



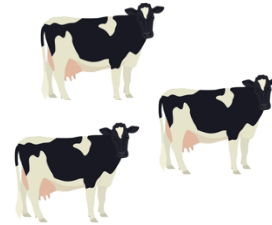
Exploiting milking robot data for genetic evaluation of behavioral traits in Holstein cattle

Hugo Bérat, Nicolas Gengler, Jacob M. Maskal, Jacquelyn P. Boerman, Luiz F. Brito



Introduction

- Dairy industry evolution
 - Last **century** → Significant **changes**
 - **Decrease** in the **number** of farms
 - **Increase** in herd size
- AMS Adoption
 - Last few **decades**
 - AMS **widespread** worldwide
 - **Major shift** in the dairy farming practices



→ **1.2 million**
dairy cows across
10,000 + herds

(Dechow et al., 2020)

Automated Milking System (AMS) = Milking Robots



Introduction

- Improved living conditions for farmers:
 - **Easier** and less demanding **tasks**
 - Better **health** and **working conditions** for farmers
- Increased farm efficiency:
 - Improved animal **welfare**
 - Cows choose when to be milked, expressing **natural behavior**
- Continuous data collection:
 - **Daily data** on milk production, health, etc. (King et al., 2021; Pedrosa et al., 2023)



Introduction

- Detailed analysis:

- Data on **milk volume, flow rate, electroconductivity, somatic cells**, etc.

- Behavioral traits:

- Link to milking **production** and milking **efficiency**
- Identification of **heritable behavioral traits**

→ Heritability ranging from 0.15 to 0.40 (Brito et al., 2020)



Research Objectives



Derive new **behavioral traits** based on **AMS data**

→ Evaluation of the **variability** of these traits throughout **lactation**

(Co-)variance components estimation based on **genomics**

→ Estimation of **genetic parameters** (h^2 and **repeatability**)

→ Calculation of **genetic correlations**

→ Breeding programs for greater **sustainability**?



Traits definition

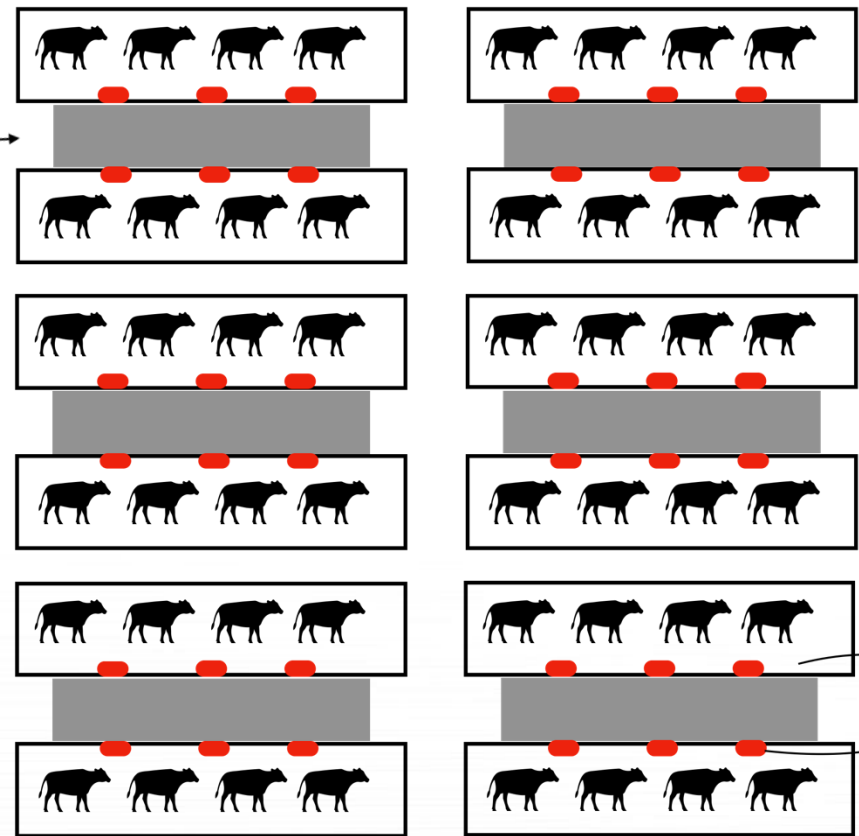
Seven behavioral traits based in AMS :

- Average milking time (**AMT**)
- Total milking time (**TMT**)
- Milking time interval (**INT**)
- Number of visits (**NoV**)
- Number of successful entries (**NSE**)
- Percentage of successful milking (**PSM**)
- Preference consistency score (**PCS**)





Phenotypic Dataset



• 5,645 cows



7,136,116
phenotypic records

• 12 pens



36 AMS
(3 per pen)

Pen

AMS



Genomic Data

- **Initial genotyping**
 - Cows genotyped using various SNP density panels
 - Data imputed to a common set of 72,820 SNPs
 - Software: FImpute (Sargolzaei et al., 2014)
- **Quality control**
 - Retained only autosomal SNPs
 - Call rate > 0.90
 - Minor allele frequency (MAF) > 0.05
- **Final dataset**
 - 57,282 SNPs retained for subsequent analyses



Statistical Models and Parameter Estimation

Variance components and genetic parameters for all traits were estimated using the BLUPF90 family of programs (Misztal et al., 2024).

