75th EAAP Annual Meeting – Florence, Italy – 2nd September 2024

# Genetic parameters for residual metabolizable energy intake in Holstein calves including maternal effects

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UNIVERSITY of GUELPH

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DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

THE Resilient Dairy GENOME PROJECT

# Feed Efficiency

**The two largest expenses on a dairy farm are the animals' feed and the rearing of heifers**

**US $3.83 to US $6.19 per calf per day**


Hawkins et al. (2019), doi: 10.3390/ani9070471

**Colostrum portion (Day 1)**

**Mixed Colostrum (until Day 1-5)**

**Fresh milk / milk replacer (until Day 50- 110)**

**Calf starter (not later than Day 14)**

Colostrum portion
(Day 1)

Mixed Colostrum
(until Day 1-5)

Fresh milk / milk replacer
(until Day 50- 110)

Calf starter
(not later than Day 14)

~~Dry Matter Intake~~

~~=~~

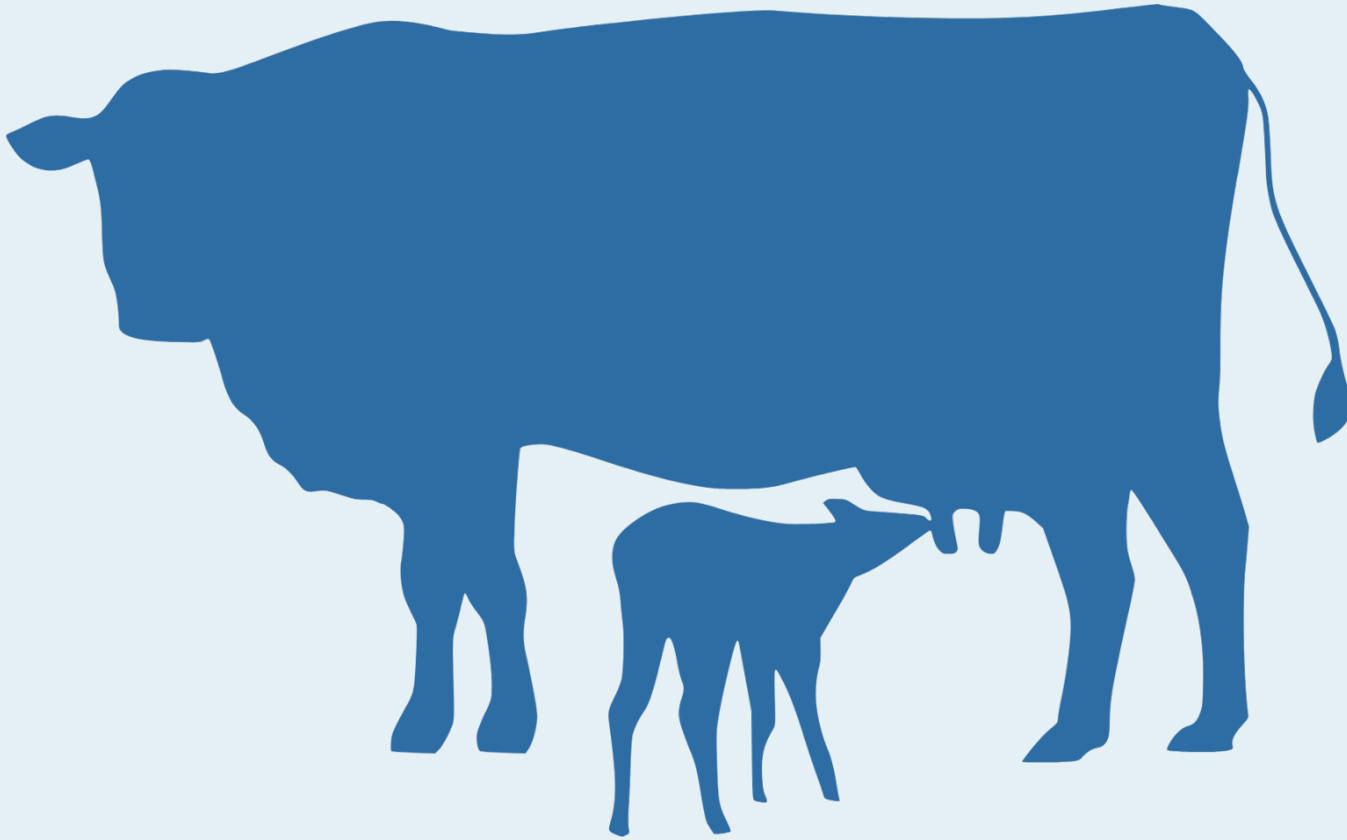
~~Residual Feed Intake~~

**Metabolizable Energy Intake** ✓

# Maternal Effects

## Causal influence of the maternal genotype on the offspring's phenotype

- Uterine environment
- Suckling period
- Milk yield



Willham, 1963, Biometrics, 18-27

# Objectives

**Estimate genetic parameters of residual metabolizable energy intake in pre-weaned dairy calves**

**Investigate the significance of maternal genetic effects**

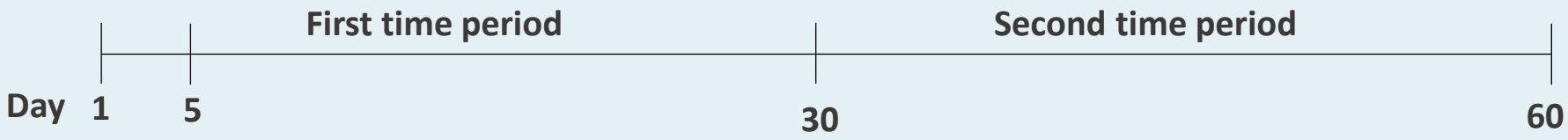
# Metabolizable Energy Intake

471 Holstein calves
from 1 herd

150 grams/L water
milk replacer
4.55 Mcal/kg powder
