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New kid on the block:
A genomic breeding value to select for heat tolerant dairy cattle

Thuy Nguyen, Josie Garner, Jennie Pryce

69th EAAP Conference
Dubrovnik
27 – 31 Aug 2018

AGRICULTURE VICTORIA


Timor Sea
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Perth
Adelaide
Sydney
Great Australian Bight
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Melbourne
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NEW SOUTH WALES
Newcastle
Perth
Adelaide
Sydney
Great Australian Bight
Cohuna
ACT
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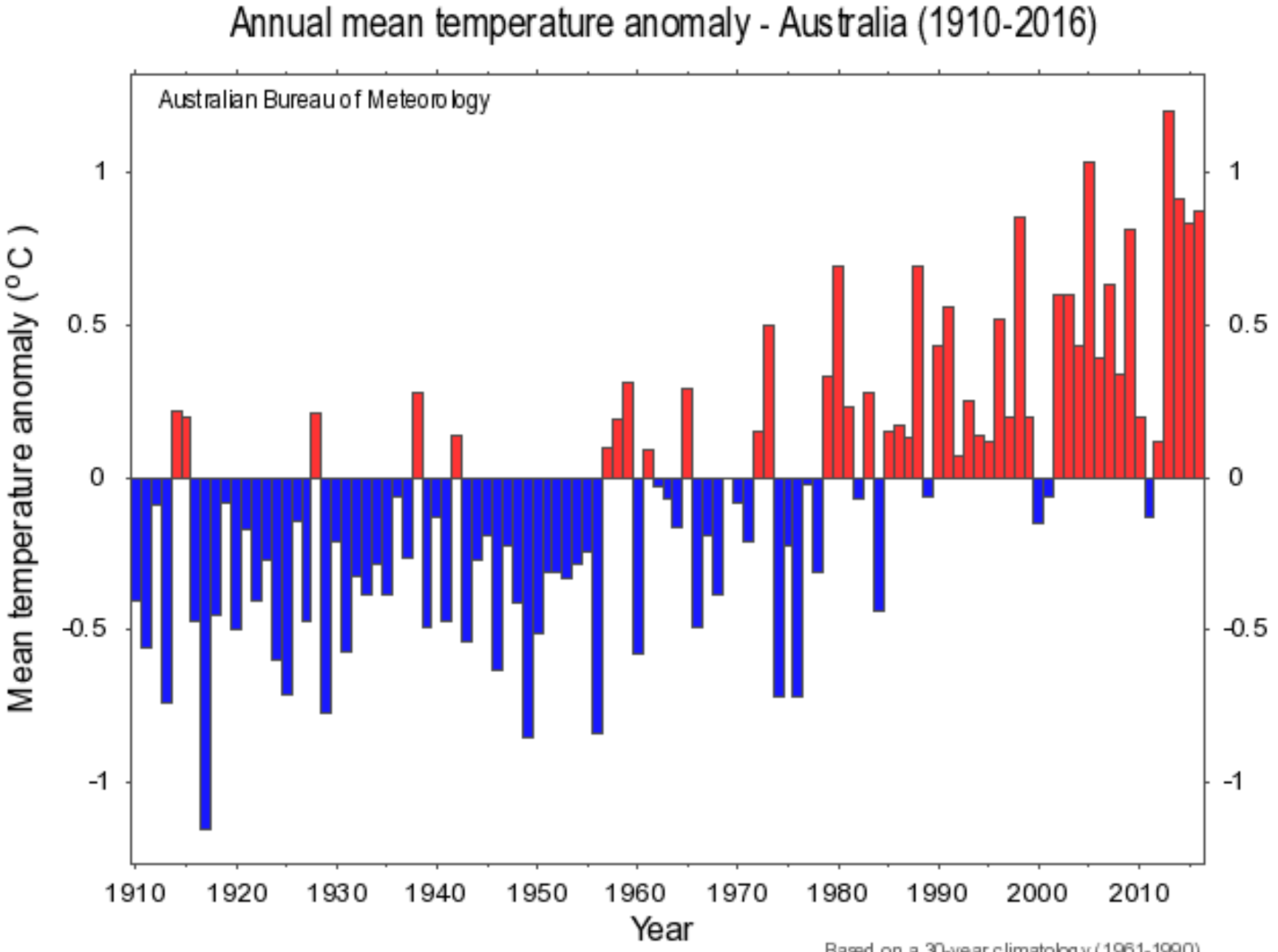
Melbourne
TASMANIA

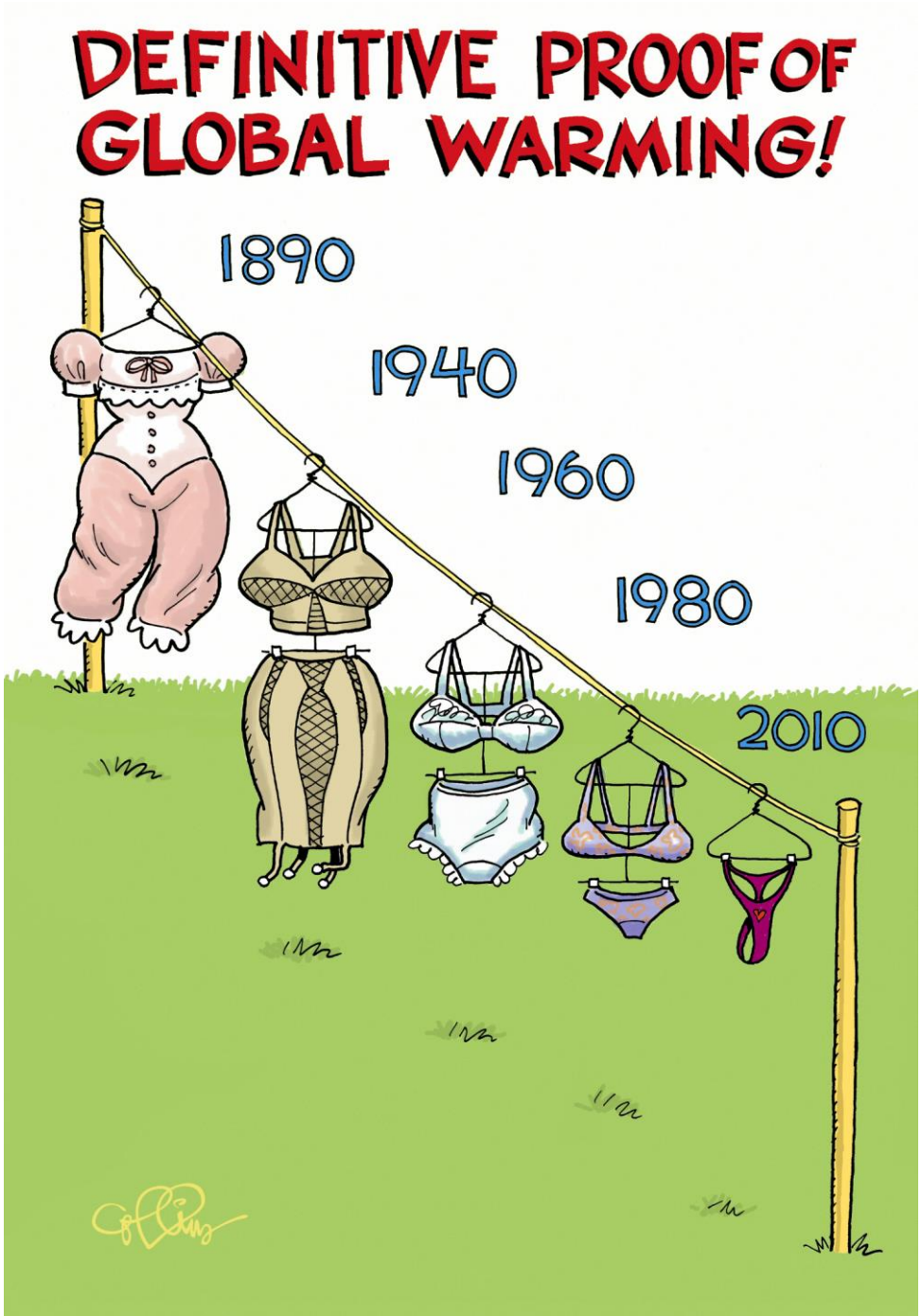
Why heat tolerance?

