This response was submitted to the Call for Evidence held by the Nuffield Council on Bioethics on *Genome editing* between 27 November 2015 and 1 February 2016. The views expressed are solely those of the respondent(s) and not those of the Council.

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Nuffield Council on Bioethics call for evidence on gene-editing

Submission by Compassion in World Farming

Compassion in World Farming is concerned about the detrimental impact on animal welfare of the gene editing of animals for food supply.

What is the current state of the art in the field?
This was helpfully summarised in a recent article in *The New York Times*. This can be seen at http://www.nytimes.com/2015/11/27/us/2015-11-27-us-animal-gene-editing.html?hp&action=click&pgtype=Homepage&clickSource=story-heading&module=photo-spot-region&region=top-news&WT.nav=top-news&_r=0

This article indicates that the work that is being undertaken in the field of gene editing of farm animals includes the production of:

- Hornless dairy cattle
- Animals that are resistant to certain diseases
- Pigs that can be fattened with less food
- Brazilian beef cattle that grow large muscles, yielding more meat
- Chickens that produce only females for egg-laying
- Cattle that produce only males, since females are less efficient at converting feed to muscle
- Meatier cashmere goats that also grow longer hair for soft sweaters
- Miniature pigs lacking a growth gene to be sold as novelty pets
- Animals with genetic resistance to a variety of diseases in livestock; this could theoretically reduce the overuse of antibiotics in farming.

One particular concern about gene editing is that it purports to offer solutions to problems that can be dealt with in a simpler, less high-tech manner or its solutions may even exacerbate the problem. An example of the former is given below as regards the suggestion that gene editing can be used to provide disease resistance thereby reducing antibiotic use in farming. This problem is much better addressed by moving away from intensive farming as this will result in healthier animals with strengthened immune systems making them less vulnerable to disease.

An example where the gene editing approach may make things worse is the suggestion that it can contribute to feeding the growing world population. In reality gene edited animals are likely to be primarily used in industrial systems which, because of their dependence on feeding human-edible cereals to animals, actually undermine food security and lead to environmental degradation.

What overall impact might genome editing have on animal lives?
Although some of the proposed uses of gene editing may appear benign, Compassion in World Farming fears that in the main gene editing will be used to further intensify the Western world's already very intensive livestock sector. Certainly this is how genetic selection has mainly been used in livestock.

Genetic selection has aimed - and continues to be directed – at increasing growth rates (in meat chickens, pigs and certain farmed fish species) or yield (in dairy cows and egg laying hens.) or litter size (in pigs). In each case this has had highly detrimental impacts on animal health and welfare.

The European Food Safety Authority (EFSA), which is responsible for reviewing the literature on animal welfare in the EU, has concluded that "long term genetic selection for high milk yield is the major factor causing poor welfare, in particular health problems, in dairy cows", and "the genetic component underlying milk yield has also been found to be positively correlated with the incidence of lameness, mastitis, reproductive disorders and metabolic disorders".[i]

EFSA has also concluded that genetic selection of pigs for rapid growth has led to leg disorders and cardiovascular malfunction.[ii] A large-scale UK study into leg disorders in broilers found that 27.6% of the chickens had gait scores of 3 or more, i.e. lameness that is likely to be painful. The study concluded that "the primary risk factors associated with impaired locomotion and poor leg health are those specifically associated with rate of growth".[iii] The high productivity of the modern laying hen causes osteoporosis and so creates a substantial risk of fractures both during the laying period and at depopulation at the end of lay.[iv]

The breeding of sows for large litters results in high levels of mortality due to low birth weights; these are also associated with a variety of negative long-term effects on piglets, such as increased reactivity to stress, throughout the pig's lifetime.[v] Large litters can result in intense teat competition which can be painful for the sow and lead to some piglets failing to gain adequate access to milk.[vi]

In light of the adverse impact of genetic selection on the health and welfare of farm animals, we fear that gene editing has the potential to be similarly damaging.

