Economic Development, Jobs, Transport and Resources

# Implementation of genomic selection for heat tolerance

T.T.T. Nguyen, J.E. Pryce et al

DairyBio

Dairy Australia
Your Levy at Work

GARDINER FOUNDATION

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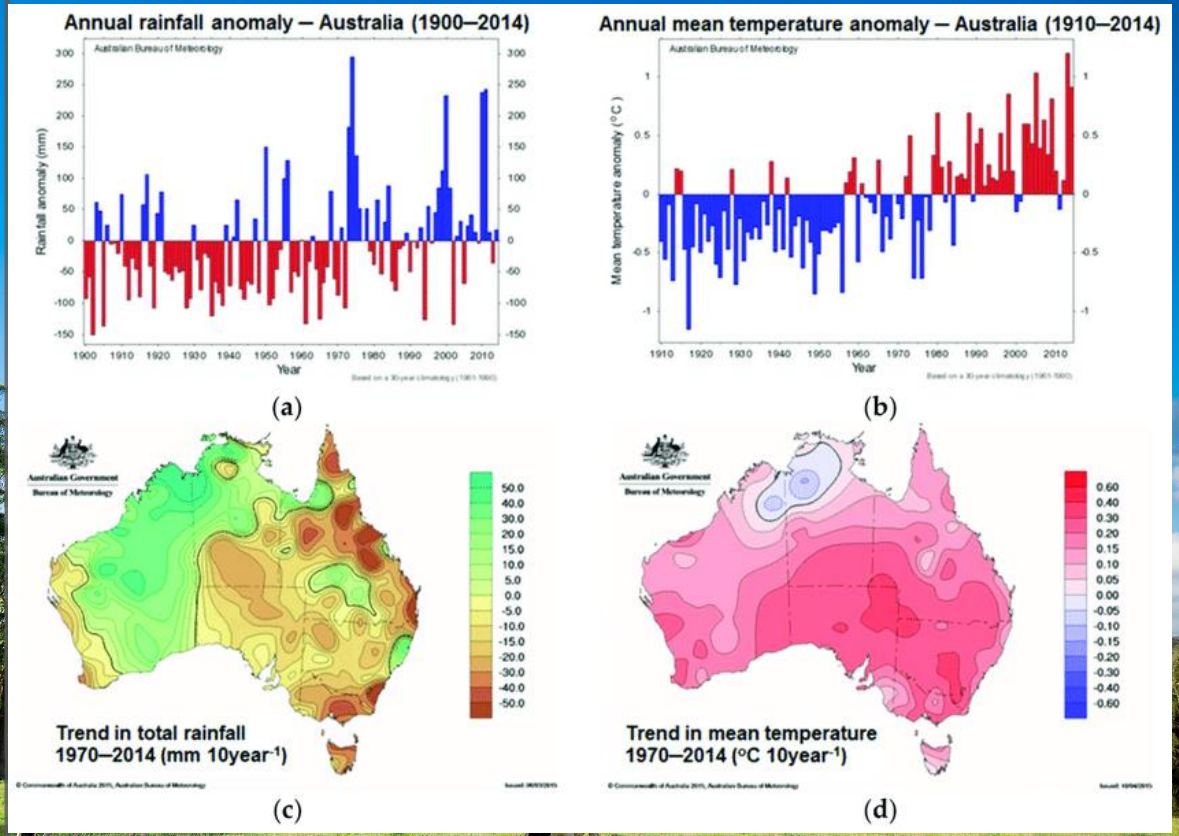
# Source: BOM Long-term annual precipitation (a) and mean temperature (b) over Australia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# CLIMATE CHANGE IN AUSTRALIA

## PROJECTIONS FOR AUSTRALIA'S NRM REGIONS

2090

2030

0.5-1.2°C above 1986-2005

2.7 to 4.2 °C (high emissions)

1.2-2.1 (intermediate)

Victorian Agriculture Minister Jaclyn Symes who announced additional government support for northern dairy farmers affected by drought. Picture: Yuri Kouzmin

DAIRY

# $2.7m drought package to help northern Victoria dairy farmers

ALEX SINNOTT, The Weekly Times
May 31, 2019 4:43pm

A NEW $2.7 million drought package was opened up for northern Victoria by the State Government today.

Victorian Agriculture Minister Jaclyn Symes announced the additional






Milk drop: Dairy Australia's panel of executives answer questions at the first inaugural Murray Muster.

DAIRY

# National milk production predicted to fall to 8.2 billion litres

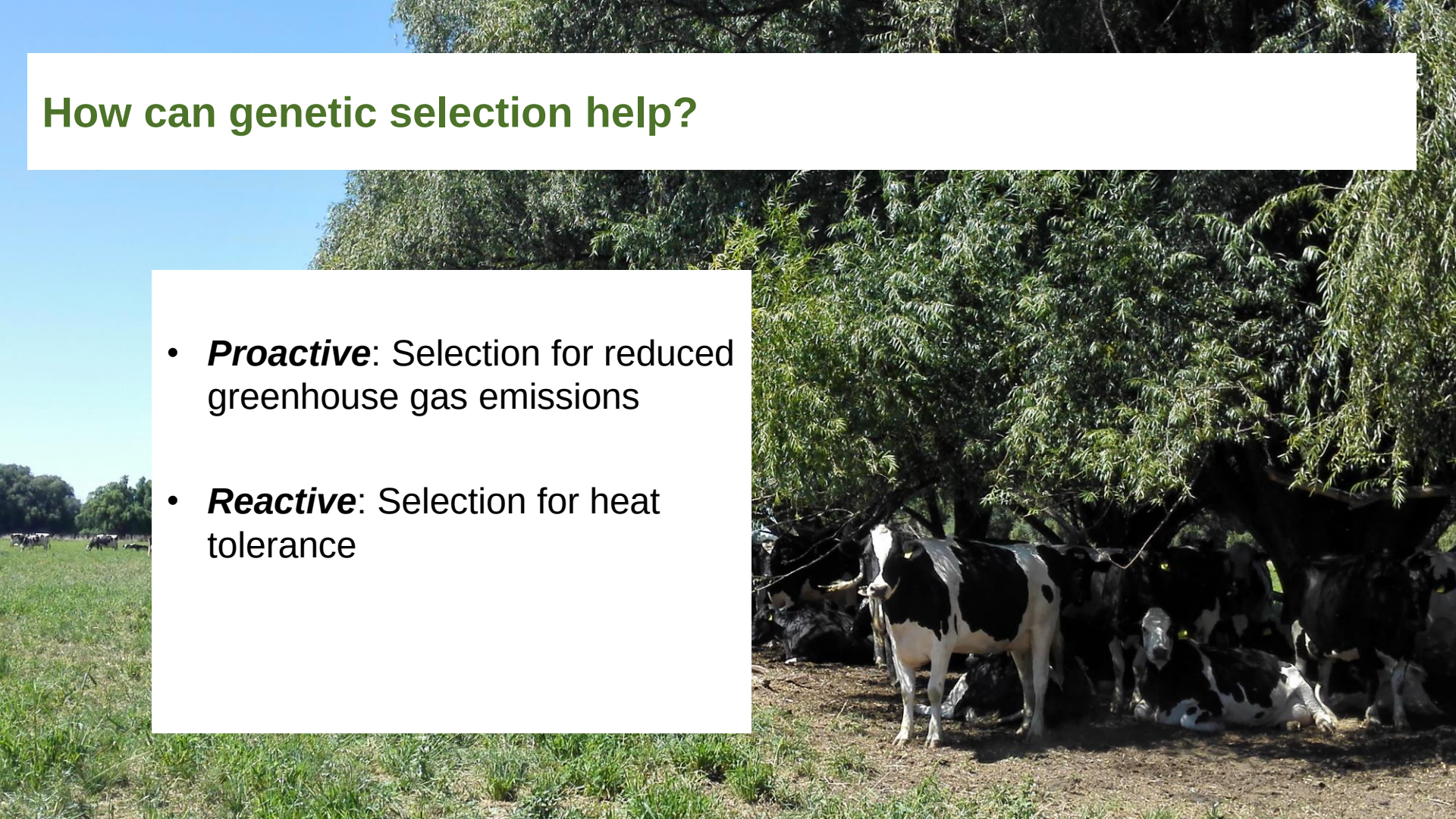
PETRA OATES, The Weekly Times
May 29, 2019 12:00am
Subscriber only

NATIONAL milk production could fall as low as 8.2 billion litres next season.