- Heat stress: temperature & humidity above the comfort zones

- Leads to:
  - Reduction in feed intake, milk yield, fertility
  - Loss of income

- Major dairying regions in Australia will experience an increase in daily average temperatures
  - And more frequent heat waves and longer duration


Annual mean temperature anomaly - Australia (1910-2016)
Australian Bureau of Meteorology
Mean temperature anomaly (°C)
1
0.5
0
-0.5
-1
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Based on a 30-year climatology (1961-1990)


DEFINITIVE PROOF OF GLOBAL WARMING!
1890
1940
1960
1980
2010

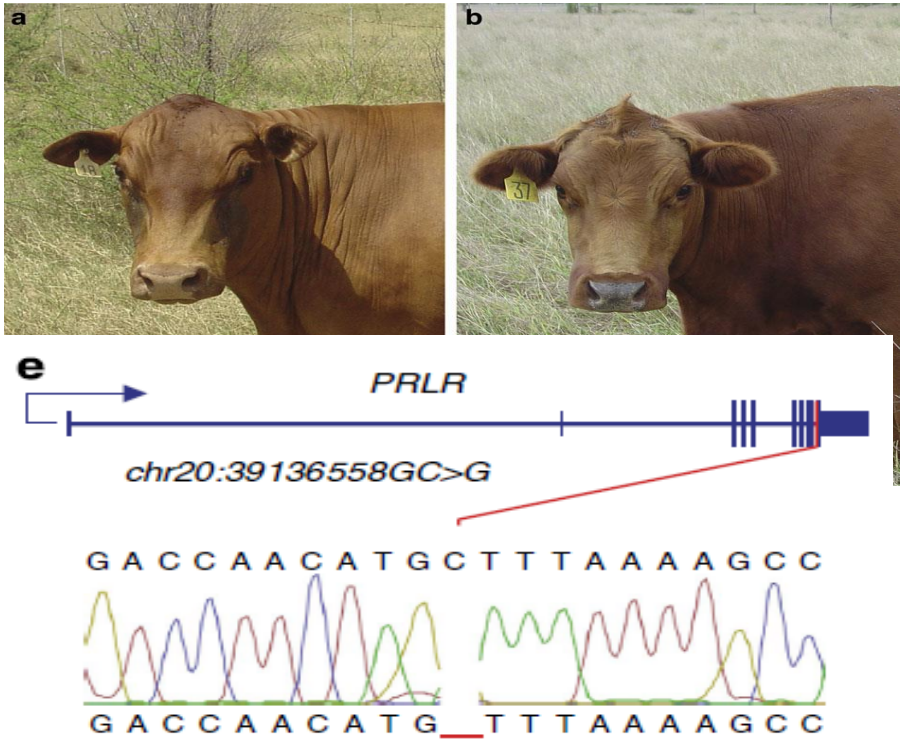
Getty images
https://www.denverpost.com
/2018/08/05/photos-historic-heat-wave-scorches-europe/