metabolizable energy

pelleted calf starter
88 % dry matter
2.51 Mcal/kg metabolizable
energy

# Residual Metabolizable Energy Intake Definition



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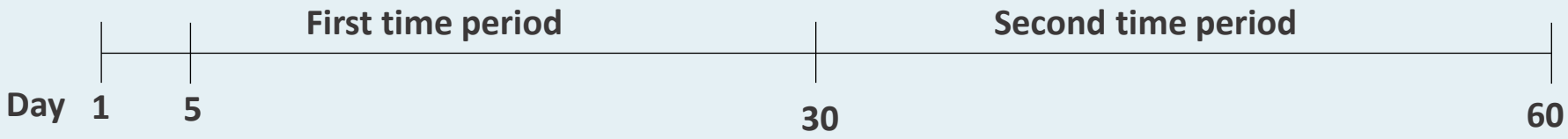


**Metabolizable energy intake of one- and two-month old calves adjusted for:**

- Colostrum quantity
- Metabolic body weight
- Average daily gain
- Calf participated in a trial
- Scours (for the first time period)

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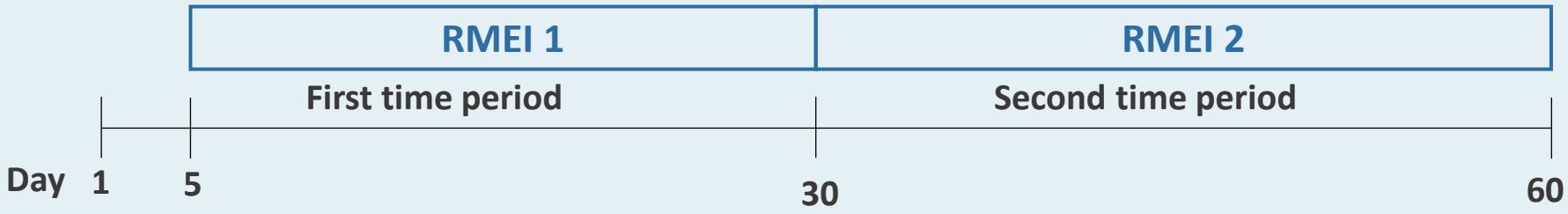


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# Residual Metabolizable Energy Intake Evaluation

**Pedigree BLUP**

$$y = 1\mu + Za + e$$

**Hoeksema** et al.

**Single-Step Genomic BLUP**

$$y = 1\mu + Zg + e$$

**Hoeksema** et al.

**Pedigree BLUP with Maternal Effects**

$$y = 1\mu + Za_d + Za_m + e$$

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**Pedigree BLUP with Maternal Effects**

$$y = 1\mu + Za_d + Za_m + e$$

$$var(\boldsymbol{a}) = \mathbf{A} \otimes \boldsymbol{G}_0$$

$$= \mathbf{A} \otimes \begin{bmatrix} \sigma^2_{a,1} & \sigma_{a,2,1} \\ \sigma_{a,1,2} & \sigma^2_{a,2} \end{bmatrix}$$

$$var(\boldsymbol{g}) = H \otimes \boldsymbol{G}_1$$

$$= \boldsymbol{A}^{-1} + \begin{bmatrix} \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \tau(0.95\boldsymbol{G} + 0.05\boldsymbol{A}_{22})^{-1} - \omega\boldsymbol{A}_{22}^{-1} \end{bmatrix} \otimes \begin{bmatrix} \sigma^2_{g,1} & \sigma_{g,2,1} \\ \sigma_{g,1,2} & \sigma^2_{g,2} \end{bmatrix}$$

