

## Future-ready breeding

### How RUMIGEN supports practical breeding goals for resilience, welfare and genetic diversity

#### EXECUTIVE SUMMARY

RUMIGEN brought together results on heat stress, health, fertility, genetic diversity, epigenetics, genome editing and societal acceptance to develop practical breeding guidelines. The aim is to help breeding organisations to design balanced breeding objectives that improve productivity and resilience while protecting animal welfare, fertility and long-term genetic diversity.

#### THE ISSUE

Dairy breeding is entering a more complex period. Animals need to remain productive, but this is no longer enough on its own. Future breeding programmes also need to support cows that are healthy, fertile, robust, better able to cope with heat stress, and part of populations with enough genetic diversity to adapt over time.

This means breeding goals need to move beyond single-trait progress. Selecting only for high output can create trade-offs if health, fertility, welfare or diversity are not given enough weight. At the same time, breeding organisations have access to more information than before: DNA data, farm records, weather data, health and fertility records, early epigenetic information, and results from societal dialogue. The challenge is to turn this information into clear and practical breeding guidance.

## RUMIGEN contribution to solutions:

RUMIGEN's integration work translates scientific results into **operational breeding guidelines** for future dairy breeding objectives.

The guidelines bring together evidence from across the project and focus on one main question: **how can breeding programmes improve animals for future conditions while protecting animal welfare and genetic diversity?**

It will be crucial to maintain genetic diversity and define breeding goals that balance production with fertility, health, welfare and heat resilience.

For heat stress, RUMIGEN supports the use of two types of information. The first is how an animal performs in hot conditions. The second is how much its performance declines when heat stress increases. This helps identify animals that are not only high-performing, but also more resilient under warmer conditions.

For animal health and welfare, the guidelines promote a "welfare-by-design" approach. This means that breeding goals should give sufficient weight to traits associated with health, robustness and resilience. Traits such as udder health, fertility under heat, metabolic stability, longevity and calf vitality should be more visible in breeding decisions.

For genetic diversity, RUMIGEN recommends treating diversity as a real breeding constraint. In simple terms, genetic progress should not come at the cost of narrowing the breeding population too much. The guidelines highlight tools such as optimal contribution selection, sire-use limits, monitoring of inbreeding and tracking long DNA regions that show reduced diversity.

The guidelines also include new and emerging information, such as epigenetic data and genome-editing considerations. These are not presented as ready-made solutions for routine use everywhere. Instead, they are treated as tools that may add value if they are carefully tested, clearly justified and used with safeguards.

A distinctive part of the RUMIGEN approach is that technical recommendations are linked with societal acceptance. The guidelines use the Room of Acceptance logic to ask whether a breeding option is likely to be broadly acceptable, conditionally acceptable, or not acceptable at this stage. This helps ensure that breeding innovation is not only technically possible, but also socially responsible.

## Applications and potential impact:

For breeding organisations and breed societies, the guidelines provide a practical framework for updating breeding objectives. They can help decide which traits to include, how much weight to give them, and how to avoid unwanted trade-offs.

For breeding companies and artificial insemination centres, the guidelines support more careful sire use, mating strategies and dissemination of genetics. This is important for maintaining genetic diversity while still achieving breeding progress.

For recording organisations and data hubs, the work points to the need for better and more standardised data. In order to calculate breeding values that reflect future weather conditions weather data, health records, fertility data and performance records need to be connected in reliable ways.

For farmers, the long-term benefit is more practical breeding information. Instead of only knowing which animals perform best in average conditions, farmers may increasingly select for animals that are also more robust under stress, especially heat stress.

For policymakers, the message is that breeding should be recognised as part of climate adaptation, animal welfare, food security and biodiversity protection. Stronger data systems, diversity safeguards and responsible innovation frameworks can help the livestock sector prepare for future challenges.

The approach also aligns well with responsible breeding principles such as **Code EFABAR**, where breeding goals are expected to be transparent, balanced and linked to animal health, welfare, sustainability and long-term responsibility.

## Conclusions:

RUMIGEN shows that future breeding programmes need to be designed around balance.

The project's guidelines help translate scientific results into practical decisions: what to select for, how to account for heat stress, how to protect health and fertility, how to manage genetic diversity, and how to consider societal acceptance.

The main message is clear: Better breeding is about developing animals that are productive, healthy, fertile, resilient and adapted to future conditions, while maintaining the genetic diversity needed for long-term progress.