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Application potential of genomics beyond Elite animals' evaluations

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Rule for New Technologies

- "We tend to **overestimate** the **short term impact** of a technology and **underestimate** the **long term impact** "

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Agenda

- Brief introduction to DairyCo

- Genomic Evaluations in the UK

- Genomics beyond Elite breeding

- Threats

- What does this mean for R&D needs

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- Levy organisation working for GB dairy farmers

- Examine the challenges facing the industry

- Identify the gaps in services and information

- Design services to fit
  – R&D
  – Market Information
  – Issues & Image
  – Genetic Evaluations
  – Knowledge Transfer

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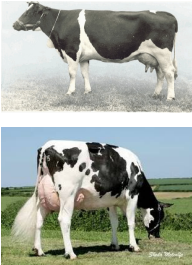---

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- Responsible for Genetic Evaluation in UK
  – **Independent and Paid for by dairy farmers**

- All breeds and crosses
  – Production traits
  – SCC
  – Lifespan
  – Fertility Index
  – Type (excl. B&W)
  – Calving Ease

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Impact of genetics

- Very powerful tool

- Seen in cow performance
  – Production traits
  – Fitness traits

- Ensure we get the balance right
  – Constantly evolving knowledge and needs

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Genomics in the UK

- National Cooperation of:
  - Milk recording (CIS, NMR, UDF)
  - Herdbooks (HUK)
  - Breeding Companies (Cogent, Genus)
  - SAC
  - DairyCo

- International collaboration
  - North America and Italy (2011)

- Genomic evaluation implementation – Dec'11

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Current Application - Elite Breeding

- Selection of Elite breeding animals
  - Increased Genetic gains

- Males
  - Pre-selection in Young-bulls
  - Higher use of Younger bulls
  - Increased reliability for Older bulls

- Females
  - Higher accuracy of Genetic index (PTA / EBV)
  - Adding value for marketing

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Application → more widespread

- Different density SNP-Chips
  - 3K, 6K, 50K, High Density,……

- Able to 'Impute' genotypes to higher density

- Lower cost Chips
  - Achieving similar accuracies to higher density
  - Enables low cost application beyond Elite animals

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Application – Beyond breeding

- Genomic testing soon Routine
  - All cows will have genotype

- Traceability
  - Animals and Products

- What doors does this open?
  - How can we add extra value

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Application opportunities

- With each cow having her own genotype, what could this mean for our activities?
  - (No longer domain of breeders only)

- In terms of:
  - Data capture
  - Service provision
  - (Application opportunities)
  - R&D needs

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Application – Parentage

- Parentage Verification
  - Currently based on Microsatellites
  - Using ~100 SNPs (>99.9% accurate)

- Method approved in 2011;
  - ICAR (Int. Com. for Animal Recording) working alongside ISAG (Int. Soc. Animal Genetics)

- International sharing of Parentage SNPs
  - Potential new role for Interbull

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Application – Parentage

- Parentage Discovery
  - Identify parents without prior information
  - Using >100 SNPs
    - Easily enough on the standard Low-Density Chip

- Parents need to have been genotyped
  - Sire x Dam
  - Sire x MGS

- Benefits for herd management

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Application – Herd management

- Screening of Young stock

- Use as pre-selection for Rearing
  - Ability to save cost by Culling poorest heifers

- Use for more targeted Herd Improvement
  - Breed Best to Elite sexed semen
  - Bottom end to Beef semen

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Herd genotyping strategies (example)

- Weigel 2011 (Univ. of Wisconsin)
  - Simulation - Benefits from genetic progress
- Genotype all young-stock
  - Very cost effective if parentage unknown
  - Less when pedigrees were well recorded
- Genotype either top or bottom 50%
  - Provides cost effective option in most cases
- Genotyping milking cows
  - Benefits depend on chooses strategy and age of cow

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Application – Genetic Abnormalities

- Management of genetic abnormalities
  - Screening all animals for known defects
  - Tests included as part of LD Genotyping

- Discovery of 'new' genetic abnormalities
  - Need for recording of abnormalities
  - Need for storage of DNA

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Opportunity to Discover new recessives

- Increased rate of genetic gain can go together with increased inbreeding

- Increased change of homozygosity of harmful recessives

- Absence of homozygosity can detect these (VanRaden et al; 2011)
  - 3 Holstein, 1 Jersey, 1 Brown Swiss

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Appliation - Genomic Matings

- Avoid matings between 'carrier' animal

- Current Mate Selection done on Phenotype
  - Sometimes combined with Genetic (Pedigree) info
  - Complementary mating on Phenotype

- Future Mate Selection incorporates Genomic data
  - Identify 'weakness' in Genetic Make-up
  - Complementary mating on Genotypes

- Ability to better estimate and manage Inbreeding
  - Offer opportunity for Genome targeted 'cross breeding' ?

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Application – Feeding

- Nutritional Genomics
  - (Nutrigenomics)
  - Interaction Genes x Diet

- Application examples:

  - Response to Concentrate Feeding
  - Which cows are pre-disposed to Milk fever
    - Supplement feeding for individual cows
  - Personalised feed advice (using better norms)

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Application – Health

- Personalised Genomic Medicine
  - Determine disease risk (Predisposition)
  - Appropriate therapeutic options

- For example
  - Dry cow therapy
  - Vaccine response
    - Drug application based on Genomic profile

- This knowledge can also help us to;
  - Improved Vaccine manufacturing
  - Breed better 'responders' to vaccination

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Application – Beyond breeding

- Revisit 'old' and Explore 'new' traits
  - Protein fractions (K-casein, Beta-lac.)
  - Fatty acids
  - Disease resistance
  - Disease shedders
  - Feed Efficiency
  - Green House Gas emissions
  - .....

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Requirements

- Accurate data needed (lots of it !)
  - Contract recording herds?
- Accurate animal identification
- Harmonised trait definitions (ICAR)
- Sharing (pooling) of Data

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In the age of the genotype…...

PHENOTYPE IS KING!

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Opportunities and Threats

- Low cost genotyping now available
  - Rapid developing Opportunities beyond breeding
  - Cost continue to come down

- Large R&D investments needed
  - Start-up costs are high and a barrier for some

- Who has access to R&D results?
  - Patents watch (EAAP & ICAR - PSAS)

- Need to ensure that the benefits are able to be used cost effectively by the industry

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Additional Threats &Opportunities

- International monitoring of genetic variation

- Also consider who 'owns';
  - Genotypes, Phenotypes, Calibration equations

- Can we do this (efficiently) on national level?

- Should we store DNA on all recorded cows?
  - Especially on cows used in research !

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Knowledge gap - Genomics

- 'missing' heritability
  - Why can't we explain all genetic variation?

- R&D efforts on-going
  - Modelling existing SNP data
  - Full genome sequencing
    - (10 Holstein bulls at 20x being done in UK)
  - Copy Number Variation (CNV)
  - Non-additive effects
  - Epigenetic
  - Other..

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Issues that need action

What should we be recording....Now;
  - More detailed phenotypes
  - New (expensive) phenotypes

- What services need to be build around this?
  - Sample collection
  - Results interpretation and presentation

- Herd management software requirement?
  - Storing, Central pooling and Reporting

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Genomics - Summary

- Faster genetic gains
  - Ensure we get right balance of traits
  - Protect (inter)national genetic variation

- Data recording and sharing critical
  - Harmonisation of Definition and Recording

- Exciting new opportunities beyond breeding
  - Both for Farmers and Support industries
  - Engagement needed with all (not just breeders)
  - International R&D efforts needed

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