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**Pedigree BLUP with Maternal Effects**

$$y = 1\mu + Za_d + Za_m + e$$

$$\text{var} \begin{bmatrix} \boldsymbol{a_d} \\ \boldsymbol{a_m} \end{bmatrix} = \mathbf{A} \otimes \boldsymbol{G}_3$$

$$= \mathbf{A} \otimes \begin{bmatrix} \sigma^2_d & \sigma_{d,m} \\ \sigma_{d,m} & \sigma^2_m \end{bmatrix}$$

# Residual Metabolizable Energy Intake Evaluation

**Significance of maternal effects: Log- Likelihood Ratio Test**

**Pedigree BLUP**

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**Hoeksema** et al.

$$var\,(\boldsymbol{a}) = \mathbf{A} \otimes \boldsymbol{G}_0$$

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**Pedigree BLUP with Maternal Effects**

$$y = 1\mu + Za_d + Za_m + e$$

$$\text{var} \begin{bmatrix} \boldsymbol{a_d} \\ \boldsymbol{a_m} \end{bmatrix} = \mathbf{A} \otimes \boldsymbol{G}_2$$

$$= \mathbf{A} \otimes \begin{bmatrix} \sigma^2_d & \sigma_{d,m} \\ \sigma_{d,m} & \sigma^2_m \end{bmatrix}$$

# Computing Genetic Parameter

## -Residual Metabolizable Energy Intake

**Pedigree BLUP**

$$\boldsymbol{G}_0 = \begin{bmatrix} \sigma^2_{a,1} & \sigma_{a,2,1} \\ \sigma_{a,1,2} & \sigma^2_{a,2} \end{bmatrix}, \quad \boldsymbol{R}_0 = \begin{bmatrix} \sigma^2_{e,1} & \sigma_{e,2,1} \\ \sigma_{e,1,2} & \sigma^2_{e,2} \end{bmatrix}$$

**Single-Step Genomic BLUP**

$$\boldsymbol{G}_1 = \begin{bmatrix} \sigma^2_{g,1} & \sigma_{g,2,1} \\ \sigma_{g,1,2} & \sigma^2_{g,2} \end{bmatrix}, \quad \boldsymbol{R}_1 = \begin{bmatrix} \sigma^2_{e,1} & \sigma_{e,2,1} \\ \sigma_{e,1,2} & \sigma^2_{e,2} \end{bmatrix}$$

**Pedigree BLUP**

**with maternal effects**

$$\boldsymbol{G}_3 = \begin{bmatrix} \sigma^2_{d} & \sigma_{m,d} \\ \sigma_{d,m} & \sigma^2_{m} \end{bmatrix}, \qquad \sigma^2_e$$

# Computing Genetic Parameter

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**with maternal effects**

$$\boldsymbol{G}_3 = \begin{bmatrix} \sigma^2_{d} & \sigma_{m,d} \\ \sigma_{d,m} & \sigma^2_{m} \end{bmatrix}, \quad \sigma^2_e$$

### Heritability:

$$h^2_t = \frac{\sigma^2_{a,t}}{(\sigma^2_{a,t} + \sigma^2_{e,t})}, t = time\ period$$

$$h^2_t = \frac{\sigma^2_{g,t}}{(\sigma^2_{g,t} + \sigma^2_{e,t})}, t = time\ period$$

### Genetic Correlations:

$$r_{g,1,2} = \frac{\sigma_{a,1,2}}{\sqrt{\sigma^2_{a,1}\sigma^2_{a,2}}}$$

$$r_{g,1,2} = \frac{\sigma_{g,1,2}}{\sqrt{\sigma^2_{g,1}\sigma^2_{g,2}}}$$

# Computing Genetic Parameter

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$$h^2_t = \frac{\sigma^2_{g,t}}{(\sigma^2_{g,t} + \sigma^2_{e,t})}, t = time\ period$$

$$h^2_{direct} = \frac{\sigma^2_d}{(\sigma^2_d + \sigma_{d,m} + \sigma^2_m + \sigma^2_e)}$$

