Effective Science Communication to Raise Awareness on Animal Biotechnology



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Gene Edited Polled Calves

Naturally-occurring bovine allele at polled locus



Production of hornless dairy cattle from genome-edited cell lines

To the Editor:

Physical dehorning of dairy cattle is practiced to protect animals and their handlers. Genetic analyses have identified variants that are associated with hornlessness (referred to as 'polled') in cattle, a trait that is common in beef but rare in dairy breeds. We have introgressed a candidate *POLLED* allele into dairy cattle by genome editing and reproductive cloning, providing both evidence for genetic causation and a means to introduce *POLLED* into livestock with the potential to improve the welfare of millions of cattle annually.

In the United States, an estimated 80%[1] of all dairy calves (4.8 million per year) and 25% (8.75 million animals) of beef cattle are dehorned every year. A lower proportion of beef cattle than dairy cattle need to be dehorned because the dominant *POLLED* locus is nearly fixed in beef cattle such as Angus, whereas dairy breeds such as Holstein have a much lower frequency of *POLLED* because of the small number of sires (6%) producing commercially available *POLLED* semen[2]. Physical dehorning of cattle, which is done to protect animals and producers from accidental injury is not only

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recombinetics

Acceligen

USDA United States Department of Agriculture National Institute of Food and Agriculture

U.S. Department of Agriculture
NIFA award 2015-67015-23316

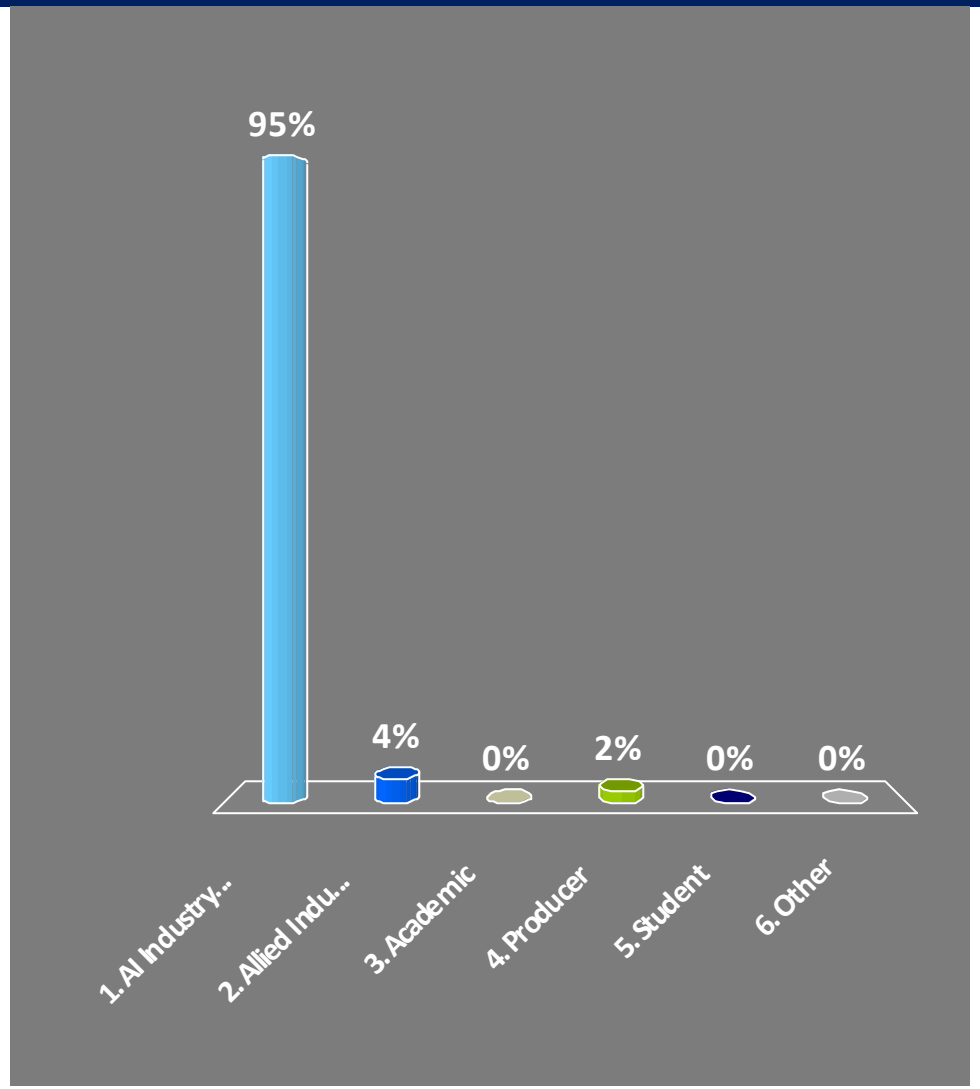


National Association of Animal Breeders (NAAB): Who are you?



