Implementation of Reproductive Performance Genetic Evaluations in Canada

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Introduction

Canada has been providing genetic evaluations for four female fertility traits, in addition to an overall Daughter Fertility (DF) index, since November 2004 (Van Doormaal *et al.*, 2004). This 4-trait multi-trait animal model has been expanded to a 16-trait model (Jamrozik *et al.*, 2005) for simultaneous genetic evaluation of female fertility and calving traits, referred to as the Canadian Reproductive Performance genetic evaluation system. The purpose of this paper is to provide details related to the official introduction in January 2008 and specifically the publication of the resulting genetic evaluations.

Data and Methods

The official Canadian Reproductive Performance genetic evaluation system includes sixteen individual traits (Table 1). Details of the multiple trait, linear animal model used for genetic evaluation were described by Jamrozik *et al.* (2006) while the same authors also published the estimates of genetic parameters for the Holstein breed (Jamrozik *et al.*, 2005). The only change to the model as officially implemented is the fixed effect of region by year of birth by season of birth (RYS) became a fixed region-year-month of birth effect and the random effect of herd within RYS became a random herd-year effect. Variance components were re-estimated (unpublished) without significant change from Jamrozik *et al.* (2005). Within the list of traits for heifers and cows, those associated with calving performance, namely gestation length, calving ease, calf survival and calf size, were evaluated by modelling both direct and maternal effects. By summation of traits, genetic evaluations for Days Open (DO = Calving to first service + First service to conception in cows) and Calving Interval (CI = DO + Gestation length to later calvings) can also be produced.

Table 1 provides the number of Holstein records and animals with data as available for the August 2007 preliminary run. While the insemination data starts in 1998, the records used to evaluate traits related to calving ease and calf survival (reverse expression of stillbirth rate) date back to 1990. Appropriate data validation checks and edits for censored data and opportunity of expression were applied for each trait. Each of the seven dairy breeds in Canada are evaluated separately.

Table 1. Number of Holstein records and animals with data by trait (August 2007 run).

Trait	Animals ('000)	Records ('000)
Heifers:		
Age at first service	936	936
56-day non-return rate	970	970
Number of services	947	947
First service to conception	622	622
Gestation length to first calving	726	726
Calving ease at first calving	1 847	1 847
Calf survival at first calving	1 329	1 329
Calf size at first calving	1 823	1 823
Cows:		
Calving to first service	1 133	2 465
56-day non-return rate	1 179	2 582
Number of services	1 138	2 473
First service to conception	775	1 496
Gestation length to later calvings	871	1 723
Calving ease at later calvings	2 154	4 308
Calf survival at later calvings	1 615	3 171
Calf size at later calvings	2 143	4 262

As usual, the genetic evaluation system computes the various counts of records, daughters and herds for each trait as well as the reliability value associated with each genetic evaluation. Reliabilities are approximated using the multivariate equivalent number of progeny method (Tier and Meyer, 2004). Additional details on data description, including population trends were published by Fatehi *et al.*, 2006.

Selection Indexes

Daughter Fertility

With the addition of new measures of female fertility derived from the 16-trait model compared to the existing 4-trait model, the overall index for Daughter Fertility (DF) was modified to:

DF = 50% NRR-C – 15% CTFS – 25% FSTC-C – 10% AFS

Holstein correlations (where positive is always desired) between the EBV for each female fertility trait (based on bulls with at least 50 daughters) and the revised DF are shown in Figure 1, noting that no significant relationship was found with AFS. Detailed EBV correlations among the female fertility traits, including DO and CI, are provided in the appendix. The desired goal of DF is to improve conception rates in cows (measured by NRR-C, NS-C and FSTC-C) while decreasing the interval measures of female fertility (i.e.: CTFS, FSTC-C, DO and CI), which is clearly achieved according to the EBV correlations.

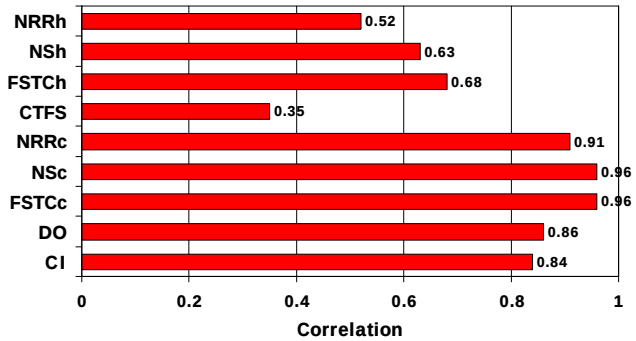

Figure 1. Correlations between Daughter Fertility (DF) and EBV for measures of female fertility.

