Utilising genomics to address global challenges facing our AgriFood industry.

Dr. Andrew Cromie, Technical Director, ICBF.
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Global Challenges.

We must produce almost as much food in the next 30 years as we did in the last ~2000 years

- Do so, in a way that protects/considers:
  - Environment,
  - Climate
  - Water
  - Bio-diversity
  - Anti-microbial resistance
  - And economic sustainability for the primary producer.
Global Meat Consumption.

Source: H Charles, J Godfrey et al. Science 2018;361
The climate/environment challenge.

- Beef cattle are not carbon efficient => Policy to cut size of beef herd.
- But need cattle => extensive systems & rural infrastructure.
- Can we breed more carbon efficient beef cattle?
Dairy
• Grass based seasonal
• 1.5m dairy cows
• 17,000 herds
• Avg herd size: 80 cows
• Export 90% of milk produced

Irish Dairy & Beef Industries.

Beef
• Grass based seasonal
• 0.95m beef cows
• 60,000 herds
• Avg herd size: 17 cows
• Export 90% of beef

• Combined = 8% of total employment & 11% of exports (€19 bn by 2025).
About ICBF.

• Co-operative, established in 2000.
  – AI, data recording, herdbooks & farmers.
• Objective => Ensure next generation of animals are more environmentally and economically sustainable than the previous.
• World-leading (research => implementation).
  – 2\textsuperscript{nd} in world to launch dairy genomics.
  – Largest beef cattle genomics project globally.
• Close relationships with key stakeholders (DAFM, Teagasc, Weatherby’s…)
• Cork based, 70 staff servicing 100k farmers.
Overview of ICBF database.
ICBF Database in Numbers (2019).

- 102k Herds
- 7.7 Million Farm Movements
- 6.5 Million Live Animals
- 2.2 Million Slaughter Records
- 2.4 Million BVD Records
- 2.4 Million Animal Births
- 4.8 Million Milk Recording Records
- 850k AI Records
- 2 million genotypes
- 95 billion rows of SNP data

- Largest central dairy & beef cattle breeding database in world => cornerstone of AgFood industry.
- Routine extraction, consolidation & modelling => Independent genetic evaluations for farmers & industry.
Genomics; Building a more accurate picture at an early stage.

- Accuracy:
  - 30% - Ancestry.
  - 50% - Ancestry + Genomics.
  - 70%-90+ - Ancestry + Genomics + Own performance. Phenotypes also provide the data for genomic predictions.

Genetic gain = \frac{i \cdot r \cdot \sigma}{L}

- Intensity
- Accuracy
- Variation
- Generation interval
Genomic selection / polygenic risk score

Reference population

Phenotypes + ‘000 genotypes

Assoc. between genotypes & phenotypes

Prediction equation
“SNP key”

Genotype + SNP key

Genomic prediction

Selection candidate
IDB Chip – Key aspect of delivery.

- Developed in Ireland.
- 54,000 SNPs
- 160 Major genes/defects
- Imputation SNPs
- Microsatellite imputation SNPs
- 800 Parentage SNPs
- V1 to V3 - Illumina platform
- V4 & now V5 - Thermofisher platform
- Lab services;
  - Weatherbys Ireland
  - Eurofins Denmark
Beef Data & Genomics Program (BDGP).

• Apply the latest DNA technology to support an important indigenous industry.
• Simultaneously addressing global challenges around GHG and food security
Irish Beef Data and Genomics Program.

- More profitable, sustainable & carbon efficient cows.
- €300m total funding 6 years (2015-2020), as part of RDP.
  - Farmers paid ~€90/cow/year to complete key actions re: the scheme, e.g., data recording & targets for 4/5 star cows & bulls.
  - ~24k farms & 550k cows.
  - ~1.5m animals genotyped to-date.
  - Cost of genomic service is €20/animal.
  - Additional action around cow and calf live-weight.
Impact of BDGP; Genetic Gain for Industry.

