

Establishment of a Single National Selection Index for Canada

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Introduction

Ten years ago, in 1991, the first selection index formula was introduced for genetically ranking dairy bulls and cows in Canada. This Lifetime Profit Index (LPI) followed the introduction of a BLUP Animal Model for estimating genetic evaluations for males and females in all Canadian dairy cattle breeds for both production and conformation traits. The combination of these two historical genetic evaluation improvements has significantly contributed to the increased rate of annual genetic progress achieved during the past decade (7).

Five years later, in 1996, a second sire selection tool was officially introduced, named Total Economic Value (TEV). The TEV was established based on published scientific research identifying appropriate economic values for traits that affect cow profitability (3). Although the LPI and TEV had common elements, mainly the relative importance of fat and protein yields, the LPI focused solely on type traits as a measure of longevity whereas the TEV included bull evaluations for Herd Life (2) as well as udder health traits (1). Given the difference in relative emphasis placed on production compared to conformation and/or longevity, the TEV was preferred by a minority group of commercially oriented dairy producers.

In recent years, the need for two national selection index tools for genetic selection in Canada had diminished. Producers and industry organizations gained recognition of the strengths and weaknesses of the LPI and TEV. The desire to combine the qualities of each formula into a single national selection index tool became a driving force for the new LPI that was officially adopted in August 2001 (5).

Previous Lifetime Profit Index (LPI)

Since its inception, the goal of the LPI was to place 60% emphasis on production and 40% emphasis on type traits that support high production over several lactations. Although the exact weights on various traits has evolved over time, the LPI in most recent years placed relative emphasis of 49.1% on protein yield, 10.9% on fat yield, 3.6% on overall conformation, 18.2% on mammary system, 14.6% on feet and legs and 3.6% on capacity.

Since bulls and cows received genetic evaluations for all traits in the LPI formula, all animals with an official evaluation for production and type traits also received an official LPI value. LPI values for young bulls, heifers, embryos, etc. were calculated based on parent averages. In the Holstein breed, bulls first proven outside of Canada received MLPI values based on their official MACE evaluations in Canada as provided by Interbull. Canadian Dairy Network published official listings of Top LPI bulls and cows as well as Top MLPI bulls. Due to its ease in understanding and broad visibility, the LPI was the primary genetic selection tool used by producers and A.I. studs.

Total Economic Value (TEV)

The TEV placed 64.5% emphasis on production, 25.8% on herd life as a measure of longevity and 9.7% on udder health, which included somatic cell score, udder depth and milking speed. Genetic evaluations for herd life, somatic cell score and milking speed were not available for cows, so TEV was published only for proven sires. The lack of MACE evaluations for the same list of traits also prevented foreign sires from having MACE TEV rankings.

Although the TEV had technical merit, its limitations in application hindered wide acceptance and use by producers. In recent years, however, advocates of the LPI recognized the value of herd life and the udder health traits, primarily somatic cell score, as they affect lifetime profitability.

Development of a Single National Selection Index

Underlying Principles

For the first step in establishing a new, single, national selection index formula, the strengths of the LPI and TEV were used to identify the following underlying principles:

- (1) Maintain the desired 60:40 relative emphasis between production and type/longevity.
- (2) Move some emphasis from protein yield to fat yield to better reflect the multiple-component pricing system applied domestically.
- (3) Minimally incorporate somatic cell score as a measure of udder health.
- (4) Replace overall conformation with herd life as a more direct measure of longevity.
- (5) Have weights sum to 10 or 100 to facilitate producer understanding.

Major Components

Since the LPI was widely used and internationally known, the approach taken was an expansion of the previous formula to create a “New LPI” with three main components:

New LPI = Production + Durability + Health

Following consideration of achieved rates of genetic progress and breed goals, the relative emphasis to be placed on each of these major components in the New LPI varied by breed, as described in Table 1.

Table 1. Relative Emphasis in the New LPI by Breed

Breed	Production	Durability	Health
Holstein	57%	38%	5%
Ayrshire	65%	30%	5%
Other Breeds	60%	35%	5%

Production Component

In all dairy breeds, with the exception of Jersey, the production component included only fat and protein yields with relative weights of 2.5 and 7.5, respectively. Since the Jersey breed desired stronger selection intensity on the milk components, a negative weight on milk volume was approved resulting in relative weights of -2 Milk, 2 Fat and 6 Protein.

