

Rumigen

GERONIMO

## GERONIMO and RUMIGEN Joint Final Event

Breeding the Future

*Genomics, Epigenomics & Societal  
Acceptability for Sustainability in Livestock*

# Selection strategies for heat tolerance in dairy cattle

S. Mattalia,

A. Vinet, M. Calus, M.J. Carabaño, C. Diaz, M. Ramon, S. Aguerre, J. Promp, R. Vallée,  
B.C.D. Cuyabano,, H.A. Mulder, J. Vandenplas and D. Boichard



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## Global Warming : a big challenge for dairy cattle

Higher average temperatures and more frequent heat waves :

→ Negative impact on all dairy cattle performances (production, fitness)

→ **Our goal: propose selection strategies adapted to future climate conditions :**

- Identify animals able to **achieve sufficient overall production** while maintaining their **health and fertility** with increasing temperatures
  - Resilience,
  - Animal welfare
  - Sustainability of livestock production

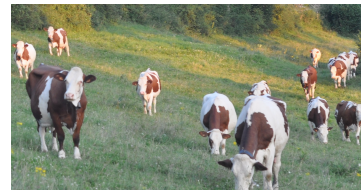




## A study based on existing large scale national data



Holstein (FRA, SPA, NLD)



Montbéliarde (FRA)



MRY (NLD)

**Performances:** Test-Day records on Milk Yield (MY), Fat Yield (FY), Protein Yield (PY), Somatic Cell Score (SCS), Conception Rate at 1<sup>st</sup> Insemination (CR)

	FRA	NLD	SPA
Period	2016-2020	2010-2020	2010-2021
# cows	7 Mo (HOL) 1.2 Mo (MON)	500,000 (HOL) 10,000 (MRY)	1 Mo (HOL)

**Daily weather information** provided by national Meteo Agencies and associated to each herd

### Temperature Humidity Index

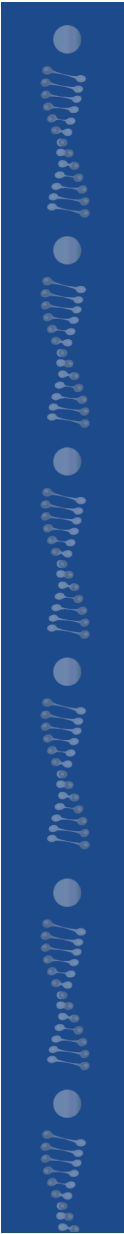
$$THI = (1.8 * T + 32) - (0.55 - 0.0055 * RH) * (1.8 * T - 26)$$

With T: average **daily** temperature (°C); RH: average daily humidity

(source: National Research Council, 1971)

Production, SCC :  
THI = average THI over a 3d period  
before TD (from d-2 to d0)

Fertility :  
THI = average THI over a 8d period  
after service (from d0 to d7)





## Estimation of the effect of a variation of THI: A common approach used on each population separately

### At the population level:

Cow  $i$ , Test Day  $j$ , submitted to a given THI (each lactation analysed separately)

$$y_{ij} = \text{THI} + \sum \text{other fixed effects}_{i,j} + a_i + p_i + e_{ij} \quad (\text{Production, SCS})$$

$$y_i = \text{THI} + \sum \text{other fixed effects}_i + a_i + e_i \quad (\text{CR1})$$

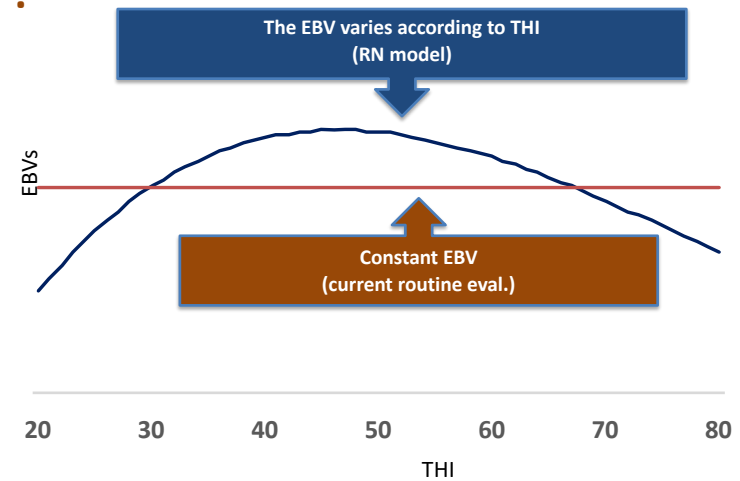
With

- $y_{ij}$ : performance of the cow
- Random effects:  $a_i$  additive genetic value,  $p_i$ : permanent effect,  $e_{ij}$ : residual
- Other fixed effects = fixed effects currently used in routine national evaluations

