Application of the Canadian Test Day Model

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Introduction

Research based on the concept of using test day (TD) records, rather than 305-day lactations, in genetic evaluations has been ongoing in Canada since the early 1990's (10). Progression from using first lactation TD records to including records from the first three lactations (3,6), from using a fixed regression analysis to a random regression approach (2,6,9,11), and from modelling only the animal genetic effect to also applying the random regression approach to model permanent environmental effects (6), have all stemmed from the research results.

Usual enhancements to genetic evaluation systems relate to improved variance component estimates, better fixed effect adjustments or new factors added to the applied model. Moving from a lactation model to a test day model involves changes, not only in the genetic evaluation system, but also in the underlying database and the methods of expression and publication criteria.

Technical aspects of the Canadian Test Day Model (CTDM) have been previously documented (3,4,5,6,8,11,12) but there are also many components related to its application as a national genetic evaluation system on a routine basis. These components can be categorized into three broad areas; (i) database development, (ii) genetic evaluation calculations and (iii) expression, publication and extension of breeding values.

Database Development

In order to implement the CTDM, historical TD records were retrieved from milk recording archives. Formerly, there were six distinct milk recording agencies with their own computer system, each with different archiving policies. Contrary to the current move to a single milk recording processing centre, the former structure created data recovery challenges. Ultimately, a complete TD database was established at Canadian Dairy Network (CDN) based on all cows which first calved since 1988, 1990, 1991 or 1992 (minimum of 7-year history) depending on the milk recording region. Requiring the presence of first lactation TD records was imposed to reduce possible selection bias when using TD records of later lactations alone. Table 1 provides the total number of TD records and cows included in the official August 1999 CTDM genetic evaluations for each dairy breed. With the current implementation of a new national milk recording data collection and processing system in Canada, new criteria for inclusion of TD records in genetic evaluations will also be introduced to capture more individual cows and their TD records.

Table 1. Number of TD records and cows by breed used in the August 1999 CTDM

Breed	No. TD Records	No. Cows
Ayrshire	1,059,874	65,020
Brown Swiss	103,660	6,764
Canadienne	27,797	1,801
Guernsey	103,088	6,990
Holstein	22,058,908	1,414,917
Jersey	576,332	37,445
Milking Shorthorn	10,814	731
TOTAL	23,940,473	1,533,668

Genetic Evaluation Calculation

The CTDM is a multiple-trait, random regression model which includes performance data from first, second and third lactation for test day milk, fat and protein, each expressed in terms of a 24-hour yield with a given accuracy, as well as test day somatic cell score. The analysis of these 12 separate but correlated traits required efficient computing strategies and increased computer memory and disk space for use as the routine national system. Currently, using an HP9000 K250 Unix computer with dual 160 MHZ processors and 2 GB of RAM, the entire process following data extraction, including the pre-adjustment for heterogenous herd-test day-parity variances (8,12), to the creation of output files for bulls and cows in all breeds takes 3 days with the Holstein iteration program requiring 40 hours.

Canada uses a rolling cow base for expression of production evaluations, which formerly included all cows which calved during the calendar year two years earlier than the evaluation year. This genetic base therefore included cows of all ages and represented the active cow population during the base year. With the CTDM, no TD records for cows beyond third lactation are included so the group of cows in the base definition represented only the younger cows in the population. In order to maintain an approximate equivalence in genetic bases used, the CTDM includes all cows with TD records in the genetic evaluation system associated with a calving date during the calendar year three years before the evaluation year.

Due to the truncation of historical data, older bulls and cows which received official evaluations based on the lactation model, either directly through their own performance data or indirectly through progeny records, are excluded from the CTDM. In order to maintain official evaluations for these older cows, a blending procedure was developed to combine cow EBVs from a one-time lactation model run based on calving dates before March 1994, adjusted to the current genetic base, with their current CTDM evaluations based on progeny only.

With any genetic evaluation system, an estimate of the accuracy of each animal s breeding values, known as reliability must also be calculated. Since previous methods used in the lactation model were not applicable, a new procedure was developed for the CTDM reliabilities (12). By determining the number of daughter equivalents associated with each source of information, a close approximation of true accuracy can be obtained. CTDM reliabilities account for all information on relatives as well as the number of test day records available for each animal in each lactation, the number of days in milk on each test day as well as the relative accuracy of each test day record, depending on the level of milk recording service used at the farm (ie: AM/PM testing versus all milkings in 24-hours).

An additional feature related to the fact that the CTDM models each cow s lactation curve at the genetic level, is the possibility to derive a genetic estimate of the lactation persistency for milk, fat and protein yields within each lactation (1). In simplistic terms, the calculation of lactation persistency bull EBVs used in Canada is the ratio of his milk yield breeding values at 280 days in milk compared to at 60 days in milk, expressed as a percentage. This EBV is calculated for each of the three lactations even if daughters have TD records in only first or second lactation.

