Genetic Analyses of Mid-infrared Predicted Milk Lactoferrin and Milk Fat Globule Size

Shadi Nayeri[1], Flavio S. Schenkel[1], Pauline Martin[1,2], Allison Fleming[1,3], Janusz Jamrozik[1,3], Luiz F. Brito[1], Francesca Malchiodi[1], Christine F. Baes[1] and **Filippo Miglior**[*1,3]

[1]Centre for Genetic Improvement of Livestock, University of Guelph, Guelph, ON, Canada; [2]INRA, Jouy-en-josas, France; [3]Canadian Dairy Network, Guelph, ON, Canada

69th Annual EAAP Meeting - Dubrovnik, Croatia, 27th to 31st August 2018

Milk Lactoferrin

- Lactoferrin (**LF**) is an iron-binding glycoprotein found in milk and in other fluids of the body
- Synthesized by granulocytes and mammary epithelial cells in response to bacteria growth
- Milk LF plays an important role in the defense mechanisms of the mammary gland in lactating animals
  - can inhibit the growth of bacteria through an iron-binding function or by directly killing certain bacterial strains
- Bovine LF is also known for its anti-inflammatory and antioxidant properties and inhibitory action on cell proliferation

Milk Fat Globule Membrane

- Approximately 95% of milk fat is in the form of milk fat globules (**MFG**)
  - created during secretion in epithelial cells of the mammary gland
  - a mainly triglyceride core surrounded by a membrane, i.e., milk fat globule membrane (**MFGM**)
- MFGM is composed of phospholipids, glycoproteins, enzymes, and glycolipids
- MFGM is valuable to the human diet as it is naturally rich in important minor lipids and glycoproteins
- Bovine MFGM has been suggested to have a prospective nutraceutical effect due to its many health-beneficial components

Milk Fat Globule Size

- The size of the milk fat globule is a critical factor in the amount of membrane material
  - Milk with small MFG have more membrane material per unit of fat than milk with larger MFG
  - The relative concentration of desired phospholipids to triglyceride will therefore be higher with small MFG
- Furthermore, MFG size has critical implications for sensory and technological properties of many dairy products

Milk MIR Opportunity

- Routine determination of MFG size and LF not feasible
  - due to the time, cost and for MFG size
  - complexity of the requirement of fresh milk
- Mid-infrared (MIR) spectroscopy recognized as a powerful tool for phenotyping traditional and novel traits
  - cost based on a large-scale regular milk recording
- Previous work at CGIL in Guelph has developed milk MIR prediction equations for these two traits:
  - **R^2_{cv} of 0.55 for LF and 0.54 for MFG size** (*Fleming et al., 2017; 2018*)

UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE
DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

Objectives

- To estimate the heritability of mid-infrared-predicted lactoferrin and milk fat globule size
- To estimate the genetic correlations of predicted lactoferrin and milk fat globule size with:
  - Milk, fat and protein yields, fat and protein percentages, and SCS in first-parity Canadian Holstein cattle

Data

- The final dataset included a total of:
  - 109,029 records from 22,432 cows and 1,572 farms (105,737 pedigree animals) for MIR-predicted Lactoferrin
  - 109,212 records from 22,424 cows and 1,559 farms (105,070 pedigree animals) for MIR-predicted MFG size
- Test-day production records included milk, fat, and protein yields, fat and protein percentages, and SCS

Model

- Four five-trait random regression test-day models
- Variance components estimated by Bayesian methods via Gibbs sampling (290,000 samples, 10,000 burn-in)
- The analyses performed for the following combinations:
  1. LF, milk yield, fat and protein percentage, SCS
  2. LF, milk, fat and protein yield, SCS
  3. MFG size, milk yield, fat and protein percentage and SCS
  4. MFG size, milk, fat and protein yield, SCS

