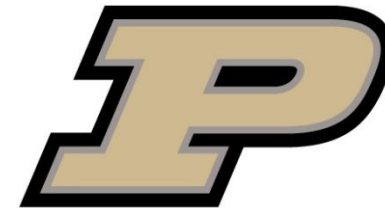




The 75th EAAP Annual Meeting
1/5 September 2024 - Florence, Italy



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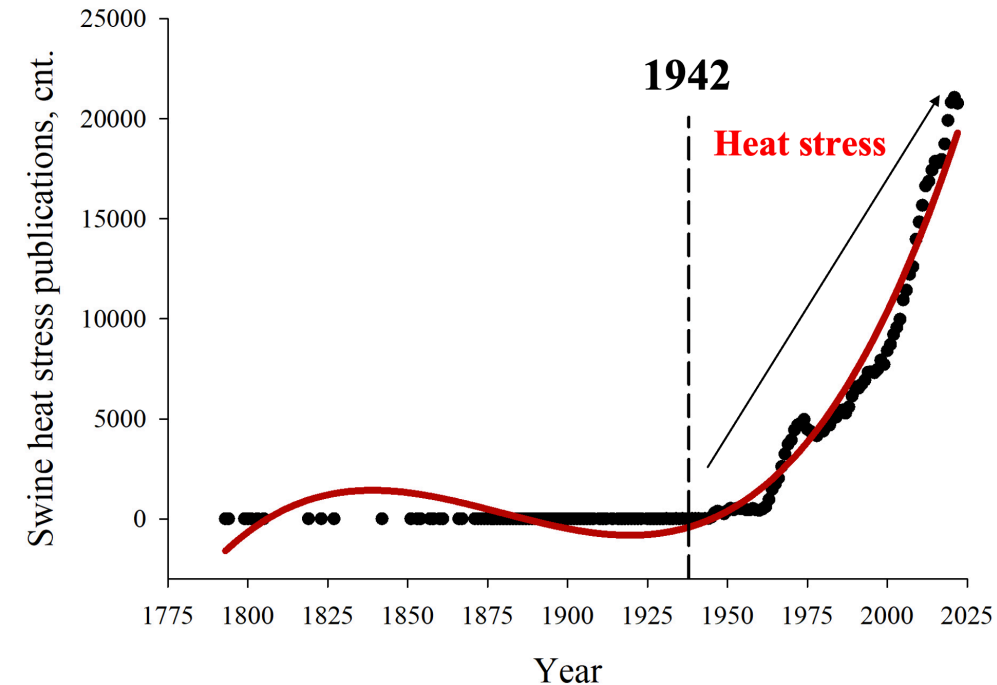
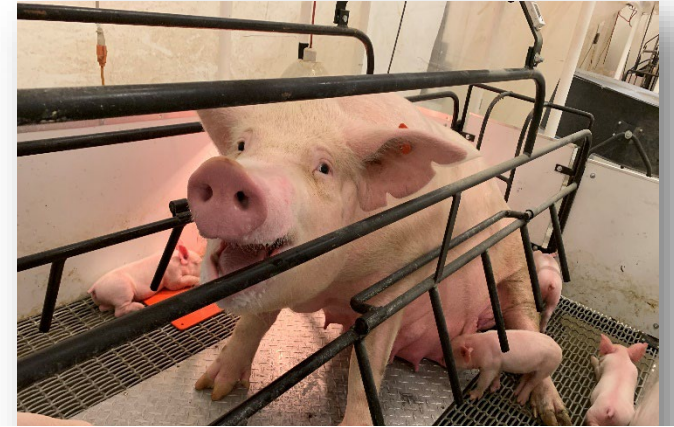
Genetic parameters for novel climatic resilience indicators derived from automatically-recorded vaginal temperature in lactating sows under heat stress conditions

Luiz Brito, Hui Wen, and Jay Johnson



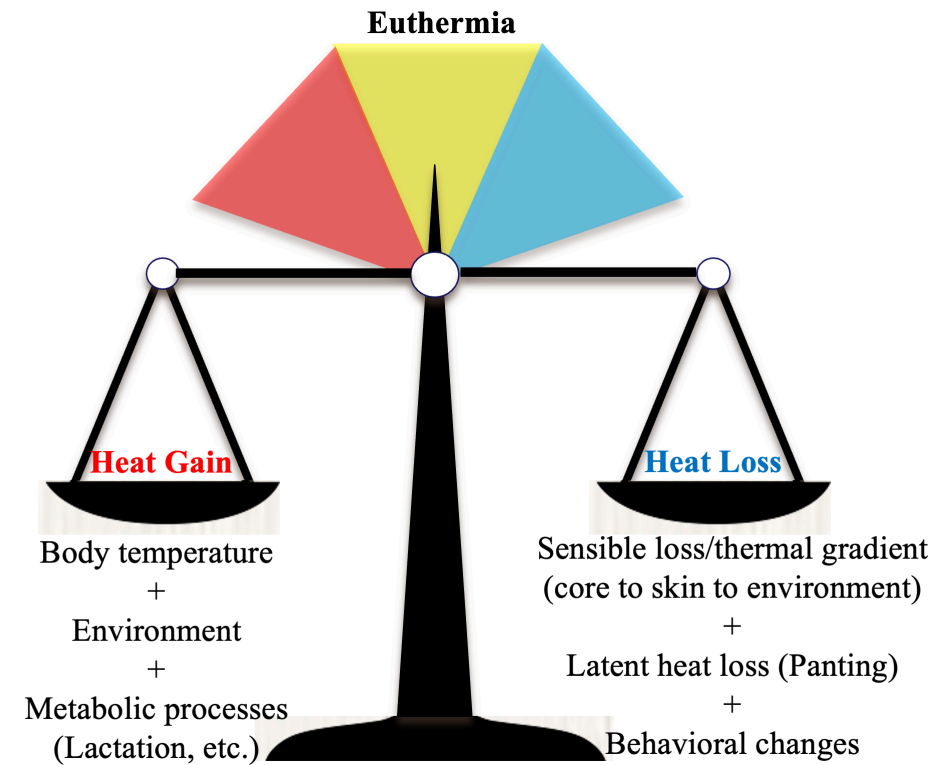
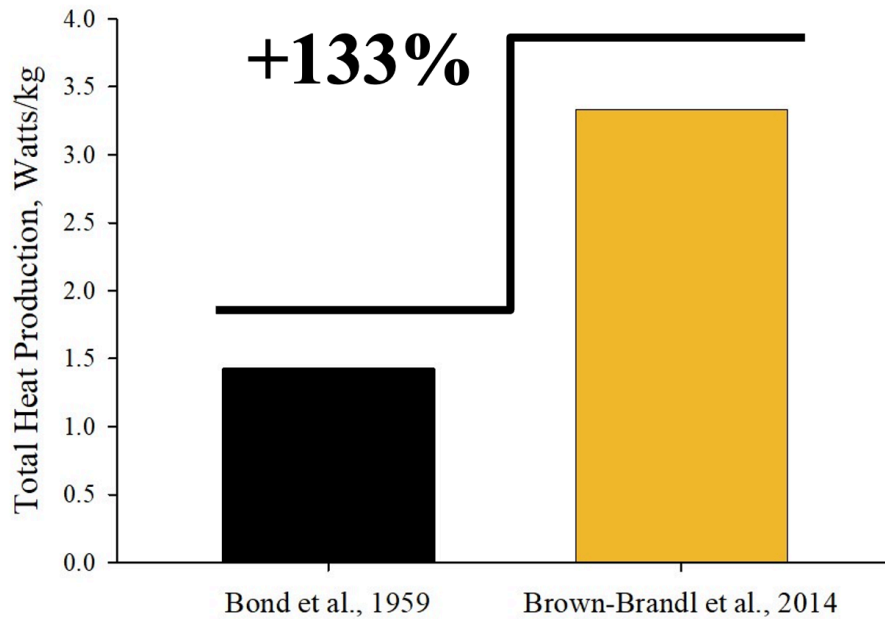
The Impact of Heat Stress in the Swine Industry