Dairy Australia
Cool Cows
Your Levy at Work

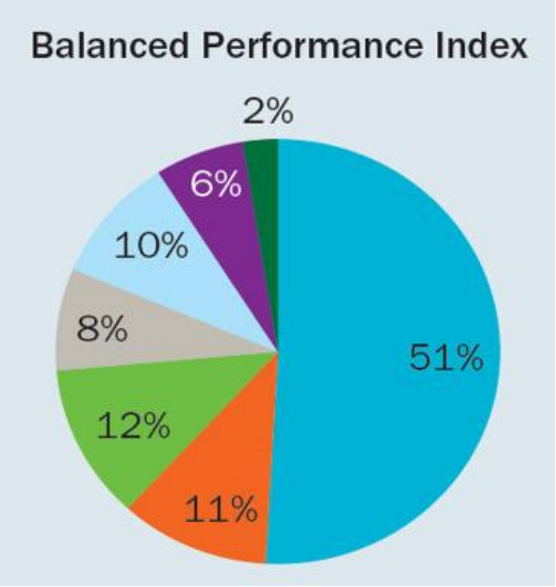
# How can genetic selection help?

- ***Proactive***: Selection for reduced greenhouse gas emissions
- ***Reactive***: Selection for heat tolerance



# Selecting for reduced methane emissions

- Dairy cattle account for ~12% of national agricultural GHG emissions in Australia
- Selecting on Australia's national index (BPI):
  - Higher yields, so fewer cows required to produce the same amount of milk
  - Feed Saved EBV leads to cows that are more efficient
  - Fertility and survival means fewer replacements required




CSIRO PUBLISHING

*Animal Production Science*, 2017, 57, 1451–1456
http://dx.doi.org/10.1071/AN16510

**The impact of genetic selection on greenhouse-gas emissions in Australian dairy cattle**

*Jennie E. Pryce*[A,B,D] *and Matthew J. Bell*[C]

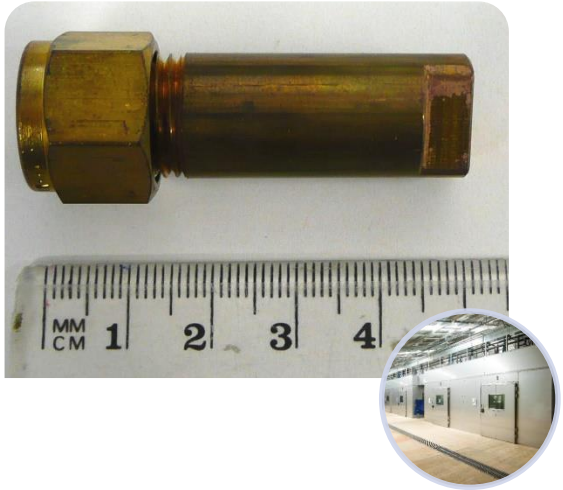
[A]Agriculture Victoria, AgriBio, Centre for AgriBioscience, Bundoora, Vic. 3083, Australia.
[B]School of Applied Systems Biology, La Trobe University, Bundoora, Vic. 3083, Australia.
[C]The University of Nottingham, School of Biosciences, Sutton Bonington Campus, Loughborough, LE12 5RD, UK.
[D]Corresponding author. Email: jennie.pryce@ecodev.vic.gov.au

## Ellinbank research farm

- 32 individual feeding stalls
- 16 metabolism stalls
- 6 climate controlled calorimeters
- 30 auto feeders
- $SF_6$ to measure methane at grazing

# Measure methane emissions of 480 lactating cows

- Feed intake, milk yield
- 480 cows with $CH_4$ emissions measured
- Ruminal fluid, faecal, milk, blood sampling for microbiome and gene expression analyses
- Milk MIR spectral analyses




Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

A modified sulphur hexafluoride tracer technique enables accurate determination of enteric methane emissions from ruminants

Matthew H. Deighton[a,b,*], S. Richard O. Williams[a], Murray C. Hannah[a], Richard J. Eckard[b], Tommy M. Boland[c], William J. Wales[b], Peter J. Moate[b]

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# Developing genomic breeding values for methane

- Enteric $CH_4$ production is heritable
  - Gross emissions ~0.1
  - Methane yield/intensity ~0.3
- Sharing phenotypes internationally
- Towards developing GEBVs

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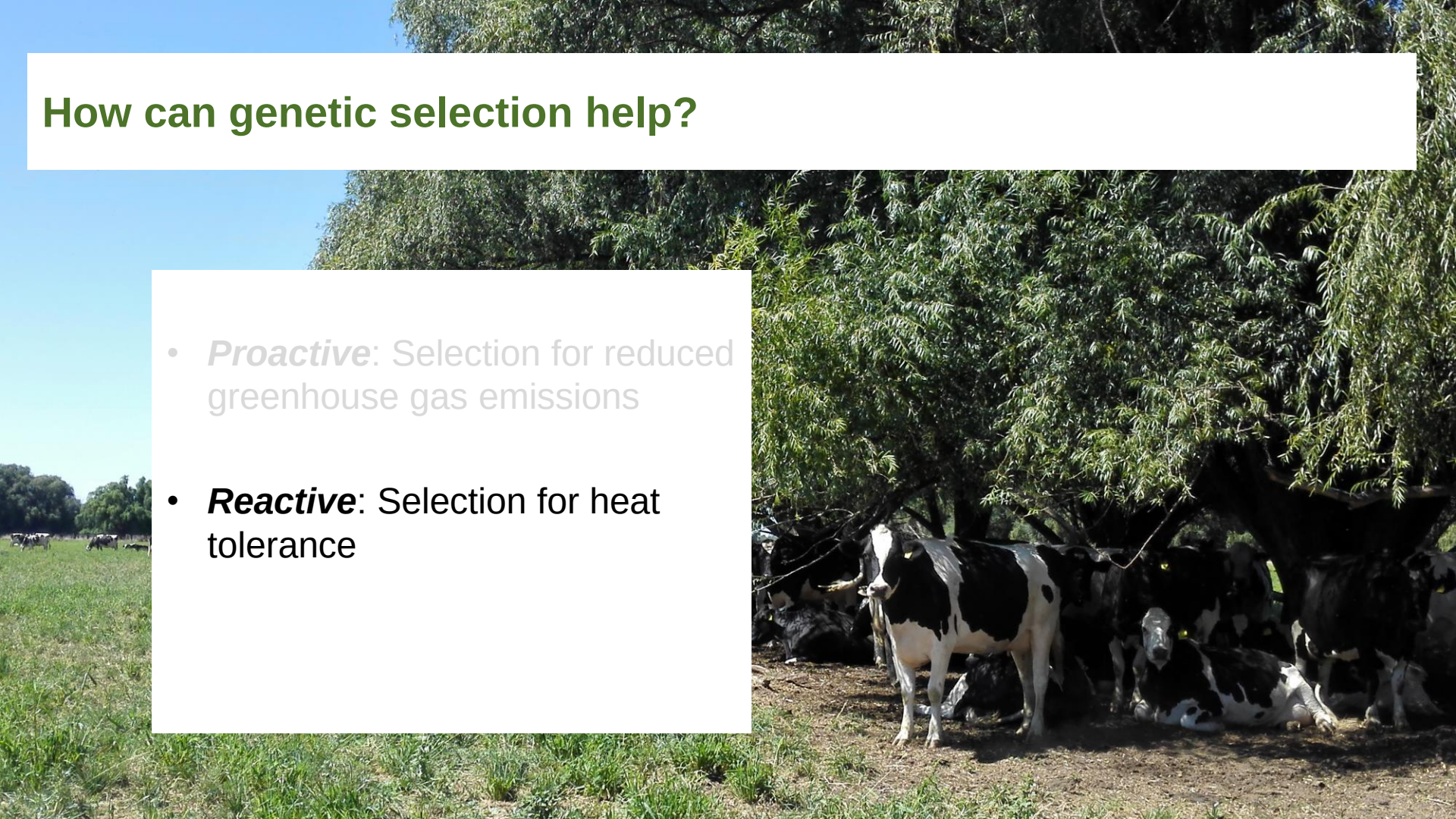
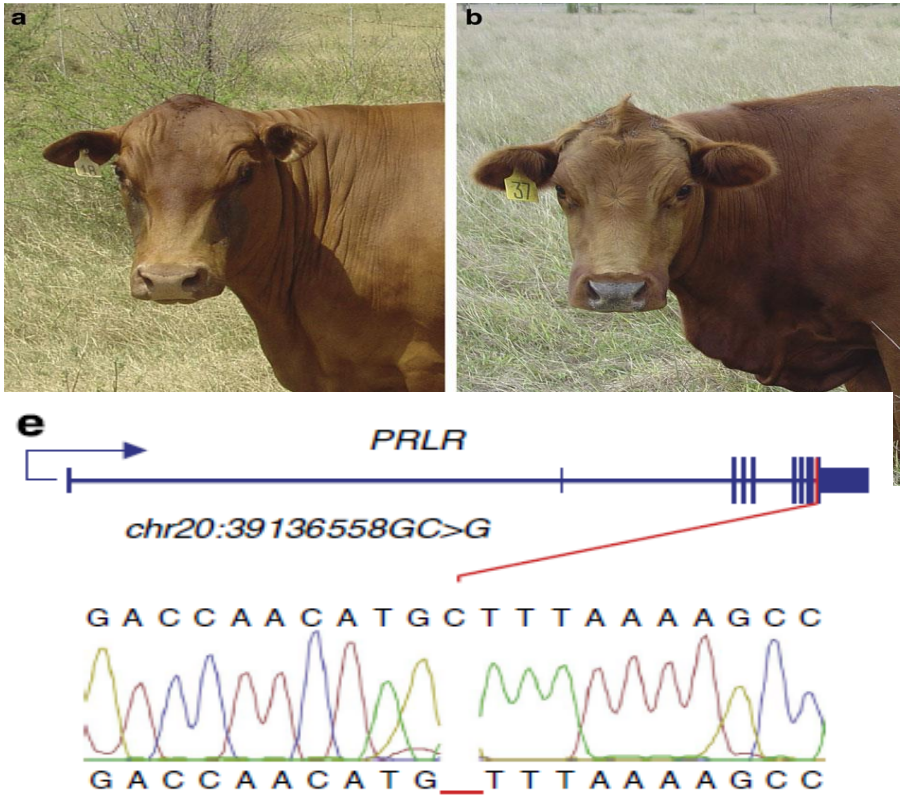
# How can genetic selection help?