Daughter Calving Ability (Maternal Effects)

The 16-trait model includes direct and maternal effects for the four calving traits expressed separately for first calvings versus later calvings. In order to simply the publication and use of this information by producers and industry personnel, two indexes associated with calving performance are being considered:

Daughter Calving Ability (DCA) =
36% MCS-FC + 24% MCS-LC
+ 24% MCE-FC + 16% MCE-LC

Correlations between DCA and EBV for various measures of calving performance are presented in Figure 2 for Holsteins. Detailed EBV correlations among the main calving traits are provided in the appendix. The desired goal of DCA is to reduce calving problems and increase the likelihood of producing a living calf, especially when daughters calve for the first time. To achieve this objective, the overall index is most related to Maternal Calving Ease (r_{MCE-FC}=.84) and Maternal Calf Survival (r_{MCS-FC}=.88) at the daughter's first calving, followed by the same traits for later calvings (r_{MCE-LC}=.67, r_{MCS-LC}=.68). The direct effects of calving ease and calf survival are indirectly included in the DCA index and therefore have lower EBV correlations.

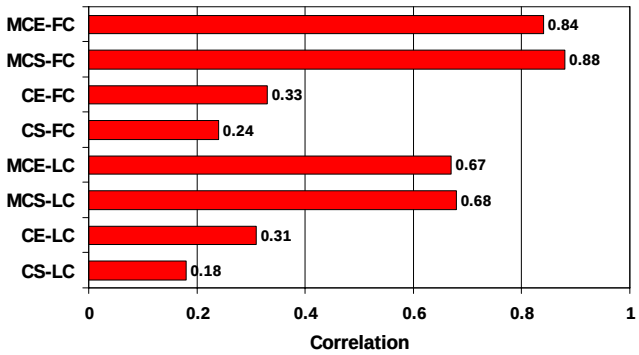

Figure 2. Correlations between Daughter Calving Ability (DCA) index and EBV for measures of calving performance.

Calving Ability (Direct Effects)

Since the DCA index mainly reflects the ability of a sire's daughters to give birth easily and produce live calves, a second overall index related to calving performance is also being considered for introduction:

Calving Ability (CA) =
64% CE-FC + 16% CE-LC
+ 16% CS-FC + 4% CS-LC

This CA index will replace the current use of Calving Ease (direct effect) evaluations in a similar way that DCA will replace the use of Maternal Calving Ease currently published in Canada.

Publication and Expression of Evaluations

The 16-trait system produces EBVs for a total of 26 different traits due to the addition of direct and maternal measures of the calving traits and the summation of various female fertility traits to produce DO and CI. After consideration of the underlying genetic correlations, the EBV correlations, the heritabilities and the timing of data availability for various traits during the sire proving process, it was decided to publish official bull evaluations for a group of 15 individual traits in addition to the three overall indexes. Published traits were grouped into three "families" (i.e.: female fertility, maternal calving performance and direct calving performance) for consideration of official publication (Table 2).

Table 2. Families of reproductive performance traits with official publication of bull EBV for Canadian dairy breeds.

Trait Family (*Index*)		Individual Traits with Published Genetic Evaluations for Bulls
Female Fertility *(Daughter Fertility)*	Heifers	Age at first service
		56-day non-return rate
		First service to conception
	Cows	Calving to first service
		56-day non-return rate*
		First service to conception
		Days Open
Maternal Calving Performance *(Daughter Calving Ability)*		Calving ease at first calving*
		Calving ease at later calvings
		Calf survival at first calving
		Calf survival at later calvings
Direct Calving Performance *(Calving Ability)*		Calving ease at first calving
		Calving ease at later calvings*
		Calf survival at first calving
		Calf survival at later calvings

** - indicates trait used to determine official publication status*

Within each trait family, a single trait was identified to establish the official publication status for all traits within the family. The criteria used to select the primary trait for determining the publication status within each family included their importance within the defined selection objective, the genetic and EBV correlations, heritabilities and timing of data availability. For female fertility traits, NRR in cows was selected since the main breeding goal is improved conception rates in cows and NRR is available much earlier than FSTC and DO, since the latter require a subsequent calving. For maternal calving performance the primary traits of interest are calving ease and calf survival from daughters calving for the first time and the heritability for calving ease at first calving (14%) is significantly higher than for calf survival at first calving (4%). On the side of direct calving performance, the ease at which progeny are born outweighs the importance of the survival of the calf and the amount of data on progeny born from first calvers is very limited on average (~15%) relative to that for progeny born from cows calving for at least the second time (~85%).

