Leveraging new technologies and novel breeding strategies to sustainably grow global beef production

M.A. Cleveland and F.B. Mokry
Genus ABS, De Forest, WI USA

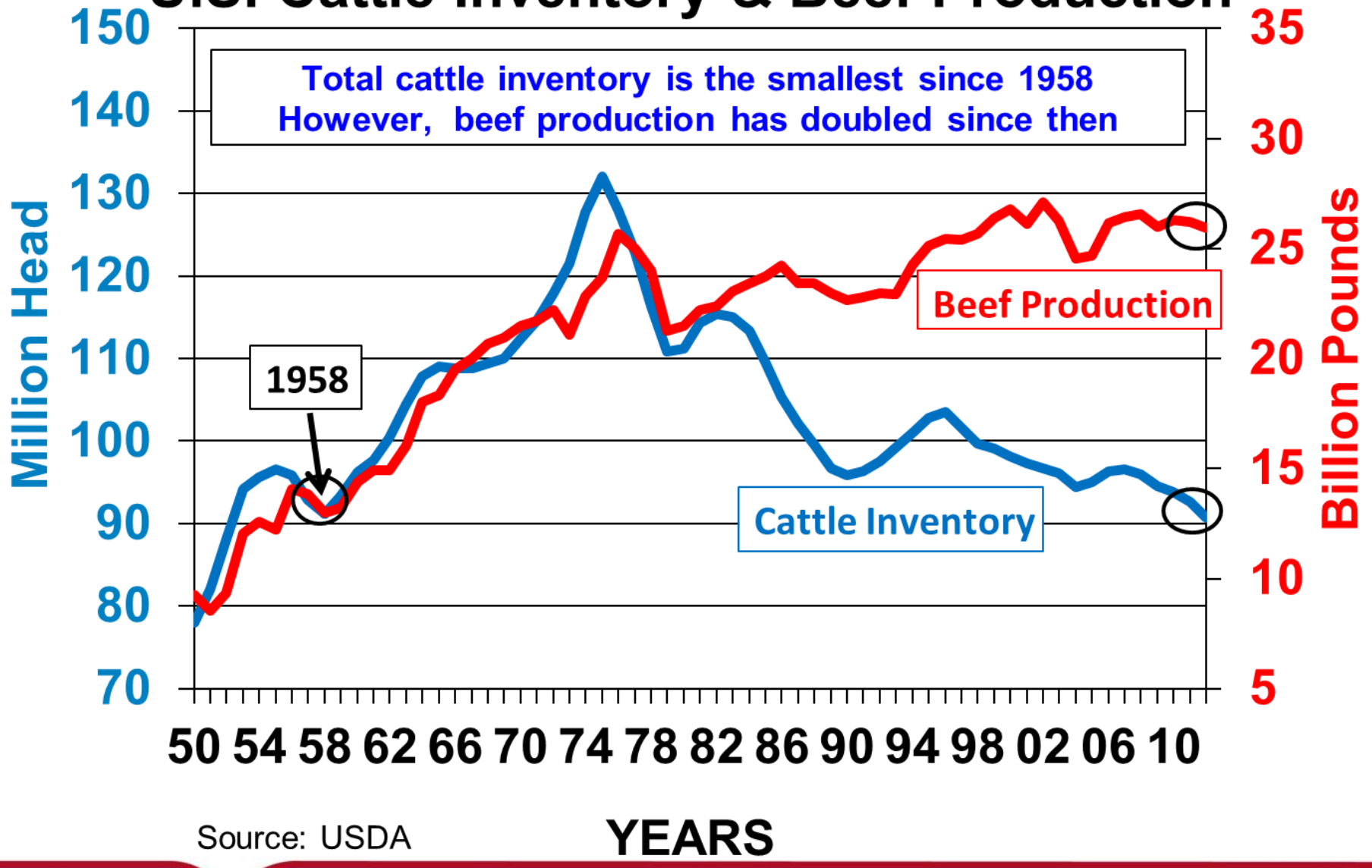
matthew.cleveland@genusplc.com

Genus

Profit From Genetic Progress

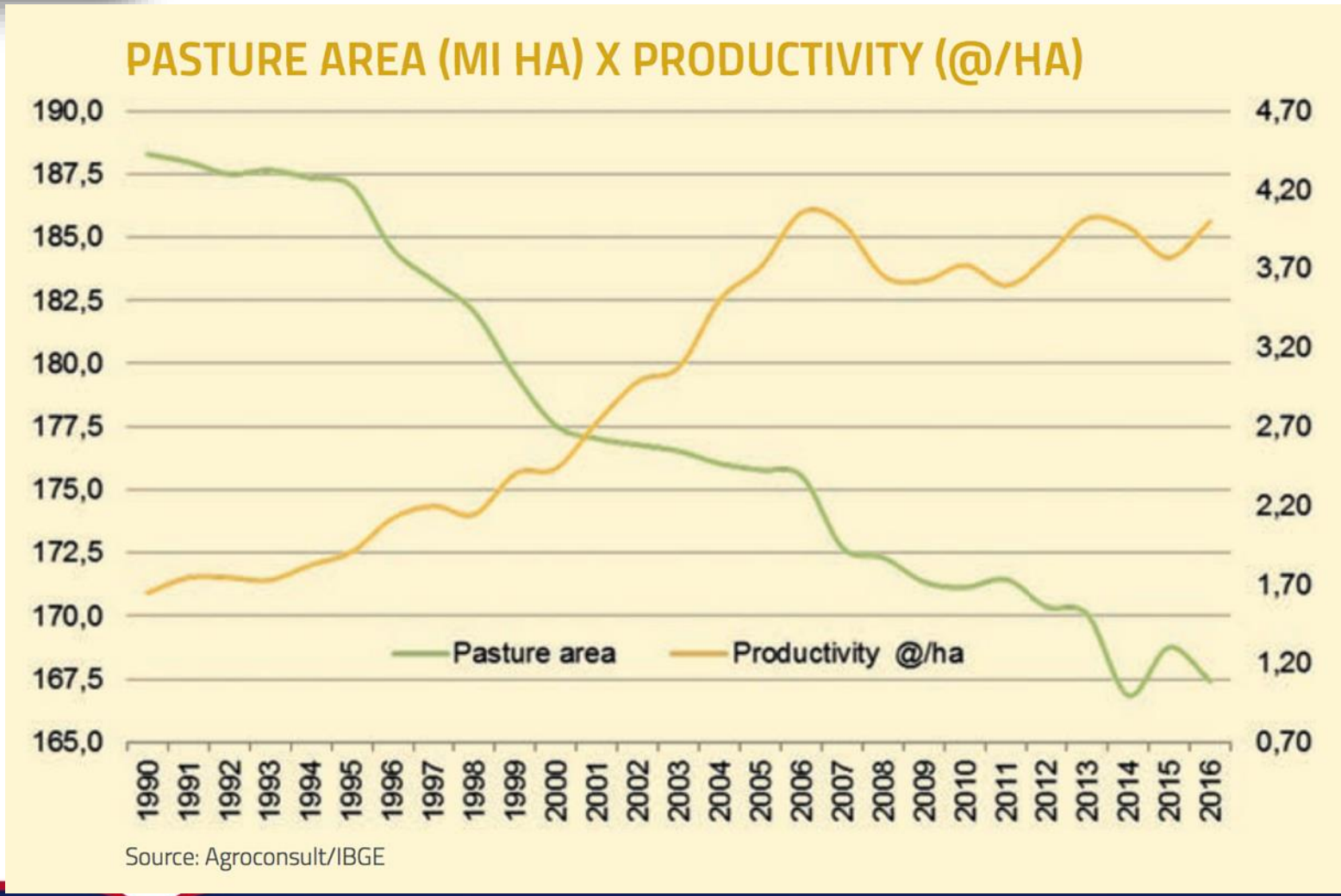
ABS

U.S. Cattle Inventory & Beef Production



Source: USDA

