

RUMIGEN: An assessment of its ethical dimensions

This report is based on observations made by Dr Andy Greenfield, the external ethics advisor, over the course of 5 years interacting with partners of the RUMIGEN project, alongside written materials on the aims and objectives of the project.

1. Summary

The RUMIGEN project is comprised of leading scientists around Europe with a shared set of aims and values – to use their expertise in improving animal breeding technologies, for the benefit of animals and humans, in order to meet the challenges we face as a society with respect to food security. RUMIGEN combines a number of approaches aimed at improving breeding methodologies in ruminants, with a view to generating animals with characteristics, such as disease-resistance and heat-tolerance, that confer improved resilience and allow them to thrive in emerging conditions of global warming. Such traits will allow productivity to be maintained in the face of changing (and more challenging) environmental conditions in future.

Over five years of RUMIGEN activities, partners have strived to make a scientific difference whilst also taking their ethical and societal obligations very seriously. This report details some of those scientific activities alongside their ethical dimensions and highlights contributions made in respect of animal welfare and alignment with public values in the animal breeding and food space.

2. Contributions made by individual work packages (WPs)

2.1 Genome Editing

WP5 used genome editing to introduce traits of improved resistance to some pathogens and climatic stress into goats and sheep. This was done by introducing genetic variants associated with those traits in other strains/species, thereby reducing the reliance on theory-based prediction concerning gene function. This is a notable contribution scientifically and is also one with a clear ethical dimension: it confers traits that improve animal health and welfare rather than for example, focusing on production traits. Moving forward, this work can contribute to **a model of responsible farming that is open to technological intervention such as genome editing but also has animal health and welfare at its heart**. The approaches used demonstrate that genome editing – not involving the introduction of any ‘foreign’ DNA i.e. transgenesis or genetic modification - can be used to introduce specific traits into farmed animals without altering other traits. This can save time when compared to alternative methods, such as introgression by selective breeding. But this approach does rely on the availability of genes in which variation can exert a major impact on the trait of interest.

Throughout, the project operated according to the principles of the 3Rs: reducing and replacing the use of animals and refining interventions (such as those required to perform genome editing e.g. surgery) to minimise any suffering.

Partners involved in this project note that genome editing has great potential to contribute to responsibly improving breeding of farmed animals, in the interests of

animals and humans, but it is too early to draw firm conclusions. Editing the genome of farmed animals is one tool amongst many that will be needed, alongside other novel breeding methods (also studied in RUMIGEN). However, partners also regret that the potential for a positive contribution by genome editing *cannot* be realised unless the legislative framework governing the breeding of farmed animals in the EU is changed.

2.2 Breeding animals better adapted to climate change using quantitative genetics

WPs 3 and 8 focused on breeding a range of cow populations with improved heat tolerance traits. They determined that excessive heat has a negative impact on animal/herd performance, such as milk yield, and on fertility. In addition, high production levels are genetically associated with lower heat stress tolerance. This research makes it clear it is important to consider all of a cow's physiological abilities together to define the best trade-off between productivity and heat stress tolerance. It also shows that the selection of dairy cattle – with a focus on genomic and epigenomic screening methods - should emphasise traits related to robustness to prepare future generations of cows able to face warmer conditions.

There is an ethical element to this research too: it is one of the aims of this research to **improve the long-term welfare of dairy cows**; firstly, by selecting thermotolerant animals based on behavioural and physiological criteria, and secondly, through developing real-time animal-centred indicators that monitor and generate alerts for farmers wishing to mitigate the impact of heat stress on their herd. Again, the 3Rs principles were adhered to during this project.

Related research in **WP4**, whilst not using animals directly, developed tools for the genomic management of genetic resources (and genetic drift) in livestock populations. These will be important in avoiding/minimising animal health and welfare issues in future livestock populations by increasing the frequency of beneficial gene variants, reducing the frequency of deleterious variants and maintaining genetic diversity.

2.3 Epigenomics and animal health and welfare

WP6 and WP7 explored the use of epigenomics in breeding of cows with improved health and climatic stress resistance. They developed the 'EpiChip', a tool for profiling the epigenetic status of 44,000 selected loci, informative for a number of relevant traits, including age, blood cell composition, inflammatory status, mastitis, nutrition, heat stress, metabolic stress and gut immunity. The EpiChip has so far been used to characterise 6000 animals and even in characterising sperm. The aim is to incorporate epigenomic profiling alongside genomic profiling in selective breeding, with a view to the early assessment of an animal's ability to adapt to environmental hazards and changes in husbandry practices, **to generate more resilient and efficient livestock farming systems with reduced environmental impact**. Such an approach might also help elaborate **recommendations for farmers** regarding herd renewal, career management, and breeding stock selection, which could contribute to improved welfare.