A genetic base including all bulls born in the most recent 10-year period (15 years for breeds other than Holstein) that have an official evaluation is used for proof expression, which is the base definition common to all non-production traits in Canada. For all individual traits and indexes derived from the Reproductive Performance genetic evaluation system, bull proofs will be expressed as Relative Breeding Values (RBV) with mean 100 and standard deviation of 5. This is consistent with a recent decision in Canada that, effective January 2008, genetic evaluations for all traits in Canada except LPI, production, somatic cell score and type, will be expressed using this RBV scale.

Lifetime Profit Index

In Canada, the primary genetic selection tool is the Lifetime Profit Index (LPI), which has three main components, namely Production, Durability and Health & Fertility, with relative emphasis in Holsteins of 54%, 36% and 10%, respectively. With the revision of the Daughter Fertility index and the introduction of Daughter Calving Ability and Calving Ability in January 2008, it is expected that the emphasis on the Health & Fertility component of LPI will increase from 10% to at least 15% and possibly up to 20%, which will reduce the weights on Production and Durability components proportionately. The current approach is that Daughter Fertility will increase from 5% to 10% in the LPI formula and either one or both of the calving performance indexes may also be added with a maximum total weight of 5%. Final decisions regarding the specific formulae to be used for the calving performance indexes and the LPI within each breed will be made during meetings to be held in October 2007.

Summary and Conclusions

Starting in January 2008, Canada will be using a multiple trait linear animal model Reproductive Performance system for computing genetic evaluations for female fertility and calving traits. After including both direct and maternal effects for various calving traits, this genetic evaluation system provides EBVs for up to 26 different traits. In addition, three overall indexes (DF, DCA and CA) will be published for all dairy breeds.

Effective at the same time will be a change of expression for genetic evaluations in Canada for all traits other than LPI, production, somatic cell score and type traits. Bull and cow evaluations will be changed to Relative Breeding Values with an average of 100 and standard deviation of 5, based on a rolling bull base of ten complete birth years.

Lastly, changes due to the revised Daughter Fertility index, combined with the addition of the Daughter Calving Ability and Calving Ability indexes are expected to yield modifications to the Lifetime Profit Index (LPI), effective January 2008.

References

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Appendix

Table 3. Correlations among Holstein EBV for female fertility traits based on bulls with at least 50 daughters in each trait pair.

	NRR-H	NS-H	FSTC-H	CTFS	NRR-C	NS-C	FSTC-C	DO	CI
Age at first service (AFS)	.24	-.07		.23	.19	-.09		.11	.10
Non return rate in heifers (NRR-H)		-.90	-.74	.17	.61	-.54	-.49	-.28	-.29
Number of services in heifers (NS-H)			.94		-.63	.64	.60	.45	.47
First service to conception in heifers (FSTC-H)				.11	-.62	.68	.66	.54	.55
Calving to first service (CTFS)					.02	.28	.38	.74	.74
Non return rate in cows (NRR-C)						-.89	-.80	-.55	-.54
Number of services in cows (NS-C)							.97	.83	.81
First service to conception in cows (FSTC-C)								.90	.89
Days open (DO)									.99
Calving interval (CI)									

Table 4. Correlations among Holstein EBV for the main calving traits of interest based on bulls with at least 50 daughters in each trait pair.

	MCS-FC	CE-FC	CS-FC	MCE-LC	MCS-LC	CE-LC	CS-LC
Maternal calving ease at first calving (MCE-FC)	.62	.38	.25	.82	.35	.35	.19
Maternal calf survival at first calving (MCS-FC)		.17	.16	.37	.54	.18	.11
Calving ease at first calving (CE-FC)			.68	.36	.20	.80	.47
Calf survival at first calving (CS-FC)				.25	.19	.55	.64
Maternal calving ease at later calvings (MCE-LC)					.27	.33	.17
Maternal calf survival at later calvings (MCS-LC)						.17	.13
Calving ease at later calvings (CE-LC)							.40
Calf survival at later calvings (CS-LC)							