“Application of Genomic Selection in Dairy and Beef Cattle in Ireland”

Dr Andrew Cromie, Technical Director ICBF.
Understanding Ireland!

- Ag-food is important.
  - 7% GDP, 10% employment.
  - Export focused (80%)
    - Population of 4.5m but producing enough food to feed 35m.

- Cohesive industry.
  - DAFM, ICBF, Teagasc....
  - Harvest 2025; Sustainable Growth.
Irish Cattle Breeding.

- Co-ordinated by Irish Cattle Breeding Federation (ICBF).
  - A co-operative of 30 cattle breeding organisations (AI, Herdbooks & Milk Recording organisations) & 2 Farm Organisations.
- Established the ICBF central database in 2002.
  - Now the cornerstone of the Irish cattle industry.
- Focused on “profit from science”.
- High level of farmer trust - independent genetic evaluations are key.
- World-leading (research => implementation).
  - 2nd in world to launch dairy genomics, after US.
  - Beef Genomics => largest livestock genomics project globally.
Less paper, more profit!

ICBF Database

Genetic Evaluation System

Insems & Genetic Evaluations

Milk Production & Management Rpts

Ped. Certs & Linears

Calf reg & movement

Animal Events

AI Companies

Milk Recording

Herd Books

DAFF - AIM

Dairy & Beef Farmers
Vets & vet labs.
Genotypes & gen labs.

ICBF Database
Teagasc Research Schemes, e.g., BVD, BGDP, Origin Green

Herd Books
AI Companies
Milk Recording

DAFF - AIM

Marts & auctioneers
7.0 m movement records/yr

1m AI recs/yr
700k MR recs/yr

1.6 m carcass recs/yr
Factories

30m animals with 100m+ records.

100k farmers are now serviced from the database.

Dairy & Beef Farmers

2.3 m birth recs/yr
2.3m BVD recs/yr

Vets & vet labs.

Genotypes for services

Health & disease data

Genotypes

Reports

Bulk Tank
Milk Co-ops
Teagasc ACA Advisors

500k genotype recs/yr

Weight & price
Carcass data
Calf reg & movements

Animal Events
Ped. Certs & Linears

Milk Production & Management Rpts
Insems & Genetic Evaluations

Data

Knowledge

Data for services

Gene Ireland
Breeding future profits
GROW for Good Measure

100k farmers are now serviced from the database.

30m animals with 100m+ records.
IDB Chip – The database in 54k SNP’s!

- The International Dairy & Beef Chip.
- Developed in Ireland, with Illumina. Currently on v3.
- 54k SNP’s.
  - 40k core, 6k for better imputation, 7k for “regions of interest” & 1k for major genes/defects.
- 160 Major genes/defect.
  - Database will drive this.
Typical Irish dairy farm; 100 cows, calving from mid-Feb (in line with grass growth in Spring) and ending lactation by mid-December.
Where we started; Irish dairy herd 2000

High index Holstein route not the answer

Very disappointing results from three year trial

Said Jack. There was just one embryo loss last year. The biggest problem for them, and for all farmers, is that there is still little known in terms of answers.

Feeding more meals is not the solution. The three-year trial clearly shows that there is no effect of feeding level on fertility.

Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Medium merit (RM 00 X)</th>
<th>Medium merit (RM 100 Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>1,498</td>
<td>1,213</td>
</tr>
<tr>
<td>1999</td>
<td>1,675</td>
<td>1,464</td>
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<tr>
<td>2000</td>
<td>1,770</td>
<td>1,564</td>
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Table 2

<table>
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<th></th>
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<tbody>
<tr>
<td>HGI</td>
<td>MGI</td>
</tr>
<tr>
<td>88</td>
<td>90</td>
</tr>
<tr>
<td>77</td>
<td>77</td>
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<td>93</td>
<td>90</td>
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<td>49</td>
<td>57</td>
</tr>
<tr>
<td>42</td>
<td>44</td>
</tr>
<tr>
<td>1.83</td>
<td>1.68</td>
</tr>
<tr>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Measures of fertility needed in index

IRISH farmers desperately need an index that includes measures of fertility.

