

The Benefits of Genomics to the Dairy Industry

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■ Take Home Messages

- Genomics is a new method of genetic evaluation of dairy cattle.
- Genomic information combined with traditional data is more reliable and accurate as a predictor of the genetic merit of young dairy animals than was ever previously available to the industry.
- It is important to remember that genomic information is still a prediction and the final outcome is subject to variation.
- Breeders can use this tool too:
 - Practise more intense selection of females within their herd.
 - Determine which animals are candidates for an embryo transfer program.
 - Select young sires for use in their herd with greater confidence.

Terms

AI	- Artificial Insemination
CDN	- Canadian Dairy Network
DGV	- Direct Genomic Value
EBV	- Estimated Breeding Values (sire proof, cow index)
ET	- Embryo Transfer
GEBV	- Genomic Estimated Breeding value
Genomics	- Study of the genome and its components through DNA
GLPI	- Genomic Lifetime Profit Index
GPA	- Genomic Parent Average
LPI	- Lifetime Profit Index
PA	- Parent Average (heifer & young sire EBV)
REL	- Reliability of future performance
SNP	- Single-Nucleotide Polymorphism (DNA sequence used to evaluate the genomics of the animal)
USDA	- United States Dept. of Agriculture

■ Introduction

Genomics is a new method of genetic evaluation resulting from a collaborative research project between Canada and the United States in cooperation with seven North American based AI businesses which started in 1992. Currently a 50,000 SNP panel chip is used to analyse the DNA and then the USDA in the U.S. and CDN in Canada interpret the results.

Official genomic genetic evaluation was introduced in the U.S. in January 2009 and in Canada in August 2009. Holstein Canada started offering the service of genomic testing females of the Holstein and Jersey breeds in November 2008 with first unofficial results distributed to owners in January 2009. The input of the seven North American AI businesses that co-operated in the research project entitles them to exclusive genomic testing of dairy bulls for a 5 year period ending March 2013. The Canadian based AI businesses included in the project are Alta Genetics and Semex Alliance.

■ Genomic Genetic Evaluation

The estimates of the significance of genomic testing are quite dramatic. Table 1 shows the relative impact of the major developments in genetic evaluation of dairy cattle during the past 75 years.

Table #1. Genetic Evaluation Advances and increases in Genetic progress

Year	Advance	% Gain
1935	Daughter-dam comparison	100
1962	Herdmate comparison	50
1973	Records in progress	10
1974	Modified herdmate comparison	5
1977	Protein evaluated	4
1989	Animal Model	4
2008	Genomic selection	>50

Source USDA

Holstein Canada in the Dec 2009 publication, Info Holstein, states, "Holstein Canada is a strong advocate of the use of genomics for genetic selection. The Association believes it will be the single, greatest development in the modern history of animal improvement".

The gold standard for genetics evaluation is the proof of sires based on the results of progeny for a multitude of traits. Most Holstein sires proven in Canada have approximately 70 daughters in their initial published proof with

85% repeatability. The most popular sires usually have well over 10,000 daughters in their eventual second round proof.

Table #2. Gains in Published REL- LPI by Sub-Group (Jan. 2010)

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Canadian Dairy Network

Sub-Group	Average Reliability (%)		
	Traditional	Genomics	Gain
Young Bulls and Heifers (2007-2009)	34	61	27
Younger Cows in 1 st or 2 nd Lactation	54	68	14
Foreign Cows with MACE in Canada	43	65	22
1 st Crop Proven Sires in Canada	86	89	3
Foreign Sires with MACE in Canada	70	80	10

Table 2 shows the difference between traditional LPI Index and Genomic LPI Index for different ages and sexes for Holsteins. The average reliability is the estimate of accuracy in predicting future performance of an animal for a trait. Bulls with thousands of daughters for example have 99% Reliability and his next group of daughters are expected to average the same as previous daughters. An analogy we see on a weather forecast is the Probability of Precipitation (POP). If the POP is 90% that it will rain, there is much more likelihood that it will than when the POP is 30.

The average Reliability % is the one used by CDN in the second official genomic proof round in Jan 2010. Of particular interest to breeders is the Reliability in Table 2 of 61% for GLPI PA of heifers. This is much higher than the 34% Traditional PA Reliability for heifers and perhaps surprisingly also the 54% for young lactating cows that have not been genomic tested.

