Genomic selection for heat tolerance in Australian dairy cattle

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Outline

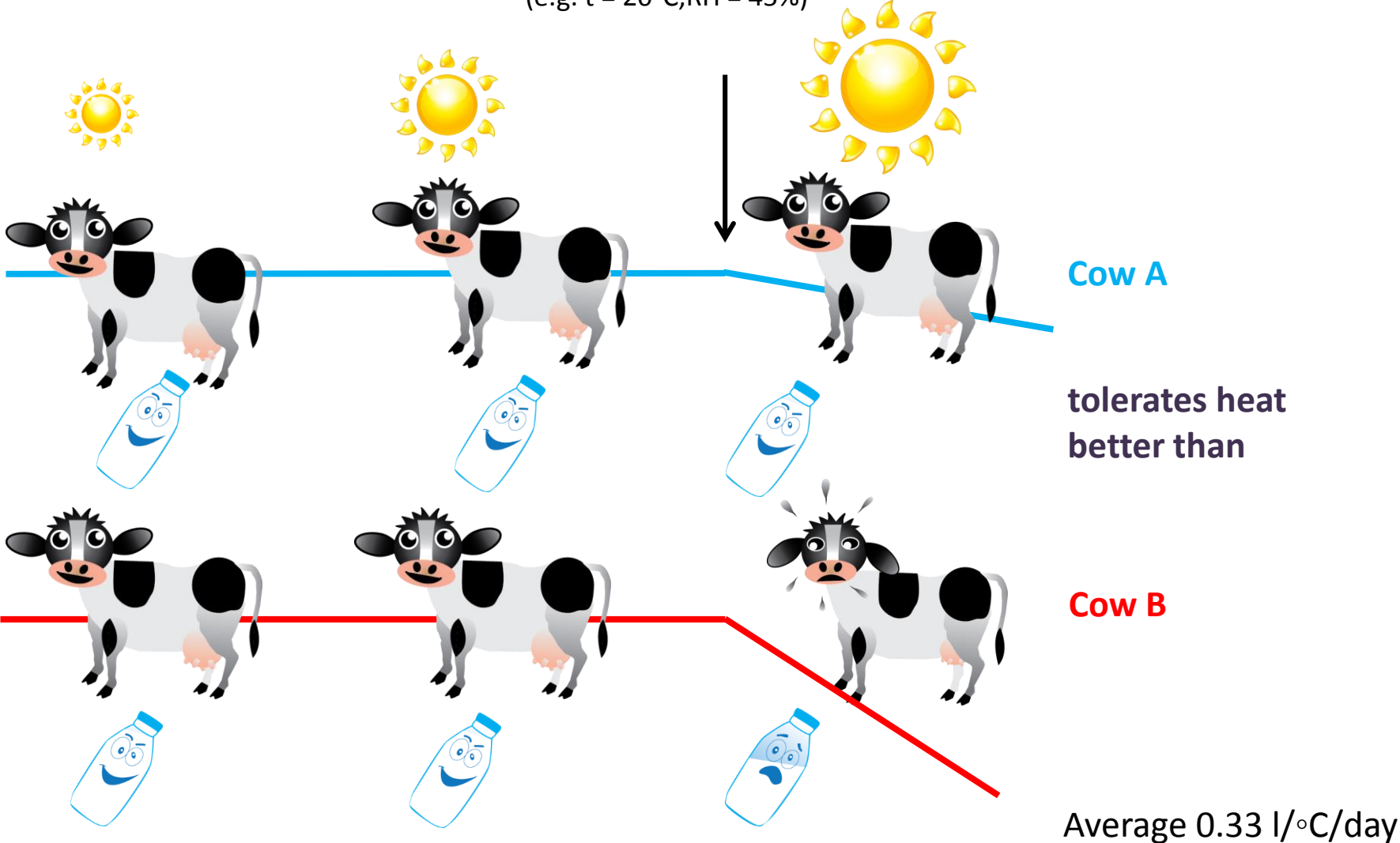