TSB Collaborative Research: Utilising sequence data and genomics to improve novel carcass traits in beef cattle

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UK
Part of ABP Food Group

BRITISH LIMOUSIN
the carcase breed

www.limousin.co.uk

Why are we doing this project?

BRITISH LIMOUSIN INDUSTRY POSITION IN 2010

- **648,000 Limousin sired registrations with British Cattle Movement Service (34%) as an average per year in the last five years.**
- **£400 Million industry per year based on the assumption of a nominal value per animal**
- **Over 9 million Limousin sired cattle registered with BCMS since 1996**
- **£6.5 Million for pedigree seedstock at official auction sales in 2010 driven by the commercial producer**

www.limousin.co.uk

BUSINESS & GENETIC IMPROVEMENT PLAN

- **A 10 year British based Genetic Improvement Plan (GIP) with a commercial focus on genetic progress in the beef breeding animal and the beef product.**
- **Building the GIP around the technologies of genomic selection, and quantitative data analysis.**
- **GIP includes a concentration on feed efficiency & liveweight gain, carcase traits, and inversion of progeny data back to the breeding animal.**
- **GIP inclusive of animal health, docility, and maternal traits including fertility and calving ease.**
- **GIP is developed in conjunction with Egenes at Scottish Agricultural College.**

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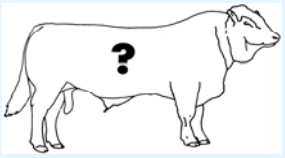
Why?

- Create business for BLCS and ABP
- Improve the collection of phenotypes
  - VIA data
- Implement genomic selection
  - Create platform for future traits
- Stimulate breeders to use appropriate bulls

Breeding Value Calculation

Genetic Evaluation

- Basic principle is to predict the contribution of genetics (the estimated breeding value (EBV)) to differences observed between animals using phenotypes collected on progeny



performance = genetics + management

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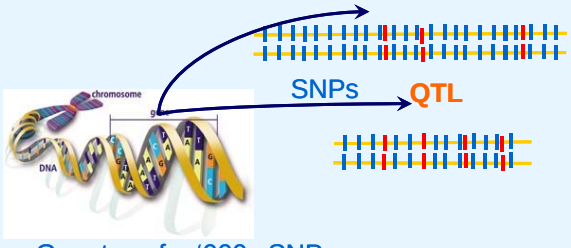
Genomic Evaluation

- Genomic merit: information provided by chromosome fragments
  - The values of each inherited/observed fragment are summed up to get the animal's genomic merit
  - Includes QTL (areas) with big and small effects
  - How do we calculate these effects?



Meuwissen et al. 2001

Genotype for '000s SNPs across genome

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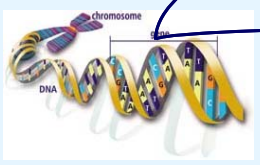
Genomic Evaluation

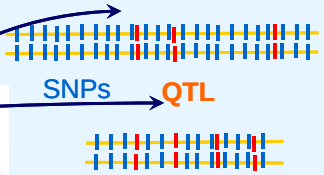
- A two-step process
  - Estimate the marker effects (**SNP KEY**) in a **training population** comprising a large number of animals genotyped with the SNP chip and having phenotypic records
  - Use the UK SNP KEY to estimate the genomic merit of a new animal (without phenotypes) based on knowledge of its SNP genotype

GE - Opportunities

- Predict breeding value using genotype alone
  - Genomic breeding value (GBV) at birth! With accuracy equivalent to having offspring recorded

Genotype for '000s SNPs across genome





Meuwissen et al. 2001

Reference population

- Genotypes to create a reference population
  - Thousands
  - Related to animals in the live population
  - Well phenotyped (accurate proofs)
- Reference population creates the SNP Key
- Genotyped animals are then compared to the Key to calculate their value
- Different density genotypes (different costs)
  - 3000
  - 7000
  - 50,000
  - 770,000
  - (Full sequence)

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Gathering phenotypes

Motivation (T. Pabiou ICBF)

- **Heritability of carcass cuts**

Forequarter

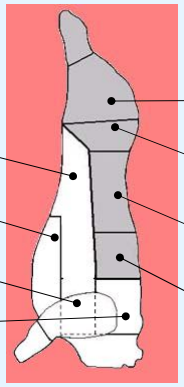
Ribs & Flank : 0.03

Brisket : 0.25

Shoulder : 0.79

Chuck : 0.83

[0.15 ≤ s.e. ≤ 0.24]



Hindquarter

Round : 0.86

Sirloin : 0.67

Strip-Loin : 0.49

Rib-Roast : 0.14

[0.16 ≤ s.e. ≤ 0.23]

Pabiou et al. J. Anim. Sci. (2009)

Motivation

- **Converting images into cut weights**

Multiple Regression Analysis

- **Lower value cuts (*LVC*)**
- **Medium value cuts (*MVC*)**
- **High value cuts (*HVC*)**
- **Very high value cuts (*VHVC*)**

Also available on steers:

- **Total meat weight**
- **Total fat weight**
- **Total bone weight**

Pabiou et al. Livestock Sci. (Accepted 2010).

