Breeding for reduced environmental footprint in beef cattle

Donagh Berry

Teagasc, Moorepark, Ireland.

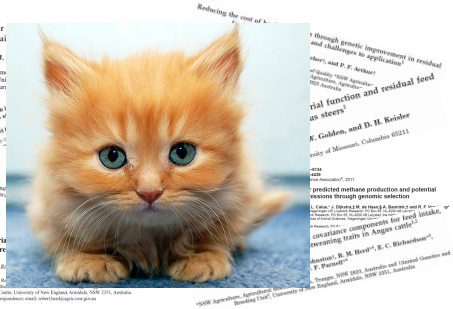
BIF Conference, Nebraska, June 2014

Today's news….

…turn the page

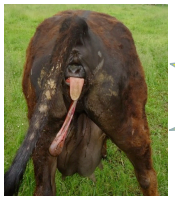
…and turn again

Is this the solution??



It's system efficiency!!

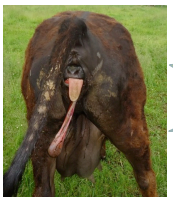
$$\text{Herd FCE} = \frac{\text{Weight}_{OFFSPRING} \cdot (\text{weaning rate} - \text{mortality})}{n_{COW} \cdot \text{DMI}_{COW} + (\text{weaning rate} \cdot \text{DMI}_{OFFSPRING})}$$



Low maintenance, fertile cow with lots of milk to feed her fast growing calf

It's system efficiency!!

$$\text{Herd EE} = \frac{\text{Weight}_{OFFSPRING} \cdot (\text{weaning rate} - \text{mortality})}{n_{COW} \cdot ENV_{COW} + (\text{weaning rate} \cdot ENV_{OFFSPRING})}$$



Low maintenance, fertile cow with lots of milk to feed her fast growing calf

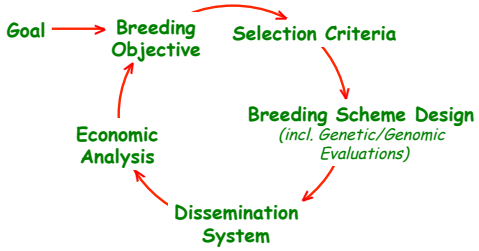
The Irish Agriculture and Food Development Authority

Set the record straight!!!!

- 16% reduction in CO_2 equivalents/billion kg beef produced between 1977 and 2007 *(Capper, 2011)*
- 37% reduction in CO_2 equivalents/billion kg milk produced in the US dairy sector between the years 1944 and 2007 *(Capper et al., 2009)*

The Irish Agriculture and Food Development Authority

Animal Breeding Program



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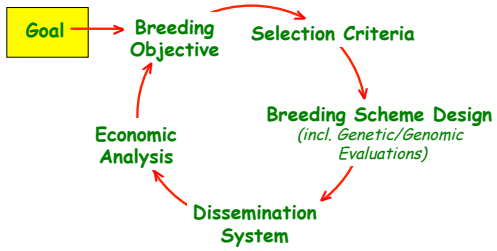
Animal Breeding Program



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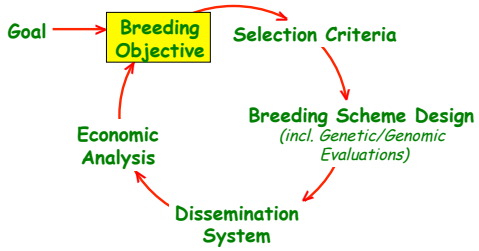
1. (Breeding) goal

- To improve the genetic ability
- of an animal's progeny to
- generate farm profitability
- in an environmentally and socially responsible and sustainable manner

Must be futuristic thinking - What will be the policies of the future?

The Irish Agriculture and Food Development Authority

Animal Breeding Program



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2. Breeding objective

- List of traits, optimally weighted, to best describe the goal
  1. Revenue generating traits
     - Carcass yield and value
  2. Cost of production traits
     - Feed intake, reproduction, longevity
     - Again must be futuristic…will traits with no current market value have a market value in the future?
- What environmental trait(s) – if any??

