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BRIDGING SCIENCE & BUSINESS

27/10/2021

Fitting environmental impact traits into economic selection indices

- GHG in the Selection Objective

Dr. John Crowley
Consultant, AbacusBio Ltd.

AbacusBio

- Private R&D consultancy founded in 2001
- 40 specialist scientists in areas of genetics, breeding & data analytics
  - 20 PhDs
  - 14 nationalities
- Specializing in application of science and technology in agriculture, horticulture, forestry & aquaculture
- Merger with tree improvement specialists Gemnetics in 2019
- Dunedin, Rotorua (NZ) & Edinburgh (UK) offices
- www.abacusbio.com

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Task

"…broader dialog to develop and explore traits associated with beef sustainability that would benefit or be suitable for genetic improvement efforts...

...the inclusion of sustainability traits in selection index efforts..."

Discussion points

- Opportunity
- Direct and indirect selection (thoughts and early state of the art)
  - Goal traits
- Approach
- Extension
- Summary

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doi:10.1017/S1751731117001549

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A methodology framework for weighting genetic traits that impact greenhouse gas emission intensities in selection indexes

P. R. Amer[1†], F. S. Hely[1], C. D. Quinton[1] and A. R. Cromie[2]

Animal (2020), 14:4, pp 834–845 © The Author(s) 2019. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution, and reproduction in any medium, provided the original work is properly cited.
doi:10.1017/S1751731119002519

anima

LIFE BEEF CARBON: a common framework for quantifying grass and corn based beef farms' carbon footprints

D. O'Brien[1,2†], J. Herron[2], J. Andurand[3], S. Caré[4], P. Martinez[5], L. Migliorati[4], M. Moro[5], G. Pirlo[4] and J-B Dollé[6]

Barwick et al. Genet Sel Evol (2019) 51:18
https://doi.org/10.1186/s12711-019-0459-5

GSE Genetics Selection Evolution

RESEARCH ARTICLE Open Access

Check for updates

Methods and consequences of including reduction in greenhouse gas emission in beef cattle multiple-trait selection

Stephen A. Barwick[1*], Anthony L. Henzell[1], Robert M. Herd[2], Bradley J. Walmsley[1] and Paul F. Arthur[3]

Animal, page 1 of 11 © The Author(s), 2020. Published by Cambridge University Press on behalf of The Animal Consortium
doi:10.1017/S1751731120001561

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Review: Genetic and genomic selection as a methane mitigation strategy in dairy cattle

J. Lassen[1†] and G. F. Difford[2]

The potential impact of breeding strategies to reduce methane output from beef cattle

P. F. Fennessy[A,B], *T. J. Byrne*[A], *L. E. Proctor*[A] *and P. R. Amer*[A]

Animal Production Science
https://doi.org/10.1071/AN21055

A method for implementing methane breeding values in Australian dairy cattle

C. M. Richardson[A,B], *B. Sunduimijid*[A], *P. Amer*[C], *I. van den Berg*[A] *and J. E. Pryce*[A,B]

Animal Production Science, 2020, **60**, 880–892
https://doi.org/10.1071/AN18383

Repeatabilities, heritabilities and correlations of methane and feed intake of sheep in respiration and portable chambers

D. L. Robinson[A,C], *S. Dominik*[B,C], *A. J. Donaldson*[A] *and V. H. Oddy*[A,C,D]

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What's the potential?

Table 1. Animal management strategies offering non-CO_2 greenhouse gas emission intensity reduction

Category	Species[1]	Effect on productivity	Potential CH_4 mitigating effect[2]	Potential N_2O mitigating effect[2]	Effective[3]	Recommended[4]
Increased productivity	AS	Increase	High[5]	High[5]	Yes	Yes
Recombinant bovine somatotropin	DC	Increase	Low	?[6]	Yes?	Yes?[7]
Growth promotants	BC and SW	Increase	Medium	Low	Yes	Yes[7]
Genetic selection (residual feed intake)[8]	BC, DC, and SW	None	Low?	?	Yes	Yes?[9]
Animal health	AS	Increase	Low?	Low?	Yes	Yes
Reduced animal mortality	AS	Increase	Low?	Low?	Yes	Yes
Reduced age at harvest and reduced days on feed	AS[10]	None	Medium	Medium	Yes	Yes