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# Computing Genetic Parameter

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**with maternal effects**

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$$r_{g,d,m} = \frac{\sigma_{d,m}}{\sqrt{\sigma^2_d\sigma^2_m}}$$

# Genetic Parameters

## - Pedigree and Genomic BLUP- No Maternal Effects

**Heritability for residual metabolizable energy intake:**

| | BLUP | ssGBLUP |
|---|---|---|
| first month of age: | 0.22 (SE=0.11) | 0.32 (SE=0.14) |
| second month of age: | 0.32 (SE=0.11) | 0.32 (SE=0.13) |

**Genetic correlations between traits:**

| BLUP | ssGBLUP |
|---|---|
| 0.56 (SE=0.34) | 0.62 (SE=0.37) |

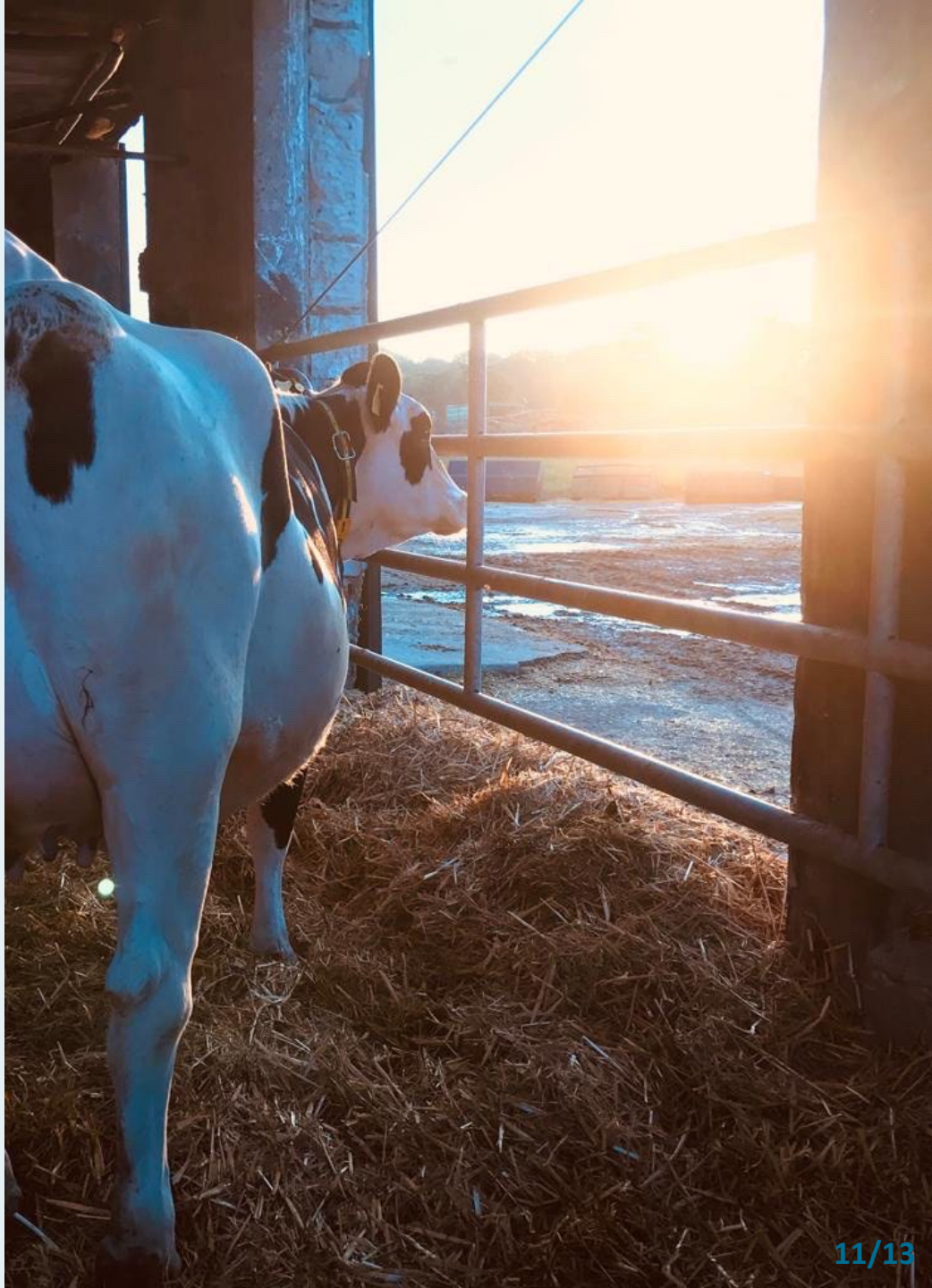
Kyle Hoeksema
MSc thesis

# Genetic Parameters

## - Pedigree BLUP- with Maternal Effects

**Significance of maternal effects for residual metabolizable energy intake:**

| RMEI | First month of age | Second month of age |
|---|---|---|
| P-Value | 0.04 | 0.96 |



# Genetic Parameters

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**Significance of maternal effects for residual metabolizable energy intake:**

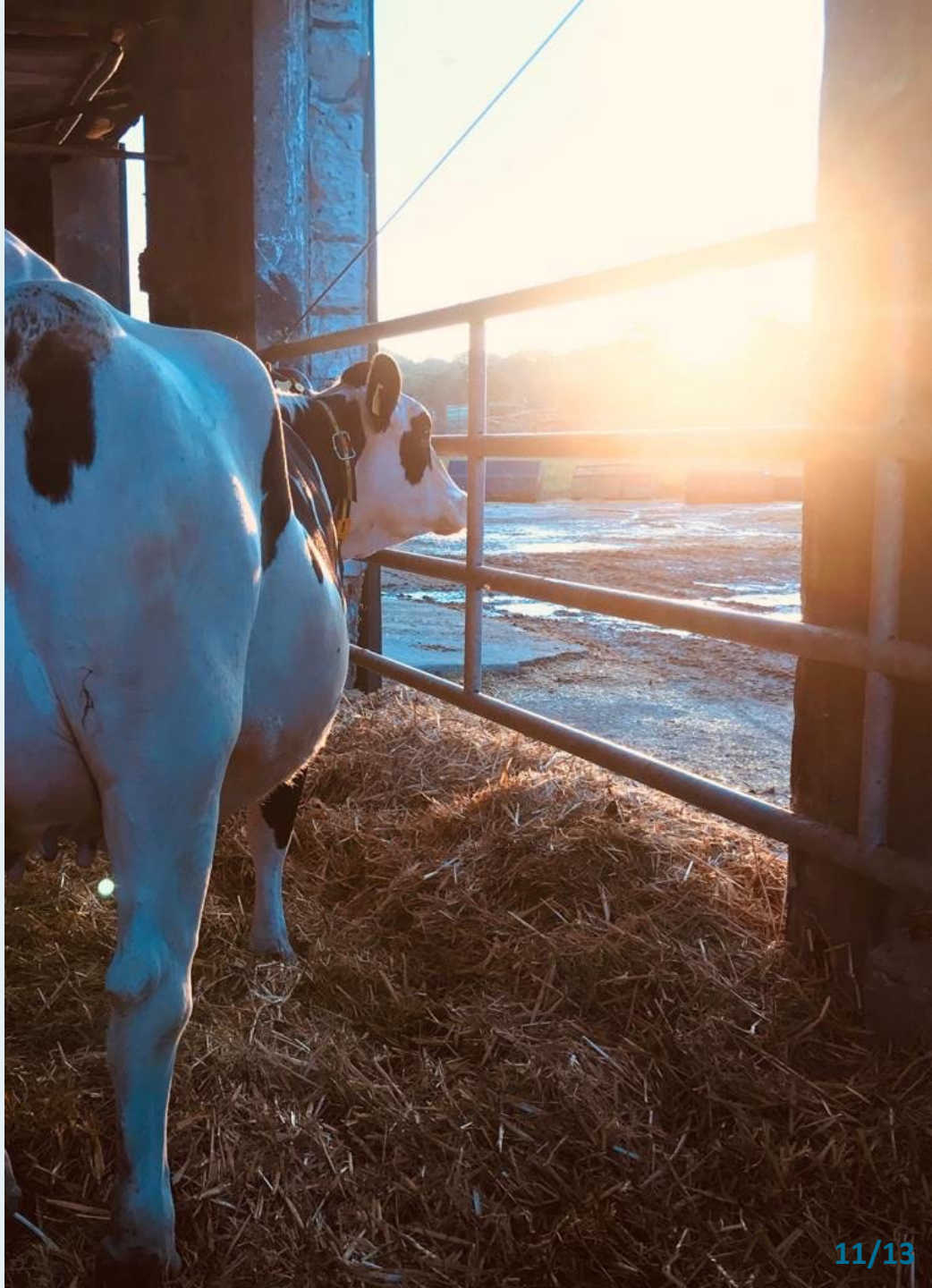
| RMEI | First month of age | Second month of age |
|---|---|---|
| P-Value | 0.04 | 0.96 |

