Genotype by environment interaction (G×E) for female fertility under conventional and organic production systems in Danish Holsteins

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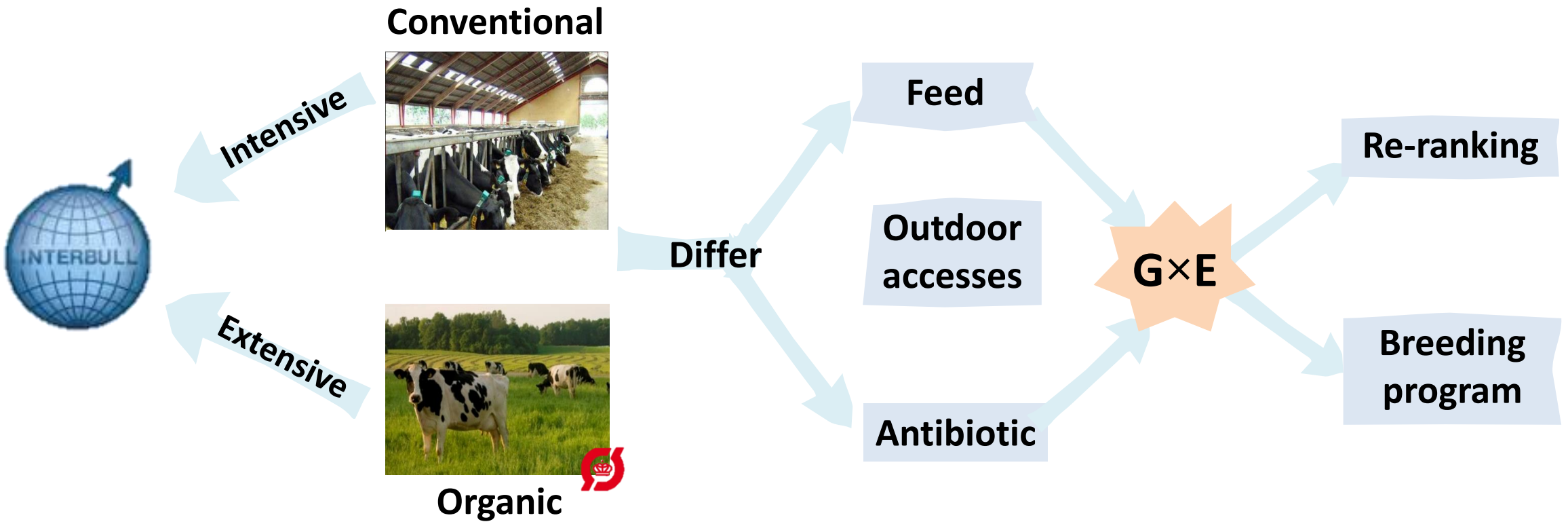
Introduction

Introduction



- ✓ **13% milking cows are from organic herds** *(Lauridsen, U., 2018)*
- ✓ **Bulls used for organic are selected from data of all herds**

Objectives

For female fertility traits in Danish Holsteins:

- ✓ **Estimate variance components and heritabilities for conventional and organic production systems separately**

- ✓ **Investigate G×E under these two production systems**

Material and methods

Workflow

- ✓ Environmental descriptor
- ✓ Grass ratio -> Energy balance -> fertility

Clean phenotype

Official registration

Convention

organic

Grass ratio of feed (2011 / 2016)

Typical Convention

Typical Organic

two-trait *DMU*

h^2

r_g

Different from 1

G×E

Full pedigree

3 gen. *DmuTrace*

pedigree

Data-Traits

- ✓ Same traits as Nordic routine evaluation
- ✓ Heifers (h) and cows (c) as different traits