In order to facilitate the industry personnel and producer understanding of the New LPI formula, the coefficients for traits within each major component sum to 10 and the sum of relative weights across the three main components is 100 percent. This approach requires that the genetic evaluation for each trait be standardized using appropriate parameters for each breed. Table 2 provides the current mean and standard deviation for milk, fat and protein EBVs by breed, as used in the New LPI.

Table 2. Mean and Standard Deviation (SD) of Yield EBVs for bulls, by Breed

Breed	EBV Mean (SD)		
	Milk	Fat	Protein
Ayrshire	-122 (527)	-4 (20)	-3 (16)
Brown Swiss	-43 (591)	-3 (25)	-2 (20)
Canadienne	11 (466)	0 (13)	0 (8)
Guernsey	-7 (619)	1 (25)	-2 (21)
Holstein	101 (830)	9 (31)	5 (25)
Jersey	142 (802)	6 (34)	4 (25)
Milking Shorthorn	-178 (574)	-4 (22)	-4 (15)

Durability Component

In addition to increased production, the Canadian breeding objective promotes long-lasting cows that can withstand the stress of high production over several lactations. The durability component of the New LPI represents increased profit expected in future daughters during their lifetime. This includes herd life, a measure of longevity independent of production, as well as conformation traits that contribute to increased profits while in the herd. The specific traits and relative weights associated with the durability component of the New LPI for all breeds are herd life (20%), mammary system (40%), feet and legs (30%) and capacity (10%). The parameters required to express the genetic evaluation for each trait in standard units include a mean of 3.00 and standard deviation of .14 for herd life while the three type traits all have scales with mean of zero and standard deviation of 5.

Health Component

The udder health portion of the TEV (1) was accepted as an obvious starting point for the health component of the New LPI. This includes somatic cell score (60%), udder depth (30%) and milking speed (10%). Somatic cell score ratings have a mean of 3.00 and standard deviation of .23. Since lower somatic cell score evaluations are desirable, the coefficient in the New LPI formula is negative. Udder depth evaluations have mean zero and standard deviation of 5 like other type traits while milking speed is expressed on a scale with 69% “Average and Fast” as the breed average and a standard deviation of 4.8 (9). Future enhancements of the LPI formula could include the expansion of this component to include management traits such as milking temperament (6), calving ease (9) and/or female fertility once appropriate economics weights are determined.

Relative Emphasis in New LPI for Holsteins

Table 3 provides a summary breakdown of the traits included in the New LPI formula applied to the Holstein breed.

Table 3. Breakdown of Relative Emphasis in New LPI for the Holstein Breed

Production (57%)	Fat Yield	(25%)
	Protein Yield	(75%)
Durability (38%)	Herd Life	(20%)
	Mammary System	(40%)
	Feet & Legs	(30%)
	Capacity	(10%)
Health (5%)	Somatic Cell Score	(60%)
	Udder Depth	(30%)
	Milking Speed	(10%)

Correlation Factors

Within the production component, the correlation between bull EBVs for fat and protein yield is reasonably high ($\geq 70\%$) which is not the case for the average correlation between the traits within each of the durability or health components at approximately 30% and 20%, respectively, for the Holstein breed. Assuming that all genetic evaluations included in the LPI formula are accurately standardized, the industry expectation is that the variation in the number of points accumulated on a bull by bull basis for each of the major components respects the desired relative emphasis on each component, when evaluated across the entire bull population. In order to meet this expectation, the Durability and Health components

require a multiplicative “correlation factor” as outlined in Table 4 for each breed.

Table 4. Correlation Factors in the New LPI by Breed

Breed	Durability Correlation Factor	Health Correlation Factor
Ayrshire	1.1846	1.3520
Brown Swiss	1.3042	1.3815
Canadienne	1.4180	1.0427
Guernsey	1.3879	1.3204
Holstein	1.2925	1.2824
Jersey	1.1716	1.5991
Milking Shorthorn	1.5456	1.5044

Improved Calculation of Indirect Herd Life

Published bull evaluations for Herd Life are a combination of an estimate of direct herd life, based on the actual survival of daughters through each of first, second and third lactation, and indirect herd life calculated using a multiple trait regression prediction equation (2). Given the intent to include Herd Life into the New LPI formula, an analysis was done to improve the calculation of indirect herd life (4). Since LPI values are calculated for bulls and cows and MLPI values are required for foreign bulls, a prediction formula for herd life was needed based only on traits for which Interbull publishes MACE evaluations.