Vnexpress.com

Possible measures: Management + Nutrition

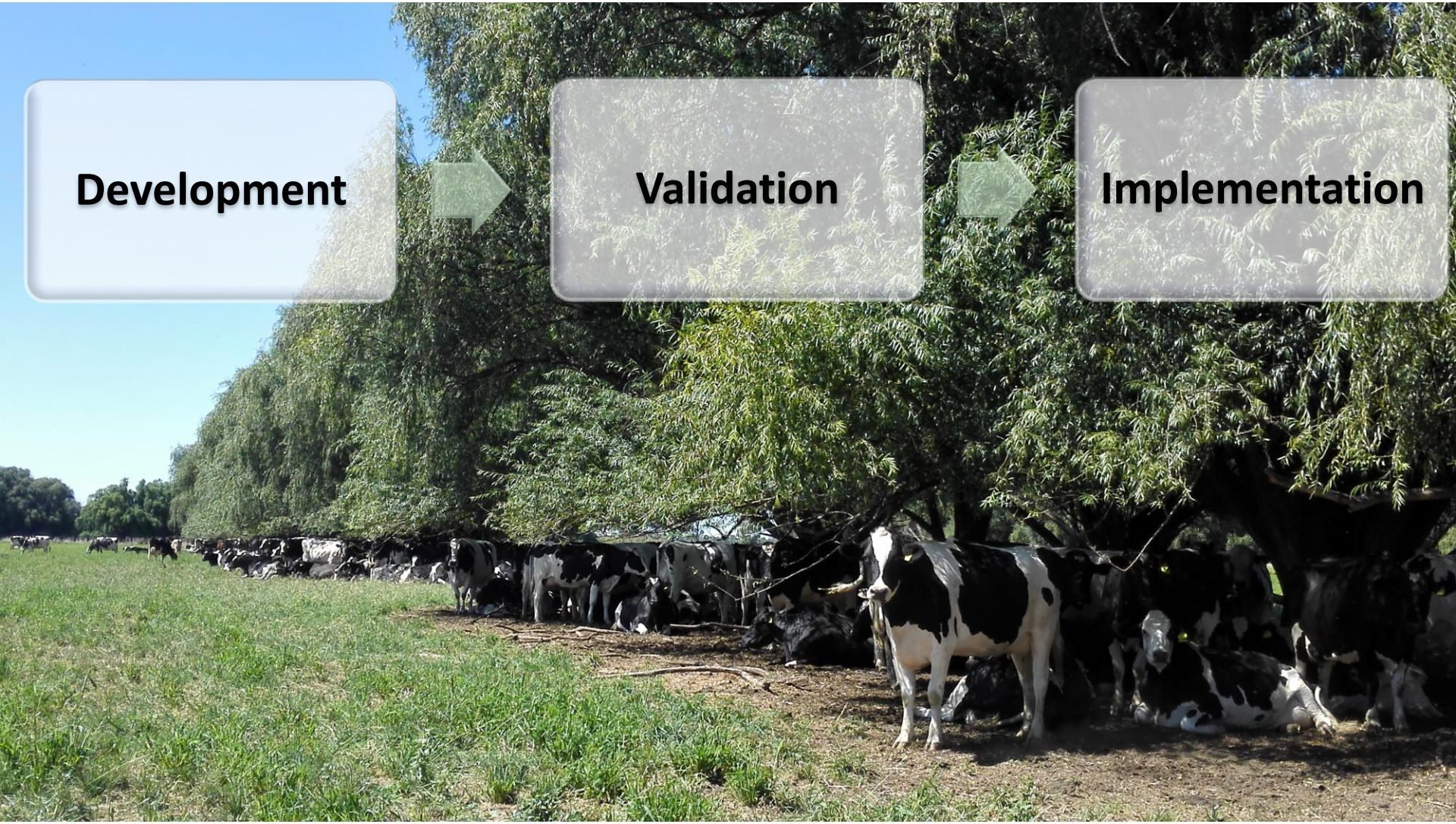
Possible measures: Use adapted breeds

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

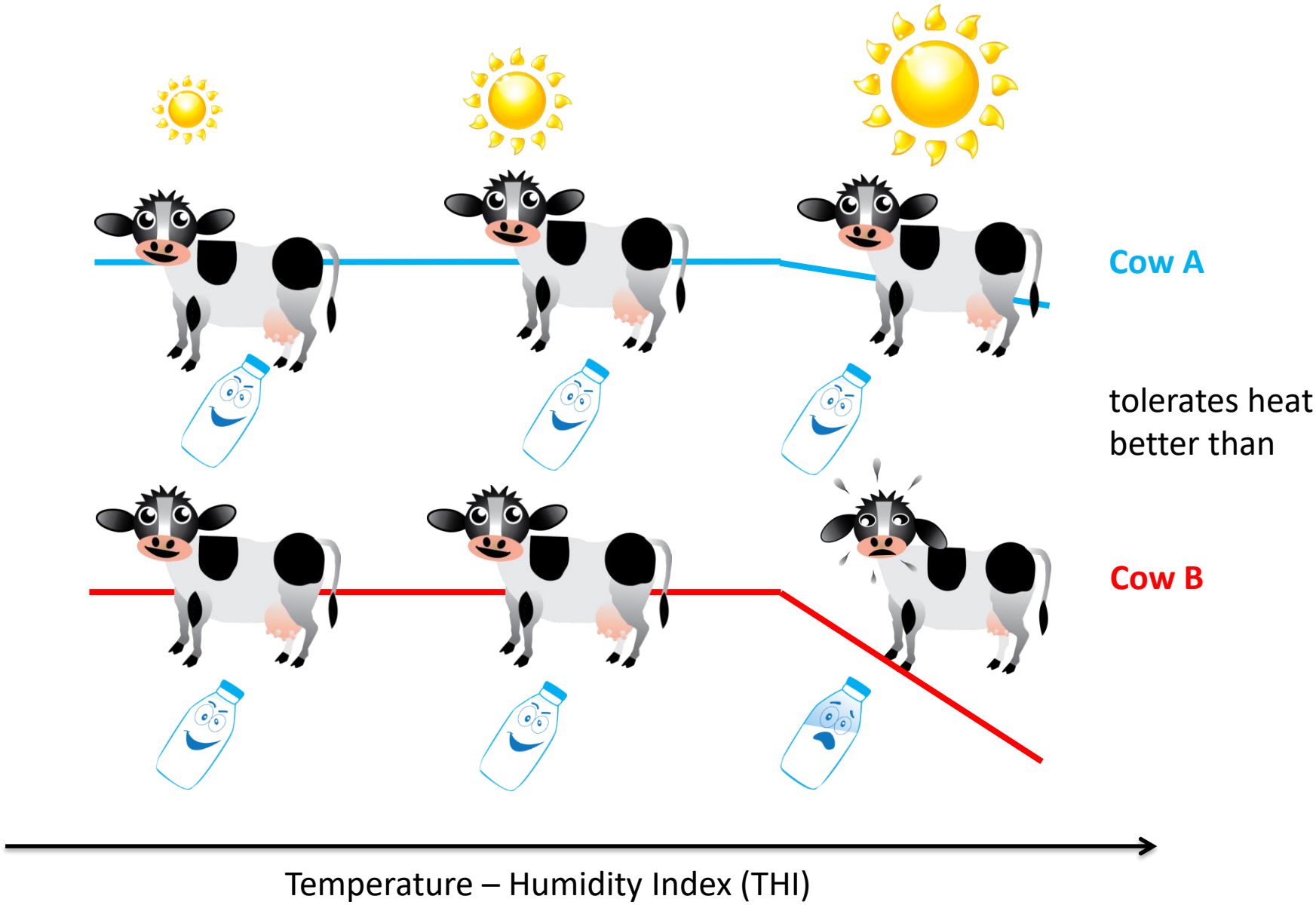


Possible measures: Genomic selection for heat tolerance

- Exploit within breed variation
- Genome wide DNA markers
- What trait/measurement to use?


Development
Validation
Implementation

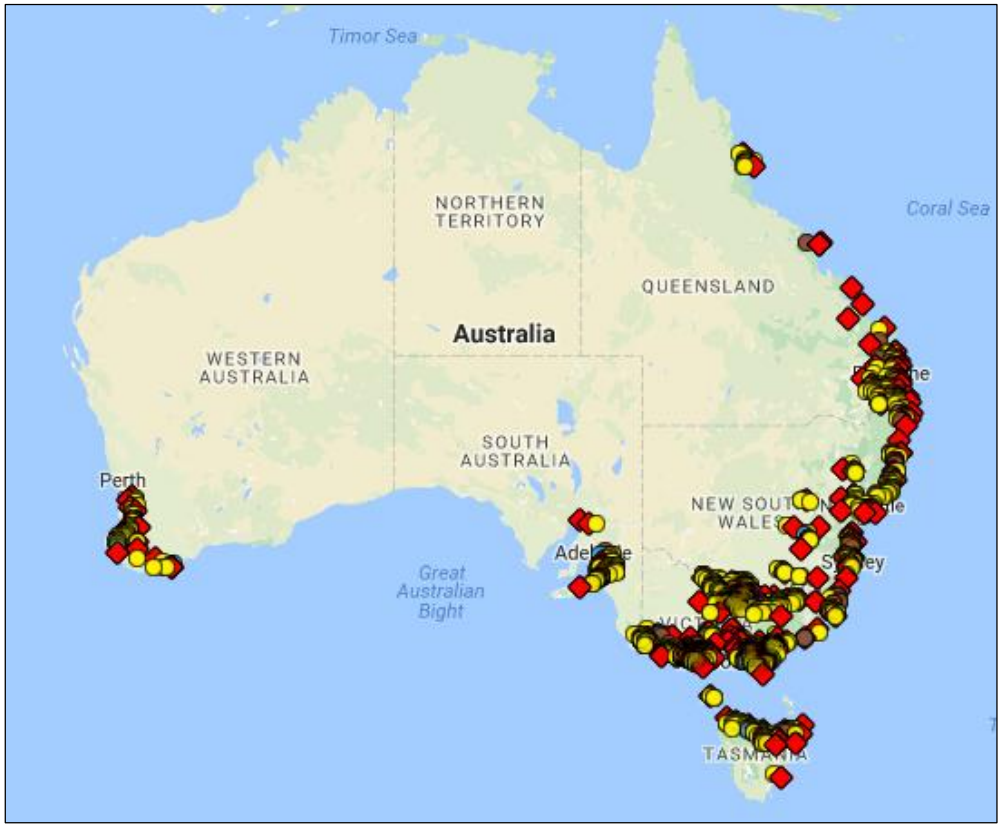
What is heat tolerance?



Development of heat tolerance GEBV

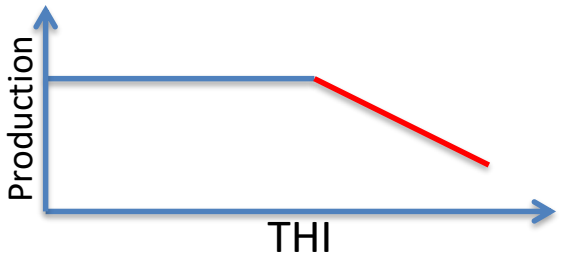
1. Phenotypic records

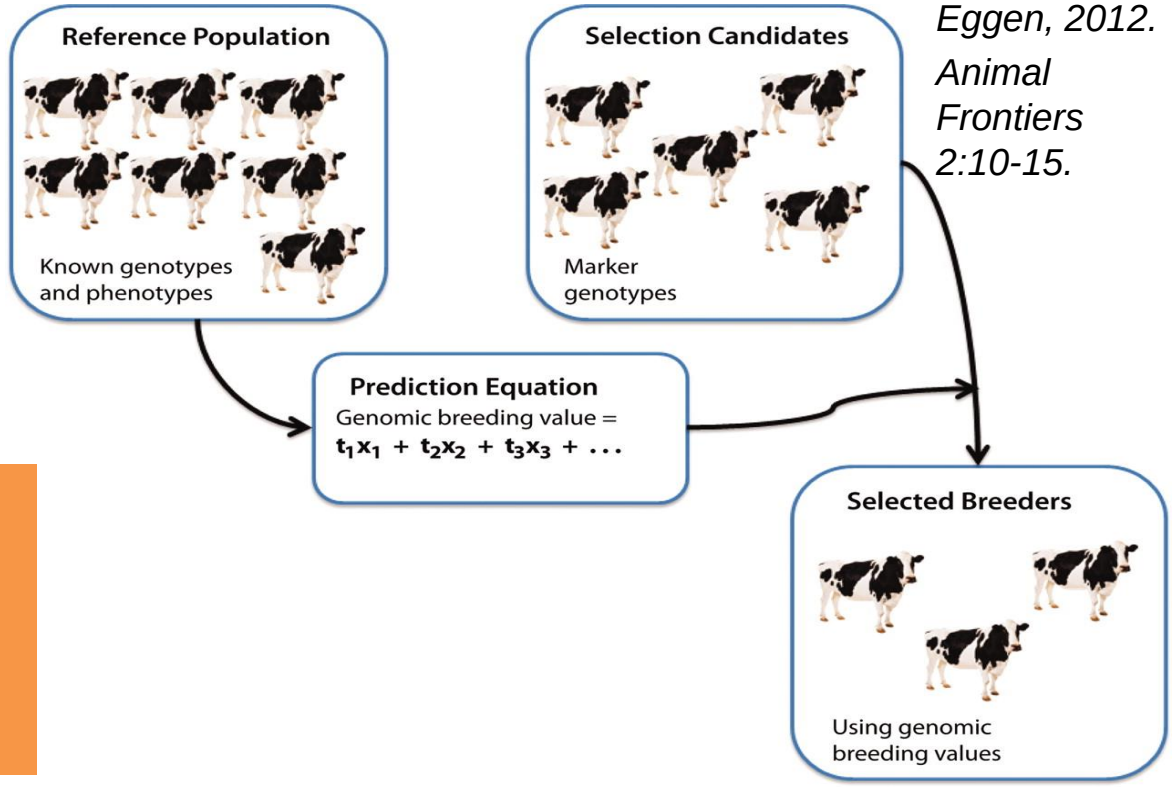
- Merge herd test records with weather data (temperature-humidity index, THI)
- 14 years: 2003 – 2016
- 1,762 Holstein & 519 Jersey herds
- 425K Holstein and 85K Jersey cows
- 1st , 2nd and 3rd parities