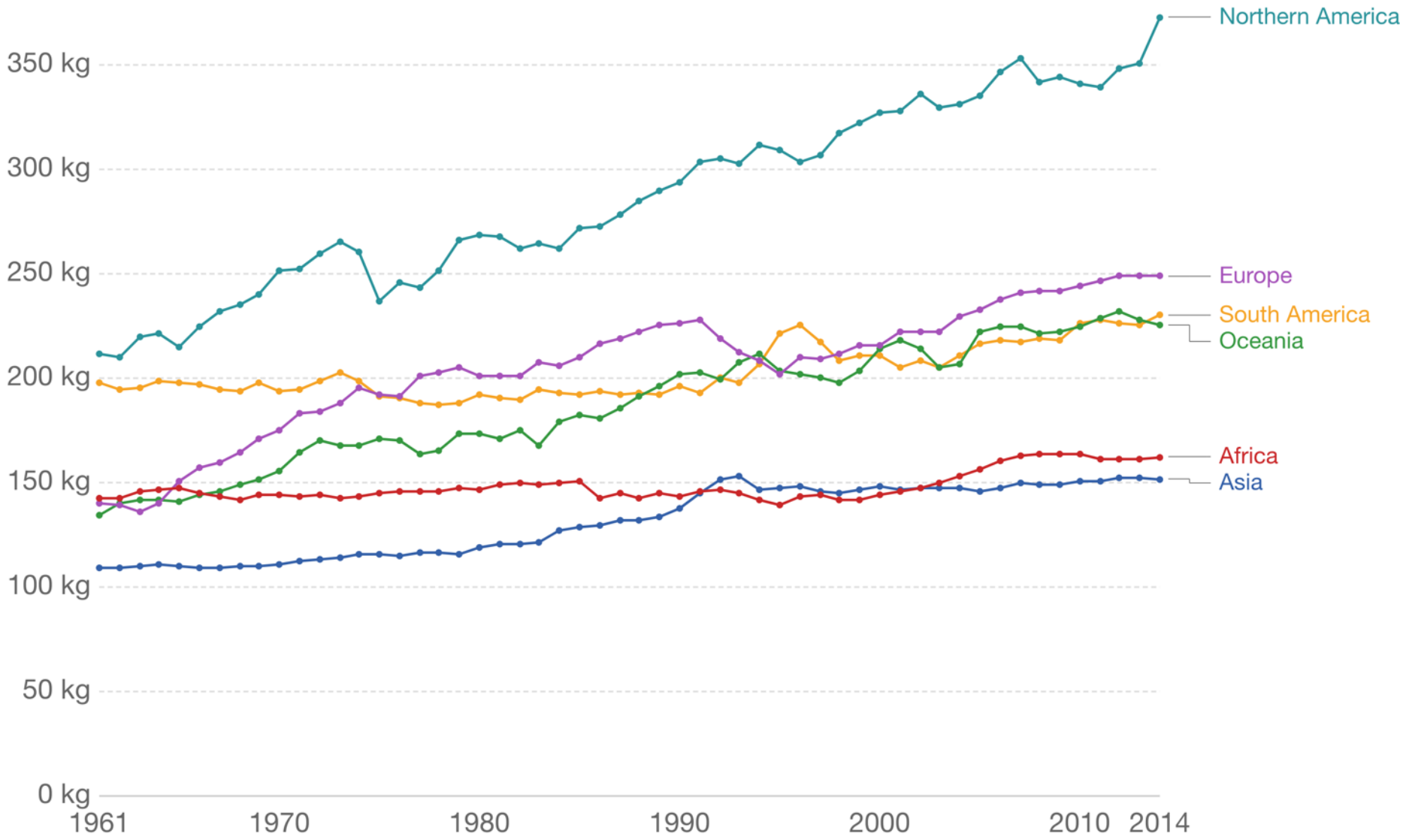
Brazil: available pasture and beef production per hectare



Brazilian livestock overview and its contribution to the sustainable development, 2016

Cattle meat yields, kilograms per animal

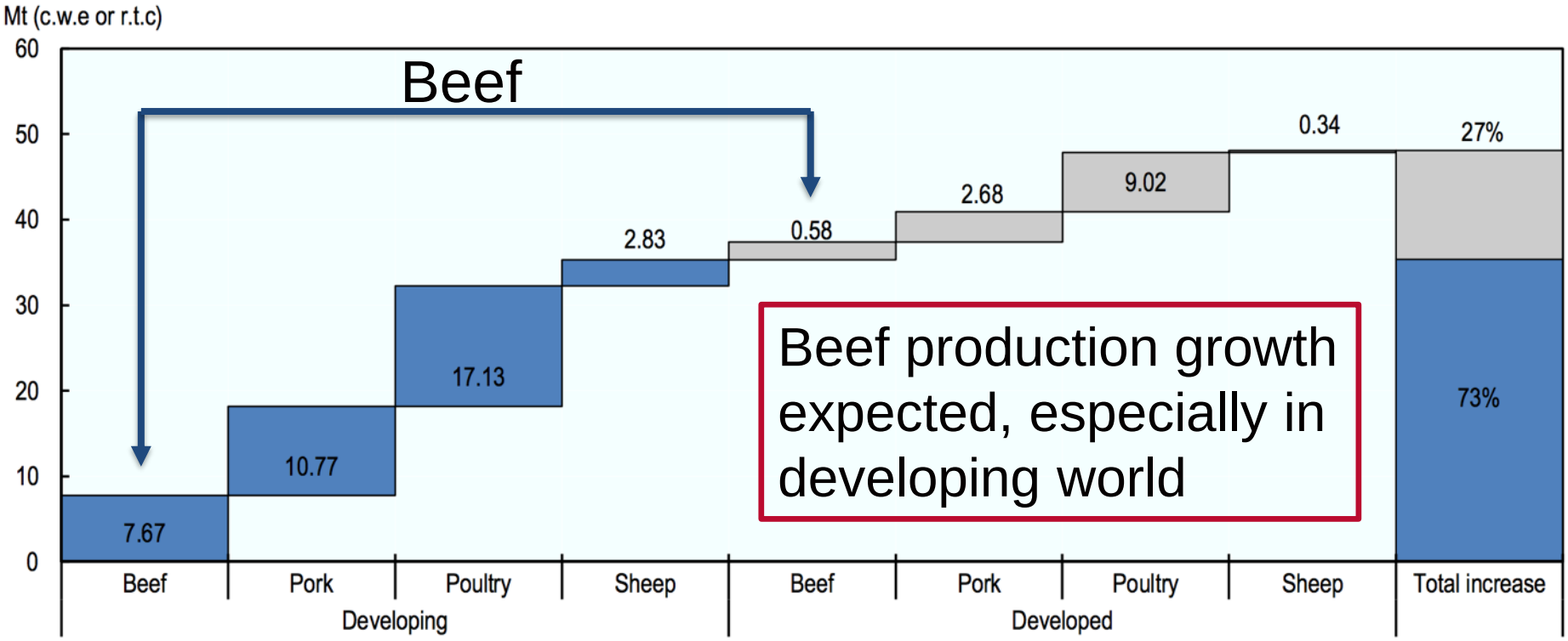
Average meat yields of cattle (beef and buffalo), measured in kilograms per animal.



Source: UN Food and Agricultural Organization (FAO)