- ✓ Global animal agriculture losses: >**\$50 Billion/year**
- ✓ \$299 million in losses for U.S. swine industry per year
 - Based on 2003 data (St-Pierre *et al.*, 2003)
 - **\$511 million/year** when adjusted for inflation
- ✓ \$55 in losses/sow/year due to reproductive issues
 - Based on 2010 estimates (Pollmann, 2010)
 - **\$79.20 per sow** today when adjusted for inflation

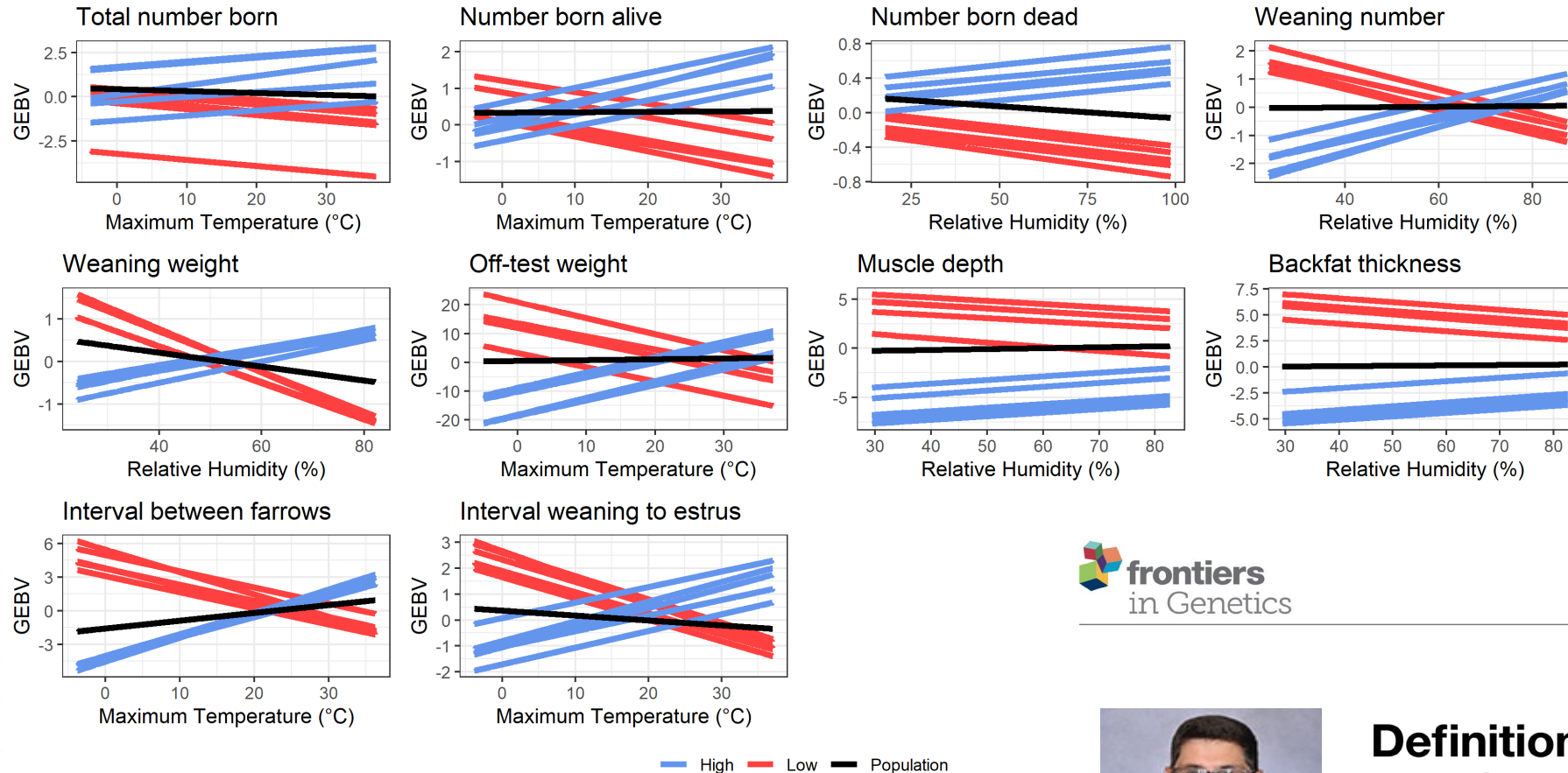


Genetic Improvement and Heat Tolerance

- ✓ Genetically selected pigs are **more productive** and have **greater metabolic heat production**



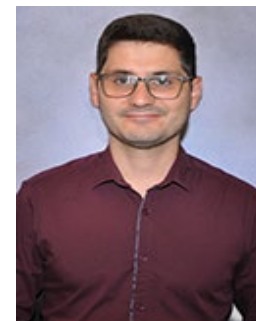
Heat Tolerance Based on Routinely-recorded Data



Clear re-ranking across environments for multiple traits

frontiers
in Genetics

ORIGINAL RESEARCH
published: 23 November 2021
doi: 10.3389/fgene.2021.717409



Definition of Environmental Variables and Critical Periods to Evaluate Heat Tolerance in Large White Pigs Based on Single-Step Genomic Reaction Norms

P. H. F. Freitas¹, J. S. Johnson², S. Chen^{1,3}, H. R. Oliveira^{1,4}, F. Tiezzi⁵, S. F. Lázaro^{1,6}, Y. Huang⁷, Y. Gu⁷, A. P. Schinckel¹ and L. F. Brito^{1*}