Development of heat tolerance GEBV

2. Genomic prediction





Eggen, 2012. Animal Frontiers 2:10-15.

Phenotype = Estimated cow slopes

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

Sire slope = average of daughters

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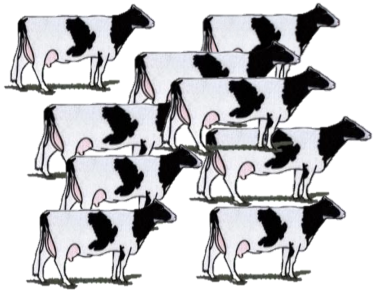
Jan 2017

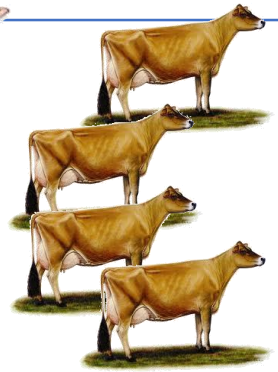
4628 bulls with
Australian daughters



10,254 cows

10,000 cow

1177 bulls with
Australian daughters



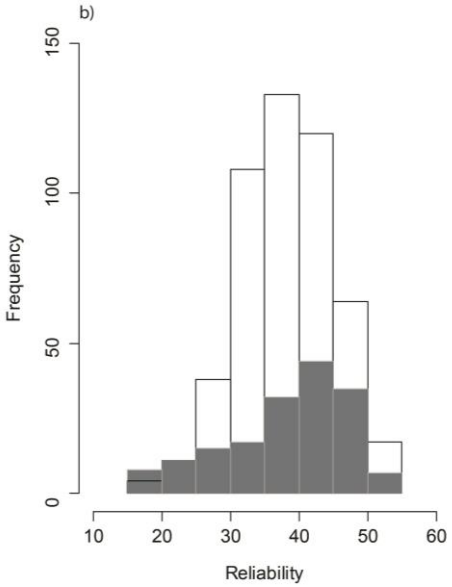
JERNOMICS

4,232 cows

Validation of heat tolerance GEBV

1. Cross validation

Breed	Trait	Reference (Validation)	Reliability (%)
Holstein	Milk	2,243 sires + 11,218 cows	42
	Fat		40
	Protein	(497 sires)	38
Jersey	Milk	484 sires + 4,037 cows	36
	Fat		38
	Protein	(183 sires)	38