The Irish Agriculture and Food Development Authority

2. Breeding objective

- Trait must be:
  1. Important (economically, socially, environmentally)
  2. Exhibit genetic variation
  3. Be (easily) measureable or correlated with a heritable measureable trait

Ignore if no data currently available

The Irish Agriculture and Food Development Authority

2. Breeding Objective

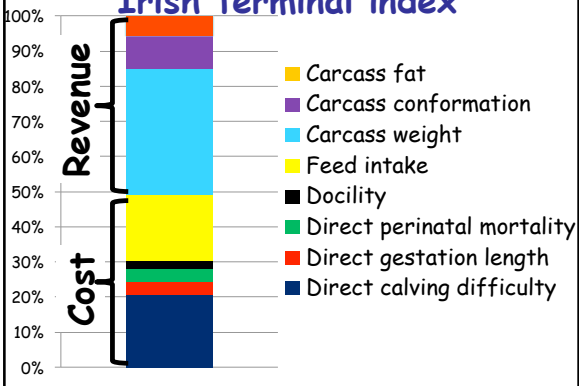
- Optimal weighting factors on each trait
  - Bioeconomic model
  - Profit functions

  } OK for performance traits
  - Choice experiments / willingness to pay
    - 1000 minds
  - Desired gains approaches

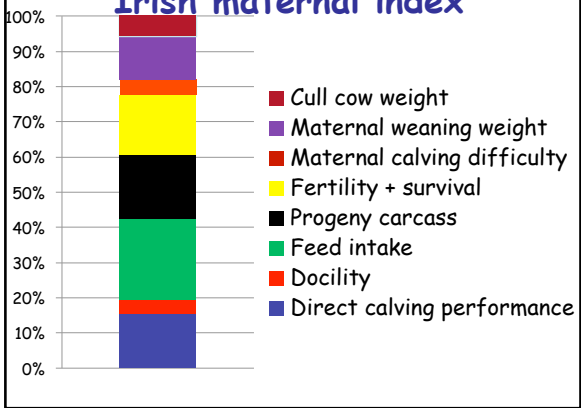
  } Environmental traits

The Irish Agriculture and Food Development Authority

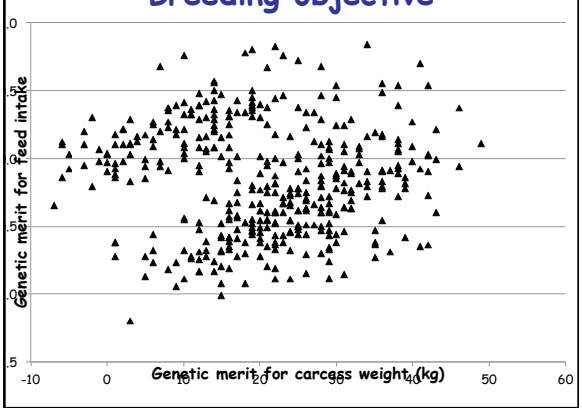
Irish terminal index



Irish maternal index

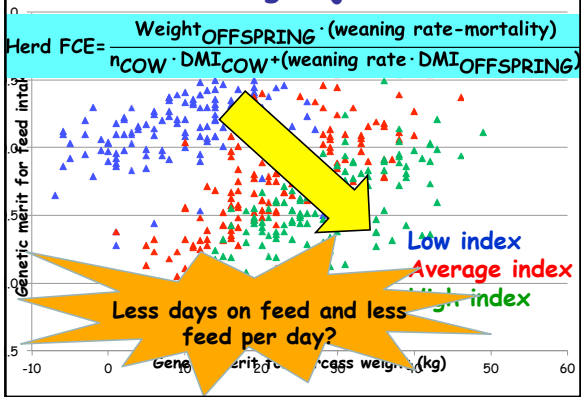


Breeding objective



Breeding objective

$$\text{Herd FCE} = \frac{\text{Weight}_{OFFSPRING} \cdot (\text{weaning rate} - \text{mortality})}{n_{COW} \cdot \text{DMI}_{COW} + (\text{weaning rate} \cdot \text{DMI}_{OFFSPRING})}$$



Can we make gains in these traits?