- *Genomic estimated breeding values (GEBV) for heat tolerance*
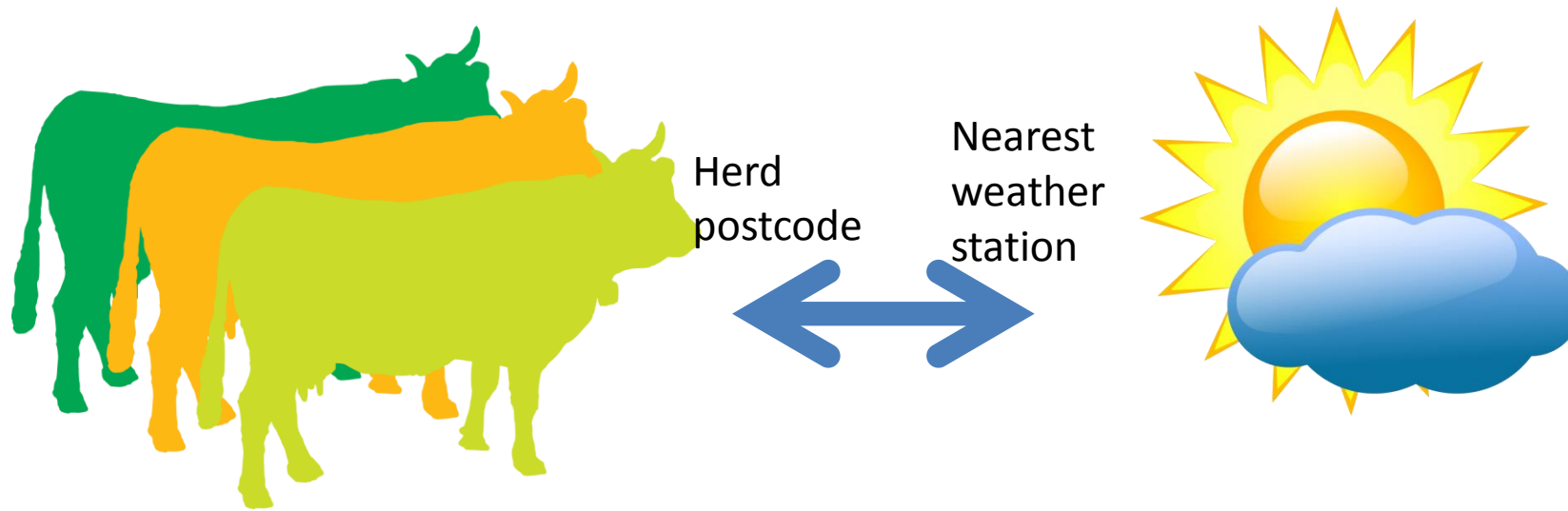
- Validation of heat tolerance GEBV

