Renewed Genetic Evaluation of Heat Tolerance in Italian Holsteins

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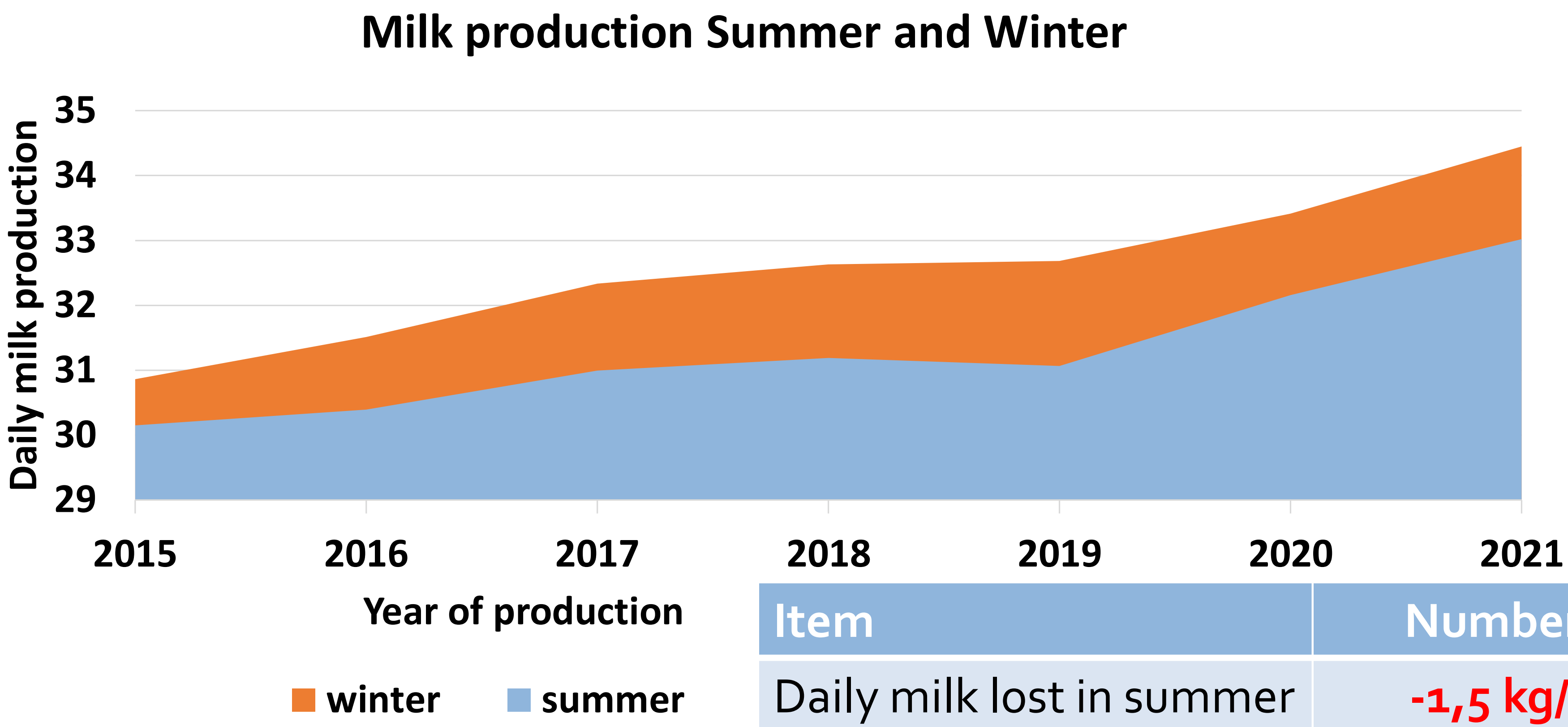
Why heat stress matters?

- Heat stress reduces milk yield, fertility, and animal welfare.
- Rising temperatures make heat stress a growing concern.
- Genetic solutions are needed to breed more resilient cows.

How is the heat affecting Italy?