Breeding objective

- Growth rate & conformation
- Fertility and survival
- Direct environmental load per animal
- Feed intake
- Health

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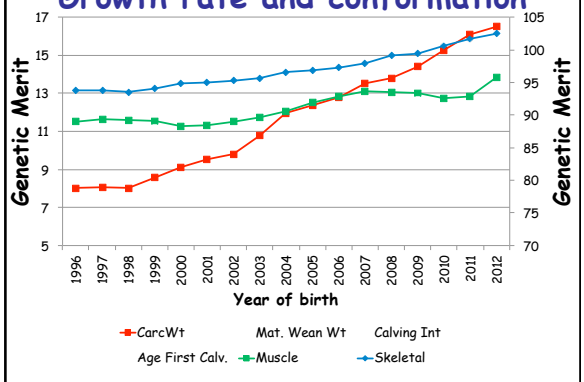
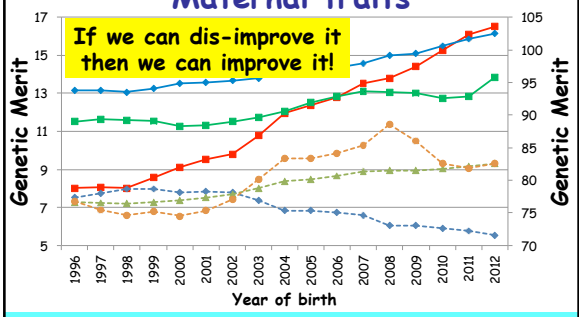
Growth rate and conformation



Maternal traits

If we can dis-improve it then we can improve it!



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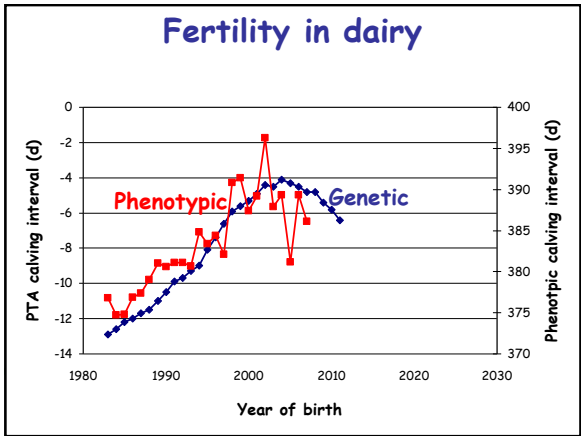
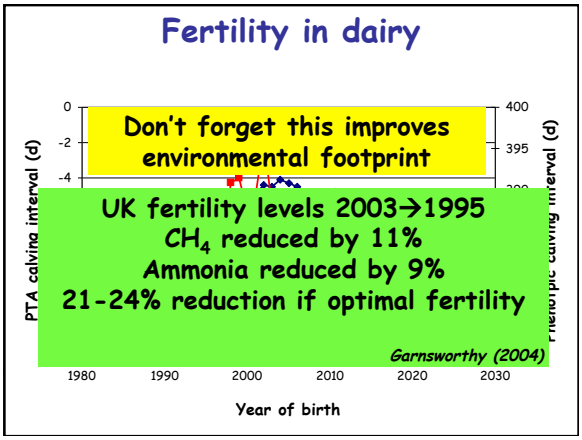
Fertility in dairy



Fertility in dairy

Don't forget this improves environmental footprint



UK fertility levels 2003→1995
CH_4 reduced by 11%
Ammonia reduced by 9%
21-24% reduction if optimal fertility

Garnsworthy (2004)

Can we make gains in these traits?