**Heritability for residual metabolizable energy intake for calves of one month of age:**

| direct | maternal |
|---|---|
| 0.15 (SE=0.13) | 0.27 (SE=0.12) |

**Genetic correlation between direct and maternal effect:**

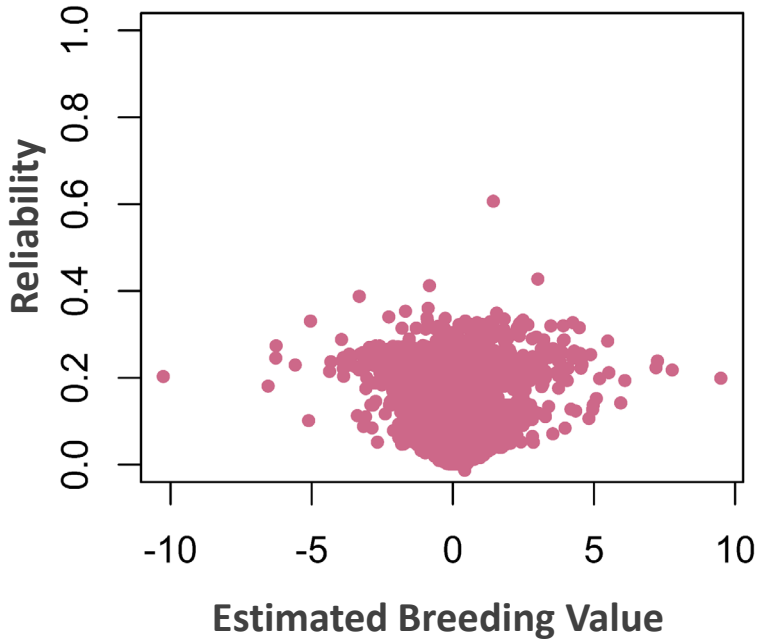
**-0.88 (SE=0.02)**



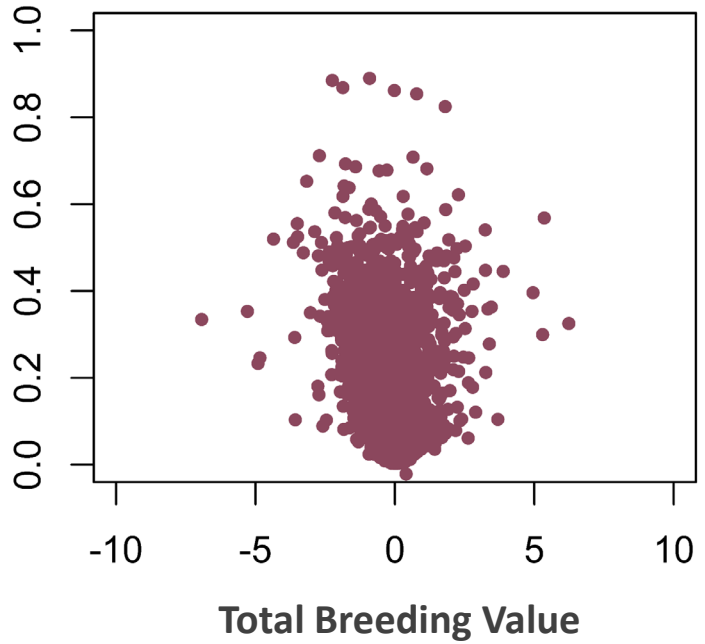
# Reliabilities for Estimated Breeding Values

## - Residual Metabolizable Energy Intake in First Month of Age Calves

without maternal effects:




with maternal effects:



# Take Home Messages

- Possible to select on residual metabolizable energy intake in dairy calves
- Maternal effects are significant

THE Resilient Dairy GENOME PROJECT

# Take Home Messages

rjahnel@uoguelph.ca

**Possible to select on residual metabolizable energy intake in dairy calves**

**Maternal effects are significant**

Thank you

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http://www.resilientdairy.ca/