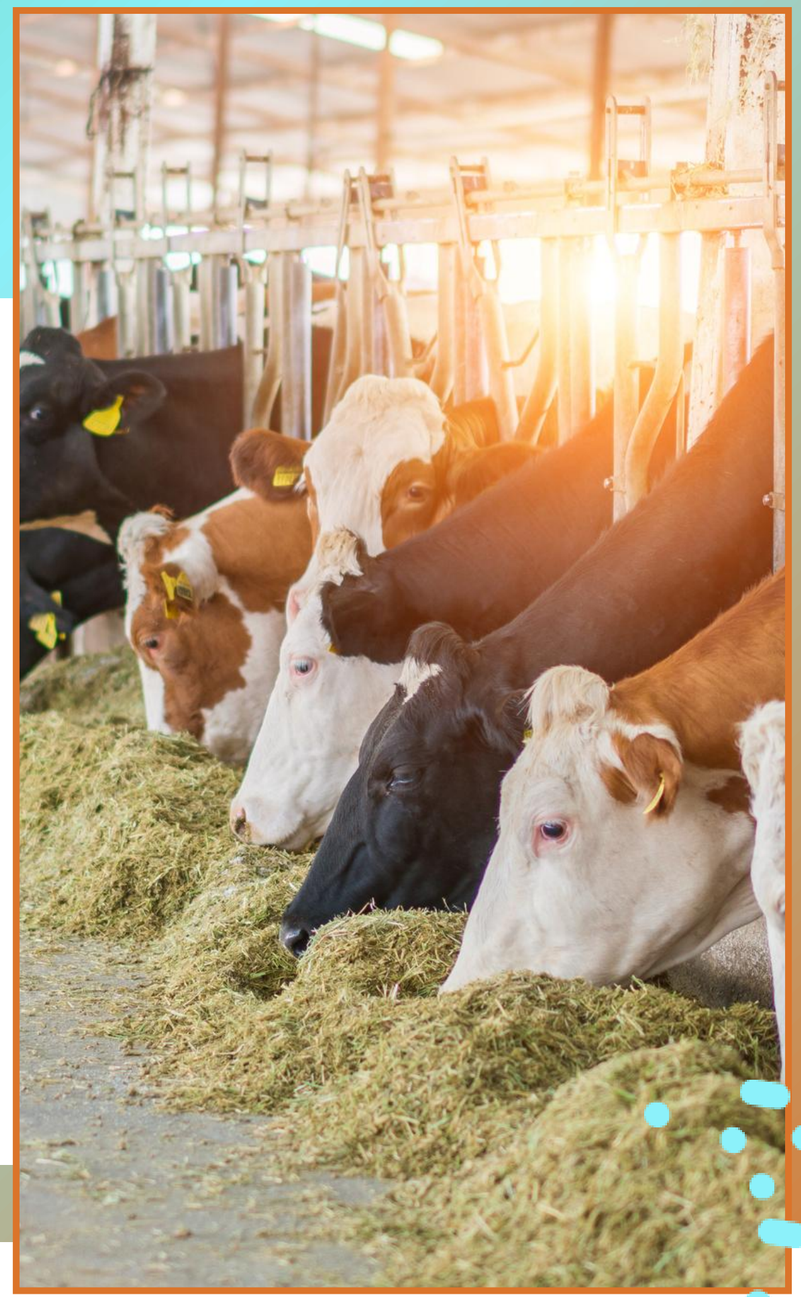
ECOGEN

WEBINAR SERIES 2026

Trade-offs between traits in the context of climate change in French dairy cows

Episode 9 | JUNE 3rd, 2026



HoloRuminant
Understanding microbiomes of the ruminant holobiont

Re-Livestock
RESILIENT FARMING SYSTEMS

GERONIMO
GENOME AND EPIGENOME ENABLED BREEDING IN MONOGASTRICS

Rumigen

3D'omics

ECOGEN

Rumigen

WP3.1 and WP3.2 **Indirect measures of heat tolerance by measuring changes in performances under various meteo data**

INRAE

INSTITUT DE L'ELEVAGE idele

WAGENINGEN UNIVERSITY & RESEARCH

INIA Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

Castilla-La Mancha Consejería de Agricultura, Agua y Desarrollo Rural

Instituto Regional de Investigación y Desarrollo Agroalimentario y Forestal de Castilla-La Mancha IRIAF

Data

Zootechnical data

Field data from national database (evaluation of reproducers)

- **Production & Health traits:**

  Test-day controls

  → milk, fat & protein yields & contents

  → somatic cell score

- **Fertility trait:**

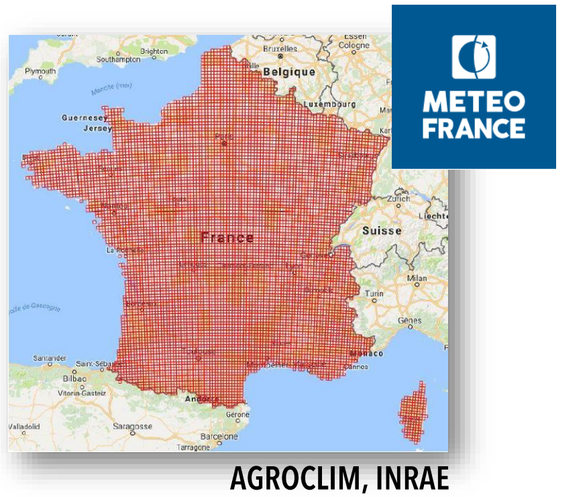
  1st inseminations and their result (calv/no calv)

  → conception rate

Meteorological data

Daily temperatures and humidity

grid of 9,892 squares 8x8 km



Temperature Humidity Index (THI)

Data

Zootechnical data

Field data from national database (evaluation of reproducers)

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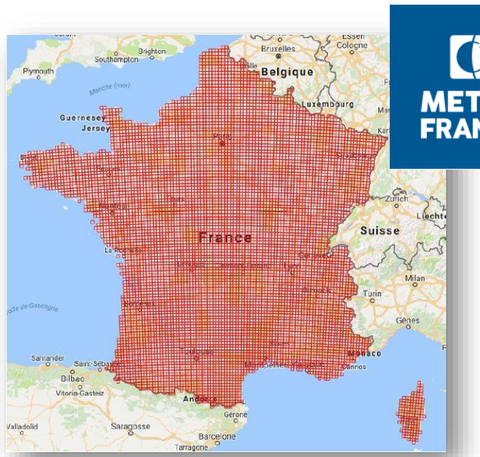


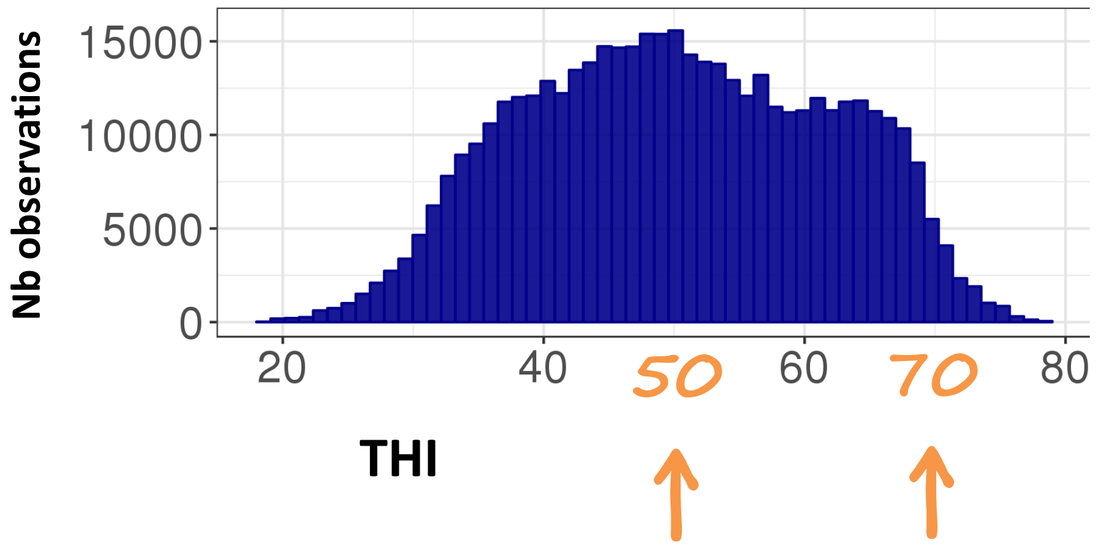
AGROCLIM, INRAE

average **THI** over a **3d** period **before** TD

average **THI** over a **8d** period **after** service

Temperature Humidity Index (THI)

Distribution of THI values over the 3d period preceding the test-day (2016-2020)

