Operation of a genomic selection service in Ireland

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Abstract

Since the launch of genomics in 2009 there has been a strong demand for a high value/low cost genomics service. This service was launched in February 2011 based on the Illumina Bovine 3K array. Initially, animals had to be genotyped on the Illumina BovineSNP50.

The cost of the 3K service was €50 per animal for bull and heifer calves. In December 2011 we advanced from the 3K chip to the Bovine LD 7K chip at no extra cost to farmers. This system gives even greater accuracy and can be applied with fewer restrictions due to the higher imputation accuracy.

Pure Friesians can now be genotyped on the 7K chip if the sire has already been done on the 50K panel. An initiative to genotype 10,000 females on the 7K chip was also launched in December 2011. This will enable dairy farmers make more informed breeding decisions before the abolition of milk quotas in 2015.

Introduction

Genomic Selection uses the DNA profile of an animal in conjunction with their ancestry and performance information to give a better estimate of the genetic merit of an animal at a younger age. The increase in reliability of a genomic proof over and above the parent average is between 10 and 25% - equivalent to around 14 daughters in milk production. The introduction of genomic selection has dramatically altered dairy breeding programmes worldwide and will be utilised by farmers not only when selecting AI bulls but as a screening tool for selecting replacement heifers. Farmers have been using genomicially selected AI bulls since 2009 but the genotyping of heifers has not been done until recently. A benefit of this will be the inclusion of these genotyped females in the reference population which should lead to an increase in accuracy of genomic selection.

Genomic Selection

The uptake of bulls selected on their genomic breeding values has been very high in Ireland since the introduction in 2009. Table 1 outlines the percentage of insemination for three categories of AI bulls, daughter proven bulls with Irish daughters (DP-IRL), bulls with international daughter proofs but no Irish daughters (DP-INT) and genomicially selected bulls (GS). GS bulls accounted for 47% of insemination in Ireland in 2011.

Table 1. Percentage insemination, average number of bulls used and average genetic merit and reliability for AI bulls used on Irish farms in 2011.

Type of Proof	% Use	Bulls/hrd	EBI* (Rel %)
DP-IRL	29	2.8	143(75)
DP-INT	24	3.3	155(47)
GS	47	5.1	218(57)

* EBI = Economic Breeding Index (Total Merit Index used in Ireland)

One of the main reasons for this was the superior genetic merit of these bulls compared to the other groups of bulls, albeit at a significantly lower reliability to the DP-IRL bulls. An important point is that a farmer using these bulls understands the risk associated with lower reliability as they use 5 GS bulls on average, 2 more than if they were only using proven bulls. This was a message that was actively promoted during the introduction of genomic bulls. Based on results of GS bulls that are now daughter proven we are subtracting €9 from the total merit index of genomic bulls to correct for some overestimation. This will continue to be monitored as more GS bulls get traditional daughter proven proofs.

Genomic Evaluation of Females

The benefits of genotyping females are two-fold. Firstly, it will provide a large amount of accurate information for use in the reference population in a shorter period of time than for bulls, and secondly, it can be used by farmers to make better breeding decisions. The genotyping service introduced in Spring 2012 allows Irish dairy farmers to genomicially test their breeding animals, facilitating more informed breeding decisions, and increase the genetic merit of their herds. A requirement of the program was that a farmer had to test all eligible females from a given cohort for example, all in-calf heifers, or yearling heifers, or both. The reason for this is to reduce the possibility of introducing bias when these females are used in the reference population as we will have genotypes of both good and poor animals, rather than just selected females.

Genomic Service Description

The Genomics Service is focused on providing genomic evaluations for dairy animals, both males and females. Once the animals are selected for genotyping, hair samples are collected from these animals and sent to a laboratory for testing. The genotype is received back into the ICBF database, the genomic information is incorporated in the genetic evaluation and the results are distributed. The Illumina Bovine LD has accounted for almost all of the dairy genotyping done to date in 2012. Table 2 contains details of the amount of genotypes for each of the different chip types.