VIA system

- E + V type – is bespoke installation
- Pneumatic actuated moving frame
- Rig to mount camera, lighting arrangements
- Computer control unit – remote access/diagnostics possible

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DWR

Image capture

- Moving frame presents carcass side
- Calibrated image captured
- Assists in fat cover estimate
- Used for fat class
- Also primal yields

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DWR

3D data extraction

- Structured lighting
- 3D form can be computed
- Primarily used to estimate conformation
- Also primal yield estimates

DWR

In the age of the genotype……

PHENOTYPE IS KING!

Project Steps

1) Data Management

- EGENES/BASCO database development
  - Storage genotypes/phenotypes
- Automated data transfer ABP -> SAC
- Consolidation of ABP/BLCS/BCMS databases
- Development of genotyping service database/web page

2) Training Population

- Developing genotyping/sequencing strategy
  - Account for phenotype info
  - Available DNA
  - Structure of breed for type of genotyping (density)
  - Refinement of imputation methodology
- SAC have donated 720 HD genotypes to establish the SNP key

3) SNP Key

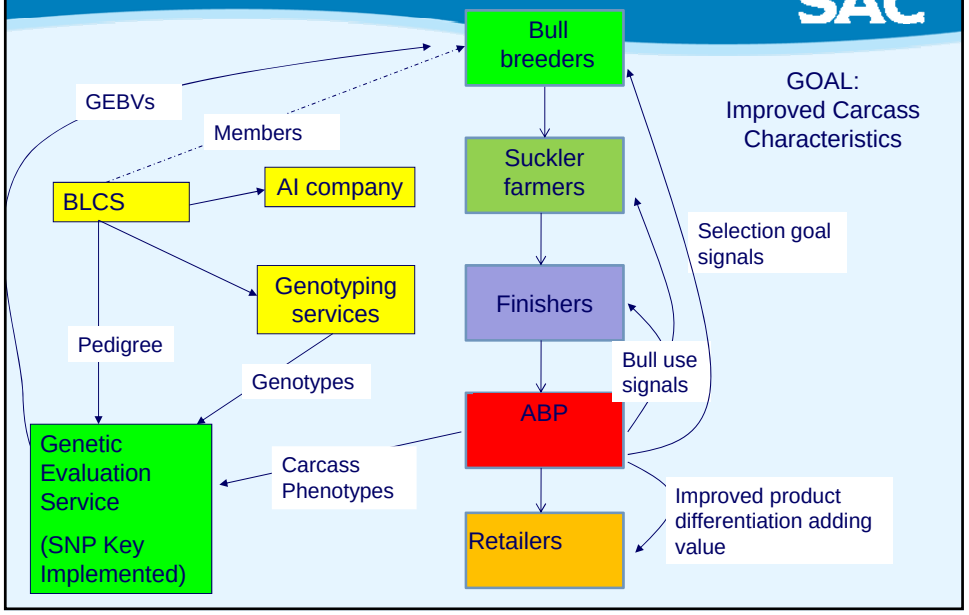
- Create phenotypes suitable for key
  - Genetic parameters
  - Account for fixed effects
- Use existing software to estimate SNP Key
- SNP key marketed by BLCS in low density chip sales
- Service identifies optimum genotyping and imputation strategy given genotypes held in database

4) Fine Phenotypes

- Utilise VIA data to produce finer carcass phenotypes
  - Management information for ABP
- Identify genetic variation in yield of specific cuts
- Incorporate new phenotypes into SNP key

Company to exploit results

Flow of New Breeding Values



Benefits

BLCS Benefits

- Accelerated genetic improvement
- More members identify genetically superior stock
- Aligned to landmark development in beef improvement
- Leading organisation in genomic selection
- Differentiate BLCS in the pedigree market place
- Construction of additional revenue stream derived from its core activity of breed improvement and promotion
- Additional business opportunities with abattoirs and retailers
  - Meat quality, GHG, efficiency

Beef industry benefits

- Wider range of EBVs to assist selection
- Greater integration of supply chain
  - Free flow of market signals
  - Market signals more closely aligned to product
- Maintain competitiveness
  - More able to invest in new technology (and research)
- Kick-start implementation of genomic selection

Summary

- Exciting time in genetic evaluations and beef production!
  - Keep up with large international effort especially in Australia and USA
- New technology
  - Phenotypes (closer to breeding goal) on a large scale
  - Genotypes on large scale
- Greater stakeholder involvement in breeding goals
- Increased output of UK beef
- Higher value UK beef

Next steps for ILC

- How to consolidate separate Limousin activity to greater benefit
  - Share genotypes
  - Share phenotypes
    - Interbeef
    - Feed efficiency
    - Methane emission etc
- International repository for genotypes?
- International nucleus schemes?
  - Exchange semen to create linkages
- International policy on parentage errors?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