

Genetic Evaluation of Female Fertility in Canadian Dairy Breeds

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Introduction

In many countries, the breeding goal has shifted to include high production, longevity and functional traits that reduce the costs of production. Among such functional traits many countries include at least one measure of daughter fertility since poor reproductive performance has a significant economic impact at the farm level.

In Canada, a national database for processing and storing all breeding data recorded for dairy cattle was developed by Canadian Dairy Network (CDN). More recently, a collaborative research effort was initiated involving CDN and the Centre for Genetic Improvement of Livestock (CGIL) at the University of Guelph. The ultimate goal of this research is the development of a comprehensive multiple-trait genetic evaluation system including all aspects of female reproductive performance. The current vision for this system includes the following traits but the final system may be reduced once genetic correlations across traits are estimated.

For virgin heifers:

- Age at first service (AFS)
- 56-day non-return rate (NRRh)
- Number of inseminations
- Interval from first service to conception
- Gestation length
- Calving ease at first calving
- Stillbirth rate at first calving
- Calf size

For cows within each lactation:

- Interval from calving to first service (CTFS)
- 56-day non-return rate (NRRc)
- Number of inseminations
- Interval from first service to conception
- Days open
- Gestation length
- Calving ease
- Stillbirth rate
- Calf size

Due to the complexity of the proposed genetic evaluation system for reproductive performance, a 4-trait system has been developed, for official introduction starting August 2004, including Age at First Service (AFS), 56-day NRR in Heifers (NRRh) and in cows (NRRc), as well as interval from Calving to First Service (CTFS).

Data and Methods

All inseminations since 1998 for animals recorded in their respective breed association herdbook have been accumulated at CDN. Table 1 shows the distribution of the breeding records by breed with Holsteins representing 94%. In total, two-thirds of the data represents technician inseminations provided by the A.I. organizations and the other one-third is data collected by milk recording personnel as provided by the producer.

Table 1. Distribution of breeding data by breed.

Breed	Records	Percentage
Holstein	7,525,833	94.00%
Ayrshire	268,107	3.35%
Jersey	149,533	1.87%
Brown Swiss	38,139	0.48%
Guernsey	14,970	0.19%
Canadienne	5,991	0.07%
Milking Shorthorn	3,700	0.05%
TOTAL	8,006,273	100.0%

The developed genetic evaluation system uses information related only to the first insemination for each heifer and within each lactation for cows. To avoid selection bias, animals included for genetic evaluation had to have information known either as a heifer or in first lactation. AFS is the difference between date of first insemination and date of birth, expressed in days, and is an interval trait similar to CTFS for cows, which is the difference between date of first service and the previous calving date, also expressed in days. 56-day NRR is a commonly used measure of success for female fertility and has an advantage of being known for all animals early in the reproductive cycle rather than waiting for a subsequent calving to confirm conception (Thaller, 1997; de Jong, 1997). Using a multiple-trait model that includes the more heritable interval traits of AFS and CTFS increases the accuracy of the genetic evaluations for NRRh and NRRc, which are the main fertility traits of interest.

Each of the four traits included were analyzed using their specific model as outlined in Table 2. All traits included the fixed effect of season of birth within year and region (RYS) as well as random effects of herd within RYS and additive genetic. While these were the only effects for AFS, CTFS also included a fixed effect of age by month of calving within parity, for the calving associated with the start of the interval, as well as a random permanent environmental effect for repeated records across lactations. For NRR, the fixed effect of month of first insemination used for NRRh was modified to be the age at the previous calving by month of first insemination within parity for NRRc. Both NRRh and NRRc also had a fixed effect of the A.I. technician by year of first insemination and

a random effect of service sire, without genetic relationships, by year of first insemination. Since repeated records across lactations were also included for NRRc, the model included a random permanent environmental effect.

Table 2. Model summary for multiple-trait genetic evaluation of AFS, NRRh, CTFS and NRRc.

Effect	Status	Heifers		Cows	
		AFS (days)	NRRh (0/1)	CTFS (days)	NRRc (0/1)
Region-Year, Season of birth (RYS)	Fixed	x	x	x	x
Herd within RYS (RYS:H)	Random	x	x	x	x
Additive genetic	Random	x	x	x	x
Month of first insemination	Fixed		x		
Age by month of previous calving within parity	Fixed			x	
Age at previous calving by month of first insemination within parity	Fixed				x
A.I. technician by year of first insemination	Fixed		x		x
Service sire by year of first insemination (SS:YFI)	Random		x		x
Permanent environment	Random			x	x

Genetic evaluations were computed using PEST (Groeneveld *et al.*, 1990) with initial variance components estimated by Muir (2004) using VCE-5 (Kovac, 2002). Heritability estimates of .185 for AFS, .103 for CTFS, .030 for NRRh and .037 for NRRc (Muir, 2004) were used to compute sire EBVs in pilot runs. Prior to official implementation, new variance components will be estimated using VCE-5 based on a portion of the final genetic evaluation data set.

Results and Discussion

Over 2 million first inseminations were eligible for use in 4-trait genetic evaluation for female fertility, of which 31.7% was on heifers. Since the data period only currently covers six years and records for later parities were included only if a heifer or first lactation records was available, it is expected that the percentage of cow data will gradually increase over time.