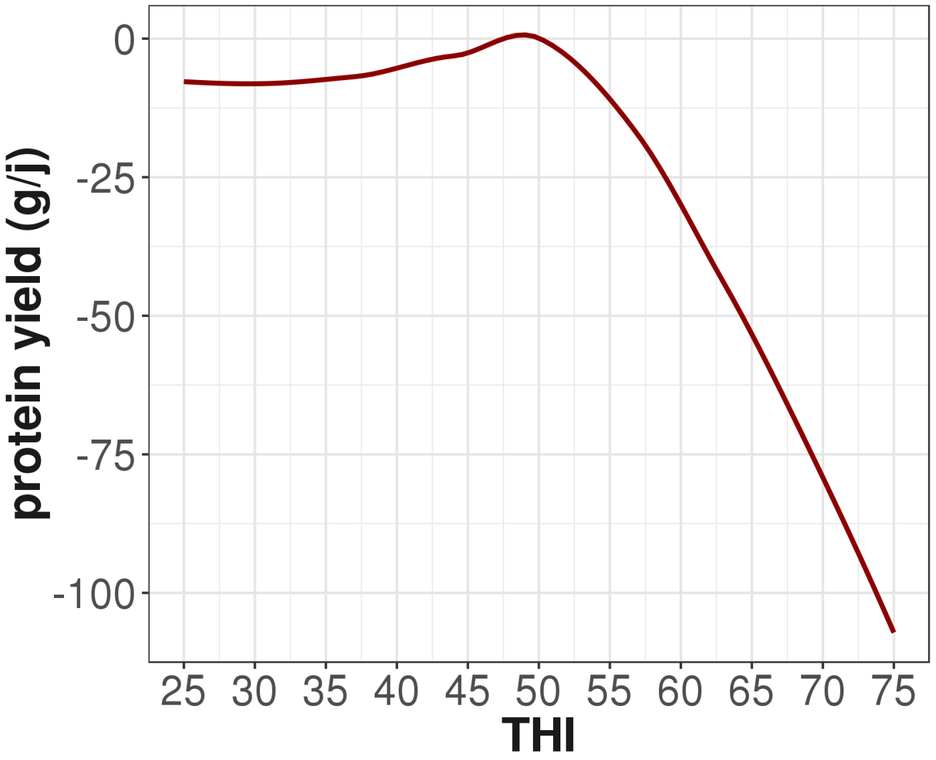


Evolution of average performances fct THI

Average effect of THI on protein yield

(Montbeliarde, 1st lactation)

Population level



More on impact of heat stress on traits in:

- Mario Calus's presentation
- Sophie Aguerre's presentation (replay of EcoGen Webinar Episode 2)

Evolution of average performances fct THI

Average effect of THI on protein yield

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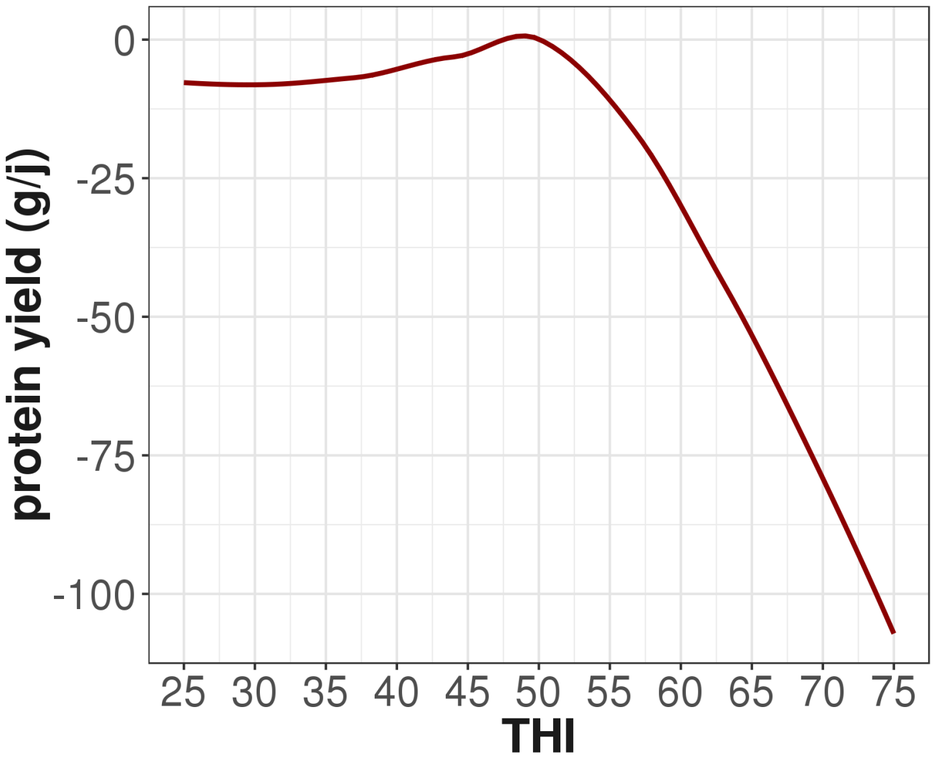


At the individual level?

Is there **individual variability** in the decline in performance?

Can we identify animals that lose more (or less) than others?

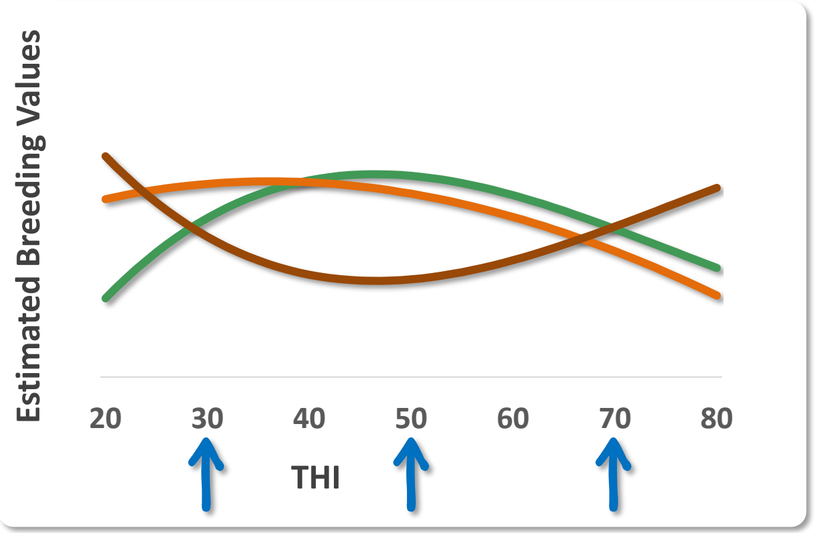
→ Genetic models that account for **interactions between genotype and environment (THI)**

Genetic X Environment (THI) models

$$y_{i\_t} = Fixed\ Effects + \sum_{m=0}^{n} Z_m(\boldsymbol{t})\boldsymbol{g_{im}} + \sum_{p=0}^{q} Z_p(\boldsymbol{t})\boldsymbol{pe_{ip}} + e_{i\_t}$$

→ Random regression models

- Legendre polynomials (order 3 or 2, depending on the trait)
- Permanent environment if repeated measures (production & health traits)
- Heterogeneous residual variances



The response of each genotype is modeled as a continuous curve along an environmental gradient (THI)

- Estimated Breeding Values may vary along the THI gradient.
- the ranking among animals,
- the genetic variances,
- and the genetic covariances & correlations between traits may evolve

Number of cows with performances:

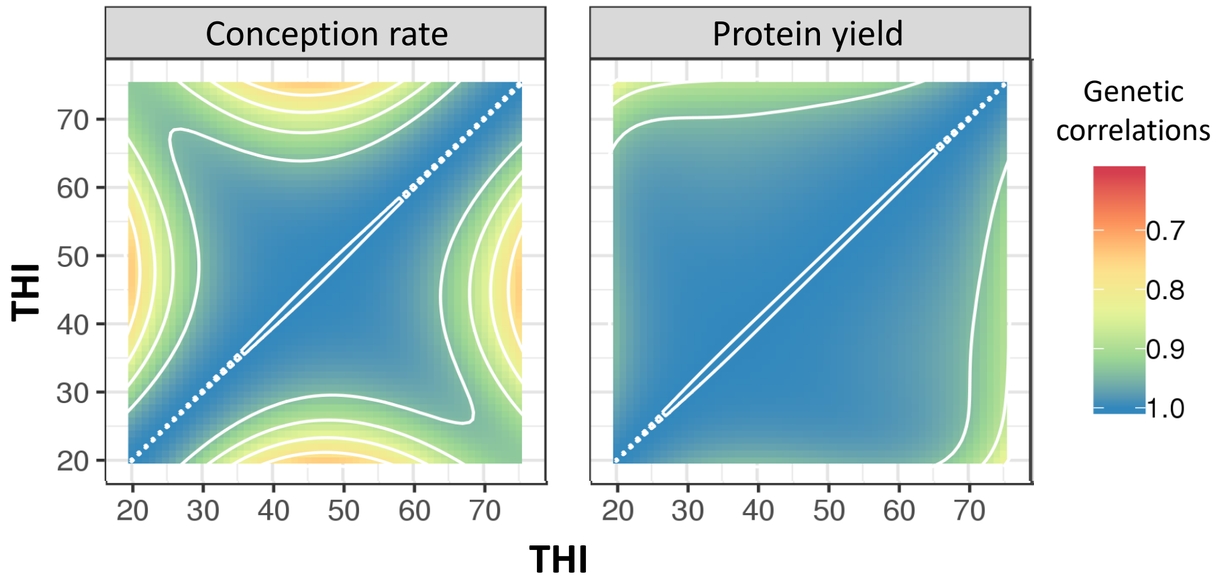
Production and SCS: 72,555 HOL ; 55,650 MON with performances

Fertility trait: 3,351,068 HOL ; 649,814 MON with performances

GxE: Within-trait genetic correlations – Is the trait at THI 50 is the same as at THI 70?