Accurate Genomic Predictions Can Be Obtained

Trait	Environmental variable	GEBV accuracies			
		Intercept		Slope	
		Average	95% CI	Average	95% CI
OTW_30	MaxT	0.6275	0.6270–0.6279	0.6347	0.6341–0.6351
MDP_30	RH	0.6557	0.6541–0.6574	0.3554	0.3539–0.3569
BFT_30	RH	0.7017	0.7000–0.7033	0.5772	0.5756–0.5787
WN_wd	RH	0.4398	0.4376–0.4420	0.3693	0.3671–0.3715
WW_wd	RH	0.4206	0.4194–0.4218	0.4726	0.4713–0.4739
TNB	MaxT	0.6562	0.6555–0.6568	0.4702	0.4696–0.4708
NBA	MaxT	0.6435	0.6429–0.6441	0.4694	0.4687–0.4700
NBD	RH	0.6144	0.6138–0.6150	0.4388	0.4381–0.4394
IBF	MaxT	0.5313	0.5306–0.5320	0.4587	0.4580–0.4594
IWE	MaxT	0.5669	0.5663–0.5676	0.4587	0.4581–0.4594

Heat Tolerance
Indicator

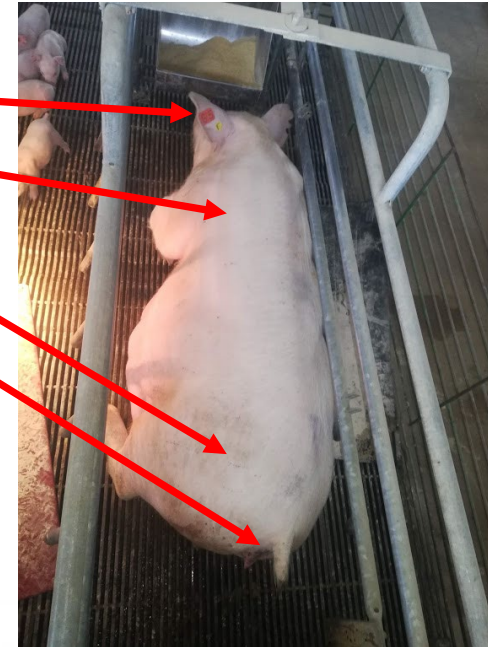
Slope

Heat tolerance can be predicted with moderate accuracy based on routinely-recorded phenotypes and public weather station data

However, in general, moderate to high genetic correlations between intercept (average performance) and slope (heat tolerance)

Novel Traits: Direct Indicators of Heat Stress Response

Trait	Number of records	Number of animals with records
Ear temp. °C	25,568	1,645
Shoulder temp. °C	25,572	1,645
Rump temp. °C	25,571	1,643
Tail temp. °C	25,570	1,643
Automatically-recorded vaginal temp. °C	932,926	1,381
Respiration rate/min	25,815	1,643
Caliper BCS	1,615	1,615
Visual BCS	1,598	1,598
Hair density score	1,344	1,344
Body size score	1,639	1,639
Average panting score	6,577	1,642
Hair cortisol	1,656	1,656
Ethogram (during shaving – multiple traits)	1,656	1,656
Ear pictures	1,656	1,656
Vaginal swabs (microbiome analyses)	1,656	1,656



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Journal of Animal Science, 2023, **101**, 1–14
<https://doi.org/10.1093/jas/skad129>
Advance access publication 27 April 2023
Environmental Animal Science

Evaluating phenotypes associated with heat tolerance and identifying moderate and severe heat stress thresholds in lactating sows housed in mechanically or naturally ventilated barns during the summer under commercial conditions

Jay S. Johnson,^{†,1,✉} Hui Wen,[‡] Pedro H. F. Freitas,[‡] Jacob M. Maskal,[‡] Sharlene O. Hartman,[‡] MaryKate Byrd,[‡] Jason R. Graham,[‡] Guadalupe Ceja,[‡] Francesco Tiezzi,^{||} Christian Maltecca,^{§,1✉} Yijian Huang,^{||} Ashley DeDecker,^{||} Allan P. Schinckel,^{‡,1✉} and Luiz F. Brito^{‡,1✉}

For sows housed in naturally and mechanically ventilated facilities:

Moderate HS threshold T_{DB} were 27.36 and 26.69 °C and Severe HS threshold T_{DB} were 29.45 and 30.60 °C

All Traits Evaluated are Heritable



Trait	Heritability
Ear temp. - T_{ES}	0.04 ± 0.01
Shoulder Temp. - T_{SS}	0.06 ± 0.01
Rump Temp - T_{RS}	0.06 ± 0.01
Tail temp - T_{TS}	0.05 ± 0.01
Vaginal temp. - T_{V4days}	0.22 ± 0.03
Vaginal temp. - T_{V8h}	0.23 ± 0.03
Vaginal temp. - T_{V12h}	0.24 ± 0.03
Vaginal temp. - T_{V16h}	0.19 ± 0.02
Vaginal temp. - T_{V20h}	0.20 ± 0.04
Vaginal temp. - T_{V8hS}	0.25 ± 0.05
Vaginal temp. - T_{V12hS}	0.29 ± 0.05
Vaginal temp. - T_{V16hS}	0.22 ± 0.03
Vaginal temp. - T_{V20hS}	0.22 ± 0.03

Trait	Heritability
Resp. rate - RR	0.06 ± 0.01
Panting Score - PS	0.05 ± 0.01
Resp. effic. - R_{eff}	0.03 ± 0.01
BCS _{Cal}	0.29 ± 0.04
BCS _{Vis}	0.25 ± 0.04
Hair density - HD	0.25 ± 0.05
Body size - BS	0.33 ± 0.05
Ear area - EA	0.40 ± 0.09
Ear length - EL	0.32 ± 0.07
Sow reactivity	0.15 ± 0.05
Handling time	0.11 ± 0.05

Freitas et al. *Genetics Selection Evolution* (2023) 55:65
<https://doi.org/10.1186/s12711-023-00842-x>