Holstein bulls with high-reliability evaluations for direct herd life were used to establish a prediction equation that could be applied to compute indirect herd life evaluations for younger bulls, cows and foreign bulls. Several multiple trait regression models were compared in order to maximize the adjusted R-square of the model while retaining only linear and quadratic terms for traits of significance. In order to avoid confusion in the interpretation of resulting regression coefficients, especially when some traits of positive relationship receive a negative coefficient, the final model concentrated on major type traits rather than descriptive ones. After accounting for the different scales of expression of genetic evaluations for various traits, the approved formula for calculating indirect herd life included somatic cell score (24% emphasis), mammary system (22% emphasis), feet and legs (16% emphasis), capacity (15% emphasis), milking speed (13% emphasis) and rump angle (10% emphasis).

Application of the New LPI

The New LPI formula was officially implemented with the August 2001 genetic evaluation release (5). For Holsteins, the correlation between the previous and New LPI was 98%. Nevertheless, bulls with extreme evaluations for newly incorporated traits, such as somatic cell score, did see an important change in their LPI rank.

LPI for Cows

With the increased interest in genetic selection for reduced somatic cell scores and the incorporation of this trait in the New LPI, cow indexes for this trait have been officially published since August 2001. The genetic evaluation system for milking speed is based on a subjective appraisal provided by the herd manager within the first six months of each cow's first lactation (9). The BLUP animal model used for estimating genetic evaluations yields cows indexes for milking speed. Although these genetic evaluations are not published they are used to compute cow LPI values in each breed. As described earlier, the herd life value used within the durability component of the New LPI formula for cows is based on the prediction formula for indirect herd life after some adjustment to the same scale and base as for the bulls.

MLPI for Foreign Sires

An important group of bulls for which the New LPI formula required special attention are those first proven in another country that only have a MACE evaluation in Canada. The introduction of expanded Interbull services to include production traits and somatic cell score for all major breeds, as well as type traits for the Holstein and Jersey breed, was beneficial for meeting the desired objective. The New LPI formula requires values for herd life and milking speed in the Holstein and Jersey breeds while the lack of MACE evaluations for type traits in the other breeds prohibit the calculation of MLPI values.

For milking speed, there is currently no alternative procedure that can be used to provide a reasonable estimate for foreign bulls from a variety of countries. For this reason, the breed average value of 69 percent is used for all foreign bulls when calculating MLPI values in the Holstein and Jersey breeds.

In the case of herd life, the research carried out to determine the prediction formula for indirect herd life, based on traits for which Interbull provides MACE evaluations, was applied to foreign bulls in the Holstein and Jersey breeds. Both the production and durability components of the formula used to compute MLPI values for foreign bulls were exactly the same as those used for domestically proven bulls.

As for the health component, since all foreign bulls were assumed to be breed average for milking speed on the Canadian scale, somatic cell score and udder depth indirectly received slightly greater emphasis in the MLPI compared to LPI values for domestically proven bulls.

Looking to the Future

The Lifetime Profit Index (LPI) has been and will continue to be the major genetic selection tool in Canada. Following the successful blending of the strengths of the former LPI and TEV formulae into the New LPI as the single, national selection index value, the publication of TEV was terminated as of August 2001.

Although the New LPI formula includes more traits than before, the expanded services of Interbull to include somatic cell score and type traits for breeds other than Holstein played an important role in achieving approval for implementation. The need for MACE evaluations for type traits in other dairy breeds, especially Ayrshire, Brown Swiss and Guernsey, as well as for MACE evaluations for longevity traits in all dairy breeds is obvious for improving the calculation of MLPI values for foreign bulls in Canada.

Given that Canada recently implemented a new genetic evaluation system for milking temperament (6), consideration will be given to including this trait as the health component expands to include health and management traits. Also of future interest would be the incorporation of genetic measures for direct and maternal calving ease (9) as well as female fertility, assuming that Interbull services will eventually include these traits as well.

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