- ***Proactive***: Selection for reduced greenhouse gas emissions
- ***Reactive***: Selection for heat tolerance



# Use adapted breeds

- Senepol cattle – heat tolerant *Bos taurus* with slick coat
- Mutation in prolactin receptor (SLICK)
  - Littlejohn et al. 2014, Nat Comms, 5:5861
- Introgressed into Holsteins – reduced drop in milk production in summer
  - Dikmen et al. J Dairy Sci. 2014 97:5508.
- Gene editing target



# How cows react to hot conditions:

- Seek shade
- Panting
- Find water
- Eat less
- Reduce yield

AGRICULTURE VICTORIA

Journal of Dairy Science
Volume 92, Issue 8, August 2009, Pages 4035-4045

Research-article

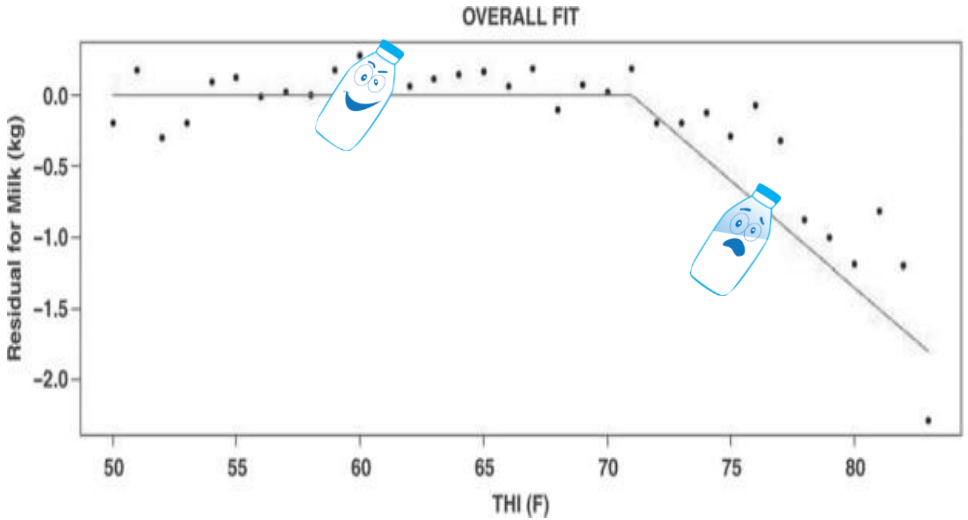
# Genetic determination of the onset of heat stress on daily milk production in the US Holstein cattle

J.P. Sánchez *, I. Misztal †, I. Aguilar †, ‡, B. Zumbach §, R. Rekaya †

Show more

https://doi.org/10.3168/jds.2008-1626



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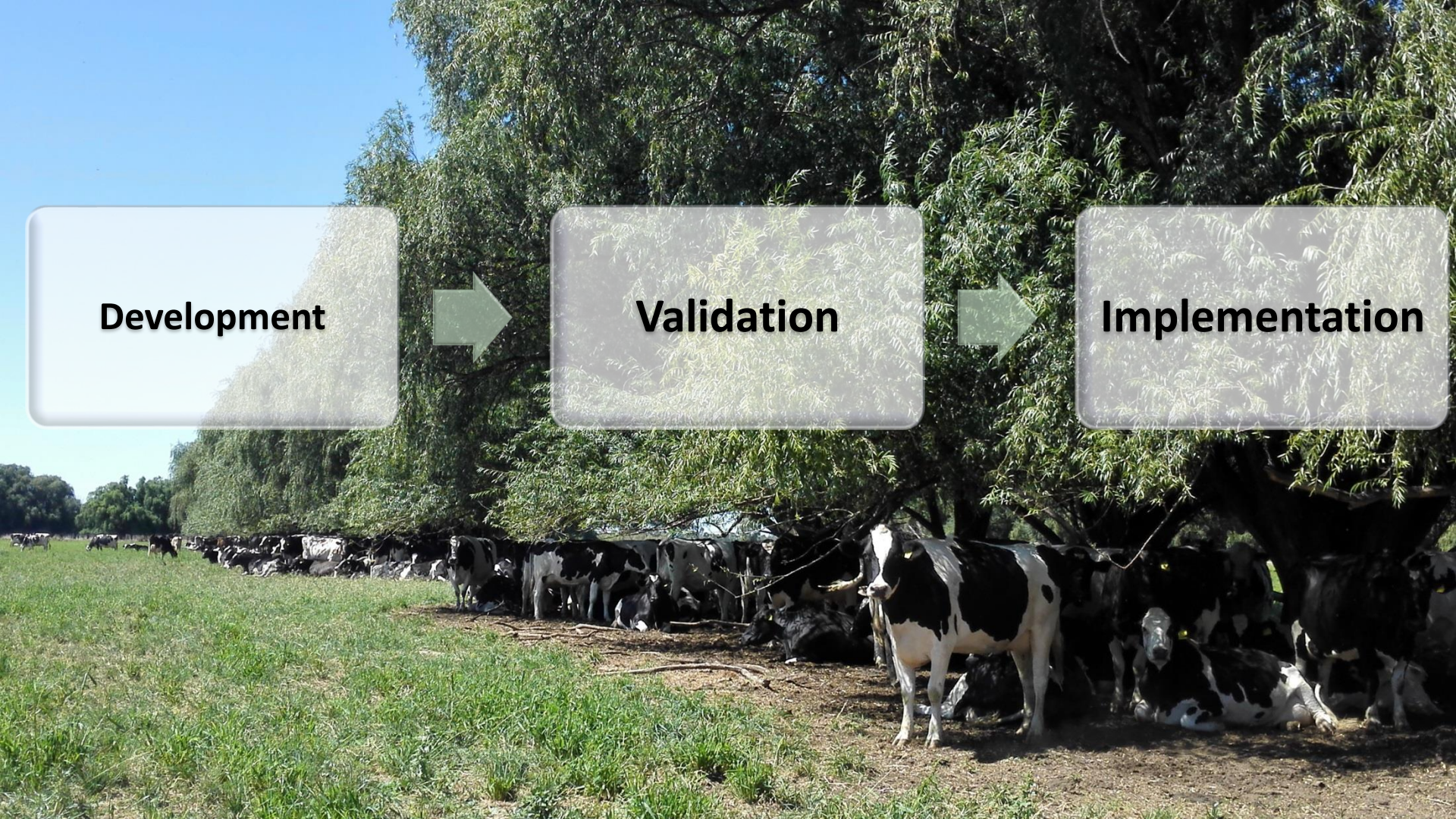
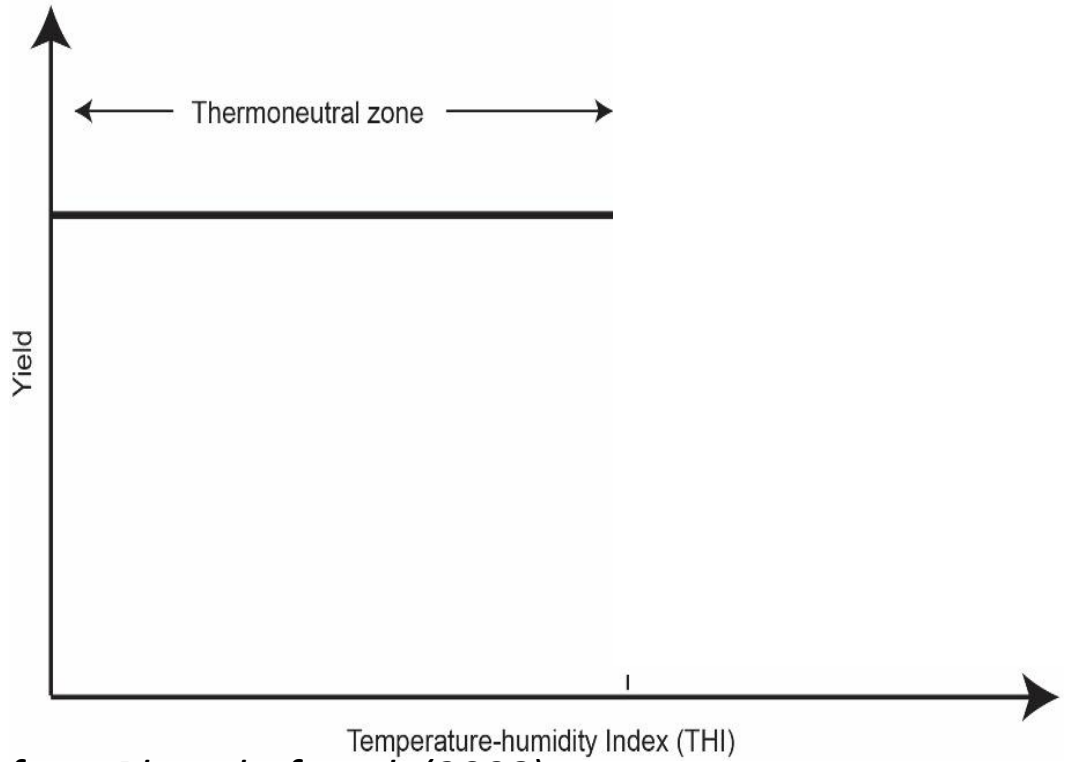

