Genetic Evaluation of Dairy Cattle in Canada

Responsibility

The calculation and publication of all dairy cattle genetic evaluations in Canada is the responsibility of Canadian Dairy Network (CDN). An 8-member board of directors, the majority being dairy producers, governs this non-profit national organization. Member organizations include all breed associations, milk recording agencies and artificial insemination centres across Canada as well as Dairy Farmers of Canada. CDN's annual budget includes approximately $1,000,000 for operations related to genetic evaluations plus $400,000 that is allocated to support research projects in the area of dairy cattle genetics. Member organizations provide all funding required each year through a pay-for-service fee structure.

Genetic Evaluation Services

Genetic evaluations are provided by CDN for seven dairy breeds, namely Holstein, Ayrshire, Jersey, Brown Swiss, Guernsey, Canadienne and Milking Shorthorn. Within each breed, all animals receive a genetic evaluation for a complete series of characteristics including production, conformation and functional traits. Bulls with sufficient progeny distributed in several herds receive official proofs and cows with their own performance data receive official genetic indexes that are published on extended pedigrees and other official documents provided by breed associations and other industry organizations. Sires proven outside of Canada receive genetic evaluations provided by the International Bull Evaluation Service (Interbull) using a methodology called MACE. For these foreign sires, as well as for foreign dams, CDN publishes MACE evaluations for a variety of traits depending on the breed and country of origin. Young sires and heifers receive genetic evaluations, termed Parent Averages, which reflect their genetic potential for each trait based on their pedigree information. Access to all official genetic evaluations, including MACE evaluations and Parent Averages, is available on the Internet through the CDN web site at http://www.cdn.ca.

Genetic Evaluation Systems

Currently, CDN maintains and executes seven different genetic evaluation systems based of groups of traits and data used. Specifically, these include (1) production, (2) conformation, (3) longevity, (4) calving ease, (5) milking speed, (6) milking temperament and (7) reproductive performance. The following is a brief description of each genetic evaluation system, including the input data, genetic evaluation methods and the expression of resulting bull proofs and cow indexes.

(1) Production

Genetic evaluations for milk, fat and protein yields as well as fat and protein percentages, somatic cell score and lactation persistency are calculated using the most sophisticated methodology in the world, called the Canadian Test Day Model. Rather than using 305-day lactation records, the use of each cow's 24-hour yields on each monthly test day is recognized globally for increasing the accuracy of resulting genetic evaluations. Herds enrolled on milk recording programs that involve supervised testing are automatically eligible for inclusion in genetic evaluation calculations. Herds enrolled on completely unsupervised milk recording services also qualify for genetic evaluations if they are using approved milk meters that are verified annually and respect minimum levels of unique identification amongst first lactation animals. In general, 70 percent of all dairy cows in Canada are enrolled on milk recording and approximately 85 percent of these are recorded with parentage in the breed association herdbook. In terms of genetic evaluations, this translates to approximately 540,000 cows spread across more than 11,000 herds that qualify for production evaluations.

(2) Conformation

For conformation traits, official classifications are used to genetically evaluate bulls and cows for a comprehensive list of 29 characteristics that describe the dairy cow, including overall Final Score, four major scorecard traits (i.e.: Mammary System, Feet & Legs, Dairy Strength and Rump), and 22 descriptive traits appraised using a 9-point linear scale. Since August 2005, the Multi-Breeds Classification System has been used to classify dairy cows in the Holstein, Ayrshire, Jersey, Brown Swiss, Guernsey, Milking Shorthorn and Canadienne breeds in Canada.

For genetic evaluations, all classifications and reclassifications within first lactation are included to calculate bull proofs and cow indexes. Classifications from later lactations may also be used. In total, approximately 200,000 new classifications are recorded each year, which contribute to genetic evaluations for type traits. Given the relatively large number of traits evaluated, genetic evaluations are standardized to a common scale for each trait such that the average bull proof is set to zero and the standard deviation is set to 5. This gives a range of evaluations from nearly –20 to +20 for bulls and cows (i.e.: four standard deviations away from the breed average).

(3) Longevity

Genetic evaluations for longevity, labelled as Herd Life, are based on disposal dates and reasons collected for cows on milk recording. The survival of each cow is evaluated to five specific points during their productive life including (1) survival from first calving to 120 days in milk in first lactation, (2) survival from 120 to 240 days in milk in first lactation, (3) survival from 240 days in milk in first lactation to second calving, (4) survival from second calving to third calving, and (5) survival from third calving to fourth calving. These trait definitions each measure a separate component of daughter survival but they are all interrelated. The genetic evaluation system utilizes the genetic correlations estimated across these five measures of longevity to compute an overall bull proof for Direct Herd Life and an associated Reliability depending on the amount of daughter survival data available. As a separate calculation, an Indirect Herd Life value

is calculated based on a function of proofs for other non-production traits that are used as predictors of longevity. This Indirect Herd Life calculation is based on a combination of conformation traits (39%), reproduction traits (35%) and udder health traits (26%). Published bull proofs for Herd Life represent a combination of their Direct Herd Life and Indirect Herd Life evaluations, which are weighted relative to the Reliability level of each indicator of longevity. Generally speaking, newly proven bulls with their first official genetic evaluation for production and type will have a Herd Life proof that has more weight on Indirect Herd Life since less actual daughter survival data exists at that time. As the bull's daughters get older and move through their productive life to their fourth calving, the published Herd Life proof reflects the Direct Herd Life evaluation. In terms of proof expression, Herd Life evaluations have an average of 3.00 for all breeds and a standard deviation of .20, meaning that 99% of the proven bull population will have a proof between 2.40 and 3.60 (± 3 standard deviations). Differences in bull proofs for Herd Life indicate the expected number of lactations more or less that the bull's average daughter will last in the herd, independent of their production performance.

