

Impact of Including Calf Gender in Models to Predict Breeding Values for Lactation Yields in Dairy Cattle

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Summary and Implications

Foetal calves produce sex hormones that can enter the maternal bloodstream. Male calves typically have longer gestations than female calves resulting in shorter lactations in pastoral production systems. Both of these phenomena could influence milk yields of the dam. North American and French studies have reported conflicting results as to the size of calf gender effects on milk yield. This study used a dataset from New Zealand dairy cattle to fit calf gender effects and quantify the impact of including calf gender when estimating breeding values. The regressions of lactation yield on days in milk were different for second parity cows according to whether the cows had produced male or female calves. The gender of a cow's second calf had an effect on second lactation milk yield in Holstein Friesians. There was minimal re-ranking of animals when calf gender was included in the model used for breeding value estimation and the expected genetic gain was similar with and without calf gender included in the analytical model.

Introduction

Foetal calves produce sex hormones that can enter the maternal bloodstream which could influence lactogenesis and influence milk production in the resulting lactation. Cows become pregnant around peak lactation and the sex of the developing foetal calf could influence the lactation currently in progress. Male calves have typically two days longer gestation than female calves which can shorten lactation length. Collectively, these phenomena could result in successive calf genders influencing lactation yields. Recent studies on North American cattle have reported that dams that gave birth to female calves had higher milk yields in the immediate and subsequent lactations than dams that produced male calves. In contrast, a study of two French cattle breeds found small increases in milk yields of cows that produced male calves but concluded the effects were too small to influence whole lactation profit. The aim of this study was to estimate these effects in two NZ breeds and quantify the impact of fitting calf gender in the model used to estimate breeding values.

Materials and Methods

Estimates of total lactation milk yield records were obtained from Livestock Improvement Corporation for New

Zealand Holstein Friesian and Jersey cows that calved between July and October of 1995 to 2005. Data was edited to exclude lactations for cows with multiple births, those with calving difficulties, or still births.

Lactation Length Model

A repeatability model fitting lactation length from any of the first 3 lactations was separately fitted in ASReml to records from 67,403 Holstein Friesian or 58,318 Jersey cows, with calf gender and herd-year combination fit as fixed effects. Significance of calf gender effects on lactation length was determined by t-test with $\alpha=0.05$.

Milk Yield Models

Milk yield breeding values were estimated for Holstein Friesians including 274,401 first lactations, 117,233 second lactations and 12,347 third lactations or for Jerseys including 85,774 first lactations, 84,960 second and 4,197 third lactations. Models were run separately for each lactation and breed. Breeding values were estimated using an animal model with lactation length as a covariate and herd-year as a fixed class effect. A subsequent model was fitted to the same data including effects for successive calf gender combinations and gender-specific regressions on days in milk to account for differences in lactation length. Calf gender combinations were fitted for the first 3 parities for lactations 1 and 2, and for parities 2-4 for lactation 3. The calf gender combinations included all $3^2=8$ sequences of male and female calves such as three successive females (FFF) or three successive males (MMM).

The male and female regressions of milk yield on lactation length were tested for significance using a t-test. LS means were calculated by ASReml and linear contrasts constructed to estimate main effects of calf gender in each parity. Significance was determined by t-tests with $\alpha=0.05$ in each test. Spearman rank correlations were calculated separately for males and females between the breeding values from the two models. The top 100 females and 30 males were compared between the two models to assess the extent to which including calf gender affects rankings of elite animals.

Results and Discussion

Effect of Calf Gender on Lactation Length

The mean lactation lengths for lactations 1-3 were 235.0 ± 0.1 , 230.3 ± 0.1 and 232.5 ± 0.5 days for Holstein Friesian cows and 234.8 ± 0.2 , 231.7 ± 0.2 and 232.3 ± 0.4 days for Jersey cows. Depending upon breed and lactation, the birth of female calves resulted in lactations from 1.1 ± 0.1 to 3.2 ± 0.7 days longer than if the calf were male, with all estimates significantly different from zero. These estimates

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are consistent with the gestation length of male calves being approximately 2 days longer than that of female calves.