Genetics Selection Evolution

RESEARCH ARTICLE

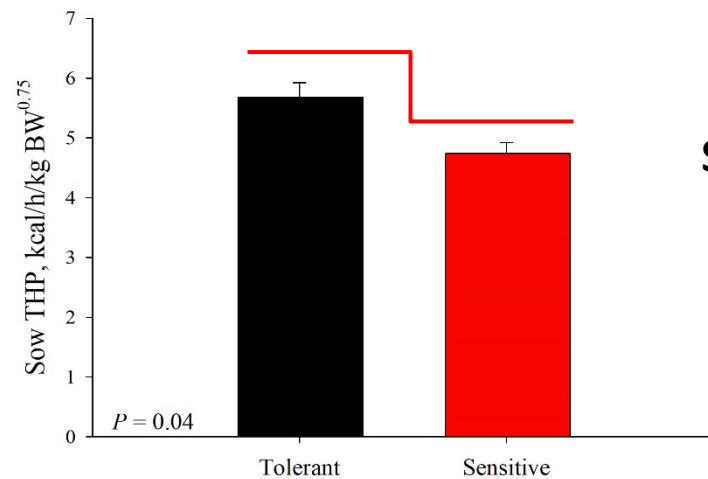
Open Access

Genetic parameters for automatically-measured vaginal temperature, respiration efficiency, and other thermotolerance indicators measured on lactating sows under heat stress conditions

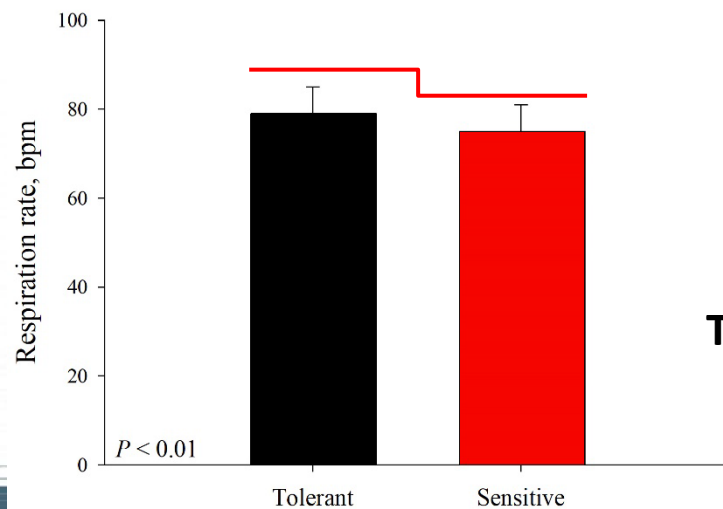
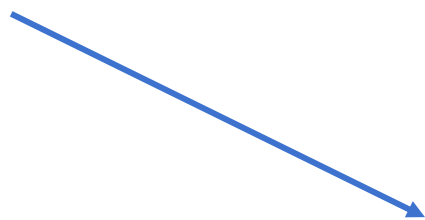
Pedro H. F. Freitas¹, Jay S. Johnson², Hui Wen¹, Jacob M. Maskal¹, Francesco Tiezzi^{3,4}, Christian Maltecca³, Yijian Huang⁵, Ashley E. DeDecker⁶, Allan P. Schinckel¹ and Luiz F. Brito^{1*}

Slope of automatically-recorded vaginal temperature on EG was the best indicator of HS response

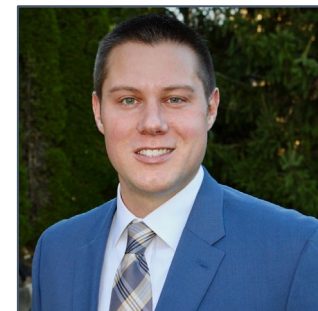
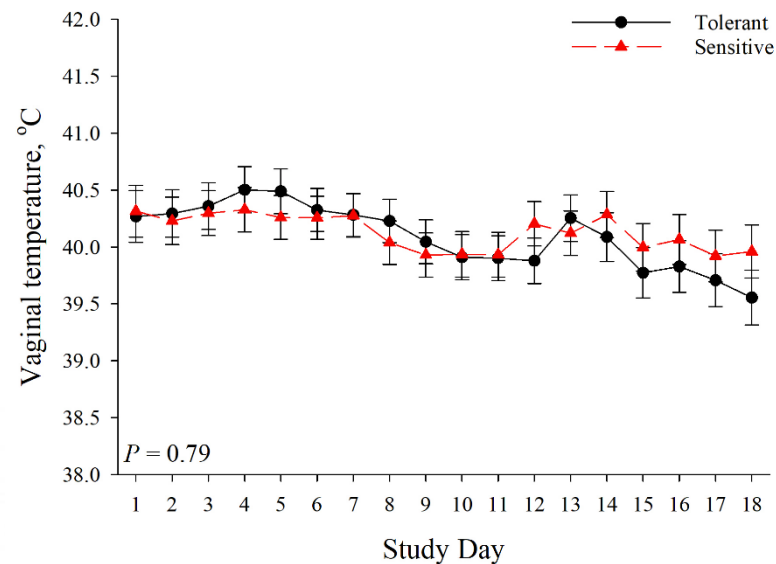
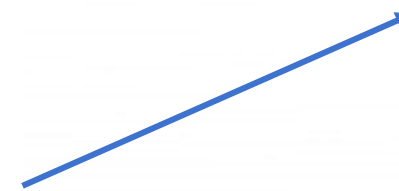
Biological Validation: F0 Generation