Only minor gains are achieved from genomic testing of proven sires but major gains are achieved using evaluation of genetic information from young bulls, heifers, and cows. Genomic Information Details are available on the CDN website (www.cdn.ca) for all genomic tested bulls that have entered AI service and for all genomic tested females in North America of the dairy breeds.

Table #3. Genomic Evaluation Details (Source CDN Jan 2010)

Genomic Evaluation Details				
HOCANM9671621		ROCKYMOUNTAIN TAILOR		
0200HO00572		ET BW BLF CVF		Born 04-APR-08
Sire:	HOUSAM132973942	EMERALD-ACR-SA T-BAXTER	07-APR-02	7.86% 14%
Dam:	HOCANF7789684	CLAYNOOK GOLDWYN TIA	21-MAR-06	6.85% 14%
MGS:	HOCANM10705608	BRAEDALE GOLDWYN	03-JAN-00	15.75% 16%

TAILOR

	Official Genomic Evaluation	Reliability (%)	Reliability Increase with Genomics	Direct Genomic Value (DGV)
LIFETIME PROFIT INDEX	GPA 10*JAN			
GPA LPI	2222	63	+27	2285
PRODUCTION	959	66	+27	814
DURABILITY	1172	61	+24	1355
HEALTH & FERTILITY	91	54	+21	116

PRODUCTION	GPA 10*JAN			
Milk Yield (kg)	801	67	+27	325
Fat Yield (kg)	74	67	+27	77
Protein Yield (kg)	25	66	+26	14
Fat Deviation (%)	0.44	67	+27	0.64
Protein Deviation (%)	-0.01	66	+26	0.05

CONFORMATION	GPA 10*JAN			
Conformation	18	61	+24	21
Mammary System	14	63	+25	16
Feet & Legs	12	57	+22	14
Dairy Strength	15	62	+25	19
Rump	9	56	+22	11

FUNCTIONAL	10*JAN			
Herd Life	GPA 104	58	+23	104
Somatic Cell Score	GPA 2.81	64	+25	2.75
Lactation Persistency	GPA 97	51	+20	96
Daughter Fertility	GPA 101	53	+20	101
Milking Speed	GPA 101	54	+20	101
Milking Temperament	GPA 101	45	+17	102
Calving Ability	GPA 95	68	+25	92
Daughter Calving Ability	GPA 101	51	+19	101

Table 3 is an example of the Change in Reliability for various traits with genomic information added versus traditional information. The gains in REL for production and conformation traits are fairly consistent between 22 and 27%. The gain for functional traits is more variable at 17 to 25% but the proportional gain in these lower heritable traits is greater so the impact on functional traits is very significant.

Table 3 shows the official genomic evaluation for the young bull ROCKYMOUNTAIN TAILOR. Exactly the same format is used for females. CDN publishes the Official Genomic Evaluation, Reliability, Reliability Increase with Genomics and the Direct Genomic Value. An animal's Direct Genomic Value (DGV) is an estimate of it's genetic merit for the specific trait as predicted using **only** its DNA genotype profile. The genotype profile is determined by comparing the DNA of 8400 bulls who have an official proof or MACE proof in Canada and who totally have over 10 million daughters. The number of bulls is expected to increase by about 500 each proof so some changes can be expected in the DGV because of the addition of data.

The official genomic evaluation is a blend of traditional data and Direct Genomic Value. For young animals it is approximately 36% traditional data and 64% DGV. For lactating cows it is approximately 44% traditional data and 56% DGV. For older lactating cows and bulls it is close to 50-50. As a bull increases daughters his DGV is impacted by his daughters and eventually the Official Proof and DGV will be about the same. The DGV for females and young bulls in Canada is not impacted by traditional data.

Actual Examples

Table 4 shows the results of genomic testing 3 young full brothers at RockyMountain Holsteins. If they were 3 full sisters the results would be presented exactly the same.

