Implementation and Uptake of Genomic Evaluations in Ireland

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1. Introduction

Genomic selection in Holstein-Friesian dairy cattle was launched in Ireland in February 2009. The objective of this document is to outline the implementation and the uptake of genomic estimated breeding values (GEBVs) in Ireland for Spring 2009. We also outline the results of the first group of Holstein-Friesian bulls that were selected on GEBVs compared to their progeny test proofs obtained in the August 2009 evaluations.

2. Estimation of GEBVs

A detailed document on the estimation of GEBVs for Ireland was reported by Berry *et al.* (2009a). Briefly, the training population was made up of just over 1,000 Holstein-Friesian bulls, genotyped using the Illumina Bovine50 Beadchip. The majority of the bulls were genotyped using funds secured through competitive funding from the Irish Department of Agriculture, Fisheries and Food (DAFF) and the remaining genotypes were provided by international collaborators in New Zealand, the UK and Poland. Direct genomic values (DGVs) are estimated in Ireland using mixed models equations by replacing the traditional numerator relationship matrix with a genomic relationship matrix as outlined by VanRaden (2008).

The dependent variable included in the genomic evaluation are the deregressed traditional EBVs of the animal as outlined by Berry *et al.* (2009a). Genomic EBVs (GEBVs) are the combination of the DGVs and the traditional EBVs. This blending procedure is done because not all animals in the pedigree are genotyped (genotypes of no females are currently included in the genomic evaluation) and therefore not all information is included in the genomic evaluation. To test the accuracy of genomic selection using Irish data only genotyped sires with at least 40 milking daughters in Ireland were retained (n=803). This dataset was divided into sires born prior to 1997 (n=596; training dataset) and sires born after 1996 (n=207; validation dataset). DGVs and GEBVs were predicted for the validation dataset. The accuracy of genomic selection was quantified by the mean bias and RMSE as well as the correlation and regression of actual EBVs (as estimated using the traditional methods) on genomic EBVs. Correlations were in the region of 0.6 to 0.8 for most traits (Berry *et al.*, 2009a) and the results were broadly in line with that achieved by other countries taking cognizance of the smaller training population size in Ireland.

3. Implementation of GEBVs

The top 75 bulls for total merit index in Ireland, the EBI, with a minimum of 2000 doses of semen available and with a minimum reliability of 58% are published twice per year in the Irish active bull list. After consultation with representatives from the Irish dairy industry it was decided to publish GEBVs of individual bulls without progeny on the list of active bulls for the Spring 2009 breeding season. Breeding organizations were supplied with the components that made up the GEBVs (i.e., parental average EBVs, and DGVs) as well as the weighting on genomic information within the GEBVs.

Bulls included on the active bull list had to have sufficient progeny born to have a reliability for direct calving difficulty of ≥50% in the country of origin. Also the reliability of the GEBV for EBI, had to be ≥35%. In 2008, prior to the introduction of genomic evaluations, each sire on the active bull list had to have a reliability of EBI of ≥58%. The effect of relaxing the threshold on reliability on the average genetic merit of sire on the active bull list can be seen in Table 1. Compared to 2008, the average EBI of the bulls on the list was higher, but the reliability was lower. In addition younger sires replaced sires that had occupied the list for many years, but the number of bulls with daughters in Ireland decreased. Also, there is a marked increase in the average EBI from 2008 to 2009 compared to increases seen since 2004.

In order to reduce the risk associated with farmers using just the top genomically selected bulls, DAFF placed a limit on the number of straws to be sold from any one genomically selected bull. The limit for maximum number of straws was based on reliability of the EBI of the sire with the highest limit set at 10,000 doses for sires with >50% reliability for EBI. In addition the recommendation to farmers was to use a minimum of 4 to 5 of these bulls during the breeding season. This message to farmers was strongly advocated by all industry partners and was reiterated throughout the breeding season.

AI companies offering fresh semen rotated the bulls used each day to ensure farmers got a greater selection of bulls and thus the risk was spread. The bulls that were offered were mainly test bulls awaiting a progeny proof as well as foreign bulls that that were genomically selected in Ireland through access to their genotype. Initially the publication rules were that a bull only got a GEBV where no EBVs based on daughter information were available. Currently we use GEBVs until a bull passes 70% reliability for production and 50% for fertility. Once we are satisfied the technology is working satisfactorily we will publish GEBVs only. Bulls were flagged on the active bull list and the website as having genomic information included (GS). Proven bulls were differentiated into the bulls that had daughter proofs with Irish daughters (DP-IRL), or daughter proofs with no Irish daughters (DP-INT). A sample of the active bull list is given in Table 2.

