

Genetics of the mid-infrared predicted lactoferrin content in milk of dairy cows

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Bovine lactoferrin

- Lactoferrin = iron-binding glycoprotein present in milk
- Important **host defence molecule**:
 - ❑ antimicrobial/antiviral, antioxidant, immunomodulatory activities
➔ role in the defence mechanisms in the mammary gland
- Used as a **food additive**:
 - ❑ beneficial effects of the oral administration of lactoferrin on the **health of humans and animals**
 - ❑ e.g. in humans: cancer protection
 - ❑ e.g. in animals: lactoferrin + penicillin ➔ ↗ antibacterial activity against *S. aureus*

Genetic selection for lactoferrin?

Measurable

Prediction by mid-infrared spectrometry

➤ $R^2_{cv} = 0.71$; $R^2_v = 0.60$; $RPD = 1.86$

➔ “indicator” of lactoferrin content in milk

Soyeurt et al., 2012, Anim.

**Economically
interesting**

- Nutraceutical properties of milk
- Defence mechanisms in the mammary gland

**Variable and
heritable**

Objectives

Measurable

**Economically
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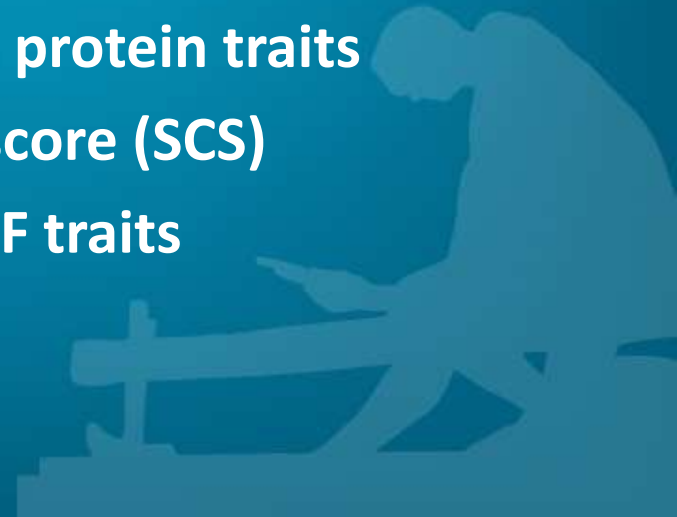
**Variable and
heritable**

Objectives:

- **genetic variability of the mid-infrared prediction of lactoferrin content in milk**
- **genetic correlations with**
 - **major production traits**
 - **udder health trait**
 - **fatty acid contents in milk**