1. AI Industry
2. Allied Industry
3. Academic
4. Producer
5. Student
6. Other

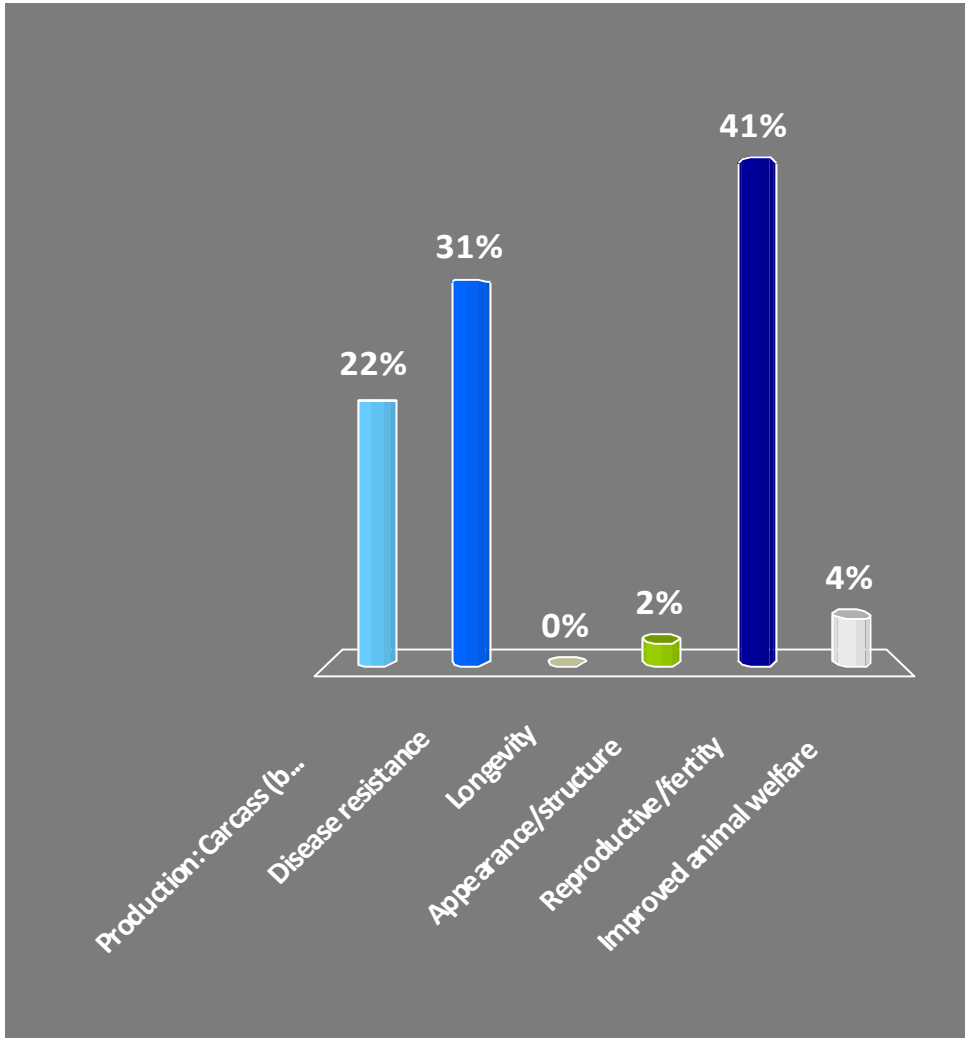
NAAB 10/14/2016



What category of traits would you value the most?



1. Production: Carcass (beef)/milk (dairy)
2. Disease resistance
3. Longevity
4. Appearance/structure
5. Reproductive/fertility
6. Improved animal welfare

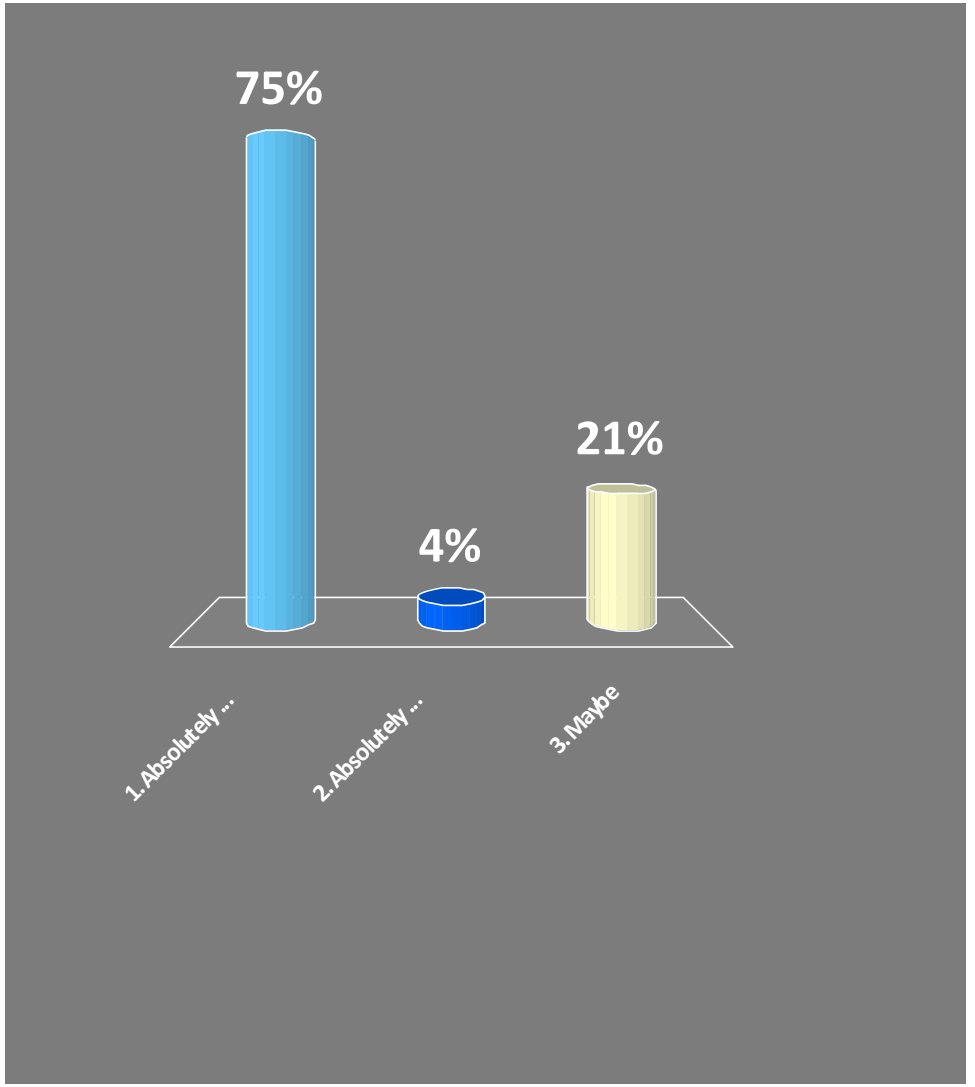


NAAB 10/14/2016

Would you/your company consider selling semen from a Holstein bull that had been gene edited for polled?



