

Genomic selection for heat tolerance in Australian dairy cattle

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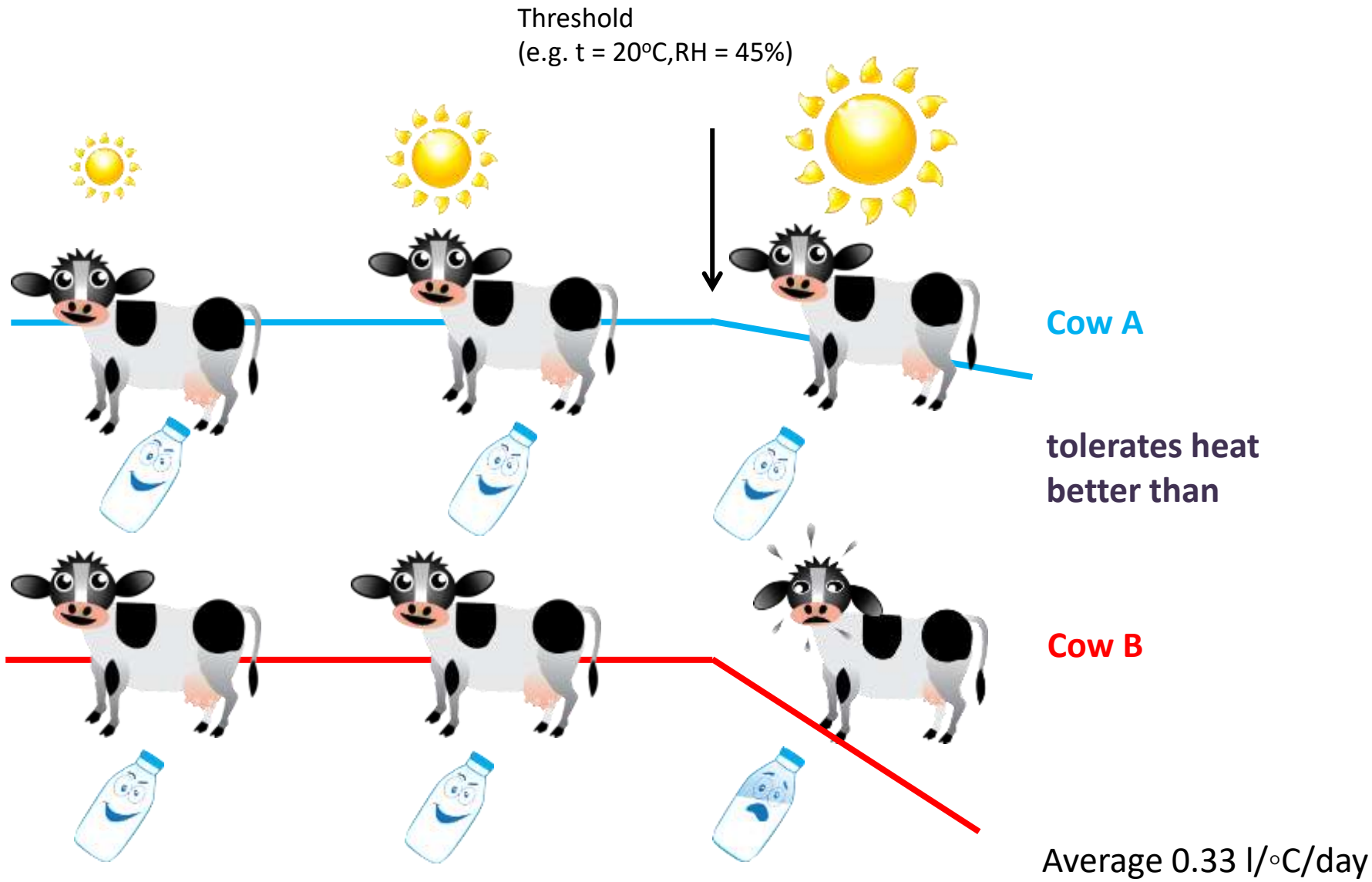
VICTORIA State Government