Implementation
- BV estimation
- Economic Value
- Presentation

Schematic illustration of heat tolerance trait

Threshold
(e.g. t = 20°C, RH = 45%)

Cow A

tolerates heat
better than

Cow B

Average 0.33 l/°C/day

Data (11 years, 2003-2013)
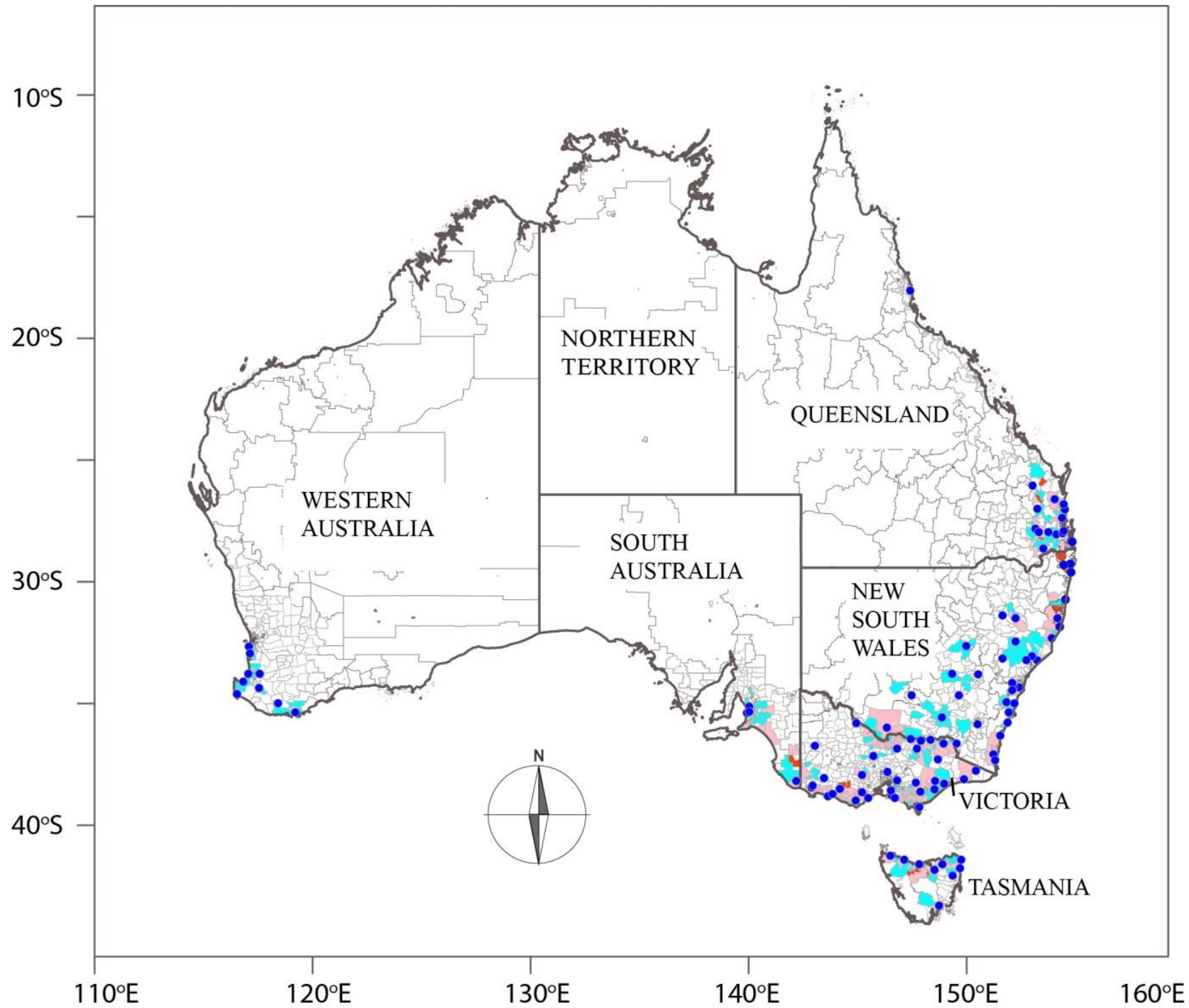
Herd postcode ⟷ Nearest weather station

- **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)

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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