SPECIAL TOPICS — Mitigation of methane and nitrous oxide emissions from animal operations: III. A review of animal management mitigation options[1]

A. N. Hristov, T. Ott, J. Tricarico, A. Rotz, G. Waghorn, A. Adesogan, J. Dijkstra, F. Montes, J. Oh, E. Kebreab ... Show more
Author Notes

Journal of Animal Science, Volume 91, Issue 11, November 2013, Pages 5095–5113,

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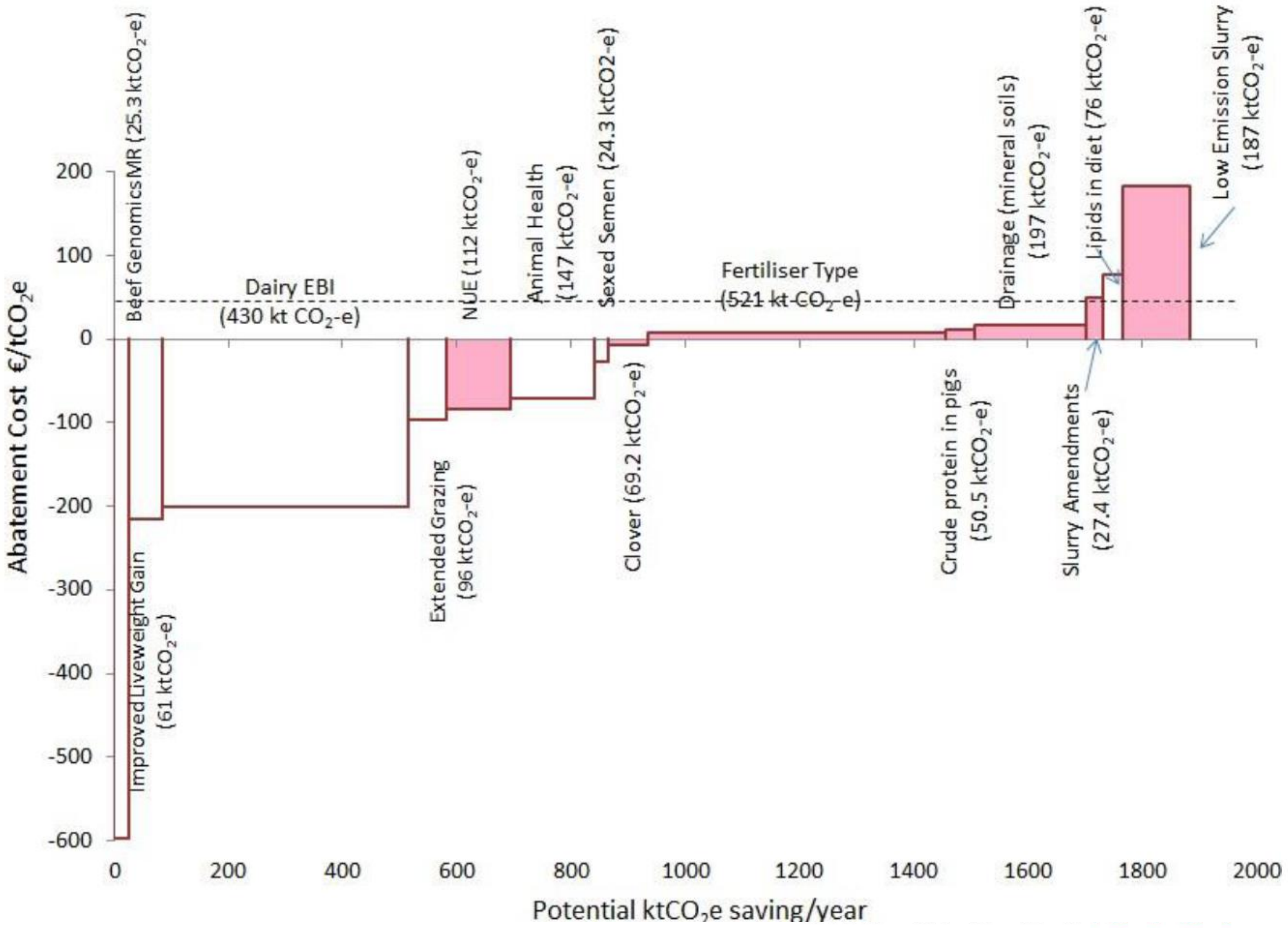
What's the potential?



