The Canadian Test Day Model using Legendre Polynomials

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Introduction

The Canadian Test Day Model has been modified to use Legendre Polynomials to model lactation curves instead of the Wilmink curve. This modified test day model has been used since May 2003 to estimate breeding values for the Holstein breed in Canada.

Test day records for the other breeds are currently analyzed using the Canadian Test Day Model based on the Wilmink curve, but the plan is to also change the genetic evaluation method for these breeds to use the Canadian Test Day Model using Legendre polynomials in February 2004. This report gives details of the changes which were made and shows the effect of the changes in the model on estimated breeding values for Holstein bulls and cows

Materials and Methods

Several programs which are part of the Canadian Test Day Model (CTDM) genetic evaluation system were changed by Janusz Jamrozik to use a fourth order Legendre Polynomial to model lactation curves instead of the Wilmink function. Additional changes were made at the Canadian Dairy Network to several other programs to adjust for the changes in model and file layouts and reduce the computational requirements.

Standardization factors that are used to standardize the variance of the estimated lactation breeding values were calculated so that the standard deviations of these estimated breeding values (EBVs) in the November 2001 official run and a test run using Legendre polynomials with the same data were equal.

Resulting lactation EBVs were combined into one overall EBV using the same weighting factors in both models. The persistency measure calculated when using Legendre polynomials is very similar to the measure used in the Wilmink model. The difference is that rather then using estimated breeding values for milk yield on day 60 and day 280, the average estimated breeding values in the intervals from 50 to 70 DIM and 255 to 305 DIM, respectively, were used. This change has little impact on the resulting persistency breeding values.

Another difference is the way in which fat and protein deviations are calculated. The CTDM using the Wilmink curve calculates these deviations from the combined EBVs. The CTDM using Legendre Polynomials calculates fat and protein deviations separately for each lactation, these three deviations are then averaged across lactations.

This research uses the Canadian data and pedigree files that were extracted for the February 2003 genetic evaluation run for Holsteins. These files were used to estimate breeding values using the CTDM based on 4^{th} order Legendre Polynomials. Resulting estimated breeding values were compared to breeding values from the official February 2003 evaluation calculated with the CTDM based on the Wilmink curve.

Results and Discussion

Correlations between official bull EBVs using the two different models and different groups of bulls are shown in Table 1. Correlations between official EBVs using all bulls were high for the production traits (.995 or .998) but somewhat lower for SCS (.985) and persistency (.973).

Table 1. Correlations between estimated breeding values using different groups of bulls with an official EBV.

Bulls Trait	All Bulls	Last TD records of the 20th daughter is in: 1st parity	2nd parity	3rd parity <250 DIM	3rd parity >249 DIM
# bulls	5886	332	824	942	3779
Milk	.996	.995	.995	.997	.997
Fat	.995	.991	.993	.997	.997
Protein	.996	.994	.995	.997	.997
SCS	.985	.959	.978	.985	.991
Persistency	.973	.960	.963	.974	.978
Fat %	.998	.996	.998	.998	.999
Protein %	.996	.987	.995	.997	.997
LPI	.998	.996	.997	.998	.998

Correlations between EBVs for bulls with the 20th daughter in first lactation were the lowest and correlations increased when the 20th daughter was further along. This shows that there are more changes in EBVs for bulls with a limited amount of information. Differences in correlations for different groups of bulls were small for production traits and were slightly larger for SCS and persistency.

Even with these high correlations there were still considerable differences in EBVs for some bulls. Differences in EBVs (Legendre EBV minus Wilmink EBV) for bulls with an official EBV ranged from –448 to +513 for milk, -17 to +11 for fat, -16 to +16 for protein, -0.23 to +0.19 for SCS and –3 to +2 for persistency. For all these traits the distribution of EBV changes was skewed with more decreases than increases, this was also true for SCS for which a decrease in EBV is good.

Changes in bull EBVs by birth year showed a clear trend (Table 2) over time. On average there was little impact on EBVs for bulls born before 1993 (Figure 1) except for SCS for which older bulls improved (they had a decrease in SCS). Bulls born in 1993 to 1995 improved relative to the average of all bulls for all traits except SCS (uses a reversed scale). Bulls born after 1995 had on average a decrease in EBVs for most traits relative to an average bull, the only exception was SCS for which these bulls had an increase in EBV.