- Breeding objective
  - Growth rate and conformation
  - Fertility and survival
  - Direct environmental load per animal
  - Feed intake
  - Health

Methane
Nitrogen
Water

Genetic variation in methane emission

- Actual question is if there is exploitable variation in "residual methane production"
  - NOT methane per unit intake

Any genetic variation??

CH_4= growth + maintenance + intake + e

N = growth + maintenance + intake + e

Water = growth + maintenance + intake + e

Don't be fooled

- Genetic variation in CH_4/DMI does not mean genetic variation in daily CH_4
  - "picking up" genetic variation in DMI
- Example:
  - John Crowley's PhD data – 2605 performance tested bulls
  - Simulated random methane emissions (h^2=0)
  - h^2 DMI = 0.49 *(Crowley et al., 2010)*
  - h^2 CH_4/DMI = 0.19 (se=0.05)

Heritability mis-conceptions!

Heritability → Accuracy ← Information

Intensity → i; r; Variation → σ

$$\Delta G_{Yr} = \frac{i \cdot r \cdot \sigma}{L}$$

Genetic gain

Generation interval

Heritability mis-conceptions!

Heritability → Accuracy ← Information

Intensity → i; r; Variation → σ

$$\Delta G_{Yr} = \frac{i \cdot r \cdot \sigma}{L}$$

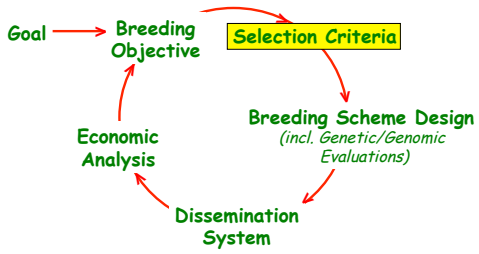
$$\Delta G_{Yr} \mp \frac{i \quad r \quad 0}{L} = 0$$

Any genetic variation??

Generation interval

Genetic gain = growth + maintenance + intake + e

Animal Breeding Program



Selection criterion

- What measureable traits best predict the breeding objective?

Objective = growth + fertility + environment+ DMI +…

Maximise the correlation

Criterion = Live-weight + Calving dates

Selection criterion

Should we even concern ourselves with this?? *(at the moment)*

Really???

Good Bad

Predicting feed intake

Traits	DMI	ADG	LWT	Fat
ADG	0.78			
LWT	0.75	0.68		
Fat	0.28	0.09	0.21	
Loin Dev	0.01	0.19	0.23	0.72

Meta-analysis of up to 20 studies

$C'G^{-1}C$ = 89.6% of genetic variance in feed intake explained

Is it worth going after the remaining 10% (at the expense of other things)
Is daily feed intake the important trait??

(2012)

Methane

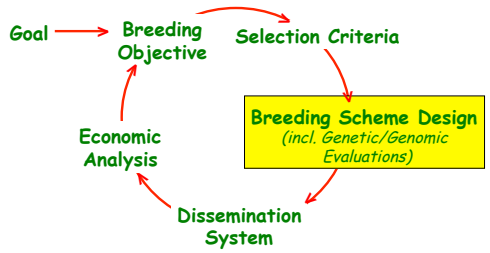
Traits	CH_4
ADG	??
LWT	??
Feed intake	??
Fertility & survival	??

$C'G^{-1}C$ = ???

What is the (co)variance matrix for methane emissions

Is it necessary to measure methane in the future??

Animal Breeding Program



4.Breeding scheme design

a) Genetic evaluations
- Accurate identification of genetically elite animals – Best linear unbiased prediction (BLUP)

