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Reproductive Technology: Genomic Selection

Scientific excellence
Industry applicability
Strategic networking
Global influence

Introduction

Since the domestication of cattle for milk and meat purposes more than 6,000 years ago, farmers have used reproductive technology to improve their cattle. In the beginning, farmers used simple breeding programs selecting a desired red male to mate with their cattle for each successive generation of animals. Today, a variety of reproductive technologies are used by dairy farmers to perpetuate the next generation of cattle to enhance milk quality and productivity, improve animal health and welfare, and increase the sustainability of the dairy industry.

This IDF Fact Sheet on Reproductive Technology (part of an IDF series of factsheets on reproductive technology) examines the use of genomic selection in its contribution to dairy sustainability.

Definitions:

- Genome: An organism's complete set of DNA [1].
- Progeny testing: Progeny testing helps prove the true breeding value of an animal. It is performed by mating the male with several females and then the average performance of the offspring is determined which gives the respective value of the bull [2].
- Bull Proofs: Genetic index of the traits that a bull may pass on.
- Generation Interval: The average age of the parents at the birth of their offspring [2].

What is artificial selection?

Most dairy farms have comprehensive breeding plans which include selecting the best mates for their cows in order to improve herd qualities such as milk production, longevity, milk components and type. This active choosing of traits to be passed on to the next generation of animals is known as artificial selection or selective breeding. The development of progeny testing and proofs for bulls significantly progressed artificial selection as it detailed what traits a bull carried and would pass on. Now, genomics is playing a large part in artificial selection [2].

What is genomic selection?

Genomics is the study of genes and their functions. It aims to create a picture of the overall gene structure of an animal, as well as how the genes/components interrelate and influence the organism. Genomic selection is a form of marker-assisted selection (an indirect selection process where a trait of interest is selected not based on the trait itself but on a marker linked to it) in which the genetic markers covering the whole genome are used so that all quantitative trait loci are in linkage disequilibrium (haplotypes do not occur at the expected frequencies) with at least one marker [3]. Based on these markers, the traits that a bull may carry can be predicted at an earlier stage of life. Instead of the 5 years it took with progeny testing, through genomic selection, it now takes an estimated 1 year to establish what characteristics a bull may pass on [2,4]. Genomic selection, should not be confused with genetically modified organisms (GMOs), whose genetic material has been artificially manipulated in a laboratory through genetic engineering.

Uses of genomic selection in dairy cattle:

- It increases the ability to predict genetic merit of dairy animals for economically important traits.
- It allows recognition of "mendelian" traits such as polled, coat color, genetic recessives [4,5,4].
- It allows producers to make accurate selection decisions without waiting for progeny test results on males or lactation records on females [4,5].
- It can shorten generation intervals due to the availability of knowledge on the bulls' traits at one year of age.
- There is increased intensity of selection [4,5].

Importance of technology:

Genomic selection has been essential to improving dairy cattle around the world. It has helped to increase genetic diversity and increase the presence of traits with low heritability [6]. Moreover, it has helped detect carriers of undesirable recessive characteristics [6]. In the bigger picture, it has helped decrease the number of culled cows because of cows bred for greater longevity in addition to improving milk quality and feed efficiency. Genomics has been proven to be useful in selecting for more "environmentally friendly" traits such as reduced methane emissions leading to a decreased milk-carbon footprint [7].

Further information: Find out more on our website: www.fil-idf.org

About this series

In 2017, the IDF Standing Committee on Farm Management and Standing Committee on Animal Health and Welfare identified a need to produce fact sheets on reproductive technology use in the dairy industry to provide information to dairy farmers and interested stakeholders. This is the first fact sheet in the series.

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