Within trait **genetic correlations**

Conception rate & Protein yield, Holstein, 1st lactation



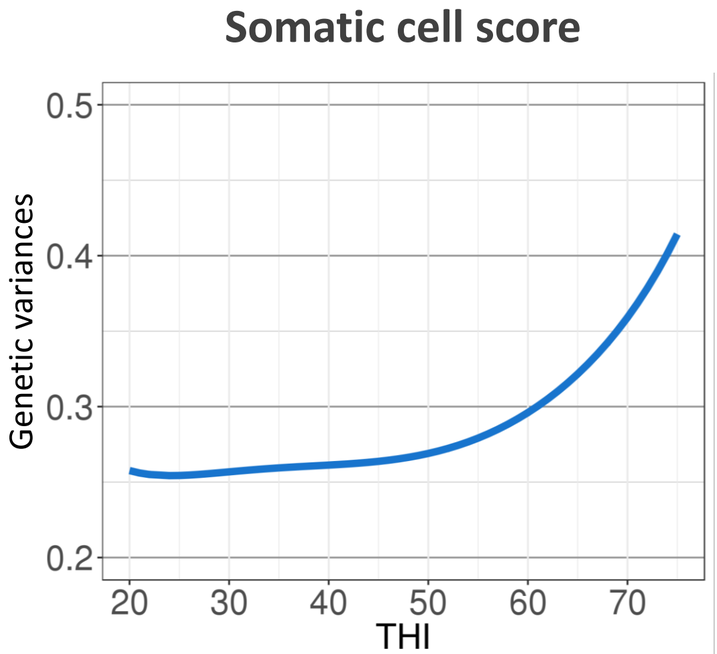
For the same trait at different THI levels: high genetic correlations

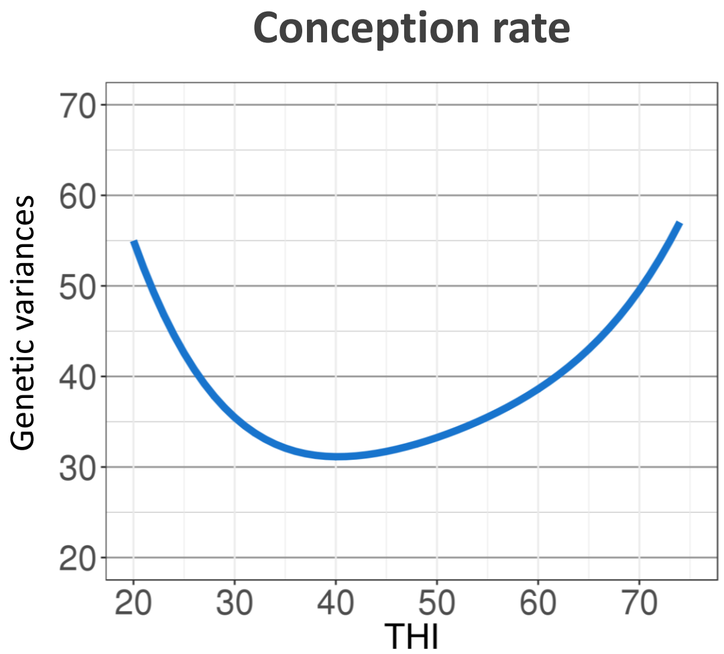
- Fertility, minimum values ≈ 0.75
- Production and SCS, minimum values > 0.80 (most are > 0.90)

Little or no interaction between genotype and THI

⇨ Few rerankings

GxE: Evolution of the genetic variances with THI (ex Montbeliarde breed)



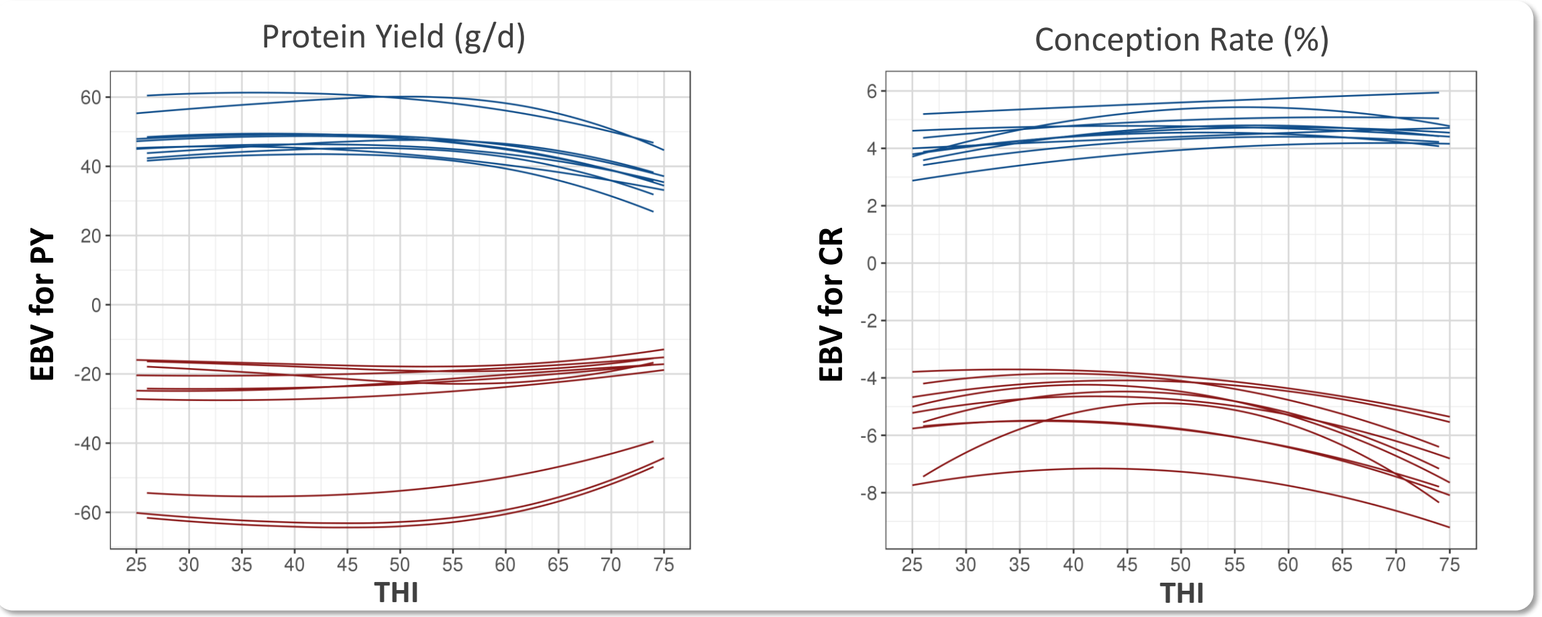


Production: ↘️ ≠ when THI becomes high

Functional: ↗️ ≠ when THI becomes high

GxE: Evolution of the estimated breeding values as a function of THI

TOP/**BOTTOM** EBV at THI 50 of Montbéliard sires



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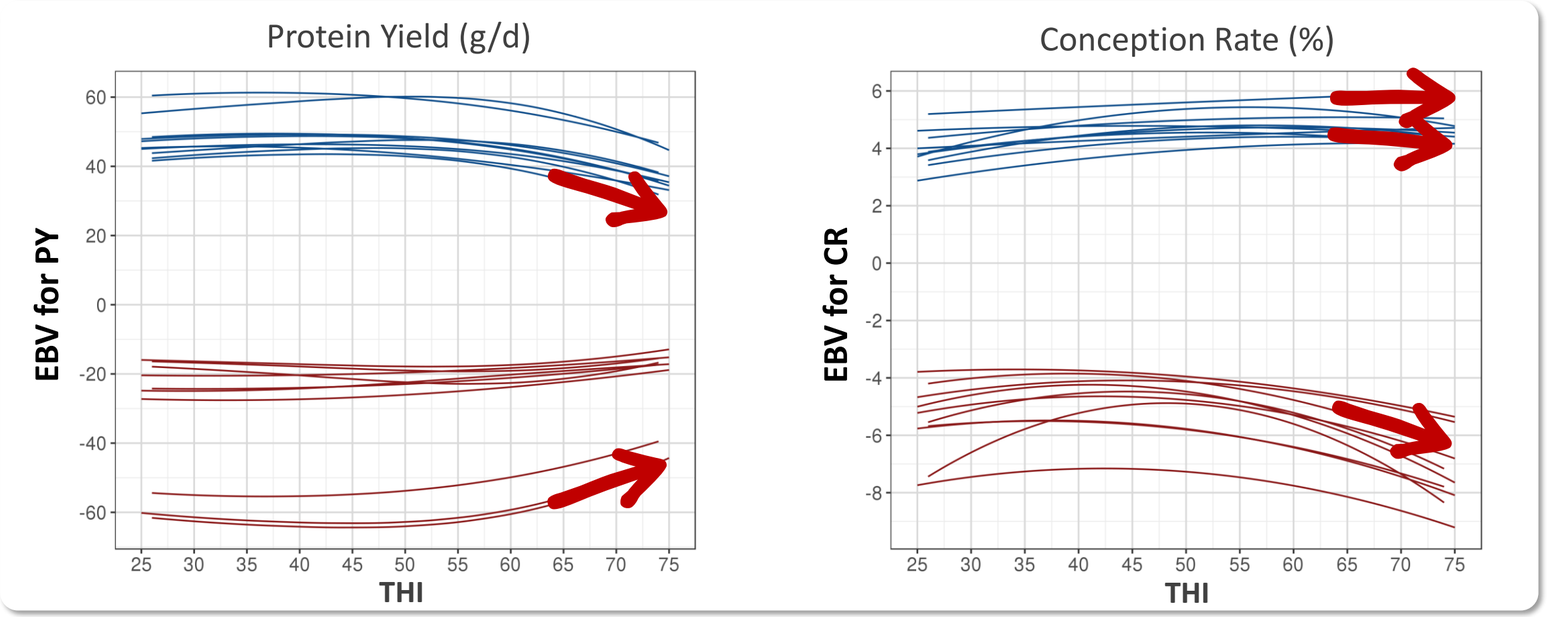