The repeatability model fitted can be described as:

$$y = Xb + Za + \boxed{Wpe} + e$$

Animals & Parities combined → **Concatenation**

Permanent environmental effect **within** and **between** parities

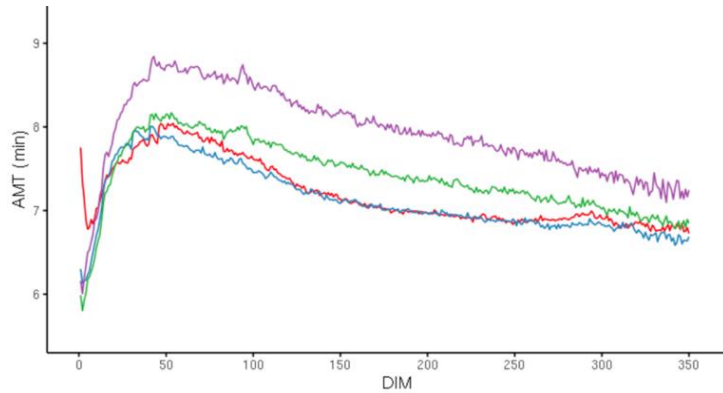
Fixed effects

- Days in lactation (350)
- Number of parities (1, 2, 3, 4+)
- Pens (12)
- Calving year-season (Sept - Nov, March - May, June - Aug, Dec - Feb)



