

# Feed Efficiency

Jennie Pryce

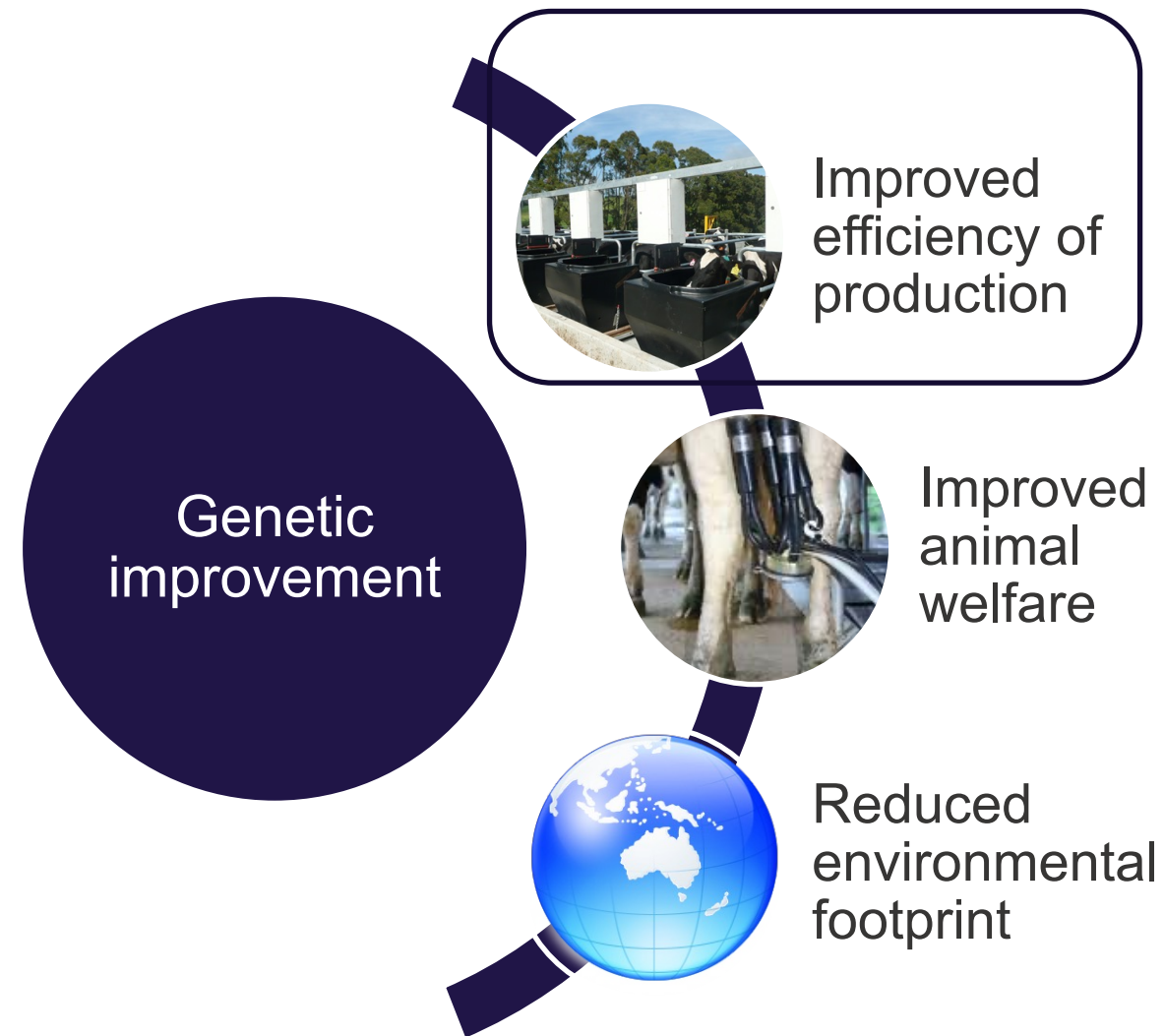
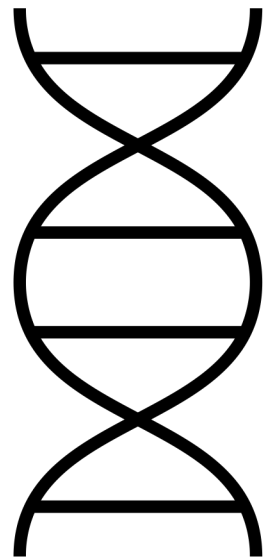
World Holstein Friesian Federation  
France, November 2023



Energy,  
Environment  
and Climate Action

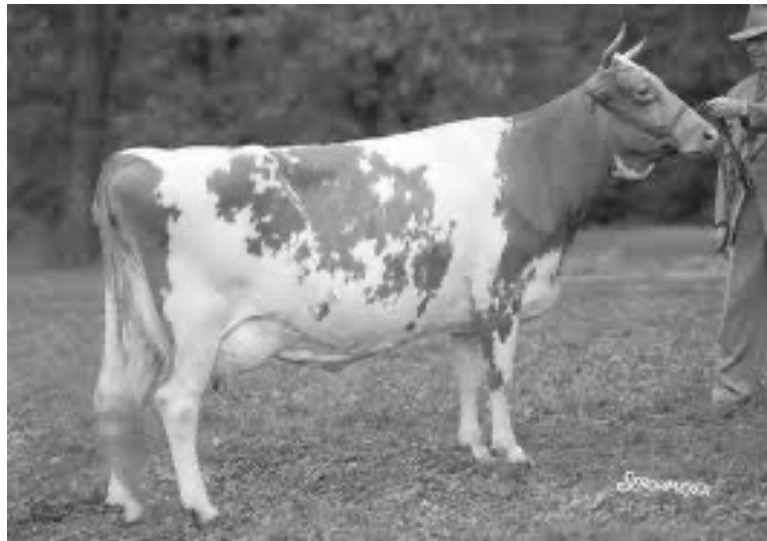
# Genetic selection – a cost-effective solution to almost any issue in plant/animal breeding

