Influence of heat stress on semen quality in Holstein bulls

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Food From Thought
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Outline

- Heat stress background
- Objective
- A look at the data
- Results - heat stress affects sperm motility
- Discussion and future directions

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Heat Stress

- Predictions for increased frequency and duration of heat waves
- Imbalance between metabolic heat production and dissipation to surroundings
- Increase in respiration rate, rectal temperature, heart rate
- Expend energy to actively cool when ambient conditions exceed thermal neutral zone
  - Sweating, panting
- Negatively affects health, production, and fertility

Heat Stress in Bulls

- Spermatogenesis (~61 days) is susceptible to temperature variation

Spermatocytogenesis ~ 21 days	Meiosis ~ 23 days	Spermiogenesis ~ 17 days	Epididymal Mat ~ 11 days
Spermatogenesis			Maturation

Collection Day

- Detrimental effects on semen productivity and quality (volume, output, motility, and concentration)

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Temperature and Humidity

- Both affect an animal's ability to dissipate heat
- Combined into a formula called the temperature humidity index (THI)

$$THI = (1.8 * T + 32) – ((0.55 – 0.0055 * RH) * (1.8 * T – 26))$$

→ T is temperature in °C and RH is relative humidity (%)

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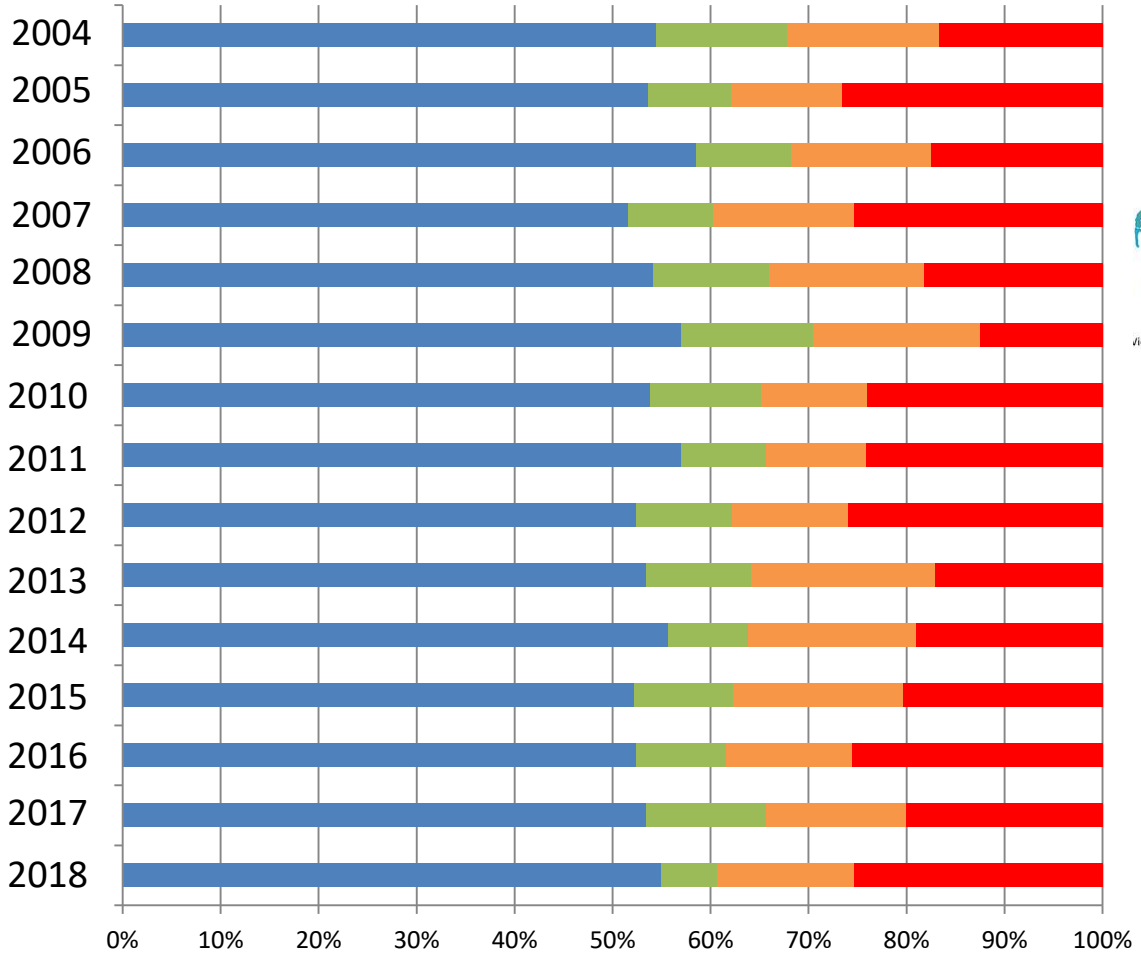
THI Threshold

