GENOME EDITING IN LIVESTOCK

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Recently developed genome editing technologies allow scientists to make very precise changes in the genome of livestock. These could be to the advantage of both humans and animals. If genome editing enables such a win-win situation, should we pursue it?

Hornless Cows

Most breeds of dairy cow have horns. These can cause serious injuries to other cows, as well as to the farmers handling them. To prevent such injuries, farmers routinely remove young calves' ability to grow horns by placing a hot iron on their horn buds, a very painful procedure that can also have detrimental long-term effects on the calves' welfare.

Some cattle breeds are genetically predisposed not to grow horns. This trait is called 'polledness'. Recently developed genome editing technologies that allow for very precise changes to an organism's genome have been used to insert this polledness trait into either the egg cells or the fertilized eggs (i.e., the early embryos) of horned dairy cows. The resulting calves do not grow horns, and, because polledness is a dominant trait, neither will their offspring. A painful procedure with long term harmful effects can be avoided.

Disease Resistant/Resilient Pigs

Worldwide, more than a billion pigs are raised and slaughtered for meat each year. This enormous pig population is under constant threat of infectious disease. African Swine Fever, for example, is a deadly viral disease for which there is neither a cure, nor a vaccine. In 2019 alone, over one million pigs were culled to prevent its spread. Another dangerous viral disease is Porcine Reproductive and Respiratory Syndrome (PRRS), which causes reproductive failure, pneumonia and increased mortality. The annual financial impact of the disease in Europe alone is estimated to be around €1.5 billion.[1]

[1] Xavier de Paz, 'PRRS cost for the European swine industry'. Pig.333.com, 17 August 2015. https://www.pig333.com/articles/prrs-cost-for-the-european-swine-industry_10069/ (accessed 27 June 2020).

Genome editing, and in particular the popular CRISPR-Cas9[2] technology, has been used to produce pigs that seem resistant to PRRS, and could potentially be used to produce pigs that are resilient to African Swine Fever, which means that though the pigs could get the disease, it wouldn't significantly affect them.

A Win-Win Situation

Should we pursue genome editing to produce hornless cows and disease-resistant or resilient pigs? At first sight, this would enable a win-win situation: it would be good for the farmers, as it would prevent enormous financial losses, and good for the animals, because it would prevent them from becoming seriously ill. Many people nevertheless object to, or are extremely suspicious of, the use of genome editing in livestock. In this chapter, I discuss some of the most serious concerns arising from the use of genome editing in livestock in cases where this could benefit both humans and animals. (I will not have anything to say about applications of genome editing that are clearly only to the advantage of humans, such as, for example, genome editing to increase meat per animal.)

Overstepping Divine or Natural Boundaries

One recurring worry about genome editing (and all technologies involving genetic modification) is that it oversteps the boundaries of humans' role in scientific research and development. These boundaries are thought to be set by either God (genome editing is then wrong because it amounts to 'playing God') or nature (genome editing is wrong because it is 'unnatural').

One problem is that we don't know, and cannot know, what God's plan is, if any such plan exists. Thus, we cannot know when we overstep some boundary set by God. Another problem is that referring to God won't appeal to those who do not believe in the existence of God.

How about overstepping some natural boundary? This objection, too, has little force, once we realise that we are constantly overstepping natural boundaries: when we wear clothes, use phones and computers, and use chemotherapy to treat cancer. For the objection to have some force, it would need to specify what is meant by 'unnatural' (artificial? unusual? unfamiliar?), explain why this kind of unnaturalness is morally problematic, and show that this understanding of 'unnatural' applies to genome editing but not to other practices that we accept, like mainstream medicine or travel into space. This is a challenge, especially in

[2] CRISPR is short for clustered regularly interspaced short palindromic repeats; Cas9 is a protein. CRISPR-Cas9 is typically used in an early embryo *in vitro* or in a fibroblast that is subsequently inserted into an enucleated cow egg by means of a cloning technique. The technology is popular because it is very precise, relatively simple, and cheap.

the context of agriculture, as current cows and pigs are the result of thousands of years of selective breeding and of the use of various technologies, including in vitro fertilisation and cloning, that seem, on the face of it, to be unnatural. It is not obvious that genome editing would add significant unnaturalness to what is already far from a natural situation. Moreover, in the case of hornless cattle and African Swine Flu resilient pigs, the genetic trait that is introduced occurs ‘naturally’ in some cattle breeds and warthogs. In the case of PRRS resistant pigs, CRISPR-Cas9 is used to remove a small section of one protein; nothing is added. Thus, in the applications under consideration, either a small section of a protein is removed, or a protein (or a part of it) that ‘naturally’ exists in the species is added. This poses an extra challenge for those trying to formulate a convincing argument against genome editing on the grounds that it is unnatural.