An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030

Lanigan et al. (2018)

Selection Objective

- Gross GHG reductions vs Emissions Intensity (kg CO_2/kg beef)
  - Stable herd, increase in output
  - Increase in production efficiency facilitates contracting herd
  - Increase herd and output
- A narrow focus (e.g. methane only) may have unintended consequences
  - What are the direct traits?
  - What are the effects of other traits (indirect)

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Approach

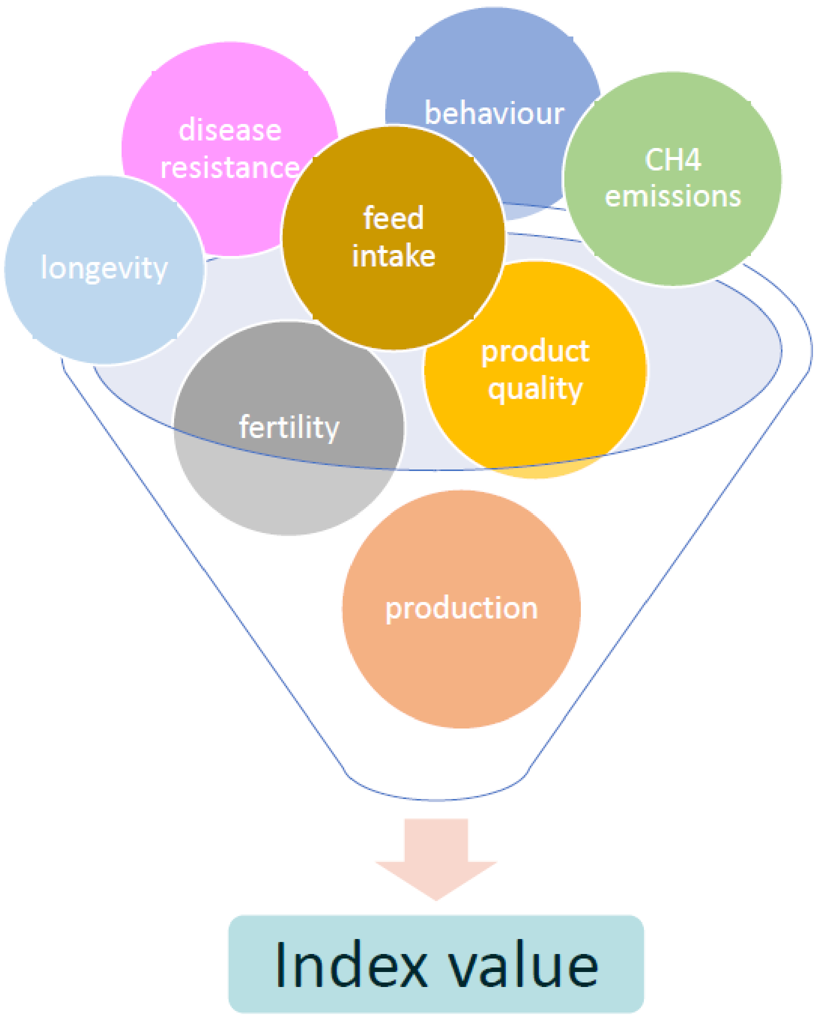
Economic Selection Index

$$I = b_1 \mathrm{EPD}_1 + b_2 \mathrm{EPD}_2 + \ldots + b_n \mathrm{EPD}_n$$

Where b=economic weight, EPD = genetic merit.

b's include economic values of traits i.e. for each trait, revenues and costs associated with 1 unit change, independent of other traits in breeding objective or index.