Table #4. Genomic Results of 3 Full Brothers, Rocky Mountain Holsteins 2009

Trait	3 Brothers		Tailor	Treasurer	Trustee
	PA	GPA	GPA	GPA	GPA
LPI	2060	1920	2222	2122	1416
DGV		1855	2285	2248	1031
MILK	1599	1324	801	1974	1196
FAT	68	62	74	75	38
PROT	42	32	25	50	21
F%	+0.10	+0.44	+0.44	+0.03	-0.06
P%	-0.09	-0.07	-0.01	-0.13	-0.08
Conformation	12	13	18	10	12
Mammary	10	10	14	8	8
Feet & Legs	9	10	12	9	9
Herd Life	104	103	104	103	102
Somatic Cell	2.91	2.91	2.81	2.94	2.97
Dau Fertility	100	100	101	100	99

(Source CDN Jan 2010)

The above table shows the similarities and variation of the results. The first column shows the PA LPI of the 3 brothers. As PA is simply 50% of the sire's and dam's EBV they are all the same. This is the number the industry has worked with to select young sires for the last 30 plus years.

The next column is the average of the 3 brothers for their GPA LPI and although there are some differences the actual average is quite similar to the average PA.

The next 3 columns show the individual bull's own GPA for key traits. The results show they can be very different than their PA and from each other. The bull Tailor with GPA for LPI at 2222 is 162 higher than his PA, 100 higher than Treasurer and a whopping 806 points higher than Trustee. An even bigger difference occurs for Direct Genomic Value with Tailor and Treasurer averaging 851 points higher than their brother Trustee. An analysis of the individual traits shows where the key differences are. Tailor with GPA milk 801 is well below Treasurer with GPA milk 1974. However, Tailor with GPA F % at +0.44 yields a GPA fat of 74 kg where as Treasurer has a GPA F% at +0.03 yielding a GPA Fat of 75 kg. Trustee has only GPA fat of 38 kg. Treasurer is the top brother for GPA protein with 50 kg and Tailor is the clear winner with Conformation GPA of +18 compared to +10 and +12 for his brothers. In the above example Tailor and Treasurer were selected for AI service and Trustee was not. In the past probably only Trustee would have been selected for AI service as he is the best looking of the 3 brothers and what a disappointment that would have been.

Virtually all young sires are genomic tested before entering AI service

providing a direct benefit to farmers because poor candidates for AI are eliminated and the overall quality for young sires available is increased.

■ Use of Young Sires

Because of genomic testing of young bulls, the opportunity now exists to use selected young sires in place of some of the proven sires with the expectation of positive genetic gain.

Proven sires with thousands of daughters are the most reliable from a genetic evaluation point of view. The problem is that by the time a bull has this many daughters he is usually 8 years old and there are many younger sires including his own sons that are genetically superior to him. Most AI services today are from the use of sires that have a first round proof (approximately 100 daughters) and before they have a second round proof. Young sires with only a PA have been considered too risky to use extensively and their use with a few exceptions has been restricted to young sire test herds. Now that there are genomic PA's available this situation will change.

It should always be remembered that all genetic evaluations are predictions of the future performance of an individual in the case of females and daughters in the case of sires.

In my view the increase in accuracy from 35% Reliability to 61% Reliability for young sires makes them a very attractive genetic source to use in a herd. Because 61% REL is still not the 85% REL of most progeny tested sires a different strategy is required for genomic tested young sires. I recommend for starters the continued use of top ranked proven sires. Instead of also using lesser-ranked proven sires I recommend the use of a group (team) of young genomic tested high-ranking sires. Talk to your AI supplier about the genetic improvement your herd requires and select a group of bulls to fit your requirements.

For example, if a dairy herd selects 10 or more high genomic ranked young sires it is very likely that half of these bulls will eventually have proofs that are as high or higher as a group of current top rated sires. In the Jan 2010 proof round CDN lists only 11 bulls with Canadian domestic proof over 2000 LPI. There are hundreds of young sires that have a GPA LPI rating between 2000 and 3000 to choose from. Ask your AI provider for a team of bulls that are over LPI 2000 or meet the criteria you set for your herd breeding goals.

■ Summary

Genomic information provides the opportunity for increased accuracy of selection of young females in a herd. It also provides more accuracy of selection of young sires for the AI industry. The opportunity now exists for breeders to make genetic gain by lowering the generation interval in the herd by using more young sire semen than is currently the practise.

I wish to acknowledge the assistance of Brian Van Doormaal at CDN, Dr. Bob Welper at Alta Genetics Inc. and Dr. Jacques Chesnais of Semex Alliance in the preparation of this presentation.