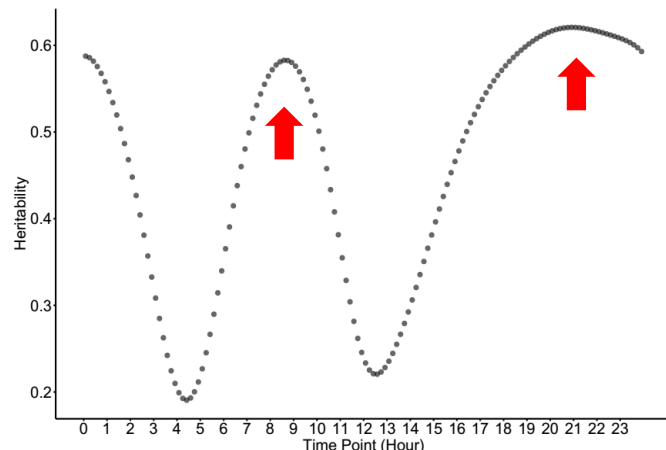
SEN = Decrease heat gain



TOL = Increase heat loss



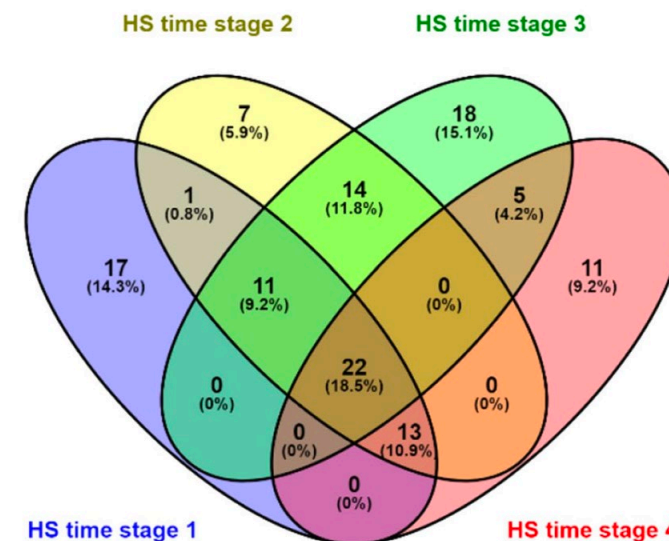
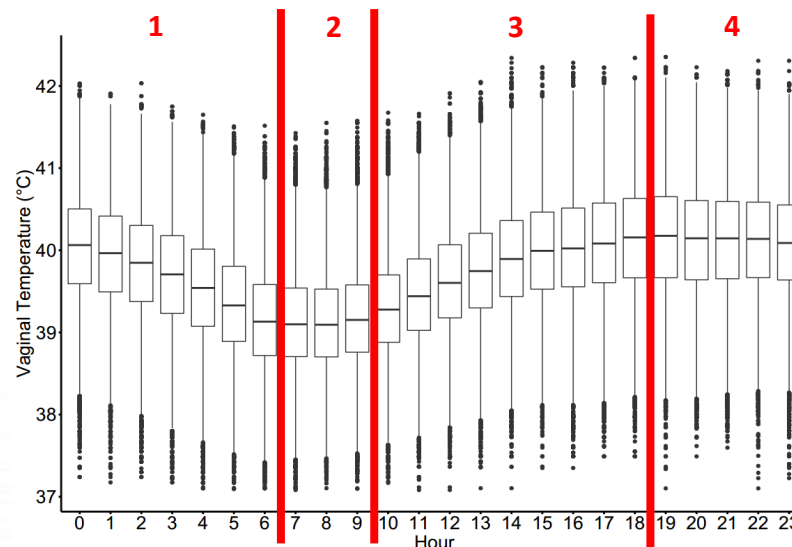
Time-dependent Genetic Effects



The heritability of T_v is variable throughout the day

Stages:

- 1) From 2300h to 0630h
- 2) From 0630h to 0930h
- 3) From 0930h to 1830h
- 4) From 1830h to 2300h



RESEARCH ARTICLE

Open Access

Longitudinal genomic analyses of automatically-recorded vaginal temperature in lactating sows under heat stress conditions based on random regression models

Hui Wen¹, Jay S. Johnson², Pedro H. F. Freitas¹, Jacob M. Maskal¹, Leonardo S. Gloria¹, Andre C. Araujo¹, Victor B. Pedrosa¹, Francesco Tiezzi^{3,4}, Christian Maltecca³, Yijian Huang⁵, Allan P. Schinckel¹ and Luiz F. Brito^{1*}

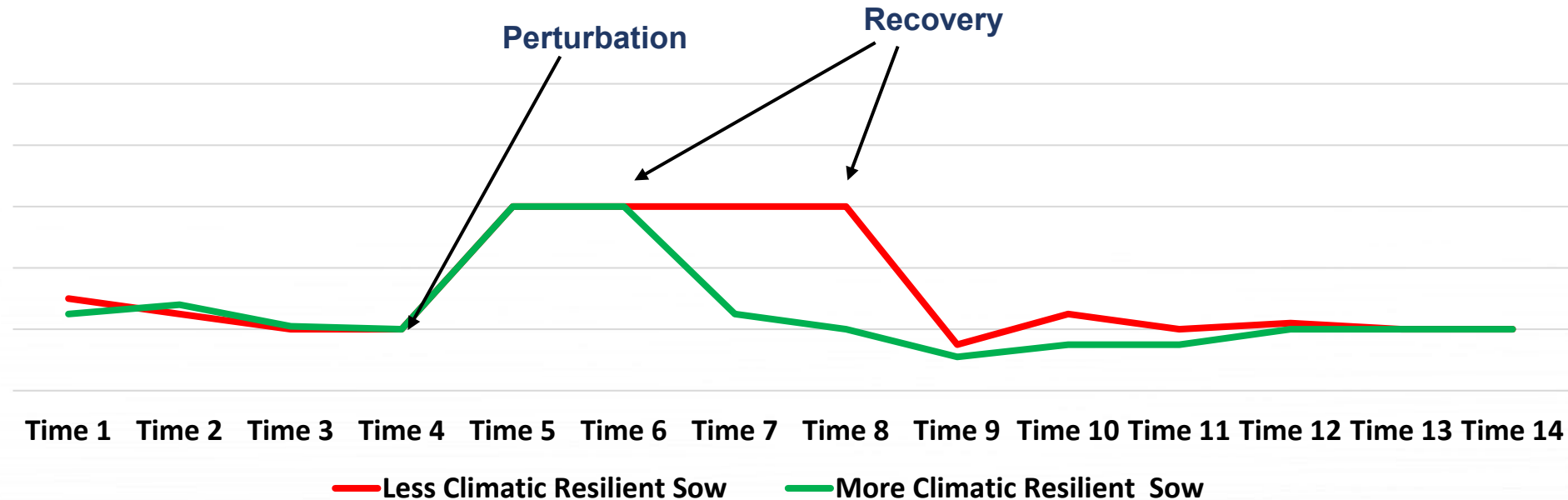
Objectives

- ✓ Derive novel indicators of climatic resilience based on automatically-recorded vaginal temperature in lactating sows under heat stress conditions
- ✓ Estimate variance components and genetic parameters for these indicators



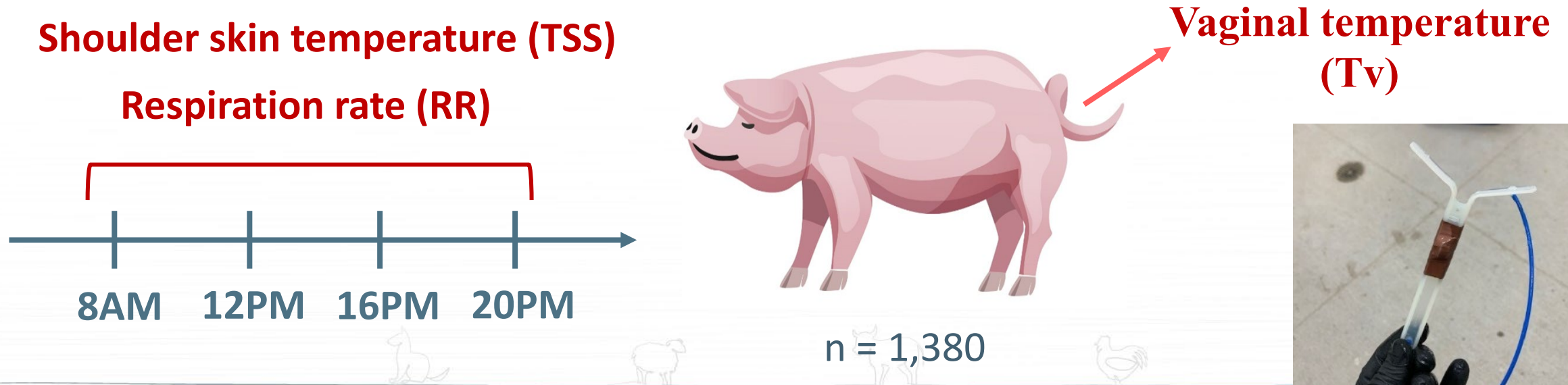
Defining Climatic Resilience

- ✓ “The ability of an animal to **maintain or rapidly return to euthermia** under thermally stressful conditions”