OurWorldInData.org/meat-and-seafood-production-consumption/ • CC BY-SA

Growth of meat production by region and meat type
2025 vs 2013-15

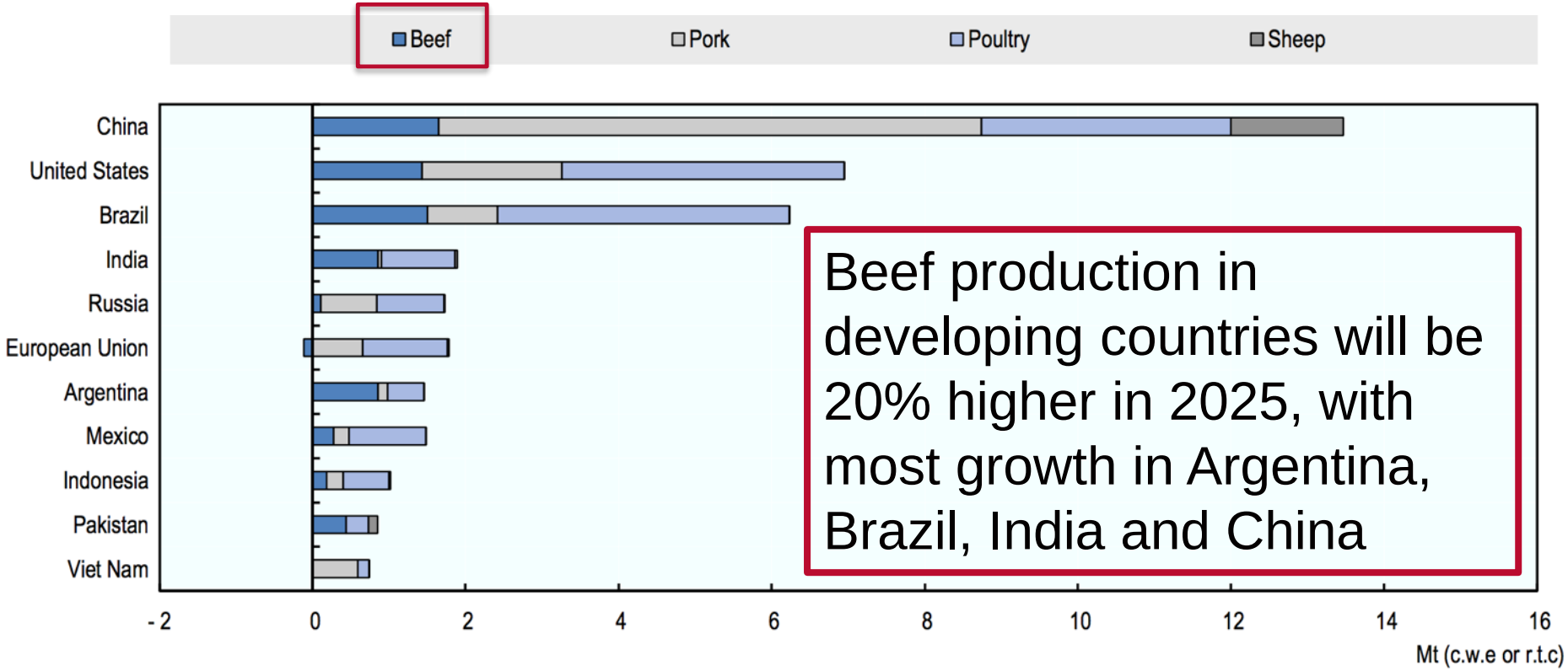


Note: c.w.e. is carcass weight equivalent, r.t.c. is ready to cook equivalent.

Source: OECD/FAO (2016), "OECD-FAO Agricultural Outlook", *OECD Agriculture statistics* (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Countries with the greatest share of additional meat production by meat type

2025 vs 2013-15

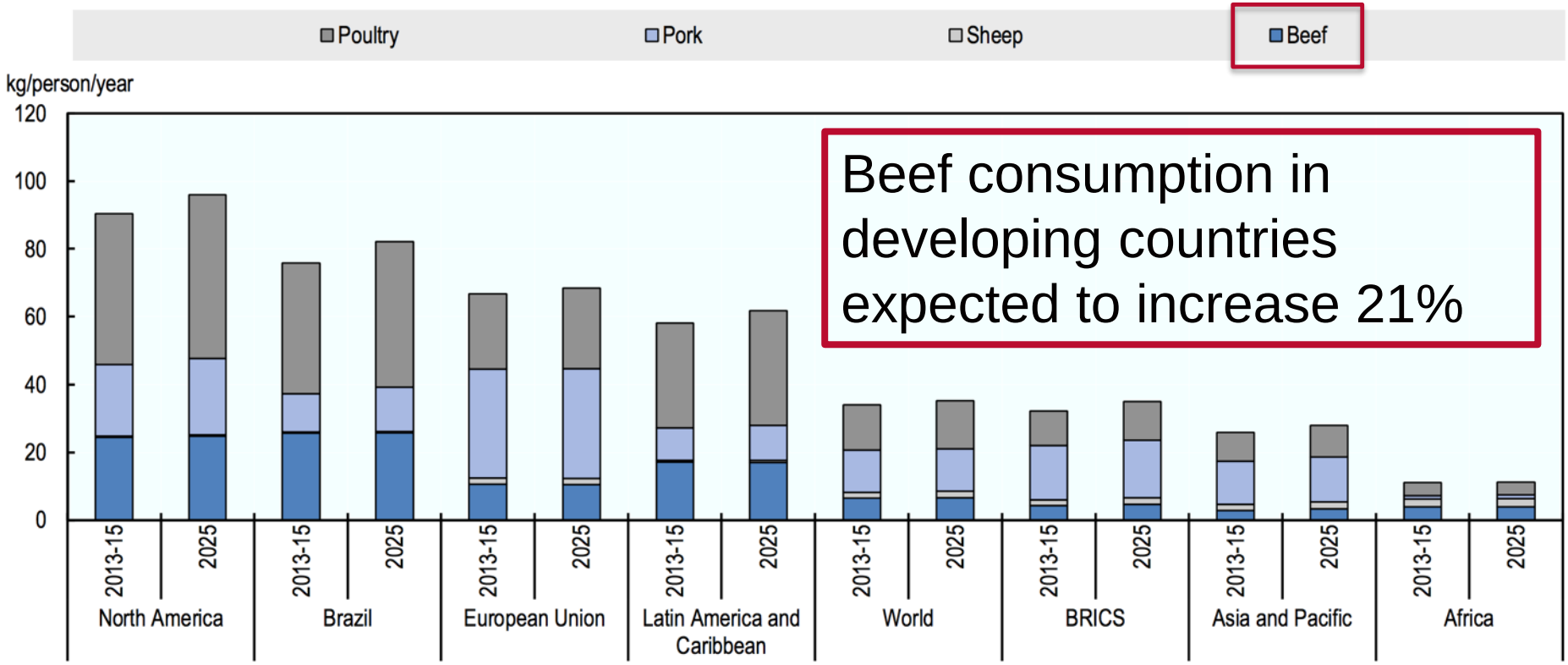


Beef production in developing countries will be 20% higher in 2025, with most growth in Argentina, Brazil, India and China

Note: c.w.e. is carcass weight equivalent, r.t.c. is ready to cook equivalent.

Source: OECD/FAO (2016), "OECD-FAO Agricultural Outlook", *OECD Agriculture statistics* (database), http://dx.doi.org/10.1787/agr-outl-data-en.

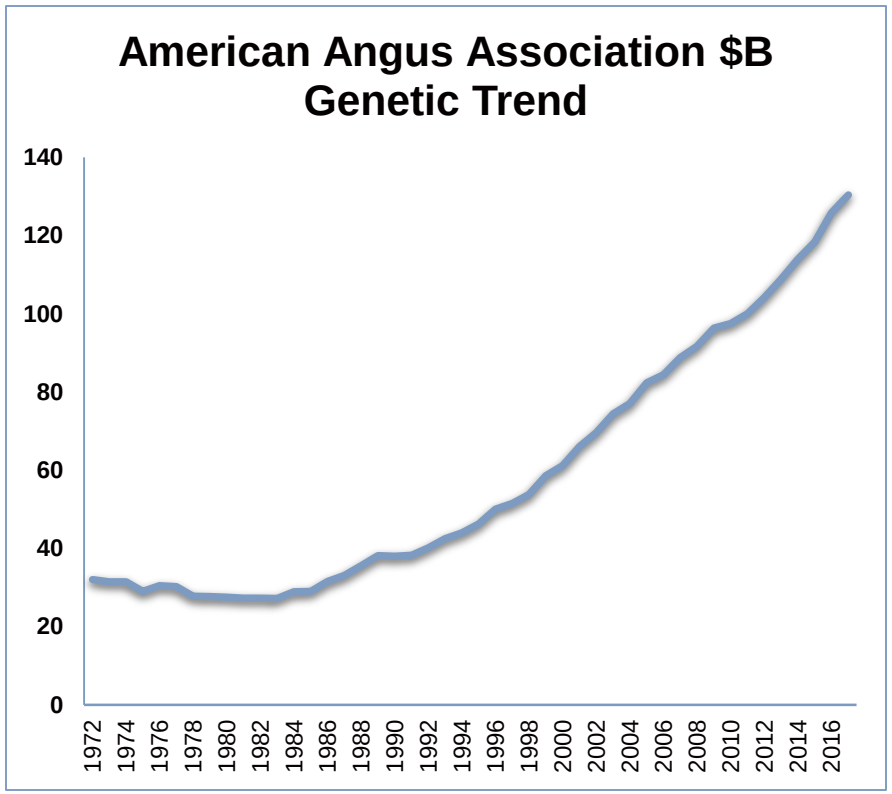
Per capita meat consumption by country and region



Note: c.w.e. is carcass weight equivalent, r.t.c. is ready to cook equivalent.