(4) Calving Ease

Milk recording agencies collect information from producers regarding the ease of calving for all births recorded on the farm. Each calving is recorded as "Unassisted or Unobserved", "Easy Pull", "Hard Pull" or "Surgery" and other information such as the sex of calf, size of calf, multiple births and stillbirths are also recorded. This data is used to estimate genetic evaluations for both Calving Ease, representing the ease of which the bull's progeny are born, and Maternal Calving Ease, representing the ease of which the bull's daughter give birth to their calves. Bull proofs for both of these calving ease traits are expressed as the percentage of progeny births (direct) or daughter calvings (maternal) that are expected to be "Unassisted" or "Easy Pull" when the bull is mated to virgin heifers. The breed averages for calving ease proofs vary by breed to represent the phenotypic differences with averages of 85% for Holsteins, 94% for Ayrshires and 96% for Jerseys.

(5) Milking Speed

Subjective appraisals of milking speed during the first six months of first lactation are provided by the herd owner to their milk recording technician, which are used for calculating genetic evaluations for Milking Speed. Each cow is evaluated as "Very Slow", "Slow", "Average", "Fast" or "Very Fast". Genetic evaluations are published for bulls in each dairy breed with the average proof set to equal 85%. Published bull proofs represent the percentage of future first lactation daughters that are expected to be "Average" or "Fast" for milking speed.

(6) Milking Temperament

Similar to milking speed, the milk recording technicians also collect milking temperament data for cows during the first six months of their first lactation. The producer provides a subjective appraisal as either "Very Nervous", "Nervous", "Average", "Calm", or "Very Calm". Genetic evaluations are computed for Milking Temperament for bulls in all breeds with the average proof set to equal 90%. Each bull's proof represents the percentage of future first lactation daughters that are expected to be "Average", "Calm" or "Very Calm" for milking temperament.

(7)   Reproductive Performance

Starting in November 2004, bull proofs have been published for Daughter Fertility as a reflection of the reproductive performance of each bull's daughters.   The genetic evaluation system uses insemination data provided by A.I. organizations as well as other breeding data collected by milk recording, especially for herds that do their own artificial insemination. In order to derive the published Daughter Fertility evaluation, the genetic evaluation system estimates separate evaluations for four traits that each measure a different component of female fertility. The four traits include (1) the age at first insemination for virgin heifers, (2) the 56-day non-return rate for virgin heifers, (3) the interval between calving and first insemination for cows, and (4) the 56-day non-return rate for milking cows. The two traits measuring fertility in cows are recorded for all available lactations and are considered in the genetic evaluation system. Once each bull has a genetic evaluation estimated for these four measures of female fertility, they are combined to derive the published Daughter Fertility proof based on a relative emphasis of 65% to increase the cow non-return rate, 25% to reduce the interval from calving to first service in cows and 10% to reduce the age at first insemination for virgin heifers. The average bull proof for Daughter Fertility vary by breed according to the breed average 56-day non-return rate across heifers and cows, which is 66% for Holstein, 62% for Ayrshire, 70% for Jersey, 68% for Brown Swiss, 63% for Guernsey, 69% for Canadienne and 70% for Milking Shorthorn.

Lifetime Profit Index (LPI)

With the focus on "balanced breeding", bulls and cows in Canada receive a value for Lifetime Profit Index (LPI), which reflects the relative profitability that can be expected during the lifetime of future daughters. The specific LPI formula for each dairy breed varies but always includes three components, namely Production (yield traits and milk components), Durability (herd life, mammary system, feet & legs, dairy strength) and Health & Fertility (daughter fertility, somatic cell score, udder depth, milking speed). LPI is used as the most important tool for the selection of sires by producers as well as the selection of parents of future young sires by artificial insemination centers.

Interpretation of Genetic Evaluations

The main objective of genetic evaluations is the selection of superior bulls and cows as parents of the next generation. Genetic evaluations for all traits are aimed at identifying the best animals in each breed, compared to a reference group, which is considered as the breed average. Table 1 provides a brief description of the interpretation of the various genetic evaluations published in Canada.