Material and Methods

- **Animal population:** 1,645 multiparous **lactating sows** (Landrace × Large White cross) during 2021 summer at a commercial farm in Maple Hill, NC, USA
- ✓ **Genotype:** PorcineSNP50K Bead Chip (50,703 SNPs)



Climatic Resilience Indicators

16 CR indicators based on vaginal temperature (T_v)

Moving value approach:

Mean or **Median** value from each moving window

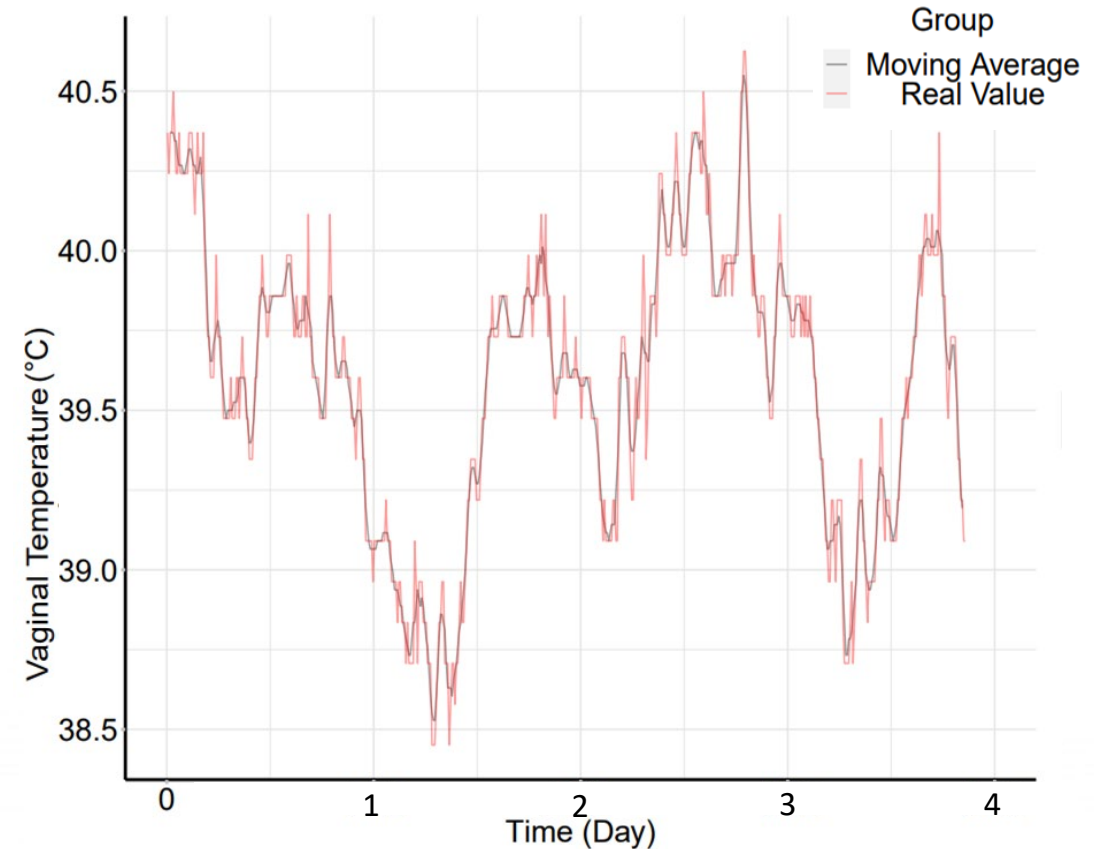
 **Deviations** between observed and moving values

LnVar: Variance of deviations

Autocor: Lag-1 autocorrelation of deviations

Skew: Skewness of deviations

Smaller values are more desirable



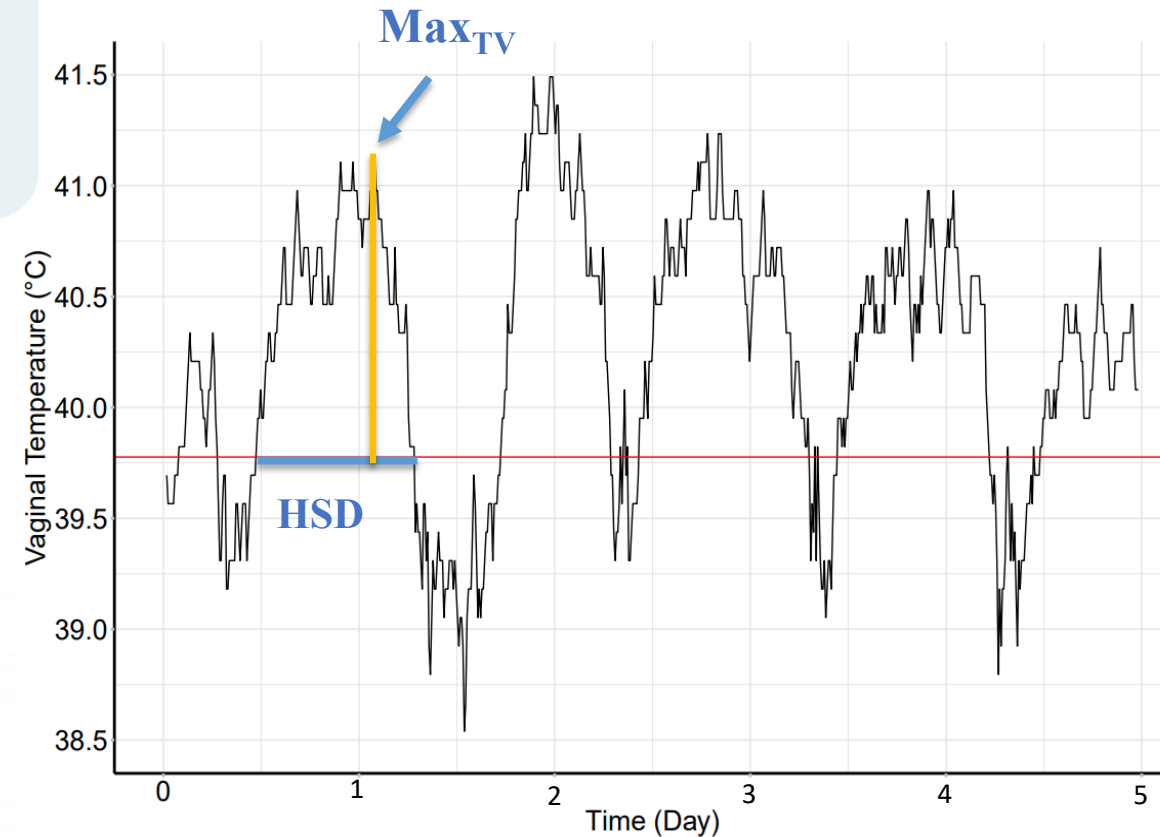
Climatic Resilience Indicators

HS threshold value for different barn types:

mechanical (39.7565 C) and natural (39.7798 C) ventilation
(Johnson et al., 2023)

