Canadian Herefords & Genomics

Genomics is re-inventing the art of cattle breeding. Traditional selection tools remain absolutely necessary. They are simply augmented and refined by new technologies. Throughout history, new science has been rejected again and again. Genomic technologies are no different. Each breeder must decide how to use these evaluations and whether or not they meet their needs or the needs of their customers. But they currently are being credited for advances in herd health, improved production parameters and better economic returns, inside other livestock industries. Those who promote the science within the beef sector swear by these new innovations as a means of saving our industry and our way of life. It is progressive, vigilant thinking.
The following three articles are three new perspectives on the science which we're all grappling with. They are all worth a read for a widened, clearer perspective.

Opportunities For Selection

A fresh perspective and overview on new genomic technologies

By Tom Lynch-Staunton Director of industry relations, Livestock Gentec and Delta Genomics Centre
& Dawn Trautman, Technology Translator

WHERE'S THE BEEF?

The Canadian beef industry has experienced some growing pains in recent years. Concerns encompass the entire production chain: from the cost of producing a market ready animal to ensuring that the consumer wants the product in the first place. One might ask, "Where's the beef?" That is, what solutions are available to re-create the momentum of an industry that is important economically but also represents a way of life?

Producers have been selecting breeding animals based on physical variations for centuries. But, improvements have been limited to relatively easy-to-measure traits and have only been achieved with trial and error, making progress slow and erratic.

Technological advancements have allowed the combination of phenotypic and genealogical information for improved accuracy in trait selection, while still using somewhat traditional methods. However, for difficult-to-measure traits with low heritability, such as feed efficiency, disease resistance and carcass quality, more precision and efficiency in selection is necessary for the industry to advance. Successful, timely, and cost-effective selection for these types of traits cannot be achieved using traditional methods alone.

The Hereford cow, L1 Dominette 01449 is the first bovine to be sequenced.

WHAT IS GENOMICS?

Selection using genomic technologies has been labeled a 'paradigm-shifting' innovation, but what is it and how does it work?

In 2002, the Bovine Genome Project was conceived and the entire genome of a Hereford female was sequenced in 2009. (The bovine genome is made up of roughly three billion base pairs with approximately 22,000 genes.) This marked the beginning of the opportunity to use analytical tools for novel applications in the beef industry.

Genetic progress is cumulative when used appropriately in a breeding program – meaning benefits will grow each year.

Genomics is the extraction and analysis of DNA in order to identify important genetic variation (e.g., SNPs, INDELs, and CNVs [1]). It is a science that analyzes the relationship between genetics and traits, and uses the data to solve problems, while considering all genes and the interacting components of an organism.

Using genomics increases the accuracy of trait selection, and can increase the rate of genetic gain in livestock. Genetic defects can be managed and valuable traits recovered.

WHAT IS LIVESTOCK GENTEC?

Livestock Gentec is an Alberta Innovates Bio Solutions Centre based at the University of Alberta. We are an organization based on the collaboration of world-class scientists in genomics research, led by CEO Dr. Graham Plastow. We partner with other leading research institutions and networks, industry associations, government agencies, and private sector companies. Our service arm, Delta Genomics, provides genotyping and sequencing services for the livestock industry and research communities.

RESEARCH ROUNDUP

Gentec is involved in over 20 beef research projects, many with the Canadian Hereford Association as a partner. One of the current initiatives is the Canadian Cattle Genome Project (CCGP). The objective of this project is to develop accurate genomic prediction equations by genotyping a large number of cattle, which will create a reference population for improving genetic progress in the Canadian cowherd.

The project, 'Accelerating the adoption of SNP based DNA genomics technology in the Canadian Cattle Industry' aims to further reduce costs of genotyping and speed up the adoption of genomic technology by facilitating the transition from microsatellite based parentage verification to SNP based parentage verification for Hereford and other breed associations.

A large collaborative project with the Canadian Hereford Association (CHA), Olds College, and others, is the Residual Feed Intake (RFI) research project. This is a three-year project where 900 Hereford bulls are being measured for RFI, with the end goal being the development of EPDs[2] for feed efficiency. Each bull is also DNA genotyped for increased accuracy of Hereford measured traits.