Traits:

Level = EBV at a given THI

Slope = Evolution of the ranking, toward ↗ or ↘

(= derivative of the EBV curve at a given THI)

GxE: Evolution of the estimated breeding values as a function of THI

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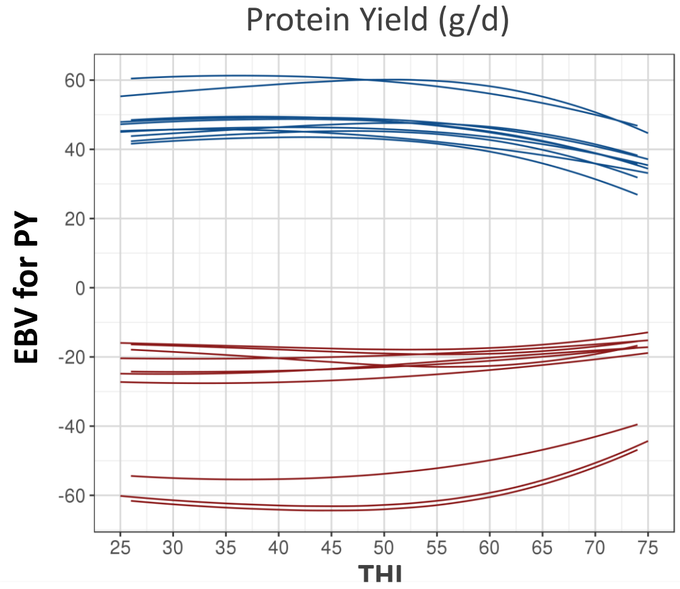
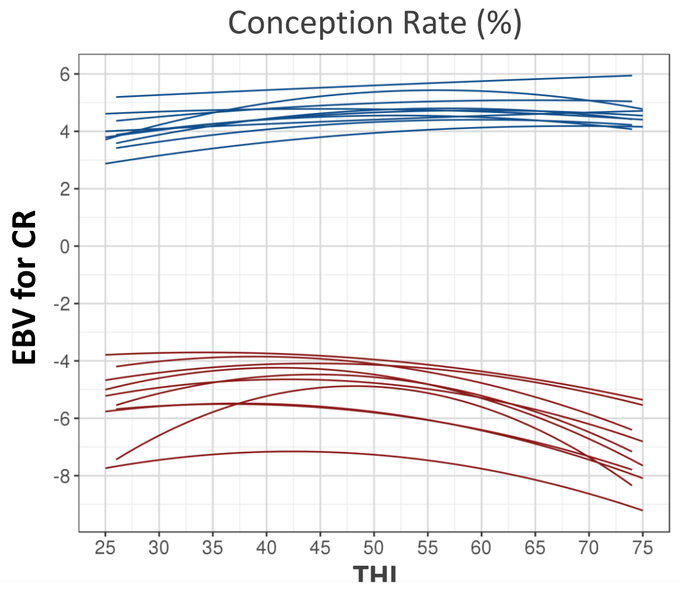
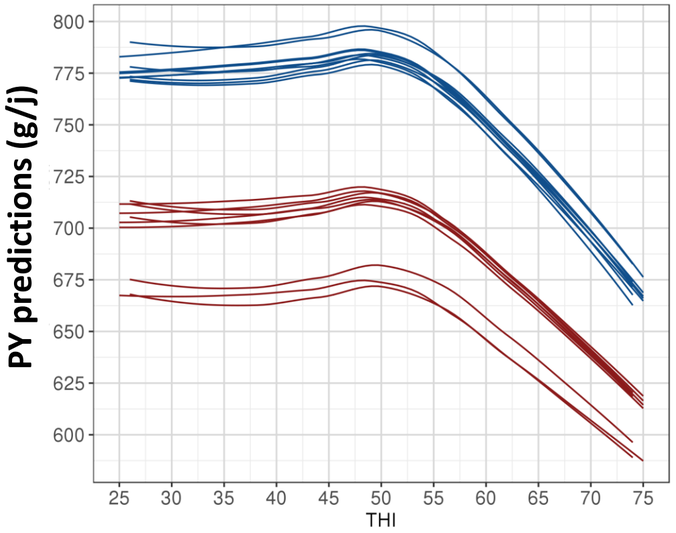
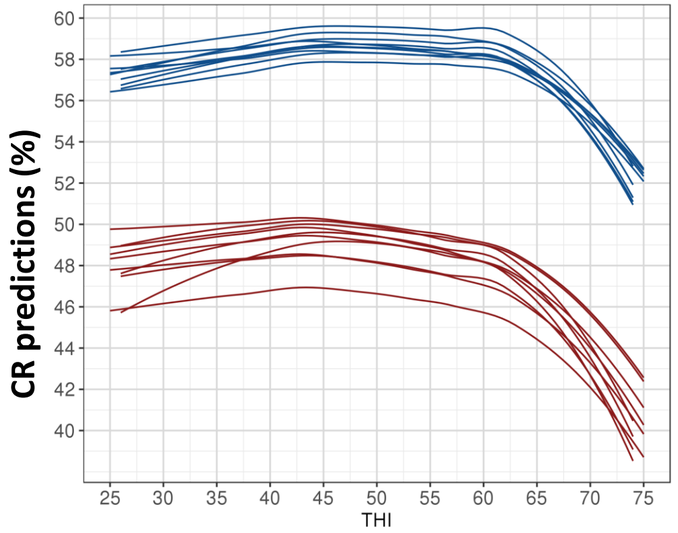








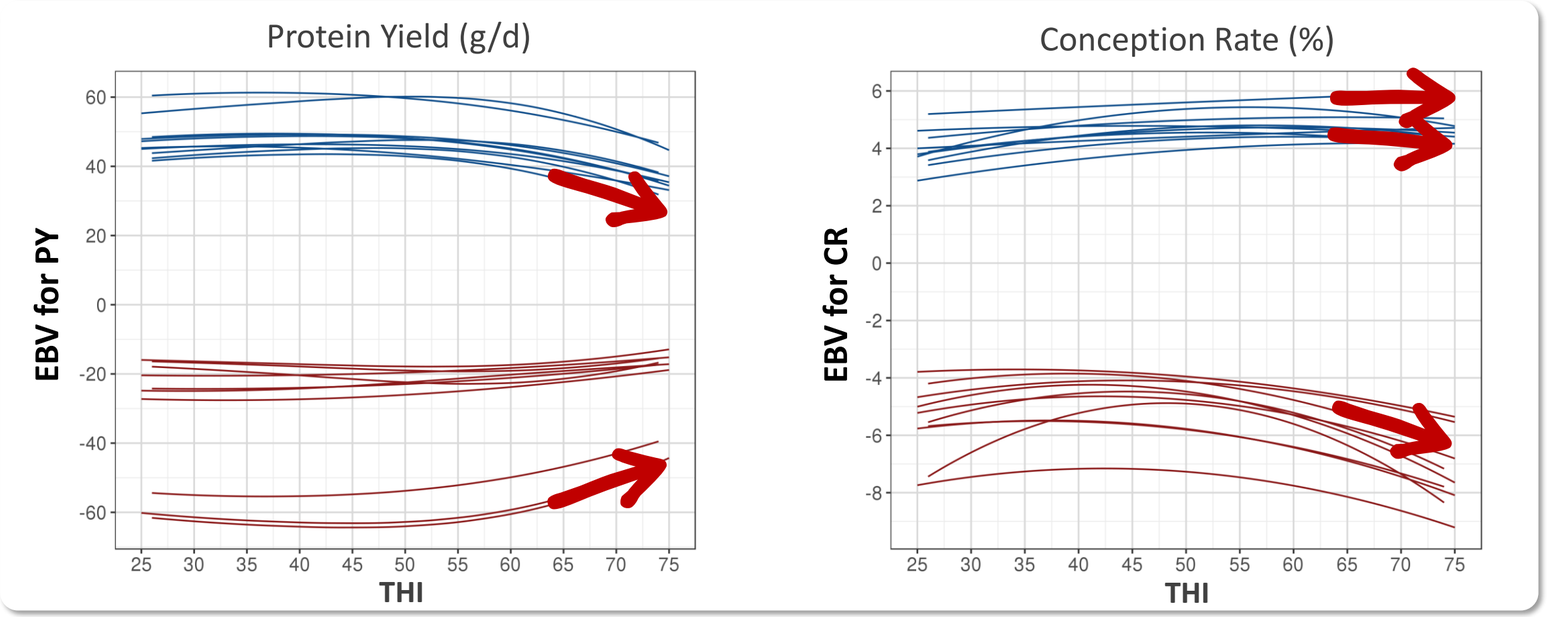
Estimated Breeding Values (EBV) give the **ranking** between animals **at a given THI**,

not the forecasted performance

All sire families experience a **decrease** in fertility and production **as THI increases**