1. Absolutely Yes
2. Absolutely No
3. Maybe



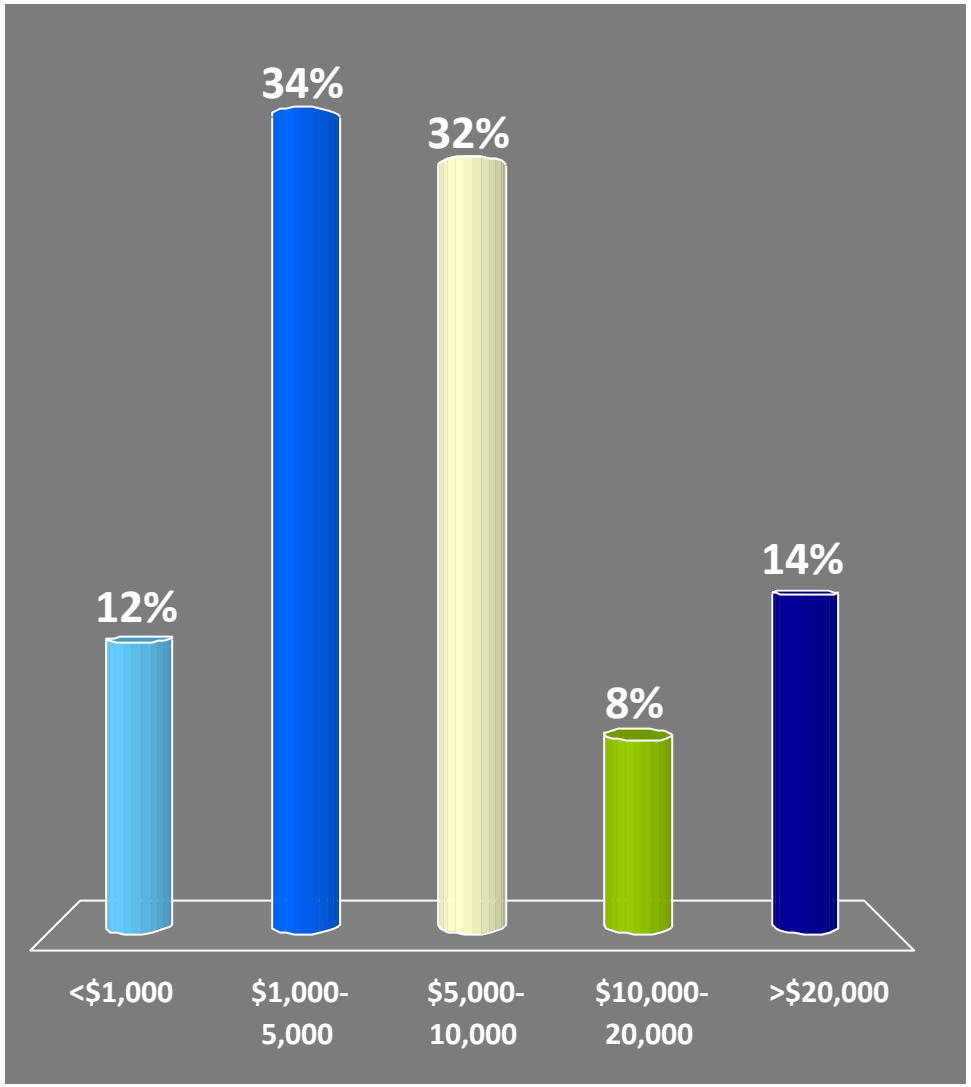
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How much more (on average) would you be willing to pay for a gene edited polled sire?



1. <$1,000
2. $1,000-5,000
3. $5,000-10,000
4. $10,000-20,000
5. >$20,000

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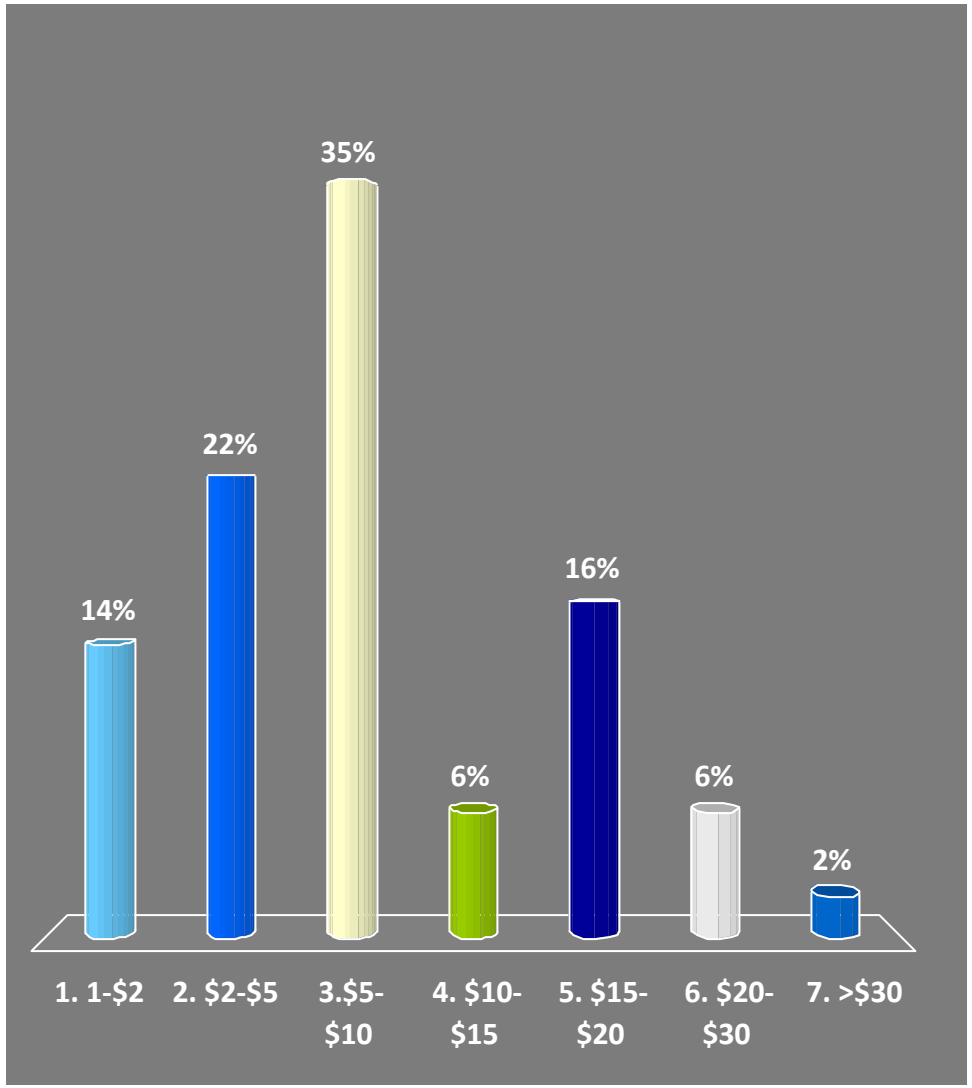
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How much more (on average) would the resulting semen have to sell for, for you to buy a gene edited polled sire?