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

Genetic parameters

Trait impacted	h² 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**

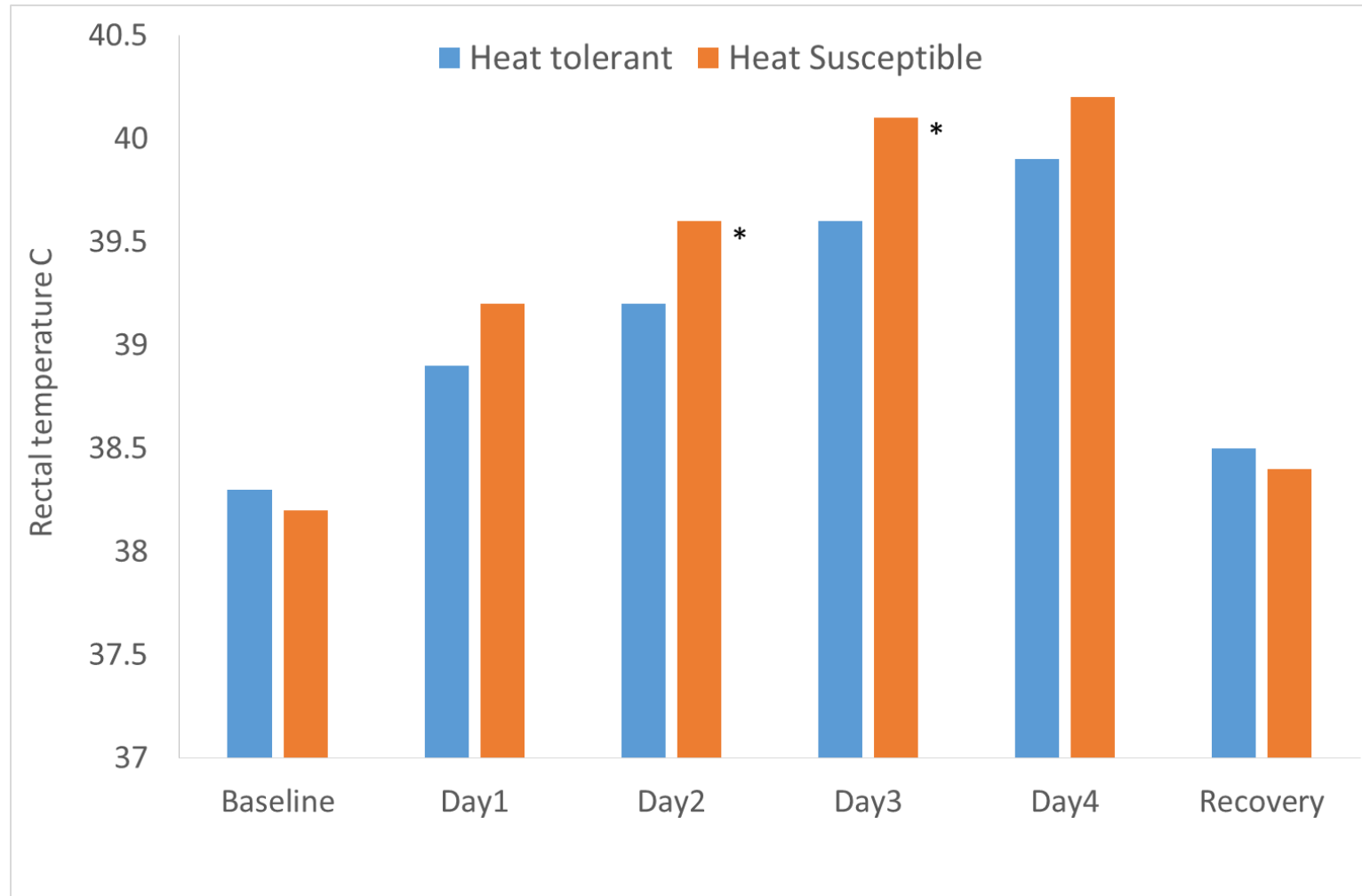# Validation study

Decline in milk production
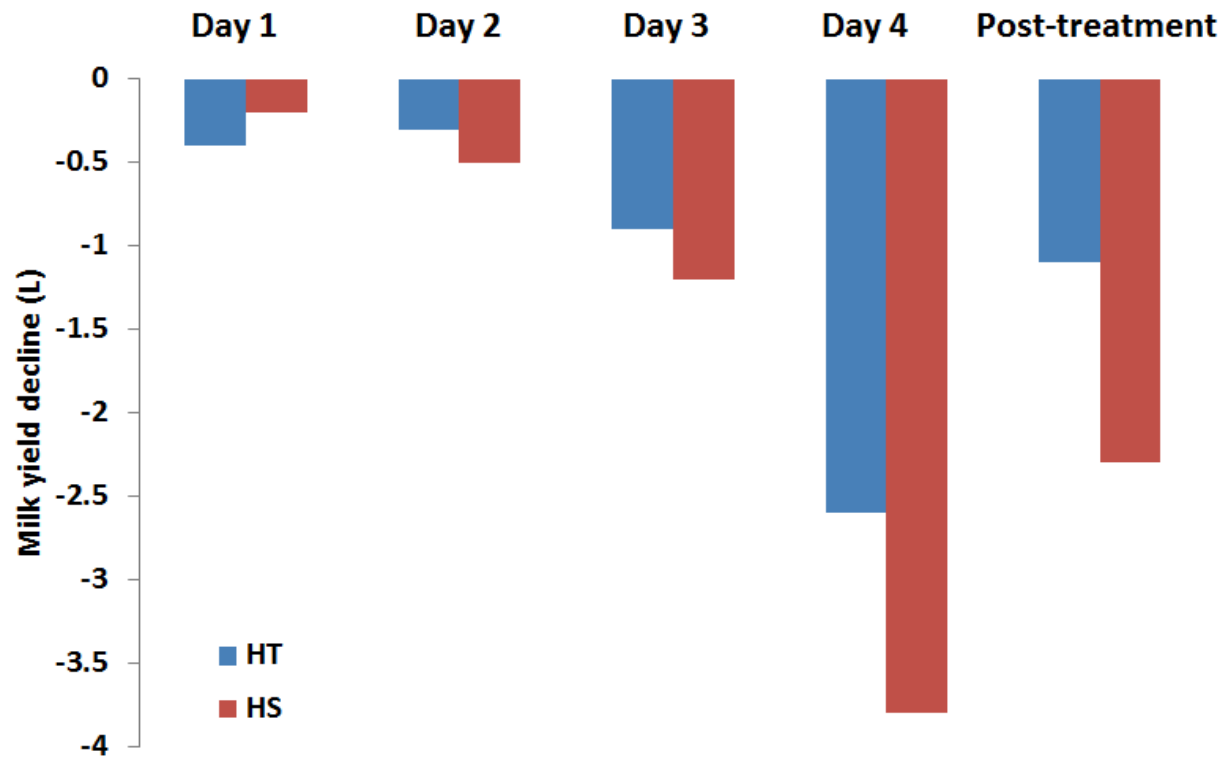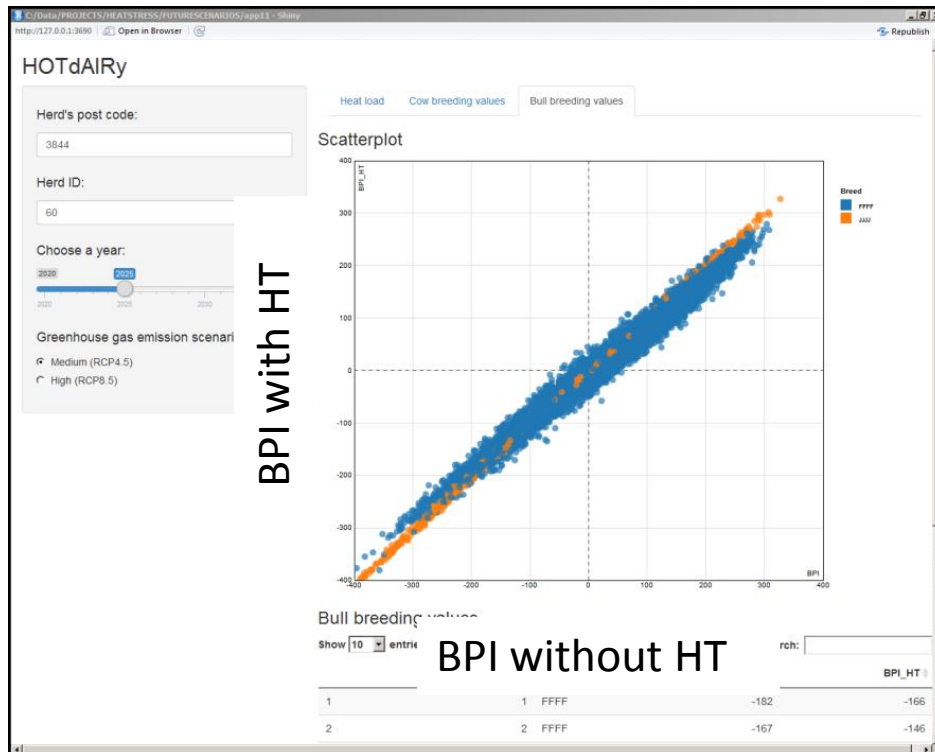
Validation study