### At the individual level :

Same fixed effects,

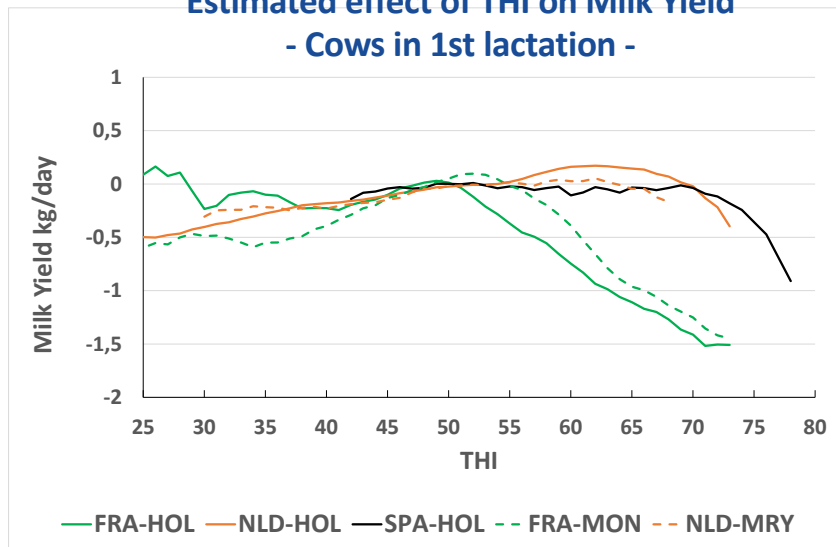
**Reaction norm models for additive genetic value**  
(= account for GxTHI) and permanent effect



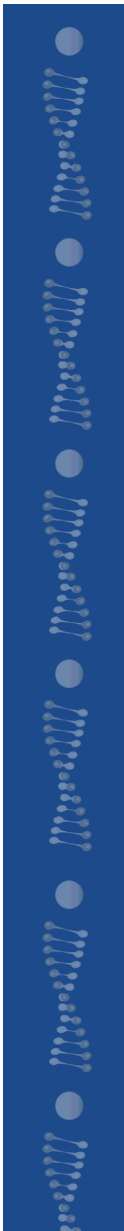
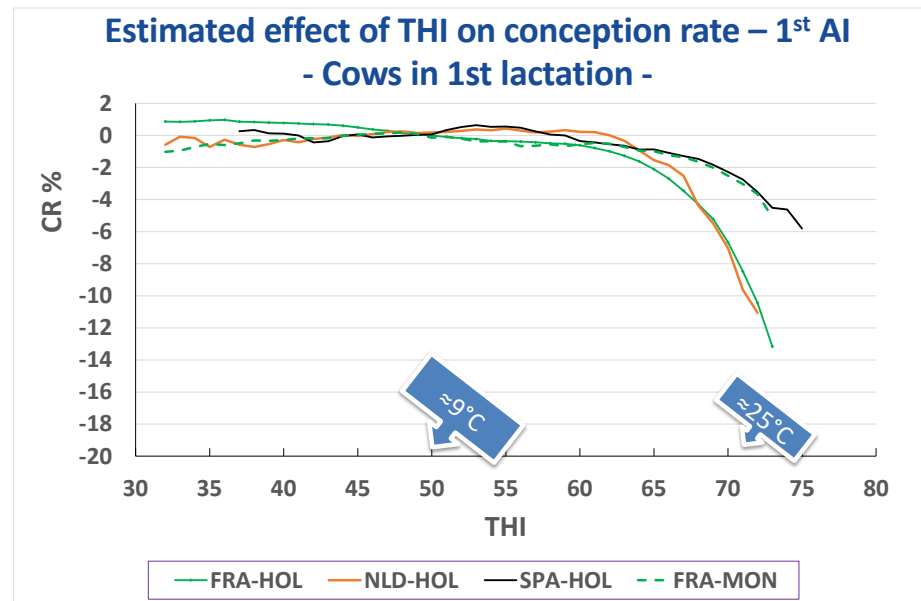


