

# Between a rock and a hard place

*Farmers' perspectives on gene editing in livestock agriculture in Bavaria*

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**C**RISPR-Cas9, a new method for precisely modifying DNA, has received significant public attention in recent years. Heralded as a breakthrough technology to genetically modify organisms with hitherto unknown ease, precision and at low cost, CRISPR-Cas9 has reignited controversies in science and society about the kind of genetic modifications that can and should be achieved in animals, plants and humans. Historically, such public debates have been particularly heated in two areas: human germline modification and agricultural applications. This article focuses on the latter and explores how small- and medium-scale farmers evaluate the possibility and the potential benefits of gene editing livestock. This article importantly adds their voices to the discussion – voices that are surprisingly often unheard or ignored in public debates about using genetic technologies in agriculture.

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## Livestock animals: a novel target for genetic modification

CRISPR-Cas9 makes genetic modification of commonly farmed animals – cows, pigs, chicken or salmon – feasible at a large scale (Lamas-Toranzo *et al*, 2017). Prior technologies for genetically modifying higher organisms were either much more costly or less

precise and required significant investment to achieve the desired outcome, particularly in mammals. Consequently, academic and commercial enterprises have shown an increasing interest in gene editing livestock – in particular cows, pigs and chickens – for the meat, poultry and dairy industries. Research currently explores a number of traits for modification, ranging from disease vulnerabilities and increased muscle mass, to hornless cows and chickens with shorter beaks (Shriver & McConnachie, 2018).

While prior debates about genetic technologies in agriculture have centred almost exclusively on plants, these developments have now come to evoke public debates about gene editing livestock. In one of the first articles on this topic, *The New York Times*, for example, asked whether the inception of CRISPR-Cas9 would soon instigate an “open season” for genetic modification of animals (<https://www.nytimes.com/2015/11/27/us/2015-11-27-us-animal-gene-editing.html>). Past public debates about genetically modifying agricultural plants were heated, particularly in Europe, and eventually led to the current strict legal regulation of genetic technologies for agricultural use in the EU (Levidow & Boschert, 2011). The recent decision by the European Court of Justice – that organisms genetically edited via CRISPR-Cas9 or other methods should be regulated in the same way as “classical” genetically modified organisms – continues this restrictive stance towards genetic technologies in agriculture in Europe. Scientists across Europe objected vehemently to this verdict (<https://www.mpg.de/13761643/scientists-call-for-modernization-of-the-european-genetic-engineering-law>).

Germany has been among the countries where public rejection of these so-called

“green biotechnologies” has been particularly pronounced. Concerns have ranged from the safety of the technology itself to fears that genetically modified variants could invade ecosystems to objections that were rooted in strong associations between green biotechnologies and industrial farming, transnational agro-conglomerates, unequal wealth distribution and the commodification of life (Bauer, 2002; Murphy *et al*, 2006). Germany is not an isolated case, however: opposition to and rejection of GM crops remains high across the EU, although citizen’s attitudes appear to be changing slowly towards a more positive appraisal (European Commission, 2005; 2008; 2011). In the United States, opposition to genetically modified food products seems to be increasing (<https://www.pewresearch.org/fact-tank/2020/03/18/about-half-of-u-s-adults-are-wary-of-health-effects-of-genetically-modified-foods-but-many-also-see-advantages/>). These histories constitute an important background against which novel debates about the possible use of CRISPR-Cas9 in livestock emerge.

## Transdisciplinary perspectives on gene editing for livestock

Our research team has been part of a transdisciplinary consortium with the goal to proactively engage with these developments. The consortium brought together life scientists, local breeding associations, legal scholars and social scientists to explore the technical, legal and social feasibility of using CRISPR-Cas9 to genetically modify livestock animals for small- to medium-scale farms in Bavaria, Germany. Life science research in the consortium focused on genetic modifications that could improve animal health, particularly to prevent diseases. For example,

gene editing could facilitate immunity to colibacterotoxaemia in pigs, a common porcine disease that is characterized by massive oedemas, or to the porcine respiratory and reproductive virus. Both conditions can cause significant loss of animal life and farmer income. Other research explored genetic loci responsible for a bovine developmental disorder and the susceptibility of chickens to the avian leucosis virus.