*Rob Banks UNE 2023*



# Selection for production has had astonishing results

1950



1746 litres/year  
350 kg liveweight  
5.6 litres/kg liveweight

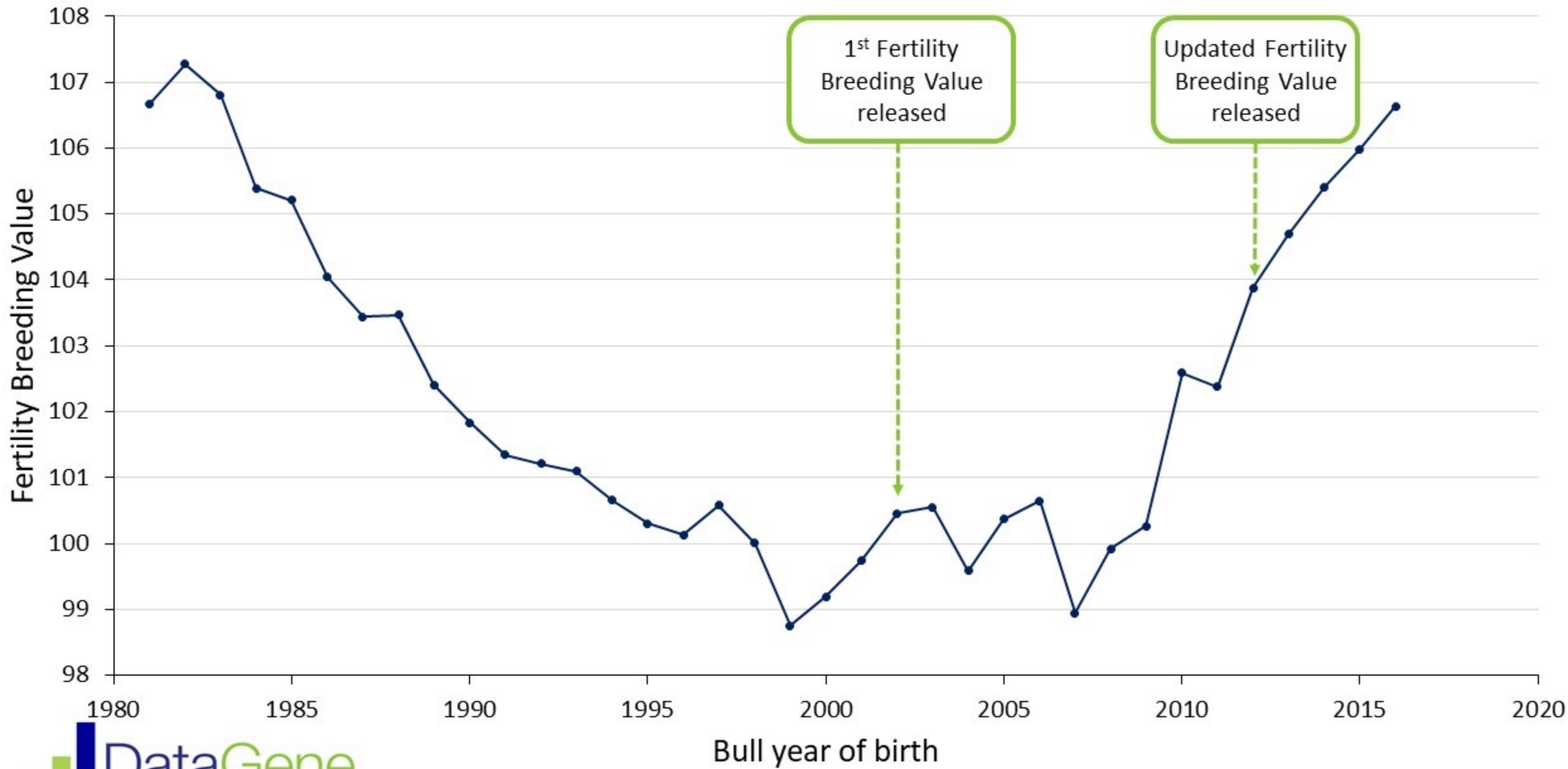
2021



7069 litres/year (DataGene stats 2021/22)  
600 kg liveweight  
11.8 litres/kg liveweight

Doubled efficiency through dilution of maintenance

# Average Fertility Breeding Value in Australian Holstein Bulls





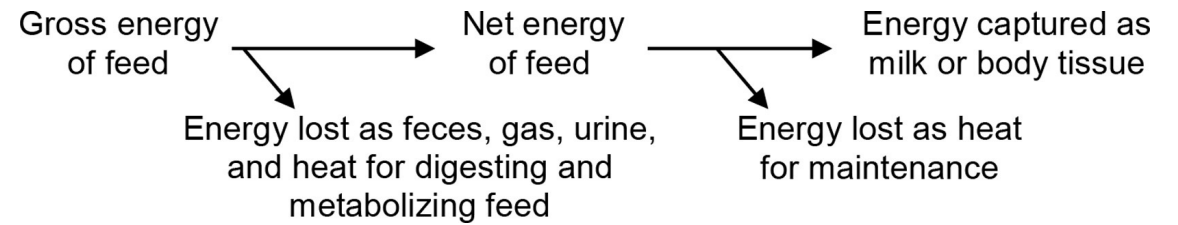




## What is feed efficiency?

- Feed efficiency can be defined as the fraction of feed energy captured into products (vandeHaar et al., 2016)
  - Almost doubled in most countries over 100 years
  - Efficiency peaks at 4x maintenance, which is 45kg/d at 3.5% fat for 680kg cow (Huhtanen et al. 2009)

## What happens to feed?



Journal of Dairy Science  
Volume 99, Issue 6, June 2016, Pages 4941-4954

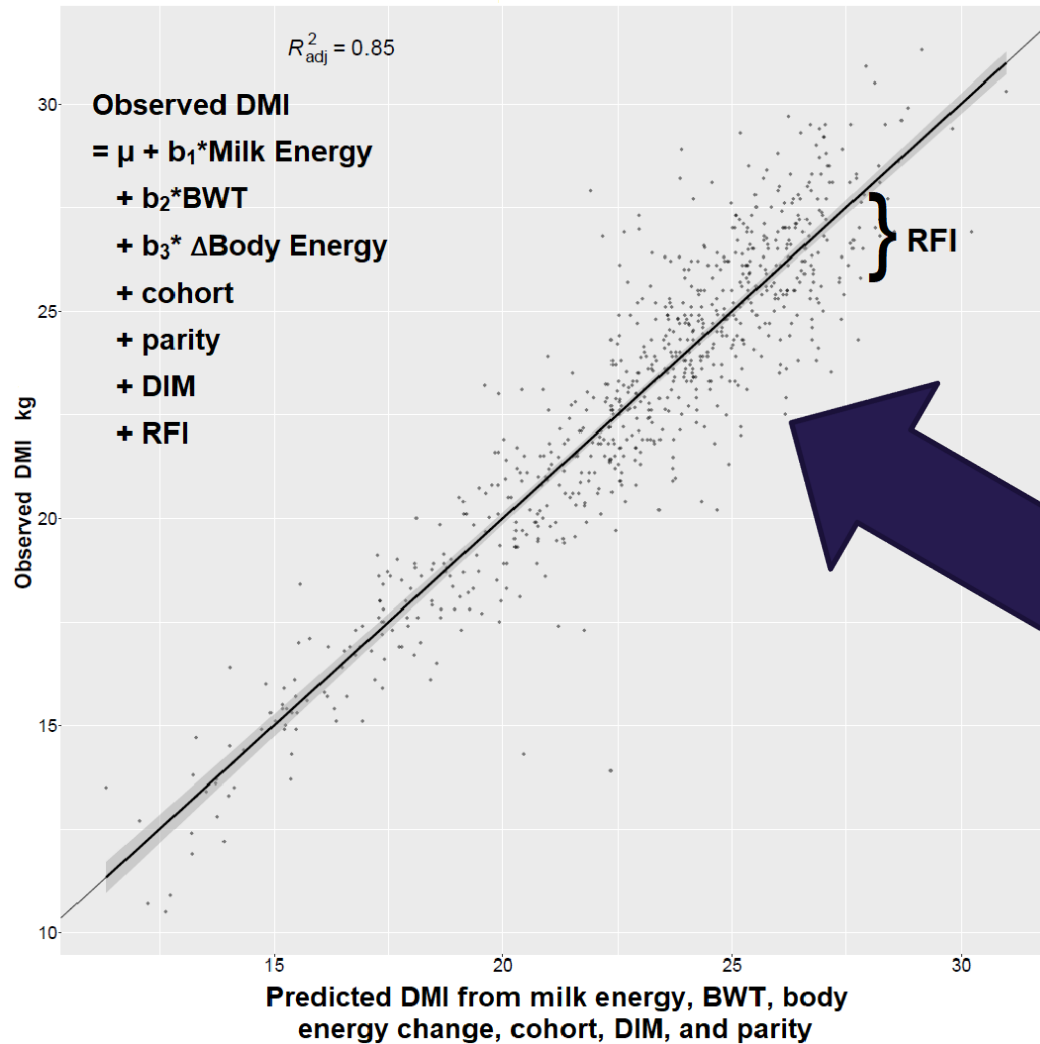


## Harnessing the genetics of the modern dairy cow to continue improvements in feed efficiency <sup>1</sup>

M.J. VandeHaar <sup>\*</sup>, L.E. Armentano <sup>†</sup>, K. Weigel <sup>†</sup>, D.M. Spurlock <sup>‡</sup>, R.J. Tempelman <sup>\*</sup>, R. Veerkamp <sup>§</sup>

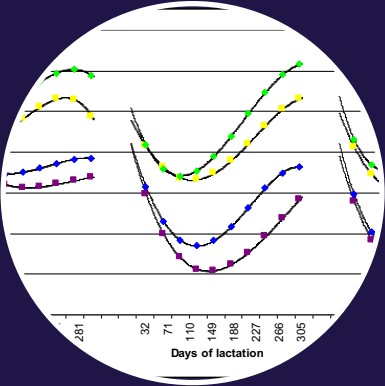
Show more

# Residual feed intake (RFI)



Residual Feed intake is  
Actual – predicted DM intake

Efficient (eat less than predict)



## Langhill

- 50 years of 2 Genetic lines on 2 diets
- Feed intake and feed efficiency



## Australia and NZ

- Feed efficiency in growing heifers
- Feed efficiency in lactating cows
- Feed Saved ABV



## Worldwide

- State of the art feed efficiency genomics







# Jennie Pryce

## Research Director Genomics and Cellular Sciences

- Quantitative geneticist
- 3 passports: UK, New Zealand and Australia
  - PhD in Edinburgh + 3 years at SRUC
  - Livestock Improvement Corp (NZ) in 2000s
  - State Gov't Victoria from 2008 to now
  - Joint appointment with La Trobe University

# What happens when we select for only milk yield?



- Langhill experiment
  - 2 lines
  - 2 diets
  - Same selection for 50 years
- There are a number of correlated responses
  - Fertility
  - Mastitis
  - Lameness
  - Condition score



Livestock Production Science  
Volume 57, Issue 3, 1 February 1999, Pages 193-201



Genotype and feeding system effects and interactions for health and fertility traits in dairy cattle

Jennie E. Pryce [ORCID](#), Birte L. Nielsen<sup>1,1</sup>, Roel F. Veerkamp<sup>2,2</sup>, Geoff Simm

Show more [v](#)

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[https://doi.org/10.1016/S0301-6226\(98\)00180-8](https://doi.org/10.1016/S0301-6226(98)00180-8)