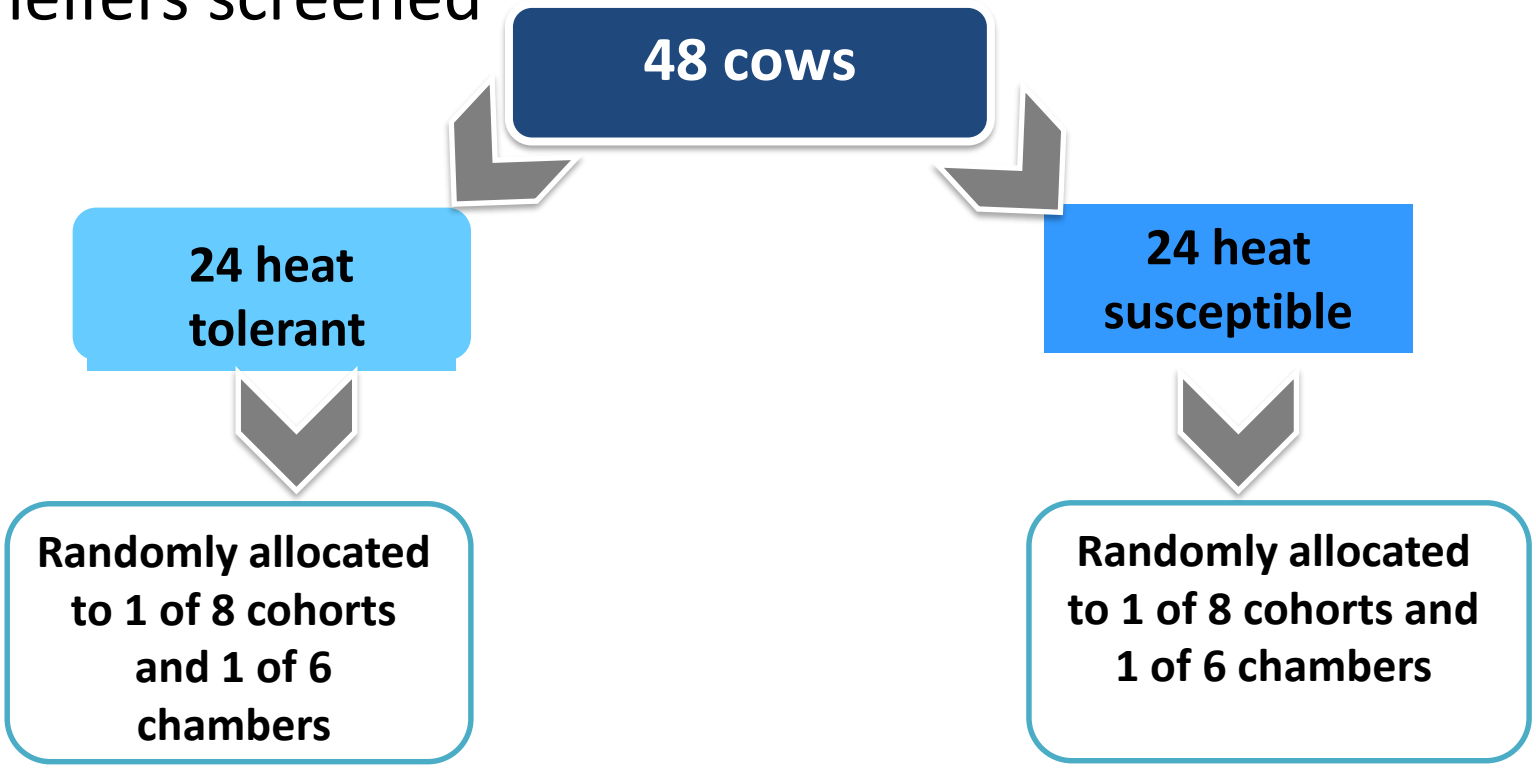


Nguyen *et al* (2017) JDS. 100:7362–7367

Validation of heat tolerance GEBV

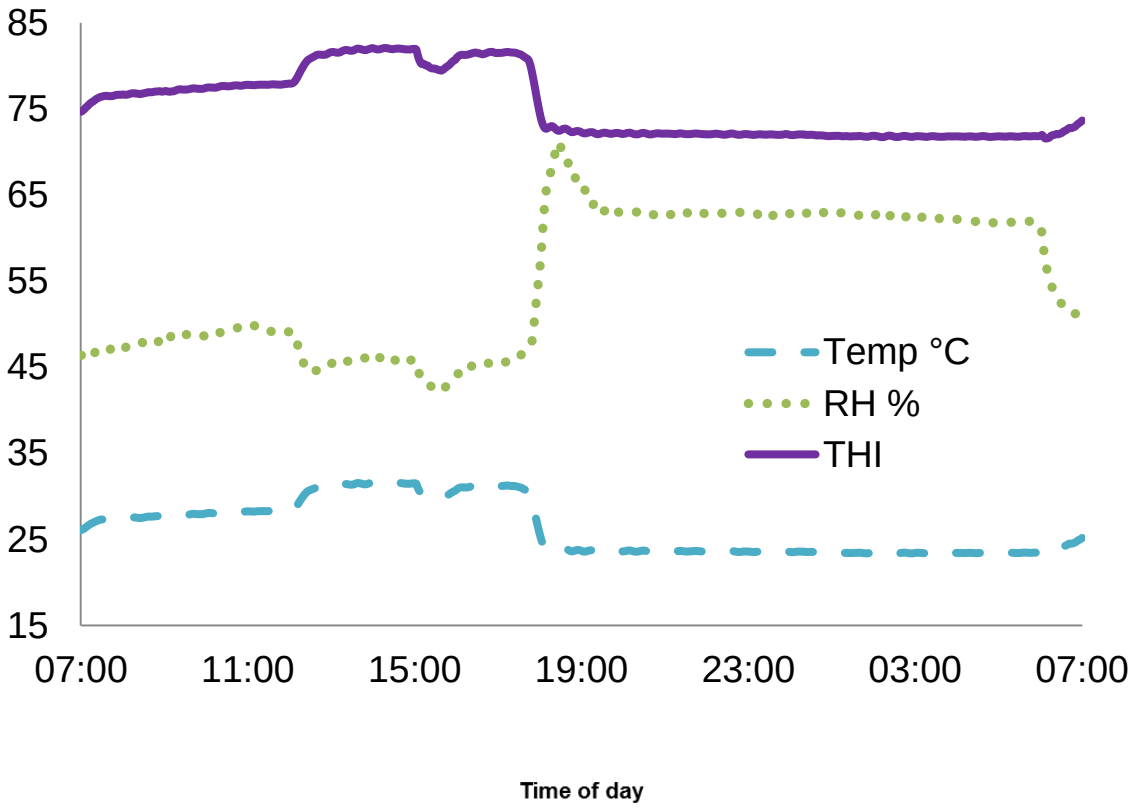
2. Empirical validation

400 heifers screened



Validation of heat tolerance GEBV

2. Empirical validation



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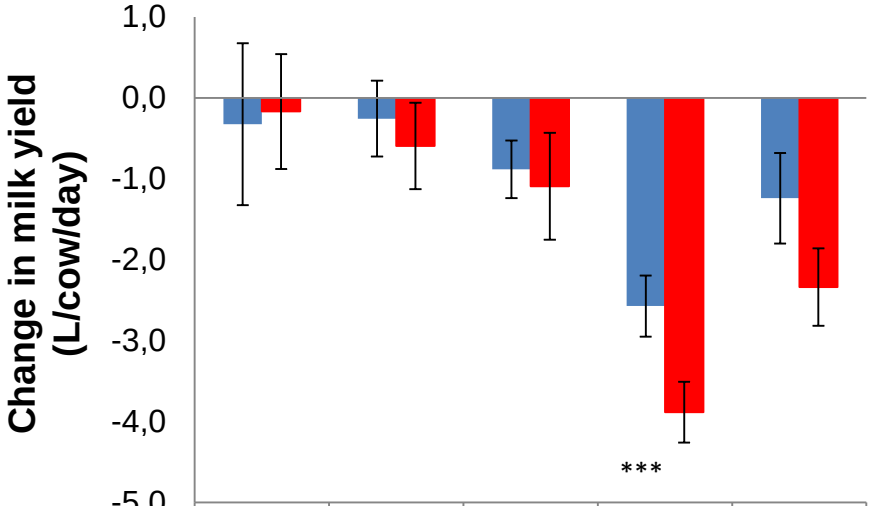
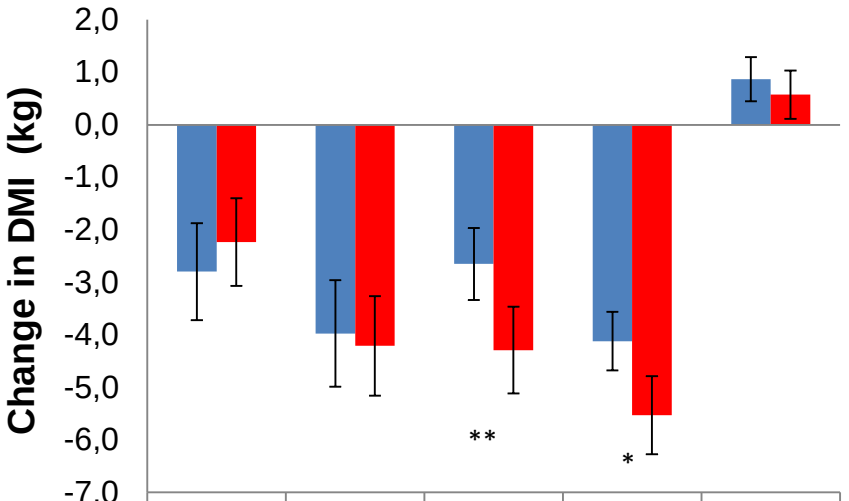
Decline in feed milk yield and dry matter intake



	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



	Day 1	Day 2	Day 3	Day 4	Recovery
HT	-2,8	-4,0	-2,6	-4,1	0,9
HS	-2,2	-4,2	-4,3	-5,5	0,6

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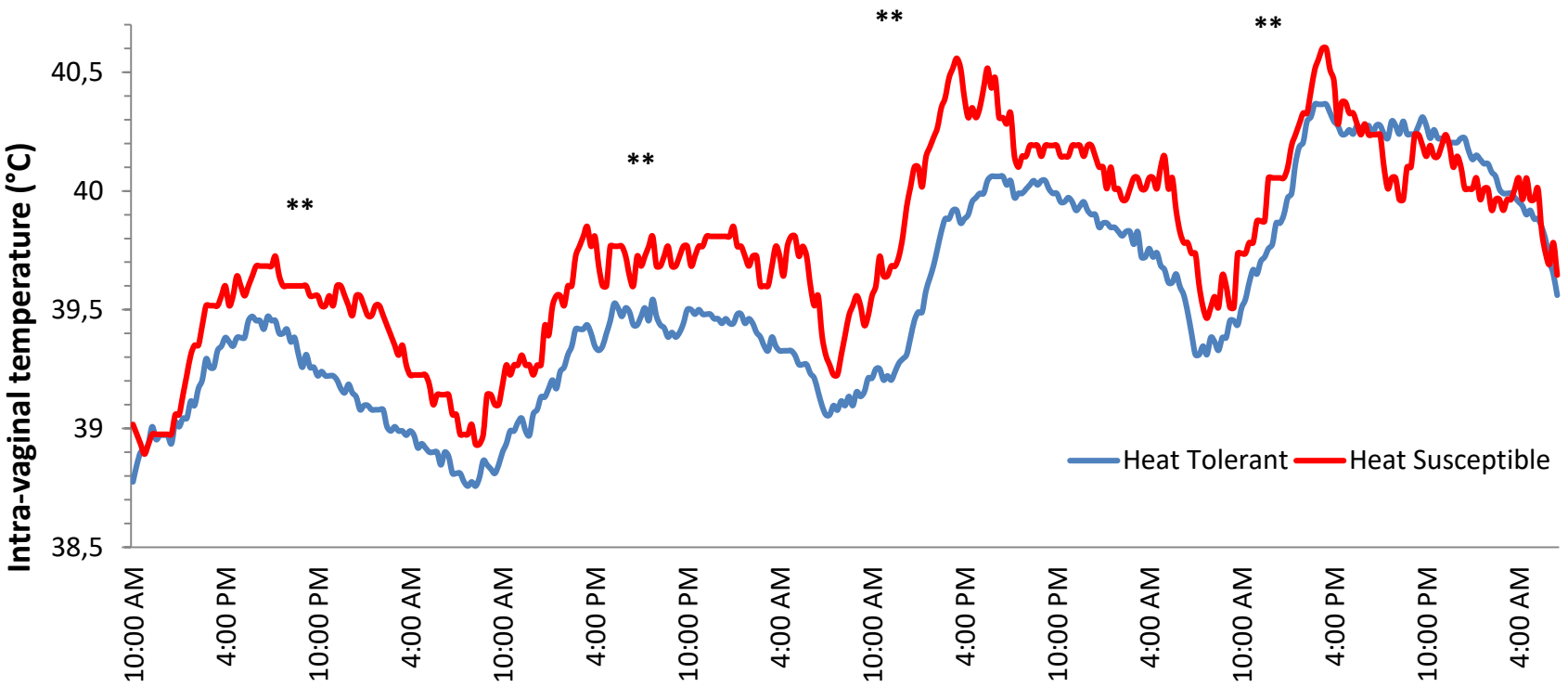
Intra-vaginal temperature