ANAFIBJ source 2022

***Approach Flamenbaum, 2016** – Summer/Winter ratio*

Item	Numbers
Daily milk lost in summer	**-1,5 kg/d**
Summer days	180
N° of cows in italy	1,000,000
Production loss	**-270,000 tons**

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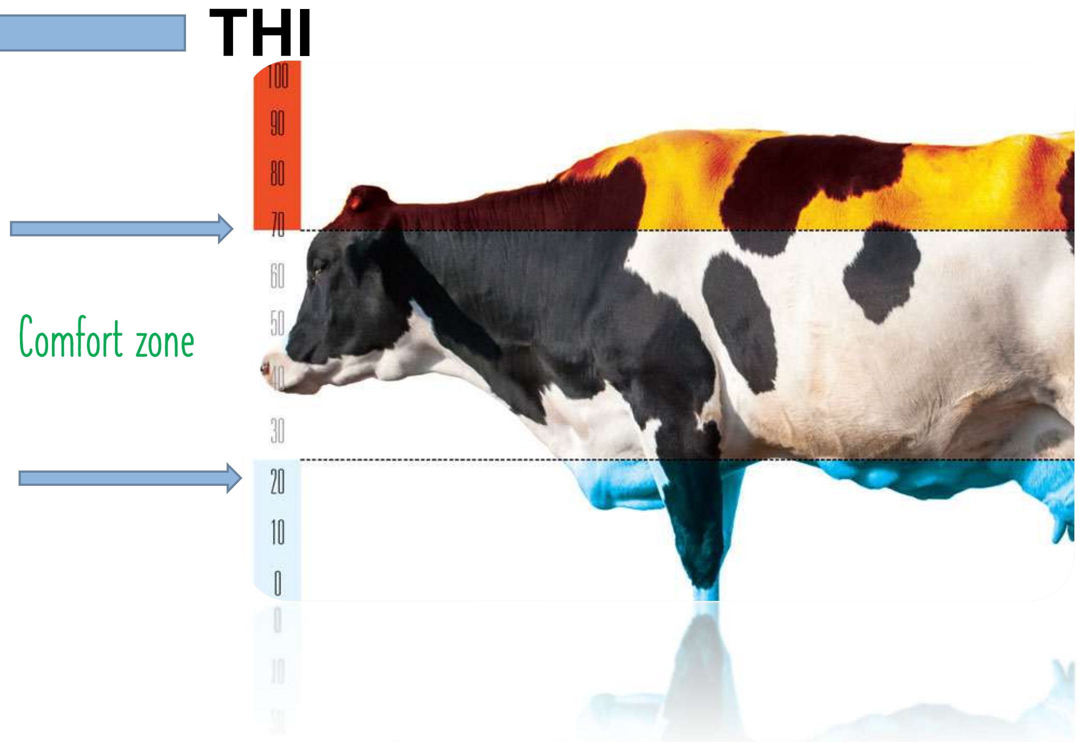
Dairy cows and heat stress

Heat stress results from a combination of environmental factors that exceed a cow's comfort zone and the cow's ability to keep cool.



THI = A single value representing the combined effects of air temperature and humidity associated with the level of thermal stress.

$$THI = \{\mathbf{T}_{Max} - [0.55 \times (1 - RH)] \times (\mathbf{T}_{Max} - 14.4)\}$$

(Kelly & Bond, 1971)

Weather Data-Set

Weather data since 1994 (Max T C° & relative humidity)/day) → **THI** (Kelly & Bond, 1971)

- **Weather stations (n=137) →**
- **Latitude/Longitude Coordinates**
- **Herds → Municipalities →**
- **Latitude/Longitude Coordinates**

1. For each herd → average **2,3** weather stations with average distance **13,5 km**
2. 7-day average THI was used
3. To each test-day THI data added

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Previous work and new goals

- Previous HT index focused on kg milk only (2021)
- New evaluation includes milk (kg), fat (kg and %) and protein (kg and %)

- **Objectives:**
  - Determine THI thresholds for milk traits declining
  - Estimate HT traits heritabilities
  - Calculate breeding values for all five milk traits

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Heat threshold analysis: Repeatability model

$$Y = \underline{HYS + YC + DIM * age\ * parity + THI} + \underline{a+pe + error}$$

Y= phenotype (milk (kg/d), fat (kg/d-%), protein (kg/d-%)

