RUMIGEN

Towards Sustainable, Resilient and Socially Responsible Ruminant Breeding

Context and overall objectives

RUMIGEN set out to improve ruminant breeding by combining genomics, epigenetics and societal dialogue to support animals that are more resilient, efficient and sustainable, while maintaining genetic diversity. The project addressed a central challenge in modern breeding: how to achieve faster and more targeted improvement without undermining long-term diversity, animal welfare, public legitimacy or broader sustainability goals. To do this, RUMIGEN brought together work on adaptation to heat stress, genetic diversity and inbreeding, genome editing, epigenetic tools and public and stakeholder engagement. The aim was not only to generate new scientific knowledge, but also to clarify under which conditions new breeding approaches may be considered acceptable and useful in Europe.

Work performed and main results

RUMIGEN developed a structured societal dialogue model centred on the Room of Acceptance. This approach treats acceptance not as a simple yes-or-no judgement, but as a conditional space shaped by animal welfare, environmental sustainability, governance, transparency, fairness and the distribution of benefits and risks. The model was built through literature review, multi-actor engagement, scenario development, citizen consultation and ex-post refinement. Citizen engagement produced 787 valid responses, with most data coming from eight European countries and a small additional sample from Belgium. The final result is a more practical and parsimonious framework that can help identify negotiable trade-offs as well as possible societal red lines before breeding innovations are scaled up.

On the biological and breeding side, RUMIGEN generated important evidence on adaptation and diversity. Analyses across several dairy cattle populations showed that heat stress reduces milk production and increases somatic cell scores, pointing to greater susceptibility to mastitis, with stronger negative effects in high-producing animals. The project also showed that in small breeding populations, breeding design and genetic management can matter as much as, or more than, genomic selection itself for preserving diversity over time. A genome-wide analysis in five local cattle breeds identified 108 significant genomic regions associated with inbreeding depression and genetic load, creating new opportunities to avoid high-risk matings more precisely than through global inbreeding control alone.

RUMIGEN also advanced innovation in epigenetics and prediction. The project developed and tested the RUMIGEN EpiChip as a targeted epigenotyping tool for livestock. Using blood methylation data, project analyses identified marks associated with performance traits and showed that epigenetic information can explain a meaningful share of phenotypic variation in dairy cows, with an average contribution of around 11.9% across the analysed traits. In parallel, new statistical methods were proposed to integrate genomic, epigenomic and environmental information into prediction models, helping to prepare the ground for more informative and potentially more accurate future breeding tools.

In genome editing, RUMIGEN combined methodological review with proof-of-concept work. The project progressed practical examples including prion-resistant goats and heat-stress-resistant sheep, while also examining questions around genome stability, ownership, risk and broader societal legitimacy. Taken together, these results show that the project did not treat advanced breeding methods only as a technical opportunity, but also as an area requiring careful governance and public reflection.

Progress beyond the state of the art and potential impact

RUMIGEN goes beyond the state of the art because it connects frontier breeding science with responsible innovation. Its contribution is not limited to new data on heat tolerance, genetic load, genome editing and epigenetics. It also provides a reusable method for societal dialogue that can support breeders, researchers and policymakers in assessing whether a breeding pathway is not only technically feasible, but also socially credible. For breeding organisations, the project offers tools and evidence to support more climate-resilient and diversity-conscious strategies. For research and innovation actors, it demonstrates that early public engagement improves the quality and legitimacy of technology development. For policymakers, it provides a practical basis for thinking about governance, transparency and conditions for trust around new breeding approaches. Overall, RUMIGEN strengthens the basis for more sustainable, resilient and publicly robust livestock breeding in Europe.

Project website: https://rumigen.eu