Rumigen

TOWARDS IMPROVEMENT OF **RUMI**NANT BREEDING
THROUGH **GEN**OMIC AND EPIGENOMIC APPROACHES

Meta-analysis for heat stress tolerance traits in Holstein in France, the Netherlands and Spain

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RUMIGEN – Introduction

- **In the context of climate change, animals will be more and more exposed to heat-stress condititions**

- **Challenge : ensure that animals maintain a good production and remain healthy**

- **European project RUMIGEN**
  Evaluate the impact of heat-stress conditions on performances and estimate the genetic variability for heat-stress tolerance in Holstein dairy cattle breed

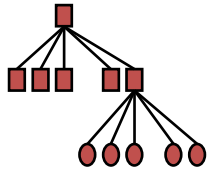
➢ **Objective : Meta-analysis to estimate genetic correlations between countries for heat stress tolerance traits in Holstein**

RUMIGEN – Datasets

- **Countries:** the Netherlands (WUR), Spain (INIA, IRIAF), France (INRAE, IDELE)
- **Breed:** Holstein – common to all 3 countries

- **Existing large scale national datasets:**
  - **Phenotypes** : national datasets for
    - production : milk yield (MY), fat yield (FY), protein yield (PY)
    - udder health : somatic cell score (SCS)

  - **Pedigrees**



  - **Weather :** daily records provided by national Weather Agencies associated to each herd through zip code

RUMIGEN – Heat stress indicator

- **Temperature-Humidity Index (THI)**

  calculated from the average daily temperature (T in °C) and relative humidity (RH)

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

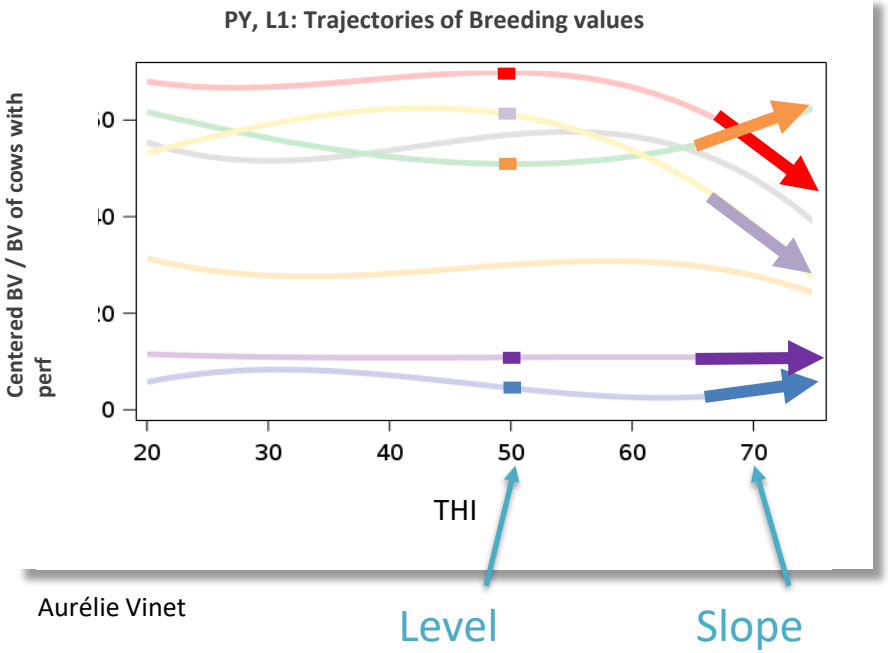
  (National Research Council. A guide to environmental research on animals. Washington: National Academy of Sciences; 1971.)

- **Heat stress indicator**

  Average THI over 3 days: 2 days before test day + test day

RUMIGEN - Traits definition

- At the **country level**, **variance components** and **breeding values** were estimated:
  - under **thermo-neutral conditions**
    - **level of production** at DIM 150 and **THI 50**
  - under **heat-stress conditions**
    - **level of production at a given THI**
    - **slope** using the **first derivative at a given THI**



RUMIGEN - Traits definition

- **Under heat-stress,** traits were defined **at different THI** in **each country**