Heifer & Cow

Conceive and keep pregnancy

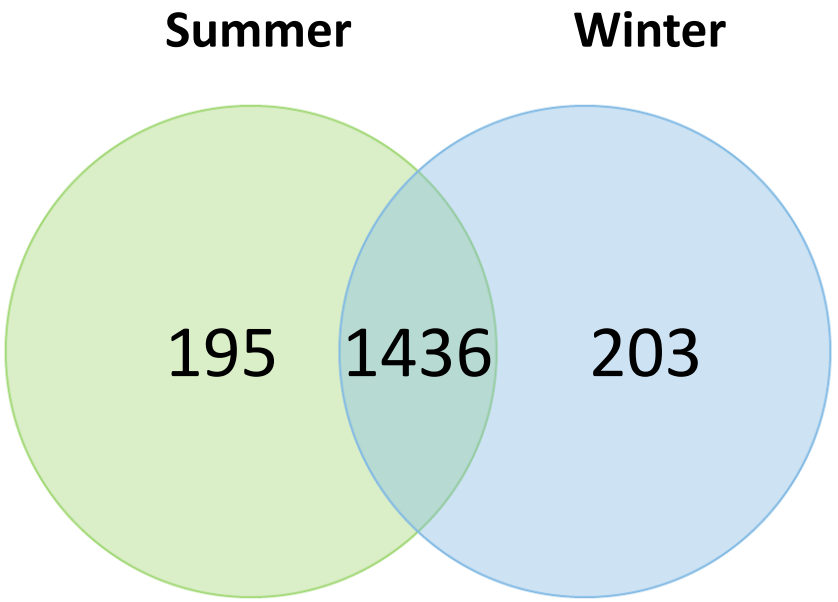
AIS	Number of inseminations
IFL	Interval from first to last insemination
NRR	Non-return rate at 56 days after first insemination