4. Uptake of GS evaluations

An analysis of the uptake of genomic selection was conducted on 349,000 AI insemination records collected via technician handhelds from January to June 2009. Do-it-yourself (DIY) inseminations, which account for about a third of all inseminations, generally are not recorded on the database by farmers until the end of the year and were thus not available for inclusion in this exercise. The usage for the DP-IRL bulls was the highest at 37% of inseminations with GS bulls accounting for 34%, and DP-INT bulls 29% (Table 3). The average number of serves per bull was much higher for GS bulls than the DP bulls (either DP-INT or DP-IRL) as fewer bulls were available. The mean number of DP proven bulls used per herd was 3 and 2.7 for bulls with Irish daughters and international daughters respectively. The mean number of GS bulls was higher at 4. The maximum number of bulls used was similar across the 3 categories and a high of 30 GS bulls used in one herd alone was achieved. A closer look at the distribution of GS bulls reveals that 56% of herds used fewer than the recommended 4 bulls however only this only accounted for 25% of the total GS straw usage (Figure 1). For example, 31% of herds used just one GS bull. One reason for this is that farmers wanted to use only the best GS bulls and did not want to sacrifice lower EBI values for reduced risk. However, many of the herds that used only 1 GS bull also used other bulls

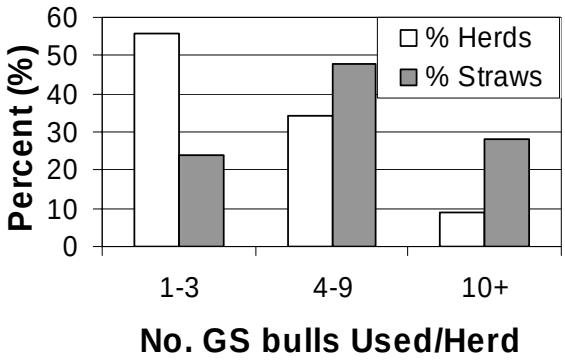

Figure 1. The distribution of GS bull inseminations (n=119,000) for Spring 2009 by herd and the number of straws.

The distribution of GS bulls suggests that many farmers, especially those who were buying larger numbers of GS bulls, did in fact use at least 4 bulls as recommended to reduce the risk of using only the top one or two bulls. Farmers that used only GS bulls accounted for only 6,500 of the total inseminations with most of these in teams of at least four bulls. The very positive uptake of GS bulls can be attributed to the difference in genetic merit between these bulls and the daughter proven bulls. The top two proven bulls had limited availability and were expensive therefore their use was low. The weighted average EBI of the GS bulls was €69, more than one standard deviation (€62) ahead of the DP-IRL bulls. The average across all three groups of bulls used in 2009 was €38 more than the bulls used in 2008.

5. Comparison of GEBV and EBV

The young bulls entering the national progeny test programme in 2006 were marketed in the Spring 2009 programme as GS bulls. These bulls had

daughters who calved for the first time this spring and we now have obtained the first accurate progeny test proofs for milk production for these bulls following the August 2009 proof run. At this point in time the results are based on records in progress for these daughters and are based on bulls with a reliability of >70% for production traits. Table 4 compares the correlation of the daughter proven EBV to the DGVs, the GEBVs, and the parent average proof for 35 bulls who received a progeny test proof in the August 2009 evaluation. The correlations between parent average and daughter proof are consistently lower than those of the GEBV and the DGV. This is especially true for fat yield which may be a function of the DGAT1 gene (Berry *et al.,* 2009b) as well as other genes. The differences in means are also given in Table 4. Currently they are over predicting each of the traits with the DGVs closest to the current EBVs. At this stage the DGVs are the best predictors of progeny performance however one must recognize the limitations of this analysis due only 35 bulls being included in this comparison, the average reliability of the sires is 80%, and the daughter records are not completed lactation records. However, it is encouraging that the correlations obtained for GEBVs are consistent with the findings from the validation and that the correlations are generally higher than if parent average proofs had been used.

