Trends in the Canadian Dairy Cattle Improvement Industry

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Take Home Messages

- Trends associated with the Canadian dairy cattle industry and the Canadian population in general will require producers, and the industry that serves them, to be more efficient with a focus on maximizing profits rather than revenue.
- As the number of Canadian dairy farms continues to decrease and average herd size increases, the implementation of new technologies will become more important as will the full participation in all breed improvement programs.
- Milk recording services will adapt to the increased automation on the farm including on-farm herd management systems and milking systems with more in-line analyzers and herd health indicators.
- The commercial availability of sexed semen and semen from cloned males will make a significant, positive contribution to increasing herd profitability for producers that use them.
- Genetic evaluation systems will increase in complexity and add new traits associated with reproductive performance, disease resistance and the nutritive value of milk and its components.
- Relative emphasis on genetic selection for increased production and longevity will gradually be decreased to a point where they are balanced with relative emphasis on traits associated with health and fertility.
- The field of genomics, in combination with current programs and services based on quantitative genetic theory, will have a major impact on breed improvement strategies by allowing for genetic evaluation estimation early in life, a higher degree of accuracy in genetic selection and mating decisions and a balanced approach between genetic gain and inbreeding.

■ Introduction

The Canadian dairy cattle improvement industry has a long history that traces back to the importation of cattle during the 19th century. It was at that time that breed associations, such as the Holstein-Friesian Association of Canada established in 1884, started the official recording of animal identification information and pedigrees. In 1905, Canada introduced its first milk-recording program, which primarily focused on measuring butterfat yields. Now, more than 100 years later, DHI services have expanded extensively to include the recording of milk yields, sample analysis for milk components, somatic cell counts, milk urea nitrogen, calving dates, calving ease, calf survival, breeding, disposal dates and reasons, milking speed and temperament as well as the whole herd inventory. More recently, in 2007, Canadian DHI partners further expanded its data collection and management information to include disease incidence and herd health. More than 80 years ago, breed associations also started a type classification program that has now resulted in a common Multi-Breeds Classification System across all dairy breeds. For the past 65 years, artificial insemination has been commercially available with young sire testing programs being introduced over 50 years ago.

While it is easy today to look back in time to see the changes that occurred over the past 100 years, it is also important to examine current trends to ensure that the industry continues to progress in the future. What are the major trends affecting the Canadian dairy cattle improvement industry and how should we prepare for the future to sustain a solid base of profitable dairy farms and the industry organizations that they support?

■ Demographics

There is no doubt that demographic trends will have a significant impact on the dairy cattle improvement industry. Of these trends the decreasing number of dairy cows and farms is one of the most important. Figure 1 shows the evolution in number of Canadian dairy farms from 1971 to 2006 as well as a further ten-year projection. It is estimated that the number of dairy farms will almost be halved by 2016 to approximately 8,000 in total (CDN, 2007). Since the rate of decreasing cow numbers has been slower (AAFC, 2007), it is estimated that the average size of the milking herd will grow from approximately 60 to 100 cows over the same time period. Alongside the move towards larger herd sizes, one could also expect greater automation and the implementation of improved technologies at faster rates than previously. Herd owners will need to become more business oriented and strive to access all information valuable for timely and accurate herd management decisions. Focus will shift from “maximum income” to “maximum profits”, especially as international pressure is applied to the existing supply management system in Canada.