- ✓ For each trait: consistent patterns between breeds & countries
- ✓ A negative impact of increasing THI for all traits

Estimated effect of THI on Milk Yield - Cows in 1st lactation -



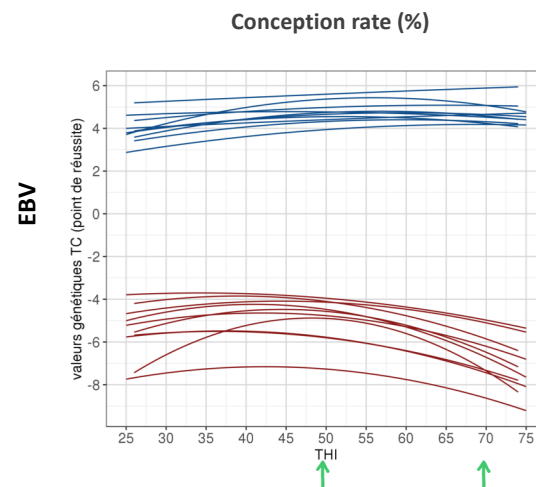
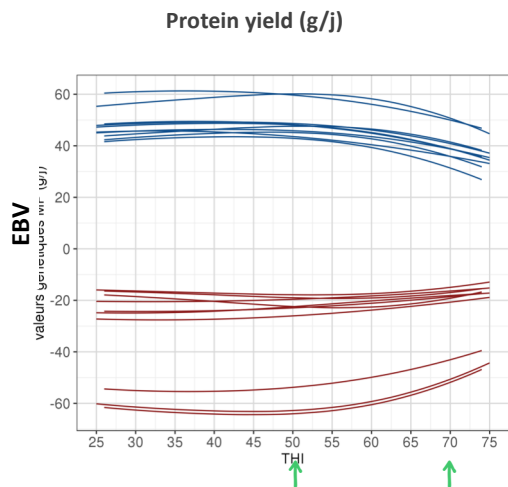
Estimated effect of THI on conception rate – 1<sup>st</sup> AI - Cows in 1st lactation -





## Results: 2.1) Heat stress (HS) at the individual level: traits definition

Evolution of the EBV as a function of THI (ex TOP/FLOP Montbeliard sires)



Level at THI 50 ⇔ Trait currently selected (thermoneutral conditions)

Level at THI 70 ⇔ Trait under heat stress

### Trait definition

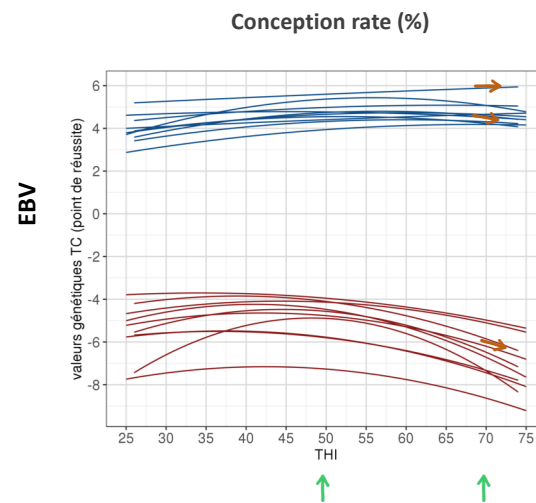
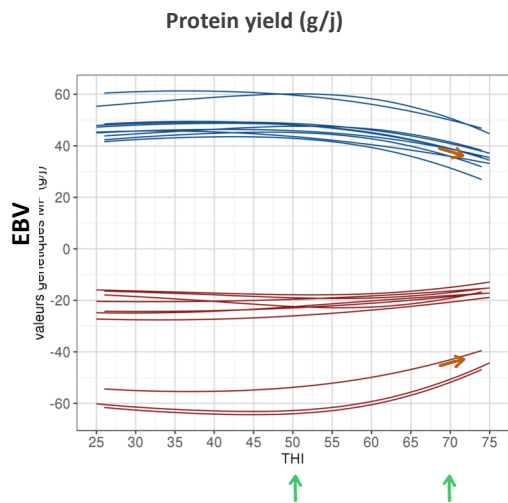
✓ *Level* = EBV at a given THI





## Results: 2.1) Heat stress (HS) at the individual level: traits definition

Evolution of the EBV as a function of THI (ex TOP/FLOP Montbeliard sires)