HSD: the length of time during which the body temperature remained above the heat stress threshold value

Max_{TV}: the highest TV of each collection day for each individual



Smaller values are more desirable

Climatic Resilience Indicators

Slope_{In}: log (slope of the increased T_v)

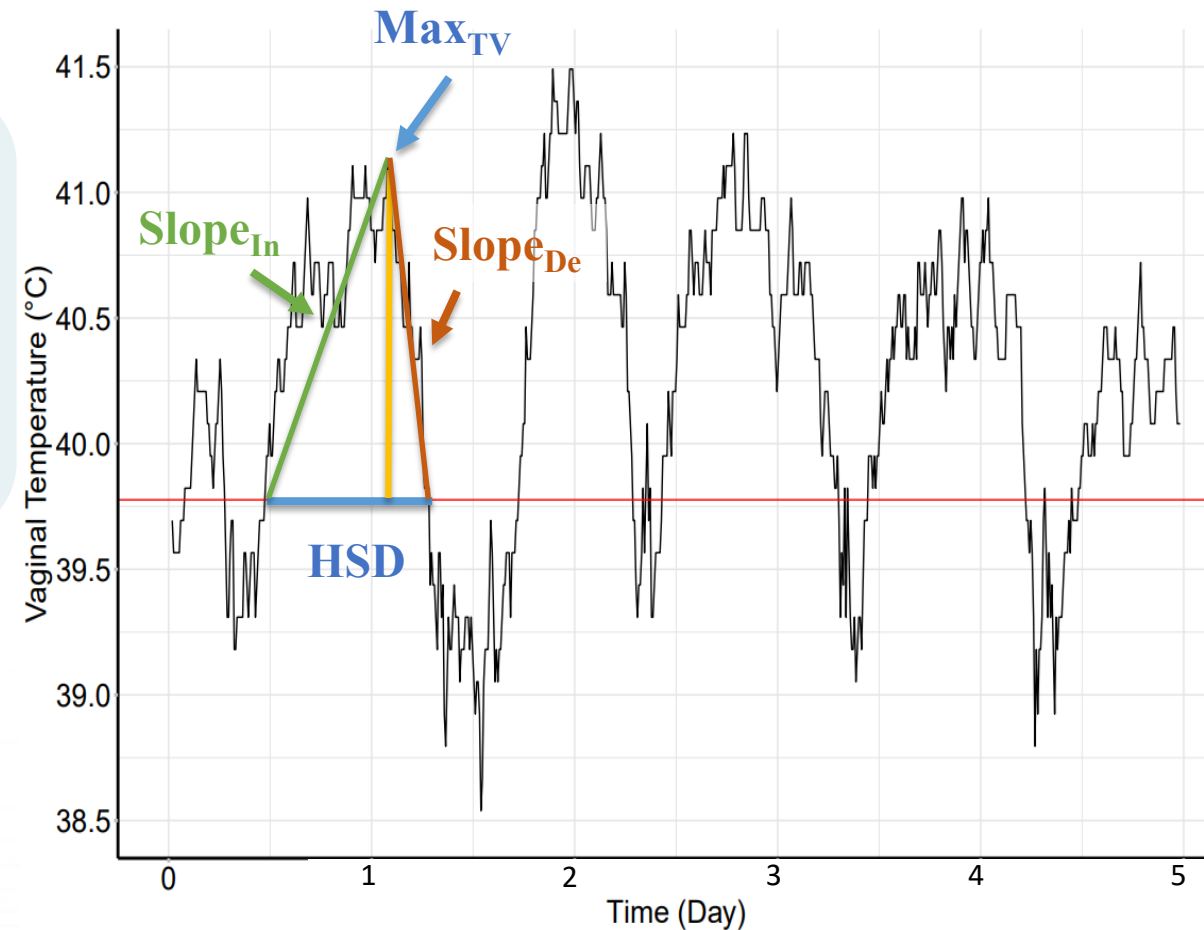
Slope_{De}: log (slope of the decreased T_v)

RA_{slope}: log (ratio between **Slope_{In}** and **Slope_{De}**)