Model Equation

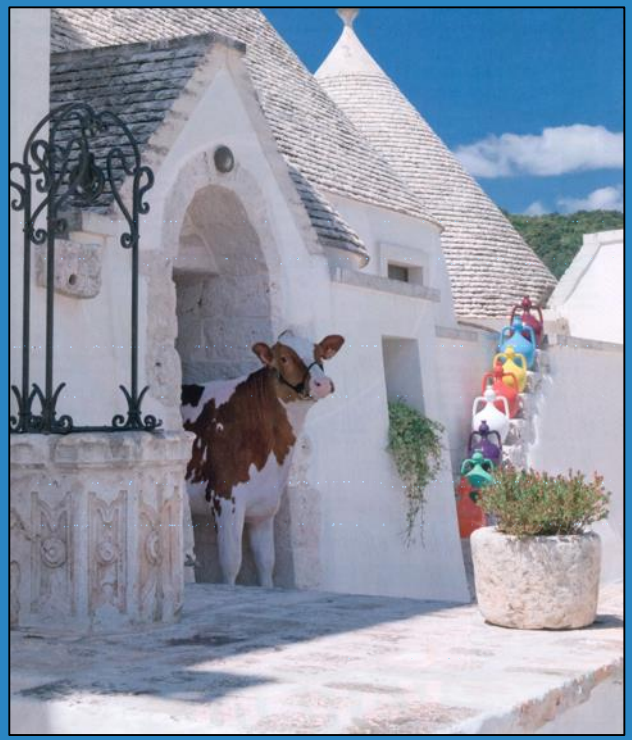
$$\boldsymbol{Y = X_c c + X_b b + Z_h h + Z_a a + Z_p p + e}$$

- $\boldsymbol{c}$: fixed effects of herd-test day and DIM
- $\boldsymbol{b}$: fixed regression coefficients for age-season of calving
- $\boldsymbol{h}$: random regression coefficients for herd-year of calving
- $\boldsymbol{p}$: random regression coefficients for permanent environment
- $\boldsymbol{a}$: random regression coefficients for animal genetic effect
- $\boldsymbol{e}$: residual

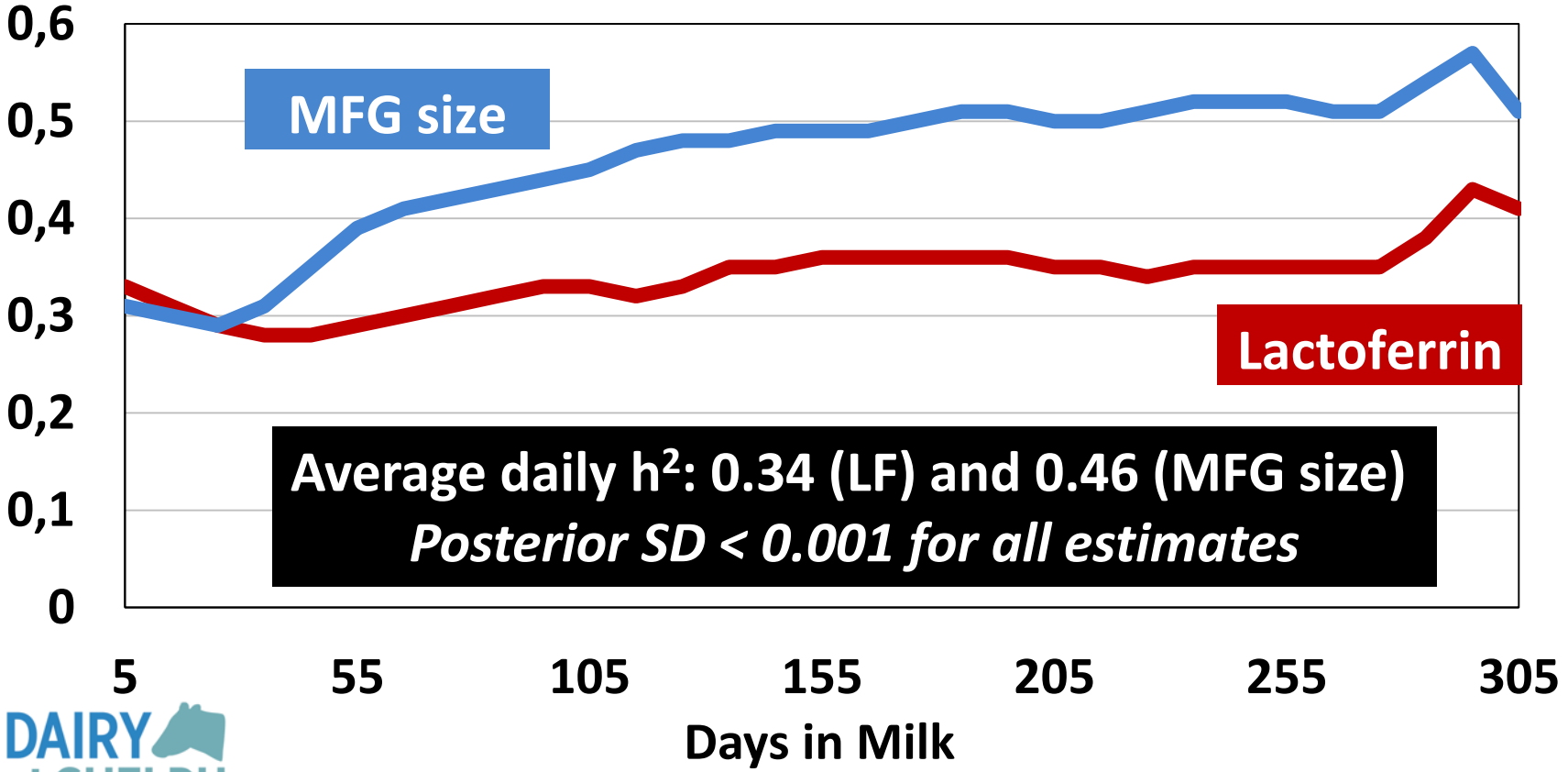
Legendre polynomials of order 4 for the fixed age-season of calving effect, and order 5 for the random effects

UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE
DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

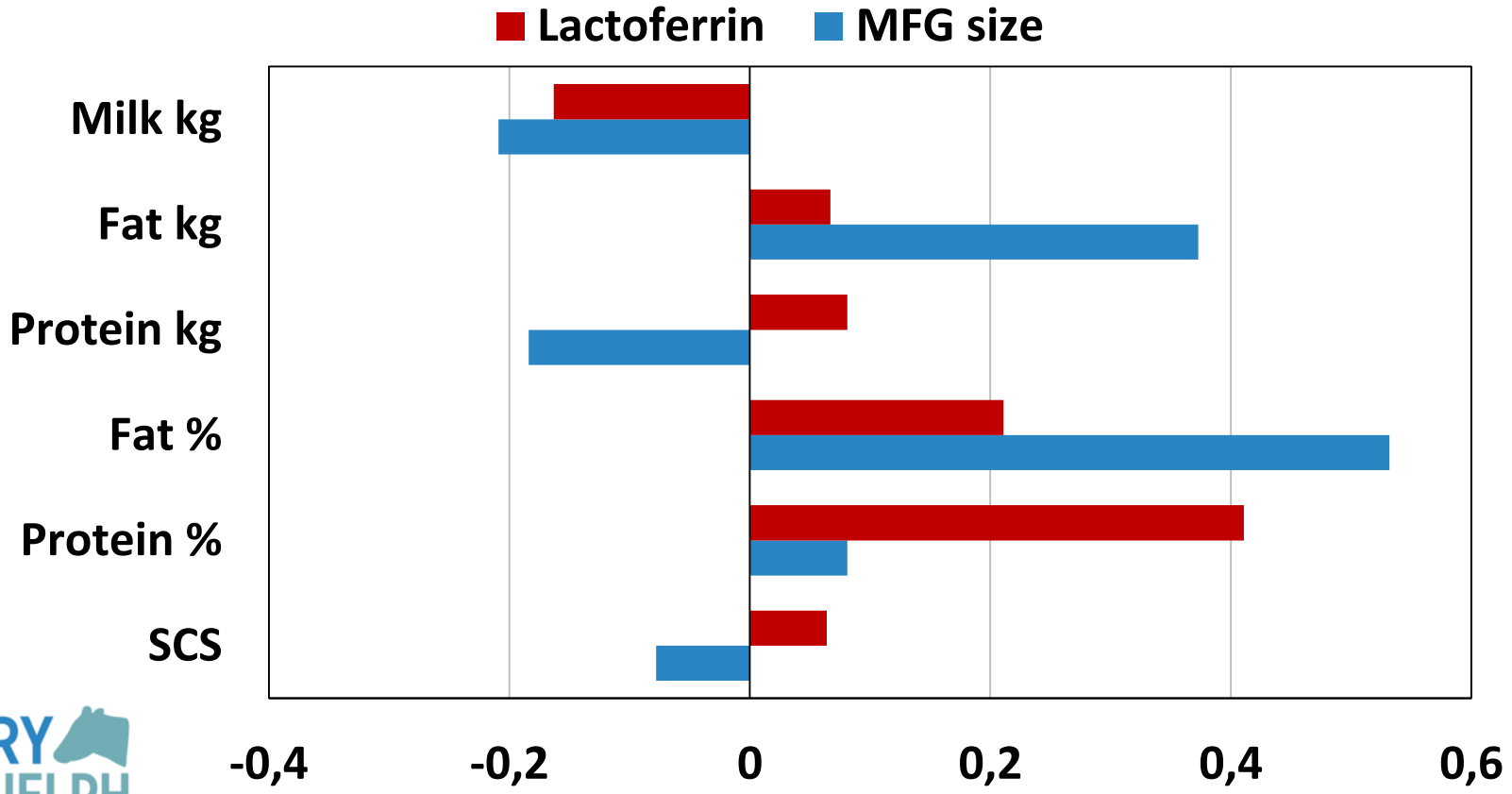
Results



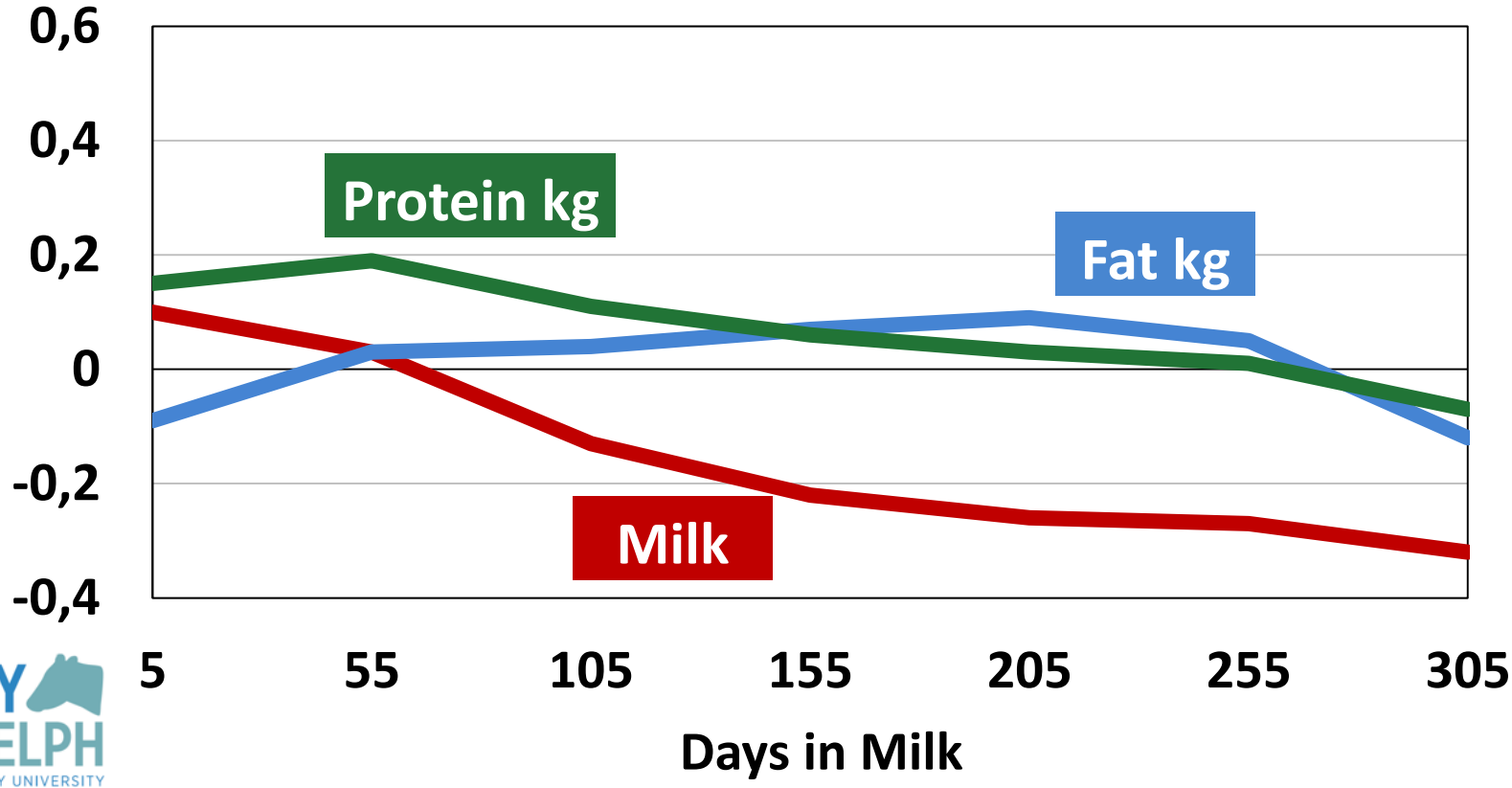