Source: OECD/FAO (2016), "OECD-FAO Agricultural Outlook", *OECD Agriculture statistics* (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Genetic programs around the world have made progress for traits related to beef production



Source: American Angus Association

Nelore Genetic Trend for weight

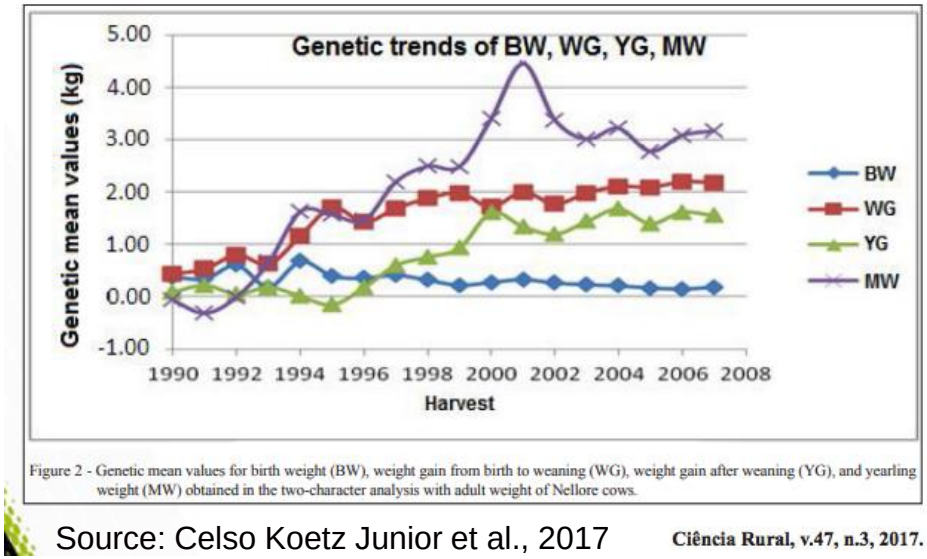


Figure 2 - Genetic mean values for birth weight (BW), weight gain from birth to weaning (WG), weight gain after weaning (YG), and yearling weight (MW) obtained in the two-character analysis with adult weight of Nellore cows.

Source: Celso Koetz Junior et al., 2017 Ciência Rural, v.47, n.3, 2017.

Progress for economically relevant traits?

- Less progress for traits directly related to producer profitability
- Beef industry structure creates challenges to improving ERT, which is critical for ensuring sustainable growth

Table1. Proposed economically relevant traits and their indicators.

Economically Relevant Trait EPD	Indicators[1]
Sale Weight[2] Weaning Direct Weaning Maternal (Milk) 600 d Direct Carcass Weight Direct Salvage Cow Weight	205 d Weight 365 d Weight Carcass Weight Birth Weight Fat Thickness Cull Cow Weight
Probability of Calving Ease	Calving Ease Score Birth Weight Gestation Length
Cow Maintenance Feed Requirement	Mature Cow Weight Cow Condition Score Milk Production[3] Gut Weight
Stayability (or LPL[4])	Calving Records Days to Calving Calving Interval Milk Production[3]
Heifer Pregnancy Rate	Pregnancy Observations Scrotal Circumference
Tenderness	Amount of Intramuscular Fat Shear Force
Days to a Target Finish Fat Thickness Days to a Target Weight Finish Endpoint Days to a Target Probability of Grading Finish Endpoint	Backfat and Age at Slaughter Weight and Age at Slaughter Grade and Age at Slaughter
Docility	Docility Scores

[1]"Indicators" means traits which are measured to provide information to produce the economically relevant trait EPD. This list contains just the most obvious indicators. It is likely that different situations will be able to use other indicators.

Economically Relevant Traits: A framework for the next generation of EPDs. Golden et al., 2000

GLOBAL ROUNDTABLE FOR®
SUSTAINABLE BEEF

The Global Roundtable for Sustainable Beef defines sustainable beef as a socially responsible, environmentally sound and economically viable product that prioritizes **Planet** (relevant principles: Natural Resources, Efficiency and Innovation, People and the Community); **People** (relevant principles: People and the Community and Food); **Animals** (relevant principle: Animal Health and Welfare); and **Progress** (relevant principles: **Natural Resources**, **People and the Community**, **Animal Health and Welfare**, **Food**, **Efficiency and Innovation**.


Natural Resources


People & The Community


Animal Health & Welfare

Natural Resources

The global beef value chain manages natural resources responsibly and enhances ecosystem health.

People & The Community

Global sustainable beef stakeholders protect and respect human rights, and recognize the critical roles that all participants within the beef value chain play in their community regarding culture, heritage, employment, land rights and health.

Animal Health & Welfare

Global sustainable beef producers and processors respect and manage animals to ensure their health and welfare.

Food

Global sustainable beef stakeholders ensure the safety and quality of beef products and utilize information-sharing systems that promote beef sustainability.

Efficiency & Innovation

Global Sustainable Beef Stakeholders encourage innovation, optimize production, reduce waste and add to economic viability.

GLOBAL ROUNDTABLE FOR®
SUSTAINABLE BEEF

The Global Roundtable for Sustainable Beef defines susta
responsible, e
economically
prioritizes **Pla**
Natural Resou
People and th
Community);
People and th
Animals (rele
and Welfare);
principles: **Natural Resources**, **People and the Community**, **Animal Health and Welfare**, **Food**, **Efficiency and Innovation**.

Efficiency & Innovation

Global Sustainable Beef Stakeholders encourage innovation, optimize production, reduce waste and add to economic viability.

Natural Resources

The global beef value chain manages natural resources responsibly and

ay

ty.

Efficiency & Innovation

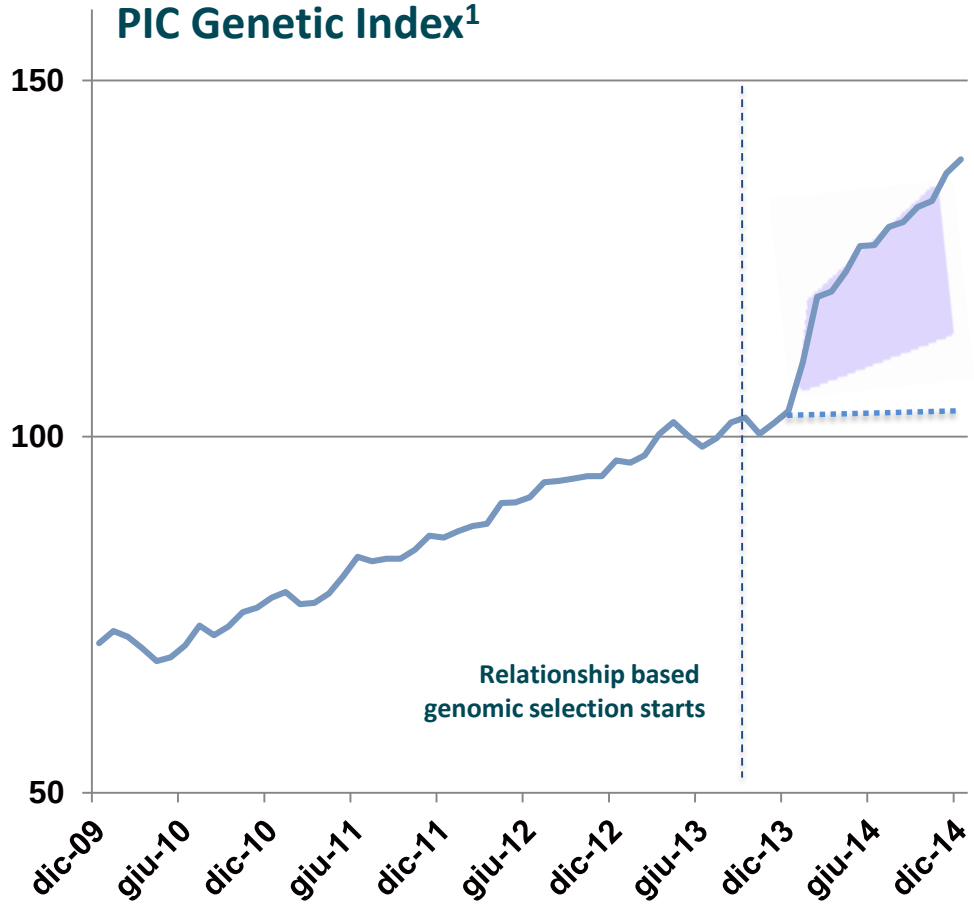
Global Sustainable Beef Stakeholders encourage innovation, optimize production, reduce waste and add to economic viability.