Our social science research set out to explore how relevant publics relate to and evaluate these possibilities. We focused on the wider public as the potential consumers of food products from genetically modified livestock and on farmers as the possible producers of such products. Our research is informed by Science & Technology Studies (STS, see Box 1), a social science research field that understands science, technology and society as inherently intertwined: new technological developments convey specific visions of the future and it is these wider “socio-technical” visions that are being evaluated when novel technologies and their possible implementations are debated in society (Hartley et al, 2016).

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For this article, we specifically draw on qualitative, semi-structured interviews we conducted with small- and medium-scale farmers in Bavaria with whom we discussed how they view the potential use of CRISPR-Cas9 to gene edit livestock. To date, it is the first study in Germany, and, to our knowledge, worldwide, that interrogates farmers’ perspectives on this topic. It is challenging to recruit farmers for qualitative social science research because their work and other responsibilities consume most of their time. The study was explorative and the results are thus based on a relevantly small sample of 20 farmers; this sample, however, is highly diverse in terms of age (28–84 years), gender and farming practices – including ecological and conventional farming, part-time and full-

time farmers as well as farmers working with different species. These interviews with farmers were complemented with interviews and group discussions with representatives of local breeding and farming associations. An overarching theme that emerged from the interviews and discussions was that the benefits of any new technology must be balanced against the difficult social and economic conditions for small- and medium-scale farmers in Europe and elsewhere.

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### A place for farming in today’s society

There have been significant public debates in Germany recently about the role of farming in society. In 2019 and 2020, German farmers brought traffic to a standstill as they rode their tractors into cities to protest federal and state agricultural politics (<https://www.zdf.de/nachrichten/heute/warum-landwirte-bundesweit-demonstrieren-wollen-100.html>). They argued that farmers were continuously pushed to produce more and sell their products at ever lower prices, while at the same time, they had to comply with increasingly tight regulations regarding environmental protection and animal welfare. This puts a particular burden on small-scale farmers, many of whom struggle to survive financially under these conditions. Farmers also protested against being blamed, unjustly, they think, for many of the ills of today’s food production system, such as water pollution or animal welfare violations. As one farmer put it in an interview with the German public television broadcaster ZDF: “Only large farms with intensified plant and animal farming can make a profit today. But these kinds of structures do not comply with the expectations many consumers and society have towards farming” (<https://www.zdf.de/nachrichten/heute/makro-zukunft-der-landwirtschaft-100.html>; translation from German by the authors). Similar protests have been taking place in France, where farmers blocked highways, and in other European countries (<https://www.reuters.com/article/us-france-protests-farmers-idUSKBN1Y10MQ>). This crisis of small- and medium-scale farming, however, is not limited to Europe. India, for example, has been facing many cases of farmers committing suicide because of their dire social, economic and political situation (<https://www.businessinsider.com/india-farmers-protest-law-suicide-epidemic-2021-1?r=DE&IR=T>).

Bavaria has been an interesting context for our research since it is one of the few regions in Germany where relatively many small-scale farmers are still holding on: overall, 30% of all farms in Germany are located in Bavaria. More than half of these farms are part-time enterprises, that is the farmers have another source of income (<https://www.agrarbericht.bayern.de/politik-strategien/index.html>). Livestock farming for meat and dairy products is particularly important in Bavaria, which is home to about 25% of all cattle in Germany (Fig 1), and smaller percentages of pig and chicken farms. Many of these farms – often handed down over generations – face substantial financial pressure to either reorganize and optimize their practices or stop their operations; in that regard, the situation of Bavarian family-owned farms is characteristic of the pressures small-scale farmers are facing worldwide.

Against this backdrop, we discussed with small- and medium-scale farmers what they thought about using CRISPR-Cas9 to change certain traits of their animals. The scenarios ranged from using gene editing to create immunity to certain diseases, such as the avian flu or porcine reproductive and respiratory syndrome, to breeding hornless cattle or cattle with lower methane emissions, to increasing yields.