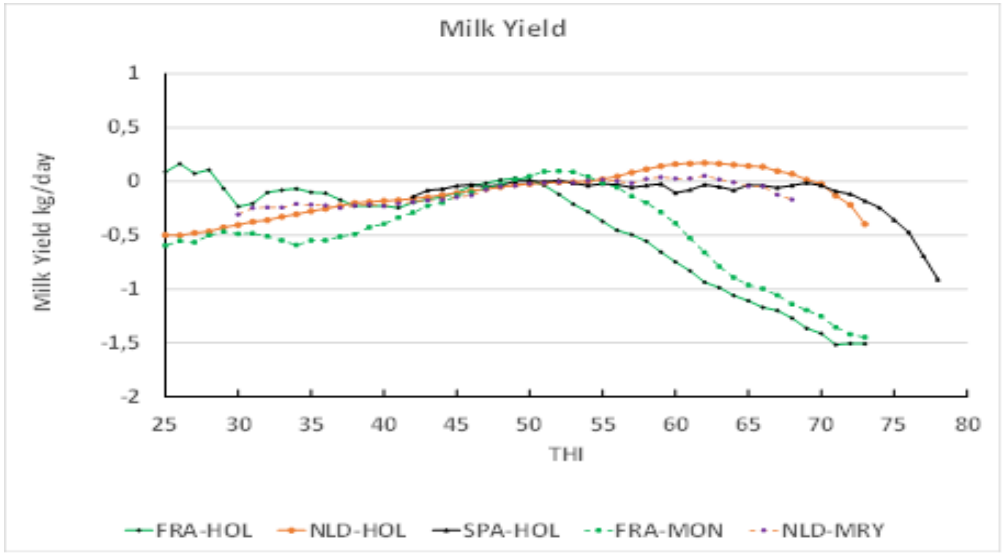
Different break points at the **population level** in each country

→ Adapt to the situation of each country

FRA : THI 65

NLD : THI 68

SPA : THI 77



RUMIGEN - Traits definition

- **Under heat-stress,** traits w… **…ent THI** in **each country**

Different breal… …try

→ Adap…

FRA : …

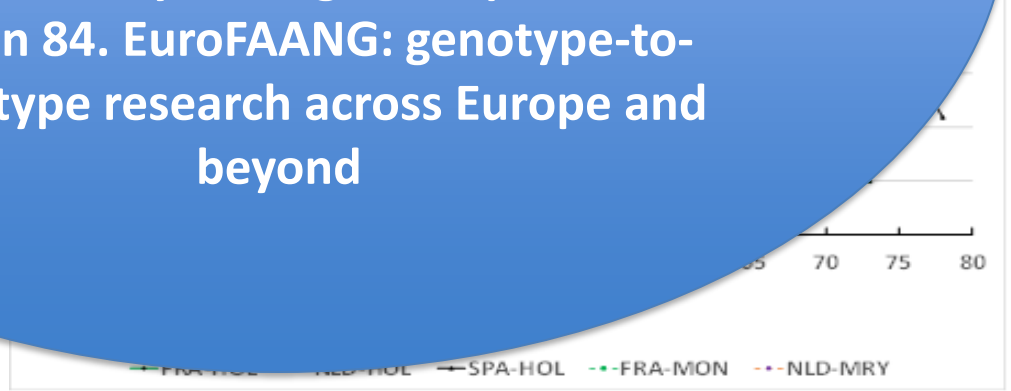
NLD : T…

SPA : THI …

More details about RUMIGEN project and population level study :

Sophie Mattalia et al.

Thursday 31 August – 5p.m.
Session 84. EuroFAANG: genotype-to-phenotype research across Europe and beyond



RUMIGEN – Genetic evaluation

- **Estimation of the effect of THI at the individual level:**

  Reaction norm models

$$y = \sum \text{fixed effects} + f(\mathbf{GxTHI}) + f(\mathbf{pxTHI}) + \mathbf{e}$$

- y: performances
- f(GxTHI): random additive genetic effects - Legendre polynomials
- f(pxTHI) : random permanent environment effect
- e: residual

➔ **Models specific to each trait and harmonised as far as possible between countries**

- **Genetic evaluation:**

  Each partner provided :
  - **EBVs** and **reliabilities** estimated for sires with at least 20 daughters
  - Pedigree file

