Heifer Management Blueprints

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Dairy Heifer Genomics 101

Introduction

Genomic testing for cattle, which became commercially available in 2009, predicts traits that are pertinent to dairy operations, such as milk yield, longevity, and fertility. Most artificial insemination (A.I.) companies have been genomic testing bulls for some time but reasonably low cost genomic tests are now available to test dairy calves and heifers. Genomic testing and predictions of future genetic merit are more accurate than previous predictions based on pedigrees alone. In addition, genomic testing can be done on dairy calves at one day of age giving dairy producers information on the genetic potential of a dairy replacement heifer at an extremely early age. This article describes the basics of genomics, what it is, and its applications in dairy heifer management.

What is Genomics?

Genomics is the study of all of the genetic material of an organism; in this case dairy cattle. The bovine genome has been mapped and genes that influence key production traits such as milk production, reproduction, physical traits, and milk quality have been identified. Genomic evaluations look at specific DNA markers that are evenly distributed across the 30 chromosomes which make up the bovine genome.

The genes inherited from the parents are identified and are compared with a reference population to determine a predicted phenotype (milk yield, fat, type traits, etc). The reference population is made up of genotyped bulls and cows with known phenotypes that are kept and maintained in vast databases by USDA Animal Improvement Programs Laboratory (AIPL). Genomic tests are currently available for three breeds: Holstein, Jersey, and Brown Swiss. Genomic testing can be done on grade or registered dairy cattle that are a minimum 7/8 Holstein, Jersey, or Brown Swiss. Genomic testing cannot be conducted on crossbred dairy cattle from a first or multiple breed cross.

How are Dairy Calves or Heifers Tested?

To test dairy calves or heifers, a blood or hair follicle sample is required. Blood from tail (Figure 1), jugular vein, or ear is acceptable. These samples can be stored and shipped in refrigerated blood tubes or on FTA cards (a specific type of filter paper for handling DNA seen in Figures 2, 3). Hair follicles are best obtained from pulling a pencil-width portion of hair out of the tail switch (Figures 4, 5). Dairy calves or heifers can be tested at any age although blood is required for dairy calves less than two months of age and hair follicle samples are required for twins.

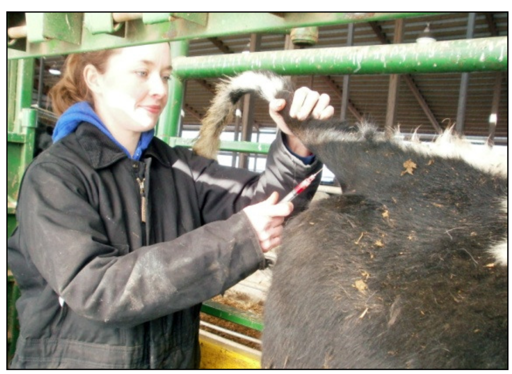

Figure 1. Obtaining a blood sample from the tail vein.

Figure 2. Applying blood to FTA card.

Figure 3. Example of FTA cards.

Figures 4 and 5. Obtaining a hair follicle sample.

After obtaining the sample, the dairy calf or heifer's identification numbers, birth date, whether she is a twin or the result of an embryo transfer, and the barcode number (on FTA cards and hair sample collectors) are entered into a form and submitted with the sample. Submission of the sire and dam ID's, although not required, increases the accuracy of the genomic proof.

The results are called Genomic Predicted Transmitting Abilities (GPTA's) which is similar to the traditional Predicted Transmitting Abilities (PTA's). GPTA's are reported for core traits such as milk yield and production indexes such as Net Merit. GPTA's are reported as ½ of the predicted ability in relative units. For example, if the GPTA for milk of a dairy heifer is +800, it means that the heifer is expected to produce 1,600 (800x2=1,600) pounds of milk more than the current breed average during a 305-day lactation. Genomic testing provides a very detailed genetic evaluation of a dairy calf or heifer. An example of the information provided by a dairy genomic evaluation at the University of Wisconsin's Integrated Dairy Herd is provided in Table 1.