The most effective way for commercial producers to take advantage of the opportunities genomics offers is to buy a bull that has been DNA profiled and which is accompanied by other physical records and EPDs – all of which reflect the traits that match the objectives of your breeding program.

WHY DOES IT MATTER?

Global demand for sustainable protein sources is increasing. We exist in a global marketplace and have an opportunity to increase food security beyond our borders. Domestically, consumption is falling. But there are opportunities to introduce value-added products consumers demand, along with information on food safety, quality, animal welfare, and environmental sustainability.

On the production side of the equation, rising feed and animal care costs are making profit margins slim, at best. Trade restrictions are proving to be on-going and challenging issues. And the effects are being felt – we have fewer producers and fewer cows.

So, what can genomics technologies offer an industry facing multifaceted challenges? For producers, genomics technology can increase competitiveness by providing information for selecting animals with decreased feed intake, improved health, improved breeding performance, and decreased management. Genetic progress is cumulative when used appropriately in a breeding program – meaning benefits will grow each year.

At the industry level, genomics will impact competitiveness by ensuring a safe, healthy meat will be delivered to consumers. Genomics can assist in selecting for animals that are naturally more docile, easy gaining, resistant to disease, and low methane emitters. These qualities, along with the ability to provide foolproof traceability for beef products, amount to an amazing opportunity to provide consumers with quality, safe, and nutritious beef products.

HOW DO I GET IN?

The most effective way for commercial producers to take advantage of the opportunities genomics offers is to buy a bull that has been DNA profiled and which is accompanied by other physical records and EPDs – all of which reflect the traits that match the objectives of your breeding program. Then, be consistent with your actions and objectives.

[1] SNPs or Single Nucleotide Polymorphisms are substitutions in the DNA sequence, INDELs are Insertions or Deletions of bases in the DNA, and CNVs or Copy Number Variations are alterations in DNA that result in variation in the number of copies in a section of DNA.

[2] Expected Progeny Difference (EPD) is an estimate of the expected performance of an animal's offspring.

Peter Fennessey, from Abacus Bio Ltd in New Zealand states "the contribution to the business of an individual producer is very much a consequence of how they behave in the sense of sourcing bulls – the key decision is choosing their bull breeder as this determines their own rate of genetic progress."

Another option, particularly for purebred producers, is to send DNA samples for a 50K SNP profile or even simple sire parentage tests, since identifying sires, and subsequent half brothers and sisters, significantly increases the accuracy and value of EPDs for better breeding animal selection. DNA tests can also help identify bulls that throw calves with high birth weights or genetic defects.

Genomics offers new solutions to old problems. It's Canadian. It's collaborative and it's changing the industry.

No matter where you fit as a producer, stay tuned for opportunities to apply genomics in your program and for information sessions from Gentec and the Hereford Association.

HERE'S THE BEEF

The Canadian beef industry has endured through times of crises – both economically and socially. The industry is not "broken" but in its current state, it simply exists. The historic success and importance of the beef industry means that there is inherent resilience and ability to make the transition to something brilliant possible.

It starts with being bold, pushing past the complacency of merely existing and taking action. The issues facing the beef industry are complex - something that genomics embraces and is able to distill clarity from the noise. Investments should pay dividends and genomics technology has proven its ability to drive productivity and profitability in other sectors, including dairy.

So, "where's the beef"?

It's here, in our own pastures. Genomics offers new solutions to old problems. It's Canadian. It's collaborative and it's changing the industry. Genomics is the opportunity to create solutions for combating environmental challenges, fighting disease, and ensuring a nutritional food supply. The opportunity is now. Let's not miss it.

Cost: Benefit Trade-offs
Economic benefits of genomic technologies

By Tom Lynch-Staunton Director of industry relations, Livestock Gentec and Delta Genomics Centre
& Dawn Trautman, Technology Translator

The Canadian Hereford Association (CHA) has now been involved with numerous genomics research programs, many with Livestock Gentec in Edmonton, Alberta. While the science of genomic technologies can be difficult to translate, the financial benefits are clear and are beginning to be recognized.