GxE: Evolution of the estimated breeding values as a function of THI

TOP/**BOTTOM** EBV at THI 50 of Montbéliard sires



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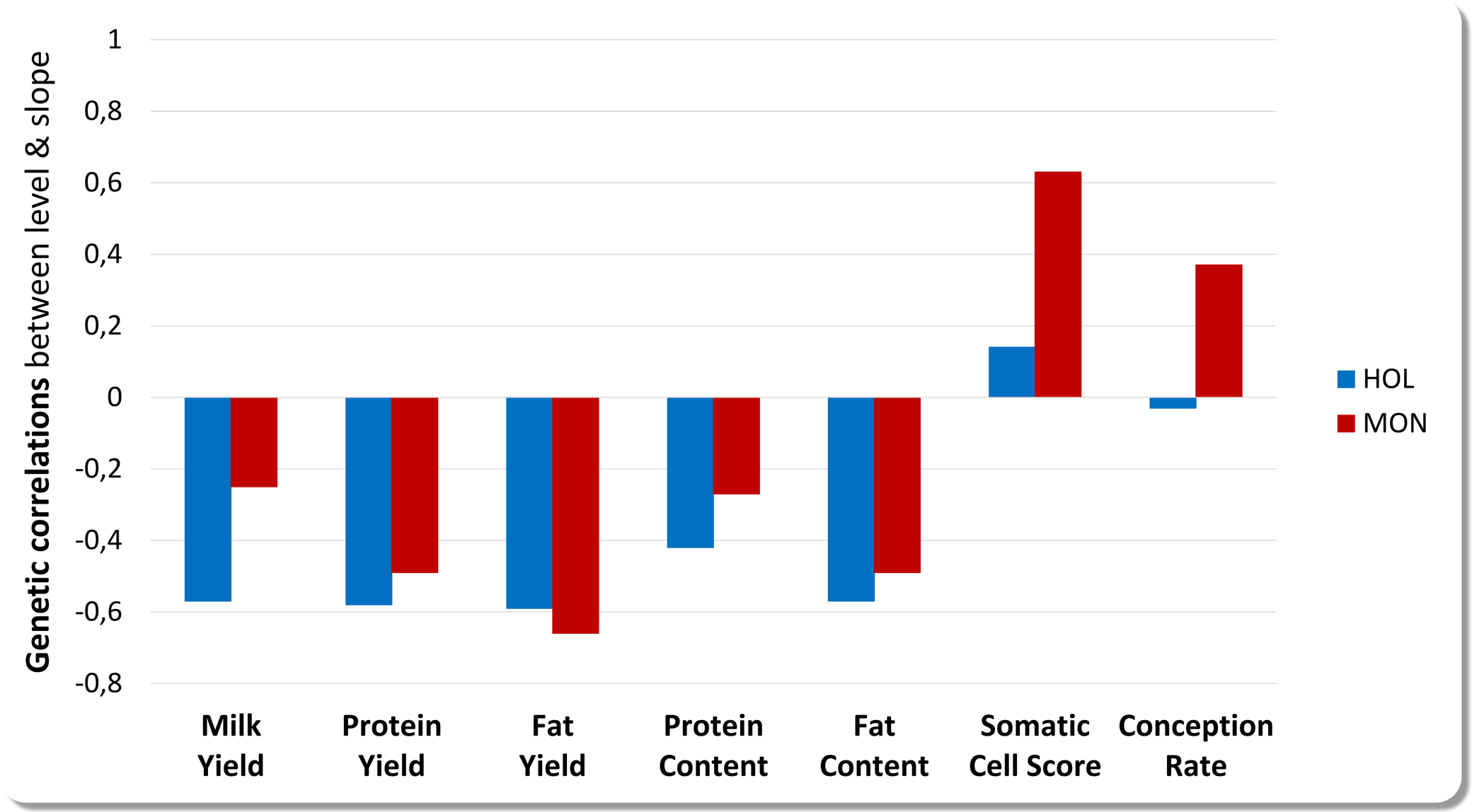
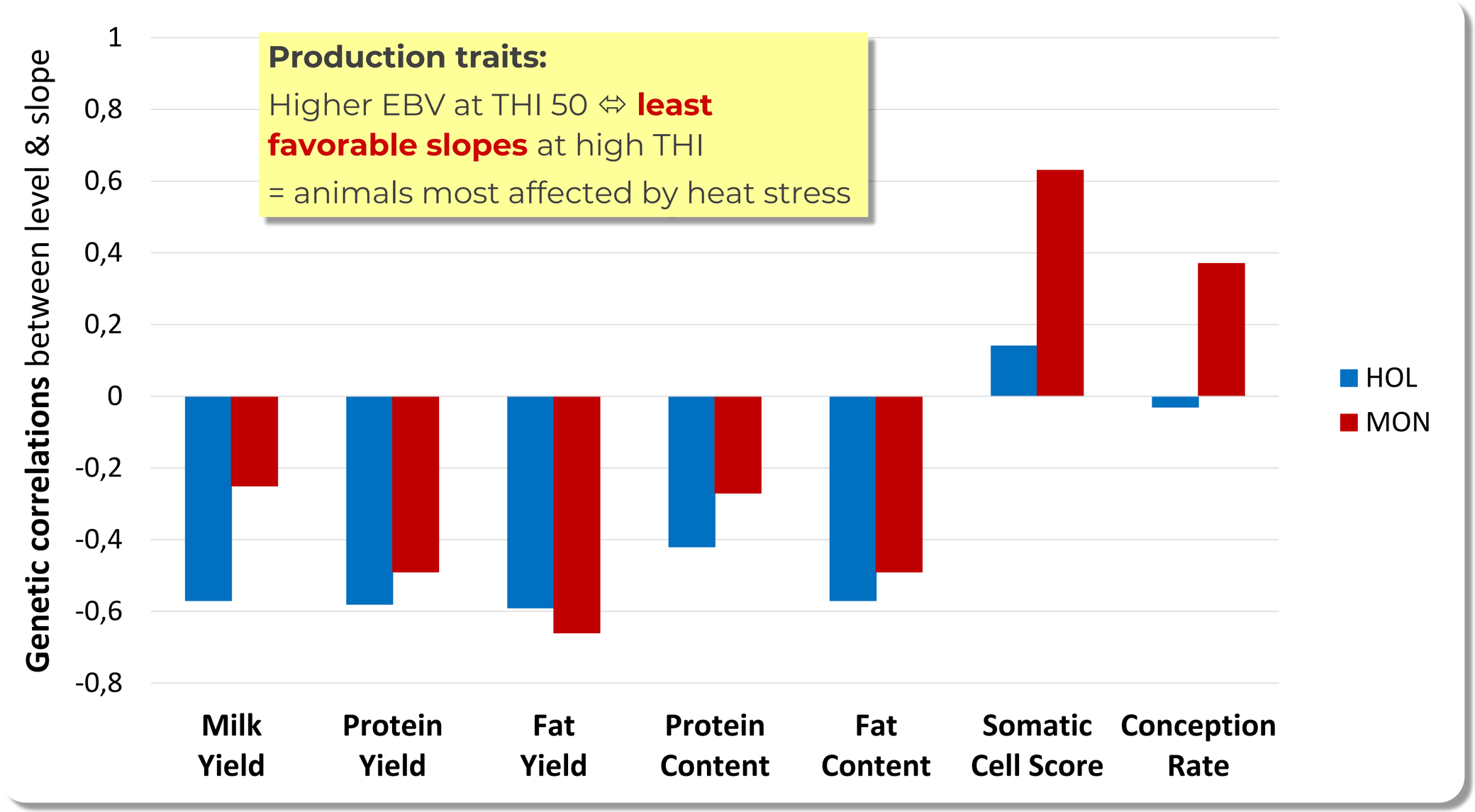
(= derivative of the EBV curve at a given THI)

Trade-offs between *level at THI 50* and *slopes at THI 70* within traits (1st lactation)



Effects of current selection on the future performances (under warmer climate)



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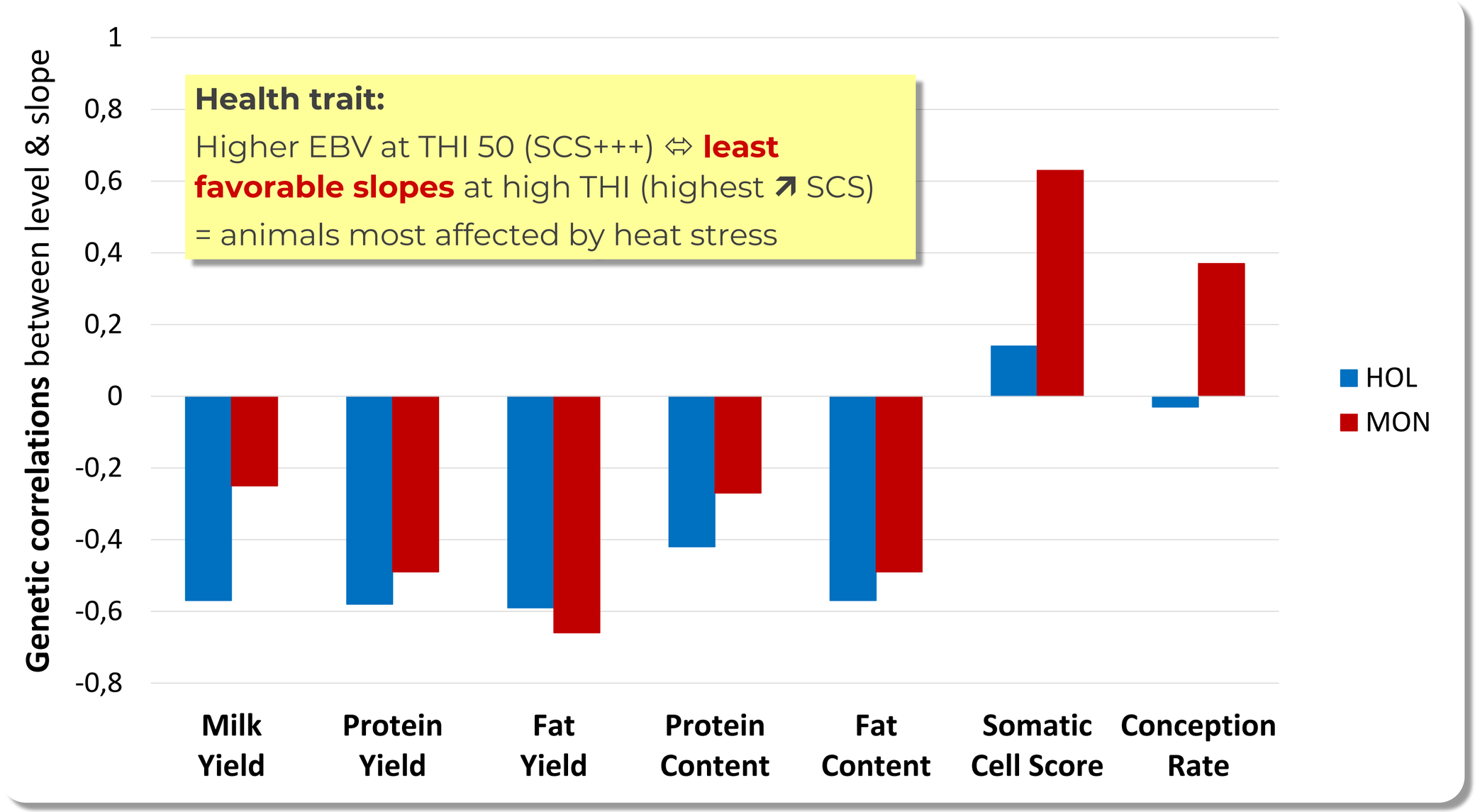