Daily Heritability



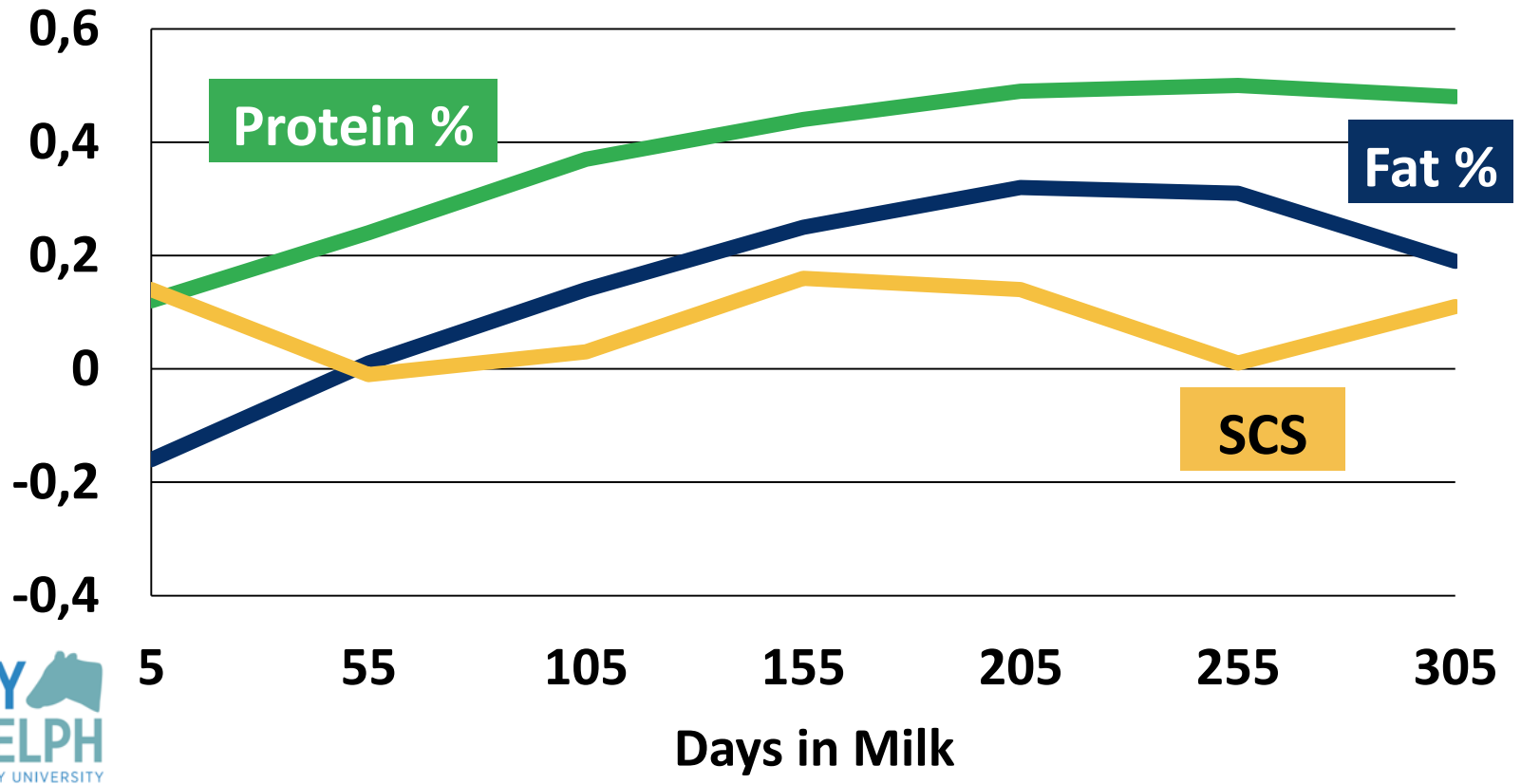
Average Daily Genetic Correlations