biosciences research

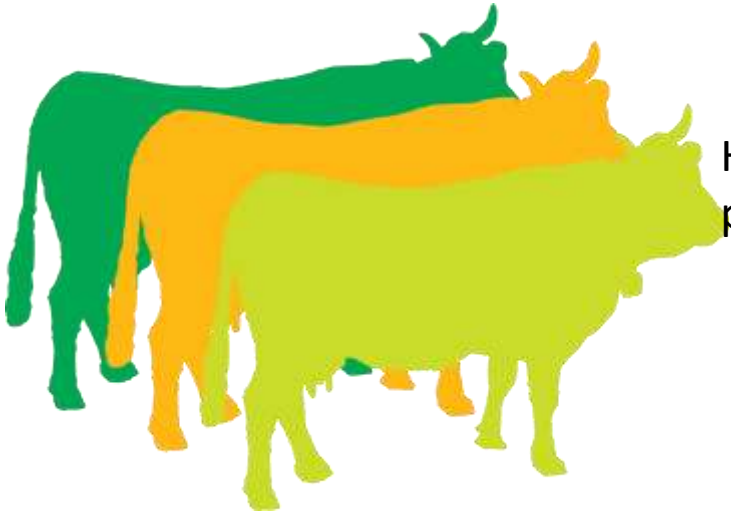
Outline


• Genomic estimated breeding values (GEBV) for heat tolerance
• Validation of heat tolerance GEBV
Implementation
• BV estimation
• Economic Value
• Presentation

Schematic illustration of heat tolerance trait



Data (11 years, 2003-2013)

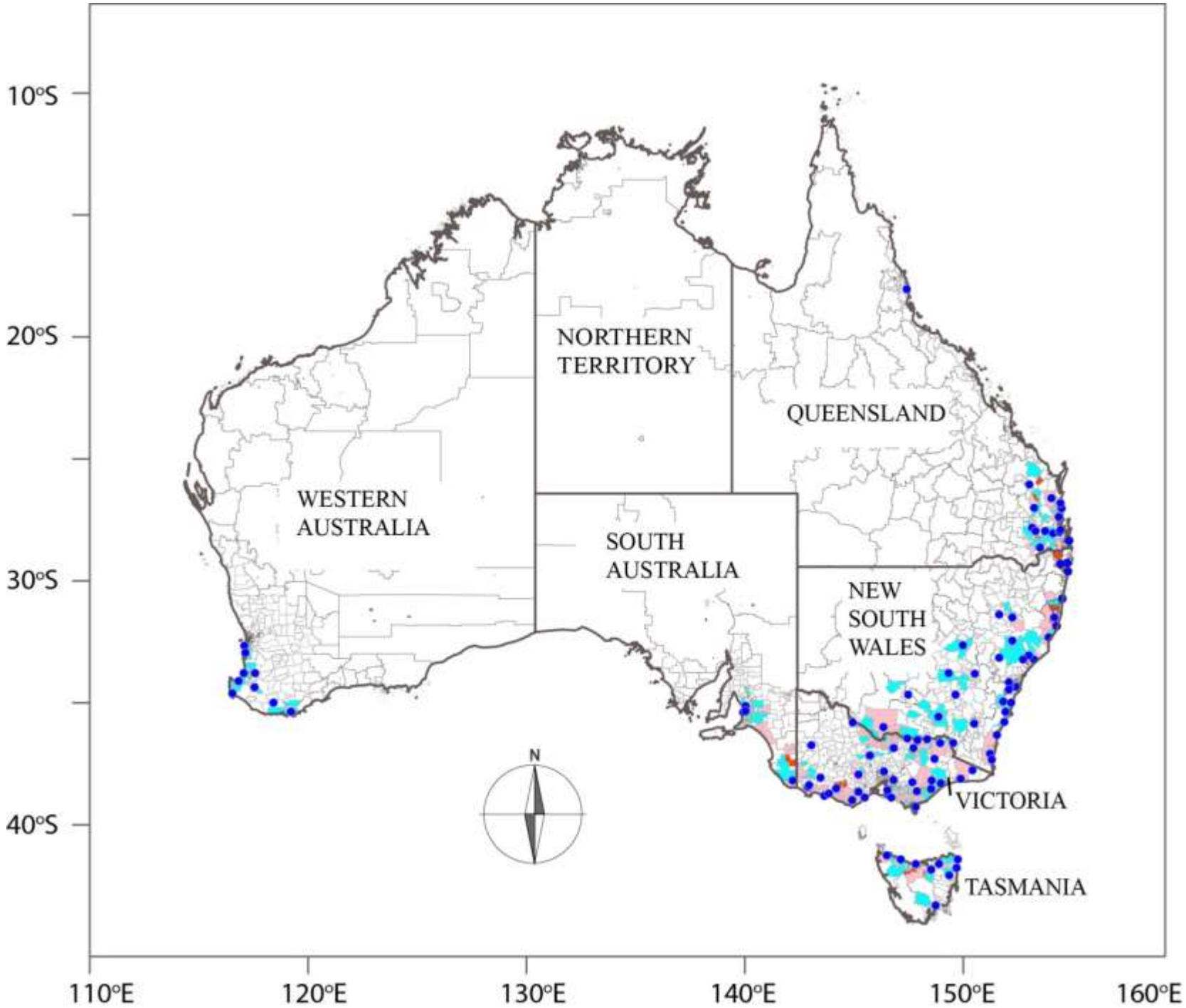


Herd postcode

Nearest weather station

- **Herd recording**
  - Milk, fat, protein yields
  - 1st – 3rd parities
  - Holsteins + Jerseys