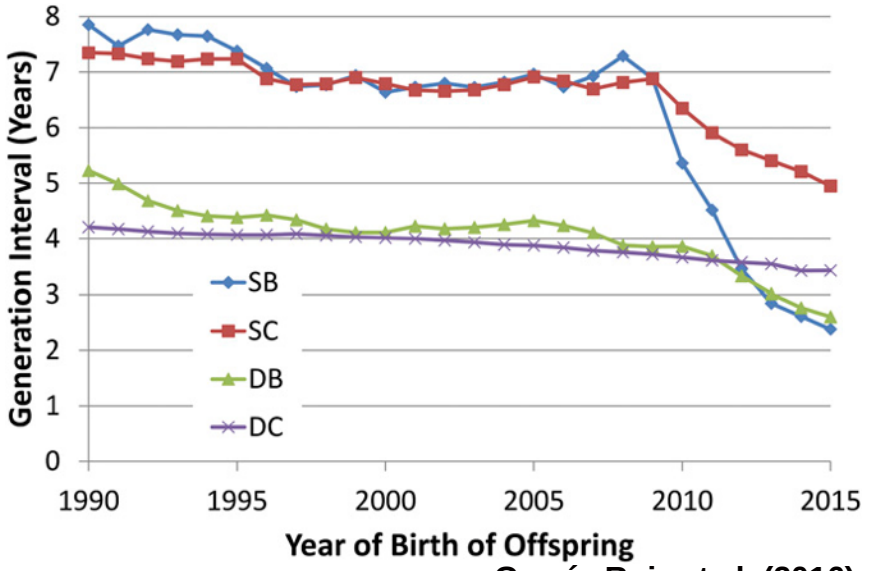
The role of breeding companies in sustainable beef production

1. Make genetic improvement for traits directly related to profitability and simplify selection decisions
2. Effectively disseminate improvement
3. Provide tools and support to maximize realized improvement and value generation

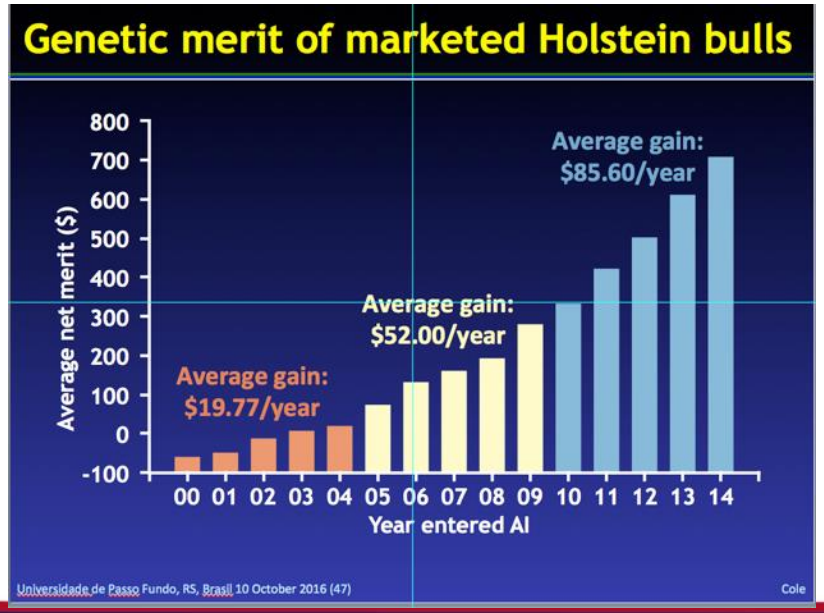
Innovation is critical: use new technology to accelerate genetic gain

Genomics

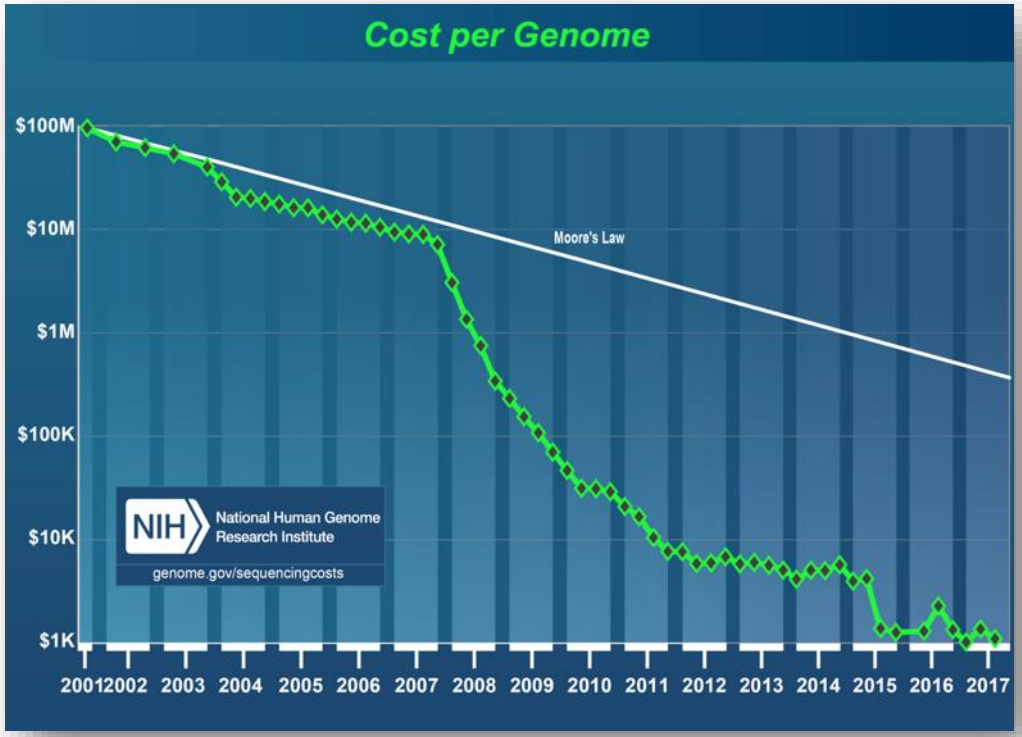




García-Ruiz et al. (2016)



Extending to sequence



Ros-Freixedes *et al. Genet Sel Evol (2017) 49:78*
DOI 10.1186/s12711-017-0353-y

GSE Genetics Selection Evolution

RESEARCH ARTICLE Open Access

A method for allocating low-coverage sequencing resources by targeting haplotypes rather than individuals

Roger Ros-Freixedes, Serap Gonen, Gregor Gorjanc and John M. Hickey*

OPEN ACCESS Freely available online

PLOS ONE

Genotyping-by-Sequencing (GBS): A Novel, Efficient and Cost-Effective Genotyping Method for Cattle Using Next-Generation Sequencing

Marcos De Donato[1,2], Sunday O. Peters[1,3], Sharon E. Mitchell[4], Tanveer Hussain[1,5], Ikhide G. Imumorin[1]*

1 Department of Animal Science, Cornell University, Ithaca, New York, United States of America, 2 Laboratorio Genética Molecular, Instituto de Investigaciones en Biomedicina y Ciencias Aplicadas Universidad de Oriente, Cumana, Venezuela, 3 Department of Animal Science, Berry College, Mount Berry, Georgia, United States of America, 4 Institute for Genomic Diversity, Cornell University, Ithaca, New York, United States of America, 5 Institute of Biochemistry and Biotechnology, University of Veterinary and Animal Sciences, Lahore, Pakistan

Abstract

High-throughput genotyping methods have increased the analytical power to study complex traits but high cost has remained a barrier for large scale use in animal improvement. We have adapted genotyping-by-sequencing (GBS) used in plants for genotyping 47 animals representing 7 taurine and indicine breeds of cattle from the US and Africa. Genomic DNA was digested with different enzymes, ligated to adapters containing one of 48 unique bar codes and sequenced by the Illumina HiSeq 2000. *PstI* was the best enzyme producing 1.4 million unique reads per animal and initially identifying a total of 63,697 SNPs. After removal of SNPs with call rates of less than 70%, 51,414 SNPs were detected throughout all autosomes with an average distance of 48.1 kb, and 1,143 SNPs on the X chromosome at an average distance of 130.3 kb, as well as

Gene editing

Transgenic Res
DOI 10.1007/s11248-017-0049-7

REVIEW

Genome editing in livestock: Are we ready for a revolution in animal breeding industry?