- THI at which production or fertility traits begin to decline
- Varies depending on breed, location, adaptability, and production level
- Heat stress thresholds in use based on milk or milk protein decline:

  →THI = 60 (Holstein cows, temperate)
  →THI = 68 (Holstein cows, temperate)
  →THI = 78 (Holstein cows, subtropical)

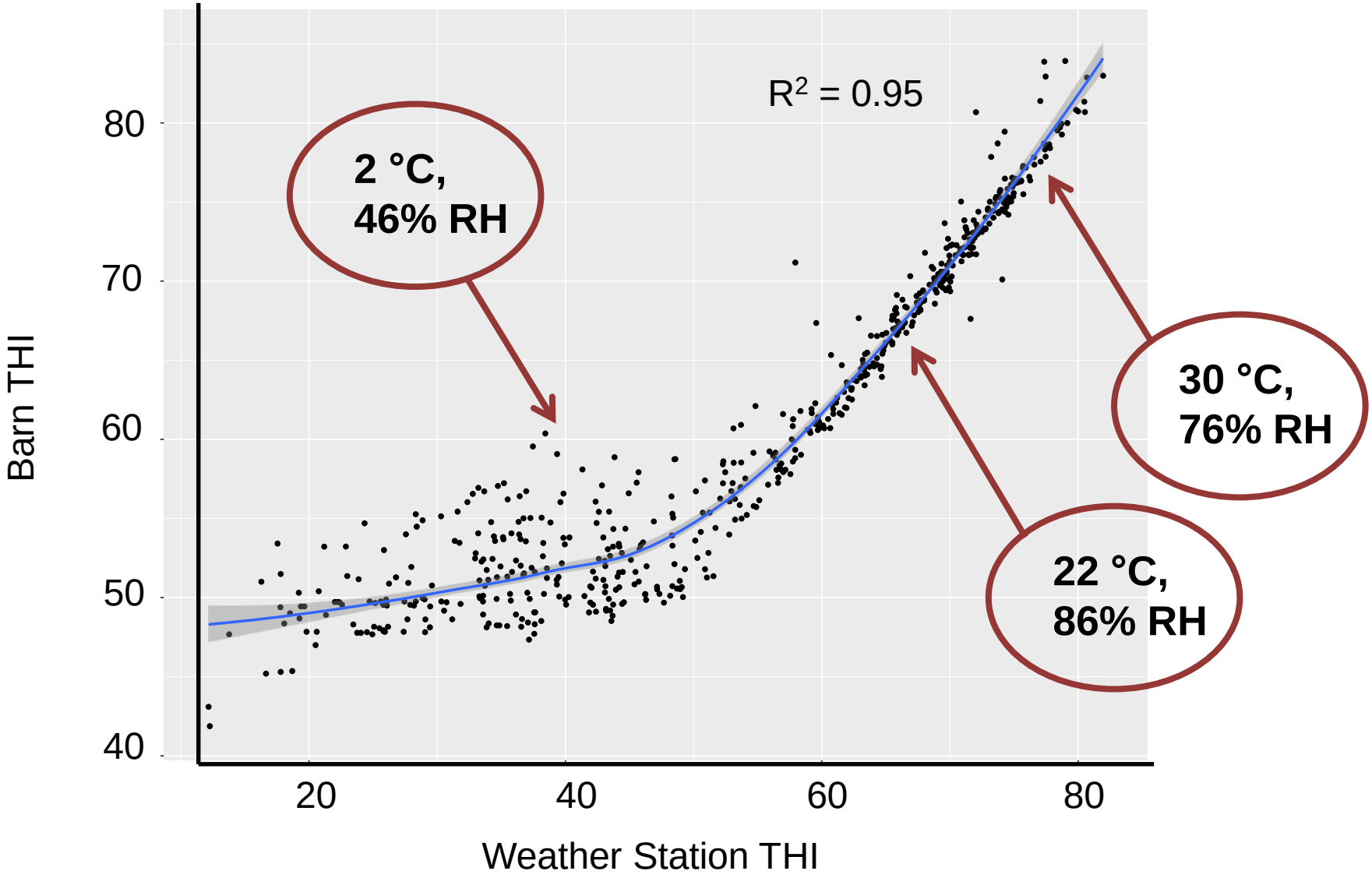
- **Al-Kanaan et al 2015 identified that semen quality and quantity traits (concentration, volume, output) in Holstein Fresian sires began to decline at THI=60**