Fixed effects

- HYS = herd-year season of test-days (4 seasons)
- YC= year of calving
- DIM = days in milk
- Age = age at calving
- Parity (3 lactations: 1,2,3)
- THI

Random effects

- a= additive genetic component
- pe = permanent environment effect
- error

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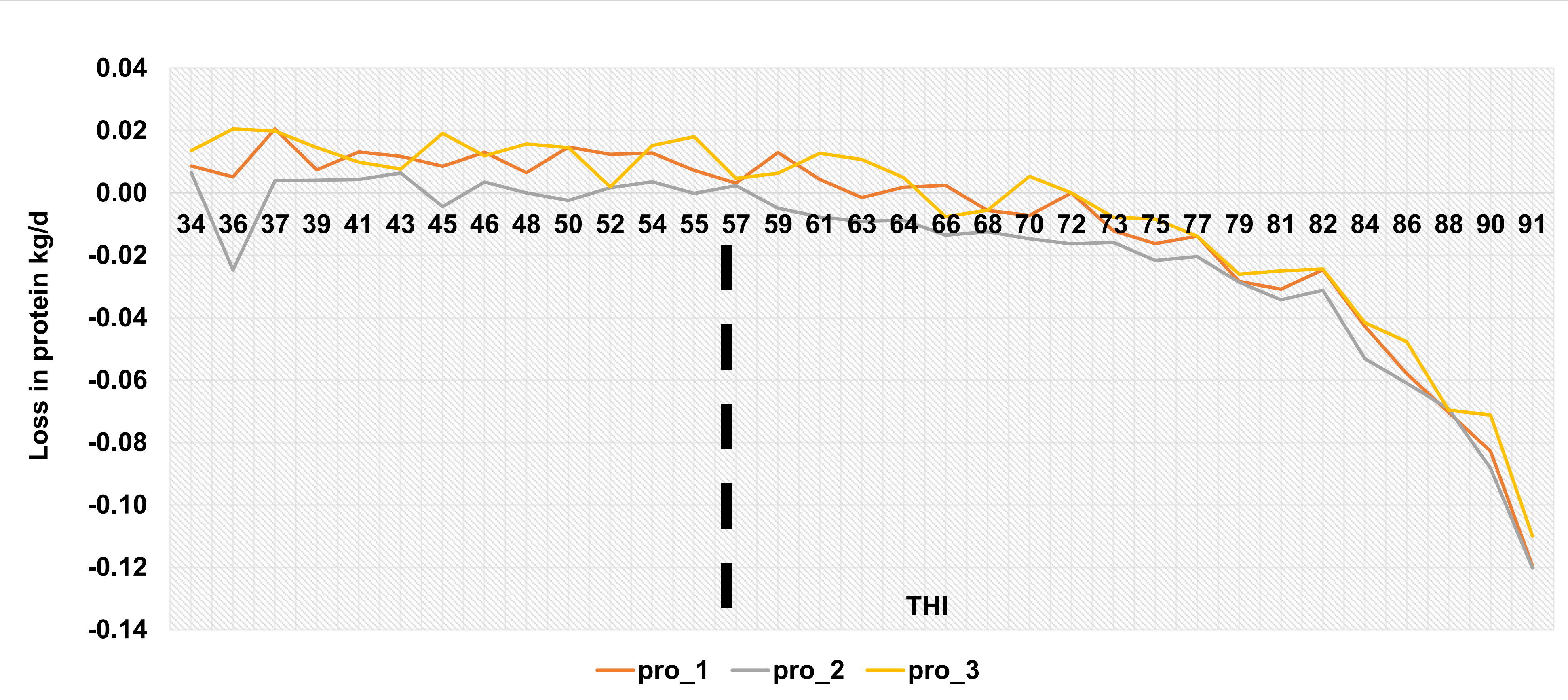
Heat threshold results – Protein kg/d