Effect of Gender-Specific Lactation Length on Milk Yield

The mean whole lactation milk yields for the first 3 lactations were 3,533±2, 4,170±3 and 4,814±10 L for Holstein Friesian cows and 2,594±2, 2,929±2 and 3,316±12 L for Jersey cows. When a gender-specific regression of lactation length was fit, the effect of an additional day of lactation was higher when a male calf was born compared to when a female calf was born, but this was only significant in second lactation cows despite the estimate for lactation 3 being twice as large as the estimate for lactation 2 in both breeds (Table 1). The lack of a significant difference could be due to low numbers of animals, particularly for lactation 3. The presence of a gender-specific lactation length effect could be indicative of a difference in the shape of lactation curves for cows that produced male vs female calves.

Effect of Calf Gender Combination on Milk Yield

Holstein Friesian dams with female calves born at the beginning of their second parity had 62 ± 22 L higher milk yield than if they had produced male calves. No other main effect of calf gender was significant for any breed or lactation. There were some significant interactions between calf gender across parities on milk yield, however there was no obvious pattern to these interactions beyond what was found from the main effects (Table 2).

Impact of Calf Gender on Breeding Values

The rank correlations between breeding values in the models that included or ignored calf gender were 1.00 for both bulls and cows in all lactations and both breeds. The mean breeding value of the top 30 sires and 100 dams did not change when calf gender information was included in the model for estimating breeding values. However, there was slight re-ranking of animals within the top 30 sires and top 100 dams between the two models. The two males that dropped out of the top 30 for lactation 3 in Jerseys had previously been ranked 28th and 30th, and moved to 34th and 31st, respectively. At least one female was dropped out of the top 100 in each lactation and each breed except first lactation Holstein Friesians. The largest drop among the top 100 dams when calf gender was added to the model, was an individual who was ranked 85th and moved to 104th. This individual was also the highest-ranked dam to drop from the top 100 dams.

This study concludes that in NZ, cows with female calves in their second lactation produce more milk during their second lactation than those with male calves, even after adjusting for lactation length, but inclusion of this effect in breeding value estimation is unlikely to change response to selection.

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Table 1. Regression Coefficients for Lactation Yield on Days in Milk.

Breed	Lactation Number	Females (L/Day)	Males (L/Day)	Males - Females (L/Day)
Holstein Friesian	1	13.50 (0.05)	13.51 (0.05)	0.01 (0.05)
	2	14.72 (0.10)	14.99 (0.09)	0.27 (0.10)*
	3	15.18 (0.33)	15.75 (0.30)	0.57 (0.33)
Jersey	1	9.40 (0.07)	9.46 (0.06)	0.06 (0.07)
	2	9.77 (0.08)	9.92 (0.07)	0.15 (0.08)*
	3	10.91 (0.40)	10.58 (0.36)	0.33 (0.40)

* Regression coefficients for males and females are significantly different.

Table 2. Effect of Calf Sex on Milk Yield by Breed and Lactation.

Breed	Lactation Number	FFF (L)	FFM (L)	FMF (L)	FMM (L)	MFF (L)	MFM (L)	MMF (L)	MMM (L)
Holstein Friesian	1	3,403 (9)	3,399 (9)	3,399 (9)	3,406 (9)	3,395 (9)	3,400 (9)	3,399 (9)	3,395 (9)
	2	4,112 (15)	4,107 (15)	4,037 (15)	4,039 (15)	4,103 (15)	4,102 (15)	4,040 (15)	4,041 (15)
	3*	4,870 (48)	4,872 (48)	4,793 (47)	4,742 (47)	4,909 (48)	4,894 (48)	4,751 (47)	4,754 (47)
Jersey	1	2,495 (12)	2,498 (12)	2,491 (12)	2,494 (12)	2,487 (12)	2,482 (12)	2,482 (12)	2,488 (11)
	2	2,869 (13)	2,867 (13)	2,836 (13)	2,840 (13)	2,865 (13)	2,866 (13)	2,841 (13)	2,838 (13)
	3*	3,273 (61)	3,315 (61)	3,370 (60)	3,385 (59)	3,289 (61)	3,247 (60)	3,354 (59)	3,360 (59)

* Note: calf gender combination for lactation 3 represents parities 2-4 rather than 1-3.