Unlocking genetic potential: The national genotyping program for Ireland's cattle herd

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Abstract

The National Genotyping Programme (NGP), a collaborative initiative between ICBF, the Department of Agriculture, Food and the Marine (DAFM), industry stakeholders and participating farmers, is the first step in achieving a fully genotyped national bovine herd in Ireland. The NGP operates under a co-funded model, sharing the cost across Irish Government, Industry Stakeholders and direct farmer contributions from the more than 10,000 participating herds. Phase one of NGP saw over 780,000 animals genotyped in 2023, including each participant's mature breeding herd. This was achieved, at no cost to the farmer, using Irish Government funding. Phase two, which began in January 2024, sees participating herds submit genotype samples at birth for all calves born in the herd, through the DNA Calf Registration Process, for the remainder of the programme (2024 to 2027 incl.). The cost of genotyping each calf in the programme is shared equally, 3 ways, between the farmer, DAFM and Industry, with each contributing approximately €6/calf. Since January 2024, over 660,000 registrations have been processed, with an average lab turnaround of 4.5 days, calves fully registered by an average of 12 days old, and with over 98,000 samples processed in a single week during the spring peak.

Keywords: National Genotyping Programme, Genotyping, Genomics, Calf Registration, Parentage.
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Introduction

Agriculture is the Republic of Ireland's single largest source of emissions, representing 34.3% of total national GHG emissions. 62.5% of agricultural emissions in Ireland are due to enteric fermentation. Manure management constitutes a further 11% of the agricultural emissions profile, meaning that combined, livestock are responsible for approx. 74% of emissions in the sector. The Irish government has committed to achieving climate neutrality across all sectors no later than 2050 with a 51% reduction in GHG emissions targeted by 2030 (Government of Ireland, 2023).

Genetic gain, particularly in this context of lowering Ireland's agricultural Green House Gas (GHG) emissions, is a key strategic goal of both industry and government (Department of Agriculture, Food and the Marine, 2020). Animal breeding, improved animal health and reduced age at slaughter all directly and indirectly reduce GHG emissions, while proving cost negative, which equals a significant "win win" in terms of GHG mitigation measures (Teagasc, 2023).

Genotyping the entire national bovine herd will underpin and accelerate the rate of genetic gain by leveraging genomic information and technologies against the existing integrated national database in ICBF to increase the accuracy of Ireland's national

breeding indexes (EBI, Beef-Eurostar, DBI) and provide further tools to improve the national breeding programme. The advancement in the scale and accuracy of genomic selection, alongside numerous auxiliary benefits, such as enhanced traceability of beef and dairy products, labour saving, reduced administration, prevention of cattle theft etc, provided by NGP, offers Irish agriculture a profound opportunity which is estimated to provide up to a 4:1 return on investment (Abacus bio, 2022).

Laying the foundations for full National Genotyping

As of the mid 2023, ICBF, Ireland's integrated national cattle breeding database, had collected over 3 million genotypes. Large scale genotyping had already been achieved in the Irish suckler herd through government schemes such as the Beef Data and Genomics Programme (BDGP), and the Suckler Carbon Efficiency Programme (SCEP).

Up to 400,000 genotypes have been submitted each year as part of these programs since 2015 leading to approximately 60% of the national suckler herd being genotyped by 2023.

Lacking equivalent external investment, the dairy herd has lagged behind in terms of genotyping, with only approximately 6.5% of the national herd genotyped by same juncture.

DNA calf registration pilots

Proof of concept trials were carried out from spring 2018 to spring 2023 on the process of DNA calf registration, a system designed to integrate the genotyping and parentage verification process into the national calf registration system. The system consists of a genotype sample being submitted for each calf being registered, prior to the full registration of the calf on the national bovine traceability database, identifying and correcting errors in the recorded parentage, sex and breed of these calves in the process.

This system has the two major advantages of (i) reducing the administrative burden of subsequently correcting parentage errors, and (ii) allowing the calf to receive a full genomic evaluation at the earliest possible opportunity.

Over this period the scale of the pilots increased from an initial 18 herds to almost 600, with the number of calves genotyped in each pilot increasing accordingly from just over 1,500 calves in 2018, to almost 50,000 in 2023.

The process was also, refined and improved over the course of these trials, with infrastructure developed which would be fundamental to the future scalability of the system.

