Beyond genetics: epigenetics!

How RUMIGEN explored why cattle with similar genetic level can perform differently

What is epigenetics?

DNA is often described as the instruction book of the body. But animals do not use every instruction in the same way all the time.

Epigenetics is about how the body reads and uses DNA, without changing the DNA itself. It can influence whether some genes are more active or less active.

The environment can affect this process. For example, nutrition, heat, stress, disease, early-life conditions and farm management can all influence how an animal's body uses its genetic instructions.

A simple way to think about it is this: **DNA is the text. Epigenetics is like the highlighting, bookmarks and notes that help decide which parts of the text are used more or less.**

This matters because two animals may have very similar DNA sequence, but perform differently if they grow up or live under different conditions.

What did RUMIGEN look at?

RUMIGEN looked at whether epigenetics can help explain why cattle with similar DNA sequence sometimes perform differently. The project focused on one type of epigenetic signal called **DNA methylation**. In simple terms, DNA methylation is a natural mark on DNA that can help control how strongly some genes are used.

RUMIGEN also developed and tested the **EpiChip**, a tool that helps researchers measure these DNA marks in cattle more easily and in larger numbers of animals.

What was found?

RUMIGEN found that epigenetic information can help explain part of cattle performance.

In one study, Jersey cows with similar genetic backgrounds were compared in Denmark and South Africa. Their DNA looked similar, but their epigenetic marks in blood showed differences. This suggests that the environment can leave measurable biological signals.

In another study, RUMIGEN looked at thousands of Holstein cows. Some epigenetic marks were linked to traits such as milk production, fertility, under health and body characteristics.

RUMIGEN also studied whether epigenetic marks in bull sperm could help explain how daughters perform. In this case, the effect was very small, because unlike DNA sequence, epigenetic marks are not necessarily transmitted to the offspring. But interestingly, RUMIGEN showed that epigenetic marks in sperm can be used to predict bull fertility.

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Why is this important?

DNA is very important in breeding, but it does not explain everything. Animal performance is also shaped by the environment, health, nutrition, heat stress and management. Epigenetics may help researchers understand how animals respond to these conditions.

This is especially relevant for future livestock systems, where animals will need to be productive, healthy and resilient under changing climate conditions.

Why does this matter?

For policymakers, this shows that climate resilience in livestock is not only about housing, feed or farm management. Animal biology and breeding also matter.

For the livestock sector, epigenetics could become an additional source of information to support better breeding and management decisions.

For society, it can help build a clearer picture of how animals respond to their living conditions.

What does this mean in practice?

- Epigenetics can help explain why animals with similar DNA sequence may perform differently.
- The EpiChip can make this type of research easier and more practical in bovine.
- Epigenetic information may support future work on fertility, health, resilience and heat adaptation.
- Epigenetics should be combined with genomic information, animal performance records and environmental data.

Key takeaway

RUMIGEN shows that genetic is not the whole story. Epigenetics can help us better understand how cattle respond to their environment and why some animals perform better than others under real-life conditions. Its strongest value is as an extra layer of information for more balanced, resilient and future-ready breeding.

RUMIGEN is an EU-funded project working to improve livestock breeding by combining genetic, epigenetic, and phenotypic knowledge to support more sustainable and resilient animal production.

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