1. 1-$2
2. $2-$5
3. $5-$10
4. $10-$15
5. $15-$20
6. $20-$30
7. >$30

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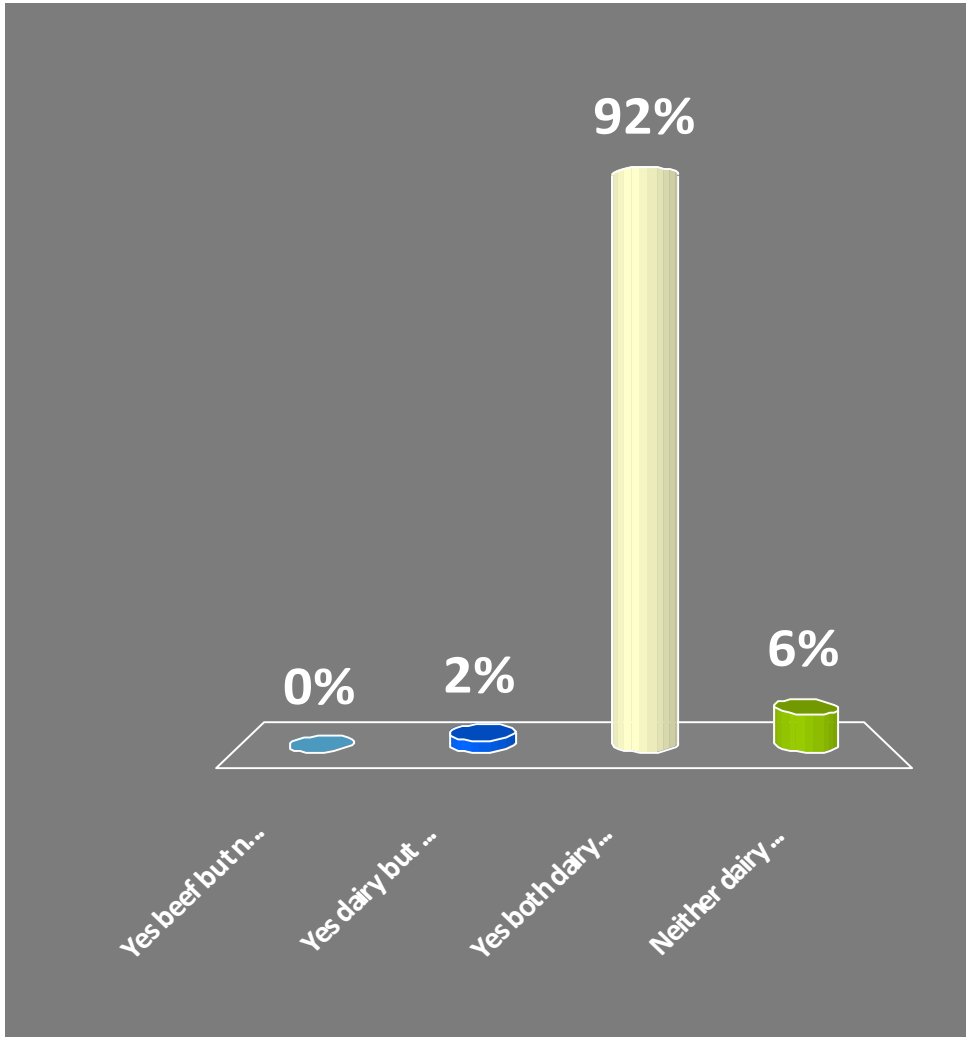


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If gene editing of livestock is regulated like conventional breeding (virtually no additional oversight), would you consider purchasing a gene edited sire?



1. Yes beef but not dairy
2. Yes dairy but not beef
3. Yes both dairy and beef
4. Neither dairy or beef

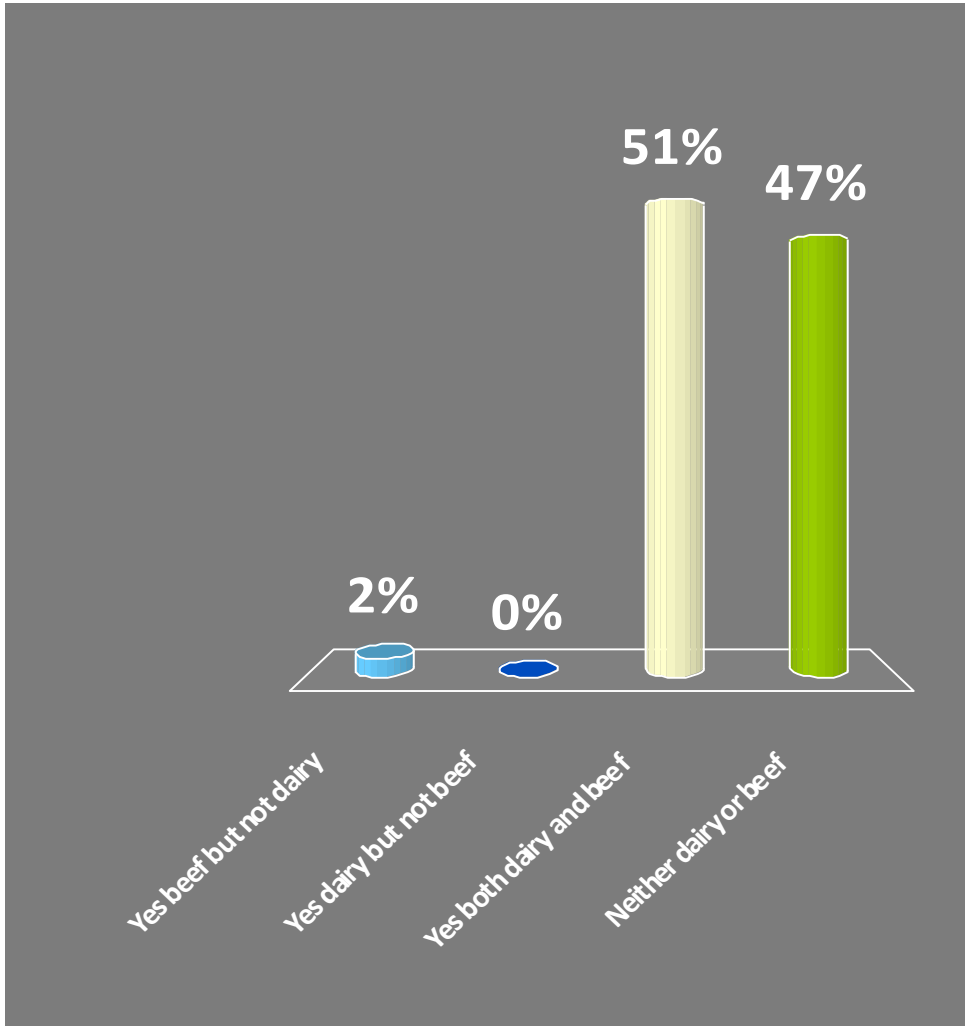


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If gene editing of livestock is regulated like genetic engineering (e.g. AquAdvantage salmon), would you consider purchasing a gene edited sire?