Rectal temperature

IMPLEMENTATION

Economic Value

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

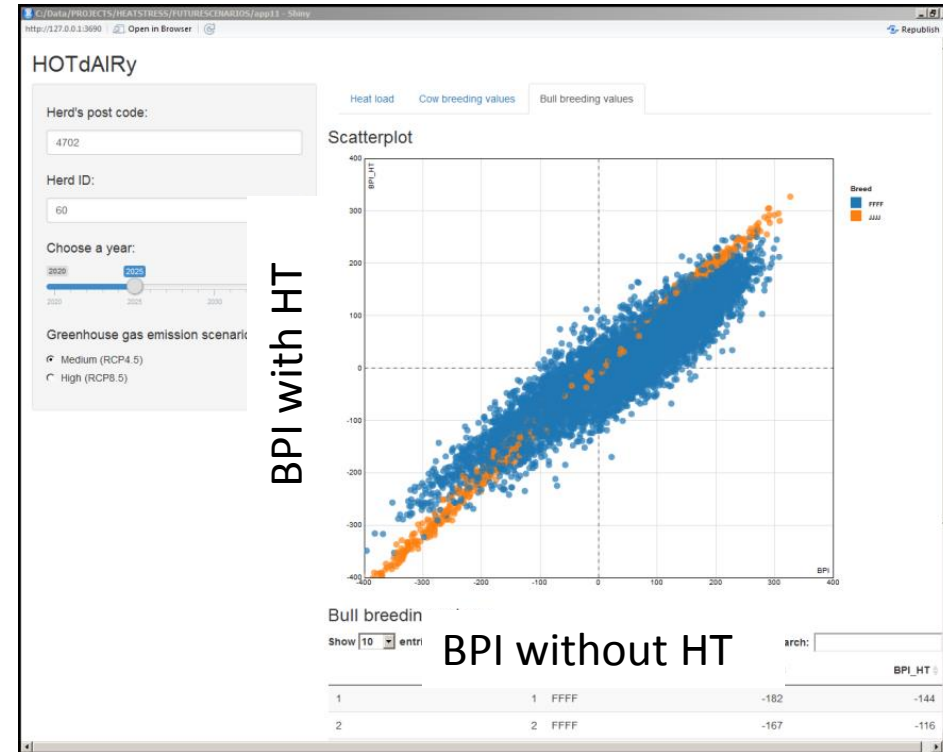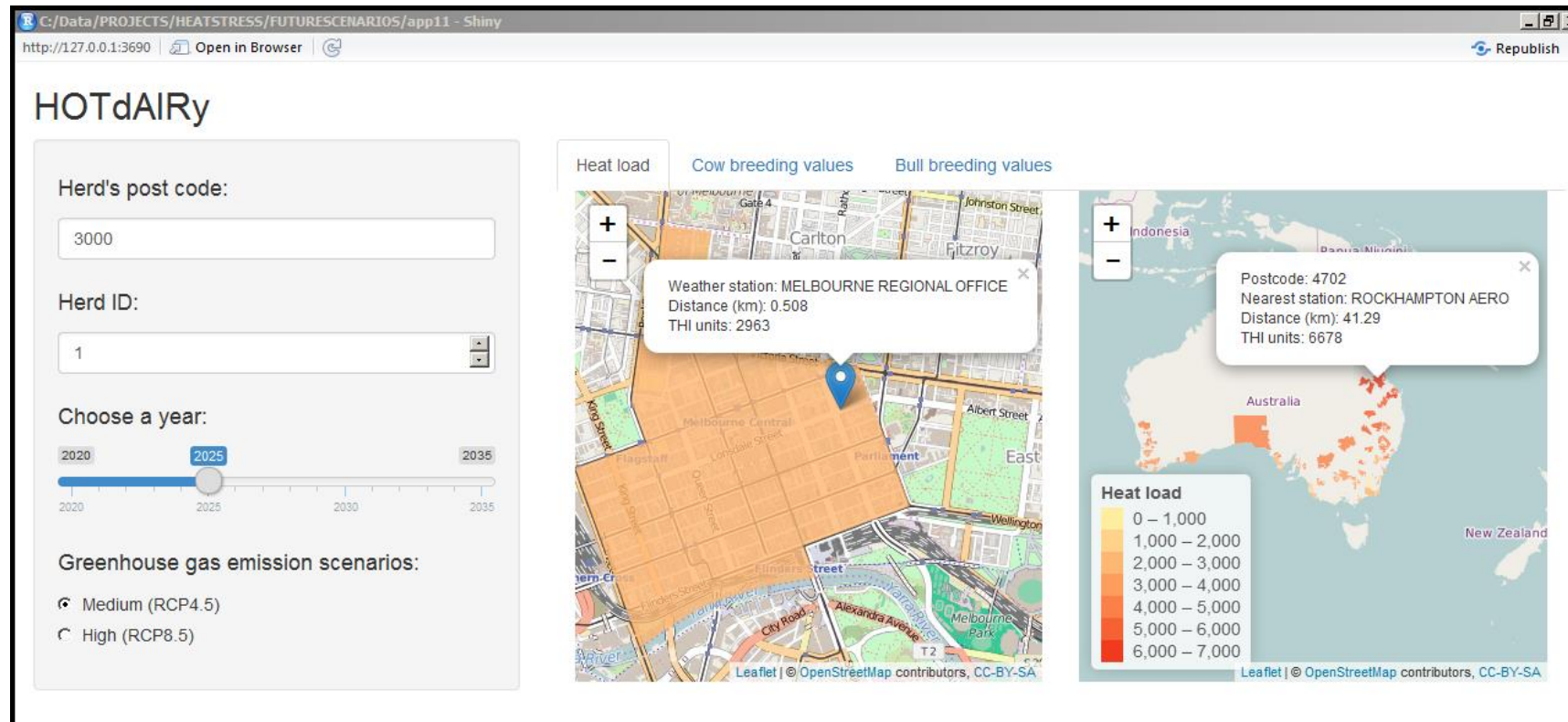Heat Load varies by herd