Development
Validation
Implementation

# Defining heat tolerance




THI threshold (60) is equivalent to
20°C (68°F) at 45% relative humidity

*Adapted from Bloemhof et al. (2008)*

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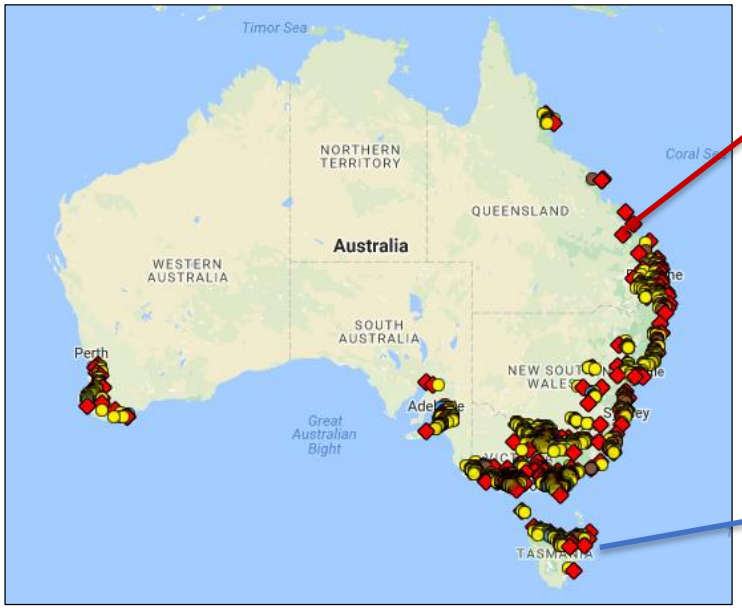
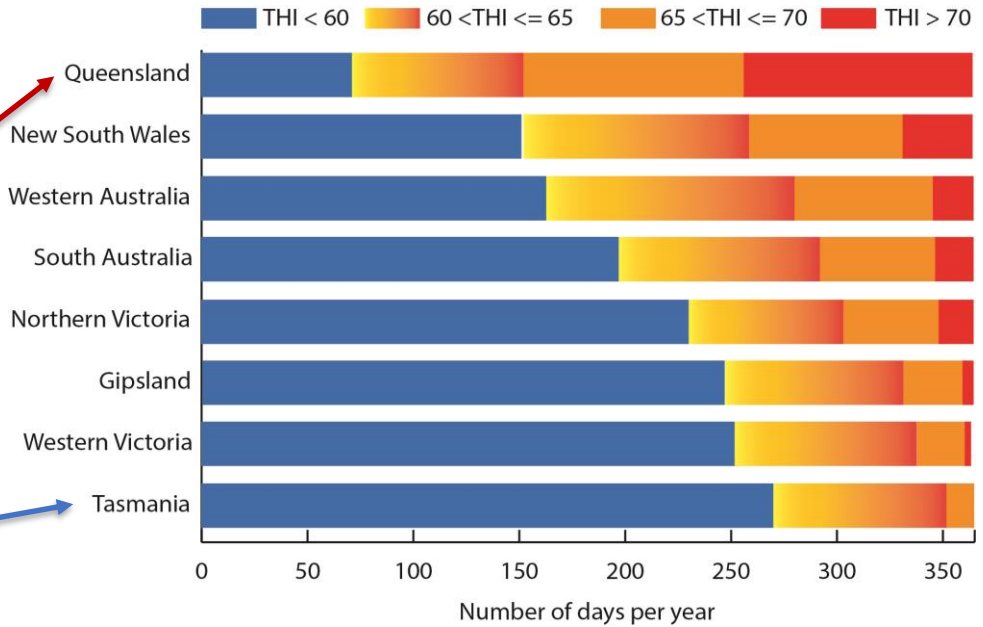
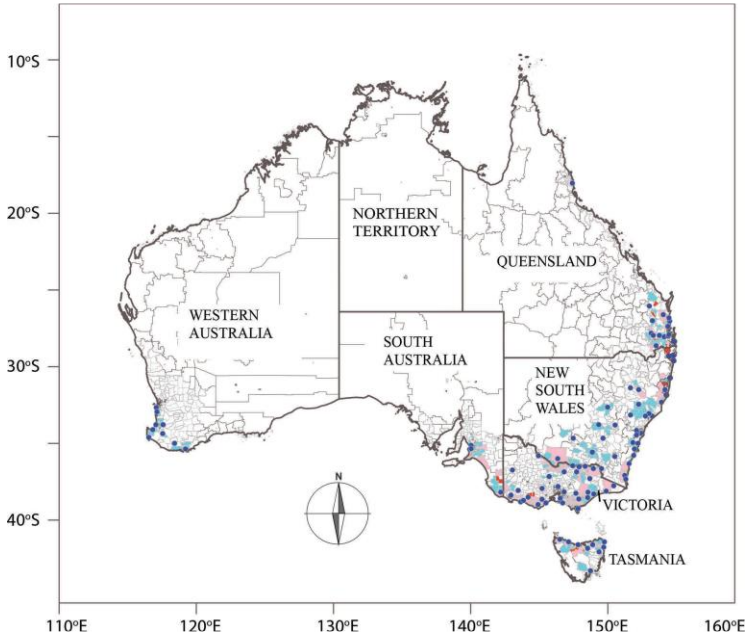