1. Yes beef but not dairy
2. Yes dairy but not beef
3. Yes both dairy and beef
4. Neither dairy or beef

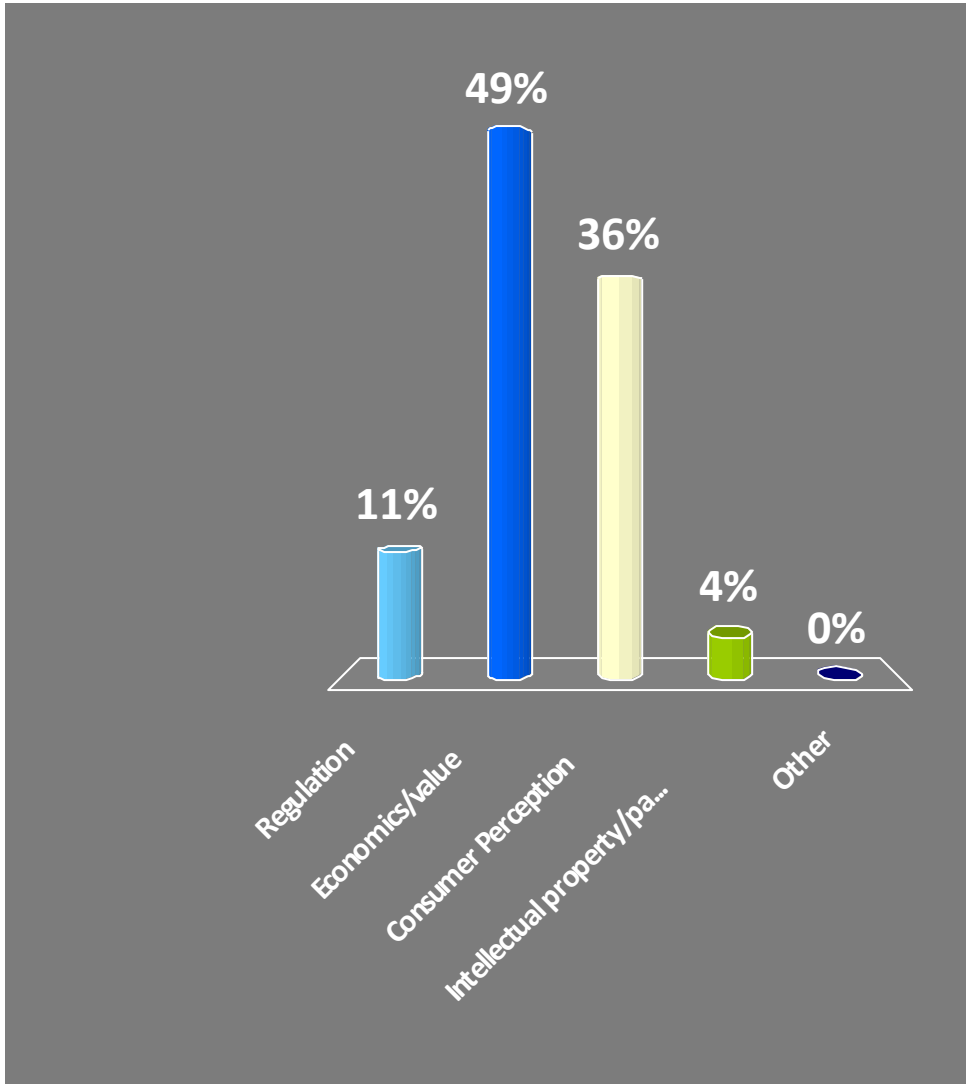


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Greatest factor influencing your decision to purchase a gene edited sire (or not)?



1. Regulation
2. Economics/value
3. Consumer Perception
4. Intellectual property/patents
5. Other



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Gene Edited Polled Calves

Naturally-occurring bovine allele at polled gene







10 base pairs (p)

212 base pairs (P)

POLLED GENE

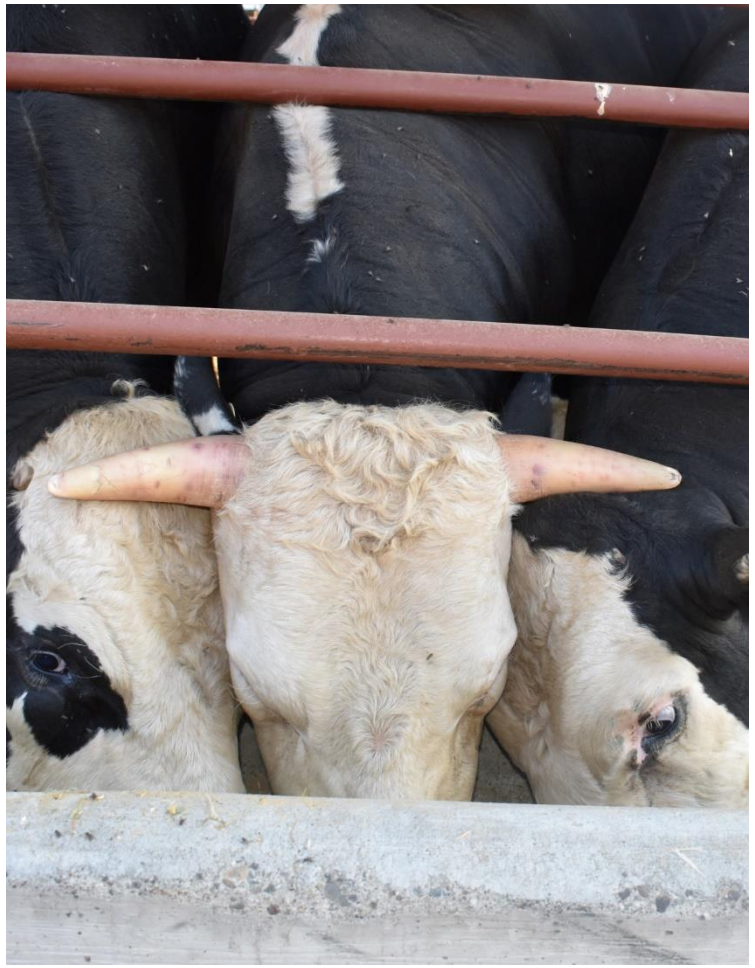








We analyzed these six polled calves and horned controls for two years





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nature biotechnology

ANALYSIS

https://doi.org/10.1038/s41587-019-0266-0

OPEN

Genomic and phenotypic analyses of six offspring of a genome-edited hornless bull

Amy E. Young[1], Tamer A. Mansour[2,3], Bret R. McNabb[3], Joseph R. Owen[1], Josephine F. Trott[1], C. Titus Brown[3] and Alison L. Van Eenennaam[1*]

Genome editing followed by reproductive cloning was previously used to produce two hornless dairy bulls. We crossed one genome-edited dairy bull, homozygous for the dominant P_C Celtic *POLLED* allele, with horned cows (pp) and obtained six heterozygous (P_Cp) polled calves. The calves had no horns and were otherwise healthy and phenotypically unremarkable. We conducted whole-genome sequencing of all animals using an Illumina HiSeq4000 to achieve ~20× coverage. Bioinformatics analyses revealed the bull was a compound heterozygote, carrying one naturally occurring P_C Celtic *POLLED* allele and an allele containing an additional introgression of the homology-directed repair donor plasmid along with the P_C Celtic allele. These alleles segregated in the offspring of this bull, and inheritance of either allele produced polled calves. No other unintended genomic alterations were observed. These data can be used to inform conversations in the scientific community, with regulatory authorities and with the public around 'intentional genomic alterations' and future regulatory actions regarding genome-edited animals.