For production traits, bull proofs and cow indexes are expressed as Estimated Breeding Values (EBVs), reflecting the animal's genetic potential for the specific trait, of which half is transmitted to their progeny. For milk, fat and protein yield, the highest values are the best and the difference between two bulls represents the expected difference in daughter yield during a 305-day lactation. EBVs for fat and protein percentages indicate the deviation of these milk components compared to the breed average percentages. Unique to Canada and selected other countries are bull proofs for Lactation Persistency

that indicate differences across bulls for how well their daughters maintain high levels of milk production throughout the entire 305-day lactation. Bulls with an above average proof (i.e.: over 66% in the Holstein breed) have daughters with a flatter lactation curve compared to bulls with daughters that have an average decrease in daily milk yields after peak lactation.

Bull proofs and cow indexes for type traits are also expressed as Estimated Breeding Values with the average bull being set to zero for each trait and the range of bulls going to a high between +15 and +20. Bulls rated +12 or better represent the top 1% of the breed for that trait. Type traits are generally used to describe the average daughter of each bull. Some bull proofs are expressed on a numerical scale generally from −15 to +15 while other traits have numerical ratings accompanied by letter codes. Regardless the method of expression, the breeding pattern for each bull is identified showing its strengths and weaknesses.

A trait of growing importance in dairy cattle breeding is Somatic Cell Score since it reflects the ability to resist mastitis therefore having better udder health, producing more milk and lasting longer in the herd. Since producers aim to reduce the somatic cell count in the milk being produced, the most desirable bulls and cows have a genetic evaluation for Somatic Cell Score (SCS) that is below the breed average of 3.00. SCS is the only trait in Canada for which the lowest numerical value is clearly considered as the most desirable.

Given the Canadian philosophy of "Balanced Breeding", it is important to have the most accurate estimate possible of a bull's genetic potential for their daughters' longevity. Daughter survival is only known later in life so a combination of true survival information (Direct Herd Life) and a prediction of expected longevity (Indirect Herd Life) is used to calculate the published bull proofs for Herd Life, which are independent of the level of production of the daughters. The average bull in each breed is set to a proof of 3.00 and the best bulls surpass 3.50, indicating that their daughters are expected to last one-half of a lactation longer in an average herd due to their ability to withstand involuntary culling.

Other functional traits published in Canada include Milking Speed, Milking Temperament, Calving Ease, Maternal Calving Ease and Daughter Fertility. In general, consideration of these traits when making mating decisions is usually limited to avoiding the use of problem sires. For example, bulls with daughters that may be slower milkers, more nervous at milking, have more difficulty at the time of calving or be less fertile would likely be less popular since producers prefer to avoid these problems, depending on the other strengths the bull has to offer.

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Table 1: Interpretation of Canadian Dairy Cattle Genetic Evaluations

Traits	Interpretation	Units & Scale
Lifetime Profit Index (LPI)	Expected relative lifetime profit of future progeny based on their genetic potential for production, longevity and udder health.	Units: Points relative to breed average equal to zero Scale: Varies by breed
Milk, Fat and Protein yields	Expected yield of milk, fat and protein during a 305-day lactation in a herd of average management.	Units: Kilograms Scale: Varies by trait and breed
Fat and Protein percentage deviations	Expected deviation from breed average for the percentage of fat and protein during a 305-day lactation in a herd of average management.	Units: Percentage points Scale (HO): ±0.80 for Fat and ±0.50 for Protein
Lactation Persistency	Expected daily milk yield of daughters at 280 days in lactation expressed as a percentage of their daily milk yield at day 60 (or day 90 for breeds other than Holstein).	Average bull is 66% (HO) while the range is from a low of 56% to a high of 76%.
Conformation traits	Expected relative superiority of first lactation daughters for each type trait.	Average bull is 0 with a range exceeding −15 to +15.
Somatic Cell Score	Expected somatic cell score of daughters during the first three lactations. Lower somatic cell counts reflect more resistance to mastitis.	Average bull is 3.00 with a range from 2.50 (desirable) to 3.50 (undesirable).
Herd Life	Number of additional lactations that daughters are expected to last due to reduced involuntary culling compared to the average bull, independent of daughter production levels.	Average is set to 3.00 for all breeds with a general range from 2.40 to 3.60 lactations.
Milking Speed	Expected percentage of first lactation daughters evaluated as "Average" or "Fast".	Average in all breeds is 85% with the poorest bulls below 70% and the highest near 95%.
Milking Temperament	Expected percentage of first lactation daughters evaluated as "Average", "Calm" or "Very Calm".	Average in all breeds is 90% with a range from 70% to about 95%.
Calving Ease	Expected percentage of progeny born from first calf heifers evaluated as "Unassisted" or "Easy Pull" at the time of their birth.	Available for Holsteins, Ayrshires and Jerseys where breed average for Holsteins is 85% and range is from below 70% to a high of over 95%.
Maternal Calving Ease	Expected percentage of daughter calvings evaluated as "Unassisted" or "Easy Pull" at the time when they give birth to their first calf.	Available only for Holsteins, Ayrshires and Jerseys where breed average for Holsteins is 85% and range is from below 70% to a high of over 95%.
Daughter Fertility	Measurement of the expected fertility of a bull's daughters evaluated across all lactations.	Average varies by breed. For Holsteins, average is 66% with a range from about 55% to 75%.