Also can be GHG coefficients, instead of, or as well as economic i.e., for each trait, increase or decrease in GHG associated with 1 unit change



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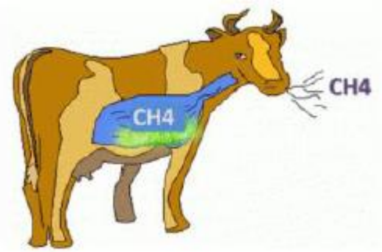
Enteric Methane Example

- Estimate how change in each trait affects feed intake and resultant carbon emission

Feed Intake +1 kg DM → **Emissions** +0.58 kg CO_2e

Cow Live Weight +1 kg → **Maintenance feed required** +3.20 kg DM → **Emissions** +1.86 kg CO_2e

Calving Interval +1 day → **Calves produced** -0.0025 → **Feed required** -2.11 kg DM → **Emissions** -1.23 kg CO_2e



GHG Value
kg CO_2e per trait unit

Emissions Intensity Value
kg CO_2e/kg meat per trait unit

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Presentation

Subindex

- Transparent, offers choice, estimate responses better
- Can be added on

$I = b_1 \mathrm{EPD}_1 + b_2 \mathrm{EPD}_2 + \ldots + b_n \mathrm{EPD}_n$ + Carbon Sub-Index

where Carbon Sub-Index = $c_1 \mathrm{EPD}_1 + c_2 \mathrm{EPD}_2 + \ldots + c_n \mathrm{EPD}_n$

where c = carbon coefficient x carbon price (cognizant of genetic expressions)

Or

$I = d_1 \mathrm{EPD}_1 + d_2 \mathrm{EPD}_2 + \ldots + d_n \mathrm{EPD}_n$

where d = EV + (carbon coefficient x carbon price)

Partial derivatives with respect to each trait at population mean can be used to estimate carbon coefficients as described by Amer et al. (2017) for enteric methane.

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Example

Table 1 *Maternal replacement and terminal index traits estimated effects on emissions per animal, numbers of animals and meat production per animal, and effects on total system-wide yearly gross emissions and emissions intensity*

Index, trait	$\beta_{e.offspring}$[1]	$\beta_{e.replace}$[2]	$\beta_{e.cow}$[3]	β_{o}[4]	β_{r}[5]	$\beta_{m.offspring}$[6]	$\beta_{m.cow}$[7]	DGE[8]	Gross emissions[9]	Emissions intensity[10]
Maternal Replacement										
Offspring feed intake	0.583							0.54	0.1889	0.0011
Offspring mortality				– 0.01				1.1	−25.4635	0.1452
Offspring carcass weight						0.686		0.54	0	−0.0250
Offspring carcass conformation						4.072		0.54	0	−0.1483
Offspring carcass fat						−2.982		0.54	0	0.1086
Cow live weight			1.8641					2.204	4.1086	0.0234
Heifer live weight		5.4835						0.614	0.6734	0.0038
Cow calving interval			−1.2324	−0.0027				2.204	−16.6943	0.0643
Cow age at first calving			3.1666					0.614	1.9443	0.0111
Cow survival					−0.0080			2.204	−36.4285	−0.2072
Cow carcass weight							0.6	0.288	0	−0.0000
Terminal										
Offspring feed intake	0.583							0.78	0.4547	0.0026
Offspring mortality				−0.01				1	−23.1486	0
Offspring carcass weight						0.686		0.78	0	−0.0601
Offspring carcass conformation						4.072		0.78	0	−0.3570
Offspring carcass fat						−2.982		0.78	0	0.2614

Quinton et al. (2017) doi:10.1017/S1751731117002373

Carbon Price

- Currently using $80/tonne
- Estimated to increase
- Is mitigation in Ag relatively cheap, and will it open up serious carbon trading possibilities?
  - Careful not to leave Ag with no mitigation accomplished (accounting)

All the GHG

- Enteric methane makes up the majority of emissions (~60% depending on system)
- Others include dung CH_4, N_2O and CO_2
- Some traits may carry a bigger CO_2 weighting that can be missed by just focussing on enteric CH_4
  - Days to calving is an example