Data integration was improved between ICBF and both the Department of Agriculture, Food and the Marine (DAFM), and the farm software providers authorized to submit calf registrations. The turnaround time to process samples was reduced, and a new double tissue national calf tag was developed by tag suppliers capable of taking both a BVD sample and a DNA sample from a single set of national calf tags.

The National Genotyping Programme

Following on from the success of the DNA Calf Registration pilots, The National Genotyping Programme (NGP) was launched in June of 2023. A collaborative initiative,

between ICBF, DAFM, beef and dairy industry stakeholders and participating farmers, the NGP is the first major step in achieving a fully genotyped national bovine herd in Ireland. The NGP operates under a co-funded model, sharing the cost across Irish Government, Dairy Industry Ireland (D.I.I.), Meat Industry Ireland (M.I.I.) and direct farmer contributions. The NGP consists of two main phases.

Phase one, 2023

Phase one of the NGP began in June of 2023 with a drive to recruit herds which lead to over 10,600 herds signing up to participate, including ~3,800 dairy herds and ~6,800 beef herds, accounting for almost 700,000 cows in total. The first phase also saw over 780,000 animals genotyped in 2023, including each participant's mature cow herd, breeding heifer replacements and expected calf sires which had not already been genotyped. This was achieved, at no cost to the farmer, using Irish Government funding. This This influx of genotypes brought the total number of genotypes in the ICBF database over 4 million and led to the largest single publication of new genomic evaluations to date, with some 620,000 females receiving genomic evaluations for the first time in January evaluation run of 2024.

Phase two, 2024 to 2027

The second phase, which began in January 2024, has seen participating herds submit genotype samples at birth for all calves born in the herd through the DNA calf registration process, which will continue for the remainder of the programme (2024 to 2027 incl.). The cost of genotyping each calf in the programme is shared equally, 3 ways, between the farmer, DAFM and industry, with each contributing approximately €6/calf. Continued process improvements, along with meticulous planning and coordination among the various stakeholders, has allowed the process to admirably handle the over 660,000registrations since January 2024, which equates to a third of all the calves registered in Ireland in the same period. This was achieved while processing samples in an average lab turnaround of 4.5 days, fully registering calves by an average of 12 days old, and with over 98,000 samples processed in a single week during the spring peak.

Correcting parentage, sex and breed errors

Since this phase of the programme began in January 2024, across all herd types, parentage errors have been identified in an average of 16.49% of cases. Errors in the recorded sex were identified and corrected in 1.69% of cases. In the 9.65% of calves submitted for registration without sire details, a sire was identified by the genotype and added in 81.26% of cases.

Genotyping and evaluation infrastructure

This level of large scale genotyping is achieved on the ICBF custom International Dairy and Beef SNP Chip (V5), a ThermoFisher Applied Biosystems™ Axiom™ Genotyping array, combined with the ThermoFisher Axiom Propel Express 384HT Workflow. In order to accommodate the volume of genotypes included in weekly genomic evaluations, significant changes were made to the imputation pipeline by limiting imputations to only new genotype samples or those belonging to animals that had parentage changes since the last imputation, and by adding an additional 4 new

High Performance Computing Nodes, each with 64 cores and an additional 3TB of RAM, which drastically reduced the run time of the imputation process and allowed for more evaluations to be run concurrently.

Table 1. Number of participating herds in DNA calf registration pilots and the corresponding number of calves genotyped at birth.

Pilot year	DNA Calf Registration Pilots	
	Number of participating herds	Number of calves genotyped at birth
2018	18	1,537
2019	35	1,652
2020	269	21,141
2021	401	33,404
2022	560	40,201
2023	594	43,676

Conclusion

Large scale genotyping and the DNA calf registration process offer many technical and logistical challenges. The operational aspects of the programme are multifaceted, involving the collection, processing, and analysis of huge amounts of genetic data and the seamless integration and flow of data across multiple databases and stakeholders. Practical innovations were also required at farm level such as the development of calf identification tags capable of taking multiple different tissue samples, while still conforming to all the existing statutory requirements around identification and traceability. With such a complex and interconnected project, absolute commitment and cooperation is required from all stakeholders involved including; farmers, government, industry, genotyping labs, tag suppliers, farm software providers, Animal Health Ireland and farm advisory bodies such as Teagasc, to ensure success at such scale and within such time sensitive timelines.

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