Climate – Southern Ontario



60% of Canadian artificial insemination sires are located in Ontario and Quebec

THI Inside and Outside are Correlated



Objective

Examine effect of heat stress on semen quality of Dairy bulls in Southern Ontario and Quebec

Indicator of semen quality:

→ Post-thaw total motility

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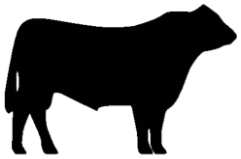
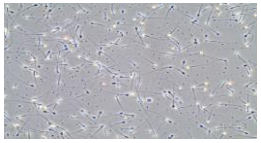
The Data

Three barns in Southern Ontario and Quebec, Canada

Post-thaw total motility



N = 2334 bulls
Aged 12-90 months old

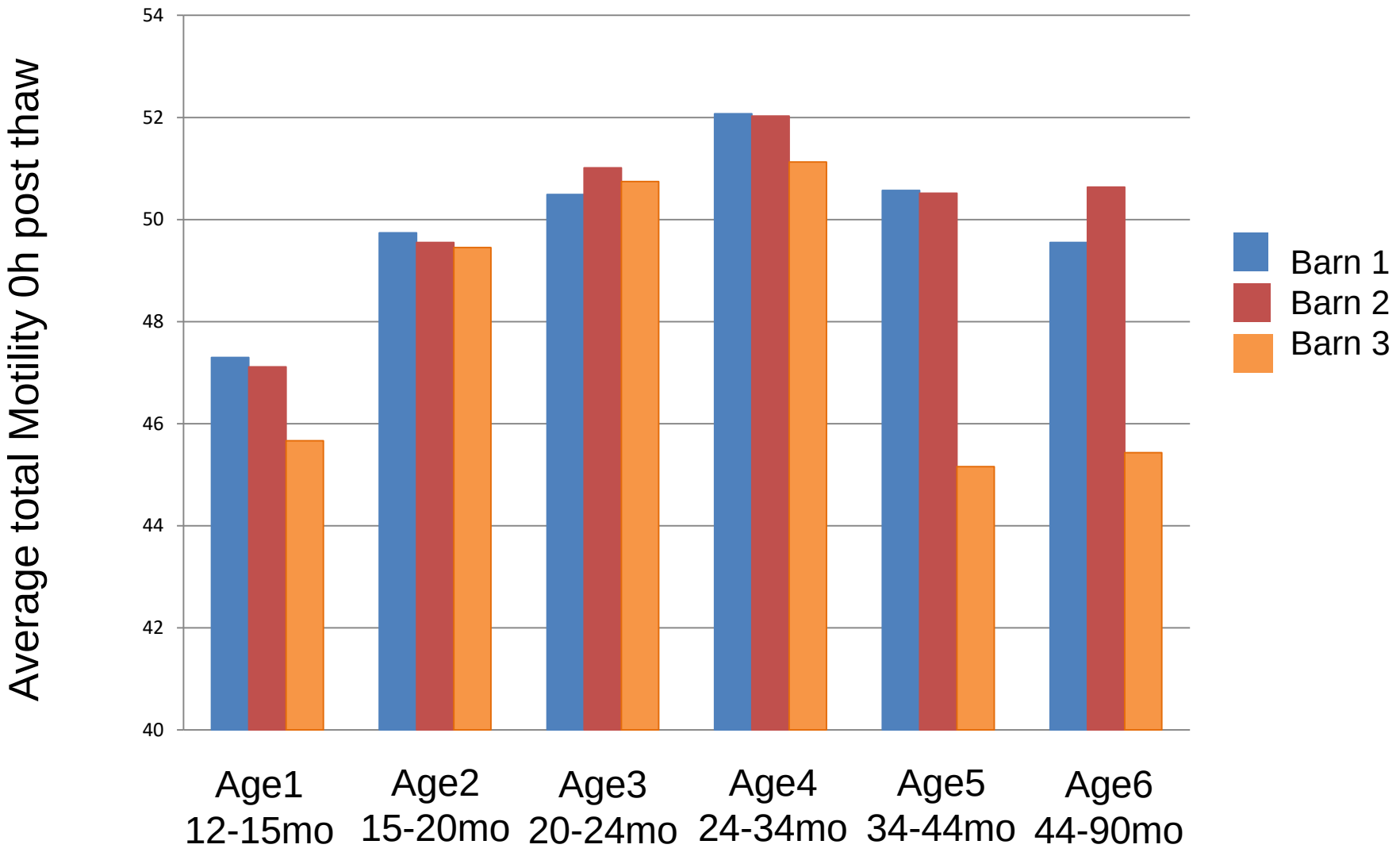


125,700 measurements
Taken from 2010-2018

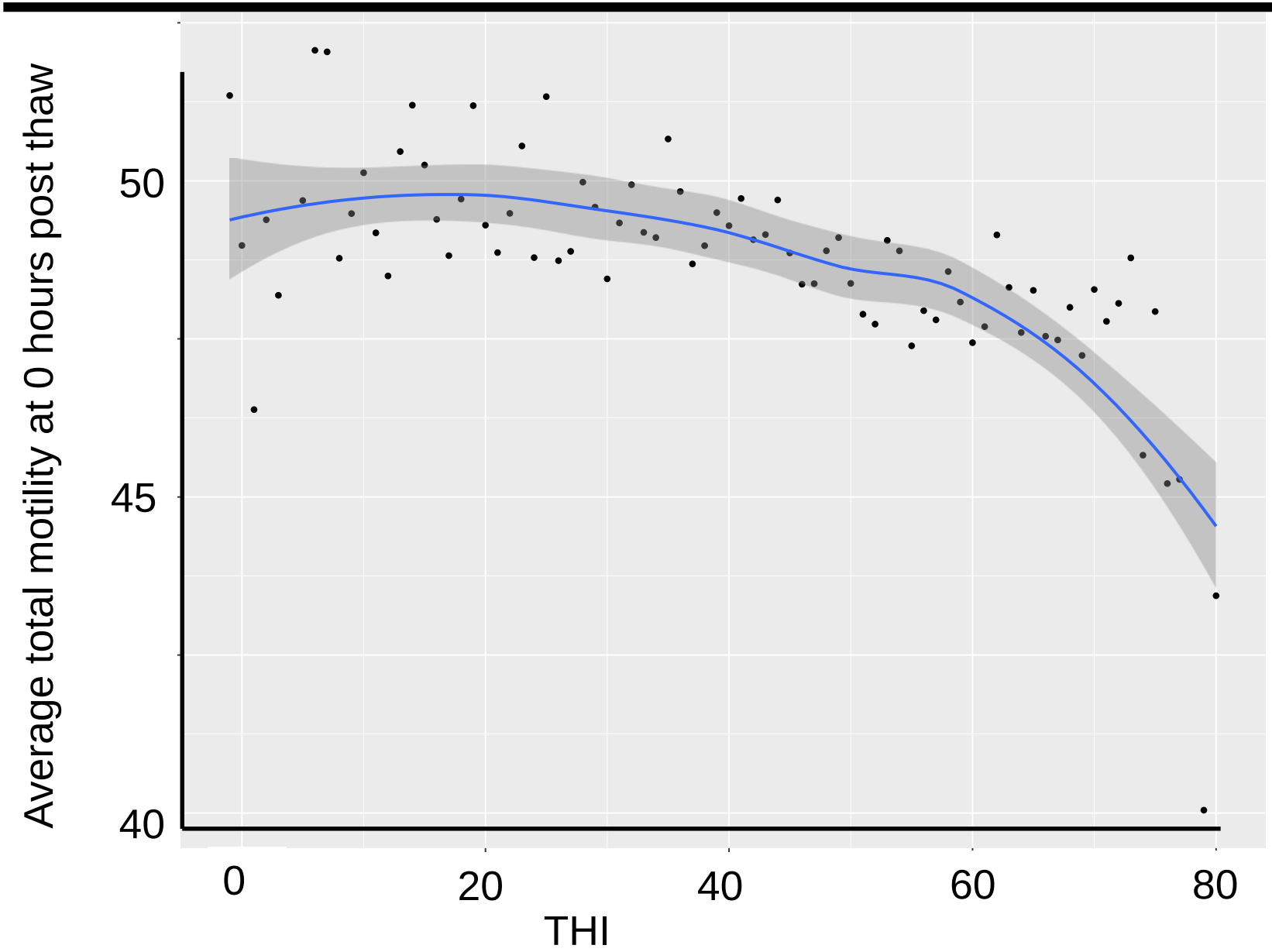
Temperature and humidity from the closest Environment Canada weather stations to each of the three barns

THI calculated from Environment Canada weather stations (within 40 km of the barns) for the days on which semen was collected.
http://climate.weather.gc.ca/historical_data/search_historic_data_e.html

Average Motility in Each Age Class



Average Motility Decreases as THI Increases



Results - THI Negatively Affects Motility

Repeatability animal model in Asreml:
h^2 = 0.11, Repeatability = 0.28

Motility ~ mu + YHS + AHS + ejaculates + herd.THIave +
AgeClass.THIave AgeClass.THIave^2 !r ID ide(ID))

- **Significant Age x THI interaction (p < 0.001)**

Other significant effects (p < 0.001):

- Ejaculate number (1, 2, or combined)
- Barn
- Year x Barn x Season of collection (YHS)
- Age x Barn x Season of birth (AHS)