2.4 Societal dialogue on animal breeding technologies

Perhaps the clearest indication that RUMIGEN has taken very seriously its obligation to develop responsible technological innovation in animal breeding is the work performed by **WP2** on societal dialogue and **WP9** on dissemination of outputs. Driven by individuals with expertise and experience in this area of social science, **WP2** has focused on how best to develop future breeding technologies that operate within boundaries that are, in principle, **acceptable to relevant stakeholders and European citizens**.

WP2 adopted new stakeholder and citizen engagement methodologies, including the Room of Acceptance framework, to approach the question of social acceptability, rejecting simplistic binaries and aiming to identify the contexts, aims, outcomes and governance arrangements that might be seen as legitimate and responsible. The values expressed during dialogue on such topics are complex, covering animal welfare, corporate power, climate change, transparency, fairness and impacts on rural livelihoods. Such an approach allows acceptable trade-offs to be explored in the context of desirable future scenarios.

This research has shown how acceptance is best understood as conditional and sensitive to context. It allows RUMIGEN partners and the wider community to better understand where acceptance is robust, where it is fragile, and which conditions appear particularly decisive for societal acceptance. It isn't simply a matter of attitudes to a technology, but rather **a matter of how a technology is implemented in the real world**. This research has also shown how early engagement, before technology pathways are locked in, is so important. It is anticipated that the tools developed here could be reused beyond the RUMIGEN project.

3. Summary

There are three ethical elements of RUMIGEN's research that have been highlighted in this report:

- The ethical treatment of animals used in RUMIGEN's research – which has adhered to the 3Rs and has been assessed at national level to ensure compliance with all legal requirements in respect of animal health and welfare;
- The long-term aims of RUMIGEN's research are ethical – the focus is not improved production traits directly but rather disease-resistance and stress-tolerance traits that can benefit animal health and well-being and *thereby* maintain productivity in a changing world;
- The awareness that changes in policy in respect of breeding require public support following inclusive ethical deliberation – RUMIGEN has self-consciously reflected on the social conditions of its own long-term success and contributed to methods to engage publics in meaningful dialogue on the ethical dimensions of technology used in farmed animal breeding.

4. Challenges

RUMIGEN is operating within a hotly contested (ethical, social and political) space that elicits strong responses – because it concerns the value, acceptability and governance of emerging technologies, human interactions with animals, the sustainability and morality of the global farming system and, finally, human relationships with (and reliance on) food. There have been recent ethical assessments of intensive farming practices and the global food system which have been highly critical¹ and there is a significant (and persistent) proportion of society that wants to see an improvement in the conditions in which animals live when farmed. It must be acknowledged that any new technologies will be introduced into a food-farming system which may not be ideal. It will be important that the breeding technologies emerging from RUMIGEN direct farming systems onto the *right* trajectory – towards a sustainable system that is fairer for all involved (humans and animals) and can garner support because it is trusted to deliver change in the public interest that incorporates shared public values, such as the need for fairness and transparency.

5. Conclusion

RUMIGEN did not explicitly adopt a particular ethical framework when planning and pursuing its research objectives, although a broadly utilitarian framework – focussing on ensuring that outcomes exhibit a favourable balance of potential harms and benefits – was implicit (and is widely used by the scientific community). But at each RUMIGEN meeting, different dimensions of the ethical challenges arising from animal breeding were considered, ranging from considerations of the need to respond to climate change, through to scientific literacy, openness, public values and sustainable and just farming. RUMIGEN has made significant contributions to not only the *science* of farmed animal breeding but also the society-wide *ethical* deliberations that must be had in order to legitimise policy change. RUMIGEN partners are committed to such policy change – such as in the case of liberalising regulatory frameworks in Europe to allow marketing of animals with edited genomes – and they will continue to argue for it. But they do so with a renewed conviction that such change is not simply a matter of discussing technologies – rather, it requires ongoing deliberation over the sorts of animal breeding technologies – and associated purposes and desirable outcomes - that are in Europe’s broader interest and which citizens can support.

¹ See, for example, the 2021 report from the Nuffield Council on Bioethics: [Genome Editing and Farmed Animal Breeding: Social and Ethical Issues](#).