Timor Sea
NORTHERN TERRITORY
QUEENSLAND
Australia
WESTERN AUSTRALIA
SOUTH AUSTRALIA
Perth
Great Australian Bight
TASMANIA


THI < 60
60 <THI <= 65
65 <THI <= 70
THI > 70
Queensland
New South Wales
Western Australia
South Australia
Northern Victoria
Gipsland
Western Victoria
Tasmania
0
50
100
150
200
250
300
350
Number of days per year

# Heritabilities

| Trait affected by heat stress | Holstein | Jersey |
|---|---|---|
| Milk yield | 0.22 | 0.33 |
| Fat yield | 0.20 | 0.26 |
| Protein yield | 0.23 | 0.27 |




J. Dairy Sci. 99:2849–2862
http://dx.doi.org/10.3168/jds.2015-9685


**Genomic selection for tolerance to heat stress in Australian dairy cattle**

**Thuy T. T. Nguyen,*[1] Phil J. Bowman,* Mekonnen Haile-Mariam,* Jennie E. Pryce,*† and Benjamin J. Hayes*†**
*BioSciences Research Division, Department of Economic Developments, Jobs, Transport and Resources, and Dairy Futures Cooperative Research Centre, Agribio, 5 Ring Road, Bundoora, Victoria 3083, Australia
†La Trobe University, Bundoora, Victoria 3083, Australia

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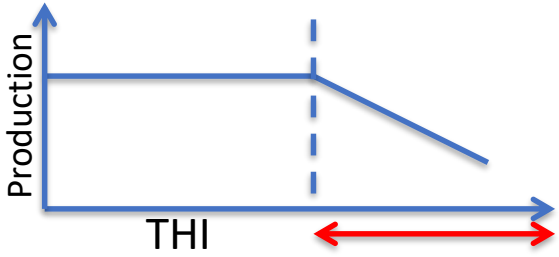
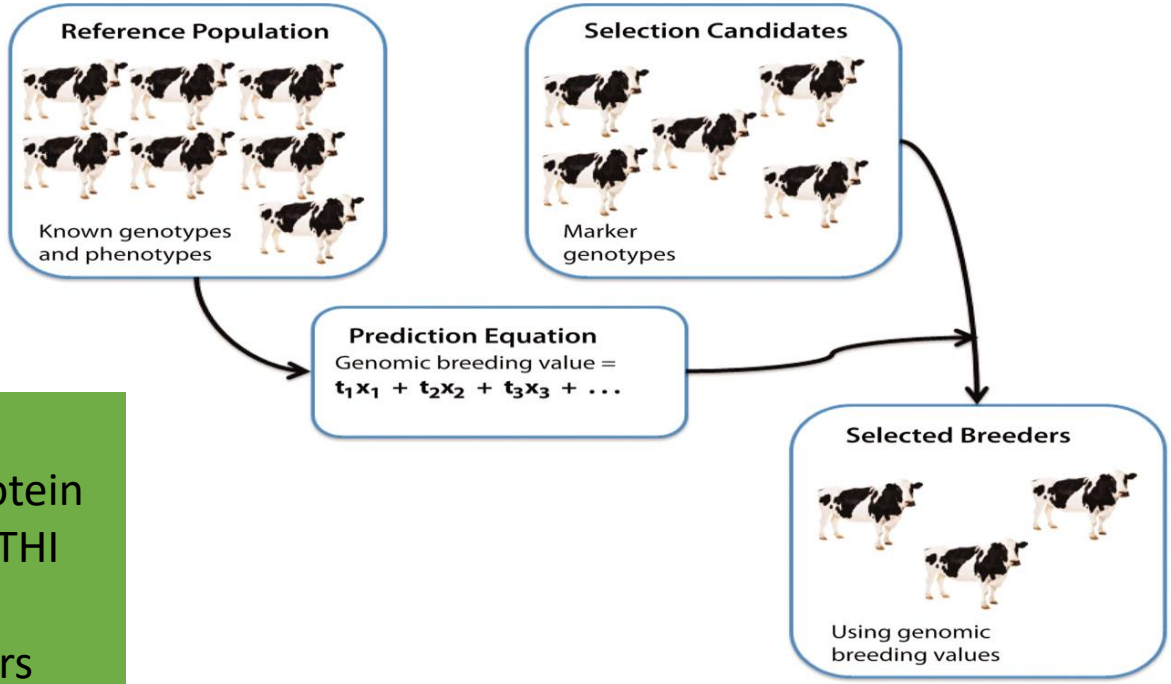
# Genomic Selection




Estimated cow slopes

Decline in milk, fat and protein yields per unit increase in THI

Sire slope = average of daughters

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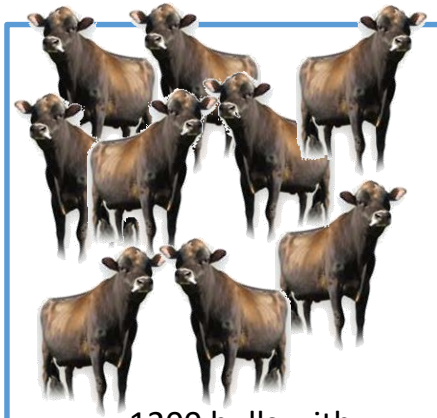
# Reliabilities

| Breed | GEBV for heat tolerance | Reliability (%) of genomic EBV |
|---|---|---|
| Holstein | Milk | 19 |
| | Fat | 20 |
| | Protein | 26 |
| | | |
| Jersey | Milk | 24 |
| | Fat | 25 |
| | Protein | 27 |

May 2019

6300 bulls with
Australian daughters



1200 bulls with
Australian daughters

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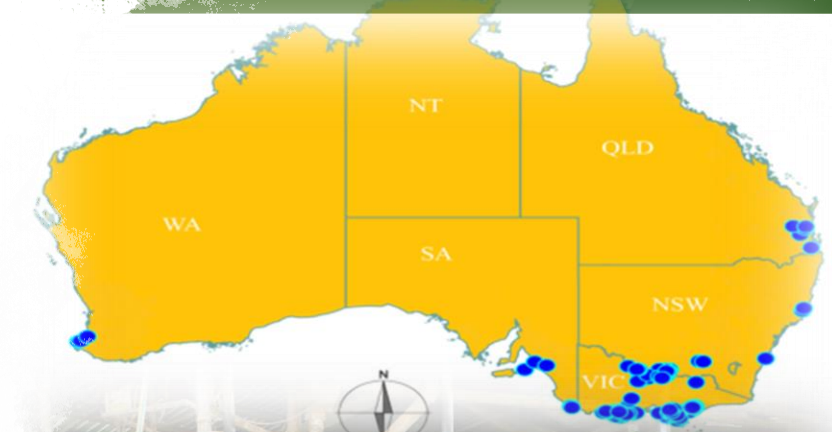
# Ginfo
## 64,636 genotyped

DairyBio

# Genomic Information Nucleus (Ginfo)

- Started in 2013
- >100 farms from across Australia and growing
- Selected for data quality and quantity
- Part of DataGene
- Research invests in Ginfo through genotyping lactating cows