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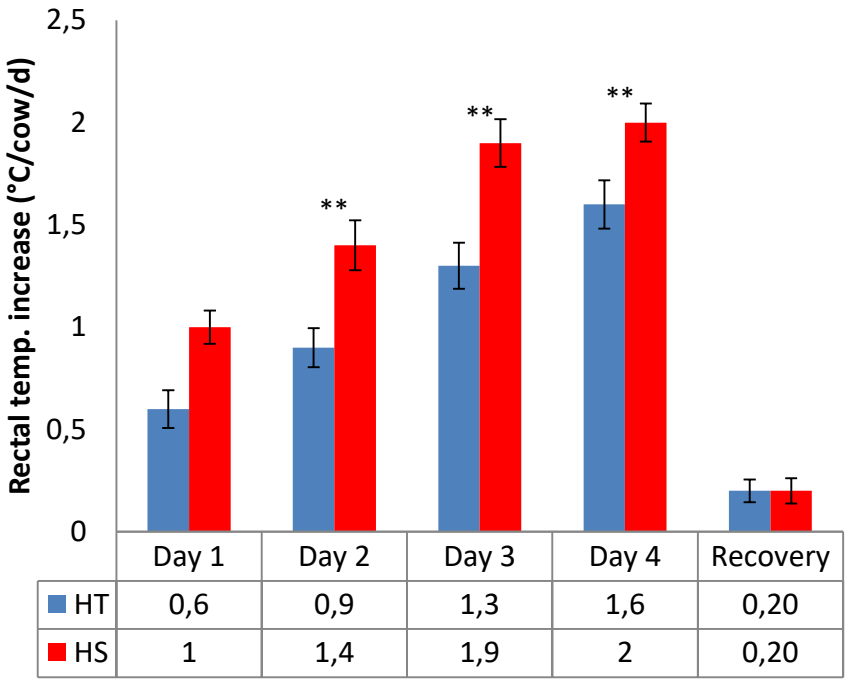
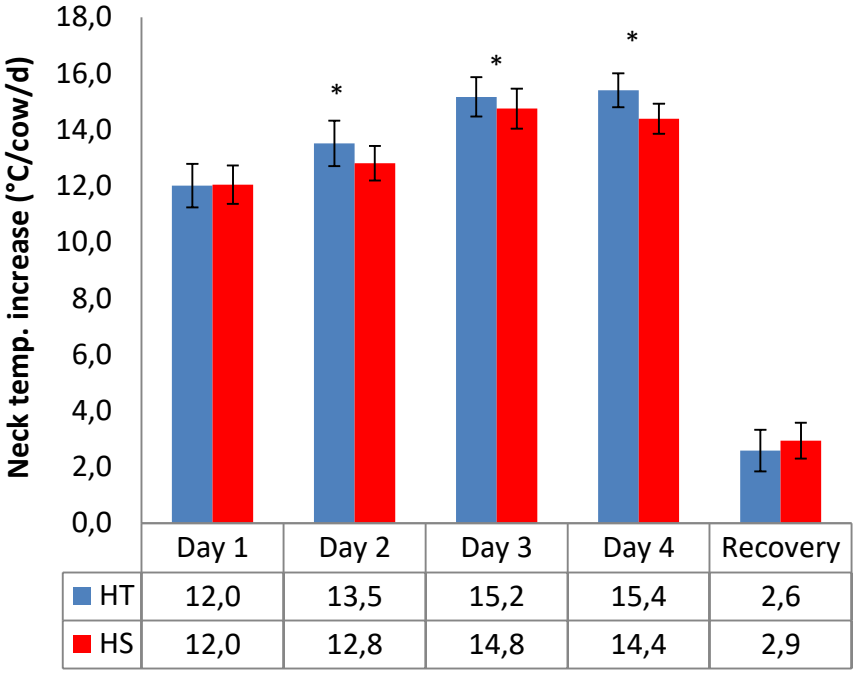
Rectal and neck temperature



	Day 1	Day 2	Day 3	Day 4	Recovery
HT	0,6	0,9	1,3	1,6	0,20
HS	1	1,4	1,9	2	0,20



	Day 1	Day 2	Day 3	Day 4	Recovery
HT	12,0	13,5	15,2	15,4	2,6
HS	12,0	12,8	14,8	14,4	2,9

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The validation findings

- Predicted heat tolerant cows is superior to predicted heat susceptible cows under heat stress
  - Higher feed intake (1.2 kg DM/day)
  - Higher milk yield (5% less decline from baseline)
  - Lower core body temperature (0.6°C)
  - Lower respiration rate (10 breaths/min)
  - Higher skin temperature (1.7°C)
  - Greater milk yield recovery after heat stress (5% better return to baseline).

Genomic breeding values for heat tolerance

- Reliabilities: ~38% average (Nguyen et al. 2016, 2017)
- Validated (Garner et al. 2016)
- Unfavourable to production traits e.g. milk, fat & protein yields
- Favourable to fertility


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


SCIENTIFIC REPORTS
OPEN

Genomic Selection Improves Heat Tolerance in Dairy Cattle

J. B. Garner[1], M. L. Douglas[1], S. R. O Williams[1], W. J. Wales[1], L. C. Marett[1], T. T. T. Nguyen[2],


J. Dairy Sci. 100:7362–7367
https://doi.org/10.3168/jds.2017-12898

Short communication: Implementation of a breeding value for heat tolerance in Australian dairy cattle

Thuy T. T. Nguyen,*[1] Phil J. Bowman,*† Mekonnen Haile-Mariam,* Gert J. Nieuwhof,‡ Benjamin J. Hayes,*