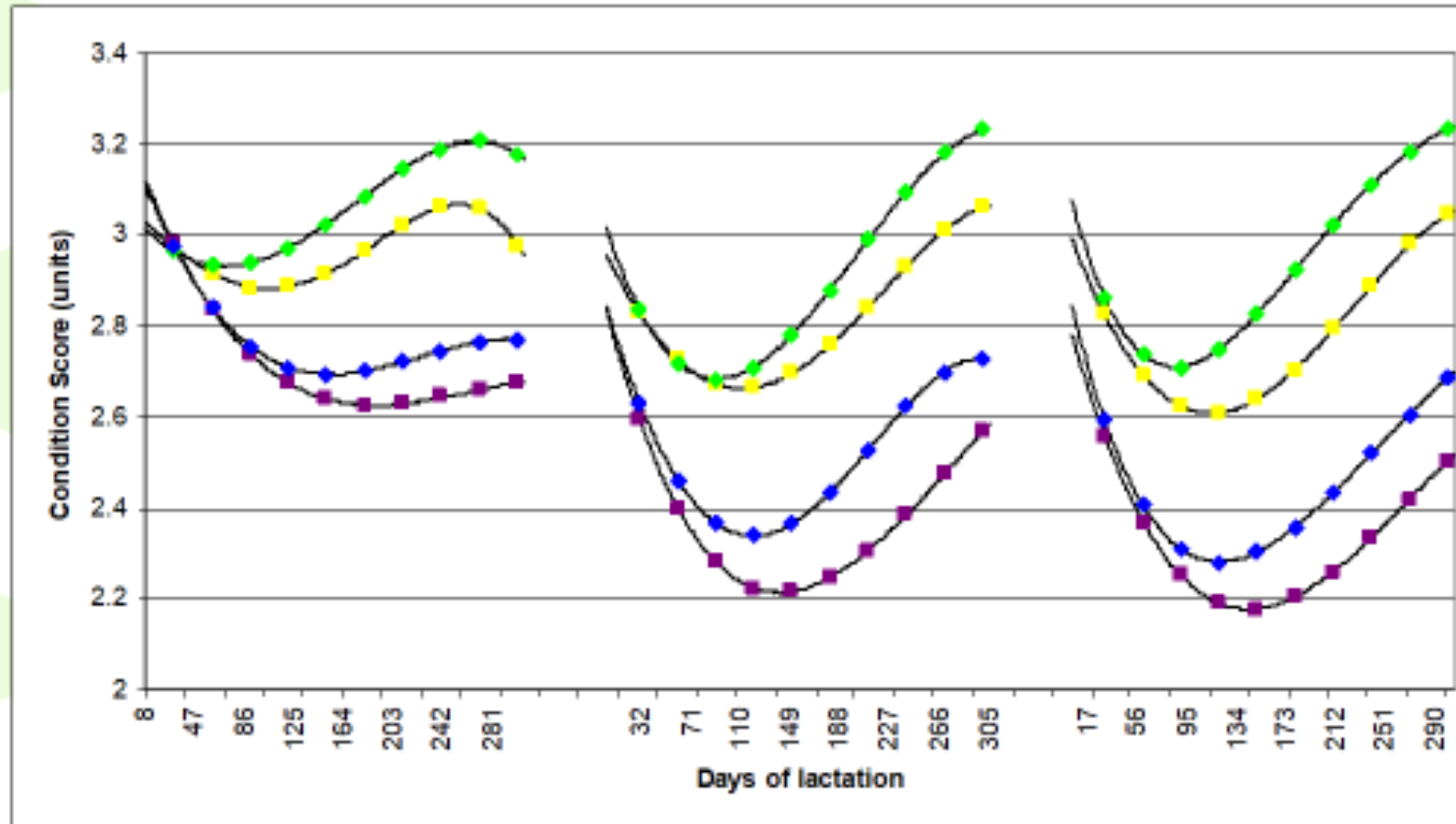
[Get rights and content](#)

# Body condition score

low concentrate control (- ■ -) low concentrate select (- ■ -),  
high concentrate control (- ◆ -) high concentrate select (- ◆ -).



Prof Mike Coffey



## Challenges....

Dealing with condition score loss correctly is one of the big challenges in defining residual feed intake properly

Knowing the consequences of selecting on residual feed intake or any new trait is important!

A lot of effort in measuring feed intake globally

## Example

Feed efficiency

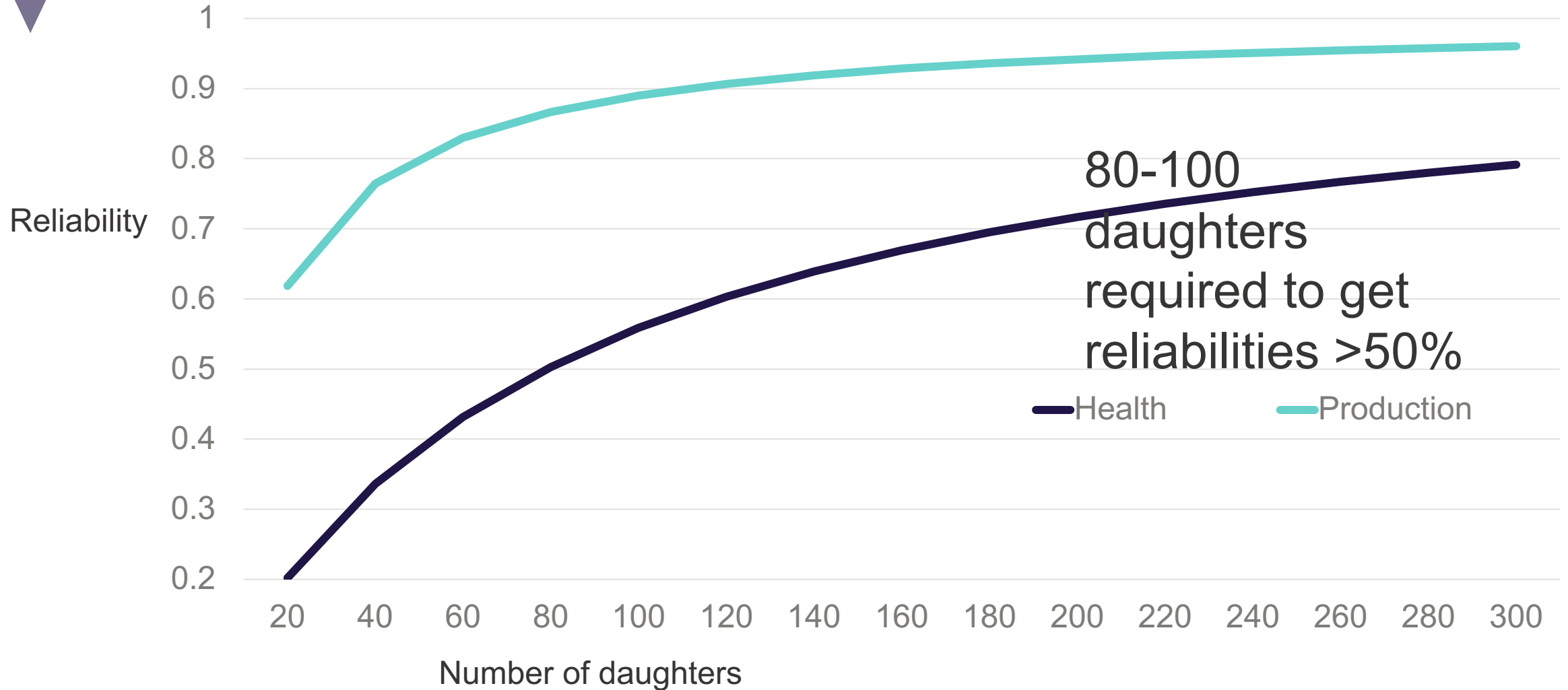


Research Farm Dairy Campus, NL



- Recording of individual feed intake in research and commercial farms
- RIC feed bins
- Several thousand cows in reference population for genomic evaluation for dry matter intake
- Cooperation between WUR and CRV