Too Risky

Some may object to the use of genome editing because it is too risky. Genome editing may create a chance of a win-win situation, but there’s no guarantee that it will work out. There could, for example, be ‘off-target’ effects - that is, unintended effects elsewhere in the genome. We might try to prevent horns from developing, but end up causing a disease. If cloning is part of the genome editing procedure, there are further risks, including a higher chance that the altered fetus will miscarry. Another worry is risk to humans. In two gene-edited calves, researchers found antibiotic resistance genes. Because these genes are present in most of the calves’ cells, the risk is high that they will be transferred to bacteria, which in turn could be transferred to humans via direct contact, food preparation or consumption, or excretion in the environment This could pose a serious danger to human health as the infections they cause may be much harder, or impossible, to treat.

However, whilst safety concerns are clearly important, these problems may be resolved as research continues. One could significantly reduce the risks to both livestock and humans by conducting research cautiously, investigating the technology step by step. If the technology is eventually deemed sufficiently safe, we’re left with the question as to whether we should apply it to produce, say, hornless cows and disease-resistant pigs.

Disrespectful

Some may think that genome editing in livestock would be disrespectful towards the animals. But what exactly does this mean? Respect is an opaque concept that requires explanation. What complicates matters is the fact that genome editing could happen before the animal comes into existence. For example, scientists might edit a skin cell, then insert this cell into an egg using cloning technology to create an embryo. Can genome editing be disrespectful to an animal when it is performed before it comes into existence?

When referring to respect, concepts like the 'intrinsic value' or 'inherent worth' of animals come to mind. Philosophers inspired by the eighteenth-century German philosopher Immanuel Kant might hold that it is wrong to use an animal merely as a means; that is, as an instrument to further one's goals. However, the applications of genome editing under consideration wouldn't involve using the animal merely as a means, since the aim would (also) be to improve the animal's welfare. Thus, the animal would also be treated 'as an end in itself'. This seems more respectful to the animal than current practices in factory farms that usually only take the animal's welfare into account insofar as it affects the quantity or quality of meat, dairy and eggs that can be produced.

Another concept that comes up in debates about respect for animals is that of 'telos', which refers to the innate purpose or goal of an individual or being. The American philosopher, Bernard Rollin, famously applied this concept to animals. Rollin understands telos as "the unique, evolutionary-determined, genetically-encoded, environmentally-shaped set of needs and interests which characterize the animal in question – the 'pigness' of the pig, the 'dogness' of the dog, and so on".[3] According to Rollin, we disrespect an animal when we prevent it from realizing its telos. But producing hornless cows and disease resistant pigs could be done in ways that do not make the cows any less cowish, and the pigs any less piggish, compared to their non-gene-edited variants. In the case of hornless cows, the cow would be hornless anyway, but as a result of a painful disbudding procedure.

Perhaps the contrast between the genetically altered cow and the farm cow today, misses the point. Perhaps we should instead simply be imagining and arguing for a world without factory farms? This brings us to the last, but, in my view, most important concern about genome editing in livestock.

A Technological Fix

Some may object to creating disease-resistant or resilient pigs and hornless cows, not because genome editing in itself is wrong, or because this would be disrespectful to the animals, but because it is the wrong kind of solution. Some may worry that it would be merely 'a technological fix' that superficially tackles the symptoms of the problem, while failing to address the 'real' or 'underlying' problem (e.g. our maltreatment of animals, or the social and economic structures that pull us towards factory farming).

Is this a convincing objection?

It's certainly true that creating, for example, disease-resistant pigs doesn't solve the more general

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[3] Bernard E. Rollin, 'Animal welfare, science and value'. In *Journal of Agricultural and Environmental Ethics*, (Suppl 2) 1993, 44–50.

problem of our exploitative attitude towards pigs, and livestock in general. But we accept many technological fixes that don't address the underlying problem. Cholesterol-lowering drugs don't solve the problem of unhealthy eating habits; a filter in a smokestack of a polluting factory doesn't address the existence of polluting factories. As long as one is clear about the target of a particular technological fix, it doesn't seem all that problematic that it only solves a narrow problem, or part of a problem, without addressing the 'real' or 'underlying' problem.