The Moorepark research increases the urgency of the new index being drawn up by the ICBF and due to be released in late November.

For the first time the index will be produced that will include traits linked to fertility.

"Other countries are starting to record traits that are linked to fertility. With our computer calving system the need in Ireland is much greater," said ICBF geneticist Dr. [Name]
The ideal Irish dairy cow; High milk solids (500 kg MS/cow/year) & excellent fertility (CI = 365 days).
EBI has delivered ~€587m additional profit to industry since 2002. With current rate of gain expect to double (€1.15bn) by 2020.

2002. Establish ICBF & EBI

2005. Establish G€N€ IR€

2009. Establish Genomics; Rate of gain doubled

2017. Next Gen Herd
What has happened as a result of EBI

Calving Interval (days)

<table>
<thead>
<tr>
<th>Year</th>
<th>Calving Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>397</td>
</tr>
<tr>
<td>2009</td>
<td>401</td>
</tr>
<tr>
<td>2010</td>
<td>402</td>
</tr>
<tr>
<td>2011</td>
<td>403</td>
</tr>
<tr>
<td>2012</td>
<td>397</td>
</tr>
<tr>
<td>2013</td>
<td>394</td>
</tr>
<tr>
<td>2014</td>
<td>396</td>
</tr>
<tr>
<td>2015</td>
<td>392</td>
</tr>
<tr>
<td>2016</td>
<td>389</td>
</tr>
</tbody>
</table>
### Next Gen Herd Fertility Performance 2013-2016

<table>
<thead>
<tr>
<th>Metric</th>
<th>Elite</th>
<th>NatAv</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission rate (%)</td>
<td>92</td>
<td>86</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Pregnancy rate first service (%)</td>
<td>60</td>
<td>46</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pregnancy rate first 6 weeks (%)</td>
<td>73</td>
<td>58</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Final pregnancy rate - 12 weeks (%)</td>
<td>92</td>
<td>81</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Calving to conception interval (days)</td>
<td>76</td>
<td>81</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>No. of services</td>
<td>1.57</td>
<td>1.77</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

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The Irish Agriculture and Food Development Authority
Impact; ICBF Active Bull List
(Top 75 available AI bulls ranked on EBI).

10 years ago, all of the highest EBI bulls in Ireland were imported, now they are all Irish bred.
Typical Irish beef farm; 25 cows, calving in Spring, producing 1 weaned calf/cow/year. Part-time farming.
No profit to be made from production on the average suckler farm – Teagasc

© 6:30 am - June 8, 2017

Gillian Dufficy
Email

Increases in support payments led to higher suckler farm income figures in 2016, which otherwise would not have been the case, according to Teagasc.

Despite a reduction in prices, the average suckler farm income increased marginally by 2%. However, the sector still reported
GHG; Beef Cows are a real problem!!

FAO, 2013
We all need beef cows.

• Suckler cows & beef cattle are a key part of rural infrastructure, especially in Ireland
  – Small fragmented farms, marginal land etc.
Lots of variation in emissions intensity. Is there some genetic variation? Can we harness/improve?

Source: GLEAM. FAO, 2013
• Apply the latest DNA technology to support an important indigenous industry
• Simultaneously addressing global challenges around GHG and food security
The Irish Beef Genomics Scheme.

- Focused on breeding more profitable, sustainable and carbon efficient cows.
- Funded from EU Rural Development Program.
- €300m total funding 6 years (2015-2020)
  - Farmers paid ~€90/cow/year to complete key actions re: the scheme.
  - ~1.2m animals genotyped to-date. ~2.5m animals in total will be genotyped during period of scheme. Cost of genomic service is €22/animal.
- Building Ireland toward DNA based calf registration (& increased genetic gain).
BDGP Data Recording; Farmer data

- ~600k records/trait/year (cow & calf).
- Excellent heritability estimates, e.g., docility @ 30% with rg of 0.85 with data from “expert” scorers.
<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>Feed Intake</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>

- The ideal Irish beef cow; A weaned calf every year of good weight & quality.
5 star cows are more profitable & more carbon efficient.