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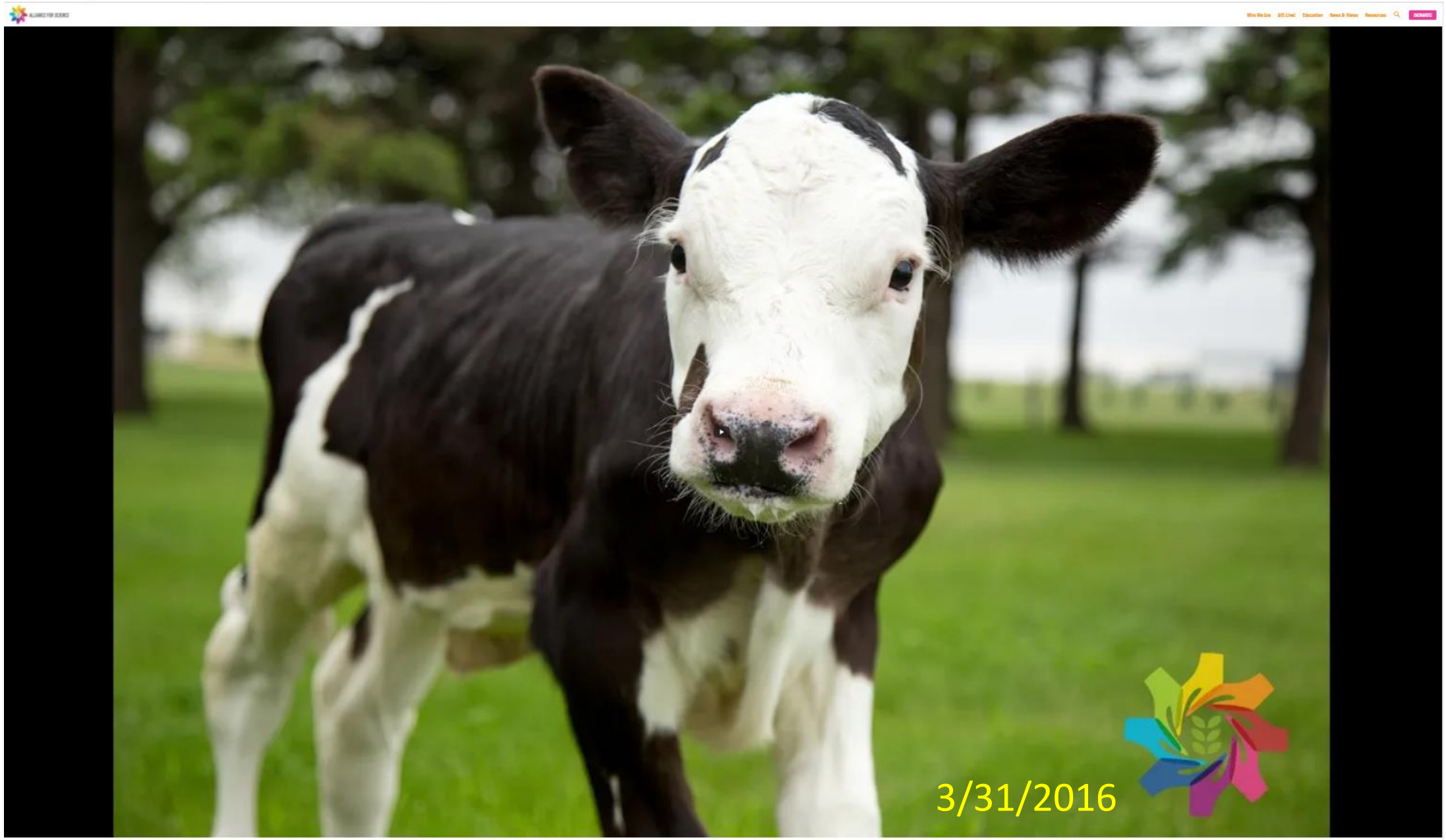
https://www.youtube.com/watch?v=tdhJdVYkThU

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https://allianceforscience.cornell.edu/blog/2016/03/video-precision-breeding-offers-new-alternative-to-dehorning-cattle/

Apps Getting Started From Google Chro... Altmetric it! DDX Reading list



Video: Precision Breeding Offers New Alternative to Dehorning Cattle

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https://www.wired.com/story/crispr-gene-editing-humane-livestock 3/19/2019

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Even a cow needs a makeover to be a covergirl







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Princess gets her 15 minutes of fame





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https://www.wired.com/story/crispr-gene-editing-humane-livestock 3/19/2019