Cow

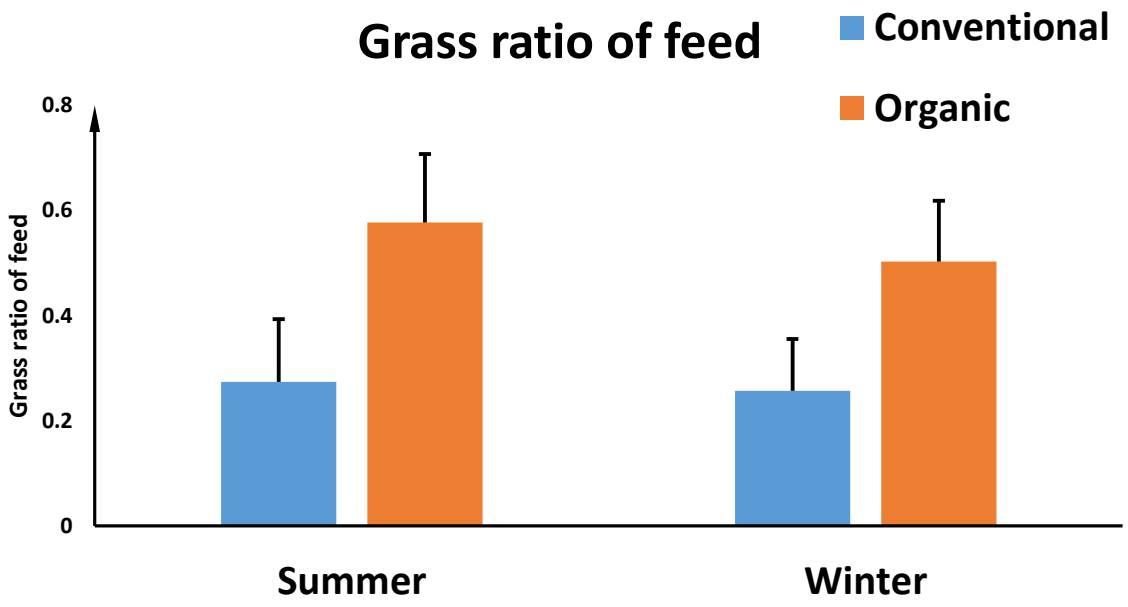
Recycle after calving

ICF	Interval from calving to 1st insemination

Data- Grass ratio of feed



No. of herds with grass ratio of feed



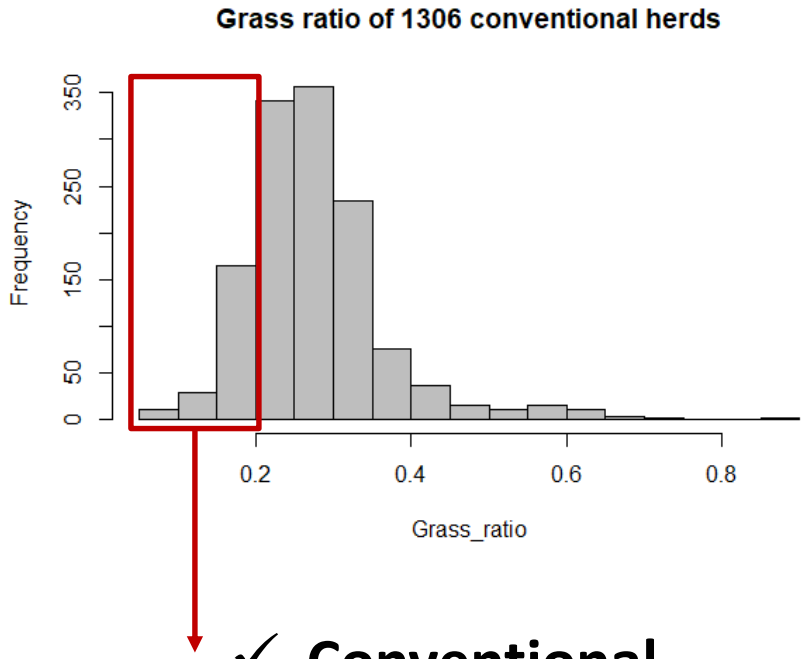
Organic > Conventional

✓ **Differences of grass ratio between seasons varied across herds**

- Herds with both seasons
- Average over Summer and Winter

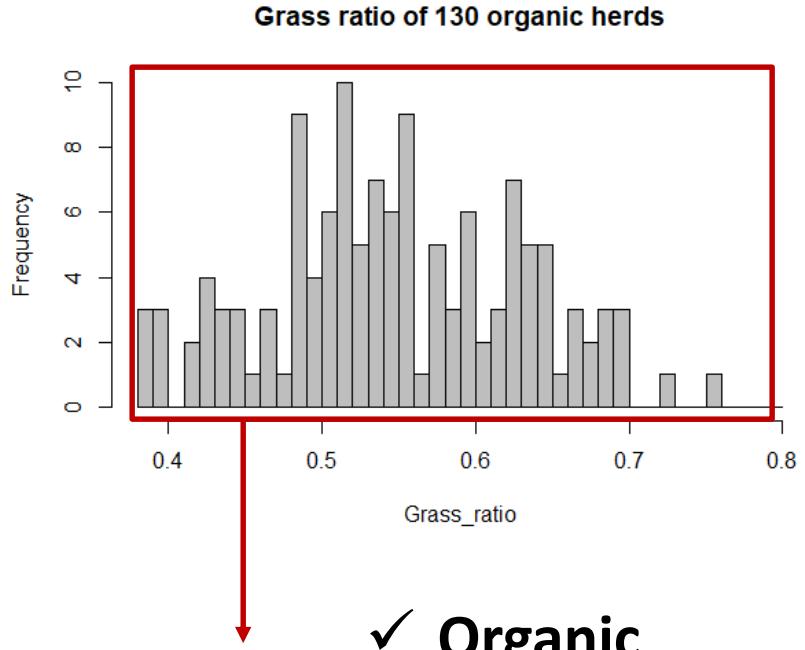
Data-Typical conventional/organic

Distribution of grass ratio of feed



✓ **Conventional**

- Herds: 204 herds grass ratio < 0.2
- Records: ~85,000 (heifer)
  ~120,000 (cow)