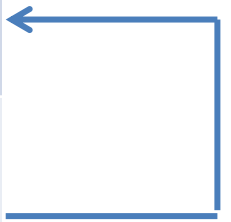
- **B. of Meteorology**
  - Temperature-Humidity Index (THI) (mean THI of test day + 4 days prior to test day)


10°S
20°S
30°S
40°S
110°E
120°E
130°E
140°E
150°E
160°E
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
TASMANIA
N

Phenotypes and Genotypes

Data	Holsteins	Jerseys
	1st parity	1st parity
Herds	1,762	519
Herd test dates	85,714	26,441
Number of cows	366,835	76,852

#SNP	Holsteins	Jerseys
800K	1,620 sires	125 sires
50K	1,115 sires 2,189 cows	585 sires 1,188 cows



Imputed using BEAGLE

Models: using ASREML

Cow slope

- $y_{ijklm} = \mu + HTD_i + YS_j + PAR_k + \sum_{n=1}^{3} A_n X_n + PAR_k \sum_{n=1}^{8} D_n Z_n + STG_l \sum_{n=0}^{1} T_n S_n + \sum_{n=0}^{1} C_{mn} W_n + e_{ijklm}$

Sire slope

- **Daughter trait deviation (averaged daughter slopes)**

GBLUP

- $\mathbf{y} = \boldsymbol{\mu} + \mathbf{Zg} + \mathbf{e}, \qquad \mathbf{g} \sim N(0, \mathbf{GRM}\sigma_g^2)$
- **y = a vector of sire slope and cow slope**

Genetic parameters

Trait impacted	h^2 of cow slope	
	Holstein	Jersey
Milk yield	0.22 ± 0.007	0.33 ± 0.018
Fat yield	0.20 ± 0.007	0.26 ± 0.015
Protein yield	0.23 ± 0.007	0.27 ± 0.016

Accuracy of genomic prediction

Breed	Reference	Validation	Trait affected by heat stress	Accuracy
Holsteins	2,300 sires	435 sires	Milk	0.43
	2,189 cows		Fat	0.46
			Protein	0.51
Jerseys	575 sires	135 sires	Milk	0.49
	1,188 cows		Fat	0.55
			Protein	0.52

Correlations of heat tolerance GEBV with EBV of fertility

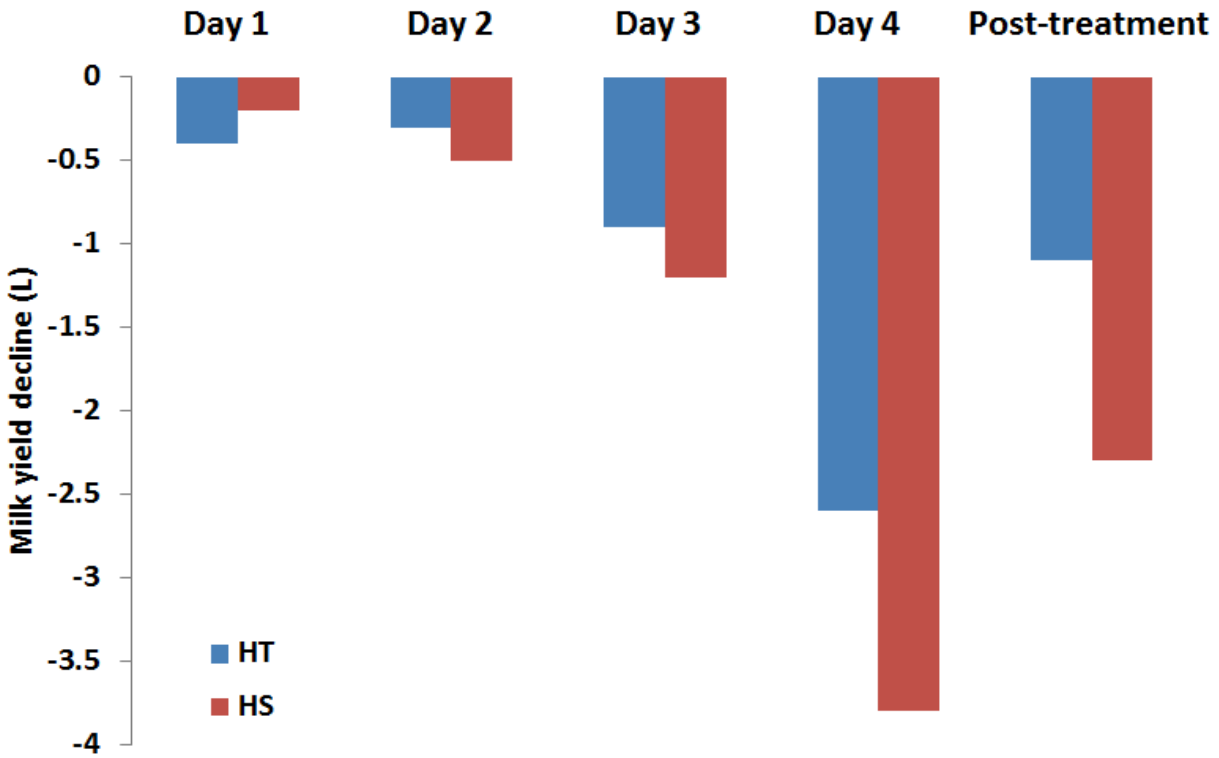
Breed	Heat Tolerance	Fertility
Holsteins	HT Milk	0.39
	HT Fat	0.38
	HT Protein	0.29
Jerseys	HT Milk	0.27
	HT Fat	0.21
	HT Protein	0.15