Increased disease resistance
Conferring improved disease resistance on animals appears to be positive. However, we fear that in many cases the diseases that will be addressed are those that are inherent in industrial livestock production. The UN Food and Agriculture Organisation stresses that industrial livestock production plays an important part in the emergence and spread of diseases. Also the European Medicines Agency has said that in production systems with a high density of animals, the development and spread of infectious diseases is favoured.

The proper way to address such diseases is to keep animals in less intensive systems. Good hygiene, husbandry and housing rather than gene editing should be used to prevent the diseases that stem from industrial livestock production.

Link with genetic engineering
The need to need to consider the animal welfare implications of biotechnology is highlighted by the recent decision by the US authorities to permit the first genetically engineered farm animal – GM farmed salmon – to be placed on the market for human consumption.

Some seek to distinguish gene editing from genetic engineering on the ground that gene edited.animals do not contain DNA from another species. However, definitions of genetic engineering are not limited to cases that involve the introduction of DNA from another species. Genetic engineering involves the insertion into an animal of genes from another

species or extra genes from the same species. Alternatively it can entail the manipulation or knocking-out of an animal's own genes.

The process of creating gene edited animals

The generation of a new GM animal involves invasive procedures and often results in the early death of some animals. One leading researcher has stressed that "The generation and use of transgenic animals are not neutral as they imply the sacrifice and in some cases the suffering of animals".

Many GM embryos do not survive, and of those that do survive only a small proportion (between 1% and 30%) carry the intended genetic modification.[vii] Current GM techniques are relatively inefficient, with many surplus animals being exposed to harmful procedures – undermining efforts to minimise animal use.[viii] It would be helpful to establish whether similar problems arise in gene editing.

Is gene editing needed to help feed a growing world population?

Advocates of the technology argue that it can make farming more efficient to help feed the growing world population with less of a toll on the environment.

The world population is expected to reach 9.6 billion by 2050. Some argue that to feed this population substantial increases in food production are required and that accordingly further industrialisation of agriculture – supported by techniques such as gene editing – is necessary.

However, industrial livestock production is profoundly inefficient because of its dependence on feeding grain – much of which could be used for direct human consumption – to animals who convert it very inefficiently into meat and milk. Studies show that for every 100 calories fed to animals in the form of human-edible crops, we receive on average just 17-30 calories in the form of meat and milk.[ix] [x] Some papers indicate that the efficiency rates may be even lower for meat.[xi] The FAO warns that further use of cereals as animal feed could threaten food security by reducing the grain available for human consumption.[xii]

Moreover, the argument that we need to produce large amounts of extra food is questionable. More than enough food is already produced to feed 9.6 billion people. Indeed some estimates suggest that we already produce enough to feed up to 14 billion people.[xiii] But over half this food is wasted. The real challenge lies not so much in producing more but in wasting less.

A report by the High Level Panel of Experts on Food Security and Nutrition states that worldwide 25% of food calories are lost or wasted post harvest or at the distribution/retail and consumer levels.[xiv] 9% of global crop calories are used for biofuels and other uses.[xv] 36% of the world's crop calories are fed to animals but three-quarters of this is wasted due to the low efficiency with which animals convert cereals to meat and milk.

The waste entailed in feeding cereals to animals is such that UNEP calculates that the cereals which, on a business-as-usual basis, are expected to be fed to livestock by 2050, could, if they were instead used to feed people directly, provide the necessary food energy for over 3.5 billion people.[xvi] Halving the use of cereals as feed would allow an extra 1.75 billion people to be fed. As indicated above, 25% of global food calories are lost or wasted post harvest or at the distribution/retail and consumer levels. Halving this waste would allow 1.3 billion people to be fed.

We are not arguing that no extra production is needed, simply that the increase needed is modest. Moreover, trying to increase production by further intensification of livestock production – achieved in part by gene editing – would be environmentally damaging.