Table 2. Number of genotypes by chip type and owner

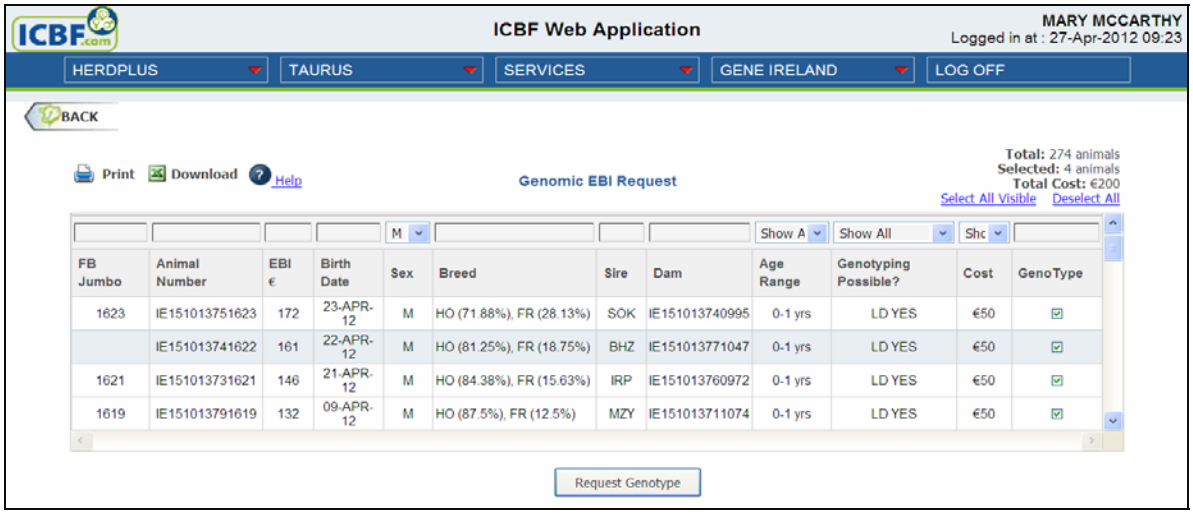
	Bovine3k	BovineLD	BovineSNP50	BovineHD – Beef reference	BovineSNP50 – dairy reference
Farmers	387	3849	14		
Industry	1997	3535	333		
Total	2384	7384	347	2606	7081

The service is available to AI Companies, breed societies and HerdPlus® clients on a user pays basis. HerdPlus® is ICBF's Breeding Information Service. The Genomic service is a fully integrated service that makes use of the ICBF database and associated systems.
At the moment genomics is only possible for Holstein and Friesian animals or a combination of both. This is because the reference population consists only of these breeds.
The sire and maternal grandsire must be recorded on the database. Animals with more than 6.25% of a breed other than Holstein or Friesian are not currently eligible. Pure Friesian animals require the Sire to have a 54K genotype.

There are currently two main users: Artificial Insemination Companies and Herd-owners. AI companies who wish to genotype recently registered male calves with a view to purchasing them for entry into an AI station receive a file of these high genetic merit male animals each week. Each company has a user name and a password to gain access to the ICBF genotype order screens.

The user enters the animal identifier to validate the tag number and select the chip type and sample type. The user will be notified if the animal number is invalid or ineligible for genotyping. The chip type is 7K or 54 K and the sample type in current use is hair. The request is then submitted. If a request has already been submitted for an animal the user will be notified. Blood or semen sample type can be submitted for relevant animals.

Herd-owners log onto the ICBF database and access the EBI/Genomics section (Figure 1). By clicking the "Place Order" button a profile of the animals eligible for genotyping is listed. Farmers can select and pay for animal genotypes via these HerdPlus® screens at a cost of €50 per animal. A discount is available to farmers who genotype a complete cohort of animals.



FB Jumbo	Animal Number	EBI €	Birth Date	Sex	Breed	Sire	Dam	Age Range	Genotyping Possible?	Cost	GenoType
1623	IE151013751623	172	23-APR-12	M	HO (71.88%), FR (28.13%)	SOK	IE151013740995	0-1 yrs	LD YES	€50	☑
	IE151013741622	161	22-APR-12	M	HO (81.25%), FR (18.75%)	BHZ	IE151013771047	0-1 yrs	LD YES	€50	☑
1621	IE151013731621	146	21-APR-12	M	HO (84.38%), FR (15.63%)	IRP	IE151013760972	0-1 yrs	LD YES	€50	☑
1619	IE151013791619	132	09-APR-12	M	HO (87.5%), FR (12.5%)	MZY	IE151013711074	0-1 yrs	LD YES	€50	☑

Figure 1. Genotype ordering process for a Herdplus® client

The user pays by credit or laser card following the selection of the animals. Payment can also be made by cheque and HerdPlus® users who don't have access to the web can place orders over the phone.