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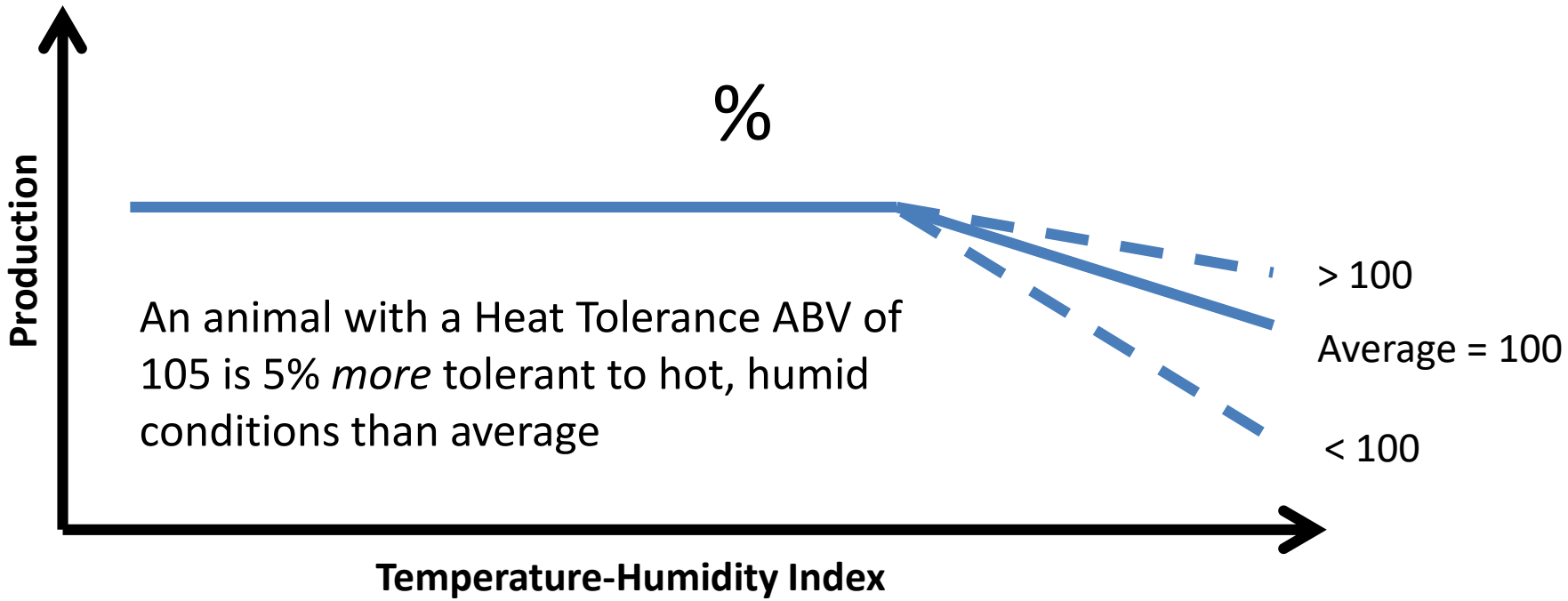
Implementation of heat tolerance GEBV
1. Expression

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

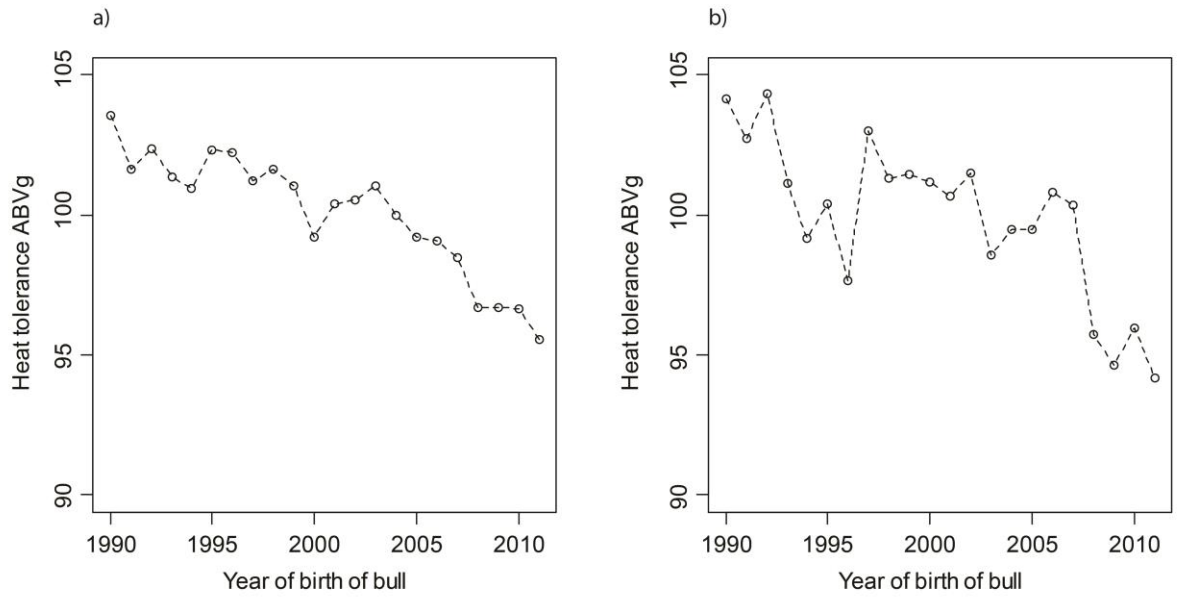
Decline of milk * Economic weight of milk
+
Decline of fat * Economic weight of fat
+
Decline of protein * Economic weight of protein

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

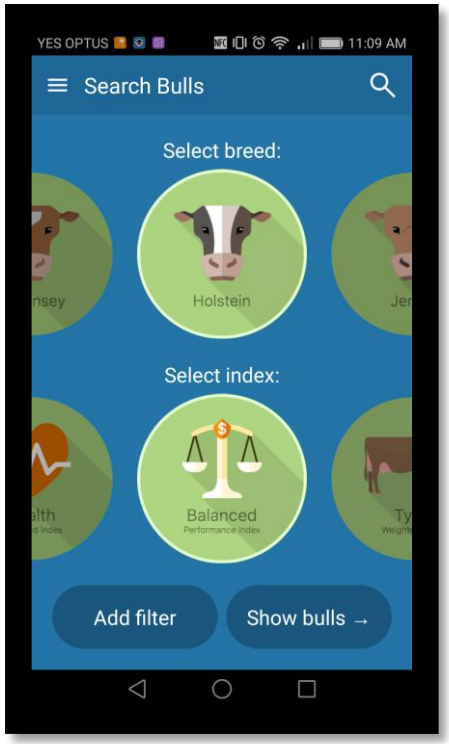
Heat tolerance ABVg

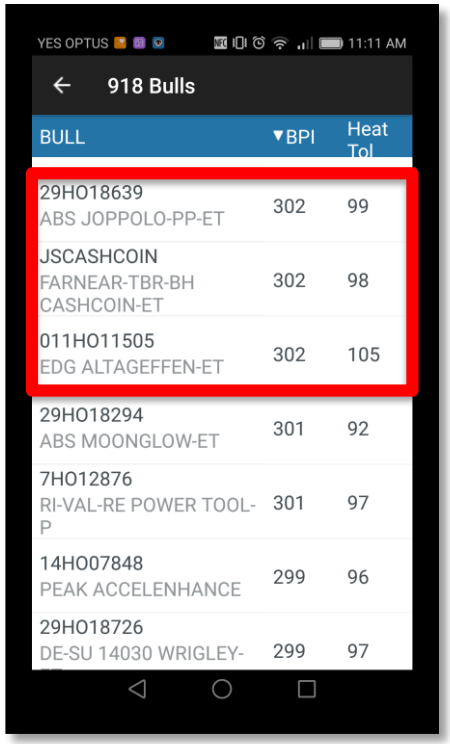


Genetic trend
(decline ~1.5 SD in 20 years)