Feeding cereals to animals – which is at the heart of industrial farming - is a wasteful use not only of these crops but of the land, water and energy used to grow them. Industrial livestock's need for huge quantities of cereals and soy as animal feed has fuelled pollution and overuse of water[xvii] as well as expansion of cropland and intensification of crop production.[xviii] These have led to deforestation[xix], land use change, biodiversity loss[xx], greenhouse gas (GHG) emissions[xxi], nitrogen pollution[xxii] [xxiii] and soil degradation.[xxiv]

Redefining the role of livestock

Research funded by the FAO argues that the role of livestock should be transformed. Rather than being fed on human-edible grain, their role should be "to use resources that cannot be otherwise used for food production".[xxv]

This research shows that the environmental pressures from livestock production could be reduced by focusing on grassland-based ruminant production and by reducing the amount of cereals fed to farm animals; this would entail a move away from intensive pig and poultry production and grain-based cattle. This would allow arable land to be farmed less intensively thereby enabling soils and biodiversity to be restored.

A 2014 paper takes a similar approach. It identifies grazing on pasture and use of crop residues and processing co-products as efficient forms of feed. It says that "together these support about 30% of current [global] livestock production; the remaining 70% has to be seen as a very inefficient use of land to produce food".[xxvi]

Such approaches to livestock production do not need advanced biotechnologies such as gene editing.

Some of the objectives of gene editing could be achieved in simpler ways

Gene editing is not necessary to produce cattle without horns. Conventional breeding methods could easily breed polled (without horns) animals. The fact that this has only been done to a small degree is not because of any inherent difficulty in doing so but due to lack of commitment from the industry.

Nor is gene editing needed to develop disease resistance in livestock in order to reduce antibiotic use. It is widely recognised that the high prophylactic use of antibiotics in farming is due to the intensive nature of today's livestock sector. *The Review on Antimicrobial Resistance* established by the UK Government published a paper in December 2015 entitled *Antimicrobials in Agriculture and the Environment*. This points out that prophylactic use is "particularly prevalent in intensive agriculture, where animals are kept in confined conditions".

Keeping animals in healthier, less intensive conditions could substantially reduce the need for antimicrobials. A strategy for promoting "positive health" in animals, which would not need recourse to regular prophylactic antibiotic use, would,:

- Reduce stress, for example by avoiding overcrowding and providing the opportunity for animals to perform types of natural behaviour that they are motivated to perform. Reducing stress can promote improved immune competence.
- Avoid mixing: mixing unfamiliar animals is a source of stress and increases the risk of transmission of infections.
- Reduce respiratory disease by maintaining good air quality in animal housing.
- Keep stocking densities low and avoid excessive herd or flock sizes: Overcrowding and very large numbers of animals facilitate disease transmission and the mutation of pathogens to become more virulent.
- Promote good weaning practice. Early weaning, before animals gain immunological and nutritional independence from their mother, can cause stress and lead to disease.
- Promote breeding for natural disease resistance and robustness and encourage a move away from genetic selection for high production levels as these appear to involve an increased risk of immunological problems and pathologies.

Treaty on the Functioning of the European Union

Failure to pay full regard to animal welfare in determining whether to carry out gene editing would contravene the Treaty on the Functioning of the EU. Article 13 of the Treaty requires the Member States when formulating and implementing the Union's policies on agriculture and technological development to "pay full regard to the welfare requirements of animals".

Proposed regulation of gene editing in animals for food

Gene editing of farm animals should not be permitted other than in the most exceptional circumstances where an impact assessment shows that:

- There will be no detrimental impact on animal health and welfare
- No less intrusive method of achieving the desired objective is available
- The desired objective does not entail facilitating the use of industrial livestock production systems as these have a wide range of inherent disadvantages for animal health and welfare.

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[i] Scientific Opinion of the Panel on Animal Health and Welfare on a request from European Commission on welfare of dairy cows. *The EFSA Journal* (2009) 1143, 1-38

[ii] Scientific Opinion of the Panel on Animal Health and Welfare on a request from the Commission on Animal health and welfare in fattening pigs in relation to housing and husbandry. *The EFSA Journal* (2007) 564, 1-14

[iii] Knowles, T. G., Kestin, S. C., Haslam, S. M., Brown, S. N., Green, L. E., Butterworth, A., Pope, S. J., Pfeiffer, D. and Nicol, C. J., 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. Plos one 3 (2): e1545. doi: 10.1371/journal.pone.0001545.