# Genomic selection the game changer

2001 Genomic selection invented

2008 Commercial SNP chips

From 2010 widespread adoption by dairy industry

Contribution to global GDP worth billions through plant and animal breeding

# Genomic selection the game changer

JOURNAL ARTICLE

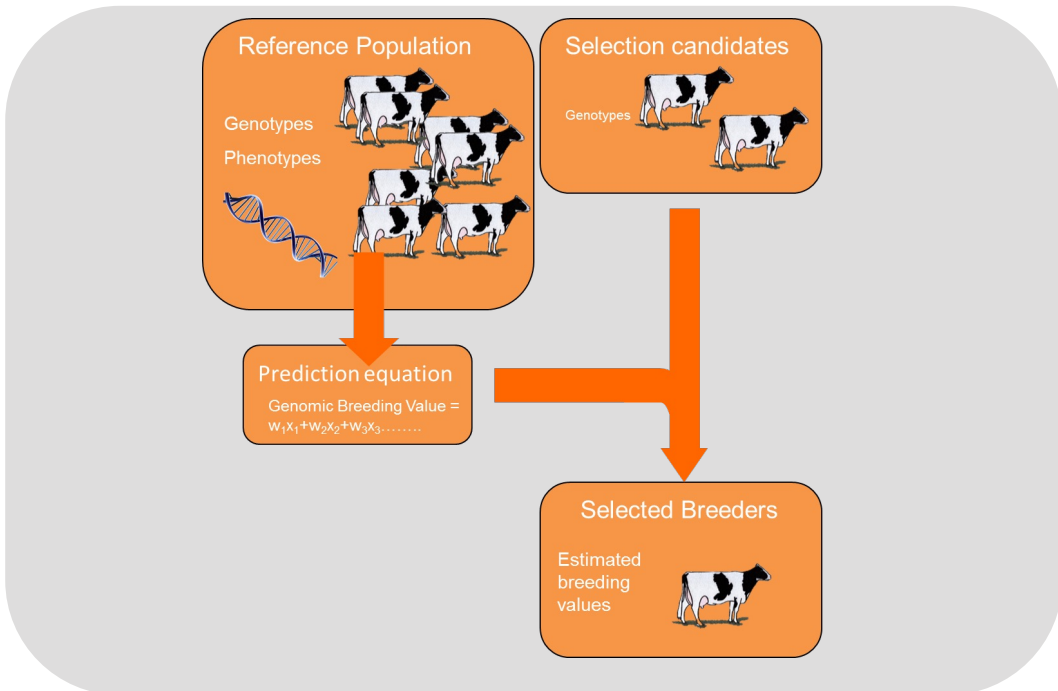
## Prediction of Total Genetic Value Using Genome-Wide Dense Marker Maps <sup>FREE</sup>

T H E Meuwissen ✉, B J Hayes, M E Goddard

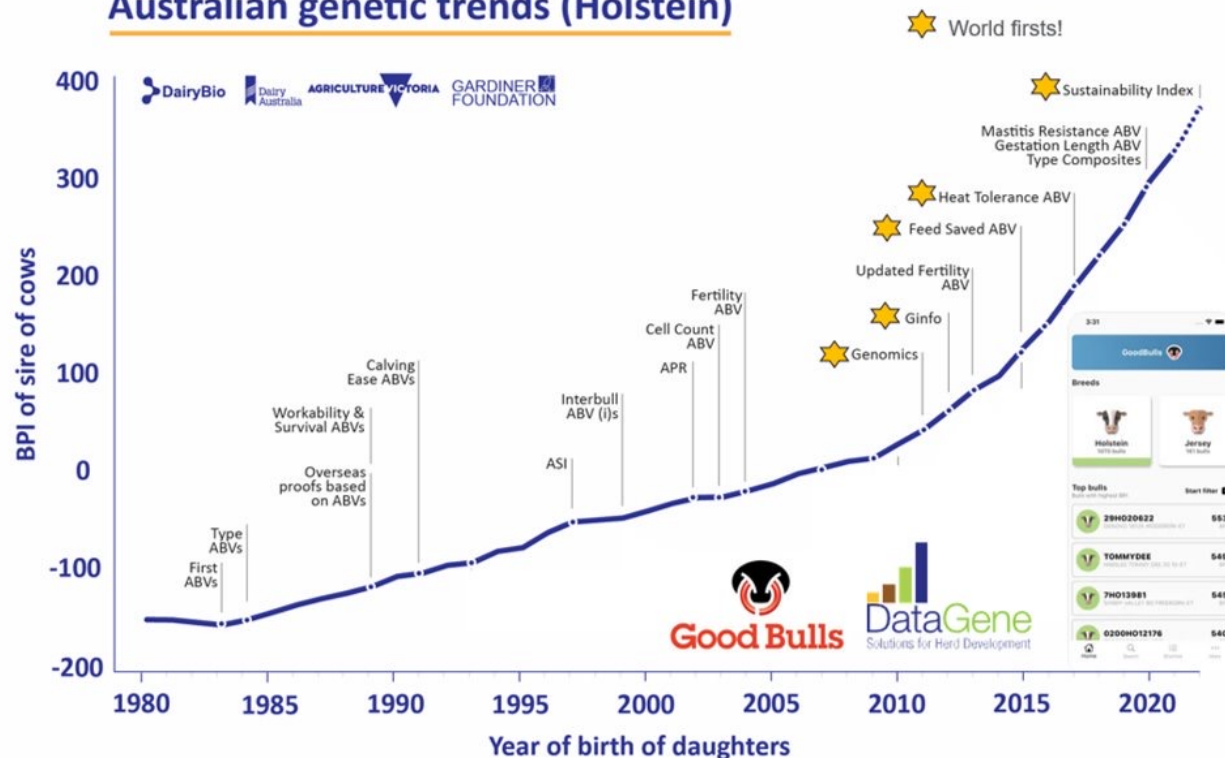
Genetics, Volume 157, Issue 4, 1 April 2001, Pages 1819–1829,

<https://doi.org/10.1093/genetics/157.4.1819>

Published: 01 April 2001 Article history ▾



## Australian genetic trends (Holstein)





- 3x heifer cohorts (Rutherglen 2009-2011)
- 900 heifers in Australia
- 900 heifers in NZ

2008-2011

2011-2015

- Individual feed intake measurements at Ellinbank
- gDMI research
- Feed Saved ABV released 2015

- International collaboration
- Individual feed intake measurements at Ellinbank
- Individual methane measurements at Ellinbank

2016-2020

2020-2021

- Genomic prediction equations of RFI cow and RFI heifer updated
- 2x reliability of RFI
- Updated ABV released in Dec 2020





J. Dairy Sci. 97:537–542  
<http://dx.doi.org/10.3168/jds.2013-7376>  
© American Dairy Science Association®, 2014.

## Short communication: Validation of genomic breeding value predictions for feed intake and feed efficiency traits

J. E. Pryce,\*†<sup>1</sup> O. Gonzalez-Recio,\*† J. B. Thornhill,†‡ L. C. Marett,†‡ W. J. Wales,†‡ M. P. Coffey,§  
Y. de Haas,# R. F. Veerkamp,# and B. J. Hayes\*†||

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†Dairy Futures Cooperative Research Centre, Bundoora, VIC 3086, Australia  
‡Future Farming Systems Research, Department of Environment and Primary Industries, Ellinbank, VIC 3820, Australia  
§Animal and Veterinary Sciences, Scotland's Rural College (SRUC), Easter Bush Campus, EH25 9RG, Scotland  
#Animal Breeding and Genomics Centre of Wageningen University Research Centres (UR) Livestock Research, PO Box 65, 8200 AB Lelystad, the Netherlands  
||La Trobe University, Bundoora, VIC 3086, Australia

### ABSTRACT

Validating genomic prediction equations in independent populations is an important part of evaluating genomic selection. Published genomic predictions from 2 studies on (1) residual feed intake and (2) dry matter intake (DMI) were validated in a cohort of 78

### Short Communication

Given the difficulty of obtaining individual animal feed intake phenotypes and the importance of feed costs to the profitability of dairying, interest has been growing in combining DMI phenotype data collected at research farms internationally (Banos et al., 2012;