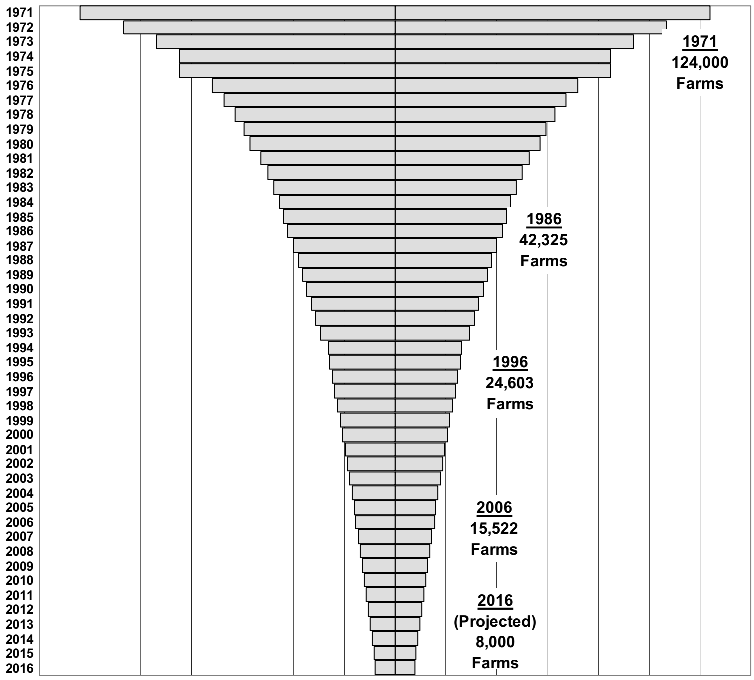

Figure 1: Number of Dairy Farms in Canada (CDN, 2007)

What about the demographics associated with the age of dairy producers? Figure 2 shows the age pyramid of the general Canadian population in 2006, which shows the number of males (left) and females (right) within each birth year (i.e.: age). It would be fair to speculate that such an age pyramid would be very similar within the dairy farming population. Based on this assumption, it is clear that those from the “Baby-boomer” generation (currently between 40 and 60 years of age) represent a major proportion of the population. This suggests that a significant number of dairy producers will be reaching 65 years of age over the next 25 years and therefore will plan to retire. Unless there are a disproportional number of younger people interested in entering the dairy cattle industry, these demographic trends indicate a major drop in the number of dairy producers and their median age during the next two decades.

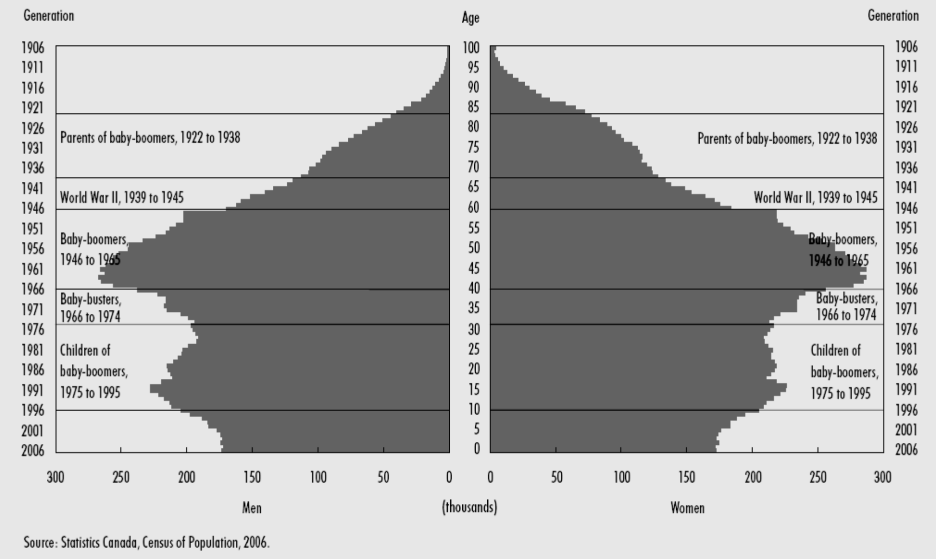

Figure 2: Age Pyramid of the Canadian Population in 2006

▪ Technology

The lower median age of dairy producers in the future will likely be associated with an exponential interest in increased technology and automation on the farm. Simple examples will be the use of computers, the Internet and herd management software packages to record information and assist in making informed decisions. As herd sizes increase, these changes become more and more important to reduce labour costs and to increase the total amount of output per man-hour of input.