Validation study

- 400 random heifers
- 24 predicted most heat tolerant, 24 predicted most heat susceptible based on GEBV
- Run through a simulated 4 day heat wave event in respiration chambers
- measure milk production, core temperature

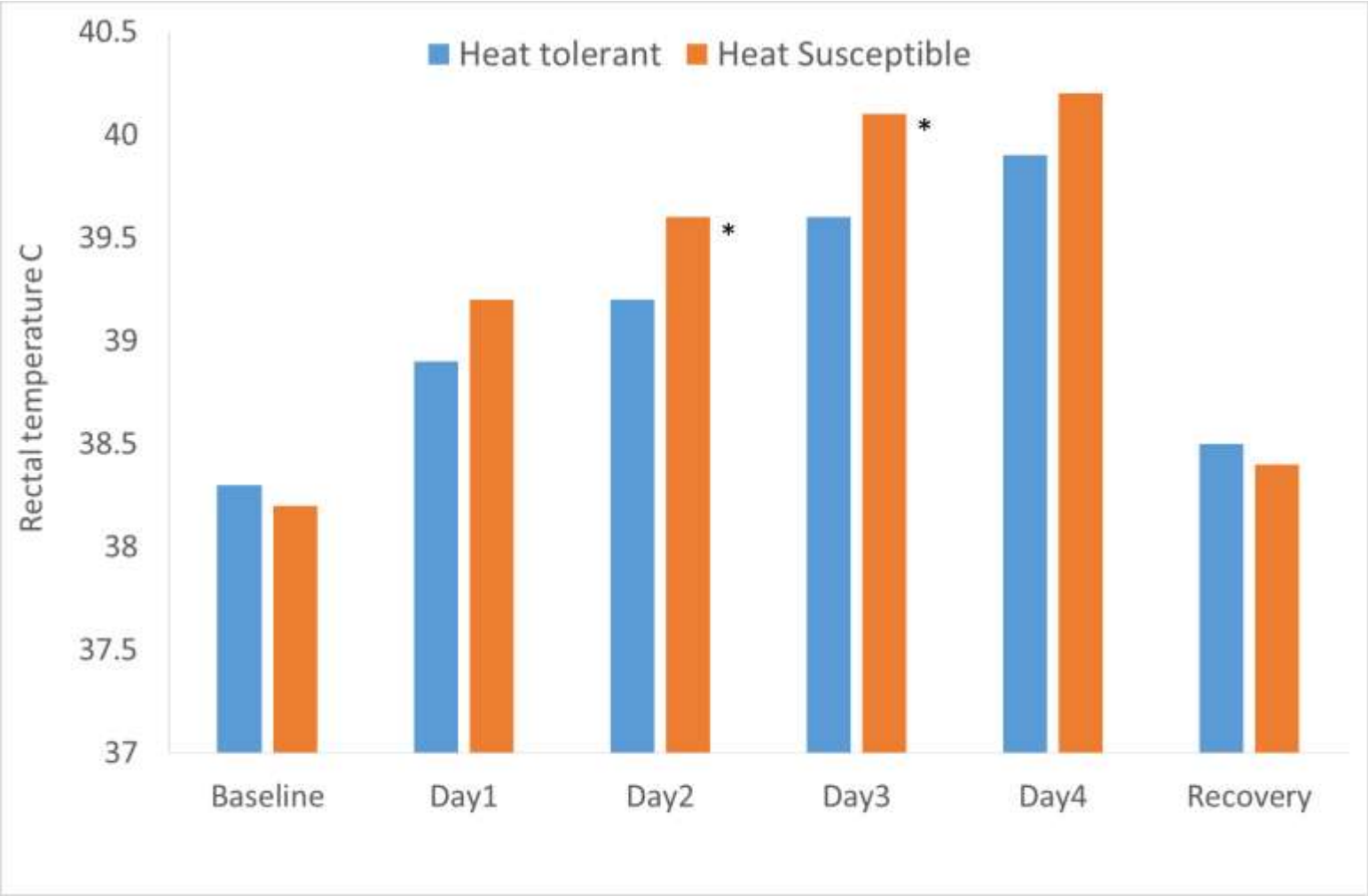
Validation study

Decline in milk production



Validation study

Rectal temperature



IMPLEMENTATION

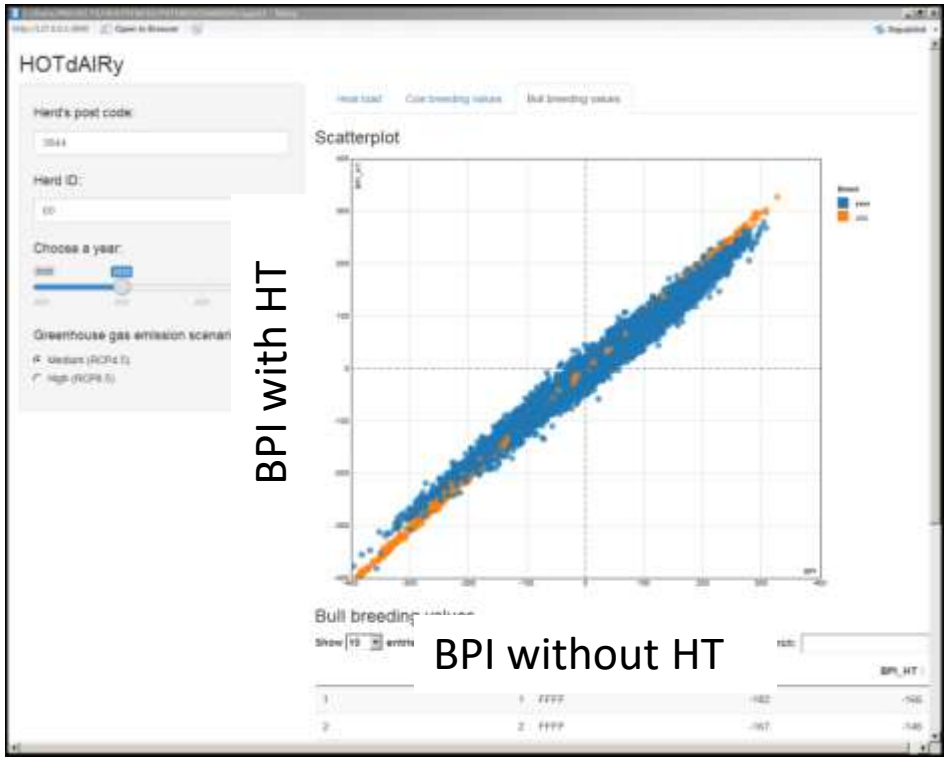
Economic Value