### Trait definition

- ✓ **Level** = EBV at a given THI
- ✓ **Slope** = derivative of the EBV curve at a given THI

**Level at THI 50** ⇔ Trait currently selected

**Level at THI 70** ⇔ BV at THI 70

**Slope at THI 70** ⇔ Sensitivity to THI increase under heat stress = Heat Tolerance

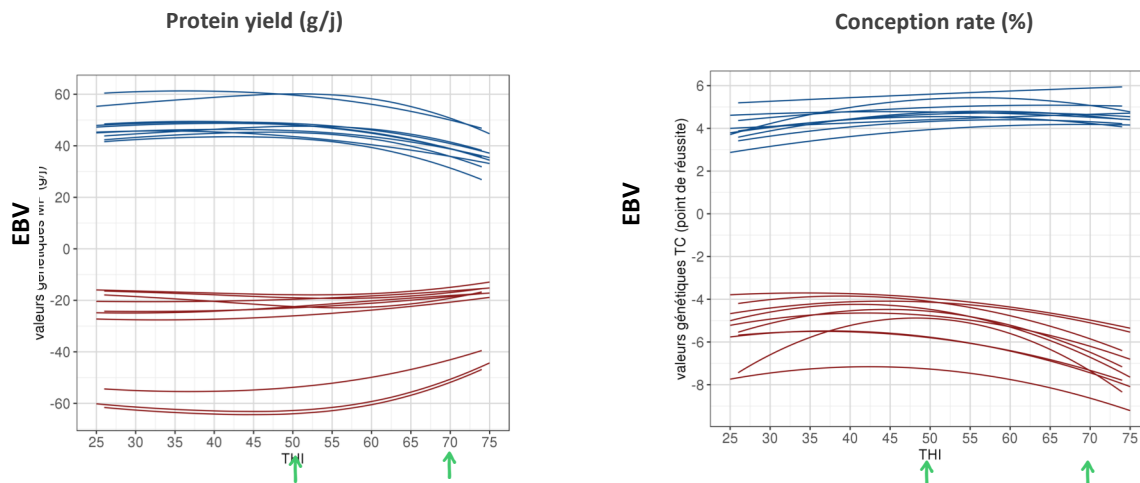
(>0 slopes ⇔ better performance maintenance at high THI)





## Results: 2.2) Heat stress (HS) at the individual level: G x THI

Evolution of the EBV as a function of THI (ex TOP/FLOP Montbeliard sires)

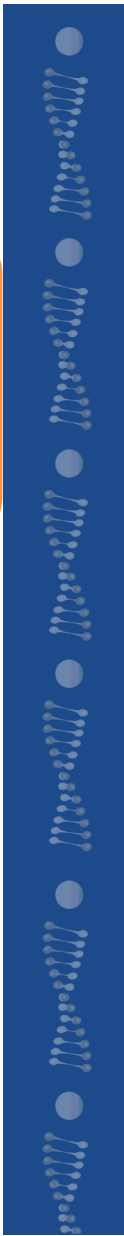


Level at THI 50 ⇔ Trait currently selected  
Level at THI 70 ⇔ BV at THI 70

**Trait definition**  
✓ *Level* = EBV at a given THI

### G x THI interactions (levels at THI 50 vs 70):

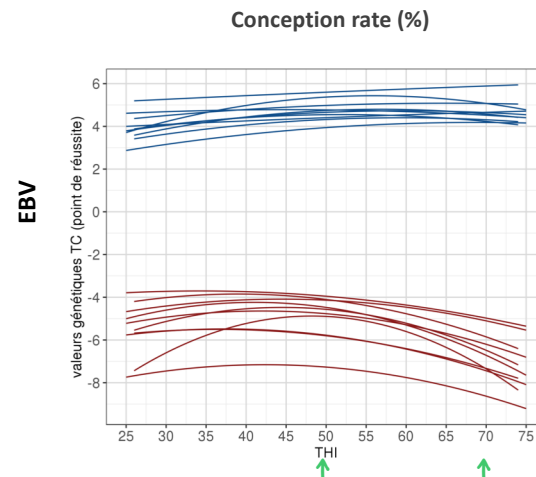
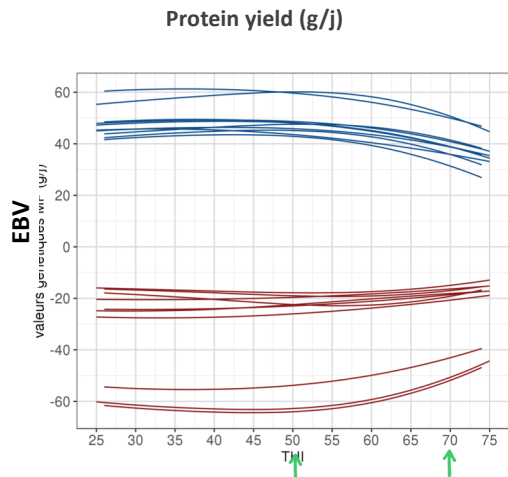
- Production, SCC: rg close to 1, few re-rankings
- Conception Rate: moderate GxTHI (but rg >0.70), more re-rankings





