and herd management. Future strategies should integrate these calving traits with carcass performance data to develop a comprehensive selection index that supports both economic viability and animal welfare.

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