[iv] Laywell: Welfare implications of changes in production systems for laying hens: Deliverable 7.1

[v] The Ethical and Welfare Implications of Large Litter Size in the Domestic Pig: Challenges and Solutions, 2011. The Danish Centre for Bioethics and Risk Assessment and The Scottish Agricultural College

[vi] *Ibid*

[vii] Ormandy E. H., Dale J., Griffin G. 2011. Genetic engineering of animals: Ethical issues, including welfare concerns. *The Canadian Veterinary Journal,* May, 52(5): 544-550. www.ncbi.nlm.nih.gov/pmc/articles/PMC3078015/)

[viii] *Ibid*

[ix] Lundqvist, J., de Fraiture, C. Molden, D., 2008. Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain. SIWI Policy Brief. SIWI. http://www.siwi.org/documents/Resources/Policy_Briefs/PB_From_Filed_to_Fork_2008.pdf

[x] Nellemann, C., MacDevette, M., Manders, et al. (2009) *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. United Nations Environment Programme, GRID-Arendal, www.unep.org/pdf/foodcrisis_lores.pdf

[xi] Cassidy E.M *et al*, 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. University of Minnesota. Environ. Res. Lett. 8 (2013) 034015

[xii] FAO, 2013. Tackling climate change through livestock

[xiii] De Schutter, Nous pourrions nourrir deux fois la population mondiale, et pourtant... 2014 Le Point 09/09/2014 http://mobile.lepoint.fr/environnement/nous-pourrions-nourrir-deux-fois-la-population-mondiale-et-pourtant-09-09-2014-1861529_1927.php#xtor=CS1-31

[xiv] HLPE, 2014. Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014.

[xv] Cassidy E.M *et al*, 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. University of Minnesota. Environ. Res. Lett. 8 (2013) 034015

[xvi] Nellemann, C., MacDevette, M., Manders, et al. (2009) *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. United Nations Environment Programme, GRID-Arendal, www.unep.org/pdf/foodcrisis_lores.pdf

[xvii] Mekonnen M and Hoekstra A, 2012. A global assessment of the water footprint of farm animal products. Ecosystems.: DOI: 10.1007/s10021-011-9517-8

[xviii] Westhoek H *et al*, 2014. Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. Global Environmental Change, Vol 26, May 2014 p196-205. http://www.sciencedirect.com/science/article/pii/S0959378014000338

[xix] European Commission, 2013. The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation.

[xx] Commission staff working paper, 2011. Analysis associated with the Roadmap to a Resource Efficient Europe Part II, SEC (2011) 1067 final

[xxi] Bajželj B. e*t* al, 2014. Importance of food-demand management for climate mitigation. Nature Climate Change http://www.nature.com/doifinder/10.1038/nclimate2353

[xxii] Eds. Sutton M.A., Howard C.M., Erisman J.W., Billen G., Bleeker A., Grennfelt P., van Grinsven H. and Grizzetti B., 2011. The European Nitrogen Assessment. Cambridge University Press.
[xxiii] Sutton M. *et al*, 2013. *Our Nutrient World: The challenge to produce more food and energy with less pollution.* Global Overview of Nutrient Management. Centre for Ecology and Hydrology, Edinburgh on behalf of the Global Partnership on Nutrient Management and the International Nitrogen Initiative.
[xxiv] Edmondson *et al*, 2014. Urban cultivation in allotments maintains soil qualities adversely affected by conventional agriculture. Journal of Applied Ecology 2014, 51, 880–889
[xxv] Schader C et al. 2015. Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability. J. R. Soc. Interface 12: 20150891. http://dx.doi.org/10.1098/rsif.2015.0891
[xxvi] Bajželj B. *Et* al, 2014. Importance of food-demand management for climate mitigation. Nature Climate Change http://www.nature.com/doifinder/10.1038/nclimate2353