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Genetic Variation in Heat Stress Tolerance of Holsteins Producing Under a Continental Temperate Environment

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Objectives

1- Estimating genetic parameters for milk yield using reaction norm models that combined different thermal indices (TI) across the lactation (DIM)

2- Quantifying the magnitude of GxE due to heat stress under temperate conditions

Data

- 107,350 test-day milk records from 2000 to 2010
- Hourly meteorological data for the same period from 14 stations
- Daily values of six TI merged with TD records
  - TI_1: Temperature humidity index (THI) (NRC, 1971)
  - TI_2: Adjusted THI for solar radiation & wind speed (Mader et al., 2006)
  - TI_3: Heat load index (HLI) (Gaughan et al., 2008)
  - TI_4: Equivalent Temperature Index (ETI) (Baeta et al., 1987)
  - TI_5: Environmental Stress Index (ESI) (Moran et al., 2001)
  - TI_6: Comprehensive Climate Index (CCI) (Mader et al., 2010)

Statistical modeling

- Six separate RRTDM using time-dependent (DIM) and specific TI-dependent
- Fixed effects: herd-test-date, age x season of calving x class of 25 DIM, class of 5 DIM
- Random effects: additive genetic, permanent environmental, and herd-calving year modelled with 2nd order of Legendre polynomials for DIM and TI

Results

Table 1. Variance components, heritability (h²), Akaike Information criterion (AIC) when using separately each of the six TI.

TI	σ^2_{AG-d}	σ^2_{PE-d}	σ^2_e	σ^2_{AG-t}	σ^2_{PE-t}	h²	AIC
TI_1	3.76	6.60	4.23	1.03	1.19	0.28	532277
TI_2	3.73	6.55	4.24	1.02	1.22	0.28	543903
TI_3	3.73	6.57	4.24	1.05	1.17	0.28	535879
TI_4	3.76	6.70	4.25	1.15	1.13	0.29	514034
TI_5	3.77	6.53	4.25	1.12	1.58	0.28	512521
TI_6	3.79	6.43	4.32	1.14	1.40	0.29	511138

σ^2_{AG-d} and σ^2_{AG-t} : average additive genetic variances for DIM- and TI-dependant effect; σ^2_{PE-d} and σ^2_{PE-t} : average variances of PE for DIM- and TI-dependant effect; σ^2_e : residual variances

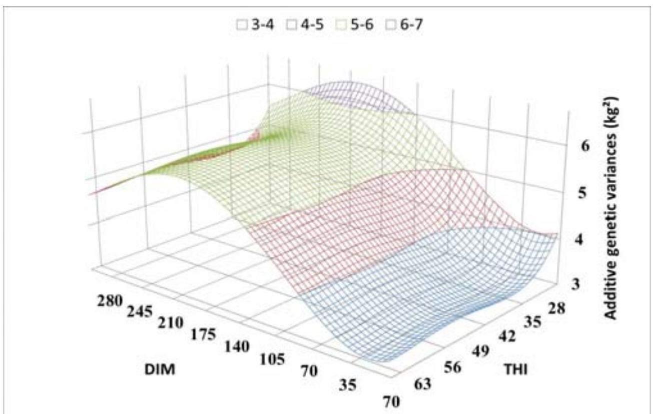

Figure 1. Additive genetic variance for milk yield by combinations of (TI1 x DIM). Variances are represented in 4 intervals (3 - 4, 4 - 5, 5 - 6, and 6 - 7 kg²)

Table 2. Spearman rank correlations between models for EBV of sires with more than 20 daughters calculated at extreme hot conditions (above diagonal) and extreme cold conditions (below diagonal) and at A) early lactation stage (DIM=61), B) middle lactation (DIM=161) and C) late lactation stage (DIM=301)

A)

	TI_1	TI_2	TI_3	TI_4	TI_5	TI_6
TI_1		0.96	0.88	0.89	0.93	0.95
TI_2	0.95		0.89	0.88	0.90	0.99
TI_3	0.88	0.89		0.90	0.90	0.89
TI_4	0.89	0.88	0.90		0.94	0.90
TI_5	0.92	0.89	0.94	0.94		0.90
TI6	0.95	0.98	0.88	0.88	0.91	

B)

	TI_1	TI_2	TI_3	TI_4	TI_5	TI_6
TI_1		0.98	0.95	0.95	0.96	0.98
TI_2	0.98		0.94	0.94	0.95	0.99
TI_3	0.94	0.94		0.94	0.95	0.94
TI_4	0.95	0.94	0.94		0.97	0.94
TI_5	0.96	0.95	0.95	0.97		0.95
TI_6	0.98	0.99	0.93	0.94	0.96	

C)

	TI_1	TI_2	TI_3	TI_4	TI_5	TI_6
TI_1		0.98	0.95	0.96	0.97	0.98
TI_2	0.98		0.95	0.96	0.96	0.99
TI_3	0.95	0.95		0.95	0.95	0.94
TI_4	0.96	0.96	0.94		0.98	0.96
TI_5	0.97	0.96	0.95	0.98		0.95
TI_6	0.98	0.99	0.95	0.63	0.96	

Conclusions

- Genetic variation of milk yield across the lactation and the trajectory of all the temperature humidity and apparent temperature indices was depicted without defining thresholds
- Breeding for reduced thermal sensitivity using adjusted TI for solar radiation and wind speed as indicator should be favored under continental temperate regions

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