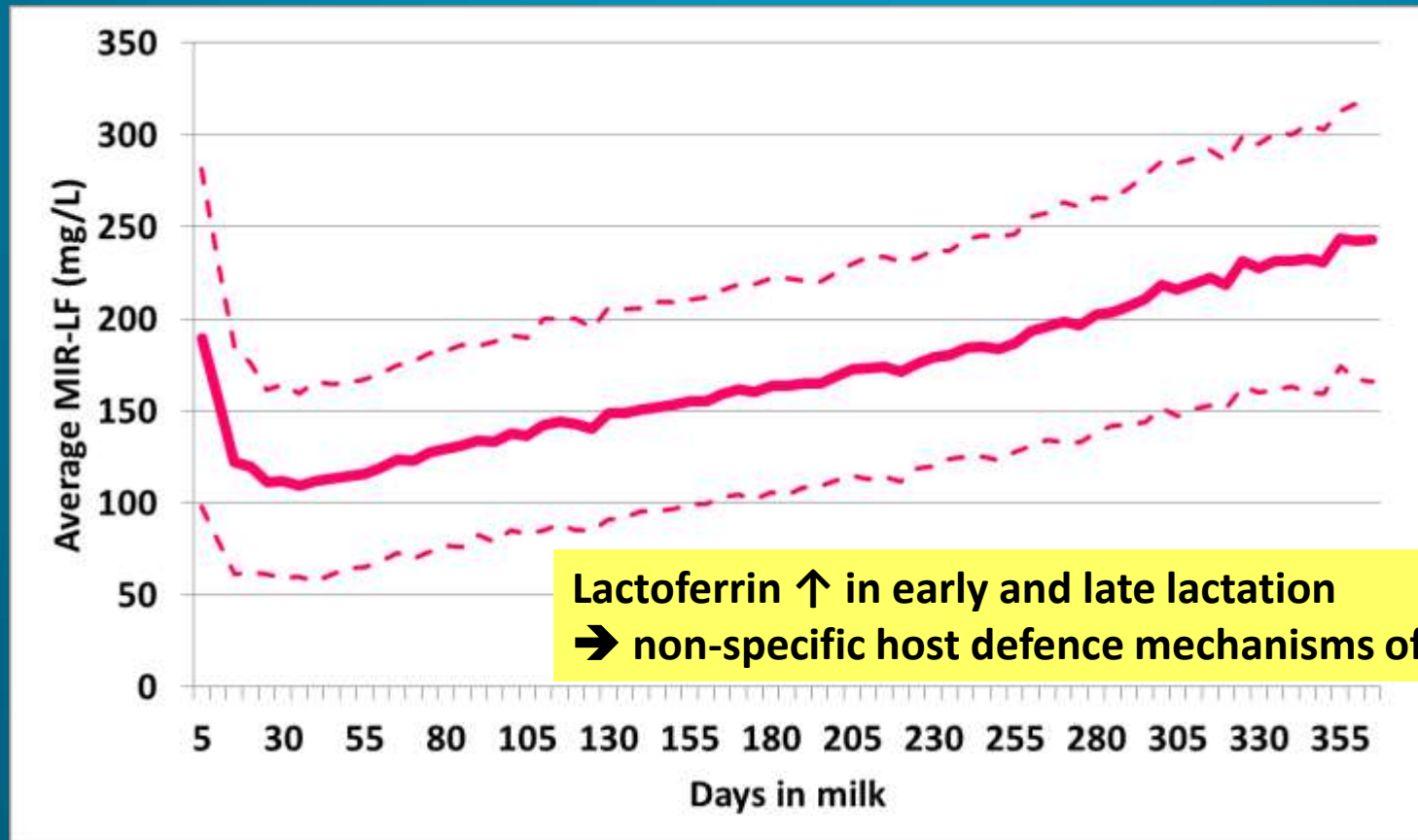
Data and edits

- **Mid-infrared prediction of**
 - lactoferrin content in milk (MIR-LF; mg/L)
 - content in milk of 10 individual and 7 groups of fatty acids (FA; g/dL)
- **After edits (and random selection of herds) :**
 - **9,878 first-parity Holstein cows** from 150 Walloon herds
 - > 88,000 records for milk, fat, and protein traits
 - > 85,000 records for somatic cell score (SCS)
 - > 61,000 records for FA and MIR-LF traits



Data: MIR-LF

- Average MIR-LF = 162.81 ± 68.76 mg/L CV=42%
- Average MIR-LF across days in milk:



Correlations among observations

➤ Correlations among observations at the same day

Correlations between MIR-LF and:	
Milk (kg)	-0.42
Fat (kg)	-0.24
Protein (kg)	-0.22
Fat (%)	0.31
Protein (%)	0.59
Somatic cell score	0.30

Correlations between MIR-LF and the groups of FA (g/dL of milk):	
Saturated	0.30
Monounsaturated	0.17
Polyunsaturated	0.15
Short chain	0.23
Medium chain	0.36
Long chain	0.06

