Multi-omics data integration approach for resilience of dairy cattle to heat stress

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Heat stress (HS): Context

➢ Economic loss

2003
USA

2013 & 2014
France & Switzerland

2018
Ireland

Average losses due to heat stress:
- Without any heat abatement: $167 per cow per year
- With optimal heat abatement system: $100 per cow per year

St Pierre et al. (2003)

Milk loss: 2.73 kg / day


Heatwave costing for dairy farmers 1,750 € / week


➢ Heat wave of July 2018

167$/cow

37°C

FURNACE FRIDAY!

THE WORLD'S ON FIRE!
Breeding for resilience to HS: Challenges

➢ Biological mechanisms
  • Complex interactions

➢ Phenotyping strategies
  • mostly reductionist approaches

Associating multiple-omics data ➔ better view of resilience to HS

Renaudeau et al. (2015)
Objectives

- Phenomics
- Climate conditions
- Holistic Approach
- More insights on biological background of resilience to HS and GxE

- Genetics
- Genomics
- Milk biomarkers
- Pedigree
- SNP’s

Objectives

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Data & models

➢ Data
  • 62,744 TD records
  • 3 days lag THI test-date
  • 8,485 third-lactation cows

➢ Multivariate reaction norm model
  ✓ 3 lactation stage

Production
  ▪ Milk, Fat, Prot yields

Fatty acids
  ▪ C4:0, C18:1 cis-9, UFA, MUFA, LCFA

Milk metabolites
  ▪ Acetone and BHB

Intercept \( a_0 \)

Slope \( a_{hs} \)

THI

Ratio of Slope-Intercept variances

Limited sensitivity to HS

Small

Large

High sensitivity to HS
Ratios of slope-intercept genetic variances

**HS: Highly affecting cows in midlactation** (Aguilar et al, 2009; Brügemann et al. 2011)

Changes in blood parameters related to energy balance and enzyme activity (Abeni et al. 2007)
Resilience to HS: GWAS

**Solutions:**
- $EBV_{\text{intercept}}$
- $EBV_{\text{slope}}$

**Genotypes:**
4077 animals (50 K SNP)
20943 animals with pedigree

**Gene mapping**
ORG.MESH.BTA.DB

**SNP effects**
Milk yield: Intercept

Early

Middle

Late

DGAT1

Number of genes shared in all periods vs specific lactation stage genes

- DGAT1 encoding for milk yield & composition

- Number of genes shared in all periods
- Early-specific
- Middle-specific
- Late-specific

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2 2 3

Shared in all periods
Early-specific
Middle-specific
Late-specific
Milk yield: Slope

Cellular thermotolerance and HS response

Number of genes shared in all periods vs specific lactation stage genes

Early-specific
Middle-specific
Late-specific

Shared in all periods

Early
Middle
Late

HSP90A
HSF1

Protein involved in the mechanism of response to HS

Cellular thermotolerance and HS response
C18:1cis9: Intercept

Number of genes shared in all periods vs specific lactation stage genes

- **Early**
  - STAT1: Regulating the transcription of milk protein synthesis
  - Chromosome 30
  - Early-specific

- **Middle**
  - STAT1: Lactogenesis & Lipid synthesis
  - Chromosome 8
  - Middle-specific

- **Late**
  - STAT1
  - Chromosome 30
  - Late-specific

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C18:1cis9: Slope

IGF1

GHR

Metabolism of lipids

Molecular markers

fertility

Chromosome

Number of genes shared in all periods vs specific lactation stage genes

- Shared in all periods
- Early-specific
- Middle-specific
- Late-specific

Early

Middle

Late

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**Take home messages**

- Milk production traits: Middle lactation vs Milk biomarkers: Early

- Changes in milk-based biomarkers under high THI are more affordable to better elucidate pathways

- Ongoing investigation using the holistic approach integrating phenomics (milk-biomarkers) and genomics is promising
  - to be consolidated for both case study traits
  - benefit from current pipelines to go one with the rest of traits
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