The increased computerization of on-farm systems will no doubt affect the type and mode of delivery of services from the dairy cattle improvement sector. Electronic and/or phone-based systems for the submission of animal identification and registration information, with or without digital photos, will continue to grow to a point where more labour-intensive paper forms will be totally eliminated. In the area of milk recording, it will not be long down the road that in-line analyzers for milk component analysis and/or somatic cell indicators will be incorporated into electronic and/or robotic milking systems at the farm level. On the other hand, there is also a clear trend towards increasing the value of the current approach to collecting regular milk samples on a cow-by-cow basis by expanded the laboratory tests that can be done. The traditional analysis of milk components, primarily fat and protein, was expanded more than 20 years ago to include somatic cell count as an indicator of mastitis. Within the past ten years, the same milk sample has been used by some DHI organizations in Canada to evaluate milk urea nitrogen (MUN) levels, as an indicator of the protein balance in the cow's diet and perhaps her reproductive performance, as well as the percentage of lactose, which may be linked to energy balance. More recently, the milk sample has been used for testing the presence of specific diseases including Johne's and Leukosis while research is ongoing to find other valuable uses of the traditional milk sample for herd management.

Genetic Improvement

Within the area of genetic improvement, there are several important developments on the horizon that will significantly change the landscape of genetic selection in dairy cattle. The developments can be categorized into three areas, namely technological, genetic evaluation systems and genomics.

Technological Advances for Genetic Improvement

Within the A.I. sector, there are various examples of new technologies that will affect the dairy cattle improvement industry in the future. Perhaps the most significant of these include the commercial availability of sexed semen as well as semen from cloned elite proven sires. Already today, all major global A.I. companies produce and offer sexed semen for selected bulls of various dairy breeds. In general, the objective is to shift the sex ratio of resulting progeny to eventually guarantee a female calf. The current technology yields success rate of approximately 90% but there is no reason to expect that it will not be able to attain "100% guarantee" in the relatively near future. The result from a producer's perspective is that they would be able to produce more heifer calves as potential herd replacements and therefore apply higher rates of selection intensity. Male calves, when desired, could be produced solely from the best cows in the breed for entry into A.I. testing programs.

The commercial usage of semen from cloned bulls is only permitted in very few countries today but the trend is towards approval of this technology as a means to reproduce superior animals. An elite proven sire with three clones, for example, would ultimately quadruple the total capacity of semen production that can be sold in their lifetime. This increased supply of semen from elite males would allow for a wider usage across many countries and, in some cases, lower the price per dose of semen at the farm level.

The following are other technological advances that will affect genetic improvement programs but to a lesser degree:

- Improved techniques for the collection, evaluation, dilution, freezing, storage and thawing of semen for artificial insemination.

- Methods of heat detection and synchronization to optimize reproductive performance of heifers and cows at the herd level.
- Advancements in techniques used for superovulation of elite donor cows and the extraction, evaluation, freezing, storage, thawing and implantation of embryos to increase genetic selection on the female side.

Advances in Genetic Evaluation

Genetic selection programs are heavily dependent upon the availability of genetic evaluations for important traits of interest. Not only are genetic evaluation methods becoming more complex but the list of evaluated traits has been growing continuously. Currently, Canadian Dairy Network (CDN) calculates and publishes genetic evaluations for a total of 78 different traits in each of seven dairy breeds, including 20 production, 29 conformation and 29 functional traits. To simplify genetic selection decisions, these evaluations are combined into a single index, the Lifetime Profit Index (LPI), which is published for every male and female in the CDN database regardless of age. Some minor differences exist across the breeds in the specific LPI formula used to reflect their specific genetic improvement goals. Details of the formula used are available on the CDN web site (www.cdn.ca). In simple terms the LPI formula can be divided into three components:

LPI = Production + Durability + Health & Fertility

Since January 2008, the LPI for Holsteins has a relative emphasis of 51% on Production with 34% on Durability and 15% on Health & Fertility. Figure 3 shows the evolution of the relative emphasis placed on the various traits since the LPI was officially introduced in January 1991. After the first decade with the LPI, during which time the major adjustments related to the relative weight on protein versus fat, the Canadian dairy cattle improvement industry made a move to replace some of the weight on type traits with direct selection for longevity and added emphasis on traits related to the improvement of udder health (i.e.: somatic cell score, udder depth and milking speed). Since January 2005, the LPI formula for all breeds was further expanded to include Daughter Fertility as a measure of reproductive performance in the daughters of each bull, which became a new trait family with genetic evaluations in late 2004. Most recently, in January 2008, the weight given to Daughter Fertility was doubled from 5% to 10% in an effort to counteract the underlying antagonistic genetic associations between production and reproductive performance.