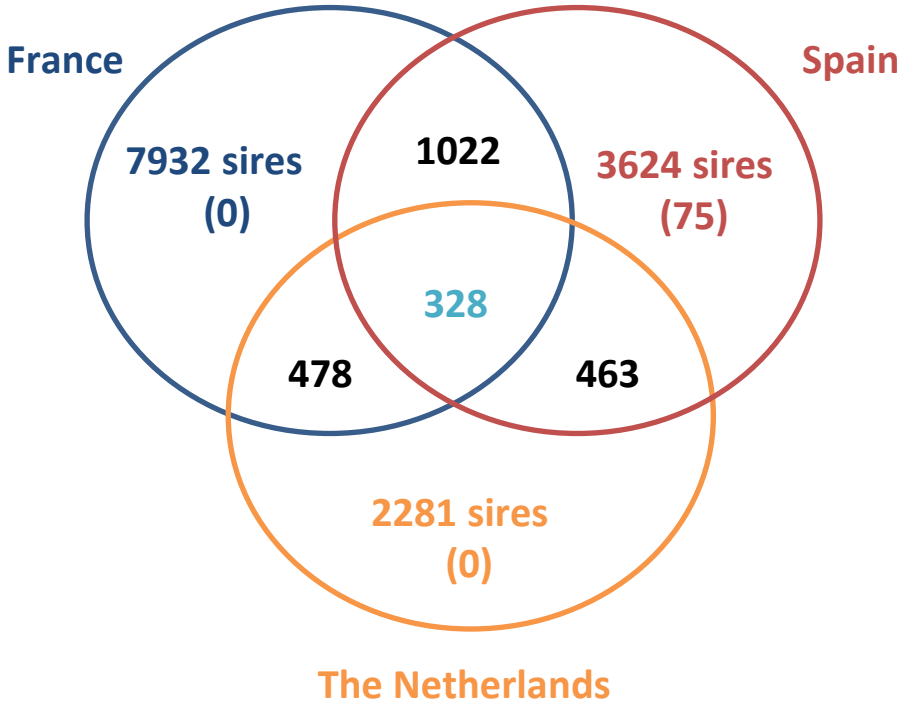
RUMIGEN - Meta-analysis methodology

- **Deregression:**
  Estimation of **deregressed proofs** (phenotypes) and **equivalent record contributions** (weights)
  - **Single trait animal model** – deregression by country and by trait
  - **Heritabilities:**
    - **estimated** for the **levels**
    - **assumed** to be equal to **0.10** for MY, FY, PY and **0.03** for SCS **slopes**
  - **Minimum reliability of 0.25**

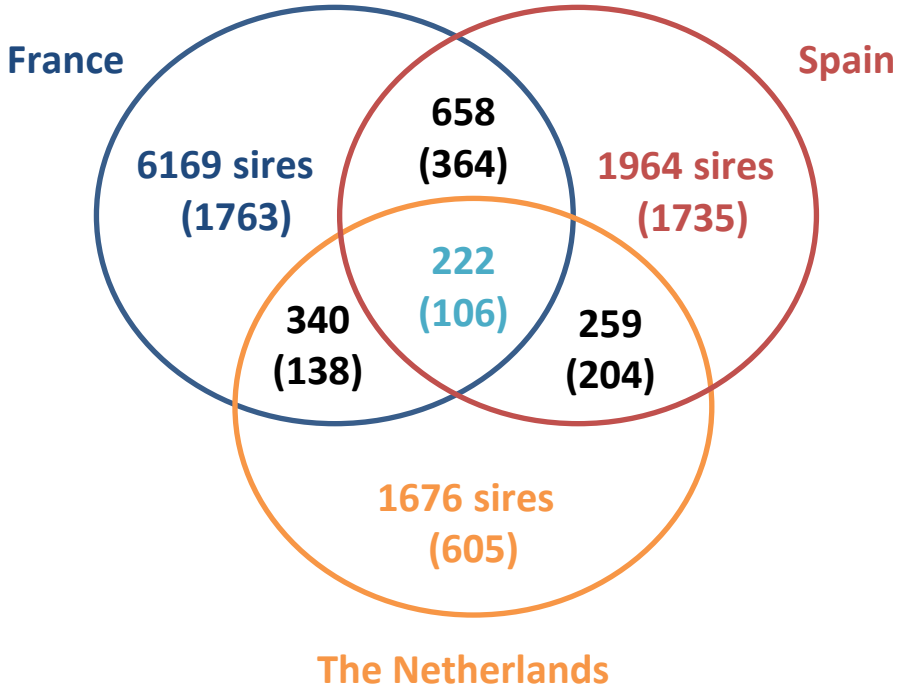
- **Genetic correlations among countries :**
  Similar to MACE approach
  Multiple trait model: **y** = **country** + **bull genetic effect** + **e**
  Blupf90 (Misztal *et al.*)

RUMIGEN - Common sires to all three countries

- **Milk productions traits - Levels**



- **Slopes for SCS**



( ) : number of sires deleted of the dataset because of low reliability

- **Elimination of sires** with **low reliability** had **more impact on slopes** than levels

RUMIGEN - Genetic correlations for the levels under thermo-neutral conditions

- **Levels at THI 50**

Milk yield	FRA	NLD	SPA
FRA	0.18 ± 0.01	**0.94 ± 0.02**	**0.96 ± 0.01**
NLD		0.25 ± 0.02	**0.92 ± 0.02**
SPA			0.19 ± 0.01