### CRISPR-Cas9: a way out of the dilemma?

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The majority of farmers were interested in gene editing technology and its possibilities. Only about a third categorically rejected it.



**Figure 1. A Bavarian cow.**

About 30% of all farms and 25% of all cattle in Germany are located in Bavaria. © Amy Clare, Technical University of Munich.

Their negative assessments were largely based on the belief that gene editing would constitute an unnecessary and unacceptable inference with nature and that it might open the door for genetic manipulations of humans. The others, however, were interested in using gene editing technologies if it could help them to improve their social and economic situation.

Importantly, none were interested in increasing yields, that is, for example, increasing the muscle mass of pigs for meat

production or the milk production of cows. They saw contemporary livestock as being at the brink of what their bodies can handle and voiced concerns that even traditional breeding techniques had pushed them too far for the sake of human consumption. Instead, they were interested in using CRISPR-Cas9 for improving animal health and possibly remedying some of the mistakes of conventional breeding. Animal health, they contended, was a topic that was equally – if not more – important for small-

and medium-scale farmers as for larger enterprises.

The main argument was that many diseases not only affect animals in intense agriculture where large numbers are confined to small spaces. The avian flu, for example, can spread from wild birds to domestic birds and free-ranging chicken are therefore more at risk as they have more contact with wild birds than those housed in small cages and halls. The financial burden of a disease outbreak is also often harder to shoulder for a small-scale business, where the cost of medication and the loss of income can doom the farm to go out of business. The farmers also raised the controversial issue of antibiotic use in the context of decreasing the risk of infectious diseases. Generally, the conversations with most farmers about gene editing were characterized by a pragmatic attitude: they were interested in the technology if it can improve animal health or reduce their environmental impact.

### What will the public say?

Yet, there is a big “but” in these narratives. The farmers made it very clear that they can only work with gene edited livestock if the public approves of it. Indeed, most interviewees were worried about how the public perceives their work and what they would think if they used genetic technologies. One farmer commented that if you listened to public opinion, you “could get the impression that farmers get up in the morning and first think about how to torture their animals and then go on to spray their fields and everything with pesticides”. Thus, even if gene editing provided benefits to small- and medium-scale farmers that allowed them to operate more sustainably, their willingness to use the technology ultimately depends on public opinion. If the public – the consumers of their products – do not approve, farmers will need to find other ways of getting by. Farmers can only work to increase animal welfare and to reduce the environmental footprint of their practices, particularly in small-scale settings, if they can sell their products at a reasonable price – in Bavaria as elsewhere.

In conclusion, we learned that farmers evaluate the benefits and perils of using CRISPR-Cas9 in livestock from their specific social and economic vantage points. Their arguments go far beyond mere “technophobic” or “technophilic” attitudes: farmers



assess the technology with regard to the potential benefits for them and for their animals, and vis-a-vis society's demands. Any discussion about the use of CRISPR-Cas9 in agriculture therefore must include farmers – after all, they are the ones who face the onus of producing healthy food in a sustainable way, and small- and medium-sized farms are arguably more likely to do that than corporate agri-business. This means that the debate about genetically modified crops and livestock should expand to include the place and the value of agriculture as such in contemporary society. Technology cannot be a solution for the often dire social and economic conditions of small- to medium-sized farms across the globe. That would require society and policy to better acknowledge the work and the worth of food producers. But, as one of our interview partners put it, technology could possibly be “a piece of the puzzle” that is the solution.

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us about gene editing technologies. Open Access funding enabled and organized by Projekt DEAL.

#### Box 1: Science & Technology Studies (STS)

STS is an interdisciplinary research field that studies how social, political and cultural values and structures affect scientific research and technological innovation, and how research and innovation in turn affect society, politics and culture. STS scholars analyse the means and conditions under which scientific knowledge and technologies are produced as well as the specific social, political, economic and historical contexts of research and technology development. By way of example, STS explores how major innovations such as CRISPR-Cas9 change knowledge production in the life sciences, the reasons why the technology is used to pursue specific research goals and not others, and how the outcomes of this research might affect society in social, political, economic and normative ways.

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