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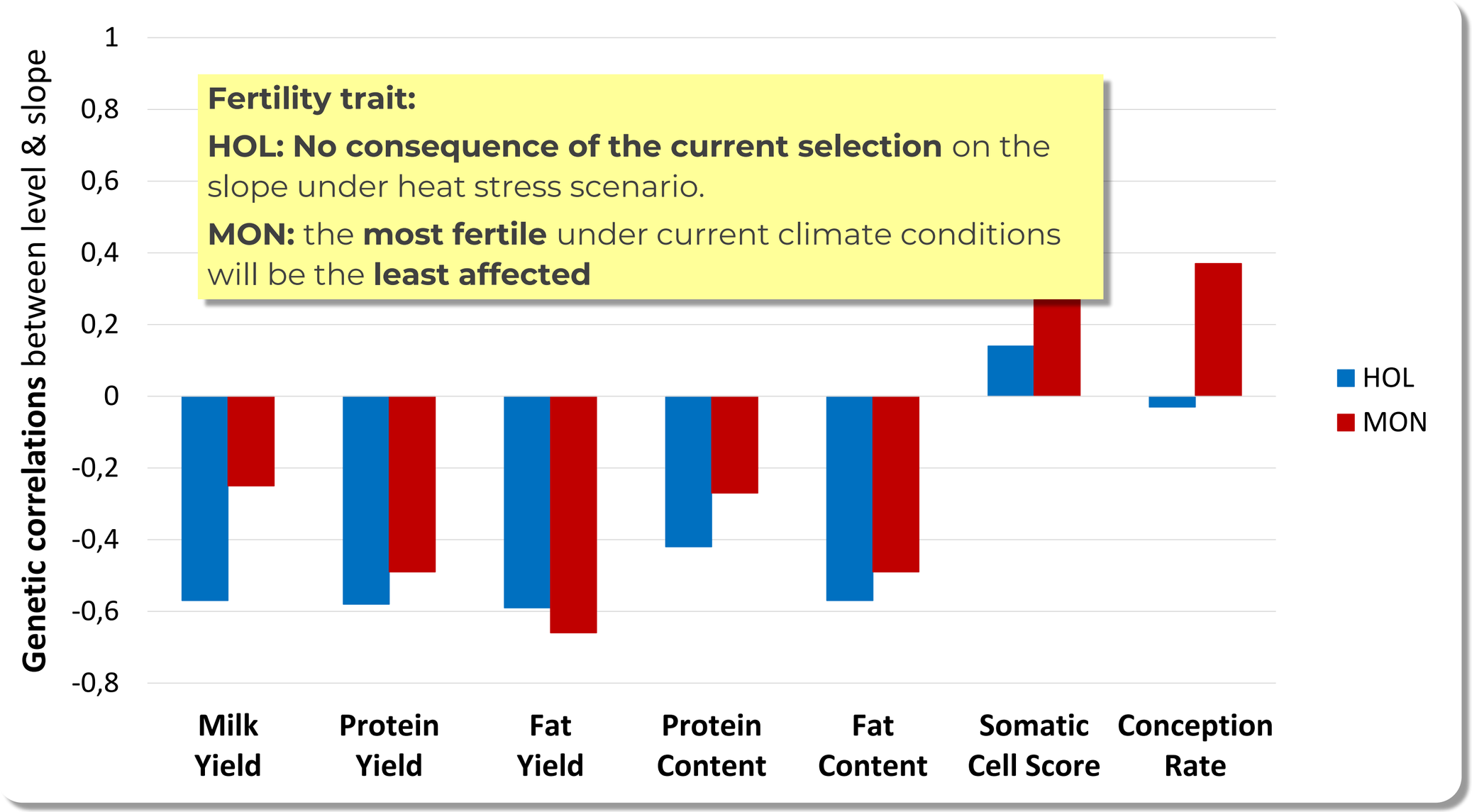


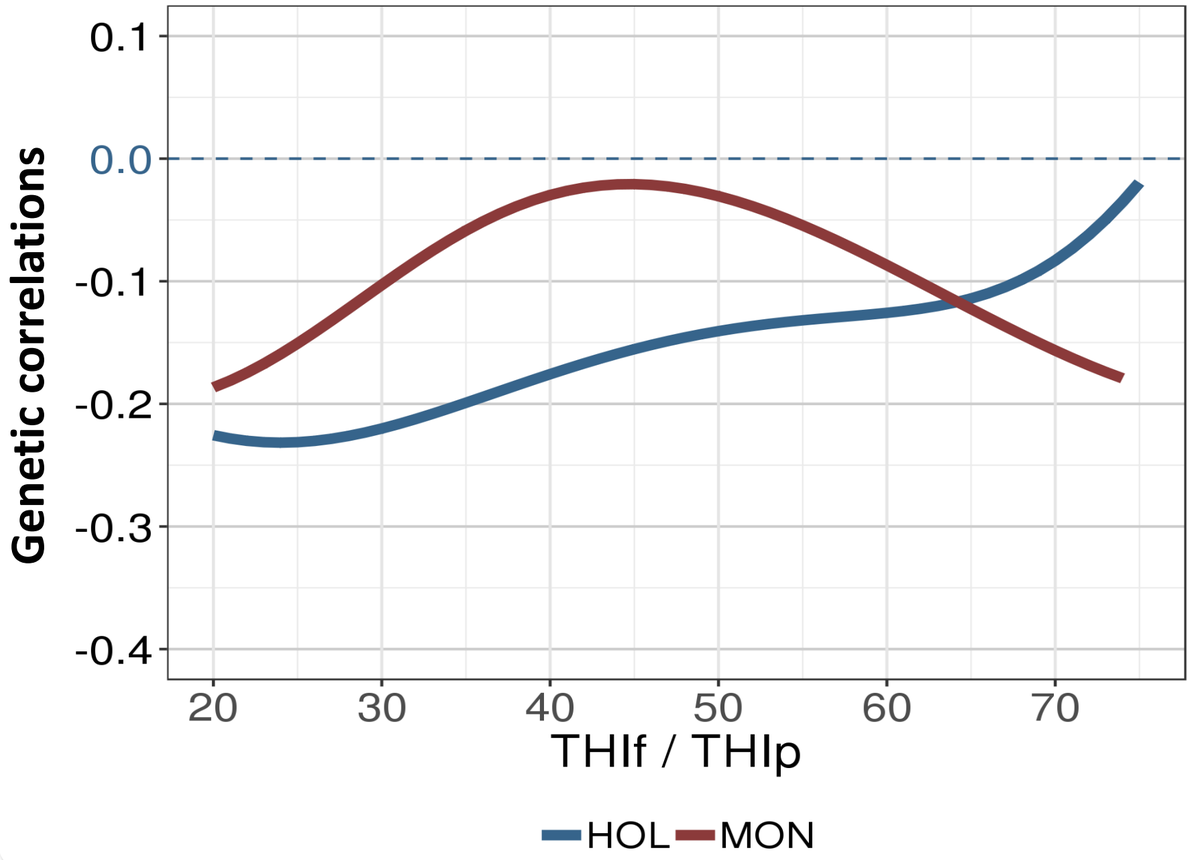
Trade-offs between PRODUCTION and FERTILITY under different climate conditions