✓ **Organic**

- Herds: 130 herds grass ratio > 0.38
- Records: ~35,000 (heifer)
  50,000 (cow)

Model-Heifer traits

✓ **Two-trait animal model**

Routine genetic evaluation

conventional

organic

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

$$\begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \sim N\left(0, I \otimes \begin{bmatrix} \sigma^2_{e_1} & \mathbf{0} \\ & \sigma^2_{e_2} \end{bmatrix}\right)$$

$$\begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \sim N\left(0, A \otimes \begin{bmatrix} \sigma^2_{a_1} & \boldsymbol{\sigma_{a_1 a_2}} \\ & \sigma^2_{a_2} \end{bmatrix}\right)$$

Model-Cow traits

✓ **Two-trait animal model**

Repeatability model
(lactation 1-3)

$$\begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \sim N\left(0, I \otimes \begin{bmatrix} \sigma^2_{e_1} & 0 \\ & \sigma^2_{e_2} \end{bmatrix}\right)$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} Z_{a1} & 0 \\ 0 & Z_{a2} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} Z_{pe1} & 0 \\ 0 & Z_{pe2} \end{bmatrix} \begin{bmatrix} pe_1 \\ pe_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

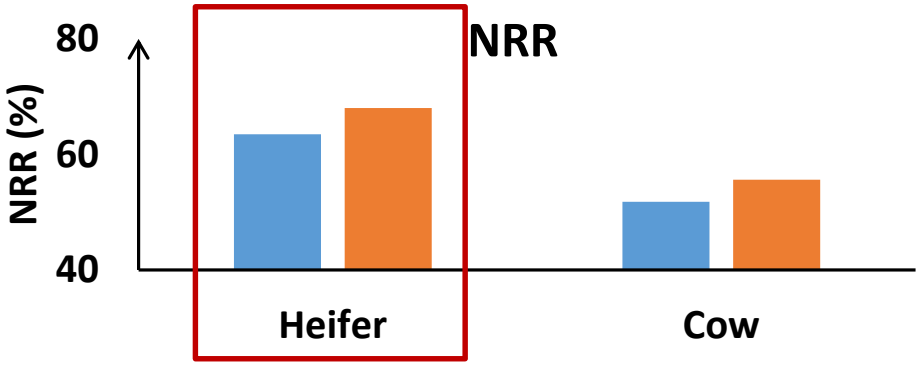
$$\begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \sim N\left(0, A \otimes \begin{bmatrix} \sigma^2_{a_1} & \sigma_{a_1 a_2} \\ & \sigma^2_{a_2} \end{bmatrix}\right)$$

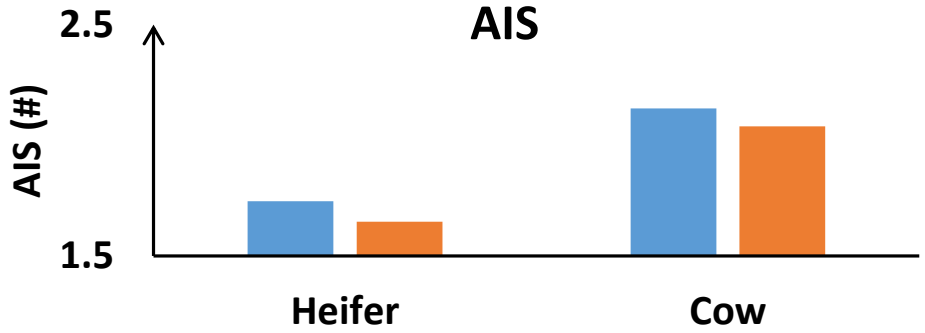
$$\begin{bmatrix} pe_1 \\ pe_2 \end{bmatrix} \sim N\left(0, I \otimes \begin{bmatrix} \sigma^2_{pe_1} & 0 \\ & \sigma^2_{pe_2} \end{bmatrix}\right)$$