Feed  
saved  
ABV



Residual  
feed intake  
Genomic BV



Maintenance from  
Bodyweight  
Breeding Value

# Feed Saved Australian Breeding Value (ABV)

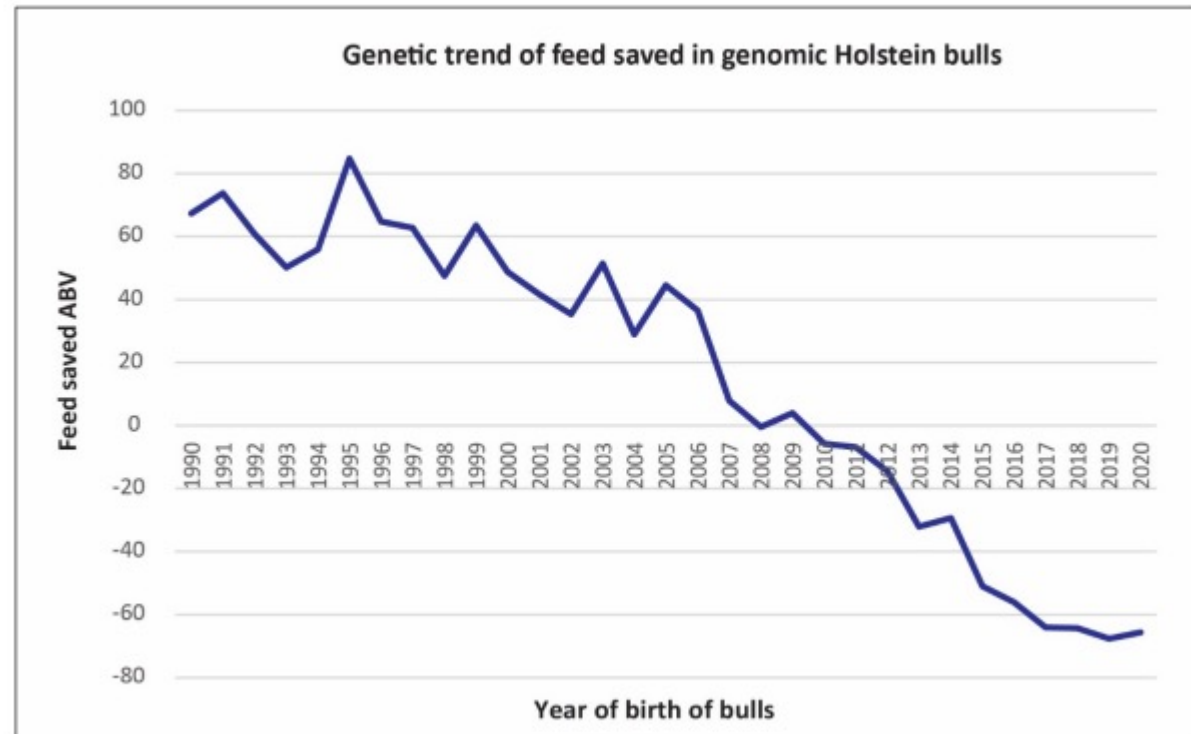
Reliability (%) of Feed Saved ABV (November 2020)				
Breed	Young genomic bull	Proven bull with genotype	Young genomic heifer	3-lactation cow with genotype
Holstein	43	50	42	45
Jersey	37	49	37	41

- For no additional cost or effort, farmers can breed a herd that uses feed more efficiently.
- The Feed Saved ABV identifies animals that produce the same amount of milk with improved maintenance and efficiency of feed use
- Our updated Feed Saved has an average reliability of 43% in young genomically tested bulls

## Example Feed Saved ABVs



Holstein		
BULL ID	BPI BALANCED PERFORMANCE INDEX	FEED SAVED FEED SAVED ABV
A	336	- 43
B	320	- 147
C	302	- 4
D	301	110
E	285	2
F	282	- 6
G	277	72
H	277	- 26





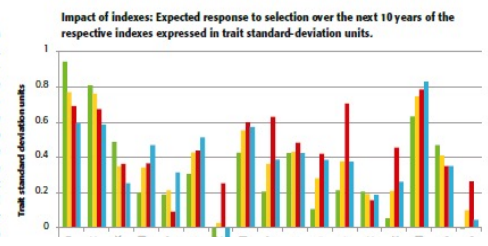
# Feed Efficiency: Exciting Feature of New Australian Proofs

After extensive consultation with farmers, the Australian Dairy Herd Improvement Scheme (ADHIS) has produced a new format for the Australian proofs which has now been implemented with the latest proof release. Proofs are now displayed using a standard deviation of five, and a brand new total performance index has been introduced. And in an exciting development, Australia becomes one of the first countries world-wide to have a proof for feed conversion efficiency.

DOUG SWAGE | IAN HOPMAN

Australia's total index APR (Australian Profit Ratio) is now a thing of the past. It is replaced by the BPI (Balanced Performance Index). Two additional alternative total indexes – the TWI (Type Weighted Index) and the HWI (Health Weighted Index) – are now also published for those farmers who would prefer greater emphasis on either type or health. Additionally, in a step that puts the Australian proofs more in line with the format used in many countries worldwide, traits will be expressed on a scale using 5 points for each standard deviation unit. Along with these changes, the new trait Residual Survival will also be introduced. The new-look Australian proofs will also feature an 18-month-long involving the direct input

**FARMER SURVEY**  
For the people at ADI this consultation process was as important as the final of the process was to genetic improvement, a very positive experience. Abernethy, manager of genetic weightings will be based on the scientific literature. With our consultation we were able to get a range in economic values for the different performance indexes. As a result, the new proofs are scientifically based and accurate for the specific Australian conditions. The consultation process took place through an on-line survey for farmers and also had a series of focus groups that would be held at various practices and would



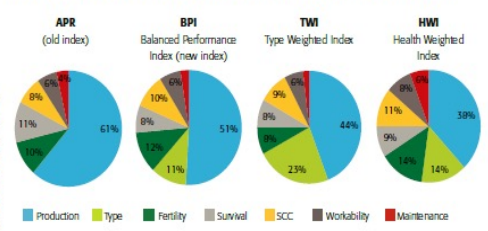
## Feed Saved (FSAV)

**INTRODUCTION DATE**  
December 1, 2020, and then in all subsequent weekly, monthly and triannual evaluations

**BENEFITS OF TRAIT**

- Feed costs can make up over half of the total costs on a dairy farm<sup>1</sup>. Selecting for more feed-efficient cows can reduce the cost of production and improve

Percent emphasis on traits within the APR and the three new indexes BPI, TWI and HWI



**PROOF EXPRESSION**

The ease of understanding proofs was a major factor in moving to a system of expressing proofs whereby each standard deviation is given a value of 5 with breed-average being 100. This means that traits are expressed on the same scale with a range of a minimum of 80 up to a maximum of 120. Unlike the old system, it is now possible with one glance at a proof profile to tell which traits an animal really excels at and which ones could be considered weaknesses. In keeping with efforts to provide more complete information, traits such as forerunner attachment will now also be displayed.

**FEED SAVED**

While the introduction of health trait proofs was the major revelation for genetic evaluations worldwide over the past decade or so, it has often been predicted that feed conversion efficiency would be the next era to follow. Now that new era has arrived. A highlight of the changes to the Australian system was the addition of two new traits, the first of which is Feed Saved, a measure of feed conversion efficiency. The research for this trait started nine years ago and involved the measuring of feed intakes on animals right from when they were

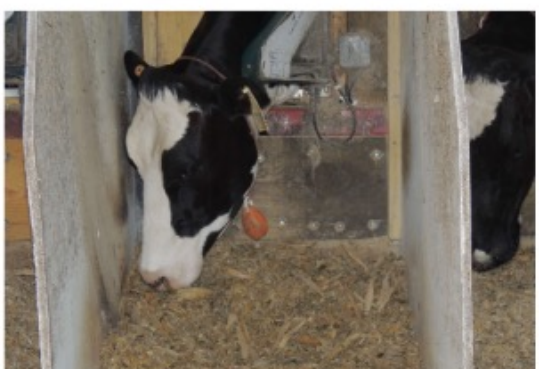
born. However, those animals that have been genotyped will have much greater accuracy for this trait as their genomic information can be compared to the reference group using the identified genomic predictors.

**RESIDUAL SURVIVAL**

The second new trait to be introduced was Residual Survival. There are many things affecting how long an animal survives, including production level, fertility, mastitis, feet and leg issues,' explains Daniel. 'Two animals could have exactly the same production but one will still live longer because it is more resistant to such things as metabolic problems or lameness, and it is that part of survival that we want to measure as Residual Survival. Essentially

we want to avoid double counting production and so we separate it out and what is left after adjusting data for the effects of production is Residual Survival.' The percentage contribution of the different trait groups to the makeup of the new indexes can be seen in the pie-chart diagrams. However, a better way to evaluate the effectiveness of these indexes – the BPI, TWI and the HWI – is to look at the predicted impact they will have on the individual traits over the next 10-year time period. While each of the new indexes will result in somewhat smaller production gains than the outgoing APR had it been retained, they will each produce greater gains for health and management traits and overall type. Australian genetic evaluations now move into a new era

## Trait Reference Sheet November 2020



CDCB Industry Meeting November 2, 2020  
  
 Paul VanRaden, PhD  
 USDA Animal Genomics and Improvement Laboratory



**What is Saved Feed Index?**

Today dairy farmers have access to a number of indexes that rank sires for feed efficiency, including both the national indexes (Australia, Canada, the Netherlands, the Nordic countries, the United States, the United Kingdom) and company feed efficiency indexes.

will help  
and energy  
required.  
that are more



## ICAR Working group - Feed and Gas

Focus on measuring CH<sub>4</sub>

How can we work together to get the best outcome

Open conversations essential!