Mid lactation PY

CR after 1st service

Genetic correlations between **PY and CR** along THI gradient

considering an equivalent THI for both traits



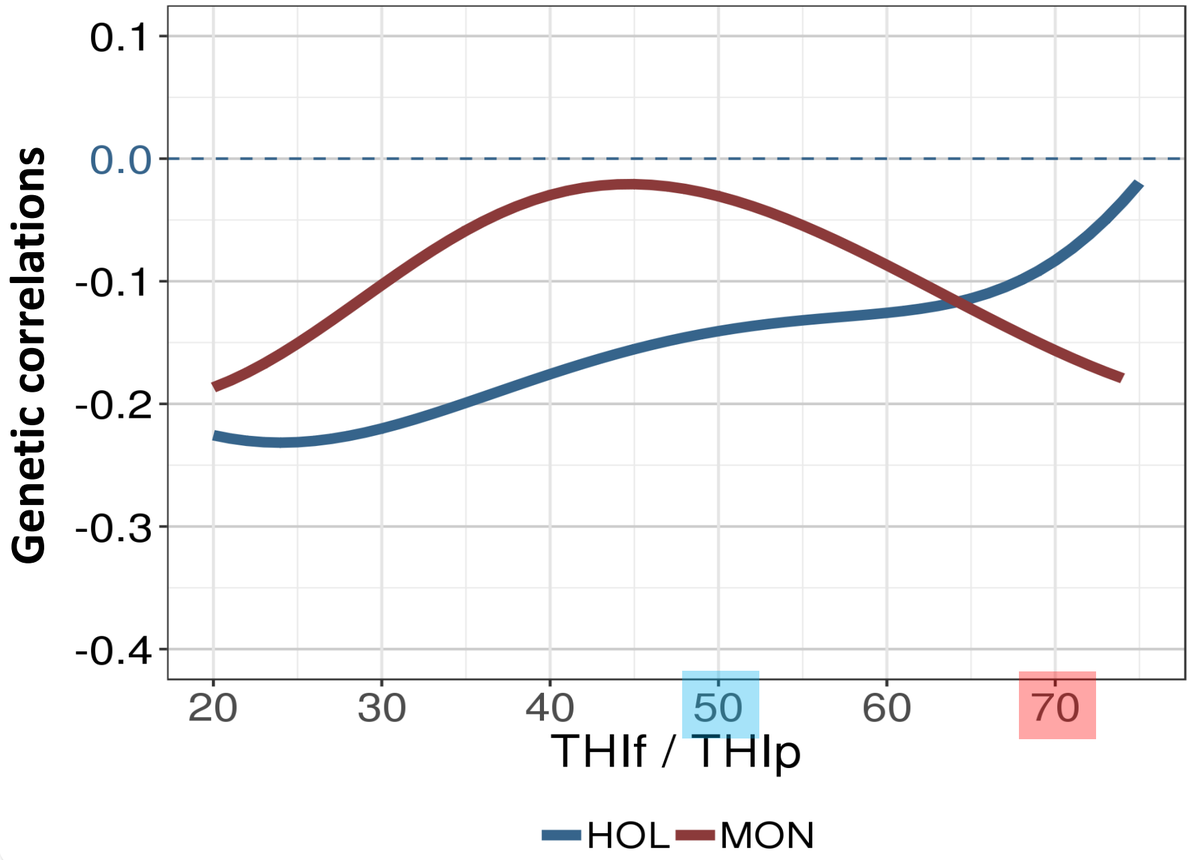
Low to moderate genetic correlations between CR and (mid lactation) PY

Trade-offs between PRODUCTION and FERTILITY under different climate conditions

Mid lactation PY *CR after 1st service*

Genetic correlations between **PY and CR** along THI gradient

considering an equivalent THI for both traits



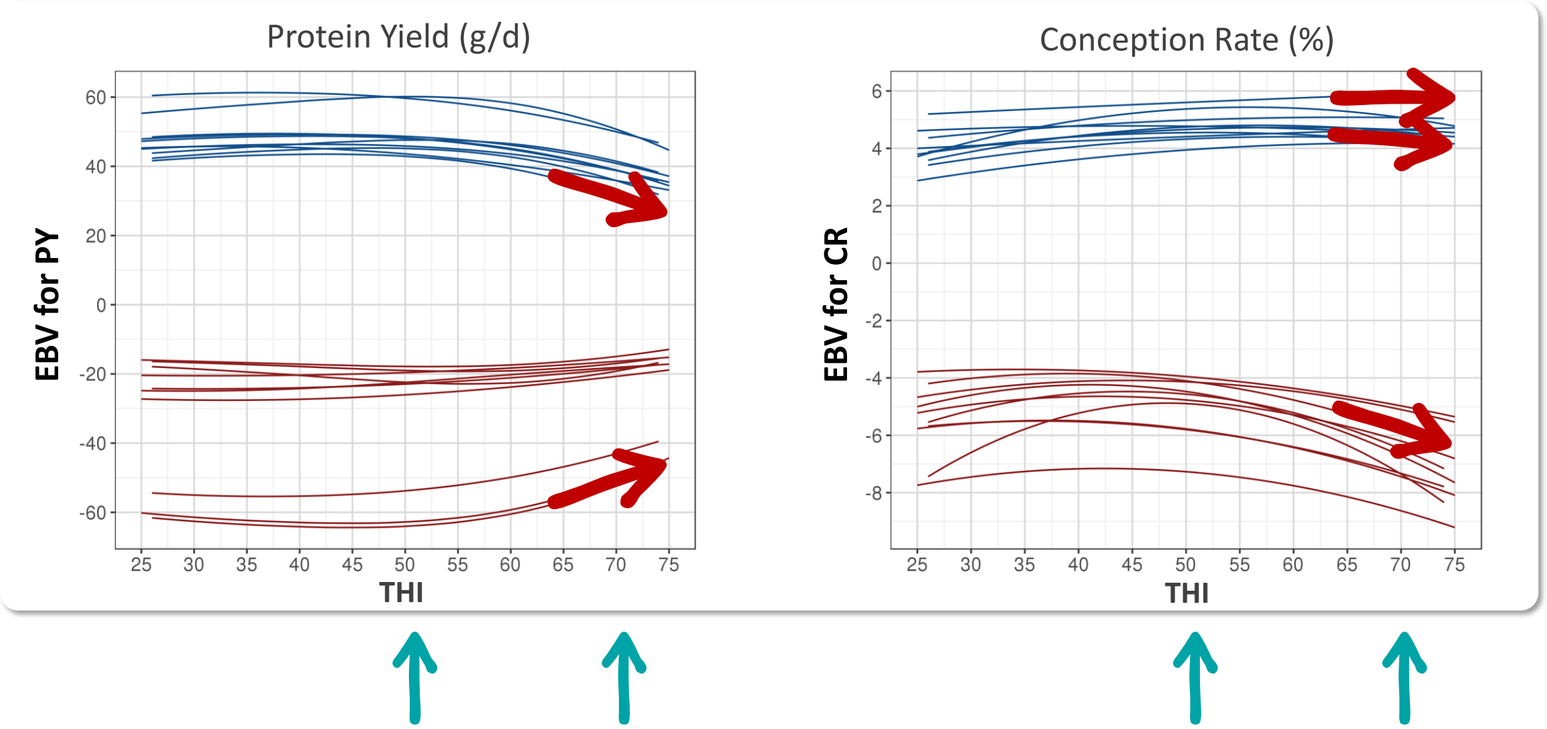
Current genetic correlation between CR and PY

⇔ -0.14 for HOL; -0.03 for MON

Genetic correlation between CR and PY for **heat stress scenario**

⇔ -0.08 for HOL ; -0.16 for MON

Effects of current selection on the future performances (under warmer climate)



Traits:

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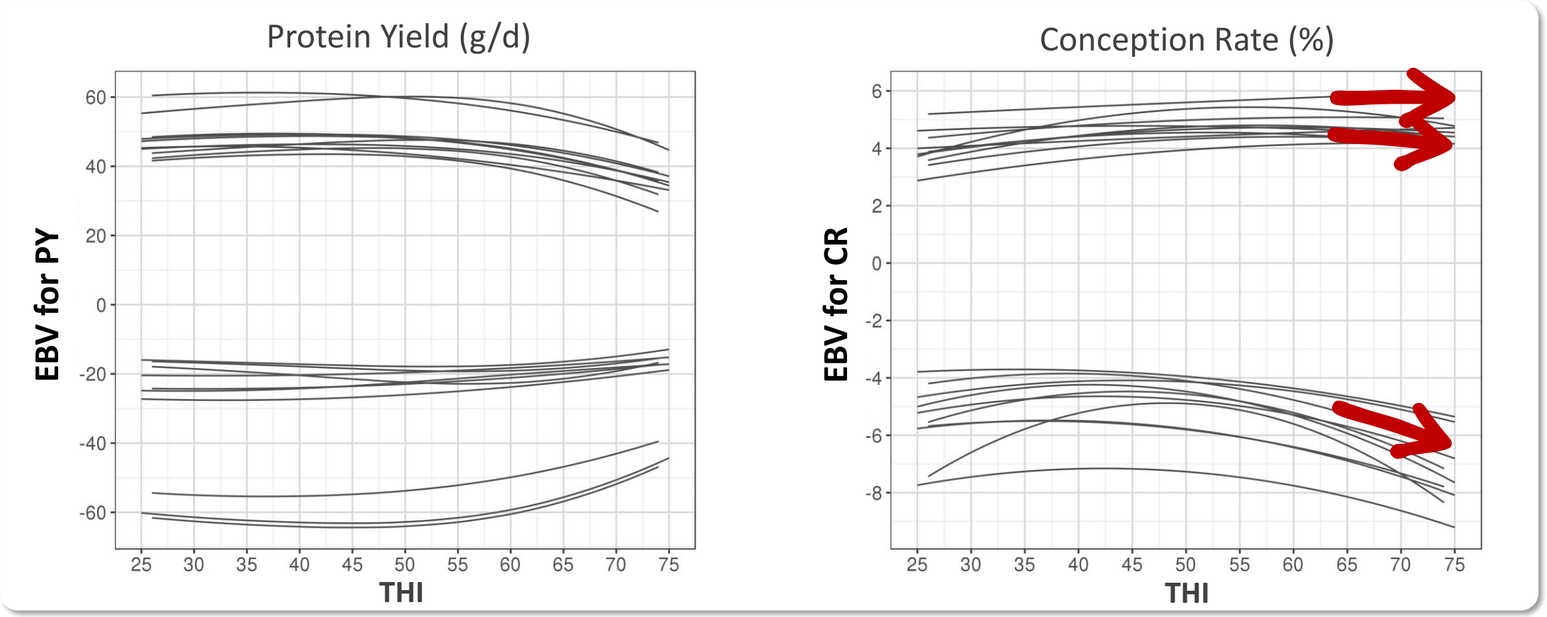
Slope = derivative of the EBV curve at a given THI