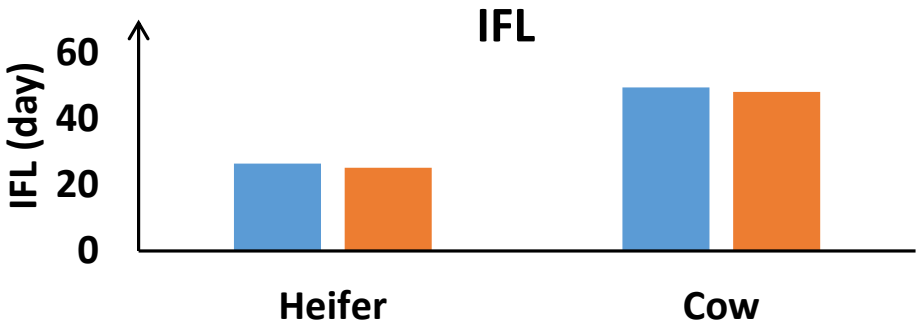
Results and discussion

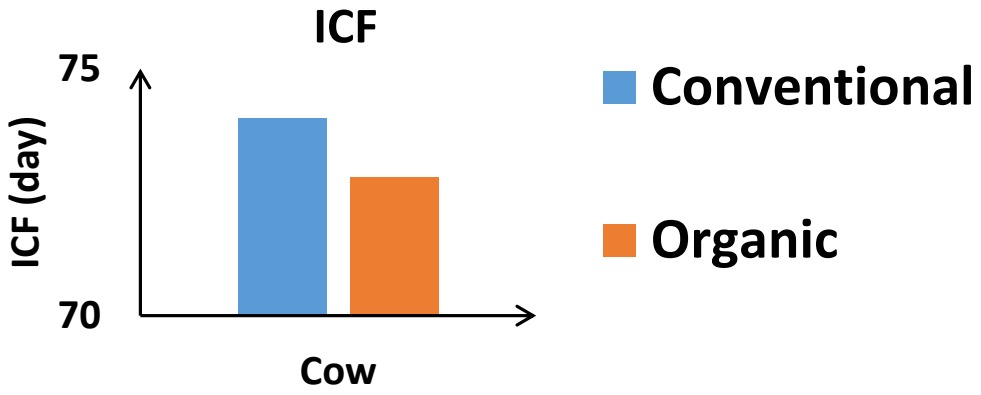
Results-Mean of phenotypes

e.g. NRRh: organic is ~5 percentage point higher than conventional



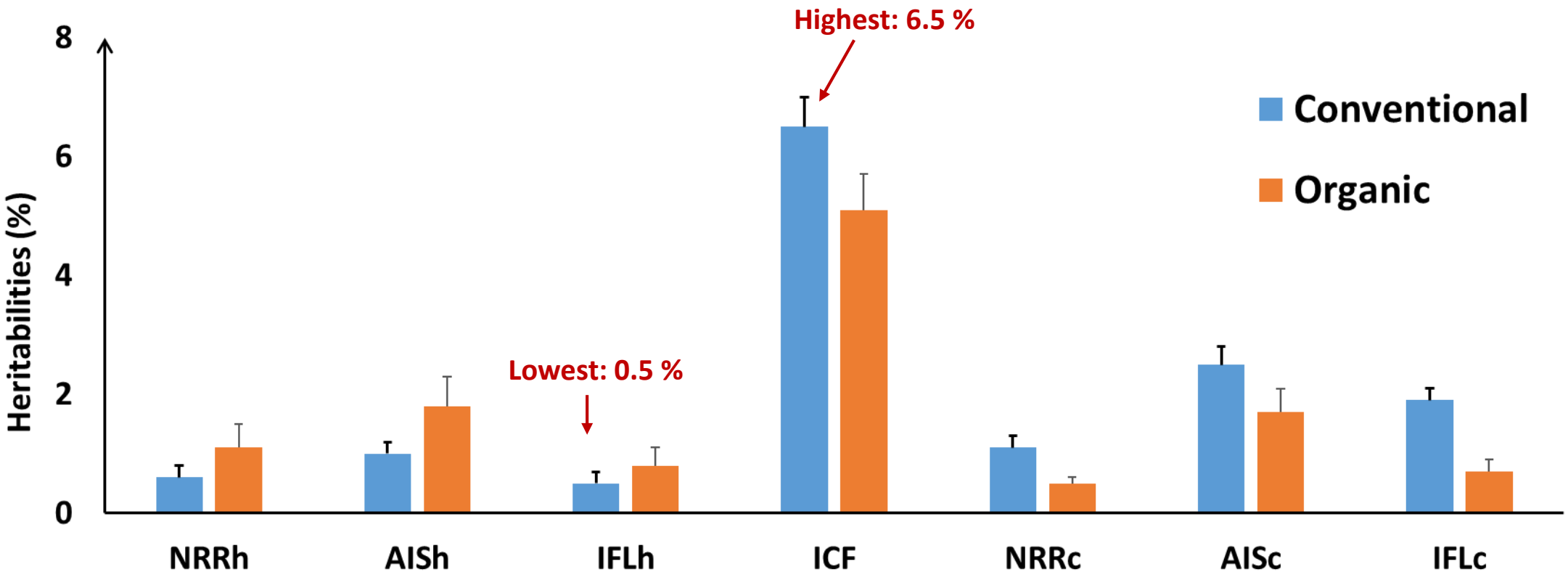






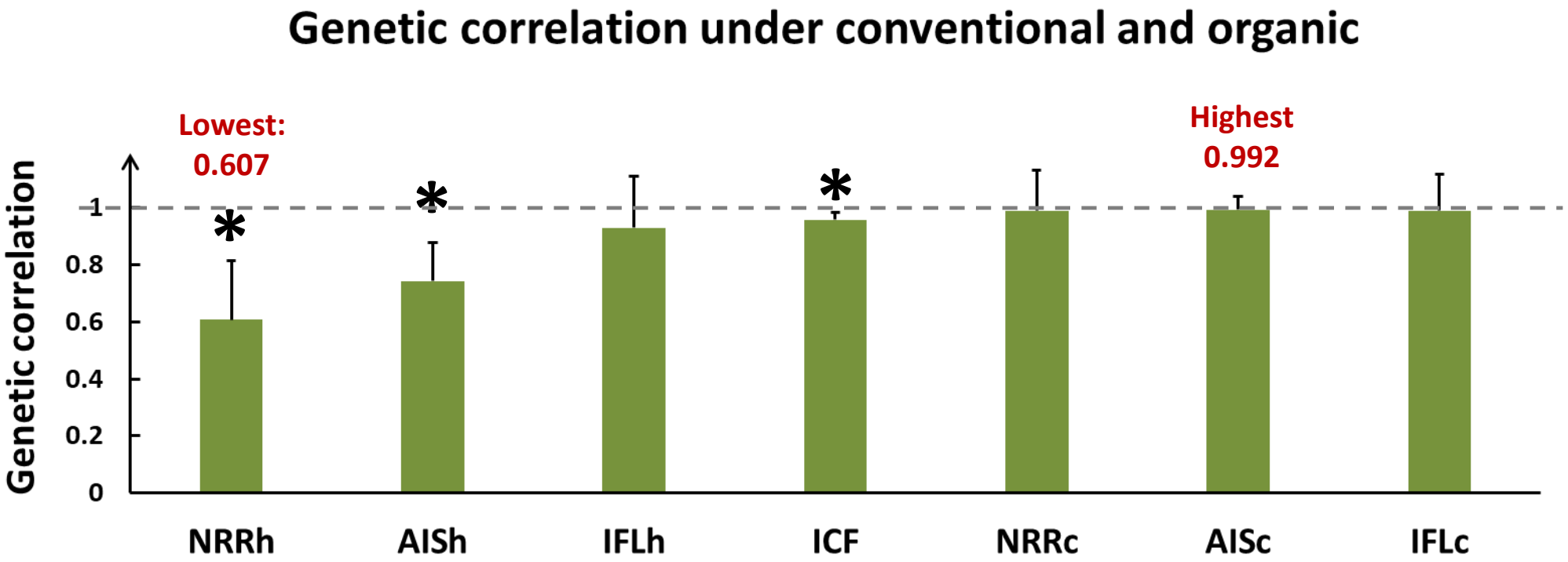
✓ Organic better than Conventional

Results-Heritabilities



- **Heritabilities were low in both organic and conventional**
- **Heterogeneity in heritabilities between organic and conventional,** indicating genetic evaluation based on data of all herds requires a model able to handle the heterogeneity