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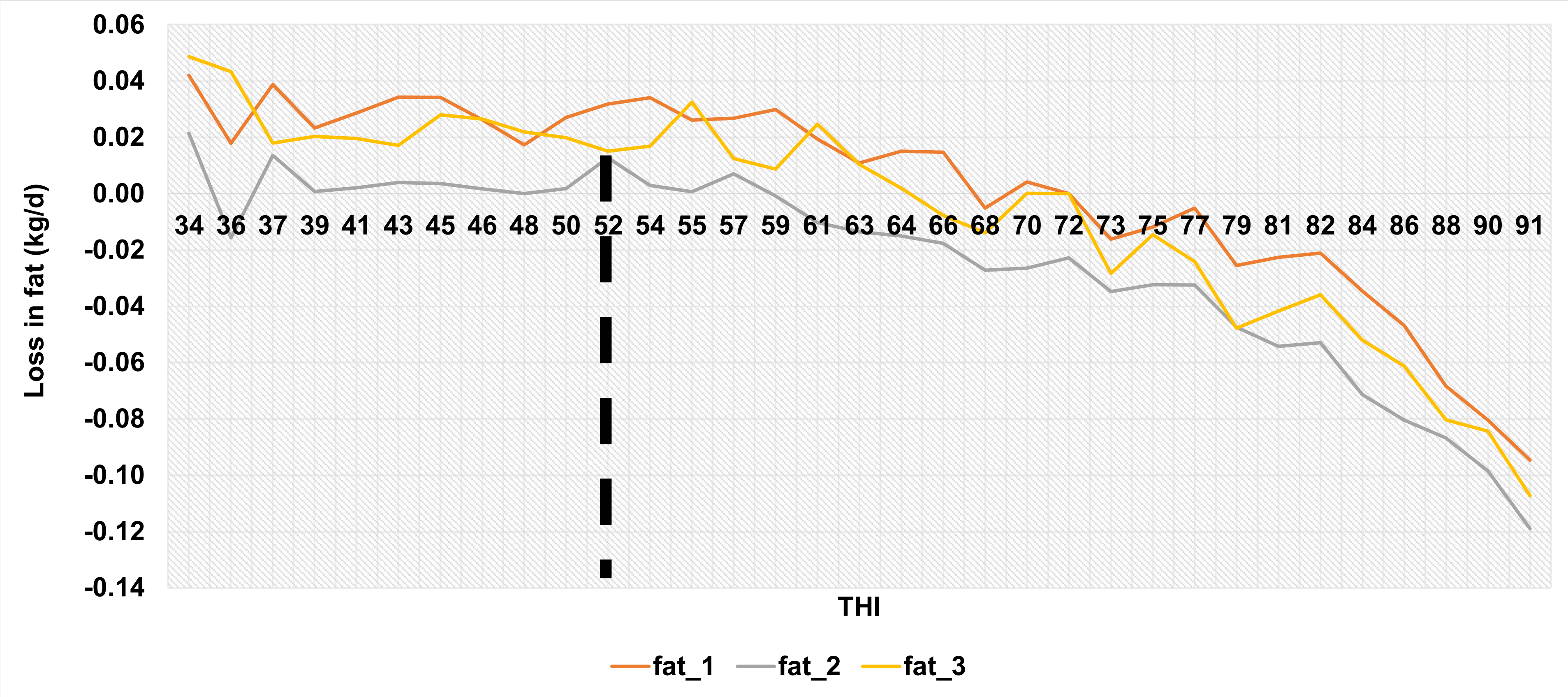
Heat threshold results – Fat kg/d