ABOUT US TECHNICAL BODIES CERTIFICATIONS PUBLICATIONS

The page shows introductory information about the Feed and gas Working Group

### Introduction

In June 2015, at the ICAR Technical Meeting held in Krakow, the Board endorsed the Feed and gas Working Group whose Terms of Reference are available [here](#)

The Chairperson of the WG is [Birgit Gredler-Grandl](#)

### Members of the Working Group

- Christine Baes
- Lorenzo Benzoni
- Raffaella Finocchiaro
- Maria Frizzarin
- Phil Garnsworthy
- Nina Krattenmacher
- Jan Lassen
- Jennie Pryce

### Brian Wickham Young Persons Exchange Program Bursary

- Caelli Richardson

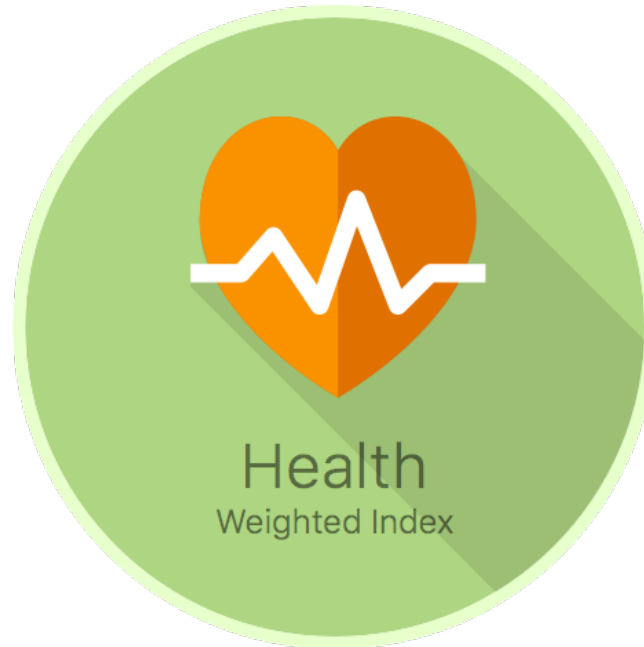
### Industry liaison group

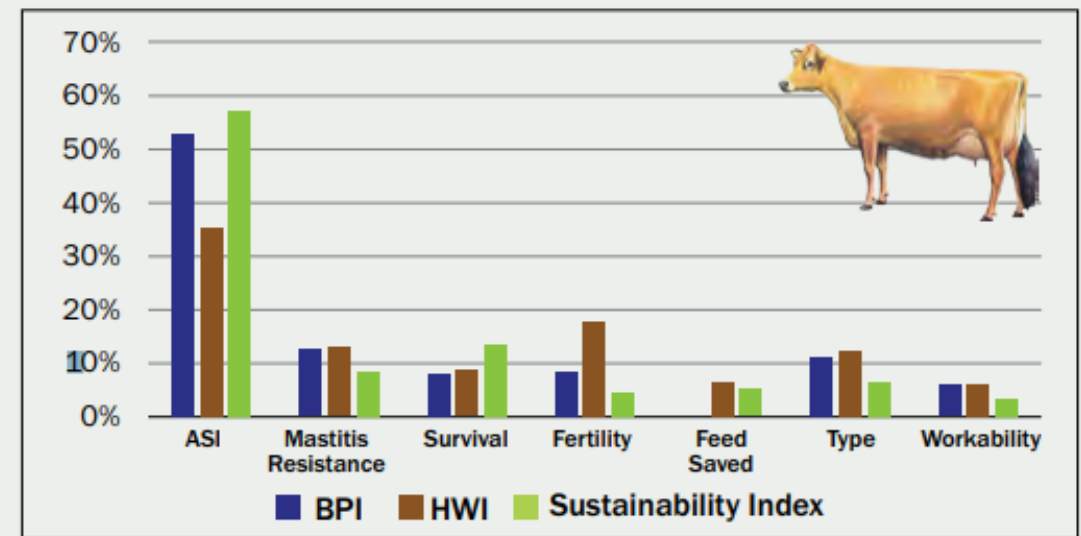
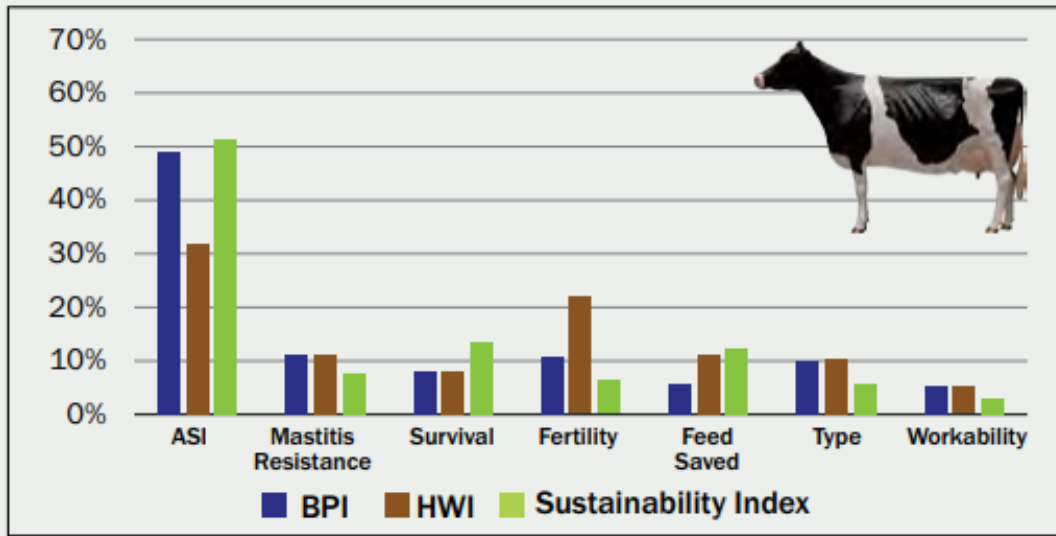
- Michelle Axford
- Andrew Cromie
- Juan Pena
- Sijne Van Beek
- Marco Winters








# Australia's breeding indices

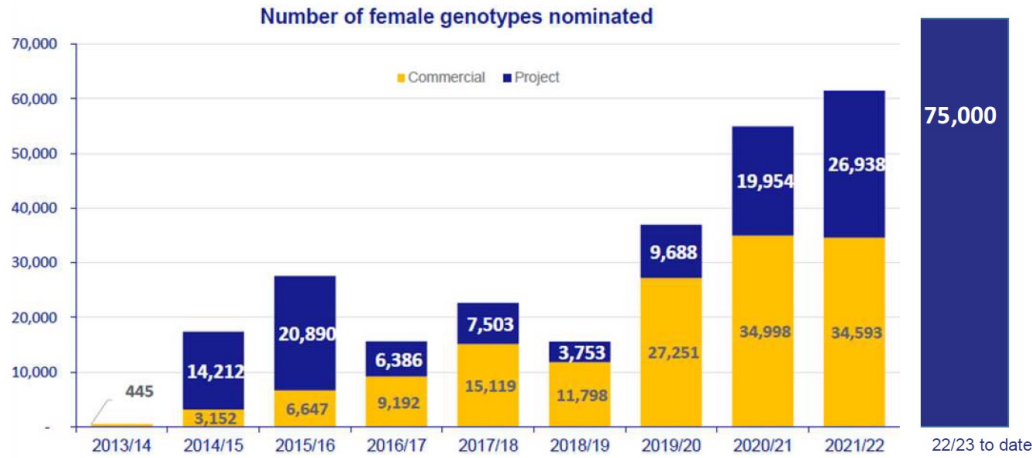




<p><b>Balanced Performance Index (BPI)</b></p>  <p>\$</p>	<p><b>Health Weighted Index (HWI)</b></p>  <p>Index units</p>	<p><b>Sustainability Index (SI)</b></p>  <p>Index units</p>
<p><b>Eg. BPI of 300</b> On average this animal returns \$300/year more income over feed/herd costs. The average is 0.</p>	<p><b>Eg. HWI of 280</b> This animal is 280 units greater for the desired objective than average. The Average is 0.</p>	<p><b>Eg. Sustainability Index of 250</b> This animal is 250 units more efficient for emissions intensity than average. The average is 0.</p>



# Metrics

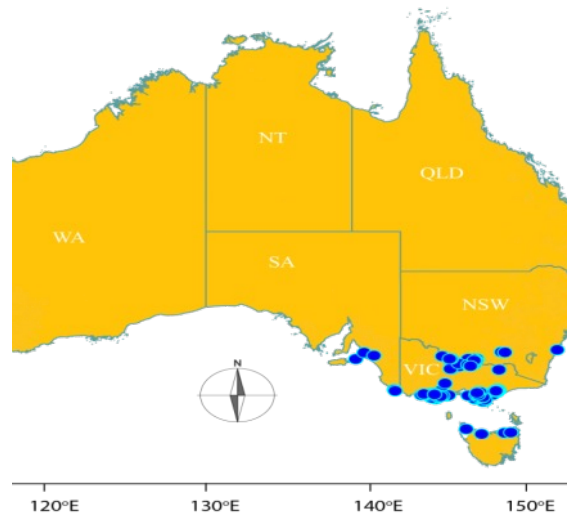


**Do you have excellent herd records?**

DataGene is recruiting herds for the Ginfo project\*

Participating farmers have their 2-year-old heifers genotyped and classified for free and the option to have young calves genotyped at a discount.