Results-GxE



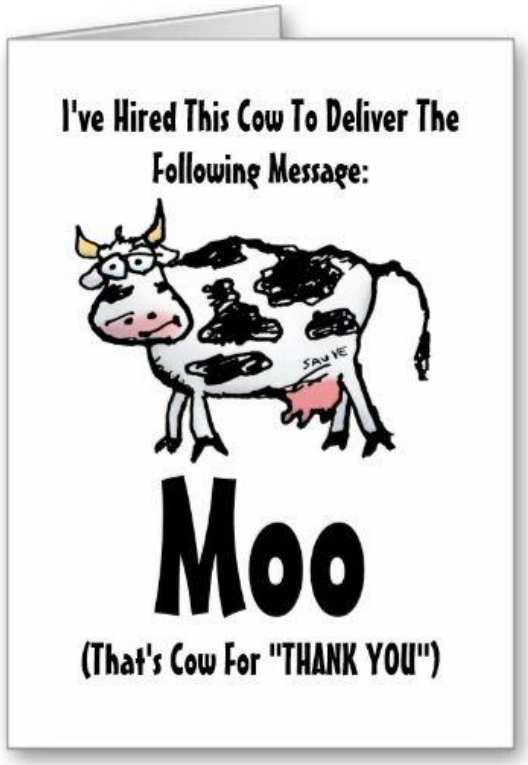
- ✓ **Significant G×E** were observed for **NRRh, AISh** and for **ICF**
- ✓ G×E for three traits and increasing organic population suggested it may have a **potential to develop a breeding program optimal for both production systems**

Conclusion

Conclusion

- Fertility functions: **organic better than conventional**
- **Heterogeneity in heritabilities**
- **Significant G×E** were observed for **AISh, NRRh** and for **ICF**
- The existence of G×E for three traits and the increasing organic population suggested that it maybe have a **potential to develop a breeding program optimal for both production systems**

Acknowledgement



- Per Madsen, Aarhus University
- Lu Cao, Aarhus University
- Xiaowei Mao, Cornell University
- Han Mulder, Wageningen University & Research

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- ✓ **Organic dairy breeding lines? –Possibilities and requirements**

  Morten Kargo, Aarhus University

  Time: Feb 13 (TUE), 14:30-14:45

- ✓ **Breeding goals for organic dairy farming in Denmark based on the principles of organic agriculture**