Livestock Gentec is dedicated to helping Alberta and Canada maintain their position as global leaders in beef production. Gentec researchers study the uses of genomics as it relates to livestock production in terms of improving efficiency, health, product quality, and traceability. Delta Genomics is our non-for-profit service arm that provides genotyping and sequencing services for the livestock industry across Canada.

COST-BENEFIT ANALYSIS OF GENOMICS

Livestock Gentec and Delta genomics, with consultation services provided by Abacus Bio Ltd of New Zealand, examined the cost-benefit trade-offs of breeding selection tools[1]. The analysis included increased phenotypic trait recordings and genomic testing in the Alberta beef industry.

The study examined the impact of investment in genomic technologies in the beef sector on profitability at the cow and industry levels. The value of technology adoption is disaggregated by sector, including breeder, cow-calf producer, backgrounder, and feedlot/packer. The breeding objective is expressed in dollars per cow mated per year, and is developed using trait weightings, selection index modeling for genetic superiority, and finally as predictions of genetic gain using economic weights. The final value is the benefit of genomics adoption less additional production costs incurred. Beef industry costs and genetic parameter models are specific to Alberta in the analysis.

Based on trends already occurring from genetic progress in the industry, the annual increase in weaning weight is approximately 0.7 kilograms per year. To assess the impact of genetic improvement with technology adoption within beef breeder herds, maternal and feedlot/packer groups are assumed to record additional traits, as compared to the base category that only contains birth, weaning and yearling traits. Cumulating the three categories results in a comprehensive grouping (Table 1). Genomic technology adoption is included in the analysis as genomic breeding values (GBVs) with results obtained for accuracies of 25% and 50%.

THE RESULTS

The financial gains from genomic technology adoption in the Alberta beef industry are specific to participants in the value chain. It is estimated that commercial cow-calf producers, if they are buying bulls with the right information, will receive 40% of the benefit in genetic improvements, the feedlot/packer sector will gain 17%, while the beneficiaries of the remaining 43% are distributed elsewhere along the value chain.

If producers buy bulls with only recorded BW, WW, and PWG EPD's (no genomic profile), it is estimated that the additional value per cow mated per year is $3.90 over the entire industry. By selecting for maternal and feedlot/packer traits while also using current best practices, the values increase to $3.97 and $4.75, respectively. And, if selection of maternal and feedlot/packer traits are combined, the value increases to $4.81 per cow mated per year (Table 1).

The addition of genomic technologies with Genomic EPD accuracies of 25% increases the benefits to $6.37 and $6.58 per cow mated per year for the base and comprehensive traits, respectively. If an accuracy of 50% can be achieved, then the benefits increase to $8.78 and $9.43

Table 1: Estimated Value of genetic progress per cow mated per year, Alberta[2]

Scenario		Benefit value
Current selection methods	Base (BW, WW, PWG)	$3.90
	Base + Maternal	$3.97
	Base + Feedlot/packer	$4.75
	Comprehensive	$4.81
Multi-trait GBVs[3] with accuracy of 25%	Base	$6.37
	Comprehensive	$6.58
Multi-trait GBVs[3] with accuracy of 50%	Base	$8.78
	Comprehensive	$9.43

[1]This study was made possible with funding from Alberta Livestock and Meat Agency (ALMA). Industry expertise provided by the Beef Cattle Research Council, Alberta Agriculture and Rural Development, Alberta Beef Producers, Canfax, Canadian Beef Breeds Council, Beefbooster, and Canadian Limousin, Angus, Simmental, Gelbvieh, Charolais, and Hereford Associations.

Figure 1: The economic value in genetic improvement for this Hereford calf could reach $9.43 with the use of genomic tools; for the entire Alberta beef industry this amounts to over $300 million per year.

per cow mated per year for base and comprehensive trait recordings, respectively (Table 1).