App available to select bulls





Good Bulls

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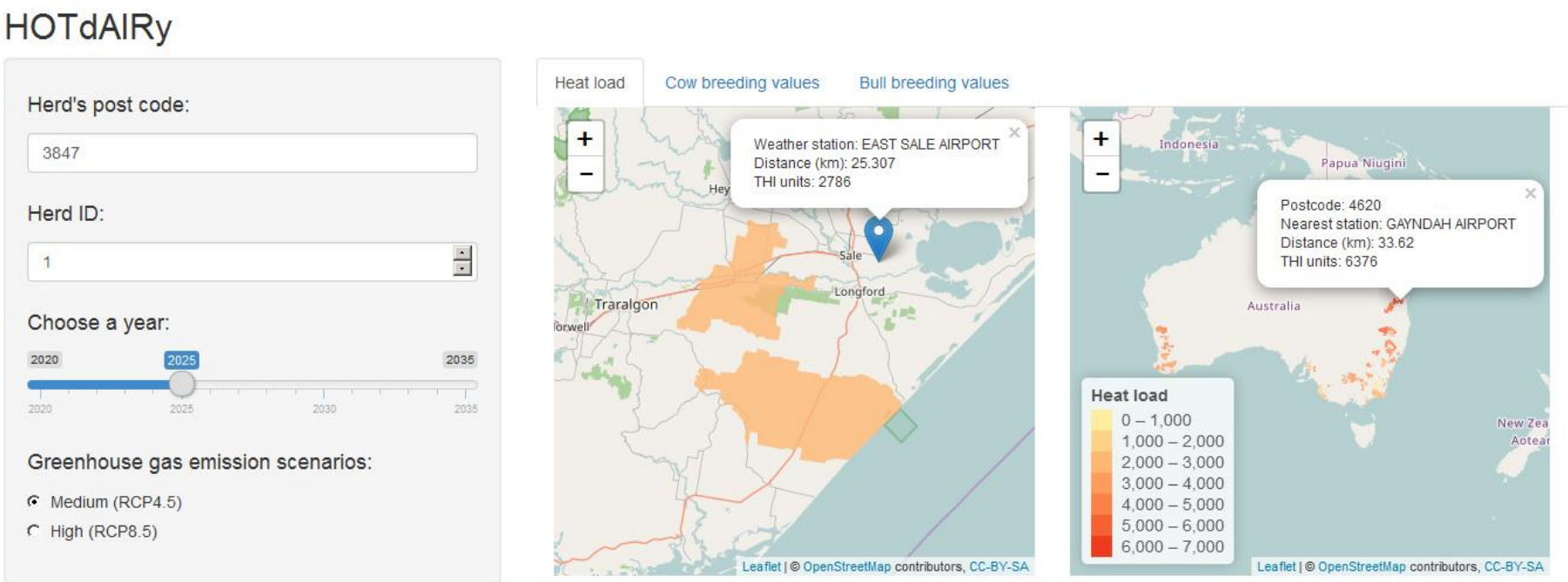
A web app available to balance selection between heat tolerance and other selection indices



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Example output

Bull breeding values

Show 10 entries Search:

	Bull_ID	Breed	BPI	BPI_HT
3212	3212	JJJJ	327	327
3017	3017	JJJJ	291	305
3068	3068	JJJJ	289	304
2447	2447	JJJJ	307	295
3030	3030	JJJJ	291	292
3113	3113	JJJJ	300	292
2939	2939	JJJJ	283	288
5654	5654	JJJJ	289	284
3687	3687	JJJJ	309	281
2920	2920	JJJJ	292	277

Showing 1 to 10 of 10,981 entries Previous 1 2 3 4 5 … 1099 Next

Download

Heat tolerance ABVg was first released in December 2017

NEWS

Breed cool cows using Heat Tolerance

By **Helen Walker**

WITH the changing weather patterns having created a trend towards higher temperatures in some dairying regions, farmers can now select to breed heat tolerant cows.

The Australian Breeding Value (ABV) allows farmers to identify animals with a greater ability to tolerate hot, and humid conditions with less impact on milk production.

The Heat Tolerance Breeding Value ABV is expressed as a percentage with a base of 100.

DataGene extension officer, Lucy Webb-Wilson, told delegates at the Northern Dairy Conference that to breed for improved heat tolerance, they needed to look for high Balance Performance Index (BPI) bulls with a heat tolerance ABV's of greater than and fat test, in-calf rates, liveweight and higher somatic cell counts, more clinical mastitis cases and other heath problems.

Some of these effects last beyond the hot months, and higher production cows are more likely to be affected.

"Dairy farmers use a variety of tools to manage hot weather such as providing shade, fans, water sprinklers and changing the timing of milking and feeding," she said.

The benefits to cooling cows in the

Lucy Web... Dat...

'Cows generate heat internally (metabolic heat) as a result of eatin... and digesting feed.'

DAIRY BUSINESS 67

THEWEEKLYTIMES.COM.AU WEDNESDAY DECEMBER 13 2017

DECEMBER ABVs

Cows ranked to take the heat

By SIMONE SMITH

AUSTRALIAN dairy farmers can now target heat tolerance as part of their breeding program thanks to world-first research conducted in Victoria.

The heat tolerance Australian Breeding Value has been launched as part of the December ABV release from DataGene and is available for genomically tested Jerseys and Holsteins or those which herd record more than five times a year.

Initial research into heat tolerance started in the early 2000s but in recent years work has ramped up using data from the Bureau of Meteorology and herd recording data.

Agriculture Victoria and La Trobe University principal research scientist Dr Jennie Pryce said validation of the heat tolerance trait was completed at Ellinbank.

Dr Pryce said this work as part of Josie Garner's PhD project and include simulating a heatwave for the two groups of cows. "By day four both the heat tolerant and heat susceptible groups had (decreased) production," she said. "The heat tolerant group was down 2.6 litres/cow with the heat susceptible group down 3.9 litres/cow."

Dr Pryce said those with higher tolerance to heat were able to physiologically better with those conditions.

Dr Pryce said there has been global interest in the heat tolerance ABV, with herself and the main researcher Thuy Nguyen invited to speak at a variety of conferences. There has also been interest from African and Indian dairy industries due to their climate.

Dairy farmers wanting to select cows that have a greater ability to tolerate heat need to look at the heat tolerance ABV expressed as a percentage with a base of 100.

According to DataGene, an animal with a heat tolerance ABV of 105 is 5 per cent more tolerant to hot, humid conditions that average. Its fall in production would be 5 per cent less than average.

DataGene has suggested farmers looking to breed heat tolerance should look for bulls with a combination of a high Balanced Performance Index and a heat tolerance than 100.

the same unfavourable correlation between production and fertility during the initial development of the fertility trait but this has now changed with bulls ranking well on the balanced performance index for both fertility and production.

Yet some bulls bucked the When it came to heat tolerance production. Three (BPI list) had heat toler...

Hay...

Driving genetic gain and herd improvement

DataGene Solutions for Herd Development

Breeding for heat tolerance

Key points

- Heat tolerance impacting breeding decisions
- A key part of bereeding programs

WHEN bull-buying clients started asking Holstein breeder Trevor Parrish about the new Heat Tolerance ABV, he knew he had to make sure he was breeding what his customers wanted.

Mr Parrish runs Illawambra Holsteins in the Kangaroo Valley, NSW, selling about 30 bulls and 100 females a year to other dairy farmers, with these sales making up a sizeable share of the farm business.

The Illawambra herd ranked number one in Australian Holstein herds for profit (Balanced Performance I - BPI), health (Health Weighted Index - HWI) and type (Type Weighted Index - TWI) in DataGene's August 2017 release of Australian Breeding Values (ABVs).

While leading the breed indices, Mr

Leading Holstein breeder, Trevor Parrish from Kangaroo Valley, NSW, intends to add breading for heat tolerance to his tool box for managing his herd in hot, humid weather.

On farm experience

The Parrish dairy business involves Trevor, his wife Leah, their daughter Toni who has taken over the book work and son-in-law Nathan helps when not doing his electrical job.

The family milks between 160 to 240 cows all year round and have had first-hand experience with the impact of high

in production will be 5pc less than the average.

The Heat Tolerance ABV is favourably correlated with fertility and unfavourably with production, but natural genetic variation means there will be some high production animals with greater heat tolerance. Its reliability is 38% which is lower than conventional production traits but in line with the newer generation of genomic-only traits. This is expected to improve with time as heat tolerance is added into breeding programs.

Mr Parrish has been genomically testing all Illawambra heifers for two to three generations, allowing him to cull on BPI.

"With our females, we focus on the whole herd rather than individual cows and draw a line in the sand for BPI at 150 - if a female is below the required level then they don't stay," he said.

"We just need to make sure we iden-

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Take home messages

- It's possible to breed for heat tolerance
  - GEBV has been developed
  - GEBV has been validated
  - Heat tolerance is unfavourable to production traits, but favourable to fertility

- Genomic breeding values was released in Dec 2017

What's next?

- Heat tolerance in relation to health and fertility
- Genotype by environment interactions for heat tolerance
- Genome wide association studies using full sequence data
- Evaluating predictors of heat tolerance

Acknowledgements

- EAAP and ADSA
- The Department of Agriculture & Water Resources
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- Dairy Futures CRC, DairyBio
- CSIRO and Bureau of Meteorology – Climate Change in Australia