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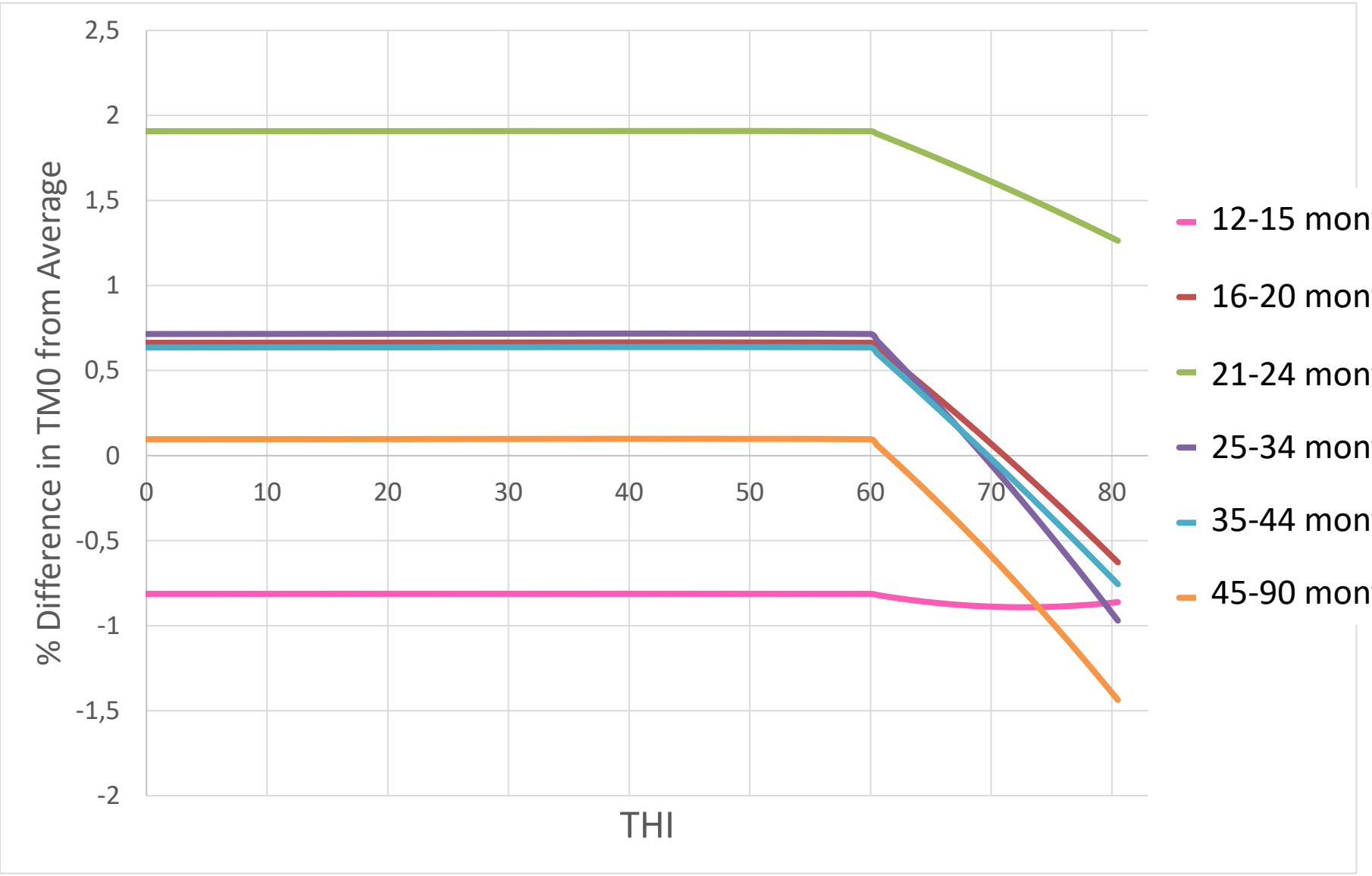
Effect of age on total motility at 0h with increasing THI, expressed as a deviation from an average across the population



THI Affects Motility Throughout Spermatogenesis

Spermatocytogenesis ~ 21 days	Meiosis ~ 23 days	Spermiogenesis ~ 17 days	Epididymal Mat ~ 11 days
Spermatogenesis			Maturation

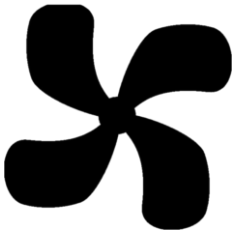
Collection Day

- THI during the above periods also significantly negatively affected motility
- A high THI today could affect semen for the duration of spermatogenesis and maturation

Conclusions

- Heat stress negatively affects sperm quality
- This affect varies with age class of the bull

What can we do?



- Install cooling systems
- Fed during cooler hours
- Identify genetic variation associated with better tolerance to heat stress

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Next Steps

- Run a random regression
- Get more information about how management and facilities differ between barns
- Future: GWAS to investigate whether better motility under heat stress has a genetic component

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Thank You

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