Expression, Publication and Extension

The CTDM uses Wilmink s three-parameter function (13) to describe the shape of the lactation curve. The resulting output for each animal are the three parameter estimates for each of the 12 traits (milk, fat, protein, somatic cell score for lactations 1, 2 and 3). Although the CTDM provides the flexibility of expressing breeding values in a multitude of ways, in order to be consistent with previous and international expressions, an EBV for each trait within each lactation, expressed as the sum of the daily breeding values from day 1 to 305 in lactation, is used. In addition to the EBVs for

milk, fat and protein yields and somatic cell score, EBVs for fat and protein deviation as well as

An important underlying assumption of the CTDM is that each trait within each lactation is considered separate but correlated. This means, for example, that milk yield within first, second and third lactation is controlled by similar but not identical genetics. In Canada, the EBVs for each trait are published separately for each lactation in addition to an overall estimate for each trait across lactations. Relative weights used for the yield traits are equal for each lactation while they are 25:65:10 for somatic cell score and 50:25:25 for lactation persistency, for first, second and third lactation, respectively.

For production traits, before combining the individual lactation EBVs for each trait, they are standardized to a common variance. In this way, first lactation EBVs for a bull can be compared to EBVs for second and third lactation to determine if the daughters genetically improve, maintain or decrease with each lactation. Table 2 provides a comparison of actual lactation EBVs for protein yield to demonstrate bull differences.

Table 2. Actual examples of lactation EBVs for protein yield (kg) for bulls with daughters in all three lactations.

Bull	First Lactation	Second Lactation	Third Lactation
A	69	67	69
B	45	65	81
C	79	48	42
D	60	49	60

The Canadian dairy improvement industry is interested in incorporating this new genetic information into their sire selection and breeding strategies. Continued economic analysis of lactation breeding values is ongoing to maximize the use of this information.

Criteria for determining which bull and cow lactation persistency are indirectly computed for each lactation.
evaluations would be officially published needed to be reviewed with the CTDM. For bulls, new criteria for the Holstein breed include a minimum of 20 daughters with a test day record past 90 days in milk distributed in at least 10 herds and a minimum reliability of 60% for bulls tested in Canada or 75% for bulls first proven elsewhere. On the cow side, publication criteria needed to allow for flexible milk recording programs which could lead to cows having any combination of supervised and unsupervised tests within the same lactation. Basically, in order for a young cow to receive her first official index, a minimum of two supervised tests and at least one test past 60 days in milk is required.

In Canada, all genetic evaluations are released by the Canadian Dairy Network (CDN) using its Internet web site (www.cdn.ca). In preparation for the introduction of the CTDM in February 1999, three formal runs parallel to the official quarterly evaluations were conducted and compared. Many extension articles have been written for publication in breed magazines as well as for the CDN web site.

Correlations between published bull EBVs for protein yield, based on the former lactation model and the CTDM, were 93% for Ayrshires, 97% for Holsteins and 98% for Jerseys. For cow evaluations, analogous correlations for each breed were lower at 82%, 93% and 93%, respectively. Comparing changes in bull EBVs each run, CTDM evaluations are more stable and predict the future higher reliability EBV better than the former lactation model. These correlations are significant when examining top bull and cow lists, so communicating the advantages and increased accuracy of the CTDM to the industry was critical to its adoption. Based on a simulation study, it was shown that the CTDM improves the accuracy of evaluations for cows by 9% and 6% for bulls with less than 50 daughters (7). Also, important was the use of EBVs for later lactations when daughters are only in first lactation. Since the CTDM is a multiple trait analysis all bulls receive an evaluation of all traits and lactations. This feature

was new to the Canadian industry but acceptance of later lactation EBVs for newly proven bulls was gained with experience and an CDN study showing an 86% correlation between the third lactation EBVs based on first lactation daughters compared to two years later when they are based on actual daughter performance in third lactation.

The Canadian dairy industry is planning to focus the publication and use of genetic evaluations for production traits on the individual lactation EBVs rather than those combined across lactations. This requires economic weights for proper inclusion in the Lifetime Profit Index and the Total Economic Value used for ranking bulls in Canada. Also, research is ongoing in conjunction with the Interbull Centre to develop a modified procedure for including the individual lactation EBVs from the CTDM in the Interbull MACE system for production traits.

Conclusions

The Canadian Test Day Model has been an important development towards improving the accuracy of genetic evaluations for production related traits including the addition of a new secondary trait called Lactation Persistency. With this change in genetic evaluation methodology, approaches for combining cow EBVs for a 305-day model and a test day model as well as for calculating breeding value reliabilities needed development. Also, substantial changes were required to the database design and structure as well as to areas related to the expression, publication and extension of bull and cow breeding values. Promotion of advantages and increases in accuracy are key to the success of implementation and acceptance. Further research is required to maximize the benefits from the CTDM evaluations in international rankings calculated and provided by Interbull.

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