Jinxue Ruan · Jie Xu · Ruby Yanru Chen-Tsai · Kui Li

Received: 23 April 2017 / Accepted: 24 October 2017

Bastiaansen *et al. Genet Sel Evol (2018) 50:18*
https://doi.org/10.1186/s12711-018-0389-7

RESEARCH ARTICLE Open Access

The impact of genome editing on the introduction of monogenic traits in livestock

John W. M. Bastiaansen*, Henk Bovenhuis, Martien A. M. Groenen, Hendrik-Jan Megens and Han A. Mulder

Jenko *et al. Genetics Selection Evolution* (2015) 47:55
DOI 10.1186/s12711-015-0135-3

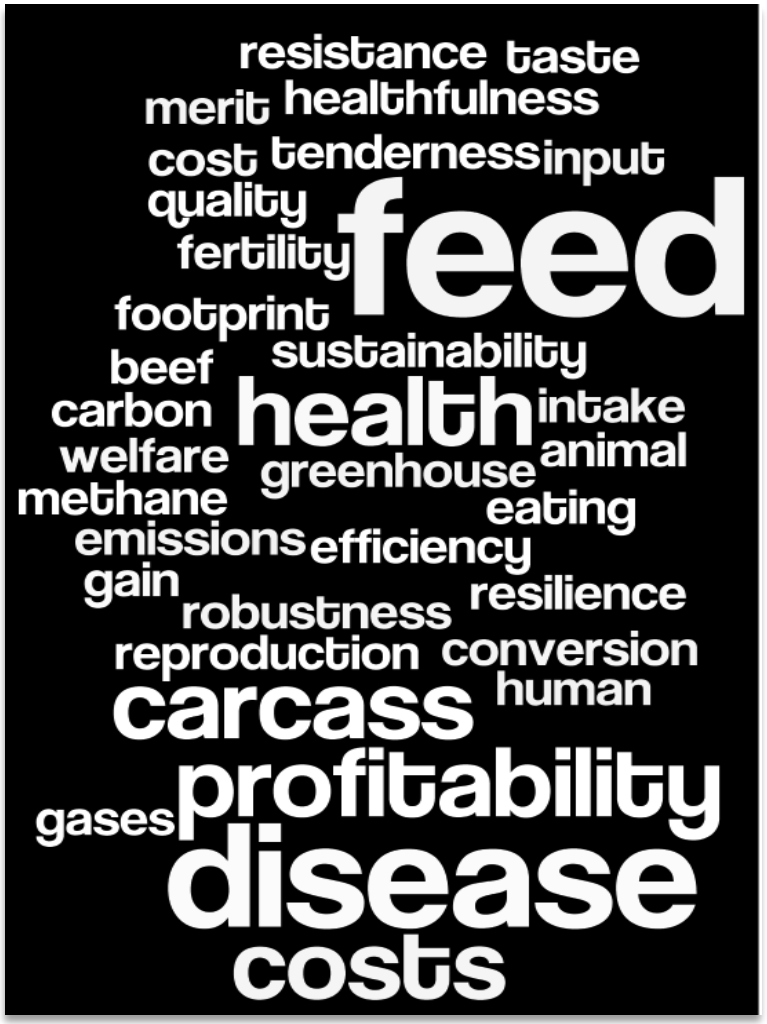
RESEARCH ARTICLE Open Access

Potential of promotion of alleles by genome editing to improve quantitative traits in livestock breeding programs

Janez Jenko[1], Gregor Gorjanc[1], Matthew A Cleveland[2], Rajeev K Varshney[3], C. Bruce A Whitelaw[1], John A Woolliams[1] and John M Hickey[1*]

#phenotypeisking

- Phenotyping underutilized in many breeding programs
- Novel phenotyping provides opportunity to improve ERT that have not been measured before



Artificial insemination & IVF/ET

PURDUE UNIVERSITY

PURDUE EXTENSION

Animal Sciences

AS-575-W

EXPERT REVIEWED

Timed-Artificial Insemination in Beef Cows: What are the Options?

Allen Bridges, Scott Lake, Ron Lemenager, and Matt Claeys,
Purdue Beef Team, Department of Animal Sciences, Purdue University

Overview

As research on the reproductive physiology and endocrinology surrounding the estrous cycle in beef cattle has been compiled, several estrous synchronization programs have been developed for use with beef heifers and cows. These include several programs that facilitate the mass breeding of all animals at a predetermined time (timed-AI) rather than the detection of estrus.

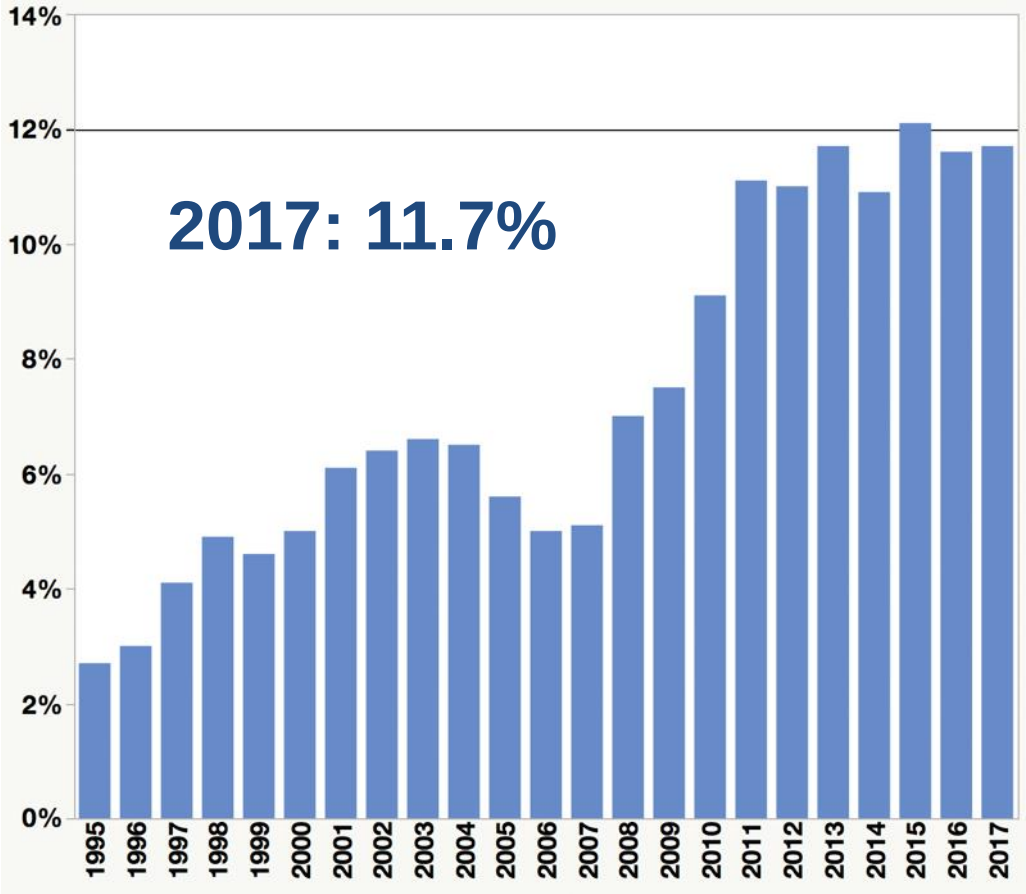
Timed artificial insemination (timed-AI) programs are often advantageous to the beef producer because they reduce the time and labor required for the detection of estrus and allow all animals to be managed in groups rather than individually. Given these advantages of timed-AI, a wide variety of effective timed-AI programs have been developed for beef cows. No one program is "perfect" for every beef producer, thus the goal is to find the right program for your operation.