- Genetic gain in EBI unquestioned across industry.
  - Equivalent to €1.5 bn or 4 cpl in milk price.
- Could the same be achieved in Suckler beef => objectives of BDGP.
- Both EBI and Rep Index are now gaining at same rate (0.2 gsd/year). Only difference is 15 year time lag.
  - Rep Index => Has delivered ~€50m (0.15 cents/kg) to beef industry. Will grow to €300m by 2030.
- Direct impact of BDGP for Industry.
Impact of BDGP; Genetic Gain for Farmers.
Pre-Genotyping Replacement Indexes

Post Genotyping Replacement Indexes
Validation; Approach Taken.

• Key question; How accurate were the initial €uro-Star evaluations at predicting future performance?
  • Proofs taken from Autumn 2016, i.e., before animals own performance data was included in the evaluation. Animals ranked on this proof.
  • Subsequent performance for key profit traits assessed for key profit traits.
• 59,466 replacement females, calving for first time between 1st January 2017 and 30th June 2017.
  • With calving, cow & calf live-weight & progeny carcass data.
  • Correction of non-genetic effects, such as age, parity, heterosis etc.
Recap; Euro-Star Replacement Index.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Goal</th>
<th>Relative wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving</td>
<td>Less</td>
<td>16%</td>
</tr>
<tr>
<td>Cow size/maintenance</td>
<td>Less</td>
<td>18%</td>
</tr>
<tr>
<td>Carcass wt (for age)</td>
<td>More</td>
<td>21%</td>
</tr>
<tr>
<td>Maternal milk</td>
<td>More</td>
<td>18%</td>
</tr>
<tr>
<td>Female fertility</td>
<td>More</td>
<td>23%</td>
</tr>
<tr>
<td>Docility</td>
<td>More</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Emphasis:**
- **Cow traits 71%**
- **Calf traits 29%**
Rec-cap; Identifying the “curve-benders!”

Relationship between Maternal Milk and Progeny Carcass Weight

\[ r = -0.46 \]

Bulls that have milk in their daughters and carcass weight in their progeny
## Validation Results for Key Profit Traits*

<table>
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<tr>
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<th>Rep Index</th>
<th>Age 1\textsuperscript{st} calving</th>
<th>CI Days</th>
<th>Cow surv%</th>
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<tbody>
<tr>
<td>5 stars</td>
<td>€114</td>
<td>816</td>
<td>365</td>
<td>0.89</td>
<td>271</td>
<td>672</td>
<td>335</td>
<td>7.8</td>
<td>9.7</td>
</tr>
<tr>
<td>4 stars</td>
<td>€82</td>
<td>812</td>
<td>367</td>
<td>0.88</td>
<td>267</td>
<td>674</td>
<td>333</td>
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</tr>
<tr>
<td>3 stars</td>
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<td>824</td>
<td>367</td>
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*Expressed relative to a 3\textsuperscript{rd} parity cross-bred suckler cow.*
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<td>Diff 5 vs 1</td>
<td>€91</td>
<td>-30</td>
<td>-6</td>
<td>0.05</td>
<td>4</td>
<td>-18</td>
<td>1</td>
<td>-0.2</td>
<td>0.1</td>
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</table>

| Diff 5 vs 1 | €91 | -30 | -6 | 0.05 | 4 | -18 | 1 | -0.2 | 0.1 |
| E Value (€) | -0.99 | -5.07 | 8.86 | 5.58 | -0.55 | 2.1 | 10.2 | -5.4 |
| Overall (€) | €29.7 | €30.4 | €44.3 | €22.3 | €9.9 | €2.1 | €-1.7 | €-0.5 |

- Indexes predicted a difference of €91. Actual was €137.
Further opportunities.

• Opportunity to further increase genetic gain for GHG/Climate traits in the future;
  – Direct measurement of Methane.
  – Age at Slaughter Traits.
  – Further expansion in level of genotyping.
1. Direct measurement of Methane.