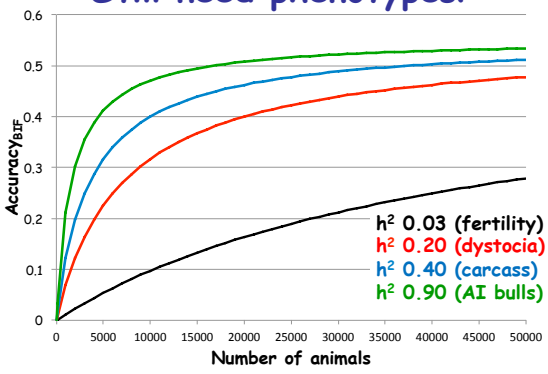
b) Genomic evaluations
- Supplementing pedigree data with genomic data (just another source of information)

c) Selection pathways
- Maximise genetic gain and constrain inbreeding

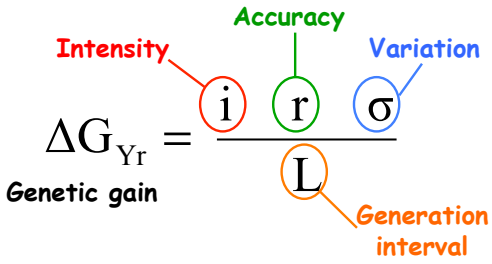
Genomics

- Genomics is USELESS unless the basics are already in place
  - Live, complete, & accurate phenotypic database
  - Pertinent and appropriate genetic evaluations
  - Well structured breeding program
  - Efficient and effective dissemination
  - Good management!
- I'm glad we didn't have genomic selection 30 years ago (in dairy)!

Still need phenotypes!

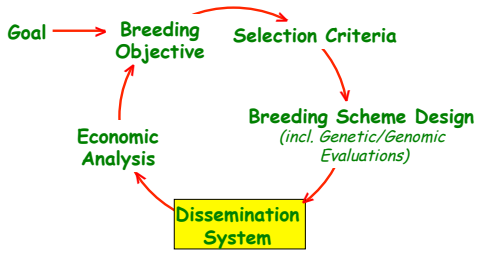


Fundamentals of genetic gain



Rendel & Robertson (1950)

Animal Breeding Program

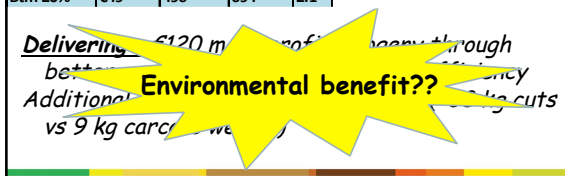


5. Desemination system

- Not much good having the best genetics if no one will use it!
- AI is arguably the best
  - Not suitable to all (e.g., rangelands)
- Genomic selection causing a paradigm shift
  - Role of the natural mating bull?
  - Bull functionality??
- The role of social science in animal breeding programs (and all science!)
  - Convince a breeder to breed for a trait with no direct economic impact

Potential from genetics

Category	Genetic Index*	Lwt start test kg	Lwt end test kg	ADG
Top 20%	**€115**	**497**	**679**	**2.0**
Next 20%	€95	488	673	2.0
Med 20%	€83	486	678	2.1
Next 20%	€71	509	707	2.1
Btm 20%	**€49**	**496**	**694**	**2.1**



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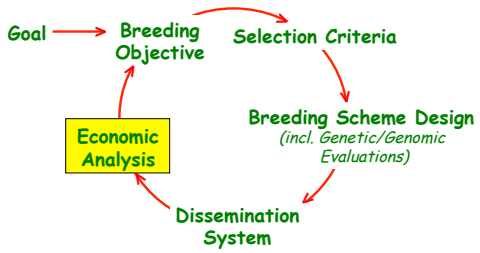
Btm 20%	**€49**	**496**	**694**	**2.1**

Delivering *€120 m* *through* *better* *efficiency* *Additional* *cuts* *vs 9 kg carc* *we*

Less days on feed and less feed per day?

Animal Breeding Program



6. Economic analysis

- Rate of genetic gain
  - Profit!
  - For breeding companies
  - For farmers/industry
  - Nationally/Globally
- Remember: Genetics is cumulative and permanent

Conclusions

- Need to consider full system efficiency
  - Already making environmental gains
    - Can go faster…at a financial cost!
  - Role of the sexy sciences?
    - Methane chambers, genomics..
- Prioritisation
  - Get the basics right
  - Extension!