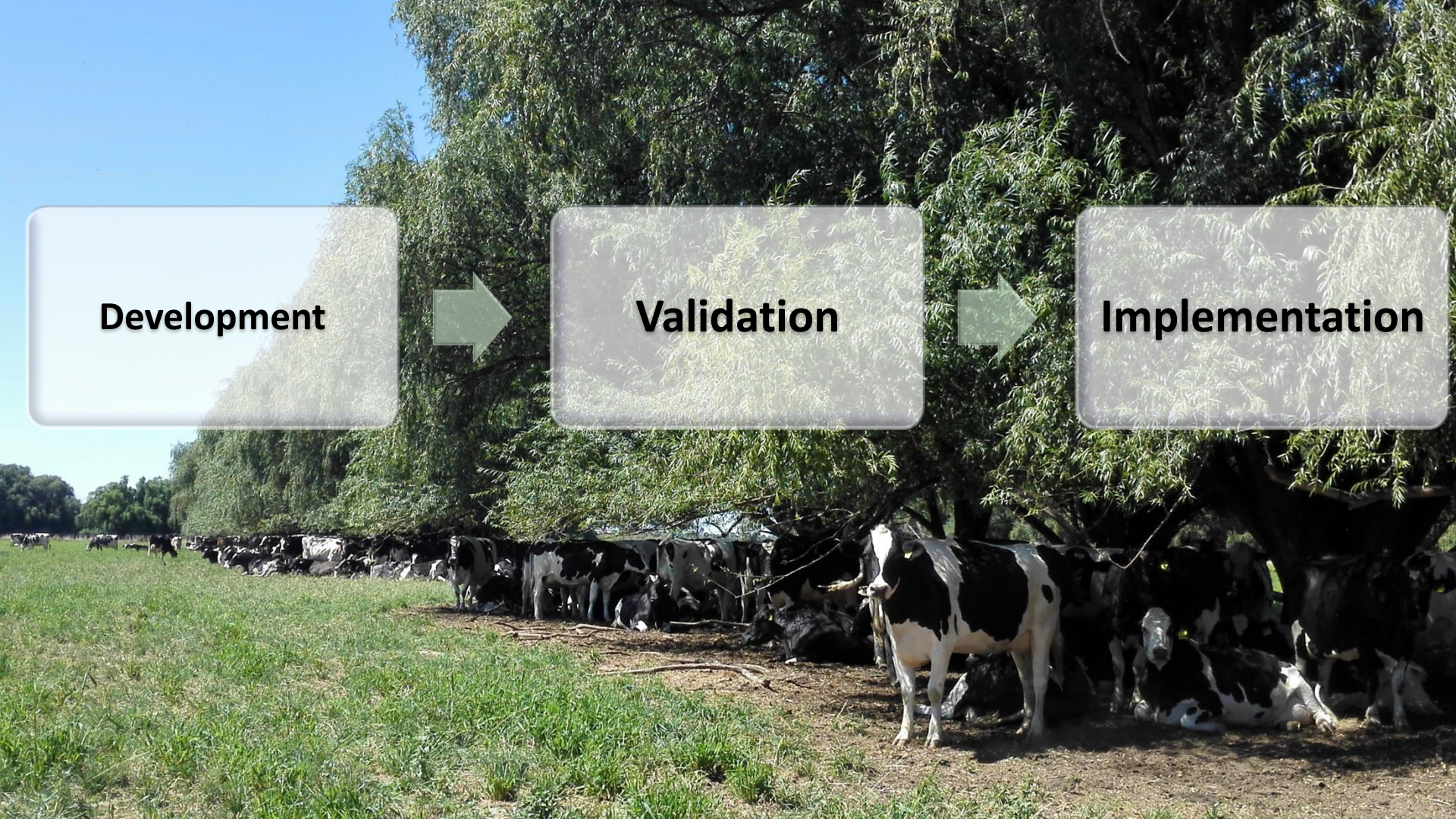



# Ginfo cows improved reliability

| Breed | GEBV for heat tolerance | Without Ginfo Reliability (%) | With Ginfo Reliability (%) |
|---|---|---|---|
| Holstein | Milk | 19 | 42 |
| | Fat | 20 | 40 |
| | Protein | 26 | 38 |
| | | | |
| Jersey | Milk | 24 | 36 |
| | Fat | 25 | 38 |
| | Protein | 27 | 38 |

# Correlations with protein and fertility EBVs

| Breed | GEBV for heat tolerance | Protein yield | Fertility |
|---|---|---|---|
| Holstein | Milk | -0.72 | 0.39 |
| | Fat | -0.43 | 0.38 |
| | Protein | -0.75 | 0.29 |
| | | | |
| Jersey | Milk | -0.75 | 0.27 |
| | Fat | -0.63 | 0.21 |
| | Protein | -0.88 | 0.15 |


Development
Validation
Implementation

# Validation under experimental conditions

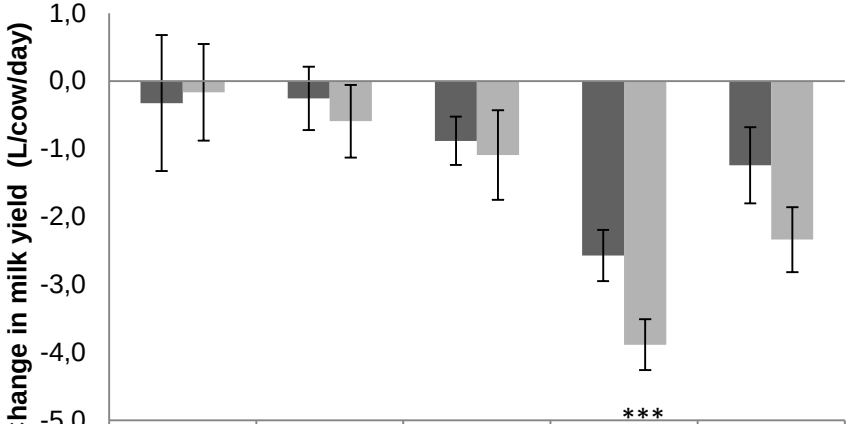
# Validation of heat tolerance breeding value

- 400 heifers evaluated using genomics
- Extreme (24 high, 24 low) for heat tolerance breeding values
- Simulated heat wave event at Ellinbank Research Farm