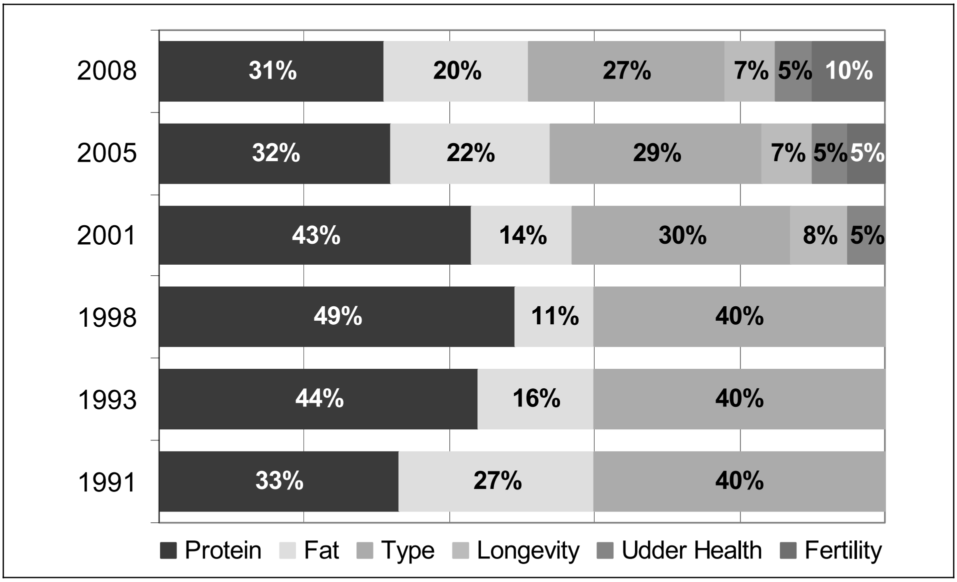

Figure 3: Evolution of Trait Emphasis in the Lifetime Profit Index (LPI) for Holsteins

In terms of the future traits of importance and relative weights between the Production, Durability and Health & Fertility components of the LPI, the crystal ball appears quite clear for the next decade or two. Prior to 2001, the Production component represented 60% of the overall selection emphasis in the Canadian dairy cattle improvement industry. Since that time, the trend has been a gradual reduction in the emphasis on this component, to a current level of 51%, while Health & Fertility has gained importance from 5% to 15%. The Durability component, which represents longevity and important type traits related to survival, has decreased from 40% prior to 2001 to the current relative weight of 34%.

With the growing producer interest in managing costs associated with reproduction and health, there is no doubt that the relative emphasis on the Health & Fertility component of the LPI will continue to increase. In fact, with the 2007 introduction of the national dairy cattle health data management system milk-recording agencies across Canada have expanded their services to include the collection of health events including the incidence of eight specific diseases. As individual cow data is collected from many herds for these key dairy cattle diseases, namely mastitis, lameness, cystic ovarian disease, displaced abomasum, ketosis, metritis, milk fever and retained placenta, the development of a national genetic evaluation system for the selection of improved disease resistance will be a natural by-product within the next 3-5 years. Once such genetic evaluations are available, the Health & Fertility component of LPI will be further expanded, perhaps with an overall weight of 20-25%, leading to a reduction of emphasis on Production and possibly Durability.

Other traits on the horizon for which genetic evaluations are expected include body condition score, milk urea nitrogen and milk lactose content. To a certain degree, research has suggested that each of these traits may contribute to a cow's reproductive performance through the protein and/or energy balance of the diet. In addition to the current uses of a milk sample for herd management, current research is examining the potential for genetic improvement of the content of conjugated linoleic acid (CLA) in milk as an additional measure of its nutritive value for human consumption. Any or all of these "new" traits that may be available for genetic improvement within the next ten years will also increase the emphasis on the current Health & Fertility component of LPI at the sacrifice of selection for Production and Durability per se. By the year 2018, it is reasonable to predict that the current relative weights of 51% Production, 34% Durability and 15% Health & Fertility in the LPI formula will progressively approach equal emphasis of approximately one-third on each component.

Genomics

All current programs and tools available to achieve genetic improvement of dairy cattle have been based on principles and theory associated with quantitative genetics. While these tools have been very successful over the past fifty years or so the future lies in combining the fields of quantitative genetics and genomics together to identify genetically superior animals. Two major areas where the field of genomics can add significant value over and above the current breed improvement strategies include the reduction in generation interval and the increase in accuracy of selection.

