Use of DNA in animal breeding

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Summary

- DNA technology has a range of uses in animal breeding and management.
- Genomic evaluations use DNA to supplement parentage and own performance information, enabling identification of genetically elite heifers and cows.
- DNA calf registration uses genomic information to verify or assign parentage, thus providing more reliable estimates of the value of animals.
- DNA influences performance, with some individual genes like myostatin having a large effect on performance traits like calving difficulty and carcass value.

Introduction

The genotype of an animal (i.e. its DNA profile) impacts performance not just of the animal itself but also its progeny. Therefore, knowing the DNA profile of the calf at birth, and knowing how the DNA profile affects performance, enables prediction of the performance of that animal and its progeny. DNA information currently exits for almost three million Irish cattle and has been incorporated into the national genomic evaluations. The outcome is not only more reliable genetic evaluations at birth but also the ability to screen more animals for traits of economic interest, thereby increasing the intensity of selection and thus genetic gain. In addition to its use in genomic evaluations, the DNA of an animal has many other uses (Figure 1).

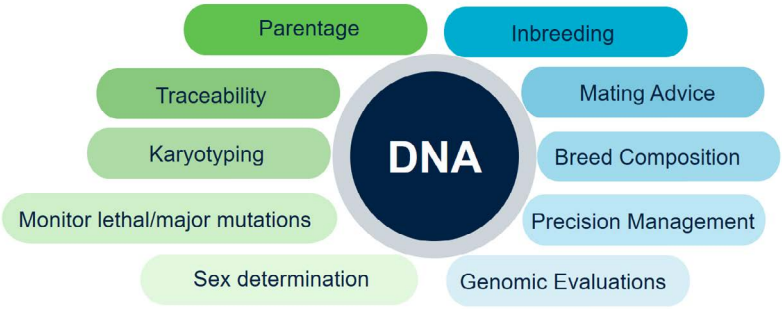

Figure 1. *Potential uses of DNA information in cattle*

Advances in genomic selection

Genomic selection uses DNA information to supplement ancestry information and own performance data to generate a more accurate estimate of the genetic potential of an animal (and thus also its offspring). All calves receive half their DNA from their sire, but it is a random half, and thus the animal has to be genotyped to determine what half it received and how that half affects a wide range of performance traits; the same is true for the dam. Predictions of an animal's genetic merit from DNA are still only predictions; to overcome the uncertainty that still exists, teams of animals should be used. This includes teams of bulls for breeding, but also when selecting genotyped heifers, the team of heifers should be the focus and not individual heifers. The number of bulls per team currently recommended for different herd sizes is indicated Table 1. The ICBF sire advice system calculates the reliability of the team of bulls selected; aim for a target bull team reliability >90%. Using a team of bulls also minimises the risk of an individual bull (or even straws from an individual ejaculate) having compromised fertilising capacity, especially when using sexed semen.

Table 1. *The number of bulls required for different herd sizes*

Herd size	Minimum number of bulls
1-50	7
51-100	7
101-150	8
151-200	10
201-250	11
251-300	12
301-350	13
351-400	14

DNA calf registration

The incidence of incorrect sire recording in Irish dairy herds is approximately 14%. This not only affects genetic gain, but can also result in mating events between animals that were thought to be unrelated. DNA can be used to verify or refute assumed parentage, and if incorrect, it can be used to assign parentage. This is because each individual receives half its DNA from each parent and the DNA is unique to each individual (except for identical twins). Hence, this can be useful if a mob of natural mating bulls is used, where sire assignment is not possible or cumbersome. DNA can also be used to assign breed composition to an individual; the breed composition of the progeny from a crossbred parent cannot be known unless the progeny itself is genotyped.

Genetic defects and chromosomal abnormalities

DNA information is a valuable tool for monitoring the incidence of genetic defects in livestock and identifying carriers. Most genetic defects only materialise when an animal has two bad copies of the gene; animals with one copy are called carriers and generally have no noticeable effect. If two carriers are mated, however, then there is a 25% chance (i.e. one in every four calves born) that the resulting calf will have two copies of the bad gene and express the defect. Genotyping can be used to screen for carriers thereby informing an appropriate mating plan and downstream culling decisions.

Major genes

Major genes, as the name suggests, are genes with a major effect on performance; myostatin is a major gene that causes extra muscle with or without a concomitant increase in calving difficulty. There are 21 known mutations in the myostatin gene, all of which are now tested when animals are genotyped. The F94L mutation (often called the Limousin mutation) is one such mutation that increases carcass weight and conformation, but without any increase in calving difficulty.

Conclusions

Incorporation of DNA information into the national genetic evaluations increases the accuracy of predictions of an animal's genetic potential at birth, aiding identification of the most genetically elite replacement heifers and cows. DNA information is also used to verify parentage, assign breed composition, screen for carriers of genetic defects, and identify carriers of major genes that have a significant impact on performance.