Garner et al (2016) Scientific Reports

# Heat tolerant cows had a……

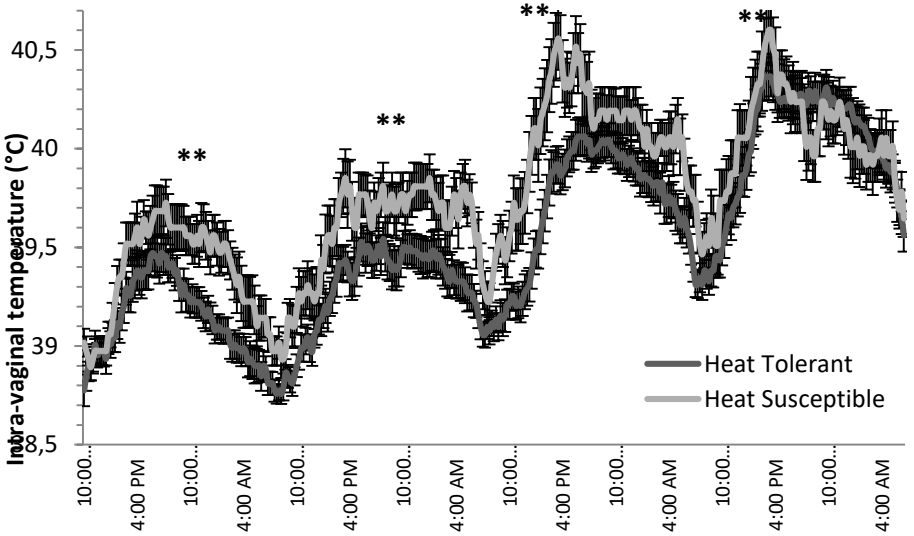
## Smaller decline in milk production

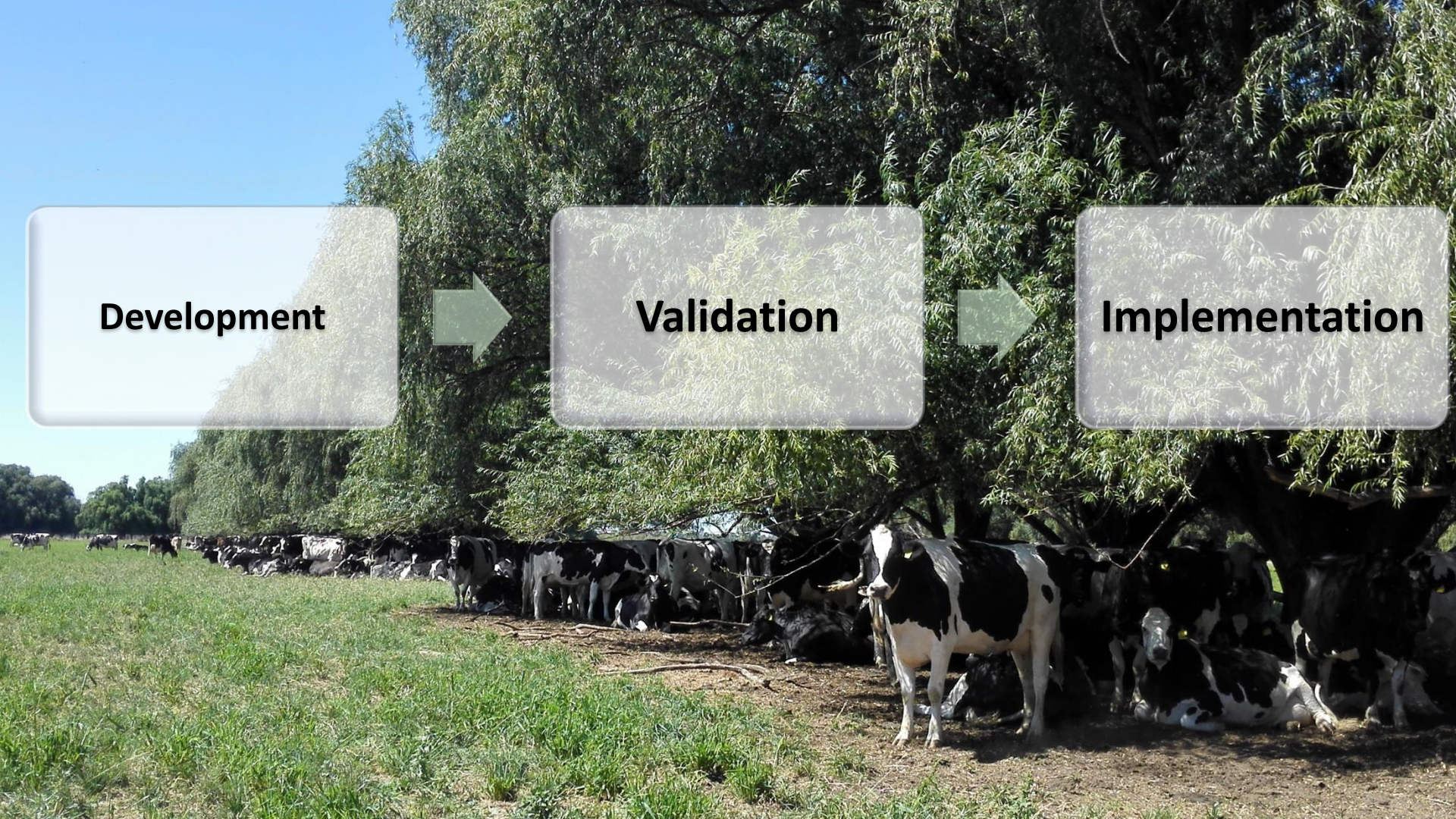



| | Day 1 | Day 2 | Day 3 | Day 4 | Recovery |
|---|---|---|---|---|---|
| HT | -0,3 | -0,3 | -0,9 | -2,6 | -1,2 |
| HS | -0,2 | -0,6 | -1,1 | -3,9 | -2,3 |

Garner et al (2016) Scientific Reports

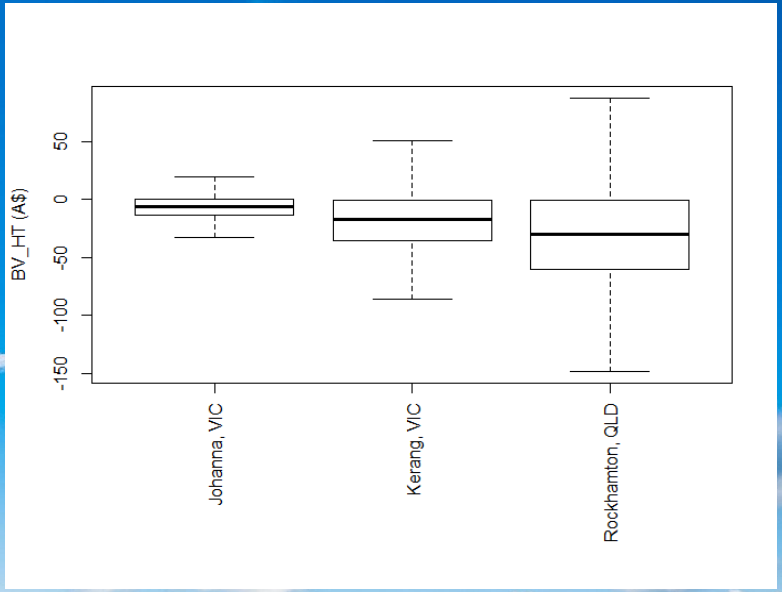
## Lower intra-vaginal temperature




Development
Validation
Implementation

# Expression

- Decline in production ($) per unit increase of THI
- Components $\left( \begin{array}{l} EW_m * GEBV_{HTm} \\ + \\ EW_f * GEBV_{HTf} \\ + \\ EW_p * GEBV_{HTp} \end{array} \right)$


**Variation in 10,981 genomic bulls at different levels of heat load: Low: Johanna, VIC; Moderate: Kerang, VIC; High: Rockhampton, QLD)**

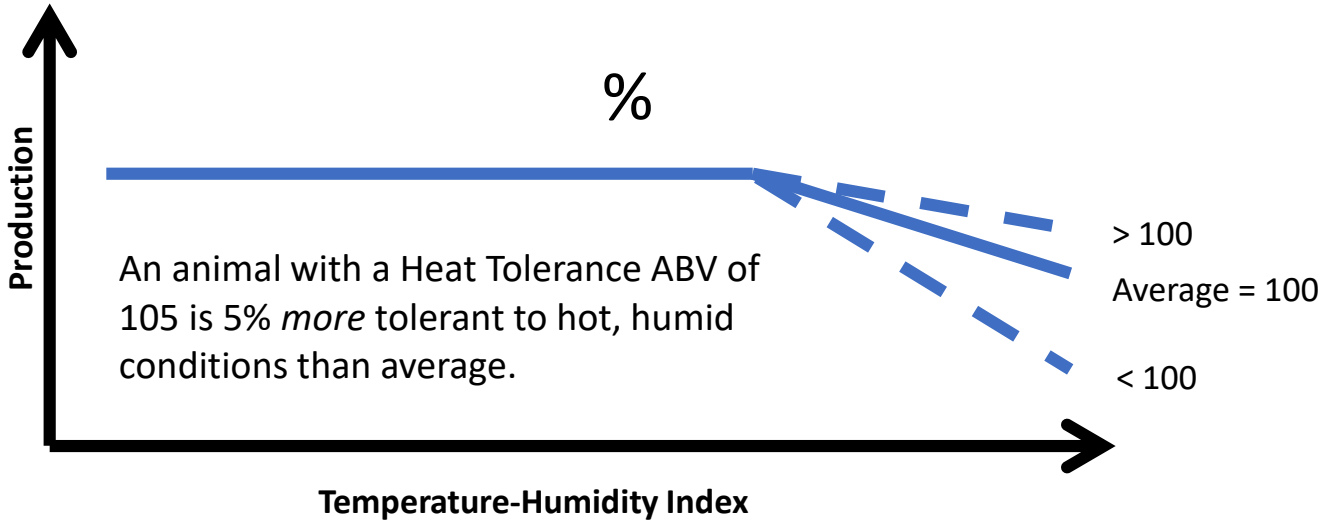
# Expression

- Decline in production ($) per unit increase of THI
- Components

$$\left( \begin{array}{l} EW_m * GEBV_{HTm} \\ + \\ EW_f * GEBV_{HTf} \\ + \\ EW_p * GEBV_{HTp} \end{array} \right)$$