## Results: 2.2) Heat stress (HS) at the individual level: G x THI

Evolution of the EBV as a function of THI (ex TOP/FLOP Montbeliard sires)



Level at THI 50 ⇔ Trait currently selected  
Level at THI 70 ⇔ BV at THI 70

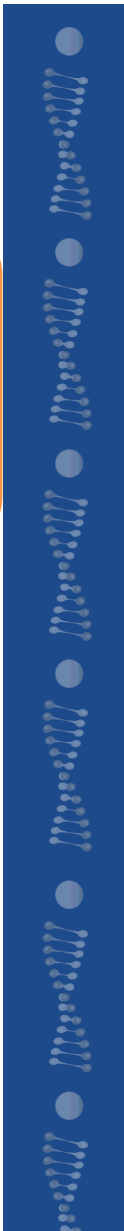
**Trait definition**  
✓ *Level* = EBV at a given THI

### G x THI interactions (levels at THI 50 vs 70):

- Production, SCC: rg close to 1, few re-rankings
- Conception Rate: moderate GxTHI (but rg >0.70), more re-rankings

### Impact of THI on genetic variances:

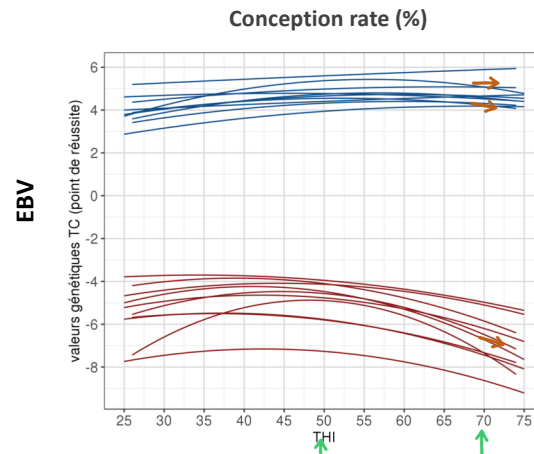
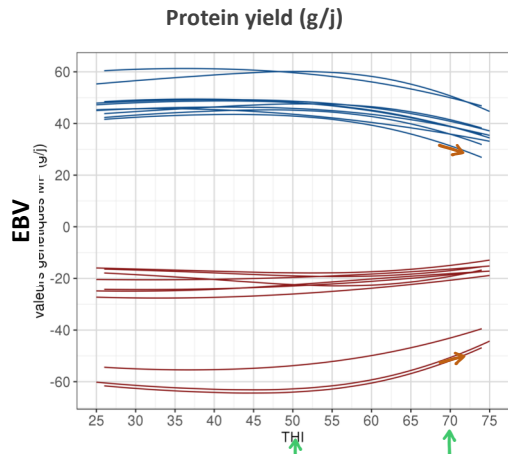
- Production: ∩ (less differences betw best and worst bulls)
- SCC, Conception Rate: ↗↗ (much more differences)



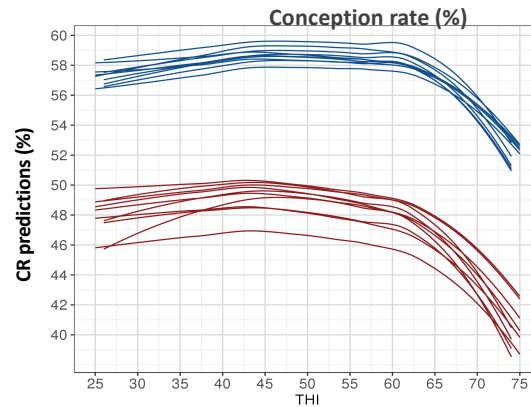
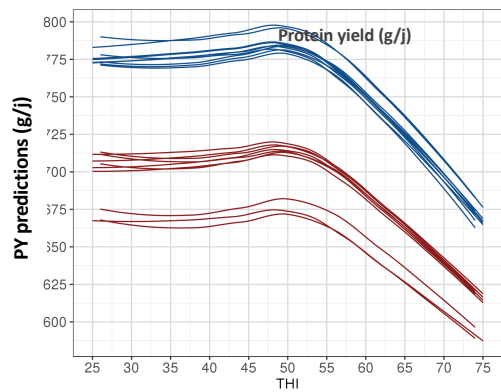