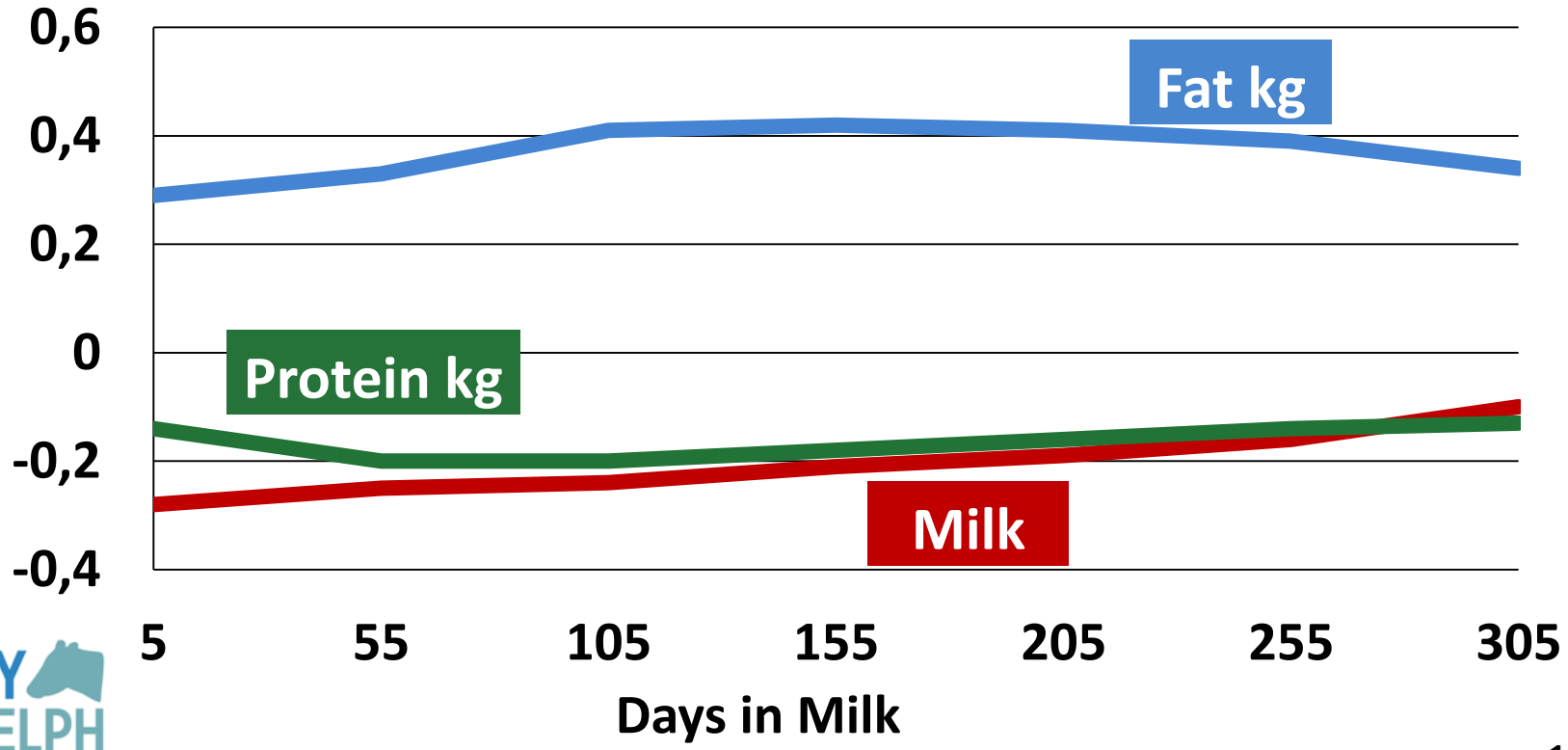
Daily Genetic Correlations - Lactoferrin