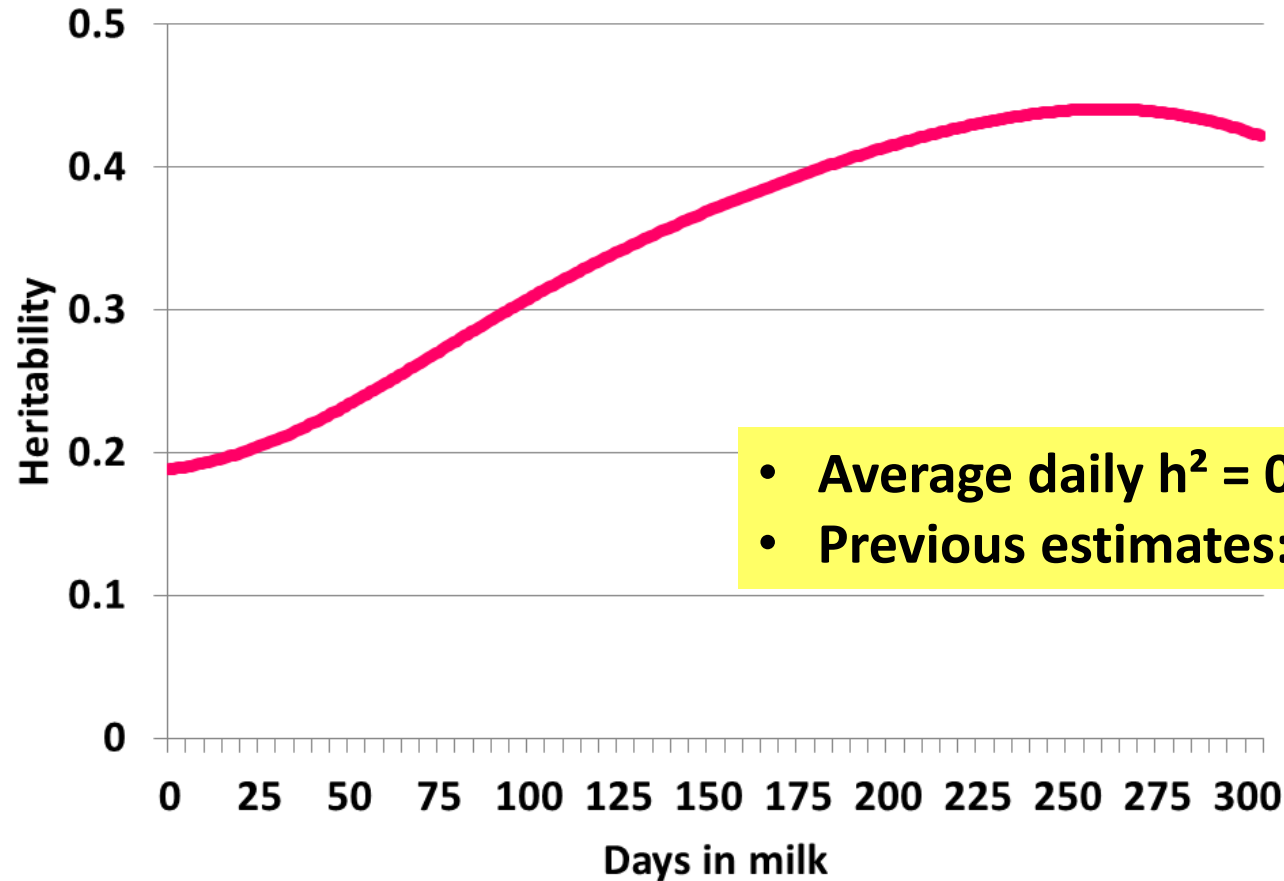
Model

➤ 23 two-trait random regression test-day models

$$y = X\beta + Q (Zp + Za) + e$$

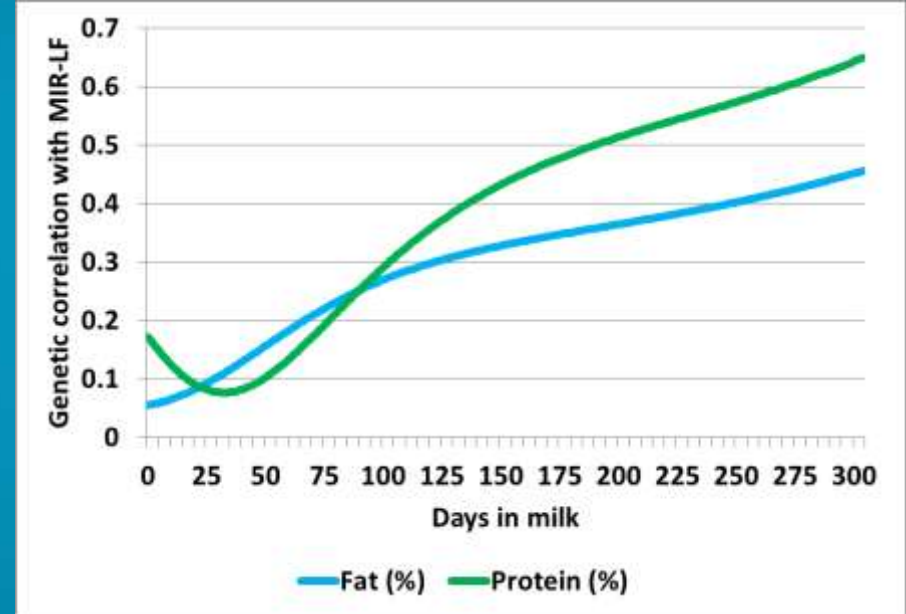
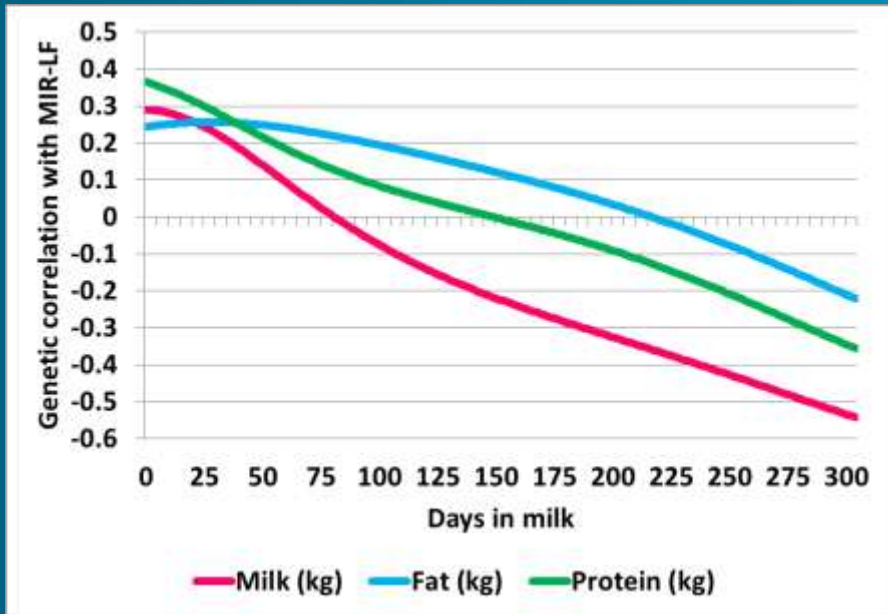
- β = fixed effects
 - herd x test day
 - lactation stage (classes of 5 days)
 - gestation stage
 - age at calving x season of calving x lactation stage
 - p = permanent environmental random effect
 - a = additive genetic random effect
 - regression curves modelled with 2nd order Legendre polynomials
- Variance components estimated using AIREMLF90 (Miszta, 2012)