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

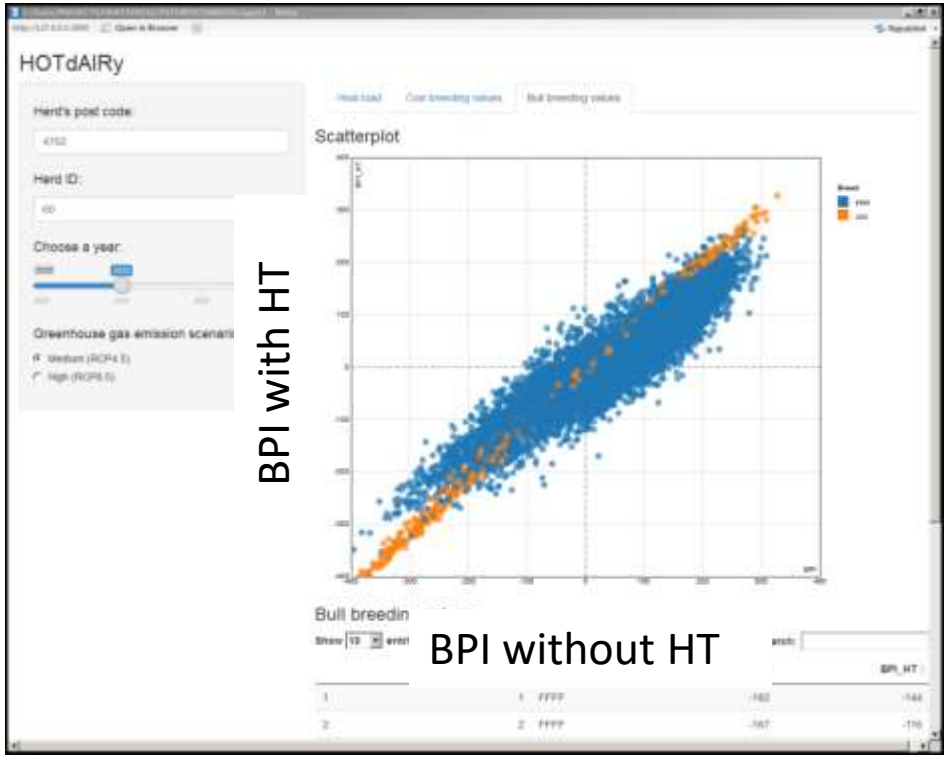
Heat Load varies by herd

Bull breeding values

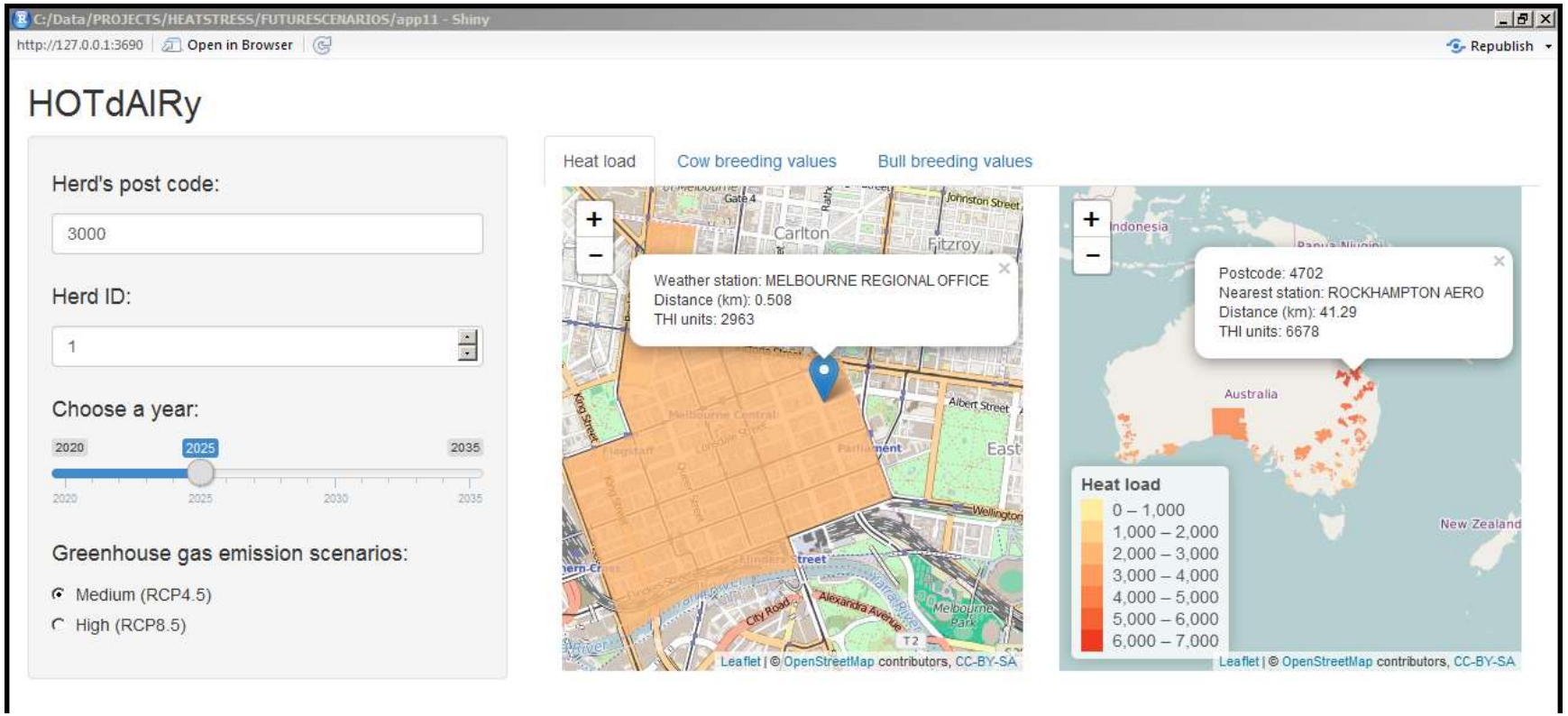
SE Victoria



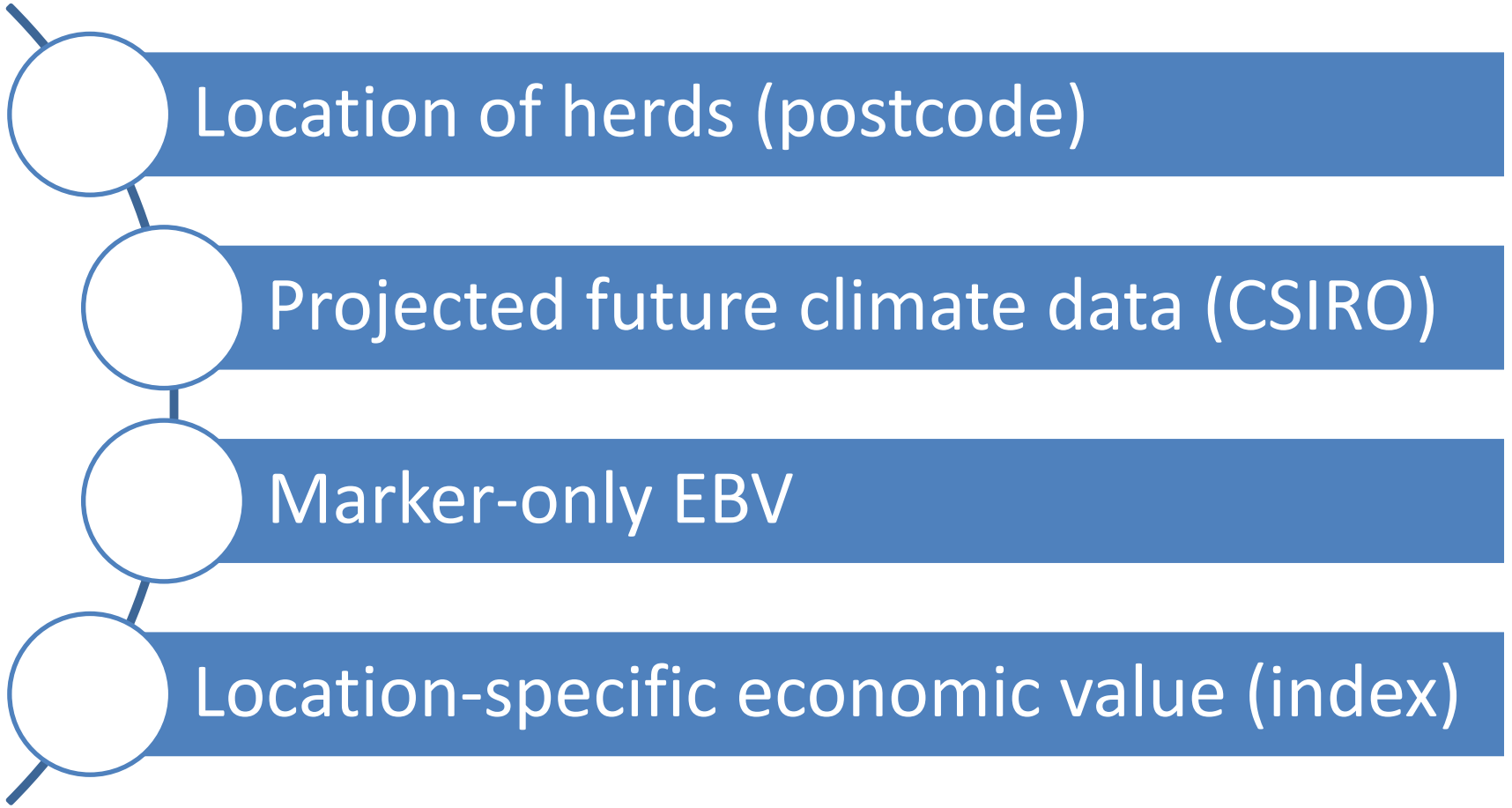
Queensland



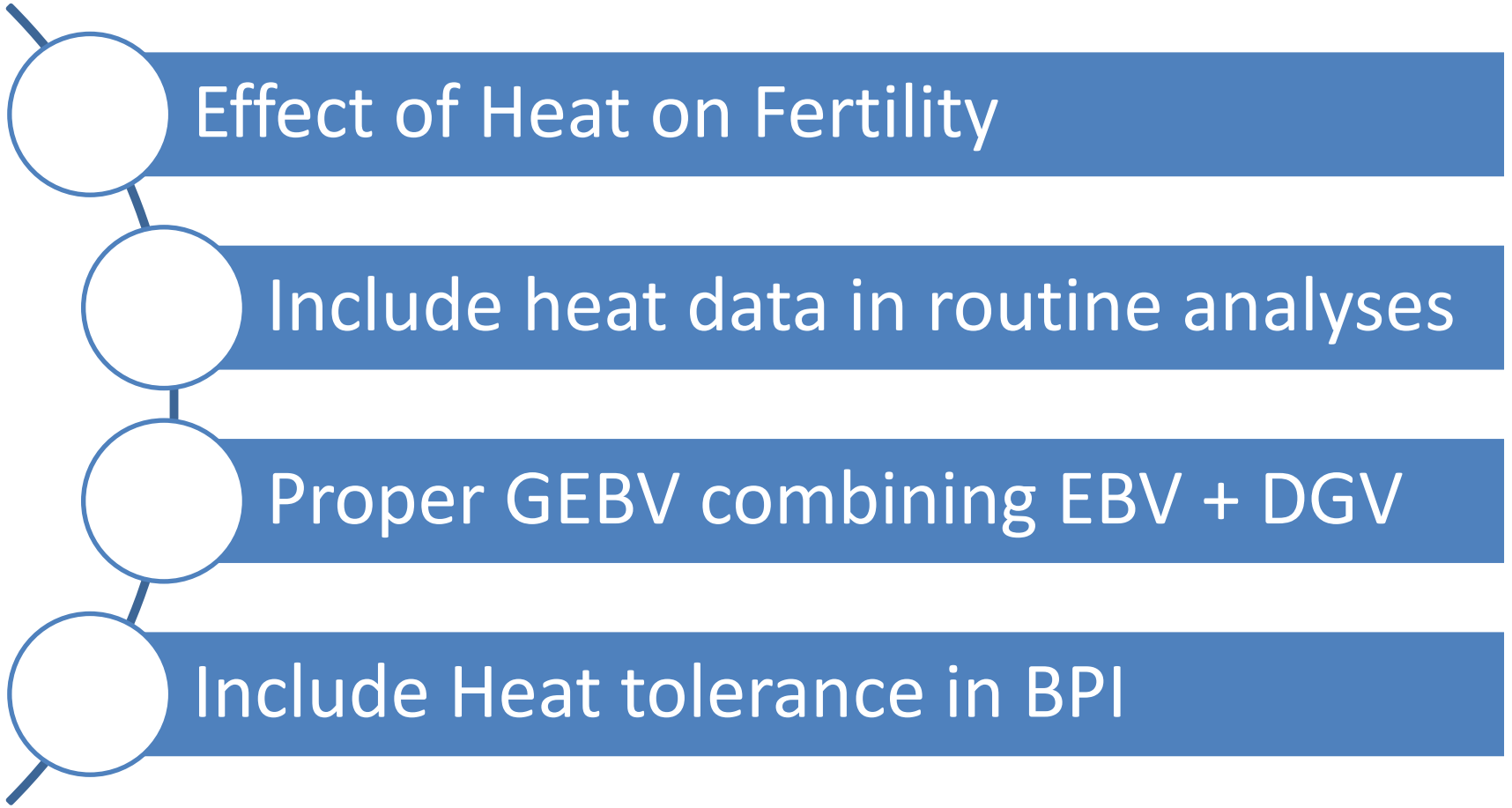
Heat load


C:/Data/PROJECTS/HEATSTRESS/FUTURESCENARIOS/app11 - Shiny
http://127.0.0.1:3690
Open in Browser
Republish
HOTdAIRy
Herd's post code:
3000