- Compared to 1 star cows, 5 stars are;
  - more profitable, sustainable & carbon efficient (+€100/cow). Cows that will produce more from less

- How do we generate more 4 & 5 star cows?

<table>
<thead>
<tr>
<th>Stars</th>
<th>Repl Index</th>
<th>Cow Wt</th>
<th>Calf wean weight</th>
<th>Calving Interval</th>
<th>Progeny carcass wt</th>
<th>Co2 Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Stars</td>
<td>€108</td>
<td>669 kg</td>
<td>336 kg</td>
<td>403 days</td>
<td>358 kg</td>
<td>3,355 kg</td>
</tr>
<tr>
<td>4 stars</td>
<td>€86</td>
<td>680 kg</td>
<td>324 kg</td>
<td>407 days</td>
<td>356 kg</td>
<td>3,432 kg</td>
</tr>
<tr>
<td>3 Stars</td>
<td>€60</td>
<td>690 kg</td>
<td>319 kg</td>
<td>411 days</td>
<td>356 kg</td>
<td>3,475 kg</td>
</tr>
<tr>
<td>2 stars</td>
<td>€43</td>
<td>691 kg</td>
<td>315 kg</td>
<td>416 days</td>
<td>357 kg</td>
<td>3,502 kg</td>
</tr>
<tr>
<td>1 Star</td>
<td>€12</td>
<td>739 kg</td>
<td>309 kg</td>
<td>423 days</td>
<td>357 kg</td>
<td>3,552 kg</td>
</tr>
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</table>
Moved from zero genetic gain (2000-2013) => €25m since start of BDGP (2014-2017) => €80m by time program ends in 2020. For an investment of ~€40m

But genetics is permanent and cumulative => +€600m by 2030 & with 10% less GHG output.
Computer requirements for ICBF genomic evaluations

<table>
<thead>
<tr>
<th>Year</th>
<th>Device</th>
<th>RAM</th>
<th>Disk</th>
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</thead>
<tbody>
<tr>
<td>2005</td>
<td>iPhone 5</td>
<td>1 GB</td>
<td>1,800 GB</td>
</tr>
<tr>
<td>2007</td>
<td>163</td>
<td>16 GB</td>
<td>698 GB</td>
</tr>
<tr>
<td>2010</td>
<td>143</td>
<td>64 GB</td>
<td>1,500 GB</td>
</tr>
<tr>
<td>2013</td>
<td>109</td>
<td>120 GB</td>
<td>1,800 GB</td>
</tr>
<tr>
<td>2015</td>
<td>198</td>
<td>356 GB</td>
<td>4,000 GB</td>
</tr>
<tr>
<td></td>
<td>Igen2</td>
<td>6,000 GB</td>
<td>40,000 GB</td>
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<tr>
<td></td>
<td>Cerus x 2</td>
<td>760 GB</td>
<td>4,000 GB</td>
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<td>356 GB</td>
<td>4,000 GB</td>
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<td>1,800 GB</td>
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<td>698 GB</td>
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<td>2 GB</td>
<td>80 GB</td>
</tr>
</tbody>
</table>
Ireland & Turkey – Opportunities.

- Export of semen from high genetic merit AI sires for use in Turkey.
  - 150k units/year.
- Export of live cattle.
  - 20k male weanlings for slaughter in Turkey.
  - 3.5k females for breeding.
  - 1200 of these are genotyped with 70% of these 4&5 star!
What should Turkey do next?

- Embed the technology => key focus of today's conference.
- Establish infra-structure to deliver the potential of genomics.
  - Database, genotypes, training population, genomic evaluations.....
  - Govt & industry must work together.
- Build your own indigenous livestock breeding program to support the growing needs of your country.
- Work with partners to help you achieve this.
Summary.

- Agriculture is undergoing a DNA technology revolution.
- Ireland is at the front edge of that revolution.
  - Strong partnership between ICBF, DAFM, Teagasc, cattle industry & farmers is allowing this happen.
- Genomics works. It will have a major role in addressing global challenges around environment and food security in the future.
- Great opportunity for Turkey to initiate large scale genomics based breeding programs in the future.
  - Disruptive yes, but allows you start very quickly.
Thank You.