SCS	FRA	NLD	SPA
FRA	0.34 ± 0.01	**0.88 ± 0.02**	**0.95 ± 0.02**
NLD		0.15 ± 0.01	**0.89 ± 0.03**
SPA			0.08 ± 0.01

Fat yield	FRA	NLD	SPA
FRA	0.25 ± 0.01	**0.90 ± 0.02**	**0.97 ± 0.01**
NLD		0.21 ± 0.01	**0.89 ± 0.02**
SPA			0.13 ± 0.01

Protein Yield	FRA	NLD	SPA
FRA	0.15 ± 0.01	**0.89 ± 0.02**	**0.96 ± 0.01**
NLD		0.20 ± 0.01	**0.90 ± 0.02**
SPA			0.12 ± 0.01

- Heritabilities were mostly consistent with the national estimations.
- **Genetic correlations** between countries estimated for the **levels of production at THI 50** were **high and consistent with Interbull estimates**.

RUMIGEN - Genetic correlations for the levels under heat-stress conditions

FRA : THI65
NLD : THI68
SPA : THI77

- **Levels at high THI**

Milk yield	FRA	NLD	SPA
FRA	0.18 ± 0.01	**0.89 ± 0.02**	**0.92 ± 0.01**
NLD		0.25 ± 0.02	**0.86 ± 0.02**
SPA			0.25 ± 0.01

SCS	FRA	NLD	SPA
FRA	0.30 ± 0.01	**0.88 ± 0.02**	**0.96 ± 0.02**
NLD		0.16 ± 0.01	**0.88 ± 0.03**
SPA			0.09 ± 0.01

Fat yield	FRA	NLD	SPA
FRA	0.25 ± 0.01	**0.87 ± 0.03**	**0.97 ± 0.02**
NLD		0.20 ± 0.02	**0.85 ± 0.04**
SPA			0.13 ± 0.01

Protein yield	FRA	NLD	SPA
FRA	0.17 ± 0.01	**0.81 ± 0.02**	**0.89 ± 0.01**
NLD		0.21 ± 0.01	**0.83 ± 0.02**
SPA			0.17 ± 0.01

- **Genetic correlations** between countries estimated for the **levels of production at high THI were high**…

RUMIGEN – Comparison of genetic correlations under thermo-neutral conditions and under heat-stress conditions

- **Levels at THI 50**

Milk yield	FRA	NLD	SPA
FRA	0.18 ± 0.01	**0.94 ± 0.02**	**0.96 ± 0.01**
NLD		0.25 ± 0.02	**0.92 ± 0.02**
SPA			0.19 ± 0.01

- **Levels at high THI**

Milk yield	FRA	NLD	SPA
FRA	0.18 ± 0.01	**0.89 ± 0.02**	**0.92 ± 0.01**
NLD		0.25 ± 0.02	**0.86 ± 0.02**
SPA			0.25 ± 0.01

- **… even though they were lower than at THI 50**

RUMIGEN - Genetic correlations for the slopes under heat-stress conditions Example of milk yield

- **Inconsistent genetic variances from one country to another**
  - France : 0.5 ± 0.01
  - The Netherlands : 2.7 ± 0.05
  - Spain : 0.01 ± 0.001

- **Different variance estimates at different THI**
  - Residual variances of 4.9 ± 0.17 at THI68 vs 8.6 ± 0.66 at THI70 for the Netherlands

- **h^2 estimates much higher than expected** (expected value ≈ 0.10)
  - France : 0.21 ± 0.01
  - The Netherlands : 0.44 ± 0.06
  - Spain : 0.09 ± 0.01

→ Unreliable results

RUMIGEN – Discussion

- **Levels:**
  - Our approach **was validated**
  - **High genetic correlations** were found between the 3 countries
    - **Consistent with Interbull references at THI50**
    - **Lower correlations under heat stress** than under thermo-neutral conditions

- **Slopes:**

  Difficulties in correctly estimating variances
  - Estimated as **derivative at a given THI** → sensitivity to potential error

  - **Deregression**

    Few data at high THI on which to base estimates of the slopes

    → **indirect prediction** of the slopes based on the performances at low THI

    It leads to several issues for the deregression :
    - low reliabilities
    - the hypothesis of a single trait model for the deregression is probably too strong

RUMIGEN – Conclusion

- **Slopes:**
  - give an indication of the **animals' ability to maintain production despite high temperatures**

  BUT
  - were **difficult to use in practice** with our dataset (few data at high THI)

- **Levels:**
  - give an indication of **the level of production we can expect in the future**
  - **there is an interest in working on levels at high THI**
  - there is an interest in developping **collaborations** between countries that are already facing high temperatures and countries that will face high temperatures in the future

RUMIGEN PARTNERS

Thank you for your attention

www.rumigen.eu

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