Perhaps the concern is not only that genome editing does not address the real or underlying problem, it might actually entrench the problem that it was meant to fix. A quote by an organic farmer expresses this worry:

> "If gene editing is being used for disease resistance and it is not encouraging companies to change the way they keep their pigs so they don't get the disease in the first place, then it becomes a problem rather than a solution".[4]

The idea seems to be that genome editing to produce disease resistant pigs will remove incentives to move towards a morally preferable solution to the spread of infectious disease, namely, keeping pigs further apart.

An additional concern may be that not only will genome editing remove incentives to keep pigs further apart, it will also diminish incentives to abandon factory farms altogether. It could then be said that genome editing in livestock makes us complicit in ethically problematic agricultural systems that contribute to global problems, such as massive animal suffering, pollution, spread of infectious disease in animals and humans, and climate change. It takes us further from the ideal solution, which would be to get rid of factory farms altogether.

Nevertheless, at least two questions arise. First, can genome editing be expected to slow down the transition to better solutions, and second, if so, is this sufficient reason to justify not pursuing it?

Whether genome editing would slow down the transition to better solutions is an empirical question that is difficult to answer. Pigs are kept in close confinement for several reasons. At present, the threat of disease doesn't seem to be an effective incentive for keeping animals in factory farms further apart, so it seems unlikely that making them disease resistant would affect how they are housed.

How about incentives to move away from factory farming altogether? This is even more difficult to assess. It is a matter of time before factory farms cause a new pandemic, perhaps one that is even worse than Covid-19. If there is one thing that may stop factory farming, it is the fear of such a pandemic. But if genome editing prevents infectious disease in livestock, we would no longer have such a fear. And so, the argument runs, we would lose the main rationale for reducing our

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[4] Pallab Ghosh, 'Gene-edited farm animals are on their way', *BBC News*, 22 June 218, https://www.bbc.co.uk/news/science-environment-44388038 (accessed 28 June 2020).

dependence on factory farming.

There is certainly something to this point. And the point is also somewhat specific to genome editing. Though there is some chance that any measure to improve animal wellbeing—even, say, providing larger cages for chickens—might delay the abolition of factory farms, the risk seems greater with genome editing. Providing larger cages goes much more against the spirit of factory farming. It comes much closer to what it would be like if animals were not contained in factory farms. Genome editing could be 'accused' of going along with the practice of factory farming – of facilitating it. This may entail more risk that it will indeed slow down a transition to alternative agricultural practices.

However, the effects of genome editing on incentives to move away or towards factory farming are uncertain, and it seems reasonable to choose to pursue genome editing to almost certainly prevent disease, and thus a pandemic, rather than relying on the hope that the risk of a pandemic may motivate a move away from factory farms. Moreover, even if genome editing would certainly delay the abolition of factory farms, this is not necessarily a conclusive argument against pursuing it. For the same reasoning would suggest it was wrong to improve the welfare of slaves in the United States in the 18th and 19th century, which may have delayed the abolition of slavery. Even if it did delay abolition, we surely think that it was morally justifiable, even obligatory, to improve the slaves' lives whenever that was feasible.

Ideally, we should try to improve animal welfare when we can, and simultaneously support a move away from factory farms (at least factory farms as we know them now) through other means. For example, we could combine genome editing with higher taxes for meat, dairy and eggs, or with financial and institutional support for the production of lab-grown meat.

Conclusion

Genome editing in livestock is around the corner. At least some applications seem to offer a win-win for the farmers and the animals. We considered the use of genome editing to produce hornless dairy cows or disease resistant/resilient pigs. Concerns about overstepping some divine or natural boundary are unconvincing as it is difficult to find an interpretation of 'unnatural' such that unnaturalness is morally problematic and applies to the applications of genome editing under consideration but not to other practices that we accept. Safety concerns can be met by proceeding carefully with the research and the translation of this research to the practice. Concerns about disrespect for animals are also not strong enough to ground an objection to genome editing as the applications under consideration would (also) use the animals as an end in themselves, and would respect the animals' telos, at least to the same extent as current factory farming. Finally, the 'technological fix' objection raises the important point that we need to keep the bigger picture in mind. However, it is not clear that genome editing to produce hornless cows and disease resistant or resilient pigs would move us away from morally preferable solutions. Even if they did, the best thing to do is to improve animal welfare and support measures that move us closer to a morally preferable solution, such as the abolition of factory farms.

I conclude that we should support research into applications of genome editing that would be to the benefit of both humans and animals, but that it is important to proceed cautiously. Simultaneously, we should do what we can to transform farming practices in other ways that improve animal lives and reduce environmental damage.

Further Reading

B. Rollin, The Frankenstein Syndrome: Ethical and Social Issues in the Genetic Engineering of Animals (Cambridge University Press, 1995).