- Standardised to **mean = 100**, **standard deviation = 5**

# Heat tolerance ABVg

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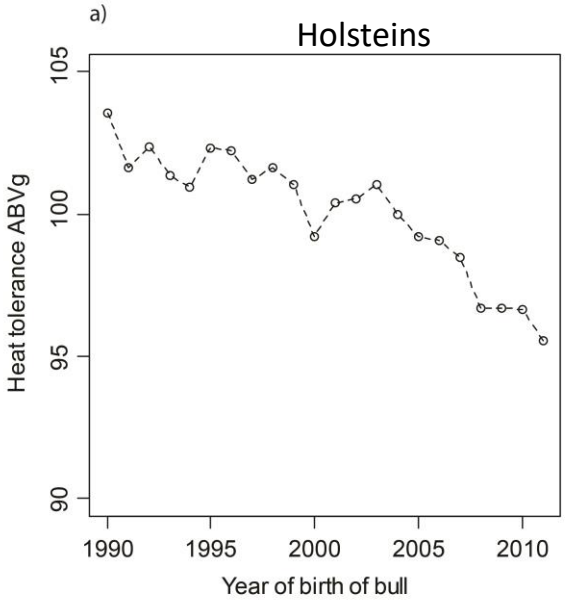
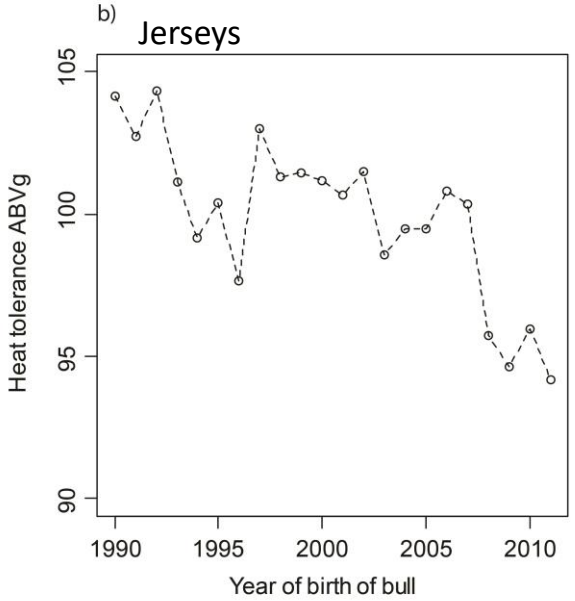
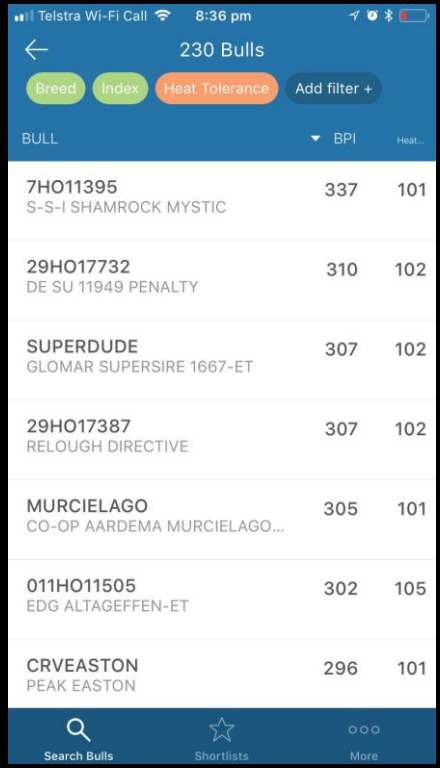
# Genetic trend (decline ~1.5 SD in 20 years)



# Advice to farmers

- Choose bulls from the Good Bulls Guide
- If Heat Tolerance is important, select above average bulls

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# Trevor Parrish, New South Wales

*“Now when I get a list of bulls I’m going to be looking for bulls which combine increased production and increased heat tolerance – they are going to be the ones who buck the trend.”*

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# Shane Gardiner, Mt Gambier South Australia

*“Heat Tolerance is something we can breed in our cows for free so why not? Like all genetic traits, it will be permanent and cumulative.”*

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# Ross Gordon, Cohuna, Victoria

*“If two bulls have the same BPI but one has better heat tolerance than that’s the one we will be selecting”*

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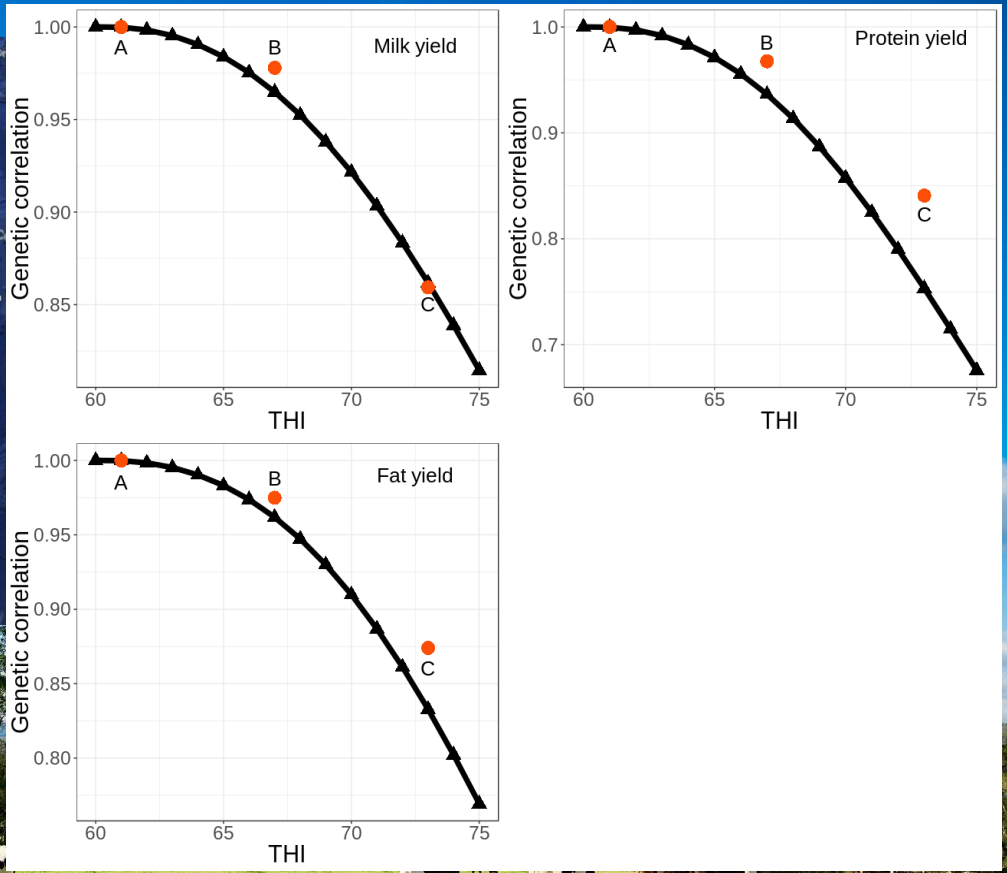
Solutions for Herd Development

# What's next for us….

- Impact of heat stress on fertility
  - Hansen and Arechiga (1999) reported reduced estrous behaviours of heat-stressed dairy cows
  - Evidence that conception rate, oocyte quality and pregnancy loss affected by heat
- Impact of heat stress on health
  - More lameness due to more time spent standing?
- Use of mid-infrared spectral data to predict heat tolerance/resilience
  - Hammami et al (2018)
- Genotype by environment interactions
  - USA: Tiezzi et al (2015)
  - Australia: Haile-Mariam et al (2008); Hayes et al. (2009)


# Variation across regions

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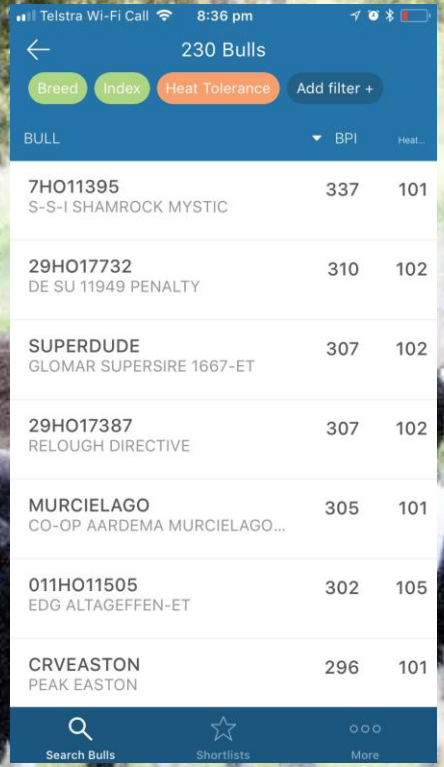
# Key messages

- The Heat Tolerance ABV identifies animals with greater ability to tolerate hot, humid conditions with less impact on milk production
- Released in December 2017
- Validated in research conditions
- The Heat Tolerance ABV is unfavourably correlated with production but there are high Balanced Performance Index bulls that are also above average for Heat Tolerance



Email: jennie.pryce@ecodev.vic.gov.au
Twitter: @jenniepryce

# Thank you!

DataGene
Solutions for Herd Development

# Senior scientist contract position for 6-12mths

Contact: Michelle Axford (maxford@datagene.com.au)

# Expression of heat tolerance EBV

**Decline in $**

- Using economic weight of milk, fat and protein

**Standardise**

- Mean =100
- Standard deviation = 5

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