Table 2. Average change in bull estimated breeding values by birth year.

Birth year	# Bulls	Milk	Fat	Protein	SCS	Persistency
1984	236	-31	-.71	-1.89	-.02	-.25
1985	271	-24	-.32	-1.53	-.02	-.27
1986	305	-21	-.02	-1.11	-.01	-.24
1987	389	-25	.06	-1.07	-.01	-.18
1988	391	-32	-.32	-1.25	-.01	-.21
1989	407	-15	.15	-.57	-.01	-.17
1990	456	-23	-.35	-.61	.00	-.16
1991	495	-15	-.49	-.14	.00	-.21
1992	478	-18	-.64	-.27	.00	-.24
1993	477	10	.33	.55	.00	-.13
1994	406	20	.43	.90	.01	-.16
1995	398	10	-.49	1.02	.01	-.23
1996	394	-61	-3.33	-1.05	.03	-.43
1997	384	-92	-5.97	-3.05	.03	-.76
1998	45	-69	-8.42	-5.91	.01	-.22
All	6135	-21	-.82	-.74	.00	-.26

More important than changes in EBVs for all bulls are the changes in EBVs for the top bulls (Table 3). Top LPI bulls had on average a larger change in EBVs than all bulls. This resulted in some re-ranking but approximately 90% of the top LPI bulls were the same when changing from Wilmink to Legendre.

Table 3. Average difference in estimated breeding values (Legendre minus Wilmink) for top LPI bulls.

TOP	10	25	50	100	500
Milk	-50	-73	-86	-76	-57
Fat	-5.7	-5.7	-5.9	-5.3	-4.4
Protein	-3.4	-2.8	-3.2	-2.6	-1.8
SCS	.01	.03	.04	.03	.03
Persistency	-.90	-1.00	-.86	-.70	-.59
Bulls in common	9 90%	23 92%	42 84%	87 87%	460 92%

Correlations between cow EBVs from the two models were lower than correlations between bull EBVs (Table 4). Correlations between EBVs for the yield traits were high (0.99) but for SCS and persistency they were considerably lower.

Table 4. Correlations between official bull and cow estimated breeding values.

Trait	Bulls	Cows
Number of animals	5886	1842793
Milk	0.996	0.991
Fat	0.995	0.990
Protein	0.996	0.990
SCS	0.985	0.945
Persistency	0.973	0.940
Number of animals for LPI correlation	5886	1632375
LPI	0.998	0.995

The top 100 LPI cows had, on average, an increase in their EBVs for yield traits (Table 5) in contrast to the top bulls which had on average a decrease in their yield EBVs. The reason is that the top LPI cows are usually not the daughters of the top LPI bulls but in most cases are daughters of bulls which already have a second crop and therefore are not affected by the drop in EBVs for the youngest (first crop) bulls.

Table 5. Average difference in estimated breeding values (Legendre minus Wilmink) for top LPI cows.

TOP	25	100	500	1000	5000
Milk	137	76	25	8	-25
Fat	2.92	1.72	0.32	-0.95	-1.91
Protein	2.56	0.92	0.1	-0.11	-0.73
SCS	-0.02	0.01	0.01	0.02	0.03
Persistency	-0.52	-0.73	-0.64	-0.65	-0.65
LPI	60	23	1	-10	-27
Cows in common	21 (84%)	85 (85%)	392 (78%)	783 (78%)	3919 (78%)

The majority of the cows in the top 100 LPI remain in the top 100 but there are 15 new animals in the top 100 showing that the new model has an effect on the ranking of the top cows.

Conclusion

Correlations between bull and cow EBVs in the two models are quite high but there are considerable differences in the EBVs for some animals.

The main differences in EBVs were associated with bulls that had a large percentage of first lactation test day records. These bulls had on average a decrease in their production EBVs.

Effects on rankings of bulls were smaller than the changes in EBVs would suggest because specific groups of bulls tended to be affected in a similar way. Most of the top bulls had a similar change in EBVs and therefore there was relatively little re-ranking among them.