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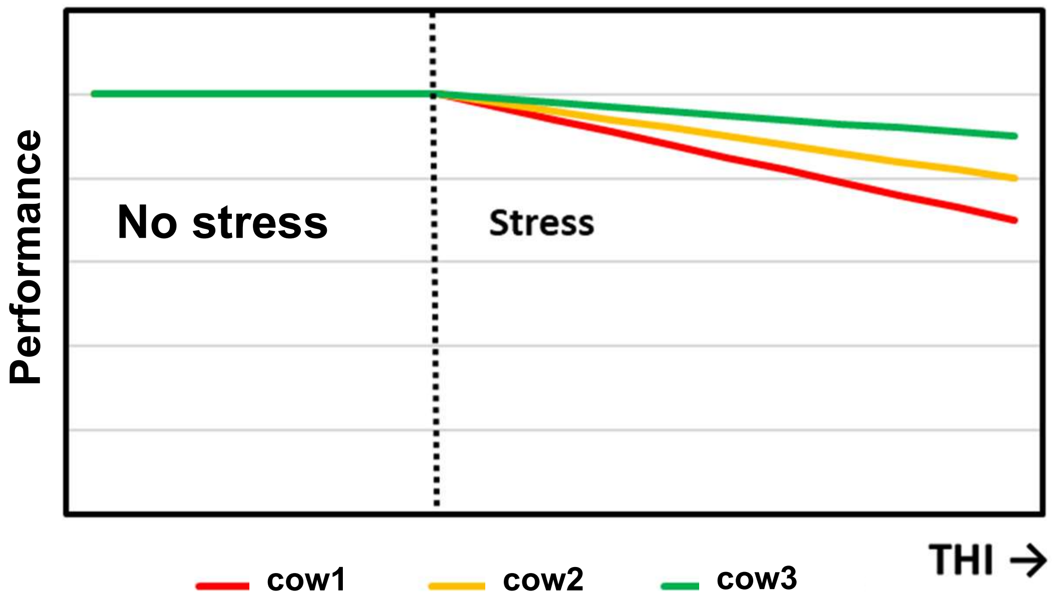
Genotype*Environment interaction (GXE)

Random effects were regressed on a function of THI

$$f(THI) = \begin{cases} 0, & \text{THI} \leq \text{THI}_{\text{threshold}} \ \text{(no heat stress)} \\ \text{THI} - \text{THI}_{\text{threshold}}, & \text{THI} > \text{THI}_{\text{threshold}} \ \text{(heat stress)} \end{cases}$$

Milk production traits	Threshold level
Milk (kg/d)	70
Protein (kg/d)	59
Fat (kg/d)	52
Protein (%/d)	55
Fat (%/d)	52



Heat threshold analysis: Repeatability model

$$Y = HYS + YC + DIM * age * parity + a + \alpha(f(THI)) + pe + \beta(f(THI)) + e$$

Y= phenotype (milk (kg/d), fat (kg/d-%), protein (kg/d-%)

Fixed effects

- HYS = herd-year season of test-days (4 seasons)
- YC= year of calving
- DIM = days in milk
- Age = age at calving
- Parity (3 lactations)

Random effects

- a= additive genetic component ← General animal genetic merit
- $\alpha(f(THI))$ = heat tolerance genetic effect ← Heat tolerance genetic merit
- pe = permanent environment effect
- $\beta(f(THI))$ = heat tolerance permanent environmental effect
- error

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MiX99 Solving Large Mixed Model Equations

Correlations

Relationship between general genetic merit and heat tolerance genetic merit of production

Trait	Genetic animal effect * THI	Environmental effect * THI	Heritability
Milk (kg/d)	-0,51	-0,40	0,16
Protein (kg/d)	-0,48	-0,47	0,13
Fat (kg/d)	-0,42	-0,54	0,12
Protein (%/d)	-0,43	-0,51	0,37
Fat (%/d)	-0,50	-0,54	0,26

Negative correlations indicate opposing relationship, but they are moderate

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Heat Tolerance EBVs

- Standardized mean 100 and DS 5

- Genomic evaluation for single index and later combined in an Aggregate index
  1. Milk (kg/d)
  2. Fat (kg/d)
  3. Protein (kg/d)
  4. Fat (%/d)
  5. Protein (%/d)

Aggregate index	
Single EBVs	**Weight**
IHT milk (kg/d)	25%
IHT fat (kg/d)	15%
IHT protein (kg/d)	45%
IHT fat (%)	5%
IHT protein (%)	10%

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Comparison of High vs. Low HT Bulls – Summer vs. Winter Milk Yield

Identified bulls with > 1000 daughters

	HT ≥ 105 (High Tolerance)
Summer milk (kg/d)	30.05
Winter milk (kg/d)	30.38
Difference (kg/d)	-0.33
	HT ≤ 95 (Low Tolerance)
Summer milk (kg/d)	29.90
Winter milk (kg/d)	31.14
Difference (kg/d)	-1.24

Difference between the two losses:

Δ Difference = -0.33-(-1.24) = +0.91 kg/day

Daughters of bulls with high heat tolerance (**HT ≥ 105**) lose **0.91 kg/day milk less** in summer compared to daughters of bulls with low heat tolerance (**HT ≤ 95**).

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Thanks!

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