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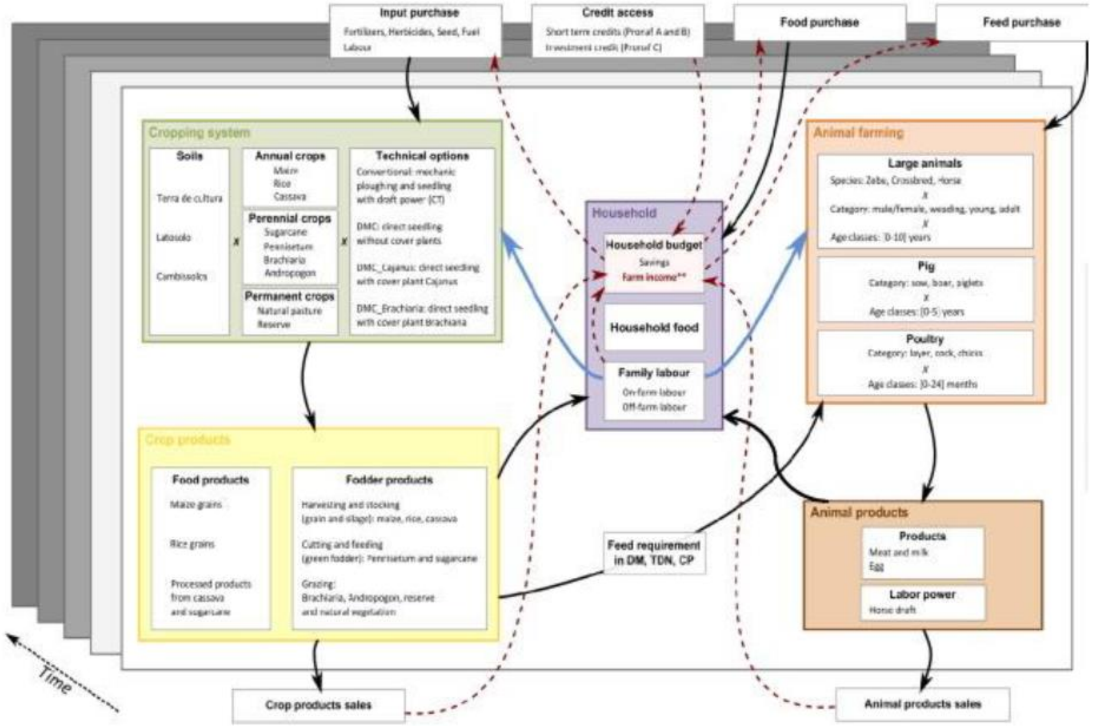
All the GHG

- So (currently under development), we need total system CO_2e coefficients;
  - Need a well defined systems model where we can change traits (wean weight, AFC, carcass weight, CE etc.) by 1 unit and see how the end system CO_2e (gross or per unit product) changes.
  - Need to be careful of double counting, and results can be opaque



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All the GHG

- Or, remember

  $$\text{Carbon Sub-Index} = c_1\text{EPD}_1 + c_2\text{EPD}_2 + \ldots + c_n\text{EPD}_n$$

  where c = carbon coefficient x carbon price (cognizant of genetic expressions)

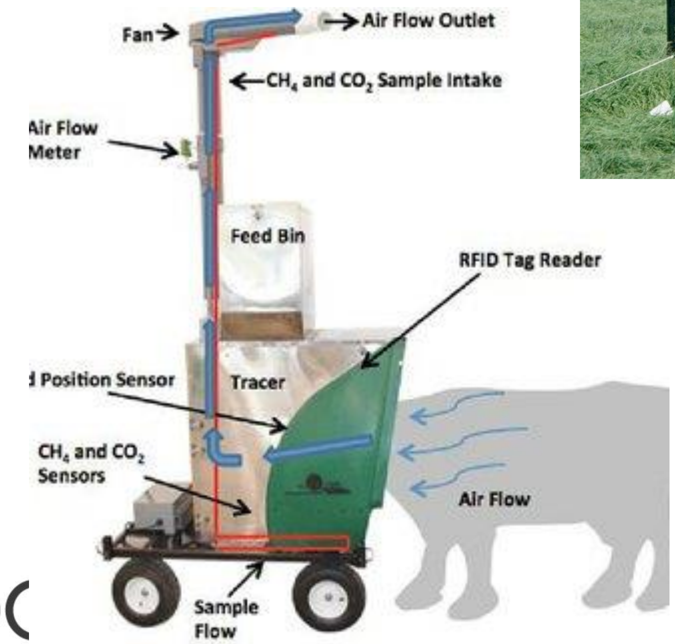
- We can have the carbon coefficient made up of a sum of specific GHG coefficients e.g.