With strategies based on quantitative genetic principles, such as young sire testing programs, the genetic merit of the sire is known after five years of age based on the performance of his daughters. With current progeny group sizes of approximately 100 daughters, traits of lower heritability do not reach levels of accuracy acceptable to producers for confident selection decisions. As new traits, especially those related to health and fertility that tend to have lower heritability levels, become more important, the dairy cattle improvement industry will need to find ways of increasing the accuracy of genetic evaluations. While this can be achieved through a significant (i.e.: 2-3 fold) increase in progeny group sizes resulting from young sire testing programs, the most promising solution seems to come from the field of genomics.

Genomics is the study of how the genome of an organism (in this case the dairy cow) is structured and how the genes and their controlling elements function individually and in concert with each other to produce the observed phenotype. Simply stated, genomics research is aimed at establishing links between genes and phenotypic performance for traits of interest.

Early work in the area of dairy cattle genomics tried to find the genes that had a major effect in dairy cattle production. In the end, this approach provided more knowledge of genetic anomalies, such as DUMPS, BLAD and CVM in the Holstein breed, rather than important desirable traits such as production, reproduction and health, which are controlled by many genes. The use of *Quantitative Trait Loci* (QTLs) aims at mapping the location of a few genes that have a moderate to large effect since they explain significant levels of the variation observed within the population for the trait of interest.

A very promising technology that is now heavily used is a process that searches for variants or mutations (called SNPs) within the whole genome sequence. These variants are scientifically called *Single Nucleotide Polymorphisms*, or SNPs for short, and so far over two million have been identified within the bovine genome as part of the international sequencing initiative. The basic concept underlying this novel approach is quite straightforward. Using laboratory equipment, tests are done to associate SNPs along the entire genome with trends in variations for specific traits within the population. Once these associations are established the DNA from individual animals can be genotyped to determine if they are desirable for these traits or not. Since DNA can be collected at birth the identification of elite animals with "proven" superior genetics can theoretically be done with reasonable accuracy at a very early stage of their life rather than waiting for their own performance (cows) or that of their progeny (sires). A key advantage of genomic selection over quantitative selection is that the focus of genomics is at the DNA level of the animal rather than a detailed analysis of the phenotypic performance of the animal and/or its progeny. The collection of pedigree and individual animal performance for all traits of interest remains critical, however, such that the proper associations can be accurately identified between the SNPs and the trends in variations found in the phenotypic data. There is no doubt that the area of genomics will significantly change the landscape for breed improvement strategies in dairy cattle populations nationally and internationally. In addition, genomics will also become an important tool in accurately measuring the true inbreeding level of each animal within a population and significantly contribute to future programs and methods for balancing genetic progress with rates of increasing levels of inbreeding.

■ Conclusions

The dairy cattle improvement industry is no different that others in that it is continuously changing. While there are many external and internal forces that have and will have an impact on the dairy cattle industry in general, those that are expected to greatly affect dairy cattle improvement programs and services include demographic trends, technological advances and developments associated with genetic improvement.

Trends associated with the Canadian dairy cattle industry and the Canadian population in general will require producers, and the industry that serves them, to be more efficient with a focus on maximizing profits rather than revenue. As the number of Canadian dairy farms continues to decrease and average herd size increases, the implementation of new technologies will become more important as will the full participation in all breed improvement programs. Milk recording services will adapt to the increased automation on the farm including on-farm herd management systems and milking systems with more in-line analyzers and herd health indicators. The commercial availability of sexed semen and semen from cloned males will make a significant, positive contribution to increasing herd profitability for producers that use them. Genetic evaluation systems will increase in complexity and add new traits associated with reproductive performance, disease resistance and the nutritive value of milk and its components. Relative emphasis on genetic selection for increased production and longevity will gradually be decreased to a point where they are balanced with relative emphasis on traits associated with health and fertility. The field of genomics, in combination with current programs and services based on quantitative genetic theory, will have a major impact on breed improvement strategies by allowing for genetic evaluation estimation early in life, a higher degree of accuracy in genetic selection and mating decisions and a balanced approach between genetic gain and inbreeding.

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