Numerous factors such as the proportion of animals that are anestrus prior to breeding, the amount of time and labor available, and various management practices can dictate which timed-AI program is best suited for a given beef operation.

Purdue Extension Knowledge to Go 1-888-EXT-INFO

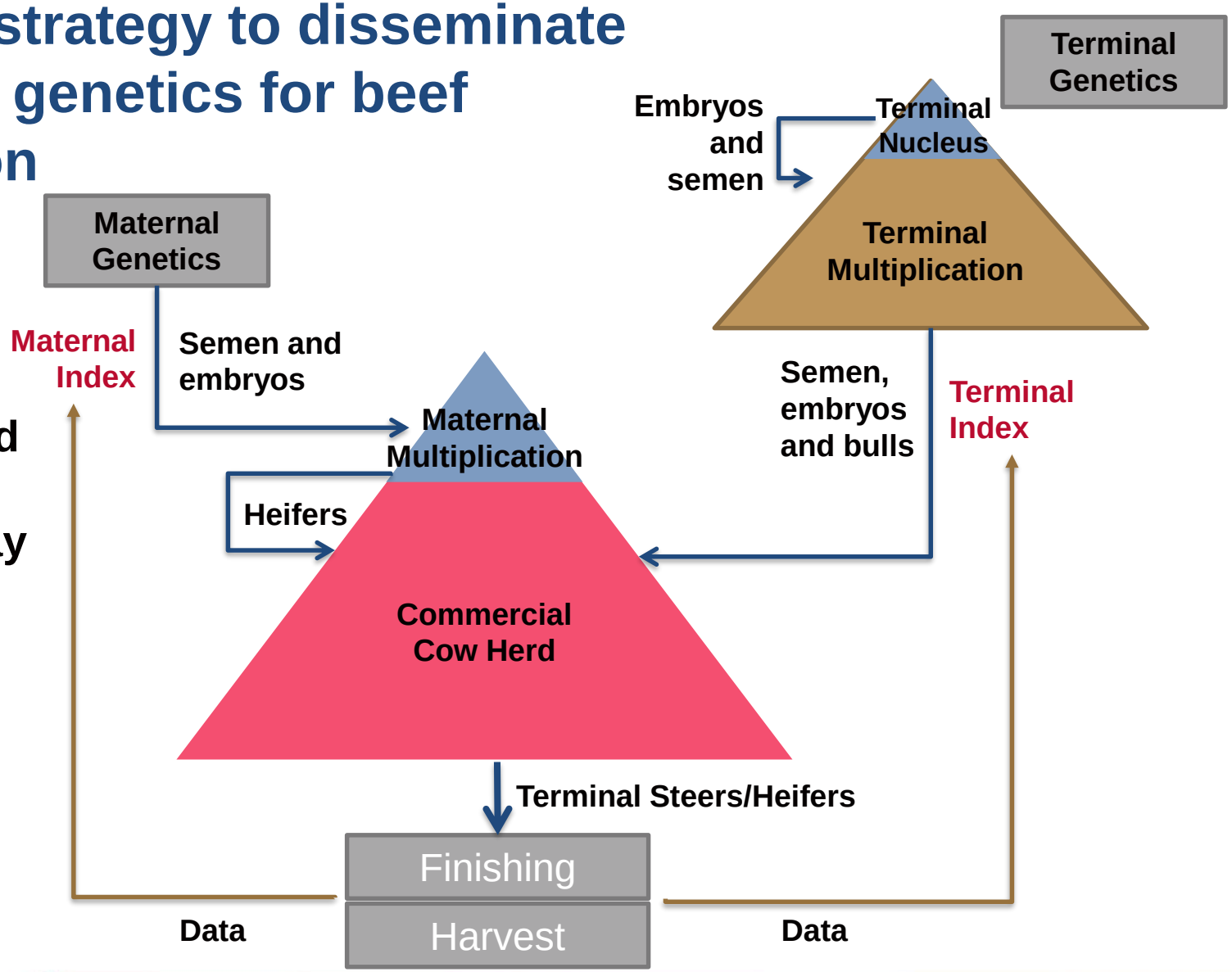
Purdue University Cooperative Extension Service, West Lafayette, IN 47907

Estimated percent beef cow AI in Brazil



Example strategy to disseminate improved genetics for beef production

Maternal and terminal genetics may come from different countries, markets and/or breeds



Optimal dissemination can lead to a product that is measurably better and demanded by the supply chain

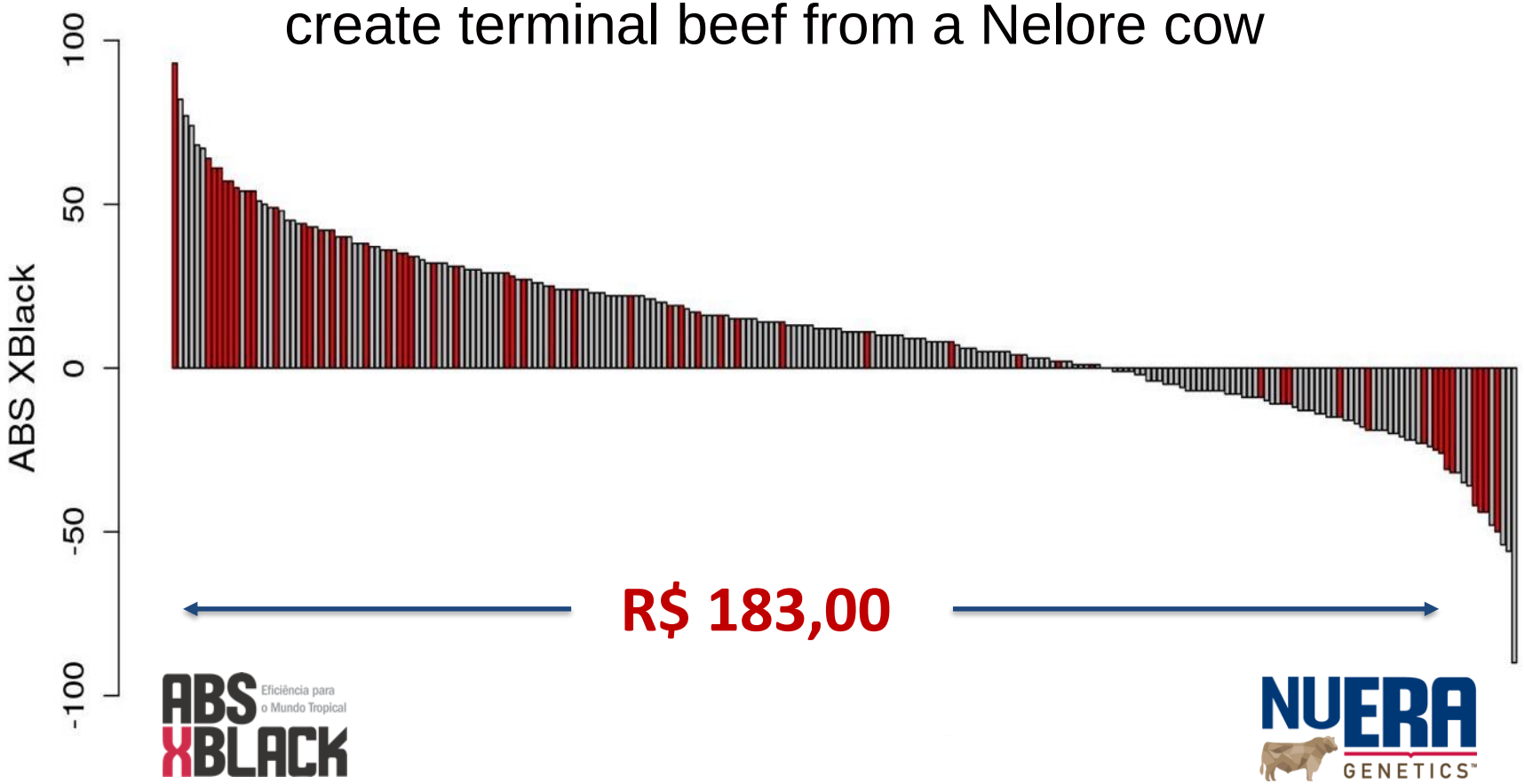
Virtual integration

=

Demand created for specific products based on price signals passed to farmers, even with multiple ownership changes