The following is a step by step guide to the service operated by ICBF once a request has been submitted:

1. Hair sampling cards, one per animal, bar coded with the full International number are mailed directly to the herd-owner along with hair collection instructions, cover letters and return envelopes. Genotype requests can be submitted for the same animal by a number of AI companies. In this case multiple request letters and contracts for each AI Company are sent to each herd-owner. The herd-owner returns one signed contract per animal with the hair samples. This indicates the AI organisation that is to receive the genotype result.

2. Hair samples and contracts where necessary are returned by mail from the herd-owner to ICBF. The hair cards are scanned daily into the database. This tracks the sample return date.

3. The samples are sent on a weekly basis to a genotyping laboratory. An electronic file of the sample details is also sent.

4. The genotyping laboratory automatically transmits genotypes with the official ID of the animal in the Interbull format to the ICBF database. The file is loaded, animals validated, parentage is validated or assigned if a conflict occurs and the tracking system is updated with the date genotype received (see Figure 2). Animals with low call rates (less than 90%) are removed and hair cards are reissued. Valid animals and valid genotypes are loaded to the IGenoP database. The different animal groups are extracted for evaluations. ICBF also caters for breeding organisations who make their own genotyping arrangements and who wish to obtain a genomic evaluation on the Irish base and scale.

5. Each week genotypes are extracted from the database, imputed and genomic breeding values are computed.

6. Genetic evaluations incorporating genomic data are distributed to the customer who placed the order. Genomic Evaluation reports are distributed to the customer via the ICBF website and/or paper reports (Appendix 1). Results can also be viewed in the herd-owners genomics profile and animals that have been genotyped are listed with an asterix in the EBI herd profile. All results for male calves are made freely available on the ICBF public bull search after a certain length of time.

It takes approximately 3 weeks from once ICBF receive the hair sample to making the genomic evaluation available.

The various stages of the genotype order can be tracked by the user who placed the order (see Figure 2).

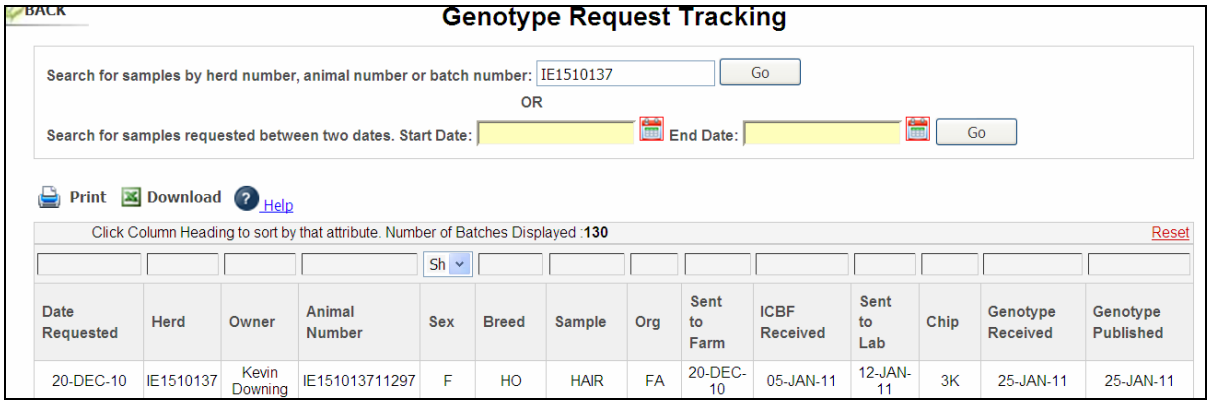


Figure 2. Example of information available to track the current status of an order.

Genomic Evaluations for other dairy breeds and beef cattle

A genomic evaluation is only available for Holstein/Friesian animals. Currently the numbers of proven bulls of other breeds (e.g., Jersey, Norwegian Red, Montbeliarde etc) are too low to be able to generate genomic evaluations. In the future, we will be looking at using cows of these breeds to boost the numbers of animals in the reference population with potential to include them in an across breed genomic evaluation with the Holstein/Friesians.

Currently, research is actively been undertaking to determine the feasibility of providing genomic breeding values for beef cattle. Just over 2600 Bovine Illumina HD genotypes have been done for beef breeds. Table 3 shows the number of genotypes by breed for the 6 most numerous breeds. These are currently being integrated with their breeding values to assess the usefulness of the SNP information in predicting future merit. At this point a service for young beef animals will be offered, done on either the Illumina 50k or the LD with potential imputation to the HD.

Table 3. Number of BovineHD genotypes by beef breed.