  Presenter: Margot Slagboom, Aarhus University

  Time: Feb 15 (THU), 10:00-10:15

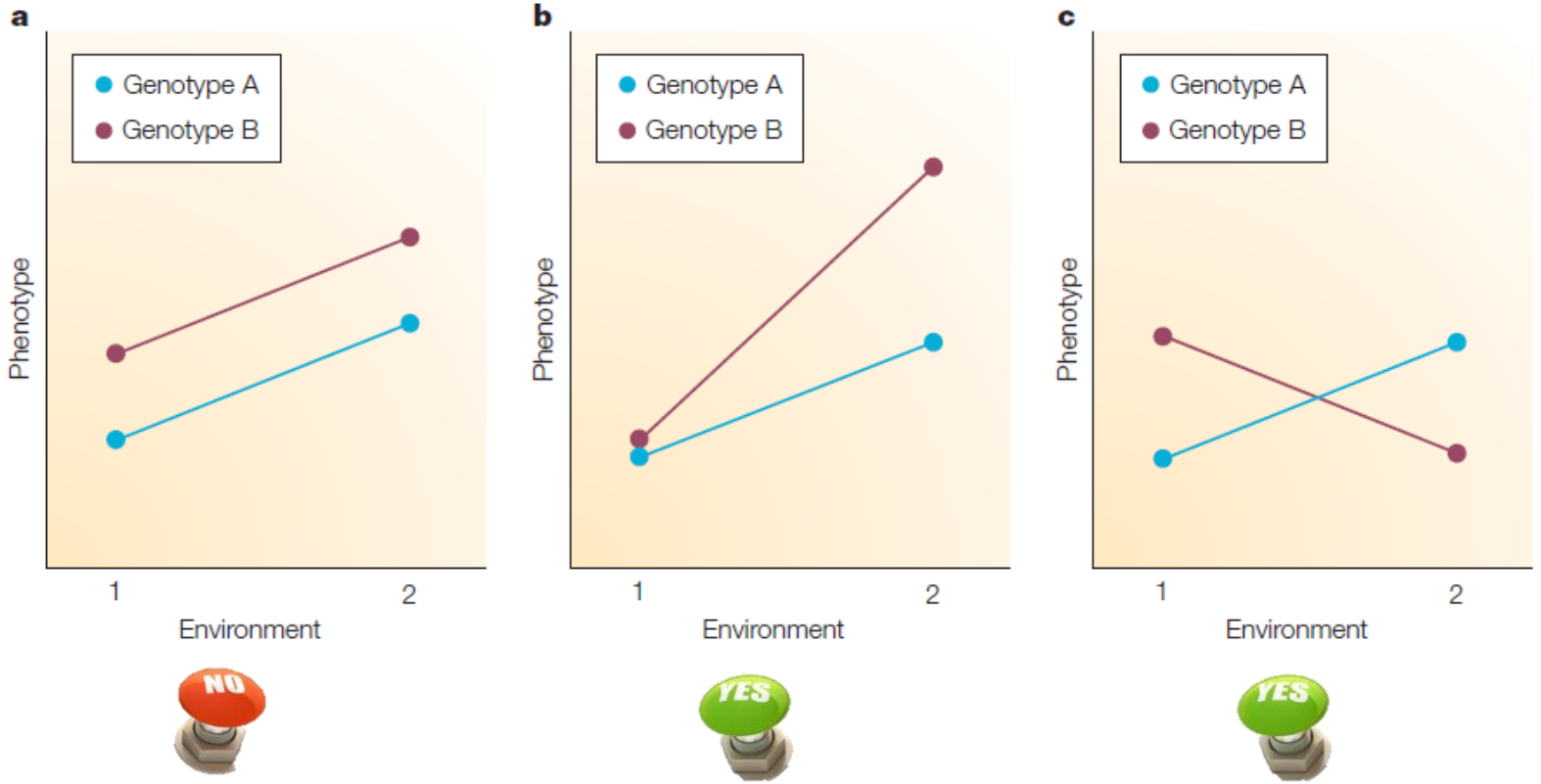
Background

✓ **Definition of G x E**

$$P = G + E + G \times E$$

Different G response differently to different E

Is there a G x E?



Falconer and Mackay (1996), Robert and Mackay (2004)

Data_Grass ratio in feed