Creating terminal genetics for Brazil

Distribution of Index values for sires used to create terminal beef from a Nelore cow

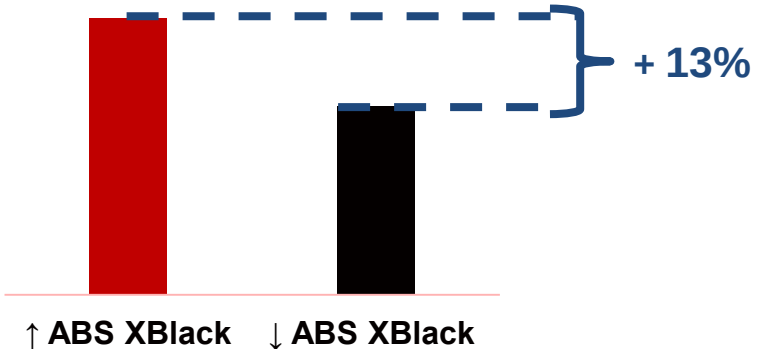


ABS XBLACK Eficiência para o Mundo Tropical

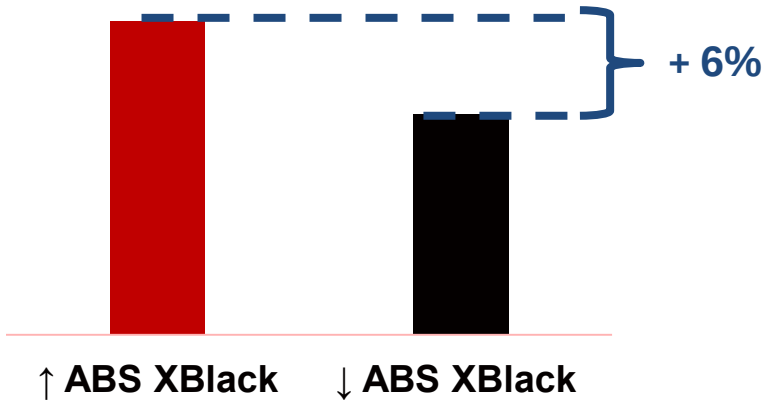
NUERA GENETICS™

Realized impact of improved genetics for Brazil terminal system

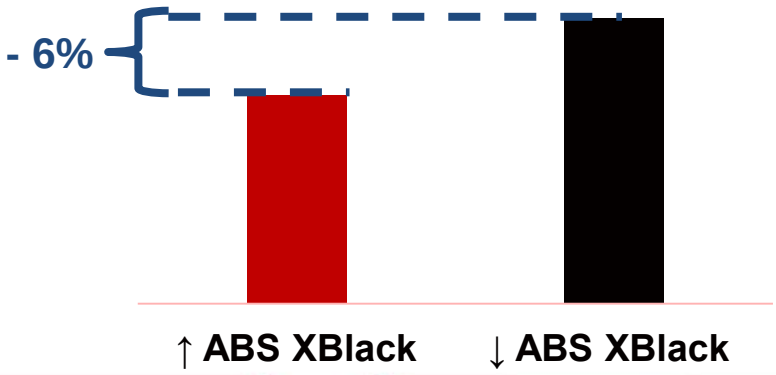
Weight Gain



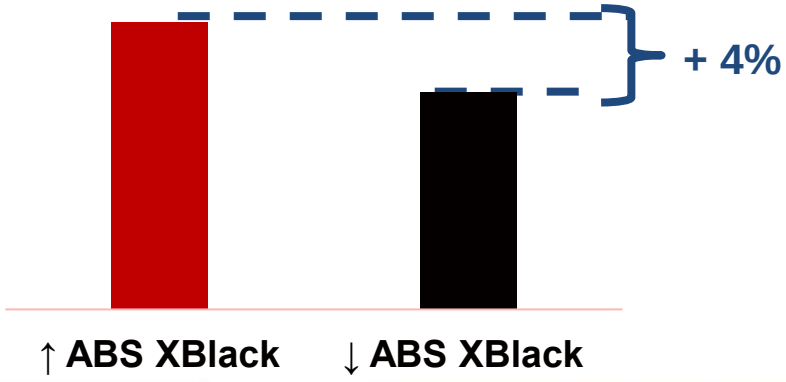
Carcass Weight



Feed Conversion

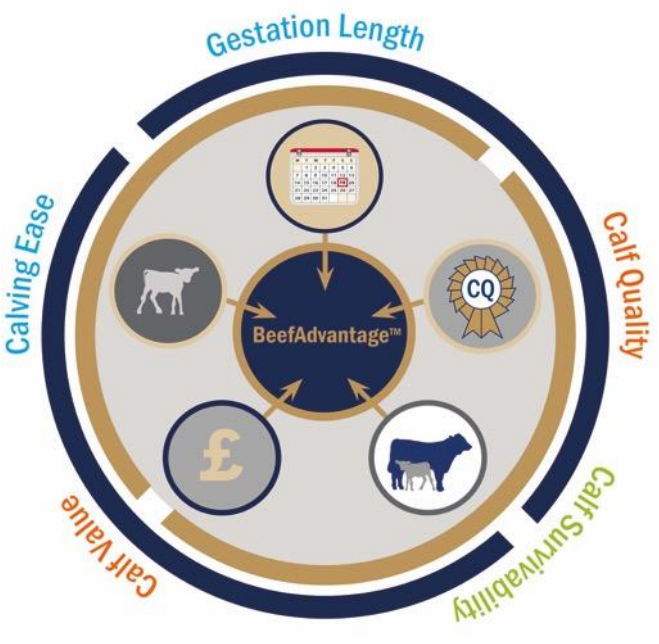


Weaning Weight



Creating beef from the dairy herd: a UK example

Maximising dairy farmers' profitability through improved beef genetics



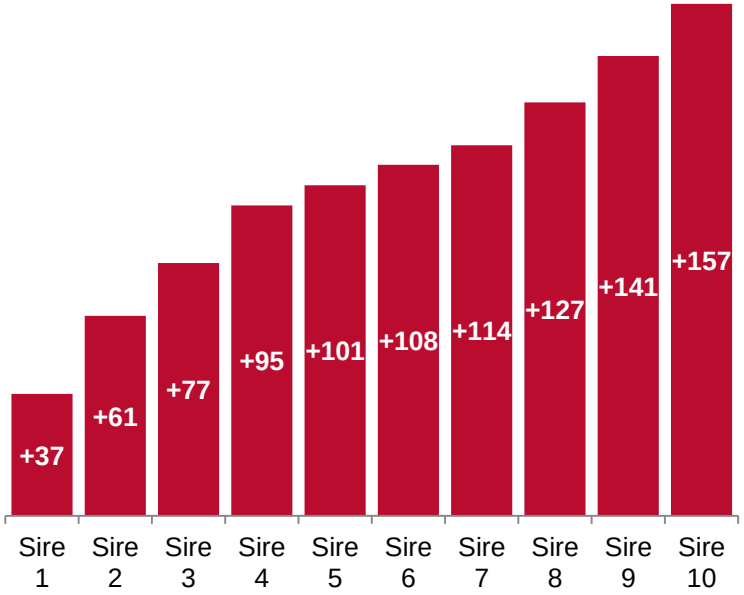
More milk
from the herd

More calves to sell for beef

More £££
per calf sold

Delivering more value

Incremental £ value to the dairy farmer by sire
(baseline = low indexing sire)



Summary

- Demand for beef continues to grow, especially in developing regions
- Many current breeding programs are not well suited to generate the improvements needed to sustainably grow beef production
- Key is to leverage new technologies for the efficient dissemination of improved genetics coupled with approaches to ensure farmers realize genetic potential

Thank you!

matthew.cleveland@genusplc.com

Profit From Genetic Progress