## Results: 2.3) Heat stress (HS) at the individual level: Predicted performances

Evolution of the EBV as a function of THI  
(ex TOP/FLOP Montbeliard sires)



Evolution of Predicted performances (same animals as above)



### Trait definition

- ✓ **Level** = EBV at a given THI
- ✓ **Slope** = derivative of the EBV curve at a given THI

**!** All animals are expected to experience a decline in performance at high THI

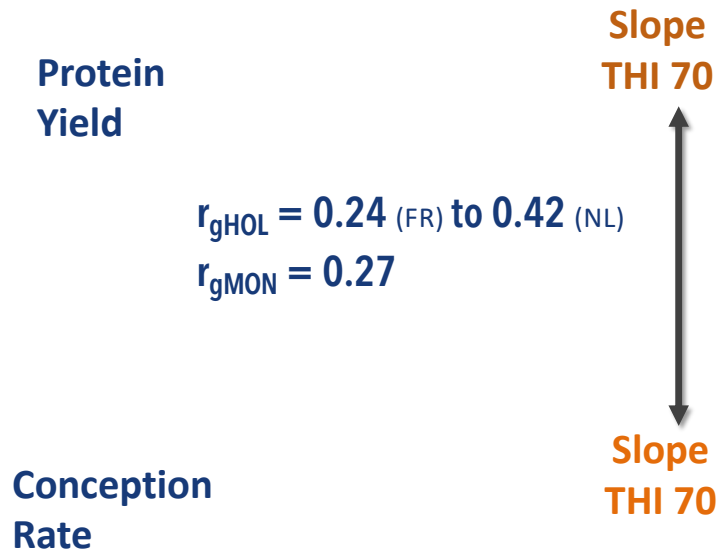




## Results: 3.1) Trade-offs Complexity of heat tolerance traits?

- Between traits related to heat tolerance (slopes 70)

Range of Genetic correlations obtained for Holstein (NL, SP and FR) and for Montbéliarde (FR)



*Heat tolerance traits are different and (moderately) correlated = selection of both is not antagonistic*