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Winter is coming



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Picnic Day











Surveyed public audience on gene editing

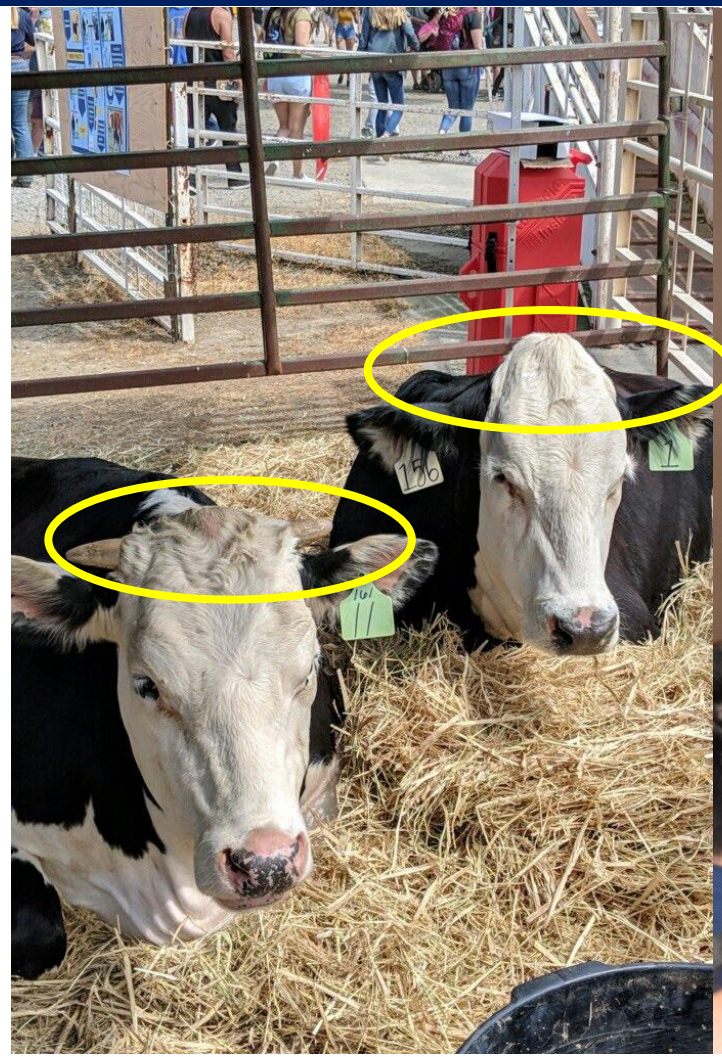


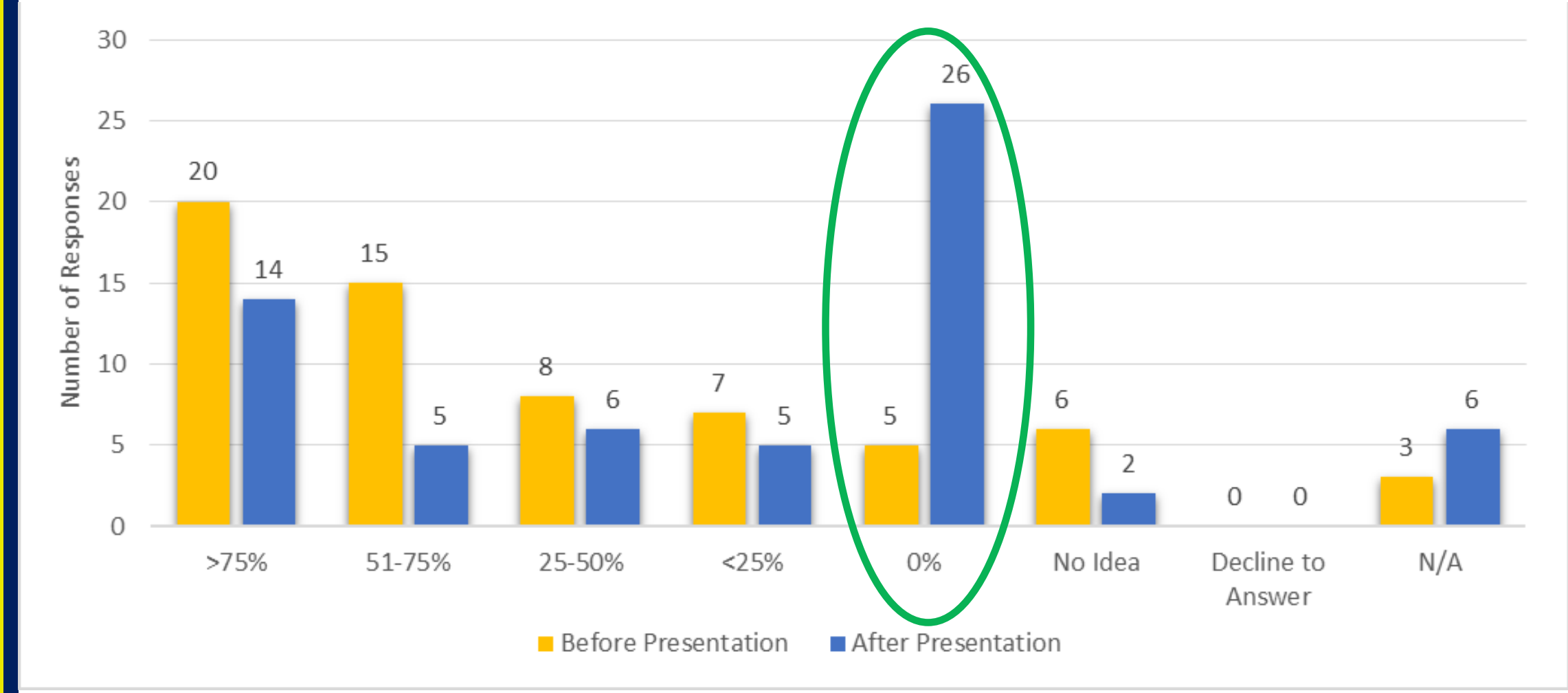


Photo credit Maci Mueller/UC Davis

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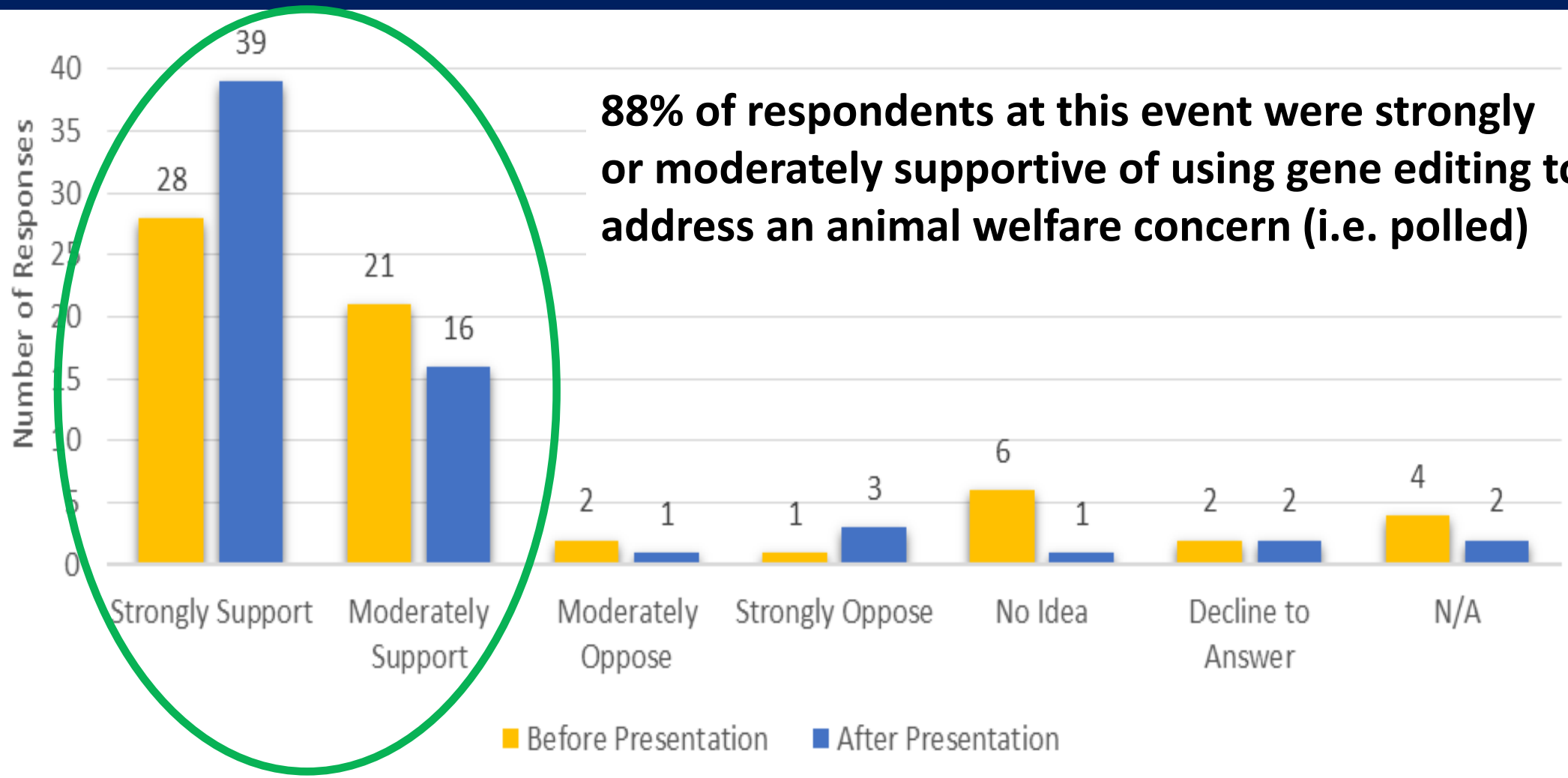


What percentage of animal products like milk, meat, and eggs currently come from animals that have been produced using genetic engineering?



How do you feel about the use of gene editing to address an animal welfare concern?





88% of respondents at this event were strongly or moderately supportive of using gene editing to address an animal welfare concern (i.e. polled)

Public attitudes towards genetically modified polled cattle

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PLOS ONE

RESEARCH ARTICLE

Public attitudes towards genetically modified polled cattle

Emilie McConnachie[1], Maria Jose Hötzel[2], Jesse A. Robbins[1], Adam Shriver[1,3], Daniel M. Weary[1], Marina A. G. von Keyserlingk[1]*

1 Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada, **2** Laboratorio de Etologia Aplicada e Bem-Estar Animal, Departamento de Zootecnia e Desenvolvimento Rural, Universidade Federal de Santa Catarina, Florianópolis, Brazil, **3** Wellcome Centre for Ethics and Humanities, Nuffield Department of Population Health, University of Oxford, Oxford, United Kingdom

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Abstract

Genetic modification of farm animals has not been well accepted by the public. Some modifications have the potential to improve animal welfare. One such example is the use of gene editing (i.e. CRISPR (clustered regularly interspaced short palindromic repeats)) to spread the naturally occurring *POLLED* gene, as these genetically hornless animals would not need to experience the painful procedures used to remove the horns or horn buds. The aim of the current study was to assess public attitudes regarding the use of GM to produce polled cattle. United States (US) citizens (n = 598), recruited via Amazon Mechanical Turk, were asked "Do you think genetically modifying cows to be hornless would be. . .", and responded using a 7-point Likert scale (1 = a very bad thing, 4 = neither good nor bad, 7 = a very good thing). Participants were then asked to indicate if they would be willing to consume products from these modified animals. We excluded 164 of the original 598 participants for not completing the survey, failing any of three attention check questions, or providing no or unintelligible qualitative responses. Respondents were then asked to provide a written statement explaining their answers; these reasons were subjected to qualitative analysis. Comparison of Likert scale ratings between two groups was done using the Wilcoxon rank-sum test, and comparisons between more than two groups were