More Details on Genomics

Genomic testing panels come in different sizes based on the number of markers analyzed. For example, a 50K panel (about 50,000 markers) is used by most A.I. companies and makes up most of the genomic data available worldwide. Most dairy operations, however, use a "low density" panel, the 6K panel (about 6,000 markers) because it is more cost effective and provides the required information for dairy management purposes. The present cost of a 6K panel is about $40-50 per dairy calf or heifer and has reliabilities of about 50-75% for the most common traits (milk, fat, net merit, etc). Reliabilities are an expression of percent confidence that the predicted values will match the actual phenotype of the animal. For example, if a heifer has a reliability of 66% for Net Merit value of $277, this means that there is a 66% chance that the net merit GPTA reported, $554 ($277x2), will match the actual net profit of the animal. The reliability for each trait is included in the report. Once the blood or hair samples are sent to the lab genomic results are available within about two months and are generally organized in electronic spreadsheet for ease of use.

Genomic testing also provides some non-production genetic information. Genomic testing can also define parentage, whether a dairy calf or heifer is a haplotype carrier, and inbreeding coefficients. Several haplotypes, which are sections of DNA inherited as a group, have been identified that negatively affect fertility. Three have been identified in Holsteins (HH1, HH2 and HH3), one in Brown Swiss (BH1) and one in Jerseys (JH1). Genomic evaluations identify whether or not a dairy calf or heifer is a carrier of any of these haplotypes. When female carriers of these haplotypes are bred to a haplotype carrier bull, there is an increased (25%) chance of failed conception or early embryonic loss. These haplotypes are common within the breeds therefore culling carriers is not warranted but haplotype status should be taken into consideration when it comes time to select a bull to breed the heifer.

Inbreeding is reported as the percent of homozygous genes the animal carries. Homozygous means the animal received the same gene from both parents. Greater percentages indicate more inbreeding and a narrowing of genetic diversity. This can lead to inbreeding depression which can have a negative effect on an animal's health and fertility.

Table 1. An example of GPTA report for five heifers in the University of Wisconsin's Integrated Dairy Herd. These results are from July 2012.

On-farm ID	7038	7041	7052	7058	7068
Birth Date	11/24/11	11/25/11	12/1/11	12/6/11	12/12/11
Net Merit	303	-61	228	667	450
Net Merit Reliability	69%	70%	71%	69%	70%
Cheese Merit	279	-112	231	718	424
Fluid Merit	325	-18	234	620	475
Breed Performance Index	1709	1319	1797	2078	1871
Milk Yield	1107	465	1217	733	1797
Fat	19	0	28	48	45
Protein lbs	25	1	37	31	44
Fat %	-0.07	-0.07	-0.07	0.08	-0.09
Protein %	-0.03	-0.05	0	0.04	-0.04
Somatic Cell Score	2.91	2.96	3.02	2.8	2.84
Daughter Pregnancy Rate	0.5	-1.4	-0.5	0.9	-0.5
Productive Life	2.9	-1.2	-0.2	6.2	3.0
Sire Calving Ease	9	8	6	6	7
Daughter Calving Ease	7	7	7	5	8
Sire Still Birth	8.7	8.0	6.8	7.0	7.6
Daughter Still Birth	7.0	7.8	9.4	4.4	7.2
Calving Ability	4.2	4.6	4.6	49.8	12.0
Final Score Type	0.88	0.61	2.13	1.33	1.01
Udder Composite	1.02	1.16	1.71	1.96	0.62
Feet and Legs Composite	0.01	-0.07	1.98	1.42	1.76
Body Size Composite	0.28	1.16	2.39	-0.4	0.32
Genomic Individual Inbreeding	18.9	13.3	12.2	16.8	12.6
Genomic Future Inbreeding	7.5	6.3	6.9	7.2	6.0
Holstein Haplotype 1	F	F	F	F	F
Holstein Haplotype 2	C	F	F	F	F
Holstein Haplotype 3	F	F	F	F	F

Genomic tests also have the ability to identify incorrect sires and dams and to find correct parents. If discrepancies are found between the sire or dam on the submission form and the genotype results, the owner will be notified. Often, the correct parent can be found in the database. It is up to the owner to accept these changes or to suggest another possible sire or dam. Once a decision is made, these changes should be reported to the breed association and/or DHIA. Genomic testing is quickly becoming the preferred method of parentage verification.

The use of genomics is progressing rapidly in the dairy industry and has already revolutionized the dairy cattle breeding industry. The commercialization of genomic testing for dairy calves and heifers will likely accelerate genetic progress.