The benefits provided so far represent the benefits per cow mated per year. So, if a producer buys a bull with maternal and terminal Genomically Enhanced EPD's (which the Canadian Hereford Association is working on), and the average trait accuracy is 50% or greater, we can expect a benefit per cow mated of $9.43 in genetic progress. This may not seem like much, but this value will build on itself year to year. So in year 10, we can expect our cows to be worth $94.30 more than they are today.

WHAT ELSE IS NEEDED?

To the bull breeder, this shows the importance of accurate phenotypic recording, complemented with genomic profiles, to add value to bulls for sale. These bulls should be worth more to commercial producers than bulls without any recorded EPDs and/or Ge EPDs at all.

The importance of information flow through the supply chain is highlighted in this study. To achieve the above results, it is assumed that information is shared between sectors in the industry. For example, if selection for carcass quality is not recognized, then the annual value per cow mated per year decreases by $2.56 in the base scenario, because cow-calf producers who are purchasing from bull breeders are not receiving a premium. In this case, it would be more profitable to focus efforts on attributes that are beneficial to the cow-calf producer, such as maternal traits.

To achieve increased adoption of genomics in the industry it is essential that benefits be translated in a manner that is clear to stakeholders.

The use of GeEPDs and indexes will result in improved profits in the industry, due to transparency of information through the supply chain. This is one of several knowledge transfer initiatives that Gentec and the CHA are working on.

WHAT IT MEANS FOR THE INDUSTRY

There are dynamic challenges in the beef industry. Globally, beef demand is increasing due to population and income growth, largely in developing countries. However, domestic trends tell a different story: Canadian per capita beef consumption was 25 kilograms per person in 2003, but by 2011 it was 21 kilograms. The decrease is associated with consumer perceptions of food safety, nutrition, environmental concerns, and a diverse selection of protein sources.

Canada exports about half the beef produced – and in 2012 beef exports were valued at over $1.2 billion. The primary destination for Canadian beef products is the United States and due to regulatory changes (i.e., mandatory Country of Origin Labeling or mCOOL) prices for Canadian beef have decreased. In order to adapt to these changes, the industry must invest in innovative solutions.

Adapting to change requires innovation, and genomics may be the economical answer for the beef industry.

Used appropriately, the Alberta beef industry can use genomics tools to position itself to be a competitive player in the global beef market. Genomic technologies have the potential for improving consumer perceptions of food safety as an application for traceability in the supply chain. Positioning beef as a safe and economical choice among consumers would result in growth opportunities for the increasing global demand for livestock protein.

The financial benefit of genomics is realized when combined with the basics of livestock breeding, including collecting phenotypes, defining clear breeding objectives, and with data collection, sharing, and management within the industry. Knowledge transfer and open access of information is essential to growth and success of this technology application. Adapting to change requires innovation, and genomics may be the economical answer for the beef industry.

With clear financial benefits for the industry, what are you waiting for? The time is now to start using genomics in your breeding plan. The sooner you start, the sooner you will see economic benefits.

[2] Estimated values are calculated as responses to selection without and with using genomic breeding values. Base values assume current practices where birth weights, weaning weights, and post-wean gain are recorded. Comprehensive values assume additional maternal and feedlot/packer traits are recorded.

[3] GBVs are genomic breeding values.

DNA Roadmap

Where we are and how we got to Genomically Enhanced EPDs

By Stephen Scott CHA Executive Director

It is finally reality! The first run of GE-EPDs (genomically enhanced Expected Progeny Differences) will become available after the June 2014 EPD run.

Over the past two years, the Hereford Digest has presented valuable information about research and development of new genomic tools that will be available for use by breeders in 2014. Genomics is still fairly new to the beef industry. However, in other agricultural sectors such as dairy, poultry and crops, genomic science has been used as a selection tool for a few years with great success.

Genomics increase the accuracy and predictability of EPDs. The easiest way to express the value of these gains in accuracy is through progeny equivalents. Canadian Hereford GE-EPDs are still in the construction phase, so the best example from the beef industry we can look to is from the American Simmental Association.

Genomics increase the accuracy and predictability of EPDs.