done using the Kruskal-Wallis rank test. More people responded that the modification would be good (Likert ≥ 5; 65.7%) than bad (Likert ≤ 3; 23.1%), and that they would be willing to consume products from these animals (Likert ≥ 5; 66.0%) versus not consume these products (Likert ≤ 3; 22.6%). Qualitative analysis of the text responses showed that participant reasoning was based on several themes including animal welfare, uncertainty about the technology, and worker well-being. In conclusion, many participants reported positive attitudes towards GM

Check for updates

OPEN ACCESS

Citation: McConnachie E, Hötzel MJ, Robbins JA, Shriver A, Weary DM, von Keyserlingk MAG (2019) Public attitudes towards genetically modified polled cattle. PLoS ONE 14(5): e0216542. https://doi.org/10.1371/journal.pone.0216542

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Data Availability Statement: All relevant data are within the manuscript and Supporting Information

"In conclusion, many participants reported positive attitudes towards GM polled cattle; we suggest that people may be more likely to support GM technologies when these are perceived to benefit the animal."

McConnachie E, Hötzel MJ, Robbins JA, Shriver A, Weary DM, von Keyserlingk MAG (2019) **Public attitudes towards genetically modified polled cattle.** PLoS ONE 14(5): e0216542. https://doi.org/10.1371/journal.pone.0216542

Thirty Years in the Making

YouTube: https://youtu.be/vrAkajpHGPI





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Conclusions

- The narrative that the public will not accept the products produced by genetically modified animals has not really ever been put to the test – **as <u>until now such food products have not been available</u>**
- If products people want are allowed to come to market, this technology can be successful – e.g. Impossible Burger with GM heme
- As we have learned over the past year – **science does not change minds** or necessarily result in evidence-based policy decisions
- Many potential applications of biotechnology address traits that are of concern to the general public such as disease resistance, animal welfare and resilience, and product quality traits
- Emphasizing shared values resulting from a genetic solution to a problem such as disease is more important than the technical aspects – and is an important consideration in the commercialization of these products

Questions?



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My laboratory receives public funding support from the National Institute of Food and Agriculture and the Biotechnology Risk Assessment Grant (BRAG) program, U.S. Department of Agriculture, under award numbers 2017-33522-27097, 2018-67030-28360, 2020-67015-31536, and 2020-70410-32899

FFAR Foundation for Food and Agriculture Research

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USDA United States Department of Agriculture

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