carbon coefficient = (Enteric CH_4 x 28) + (dung CH4 x 28) + (N_2O x 298) + CO_2

Core Traits

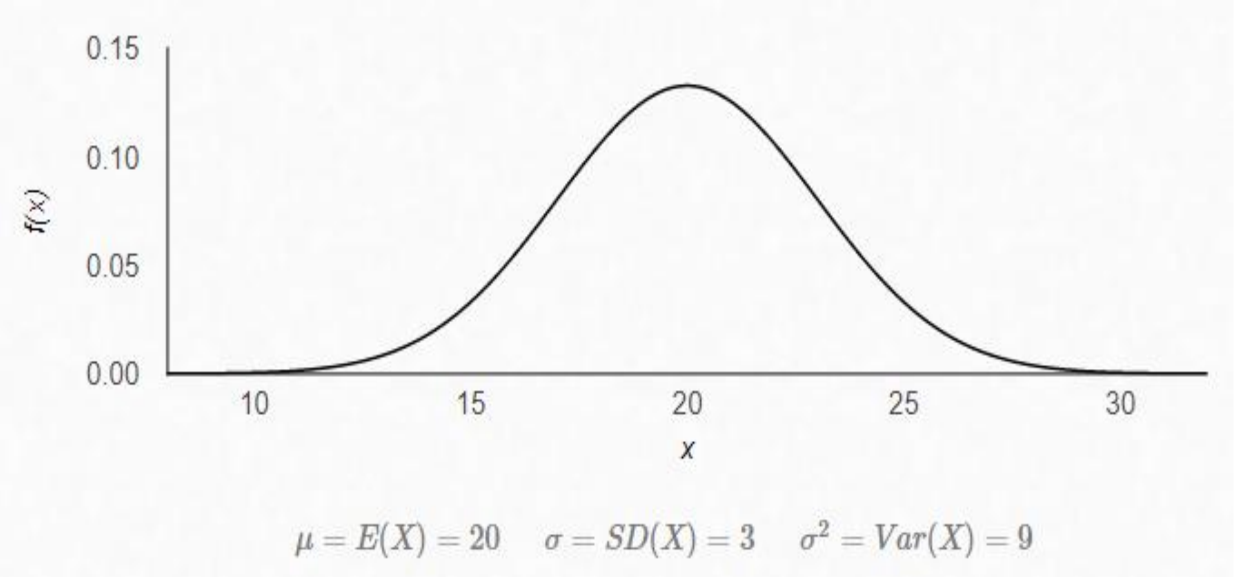
- Question from previous Brown Bagger session; What traits should we select for?
  - Age at slaughter (days to slaughter)
  - Methane Yield (methane/kg DMI)

  - AFC
  - CIV
  - Longevity
  - Feed Efficiency



Methane Yield

- Different diets have different "emission factors" (and diets within country)
  - High conc.
  - TMR
  - Grass
- Between animal variation
  - CV = 15-20%
  - $h^2 = 0.30$
- Definition
  - Methane/kg DMI
  - Residual methane/kg DMI
  - Methane/d
  - Richardson et al. (2021), JDS, 104:1:539



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Age at Slaughter

- Easily recognised in inventory
- e.g.

  10 kg DMI/d = 200 g/d CH_4

  Slaughter 20 million animals 1 days earlier/year = 110k+ tonne C saved/yr
- Other considerations for days to slaughter EPD (days to “finish”)

Some Current Examples

- UK Dairy
- Australian Dairy
- NZ Dairy
- Irish Dairy
- Irish Beef

Agriculture Victoria Principal Research Scientist Professor Jennie Pryce who is leading the DairyBio animal program.

by Agriculture Victoria | 16 Aug 2021

Healthy cows produce fewer methane emissions, and that discovery by Agriculture Victoria scientists are helping dairy farmers to breed 'environmentally friendly' cows.

Emerging challenges such as climate change and a rising consumer interest in the ethical production of

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Breeding cows to help reach net zero

Tuesday, 3 August 2021

Two new genetic indexes to help farmers breed more environmentally friendly cows will be launched in August.

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Summary

- Quickly advancing approaches for carbon in selection indexes
- Age at Slaughter and Methane Yield carry a lot of potential
- Selection index approaches to improving gross emissions and emissions intensity will differ slightly
- Price of carbon will have a bit impact on relative emphasis
- Other breeding and genetics practices also help

Thank You

Brown Bagger Team

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