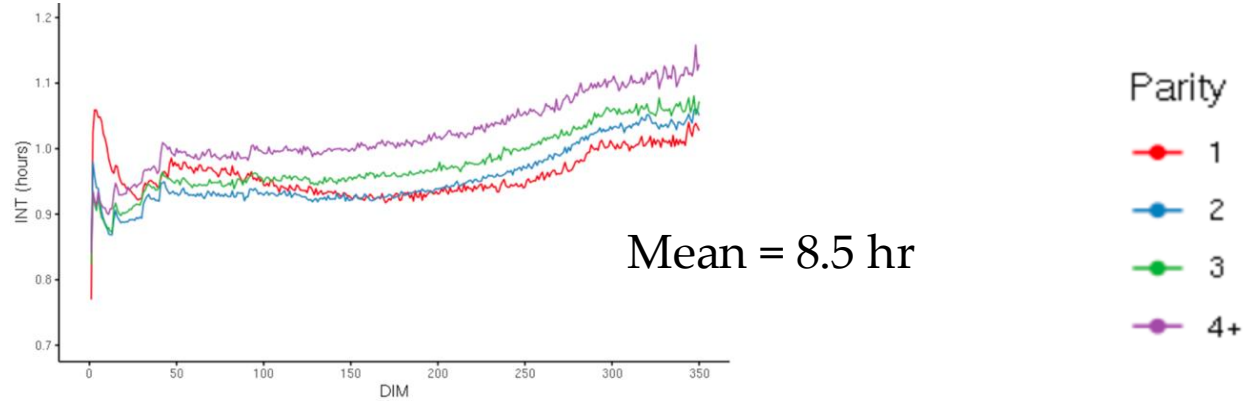
Phenotypic distribution

AMT



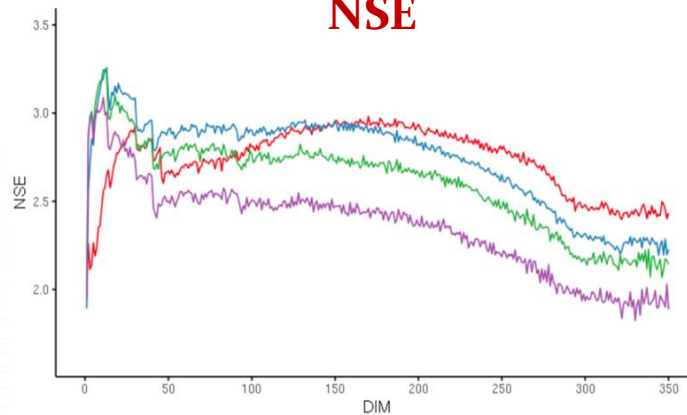
Mean = 7.23 min

INT



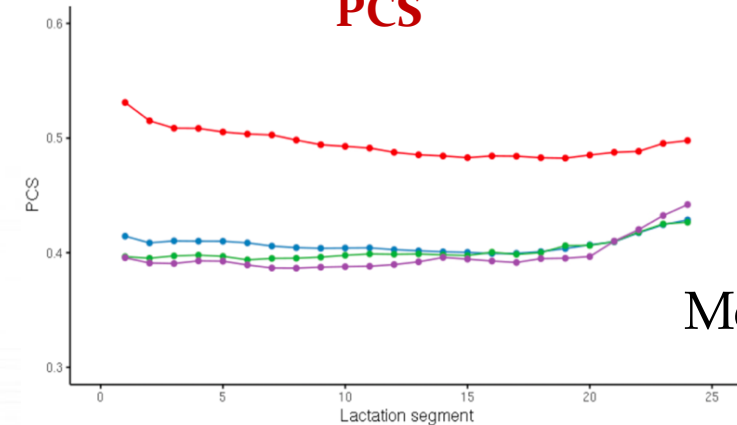
Mean = 8.5 hr

NSE



Mean = 2.84

PCS



Mean = 0.42

Genetic Parameters



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Investigating the genetic background of novel behavioral indicators of robotic milking efficiency in North American Holstein cattle

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Traits*	Parity	σ_a^2	σ_{pe}^2	σ_{pe2}^2	σ_e^2	t
AMT	1 - 6	1.75	0.72	0.34	1.02	0.74 ± 0.01
TMT	1 - 6	11.25	5.67	5.17	20.24	0.52 ± 0.01
INT	1 - 6	0.002	0.002	0.005	0.02	0.34 ± 0.01
NoV	1 - 6	0.33	0.31	0.37	2.42	0.29 ± 0.01
NSE	1 - 6	0.070	0.074	0.12	0.47	0.29 ± 0.01
PSM	1 - 6	26.83	33.21	41.38	402.47	0.20 ± 0.01
PCS	1 - 6	0.004	0.008	0.015	0.022	0.55 ± 0.01

Permanent
environmental variance
between parities

Permanent
environmental variance
within parities

h^2

0.46 ± 0.02

0.27 ± 0.01

0.08 ± 0.01

0.10 ± 0.01

0.10 ± 0.01

0.05 ± 0.01

0.09 ± 0.01



Genetic Correlations

Traits*	AMT	TMT	INT	NoV	NSE	PSM	PCS
AMT	0.46	0.84 ± 0.02	0.24 ± 0.05	-0.36 ± 0.01	-0.34 ± 0.05	0.38 ± 0.05	-0.045 ± 0.06
TMT		0.27	-0.26 ± 0.05	0.12 ± 0.05	0.22 ± 0.05	0.012 ± 0.06	-0.20 ± 0.07
INT		-	0.08	-0.90 ± 0.02	-0.98 ± 0.05	0.71 ± 0.04	0.50 ± 0.06
NoV		-	-	0.10	0.92 ± 0.01	-0.94 ± 0.01	-0.44 ± 0.06
NSE		-	-	-	0.10	-0.72 ± 0.04	-0.35 ± 0.07
PSM		-	-	-	-	0.05	0.37 ± 0.07
PCS							0.09

h^2 on the diagonal ; r_g above



Next Steps...

- **Random regression studies:**
 - Changes during lactation across parities with more data?
- **Genome-wide Association study:**

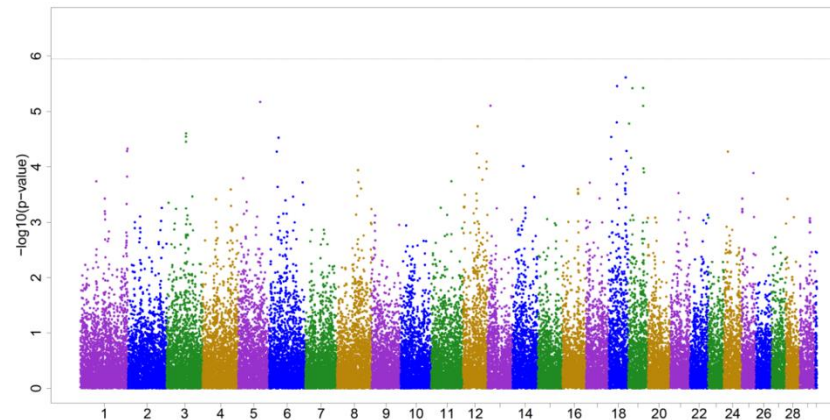


Figure 1. Manhattan plot of GWAS (-log₁₀ P-value) for trait refusals per day (RPD).

(Schafberg, 2023)





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Thank

You!



Genetic Parameters



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