In addition to the record counts usable for genetic evaluation in the five main dairy breeds, Table 3 presents the breed averages for each of the four traits analyzed. Of particular interest is the variability across breeds for AFS with Jerseys at 475 days and Ayrshires at 516 days, as well as the differences between the average NRR for heifers and cows across breeds. While the Jersey breed has the highest overall 56-day NRR at 71%, the average NRR in heifers is almost identical for Holsteins, Jerseys and Brown Swiss at 75-76%. The lower cow NRR in the Holstein, Ayrshire and Guernsey breeds results in the lowest overall NRR, especially for the latter two breeds.

Table 3. Breed averages based on data qualifying for genetic evaluation for female fertility.

	Holstein	Ayrshire	Jersey	Brown Swiss	Guernsey
AFS (days)	500	516	475	511	504
CTFS (days)	90	88	92	93	93
NRRh (%)	76%	68%	76%	75%	68%
NRRc (%)	61%	59%	68%	66%	60%
Overall NRR (%)	66%	61%	71%	69%	63%
No. Records	1,921,992	60,405	35,897	7,798	3,267

Given the current availability of bull ratings for 56-day NRR, which is computed using a non-genetic linear model (Van Doormaal, 1993) applied to first inseminations conducted by A.I. technicians during the most recent 12-month period, it was decided to publish an aggregate value of the four new female fertility traits rather than each EBV individually. To avoid confusion amongst dairy producers, the existing bull rating will be termed “Semen Fertility” and “Daughter Fertility” will be the new genetic evaluation. The main goal of the 4-trait genetic evaluation system is to take advantage of the higher heritabilities for the interval traits, namely AFS and CTFS, as well as the genetic correlations amongst the four traits to optimize genetic selection for daughter fertility in conjunction with other traits of economic importance.

Phenotypic trends for the most recent four years in the Canadian Holstein data (Table 4) show very little change for AFS and NRRh but a slight decrease for NRRc (ie: .23 percentage points per year for first lactation cows) accompanied by a slight increase for CTFS (.77 days per year).

Table 4. Phenotypic trend in Canadian Holsteins.

Year of Insemination	AFS (days)	NRRh (%)	CTFS (days)	NRRc ¹ (%)
2000	497.7	75.5	88.6	63.0
2001	497.2	75.7	89.0	62.8
2002	495.9	76.2	89.8	62.5
2003	497.3	75.7	90.9	62.3

Note 1: 56-day NRR for first parity cows only

Figure 1 shows the phenotypic trend for NRRh and NRRc within parity on a monthly basis since January 2000.

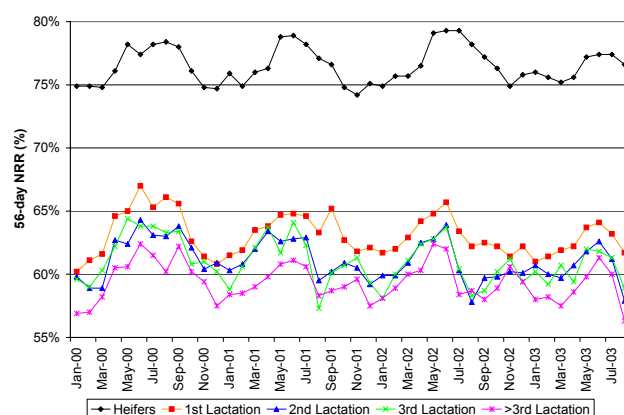


Figure 1. Monthly phenotypic trend for NRRh and NRRc within parity 1, 2, 3 and >3 for Canadian Holsteins.

Similarly, Figure 2 shows the monthly trend for CTFS across all parities. Of interest for CTFS is the consistent seasonal trend with the shortest intervals being associated with first inseminations in November and the longest occurring in July of each year.



Figure 2. Monthly phenotypic trend for interval from calving to first service (CTFS) across all parities in Canadian Holsteins.

In order to maximize the expected genetic gain for cow fertility, especially NRRc, over a 10-year time horizon, selection index theory will be used to determine the optimum relative weights to be applied on the EBV for each of the four female fertility traits to combine them into a single EBV for Daughter Fertility to be officially published by CDN.

A genetic base including all bulls born in the most recent 10-year period (15 years for breeds other than Holstein) that have at least 50 daughters for both the heifer and cow traits will be used for proof expression, which is the base definition common to all non-production traits in Canada. The average Daughter Fertility proof for bulls in the genetic base will be set to the breed average for overall 56-day NRR, as presented in Table 3. The SD of Daughter Fertility proofs for Holstein bulls with at least 100 daughters for both NRRh and NRRc is 2.5%, yielding a range of about ± 9 percentage points amongst bulls.

Summary and Conclusions

Starting in August 2004, CDN will be publishing official bull proofs for Daughter Fertility in all dairy breeds in Canada. The published EBV for each bull will be a combination of EBVs from a multiple-trait model including two heifer traits, namely Age at First Service (AFS) and 56-day NRR (NRRh), and two similar traits recorded for each lactation in cows; Calving to First Service (CTFS) and 56-day NRR (NRRc).

While only slight undesirable phenotypic trends exist in Canadian Holsteins for CTFS and NRRc, genetic evaluation of female fertility traits allows for monitoring change and selection pressure that results from emphasis on traits related to production and longevity.

In the future, Daughter Fertility will be included in the Lifetime Profit Index (LPI) in Canada. In addition, research is ongoing to achieve the ultimate goal of a comprehensive multiple-trait genetic evaluation system for female reproductive performance traits that includes female fertility, gestation length, calving ease and stillbirth rate.

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