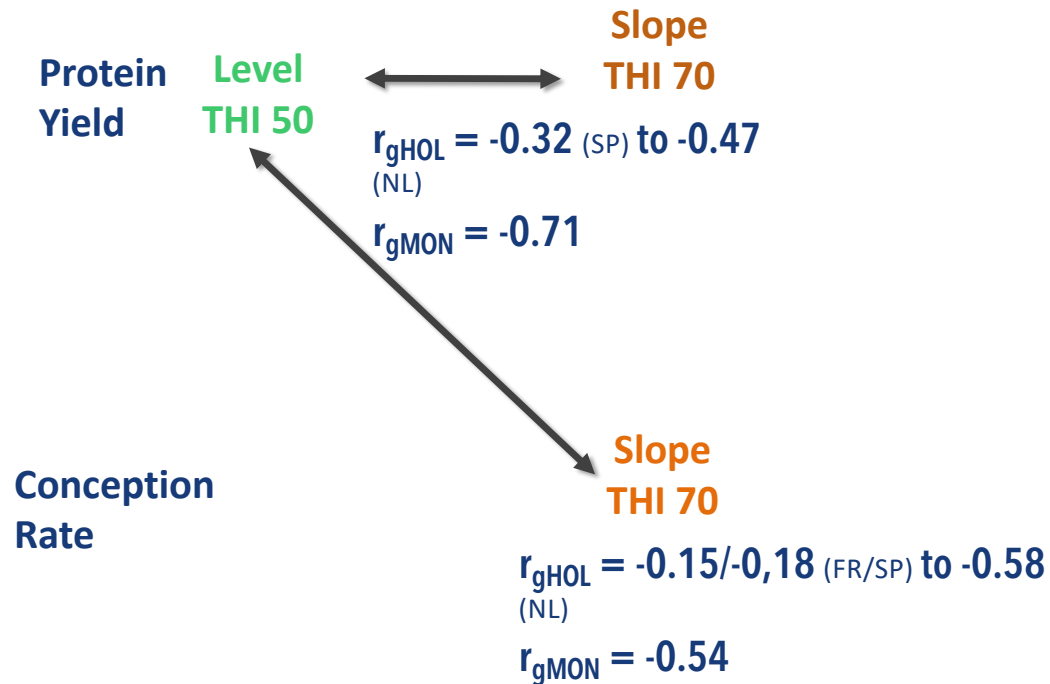




## Results: 3.2) Trade-offs - Impact of present selection on heat-tolerance traits

- Between traits currently selected (levels 50) and heat tolerance (slopes 70)

Range of Genetic correlations obtained for Holstein (NL, SP and FR) and for Montbéliarde (FR)



*The best producers will be the most affected by rising temperatures, both on prod and fertility*



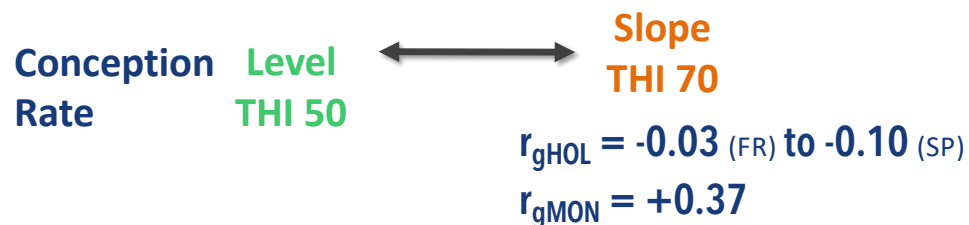


## Results: 3.2) Trade-offs - Impact of present selection on heat-tolerance traits

- Between traits currently selected (levels 50) and heat tolerance (slopes 70)

Range of Genetic correlations obtained for Holstein (NL, SP and FR) and for Montbéliarde (FR)

Protein  
Yield



*HOL: current selection for fertility has no impact on the ability to maintain fertility at high THI*  
*MON: the least fertile (at THI 50) are the most affected by rising temperatures*



**START NOW!**

**The animals of tomorrow are preparing today :**

**A decrease in performances due to climate change is expected for all traits and particularly on fitness**

- **Limited re-rankings :**
  - **Current EBVs on levels are still relevant, even in a context of climate change**
  - **Selection on fitness today is relevant to prepare future generations**
- **But scaling factor (genetic variances vary with increasing THI)**
  - **Current breeding goals (Total Merit Index) should emphasise fitness traits**

**Renew genetic evaluations: select animals adapted to future weather conditions:**

- **Heat Tolerance <-> Slopes under HS** to limit the impact of HS
  - **Weight in total merit index?**
  - **Acceptance by breeders (antagonism with production)?**
- **Levels<sup>2</sup> under HS** : to represent the future conditions and to ensure that we do not select just against the best producers



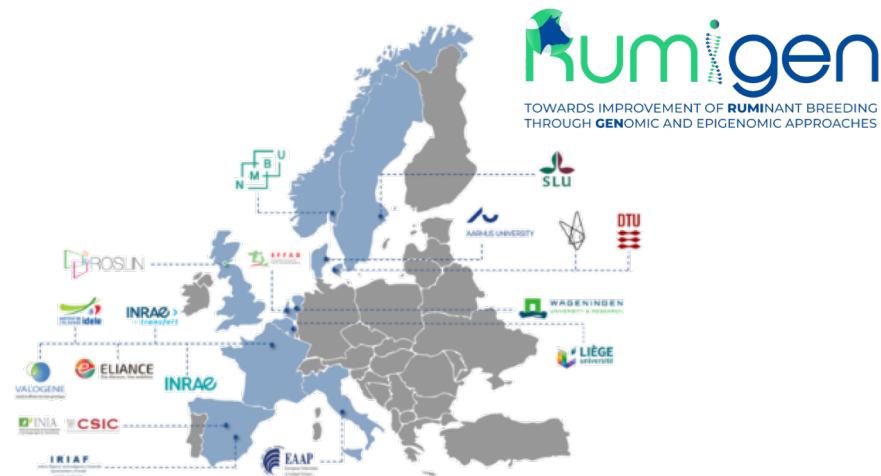
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# THANK YOU



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