To be eligible, herds need to be regularly herd testing and



Research herds  
1000s cows

Feed saved

methane

New..

Ginfo  
150 Aussie herds

Health

Heat tolerance

New...

# How to increase genomic reliability



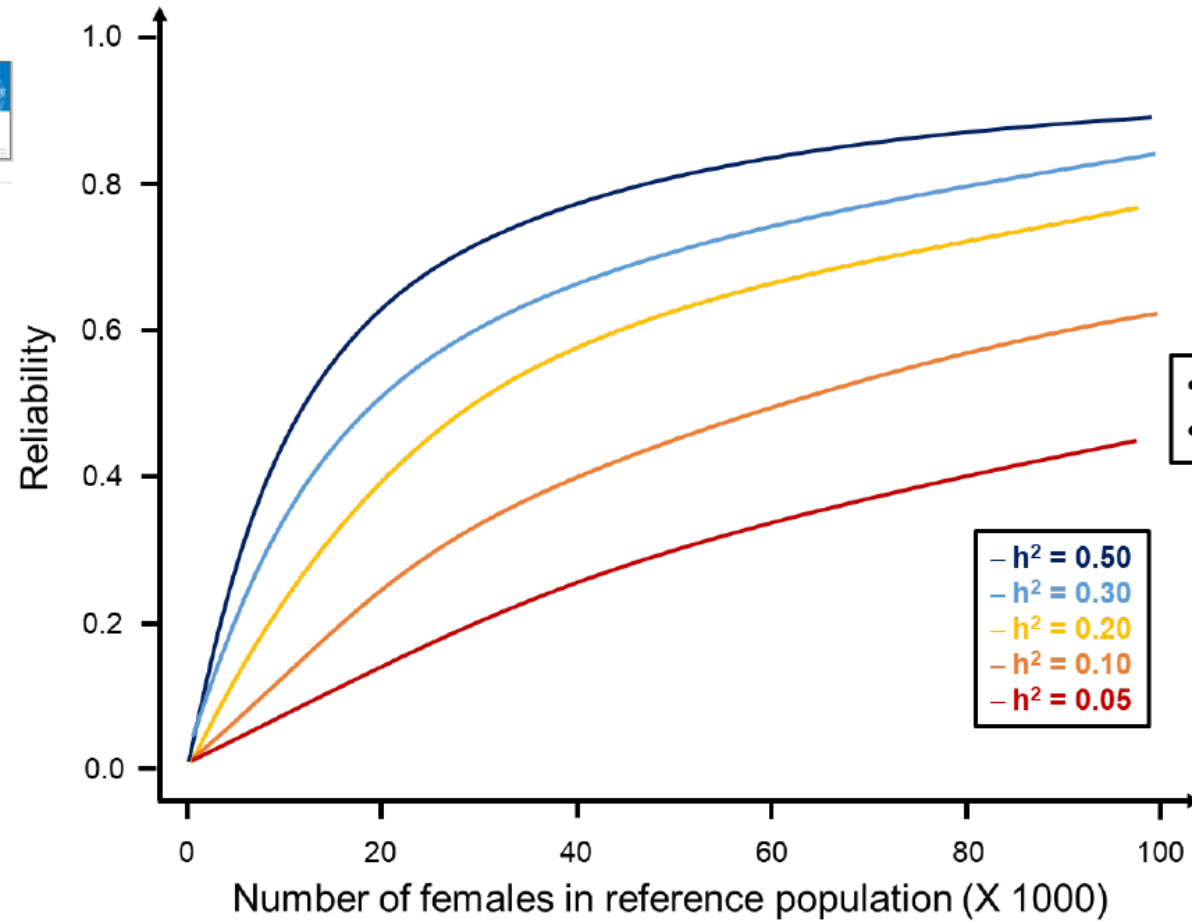
Journal of Dairy Science

Volume 97, Issue 12, December 2014, Pages 7905-7915



On the value of the phenotypes in the genomic era

O. Gonzalez-Recio <sup>\*</sup>, M.P. Coffey <sup>†</sup>, J.E. Pryce <sup>\*</sup>, <sup>‡</sup>, <sup>§</sup>, <sup>¶</sup>