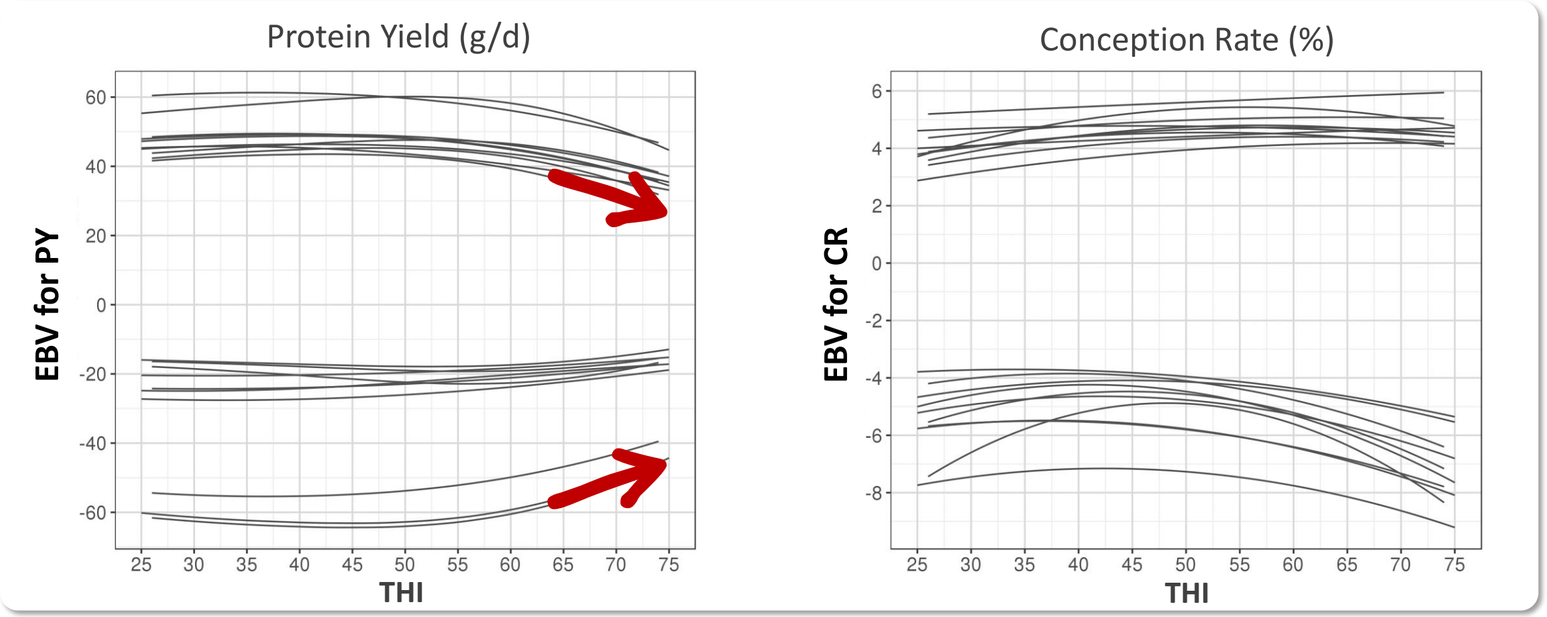
Effects of current selection on the future performances (under warmer climate)



Genetic correlations (*level PY THI50* ; *slope CR THI70*) = **-0.15** HOL; **-0.54** MON

High yielding cows under current climate conditions are expected to have **stronger decline in fertility** under heat stress

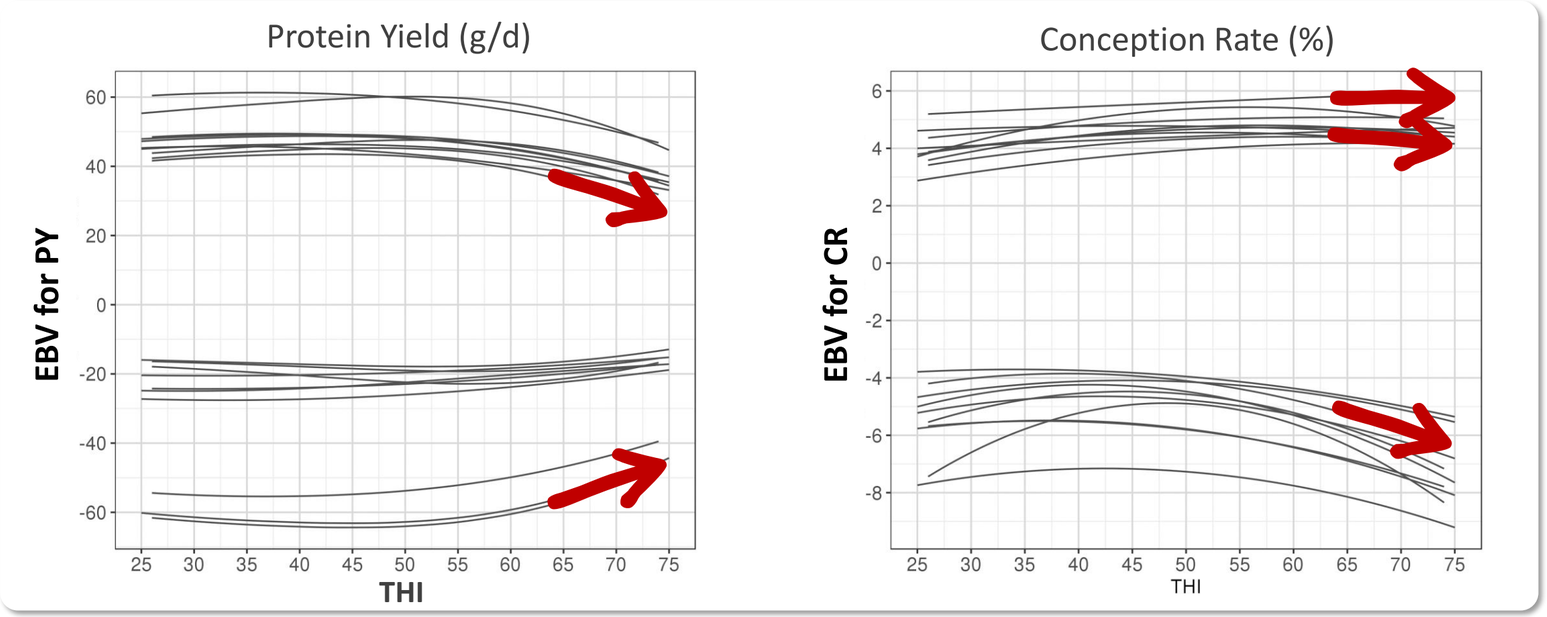
Effects of current selection on the future performances (under warmer climate)



Genetic correlations (*level CR THI50* ; *slope PY THI70*) = **0.33** HOL; **0.20** MON

Current selection on fertility has a rather favorable effect on production slope of decay

Effects of current selection on the future performances (under warmer climate)



Genetic correlations (*slope PY THI70* ; *slope CR THI70*) = **0.24** HOL; **0.27** MON

HOL & MON: positive genetic correlations between slopes

= cows with smaller decline in PROD generally have smaller decline in FERT

But high standard errors!

Take home message - How to deal with these trade-offs in selection?

→ Selection on production traits:

- The **high yielding cows are those that experience the highest decline in production** at high THI
  - Makes sense!
  - Could be a good thing if this allows to preserve other functions (basal metabolism, health, fertility, adaptation to heat,...)
- Selection on **slope of production decay** at THI70 would result in **counter-selection for production**
- Selection based on levels at THI70 (anticipate future climate conditions)

→ Selection on functional traits:

- Within trait: current **selection on levels at THI50 is favorable for future** (high genetic correlations with levels at THI70; no or slight positive effect on slopes of decay)
- Selection on slope of decay at THI70 can be helpful (it will never be beneficial to select the most sensitive cows for these traits)
- Selection based on levels at THI70 (anticipate future climate conditions)

→ Managing the trade-off between production and fertility:

- Trade-offs will remain but they should remain limited (under the THI conditions studied).
- Evolution of the genetic variances could make it easier to select for functional traits.

Vinet A, Mattalia S, Vallée R, Bertrand C, Cuyabano BCD and Boichard D, 2023.

Estimation of genotype by temperature-humidity index interactions on milk production and udder health traits in Montbeliarde cows. Genetics Selection Evolution, 55:4. https://doi.org/10.1186/s12711-023-00779-1

Vinet A, Mattalia S, Vallée R, Bertrand C, Barbat A, Promp J, Cuyabano BCD and Boichard D, 2024.

Effect of temperature-humidity index on the evolution of trade-offs between fertility and production in dairy cattle. Genetics Selection Evolution, 56:23. https://doi.org/10.1186/s12711-024-00889-4