If you were to pull tail hair on a day-old calf and submit that hair for genomic testing, the resulting GE-EPDs would have the same accuracy as if you waited for him to mature, bred him to five cows and weighed and ultrasounded the resulting five calves as they got older. Genomic evaluations are a powerful tool that can be used by any Hereford breeder. These tests give us more information on young animals than we have ever had before.

If you were to pull tail hair on a day-old calf and submit that hair for genomic testing, the resulting GE-EPDs would have the same accuracy as if you waited for him to mature, bred him to five cows and weighed and ultrasounded the resulting five calves as they got older. Genomic evaluations are a powerful tool that can be used by any Hereford breeder. These tests give us more information on young animals than we have ever had before.

Genomic evaluations don't replace the need to critically evaluate cattle on balanced and functional conformation or performance data. But using this tool can dramatically improve genetic gains within a breeding plan.

Producers should know that genomically testing their cattle is completely voluntary; a tool to be used at their discretion. Genomic testing can be used with or without phenotypic data collection but the collection of accurate weights and ultrasound data do serve to further increase the reliabilities of EPDs and GE-EPDs .

The following steps trace the evolution of the process involved to bring genomically enhanced EPDs to breeders:

THE ROADMAP TO GE-EPDS.....

Traditional Evaluation

Traditional evaluation refers to the production of Estimated Progeny Differences (EPDs) for which the process has remained virtually unchanged since the 1980s. The role of the Canadian Hereford Association (CHA) in traditional evaluation is to maintain the herdbook with current pedigrees and to collect phenotypic data such as calving ease (CE), birthweight (BW), weaning weight (WW) and yearling weight (YW), to help improve the accuracy of EPDs (Roadmap A).

The CHA collects and funnels pedigree and performance information to an Australian-based company, Agricultural Research Business Institute (ABRI). ABRI transforms this raw data into EPDs (Roadmap B) and supplies it back to the CHA to produce EDP Reports for its membership (Roadmap C).

The introduction of genomic technologies doesn't erase what we have known in the past, and will never replace the need for phenotypic data collection. It does, however, add reliability and accuracy to traditional evaluations; especially for younger animals and those with lower accuracies.

Genomic Evaluation

Using genotypes from the ongoing Genome Canada Project, the Hereford RFI trial and submissions from the membership, the CHA has had the opportunity to genomically test 1,482 animals in the herdbook. (Roadmap D).

The incorporation of highly influential animals in this initial step was necessary as these animals have many recorded progeny and therefore have high reliabilities. After the highly influential animals in the population were screened, researchers could determine what differentiated them from one another and how these differences were exhibited in their progeny, genetically. In other words, researchers measured the "SNP effect". This highly detailed process allows mathematical prediction equations to be produced in which the effect that each of the thousands of SNPs have on each trait were estimated (Roadmap E).

All of these SNP effects are added up to end up with a genetic prediction, based on the DNA of the animal, relative to animals that had the same SNP combinations. The values that are produced from this process are called Genomic breeding values (GBVs). They represent a picture of the genes within an animal that can be passed along to next generation. (Roadmap F)

Blending and GE-EPDS

Genomically enhanced EPDs (GE-EPDs) are the result of taking the traditional EPD evaluation and the GBV evaluation and blending the two predictions together. The resulting GE-EPDs should be interpreted exactly the same as traditional EPDs, to which everyone is already accustomed. The biggest change breeders will notice is the increase in the accuracy (Acc.) of EPDs.

Blending the GBV and the traditional EPD is where this technology truly shows its power as a breeding tool. Before genomics, the only way to gain accuracy of an EPD (above recording phenotype) was to wait and produce progeny from that animal.

EPDs are recalculated twice annually to incorporate the new progeny data and as more and more progeny data is entered, the accuracy of each animal's EPDs increases (the EPD value itself will also change slightly, based on the actual performance of the progeny). Adding genomic information to a young animal's traditional EPD evaluation increases its accuracy in a similar way that adding progeny information does. The more data we can measure on an animal, the more accurate the EPD evaluation.

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