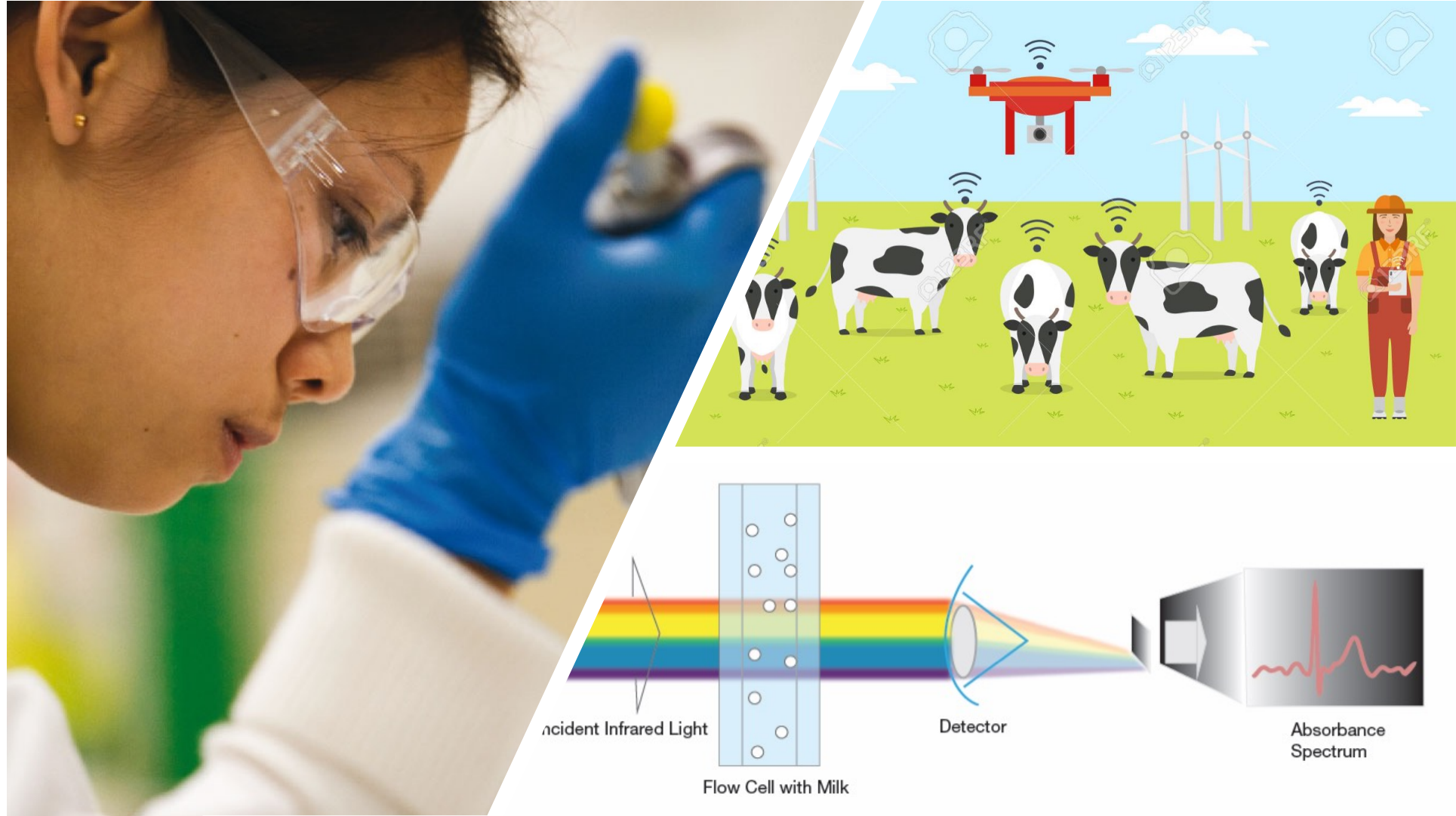


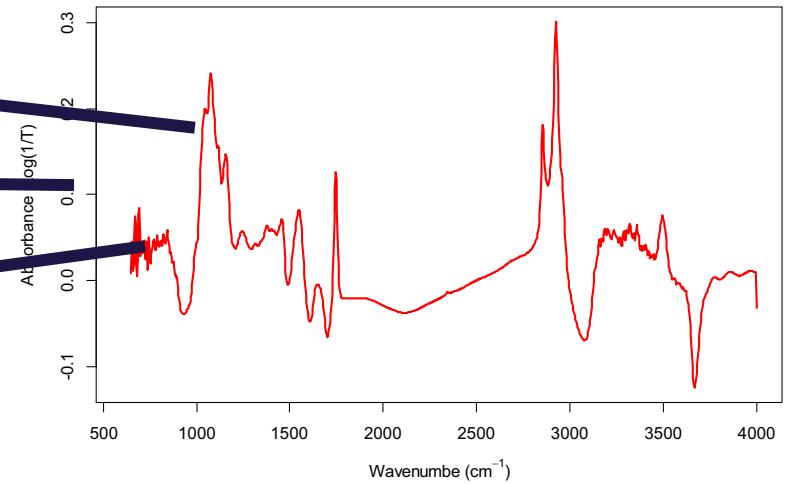
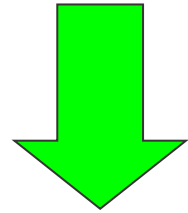
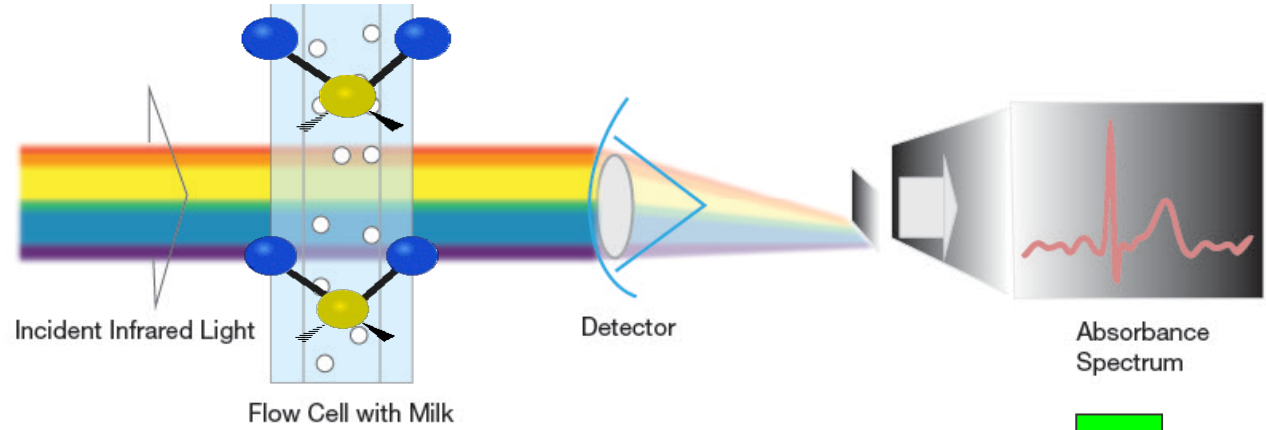
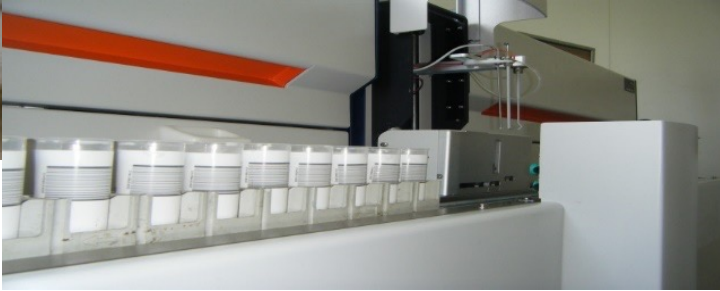
- Refined Trait Def.
- ID Functional Var.

- More Samples
- MIR-Predicted Phenotypes
- International Collaboration

OFFICIAL







**Fat%, Protein%, Lactose% etc**

**Fatty acids**

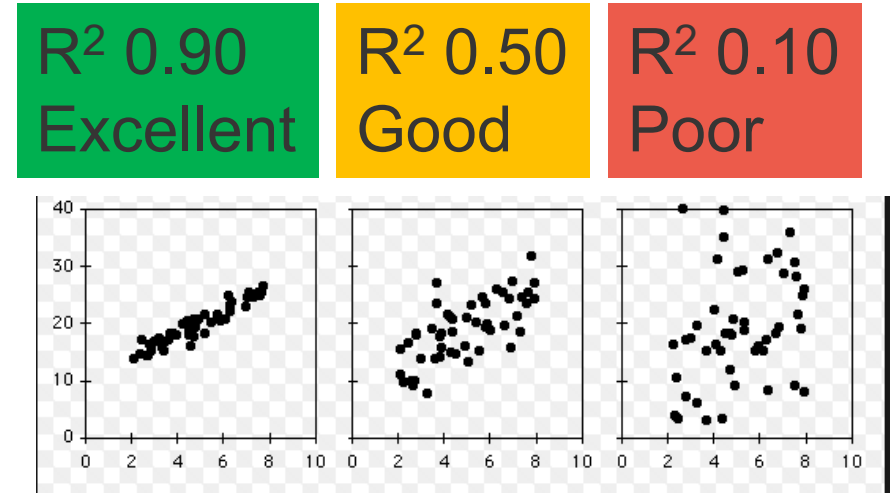
**Animal health and fertility**

**Feed efficiency, methane emissions etc**

# R<sup>2</sup> of prediction models

	R <sup>2</sup> (Australia)*	R <sup>2</sup> (other studies)
Residual Feed Intake (kg/d)	0.30 (alright)	0.28 – 0.38
Energy Balance (MJ/d)	0.48 (good)	0.64
CH <sub>4</sub> production (g/d)	0.30 (alright)	0.21-0.77
CH <sub>4</sub> intensity (g/kgMY)	0.38 (alright)	0.63 – 0.72
CH <sub>4</sub> yield (g/kgDMI)	0.58 (good)	0.38-0.49

\*Methane and feed intake: 240 cows from Ellinbank  
SmartFarm measured over 32 days



**Sustainability** – increasing demand for quality food in line with population expansion

**Importance** - agriculture accounts for around 4% of global GDP

**Animal products** - increasing criticism on societal issues (environment, welfare etc)

**Global warming** – pro-active and re-active

**Training** – next generation for our industry





- Dairy breeding programs have improved feed efficiency over many years
  - Improving production per unit of liveweight
  - Improving the efficiency of production for cow maintenance and production requirements (residual feed intake)
- For no additional cost or effort farmers can breed a herd that uses feed more efficiently.
- The Feed Saved ABV identifies animals that produce the same amount of milk with improved maintenance and efficiency of feed use
- Many countries in the world now using “Feed Saved” or similar
  - First released in Australia in 2015 (updated in Nov 2020)
  - A lot of international collaboration
  - Selection for Australian national index (BPI) will lead to improved feed efficiency, profitability, sustainability and improved fertility/health
- Measuring feed intake on scale challenging (especially grazing)
  - Sensors
  - MIR promising to multiply up phenotypes for genomic selection

Thank you and any questions?



**Agriculture Victoria staff (Ellinbank)  
And international collaborators**



**Agriculture Victoria staff (Agribio)**



# Ginfo



"Ginfo is a great tool for the entire dairy industry by providing the latest genetic information and adding to genetic reliability. At an individual farm level, Ginfo means you have genetic accuracy because of genomic testing, and the ability to make informed selection decisions because of the access to early genomics on young heifers. There are a lot of really good farmers involved in the Ginfo project so it also gives participants access a great network of progressive farmers."  
- Sam McCluggage Allansford, Victoria, milking 700 Holsteins.



"My herd is now a better, stronger and a lot more consistent herd today than it would have been were it not for the Ginfo project and the sum of these gains across all herds strengthens our whole industry.... Contributing my data to help validate the science and technology was not any inconvenience as we were already had good systems of recordkeeping of herd events and were herd testing monthly. Ginfo is about speeding up herd improvement and this has been a win-win; I would thoroughly recommend it."  
- Ruth McGregor, Busselton, WA, milking 320 Holsteins.



"Ginfo has benefits for the broader dairy industry as well as the individual farm so I can't understand why more people aren't involved. The more information you have, the better armed you are to make the right decisions. Ginfo helps us identify which heifers to keep and rear and which ones to sell and then join the best cows to better bulls."  
- Bev Carpenter, South Riana, milking more than 900 Holsteins across two herds.



"Anthea and I believe in the importance of an Australian Herd Improvement Industry and that genetic growth creates profit, so it is easy to be involved with something as important as Ginfo. One of the big advantages for us comes in the form of subsidized genome testing of our young stock. We genome test all our calves and use this information to help build our business strategy."  
- Trevor Saunders and Anthea Day, Shady Creek, Gippsland, milking 750 predominantly Jersey.





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