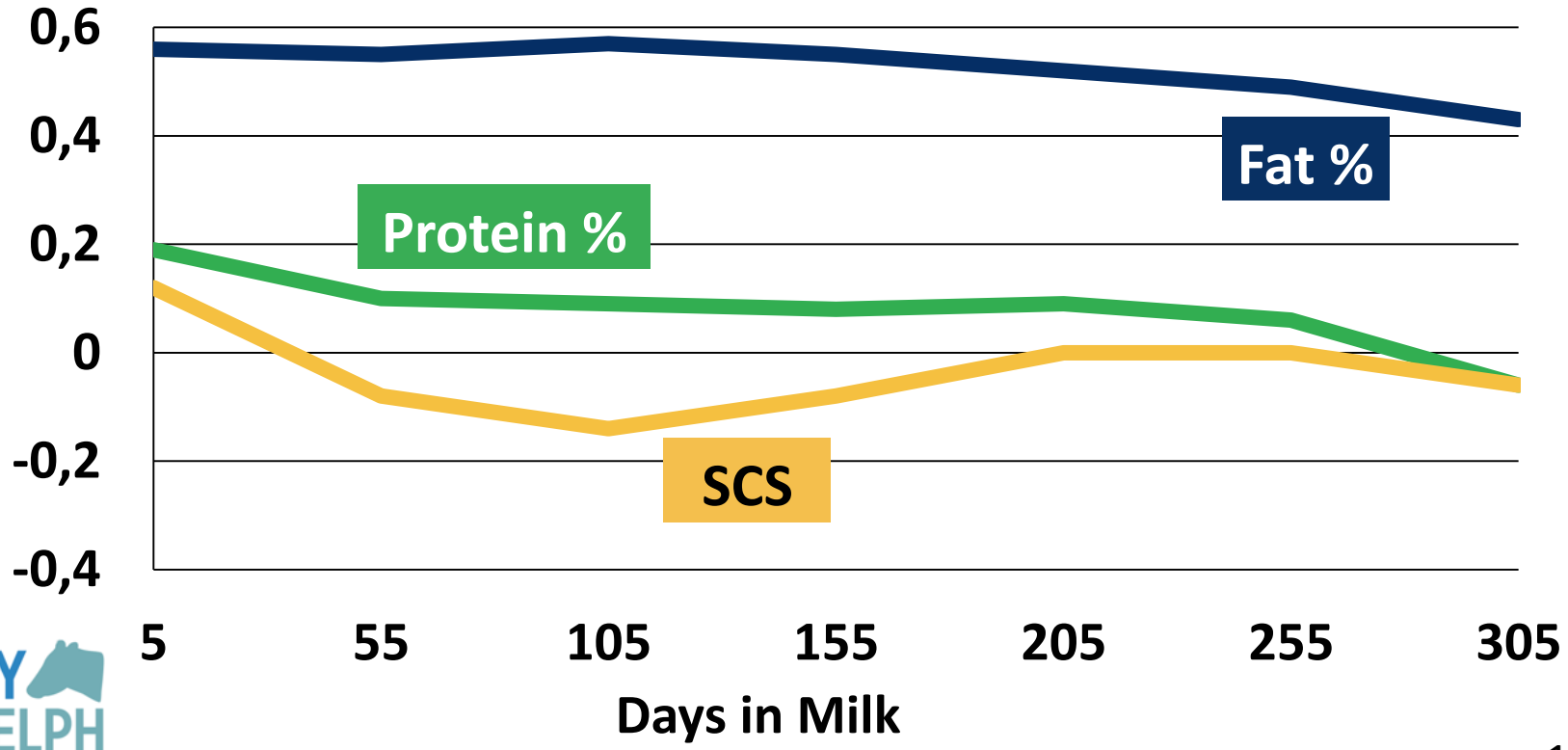
Daily Genetic Correlations - Lactoferrin



Daily Genetic Correlations - MFG Size



Daily Genetic Correlations - MFG Size



Conclusions

- MIR-predicted LF and MFG size have moderate heritabilities
  - Genetic selection for improved milk nutritional quality and technological properties is feasible
- The moderate genetic correlation between MFG size with other fat traits suggests that MFG size is not solely reliant on total fat secreted
- This study provides valuable information on selection for MIR-predicted measurements for changes in milk components in breeding programs

Acknowledgments

University of Guelph

Réseau laitier canadien
Canadian Dairy Network

NSERC CRSNG

Dairy Farmers of Canada
Les Producteurs laitiers du Canada

Dairy Research Cluster
Dairy Research for a Healthy World.

valacta

CANWEST DHI

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canadian Dairy Commission
Commission canadienne du lait