Bull breeding values

SE Victoria

Queensland

Heat load

Implementation

- Location of herds (postcode)
- Projected future climate data (CSIRO)
- Marker-only EBV
- Location-specific economic value (index)
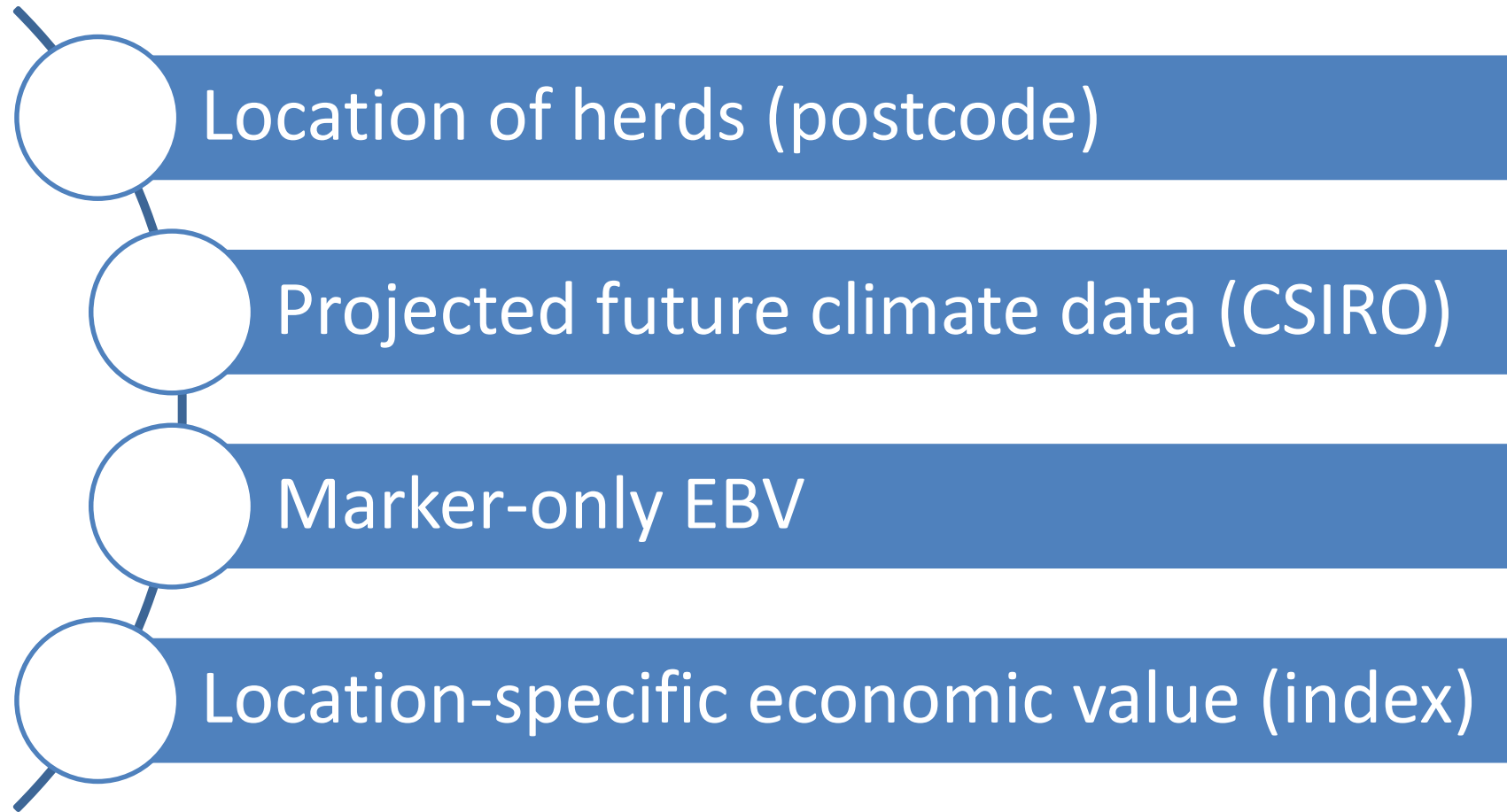
Further work

- Effect of Heat on Fertility
- Include heat data in routine analyses
- Proper GEBV combining EBV + DGV
- Include Heat tolerance in BPI

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**
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  - Test day data
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- **Dairy Futures CRC**
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  - Dr. John Clark

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