Herd ID:
1
Choose a year:
2020
2025
2035
Greenhouse gas emission scenarios:
Medium (RCP4.5)
High (RCP8.5)
Heat load
Cow breeding values
Bull breeding values
Weather station: MELBOURNE REGIONAL OFFICE
Distance (km): 0.508
THI units: 2963
Carlton
Fitzroy
Melbourne Central
Albert Street
East
Wellington
City Road
Alexandra Avenue
Leaflet | © OpenStreetMap contributors, CC-BY-SA
Postcode: 4702
Nearest station: ROCKHAMPTON AERO
Distance (km): 41.29
THI units: 6678
Indonesia
Australia
New Zealand
Heat load
0 – 1,000
1,000 – 2,000
2,000 – 3,000
3,000 – 4,000
4,000 – 5,000
5,000 – 6,000
6,000 – 7,000
Leaflet | © OpenStreetMap contributors, CC-BY-SA

Implementation



Further work



Conclusions

- **Genomic selection can be used as a strategy to improve heat tolerance in dairy cattle**

- **Dairy industry will have validated genomic breeding values to improve heat tolerance**
  - Favourable correlation with fertility

- **Further work**
  - Impact on fertility

Acknowledgements

- The Department of Agriculture of Australia funded the project
- The Australia Dairy Herd Improvement Scheme provided production data
  - Test day data
  - BPI: Paul Koh & Gert Nieuwhof
- Dairy Futures CRC
- CSIRO and Bureau of Meteorology – Climate Change in Australia
  - Dr. John Clark

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