Breed	No. Genotyped
Angus	288
Simmental	228
Belgian Blue	185
Hereford	227
Limousin	712
Charolais	712

Conclusions

The adoption of genomic selection in Ireland has been very high since it was introduced in 2009. The genomic service introduced in 2012 for females demonstrates that a there is a high level of interest among farmers to use it in management decisions. This will ultimately lead to higher levels of accuracy for AI bulls in the future when cow phenotypes are used in the

reference population. The genomic service infrastructure put in place has worked very well. Farmers, AI companies, breed societies and the genotyping laboratories all interact with database during the process which makes it very easy to track where individual samples are at any point in the process. Very quick turnaround times have been achieved at each point in the process. Research on providing genomic breeding values for other dairy breeds, as well as beef cattle is underway with preliminary results expected later this year.

Appendix 1. Example of a genomic evaluation report that a client will receive for their animal

Genomic Evaluation Report

Jumbo	1563	**Lact. No**	
Tag	IE151013731563	**Sex**	M
Name		**Sire**	LHZ (€248)
DOB	13-Feb-2012 0y 2m	**Dam**	IE151013721067 (€141)
Breed	HO (91%), FR (9%), MY (3%)	**Dam's Sire**	HFL (€170)
Date of Evaluation	11-Apr-2012		

Index	Official Genomic Evaluation	Reliability	Weighting on Genomics	DNA Value	Parent Average Evaluation	Reliability	Diff.from Parent Avg	Increase In Reliability
EBI €	**255**	**46%**	31%	235	191	26%	+64	20%
Milk Sub Index €	**90**	**54%**	39%	82	80	31%	+10	23%
Fertility Sub Index €	**151**	**38%**	26%	140	93	19%	+58	19%
Calving Sub Index €	**26**	**52%**	24%	22	27	36%	-1	16%
Beef Sub Index €	**-20**	**37%**	24%	-17	-15	21%	-5	16%
Maintenance Sub Index €	**16**	**39%**	26%	15	11	22%	+5	17%
Health Sub Index €	**-7**	**49%**	40%	-6	-6	24%	-1	25%
Milk Sub Index								
Milk (Kg)	**156**	**54%**	39%	113	257	31%	-101	23%
Fat (Kg)	**12.7**	**54%**	39%	11.2	14.1	31%	-1.4	23%
Protein (Kg)	**14.5**	**54%**	39%	12.9	14.3	31%	+0.2	23%
Fat (%)	**0.12**	**54%**	39%	0.13	0.09	31%	+0.03	23%
Protein (%)	**0.18**	**54%**	39%	0.17	0.12	31%	+0.06	23%
Fertility Sub Index								
Calv Int (Days)	**-9.16**	**40%**	28%	-8.6	-5.52	21%	-3.64	19%
Survival (%)	**3.53**	**34%**	23%	3.11	2.25	15%	+1.28	19%
Calving Sub Index								
Dir.Calv Diff (%)	**1.91**	**51%**	23%	2.35	2.27	37%	-0.36	14%
Mat.Calv Diff (%)	**8.7**	**42%**	20%	8.16	8.9	27%	-0.2	15%
Gest Len (Days)	**-1.63**	**57%**	28%	-1.18	-2.15	40%	+0.52	17%
Calf Mort(%)	**-1.25**	**37%**	12%	-1.25	-0.99	28%	-0.26	9%
Beef Sub Index								
Cull Cow Weight (Kg)	**-10.46**	**39%**	26%	-10.11	-7.07	22%	-3.39	17%
Carcass Weight (Kg)	**-7**	**37%**	24%	-6.4	-4.93	21%	-2.07	16%
Carcass Conf (Grade)	**-0.94**	**37%**	25%	-0.79	-0.73	21%	-0.21	16%
Carcass Fat (%)	**-0.08**	**36%**	23%	-0.12	-0.06	21%	-0.02	15%
Maintenance Sub Index								
Cull Cow Weight (Kg)	**-10.46**	**39%**	26%	-10.11	-7.07	22%	-3.39	17%
Health Sub Index								
Lameness (Locomotion)	**-1.4**	**8%**	21%	-1.08				
Udder (SCC)	**0.1**	**53%**	42%	0.08	0.08	26%	+0.02	27%

Explanatory Notes:
Official Genomic Evaluation = the new official index based on combining the DNA information with the parental average information. DNA Value = the index based on DNA information only.
Weighting on Genomics = the percentage of the official evaluation that is based on DNA information.
For more information on Genomics terminology see attached sheet or on relevant section of our website www.icbf.com