- Direct measurement of methane now part of G€N€ IR€LAND program at Tully, Kildare. Linked with various DAFM/Teagasc/UCD funded projects.
- Confirmation that selection for Rep Index => more carbon efficient cow (~-15-20%). Hugely significant outcomes for Irish beef (& dairy) industry.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>FCR</th>
<th>ADG</th>
<th>Terminal Index</th>
<th>Replacement Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄ g/d</td>
<td>83</td>
<td>NS</td>
<td>NS</td>
<td>-0.27</td>
<td>-0.26</td>
</tr>
<tr>
<td>MY</td>
<td>83</td>
<td>NS</td>
<td>-0.22</td>
<td>NS</td>
<td>-0.24</td>
</tr>
<tr>
<td>gCH₄/kgBW</td>
<td>83</td>
<td>NS</td>
<td>NS</td>
<td>-0.32</td>
<td>-0.29</td>
</tr>
<tr>
<td>MI</td>
<td>83</td>
<td>NS</td>
<td>Ns</td>
<td>-0.23</td>
<td>-0.37</td>
</tr>
</tbody>
</table>

![Graph showing correlation between replacement index and methane yield.](image)

- $r = -0.29$
2. Age at slaughter.

<table>
<thead>
<tr>
<th></th>
<th>24-month</th>
<th>30+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ANxDairy</td>
<td>LMxBeef</td>
</tr>
<tr>
<td>N animals</td>
<td>48,731</td>
<td>12,164</td>
</tr>
<tr>
<td>N weights</td>
<td>52,707</td>
<td>22,965</td>
</tr>
<tr>
<td>Life DMI</td>
<td>5,191</td>
<td>5,610.00</td>
</tr>
<tr>
<td>SI Age</td>
<td>732</td>
<td>738</td>
</tr>
<tr>
<td>DMI/day (kg)</td>
<td>7.1</td>
<td>7.6</td>
</tr>
<tr>
<td>SI LWT (estim. from CWT)</td>
<td>625</td>
<td>701</td>
</tr>
<tr>
<td>SI LWT (estim. growth curve)</td>
<td>626</td>
<td>696</td>
</tr>
<tr>
<td>CWT</td>
<td>319</td>
<td>386</td>
</tr>
<tr>
<td>Conform. (1-15)</td>
<td>5.5</td>
<td>8.9</td>
</tr>
<tr>
<td>Fat (1-15)</td>
<td>8.8</td>
<td>8.4</td>
</tr>
<tr>
<td>CO₂e/lifetime (kg)</td>
<td>3,026</td>
<td>3,771</td>
</tr>
<tr>
<td>CO₂e/kg CWT (kg)</td>
<td>9.49</td>
<td>8.47</td>
</tr>
</tbody>
</table>

- Work undertaken as part of G€N€ IR€LAND program to quantify GHG gains from breeding & systems changes (with Teagasc & ABP).
  - Suckler beef better than dairy beef, when expressed on a Cwt basis.
  - 24-month systems are ~ 25% more efficient than 30+ month systems.
  - 5-star animals ~15% more efficient, within systems (results not shown).
- Reducing age at slaughter from our suckler herd by 1 month is equivalent to not having to slaughter 50k suckler cows.
3. Increased level of genotyping.

Next; Which calf is worth more?

- Genotyping now widespread in suckler herds. Now growing in dairy herds.
- Once a calf is born (suckler beef or dairy beef) => generate a “beef value” based on its genotype.
- Updates through an animals lifetime, with additional weight data.
- Available through mart screens.
- Means of animals (especially dairy beef) with confidence.
Genotype every animal at birth.

- Target to have Irish Cattle herd genotyped by 2025; 2.4m new birth each year
- Compared to current rates of gain (0.2 genetic SD/year), additional 2.5 times return on investment. Govt/industry proposal being developed.
Summary.

• Genetics/genomics has delivered increased profitability and sustainability for suckler beef industry.
  - Genetic gain for industry – Rates of gain (0.2 gsd/year).
  - Genetic gain for farmers – Validation using on farm data (€137/prog).
  - Genetic gain for consumers/society – Direct measurement of methane (~15-20% reduction in GHG output/animal).

• Close collaboration amongst many Irish and international industry partners a key aspect of this delivery (ICBF, DAFM, Teagasc, AI companies Weatherby’s, Thermo, Illumina, ICAR, Interbull, Interbeef…).

• We are always keen to work with existing/new partners that share these same principles & goals.
"And he gave it for his opinion, that whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."

Irish Writer, Jonathan Swift, 1667-1745.
ICBF.com

Our Farmer & Government Representation

Our AI & Milk Recording Organisations

Our Herdbooks

Acknowledging Our Members