6. Future Work

There are several areas of future research identified for the short term and these include improving the algorithms for data editing and analysis, including sires with no progeny in Ireland in the training population via their MACE evaluations as well as accounting for possibly heterogeneity in allele frequencies within different strains of Holstein-Friesians. Other research already underway with the collaborators is the design of optimal breeding programs to fully exploit the use of genomic information. In addition, a genomic service will be offered to breeders and AI companies wishing to obtain GEBVs for male and female animals.

7. Conclusions

Overall the implementation of genomic evaluations in Ireland has been very successful. The uptake of the bulls has been very encouraging with farmers using several bulls as recommended to reduce the risks. Initial results on how the technology is working are promising and the introduction of genomic evaluations will generate greater genetic gain in the future.

8. References

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Table 1. Statistics for the top 75 active bulls in Ireland since 2004.

	2004	2005	2006	2007	2008	2009
EBI(€)	103	101	113	118	124	150
Milk Index(€)	64	59	57	46	52	69
Fert Index(€)	35	35	44	60	60	64
Minimum Reliability(%)	52	52	54	56	58	35
Mean Reliability(%)	67	70	73	74	76	58
Mean Birth date	Apr-96	Aug-95	May-06	Sep-97	Mar-98	Aug-02
No. Bulls with IRL daughter	22	35	32	43	41	16
Domestic Bulls	12	21	18	22	17	37
New Bulls (< 7yrs)	37	16	11	12	11	48
No. GS bulls	0	0	0	0	0	39

Table 2. A sample of the Spring 2009 active bull list displaying the 3 types of proof. (http://www.icbf.com).

Bull Details					EBI & Proof Details				EBI Sub Indexes				
Rk	**Code**	**Name of Bull**	**Sire**	**Hol**	**EBI**	**Rel**	**Range**	**Proof**	**Milk**	**Fertility**	**Calving**	**Beef**	**Health**
1	OJI	O-BEE MANFRED JUSTICE	HCM	100	€250	91%	+/-€35	DP-IRL	€114	€86	€49	-€6	€7
2	RXO	RAMOS	SRH	100	€216	74%	+/-€60	DP-INT	€47	€120	€38	-€6	€16
3	HTH	HAZAEL LIGHT DETECTOR S2F	LGI	71	€198	43%	+/-€89	GS	€84	€114	€25	-€23	-€2
4	OLG	BALLIVOR OLYMPIC GOLD ET	OJI	100	€194	50%	+/-€83	GS	€127	€32	€40	-€5	€1
5	BYJ	BALLYDEHOB JUSTICE	OJI	96	€189	53%	+/-€81	GS	€90	€76	€28	-€7	€1
6	HZL	HILLSDALE LIONEL	RUU	91	€188	57%	+/-€77	GS	€71	€68	€50	-€1	€1
7	RXR	MONAMORE ROMERO ET	OJI	100	€187	54%	+/-€80	GS	€90	€72	€38	-€16	€4
8	GIO	GIBOR	GBN	97	€186	68%	+/-€68	DP-INT	€74	€81	€25	-€9	€15
9	GYK	GARRYMARTIN KEET	BWZ	78	€184	49%	+/-€84	GS	€97	€71	€31	-€9	-€6
10	HZS	HAZAEL MN SWEETDREAM*	NWorthy	100	€182	35%	+/-€95	GS	€114	€71	€17	-€12	-€8

Table 3. Usage statistics and mean genetic merit and reliability for the 3 types of sires used.

	Spring 2009						Spring 2008	
Proof	**No. Bulls**	**No. straws/bull**	**% Usage**	**bulls/herd**	**Mean EBI**	**Mean Rel**	**Mean EBI**	**Mean Rel**
DP-INT	478	204	29	3	€133	56%	€99	43%
DP-IRL	754	175	37	2.7	€120	86%	€109	75%
GS	90	1310	34	4	€179	55%	N/A	N/A
Mean					€144	66%	€106	64%

Table 4. Correlations and mean difference between daughter proofs and GEBV, DGV, and PA proofs for 35 bulls genomically selected when in lay-off in Spring 2009 but now with greater than 70% reliability for milk production based on daughters milking in 2009.

	Correlation			Mean Difference		
	GEBV	DGV	PA	GEBV	DGV	PA
Milk(kg)	0.64	0.65	0.63	65	50	77
Fat(kg)	0.51	0.57	0.4	2	2	3
Prot(kg)	0.59	0.65	0.53	2	1.5	2.2