Smaller Slope_{In} / Ra_{slope} **or** **Larger** Slope_{De}



Better climatic resilience



Climatic Resilience Indicators

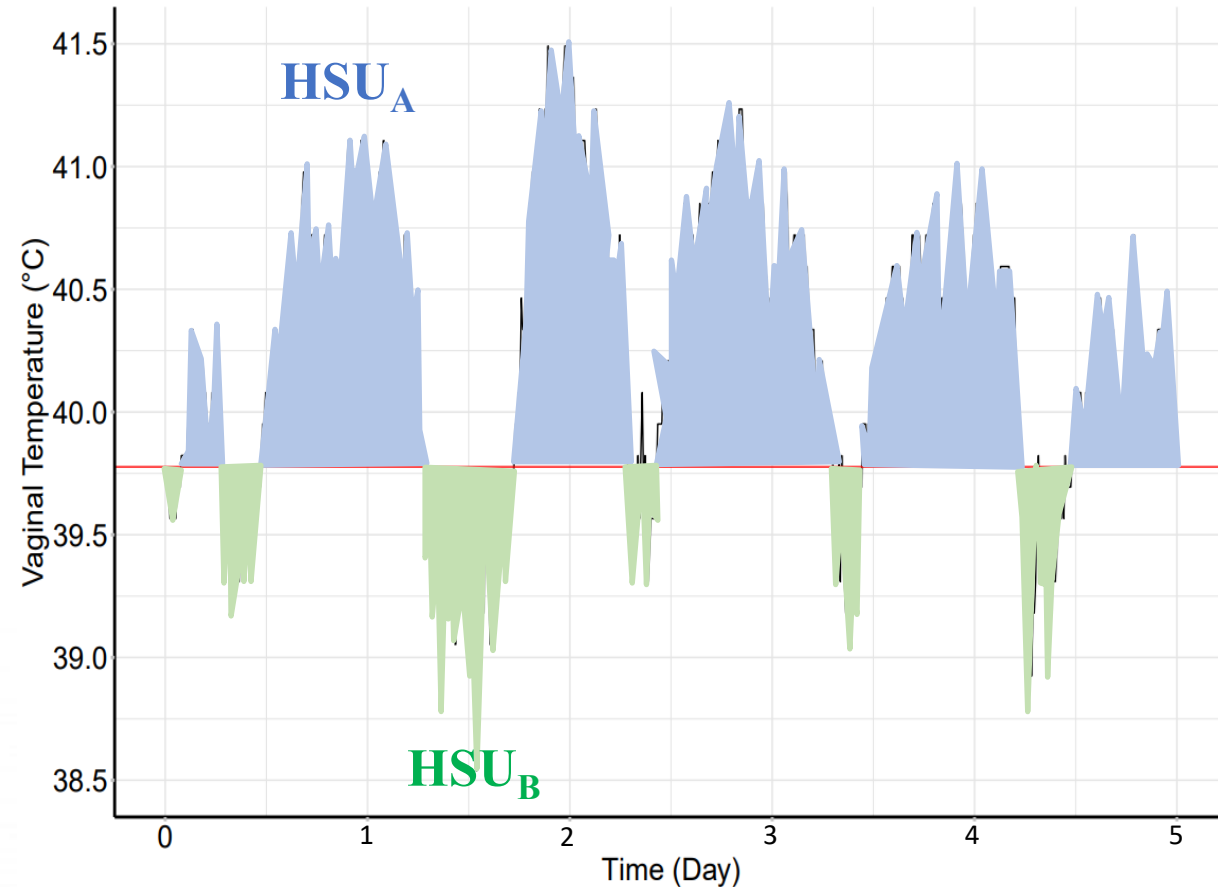
HSU_A: the sum up of the Tv **above** the HS threshold

HSU_B: the sum up of the Tv **below** the HS threshold

Smaller HSU_A and HSU_B



Better climatic resilience



Descriptive Statistics

Trait	Num. of records	Mean	SD	Median	Min	Max
LnVar (Ave)	1,380	0.0072	0.005	0.006	0.0016	0.047
Autocor (Ave)	1,380	-0.0080	0.065	-0.009	-0.2115	0.232
Skew (Ave)	1,380	-0.0249	0.375	0.016	-2.4731	1.564
LnVar (Med)	1,380	0.0065	0.005	0.005	0.0010	0.046
Autocor (Med)	1,380	0.0640	0.070	0.064	-0.1569	0.279
Skew (Med)	1,380	-0.1733	0.746	-0.083	-4.5751	2.567
RMSE _{Tv}	1,380	0.7662	0.285	0.701	0.2934	2.555
HSD	6,034	74.3871	41.350	75	0	144
Max _{Tv}	6,539	40.6210	0.594	40.646	37.4979	42.842
Slope _{In}	5,077	1.5027	0.419	1.367	0.7226	3.003
Slope _{De}	5,837	3.4670	0.026	3.473	2.9420	3.477
RA _{slope}	4,980	2.9165	0.726	2.829	0.8447	4.851
Nor_medvar	1,380	0.1340	0.080	0.120	0	0.637
Nor_avevar	1,380	0.251	0.124	0.234	0	1
HSU _A	1,380	196.290	180.689	146.400	0	979.417
HSU _B	1,380	-218.404	177.820	-177.994	-1086.628	0



Heritability Estimates and GEBV Accuracies

Trait	Heritability (SE)	Mean GEBV accuracy
LnVar(Ave)	0.18 (0.0003)	0.56
Autocor(Ave)	0.15 (0.042)	0.51
Skew(Ave)	0.15 (0.041)	0.50
LnVar(Med)	0.20 (0.041)	0.62
Autocor(Med)	0.11 (0.039)	0.45
Skew(Med)	0.08 (0.037)	0.41
RMSE _{Tv}	0.02 (0.030)	0.23
HSD	0.20 (0.033)	0.64
Max _{Tv}	0.20 (0.032)	0.65
Slope _{In}	0.02 (0.006)	0.34
Slope _{De}	0.0004 (7.16 x 10 ⁻⁶)	0.11
RA _{slope}	0.003 (0.007)	0.19
Nor_medvar	0.23 (0.047)	0.59
Nor_avevar	0.21 (0.046)	0.57
HSU _A	0.26 (0.046)	0.61
HSU _B	0.29 (0.047)	0.63



Genetic Correlations – Selected Traits

Indicator	HSD	Max _{Tv}	HSU _A	HSU _B	Nor_medvar	TSS	RR
LnVar(Med)	-0.22 (0.014)	-0.04 (0.007)	-0.09 (0.012)	-0.15 (0.011)	0.16 (0.009)	-0.07 (0.009)	
HSD		0.98 (0.034)	0.97 (0.042)	0.96 (0.056)	0.71 (0.087)	0.46 (0.069)	0.29 (0.029)
Max _{Tv}			0.96 (0.057)	0.99 (0.089)	0.83 (0.088)	0.48 (0.048)	0.33 (0.039)
HSU _A				0.89 (0.101)	0.78 (0.096)	0.38 (0.024)	0.21 (0.057)
HSU _B					0.51 (0.056)	0.14 (0.008)	0.08 (0.011)
Nor_medvar						0.43 (0.079)	0.50 (0.098)



Final Considerations

- ✓ Most of the CR indicators evaluated are **heritable with substantial additive genetic variance**
- ✓ Five of them, i.e. HSD, MaxTv, HSUA, HSUB, and Nor_medvar share similar underlying genetic mechanisms
- ✓ Individuals with better CR GEBVs are more likely to exhibit **better HS-related physiological responses**, higher body condition scores, and improved **reproductive performance under hot conditions (ongoing validation studies of CR indicators)**
- ✓ We are continuing to work on this topic (ongoing projects) and open to new collaborations



Additional Details

Wen *et al. Genetics Selection Evolution* (2024) 56:44
<https://doi.org/10.1186/s12711-024-00908-4>

Genetics Selection Evolution

RESEARCH ARTICLE

Open Access



Genetic parameters for novel climatic resilience indicators derived from automatically-recorded vaginal temperature in lactating sows under heat stress conditions

Hui Wen¹, Jay S. Johnson², Leonardo S. Gloria¹, Andre C. Araujo¹, Jacob M. Maskal¹, Sharlene Olivette Hartman¹, Felipe E. de Carvalho¹, Artur Oliveira Rocha¹, Yijian Huang³, Francesco Tiezzi^{4,5}, Christian Maltecca⁴, Allan P. Schinckel¹ and Luiz F. Brito^{1*} 



Thank You!

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