21st Century Genetic Technology and its Impact on Animal Welfare

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Department of Animal Science
An HSUS Report: Welfare Issues with Genetic Engineering and Cloning of Farm Animals

Abstract

Developments in biotechnology have raised new concerns about animal welfare, as farm animals now have their genomes modified (genetically engineered) or copied (cloned) to propagate certain traits useful to agribusiness, such as meat yield or feed conversion. These animals have been found to suffer from unusually high rates of birth defects, disabilities, and premature death. In the United States, there is significant public opposition to the introduction of meat and milk from cloned animals and their progeny into the food supply and currently no regulations exist to protect the welfare of farm animals during cloning or genetic engineering agricultural research.
Frankenfish Wins FDA Approval

After a decade of intense lobbying from a Maynard, Massachusetts-based salmon production corporation the Food and Drug Administration for the first time has given its seal of approval to a genetically modified animal.
“What’s to stop Colonel Sanders from creating a new genetically modified species of monster chickens that are market ready in a quarter of the time and possess six legs, ten wings and five breasts?”

Brief History of Genetic Selection

Genetic trend in the Duroc breed for days to 250 lbs. (1985-2008)

Genetic trend in the Angus breed for weaning and birth weights (1972-2008)
Brief History of Genetic Selection


poultryhub.org
## Net Merit Values, AIPL, USDA

<table>
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<tr>
<th>Trait</th>
<th>NM$ (2014)</th>
<th>Rel. % (2014)</th>
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<tbody>
<tr>
<td>Protein</td>
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<tr>
<td>Fat</td>
<td>3.22</td>
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<tr>
<td>Milk</td>
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<td>Udder</td>
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<td>Feet/Legs</td>
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<td>CA$</td>
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### USDA Economic Index (and Year Introduced)

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<td>Fat</td>
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<td>46%</td>
<td>45%</td>
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<td>22%</td>
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<td>27%</td>
<td>53%</td>
<td>43%</td>
<td>36%</td>
<td>33%</td>
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<td>Productive life</td>
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<td>11%</td>
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<td>...</td>
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<td>Feet/leg composite</td>
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<td>3%</td>
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<tr>
<td>Size composite</td>
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<td>-4%</td>
<td>-3%</td>
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<td>Daughter pregnancy rate</td>
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<td>7%</td>
<td>7%</td>
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<td>Calving ability</td>
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<td>...</td>
<td>...</td>
<td>4%</td>
<td>5%</td>
<td></td>
</tr>
</tbody>
</table>

K.A. Weigel, *Net Merit and its Use in Genetic Improvement Programs*, 2010
EPDs related to animal welfare (i.e., ability to cope with environment)
New Technologies Helping Animal Welfare

Australasian Veterinary Poultry Association, 2011

http://aspergillusblog.blogspot.com
GMO Livestock

Gene Engineering and Biotechnology News, 2016
GMO Livestock

• **Genetically Modified Organism** – Changing the genome of an organism

• Does NOT imply “genetic engineering”
CRISPR/Cas9 Gene Editing
Benefits of GMO Livestock

• Modify phenotype faster than through traditional genetic selection
  – Sometimes in ways not possible through traditional genetic selection strategies

• Potential to improve
  – Agricultural productivity & composition
  – Environment (“sustainability”)
  – Disease resistance and animal welfare
Improving productivity
Improving food composition

saturated fatty acid

unsaturated fatty acid

http://opm.phar.umich.edu
http://courses.washington.edu
Aqua Advantage Atlantic Salmon

- Introduced Chinook Salmon growth hormone gene into Atlantic Salmon
- Growth rate of salmon doubled, improving time to market and feed efficiency
- Approved by the FDA, 2015
Critiques of GMO Salmon

• Effects of accidental release of GMO salmon into the environment
  – Will GMO Salmon out-compete wild-type?
  – Commercial fish are all female and sterile

• Public perception
  – AquaBounty would prefer product is not labeled as GMO
Disease Resistance
Gene editing application in pigs

Deletes CD163 gene

This gene required by PRRS virus for entry into host.
Production of cattle lacking prion protein

Jürgen A Richt¹,², Poothappillai Kasinathan², Amir N Hamir¹, Joaquin Castilla³, Thillai Sathiyaseelan², Francisco Vargas¹, Janaki Sathiyaseelan², Hua Wu², Hiroaki Matsushita², Julie Koster², Shinichiro Kato⁴,⁵, Isao Ishida⁴, Claudio Soto³, James M Robl² & Yoshimi Kuroiwa⁴,⁵,⁶

Prion diseases are caused by propagation of misfolded forms of the normal cellular prion protein PrP⁰, such as PrP⁰BSE in bovine spongiform encephalopathy (BSE) in cattle and PrP⁰CJD in Creutzfeldt-Jakob disease (CJD) in humans¹. Disruption of PrP⁰ expression in mice, a species that does not naturally contract prion diseases, results in no apparent developmental abnormalities²,³,⁴,⁵. However, the impact of ablating PrP⁰ function in natural host species of prion diseases is unknown. Here we report the generation and characterization of PrP⁰-deficient cattle produced by a sequential gene-targeting system⁶. At over 20 months of age, the cattle are clinically, physiologically, histopathologically, immunologically and reproductively normal. Brain tissue homogenates are resistant to prion propagation in vitro as assessed by protein misfolding cyclic amplification⁷. PrP⁰-deficient cattle may be a useful model for prion research and could provide industrial bovine products free of prion proteins.
Holsteins without horns?

Environmental sustainability

Traditional pig

- Corn, soybeans, barley, and other grains contain indigestible phosphorus.
- Pigs excrete phosphorus that can enter into fresh water, kill wildlife, and contaminate the human water supply. Managing this waste is expensive for producers and limits the amount of pork they can produce.

Enviropig

- A combination of mouse and E. Coli DNA in pig genome prompts phytase production in the salivary gland. Even with the new DNA, Enviropig pork is chemically the same as traditional pork.
- Salivary phytase breaks down phosphorus in the pig's stomach. The pig can then absorb the phosphorus as phosphate. A small amount of phosphate is excreted in urine.
- Enviropig waste contains less phosphorus. With genetic modification, scientists created a pig that can be raised with less environmental impact.

South Dakota State University
College of Agriculture and Biological Sciences

http://enr.state.nc.us
http://snipview.com
Animal welfare concerns

• Unintended consequences?
  – Insertion of GH gene in pigs
  – Affects on survival and welfare

• Public perception
Consumer Perceptions of Food Technology, 2012

• 69% of consumers stated it was important that foods are produced sustainably

• 67-71% of consumers stated it was somewhat likely or very likely that they would purchase GE meat, dairy, or fish

Garas et al., 2015
Consumer Perceptions of Food Technology, 2012

- 58% of consumers had a favorable or neutral impression of animal biotechnology
  - 16% of consumers did not know how to answer.
  - 26% of consumers had an unfavorable view of animal biotechnology
  - 42% of these consumers did not understand the benefits of animal biotechnology
Take Home Messages

• Need for consistent regulations/approval processes for livestock GMOs

• Consumers are not, by default, against animal biotechnology
  – Especially if used to benefit animal welfare

• Education and transparency are key
Acknowledgements

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- Dr. Elizabeth Maga and colleagues
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