MIR-LF heritability



Gaunt et al., 1980, J. Dairy Sci.
Soyeurt et al., 2007, J. Dairy Sci.
Arnould et al., 2009, J. Dairy Sci.

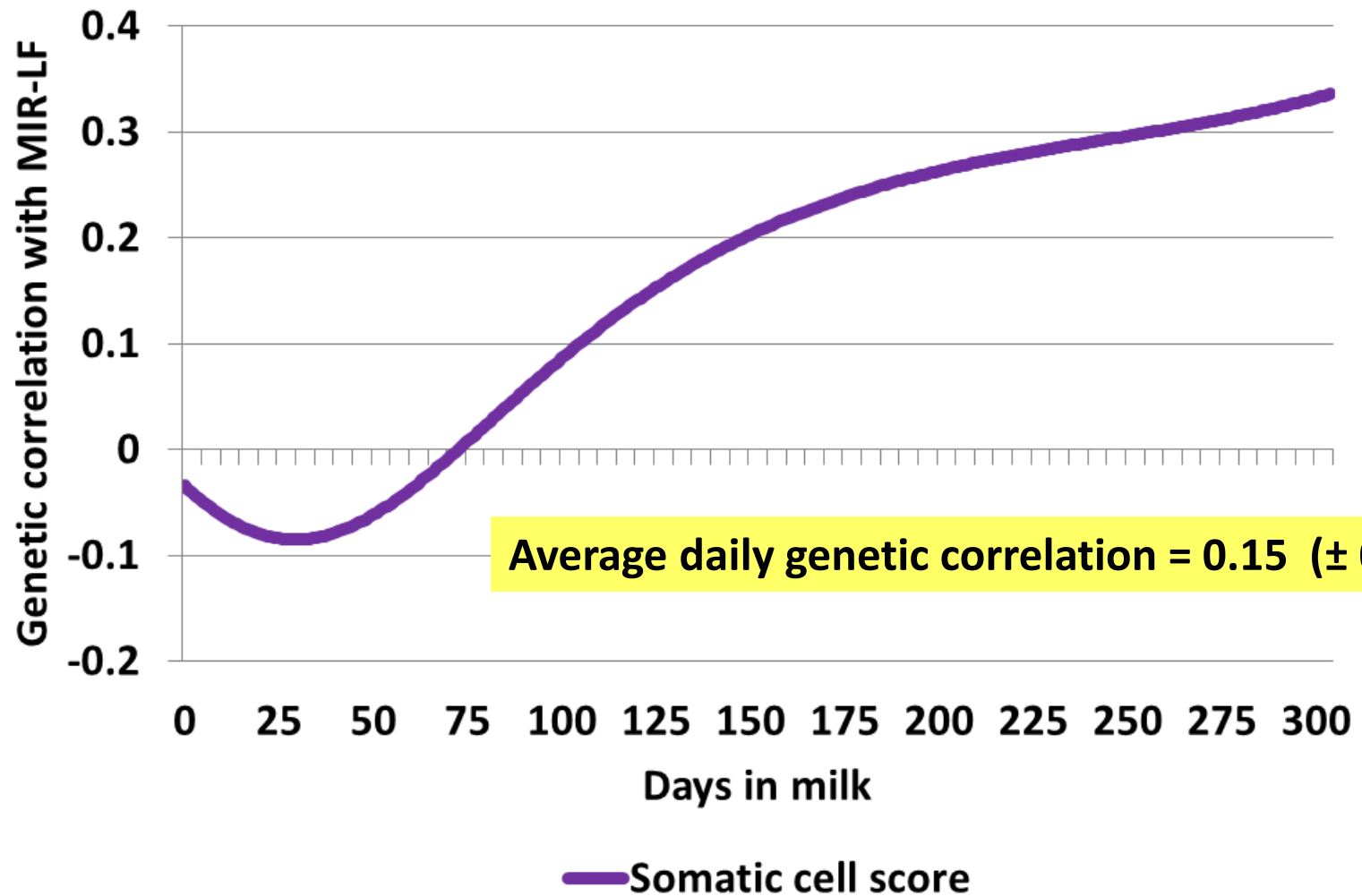
Correlations with production



Average daily genetic correlation with MIR-LF (SE = 0.06 - 0.08)

Milk (kg)	Fat (kg)	Protein (kg)	Fat (%)	Protein (%)
-0.17	0.09	-0.01	0.30	0.39

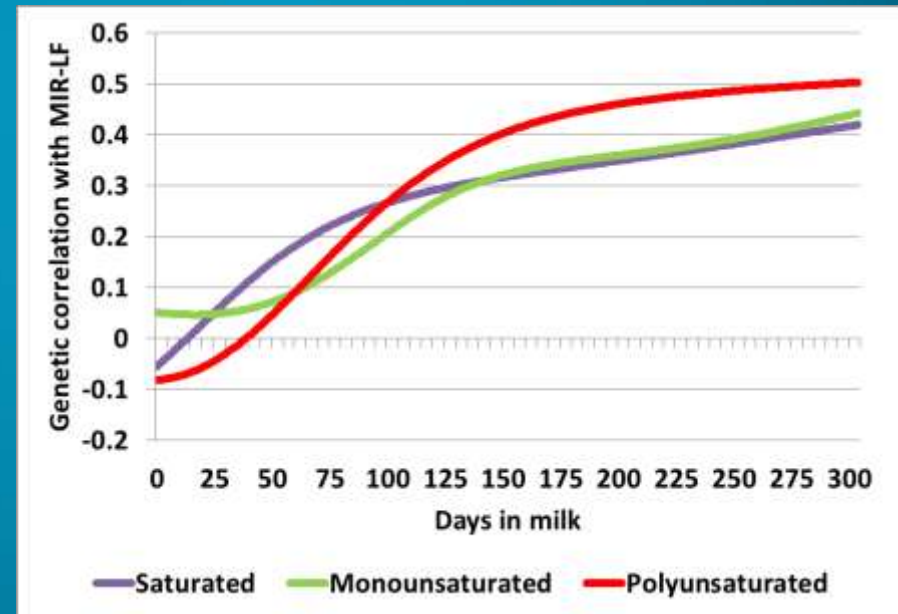
Correlations with SCS



Correlations with fatty acids

Average daily genetic correlation with
MIR-LF (SE = 0.06 - 0.08)

Individual FA (g/dL of milk)		Groups of FA (g/dL of milk)	
C4:0	0.14	Saturated	0.28
C6:0	0.21	Monounsaturated	0.27
C8:0	0.25	Polyunsaturated	0.31
C10:0	0.27	Unsaturated	0.27
C12:0	0.31	Short chain	0.24
C14:0	0.31	Medium chain	0.34
C16:0	0.33	Long chain	0.17
C17:0	0.32		
C18:0	0.04		
C18:1 <i>cis-9</i>	0.20		



Genetic selection for lactoferrin?

Measurable

- ✓ Higher MIR-LF desirable
- ✓ Interest as a biologically active food component

Economically interesting

- Nutraceutical properties of milk
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Variable and heritable

- ✓ Higher or lower MIR-LF desirable?

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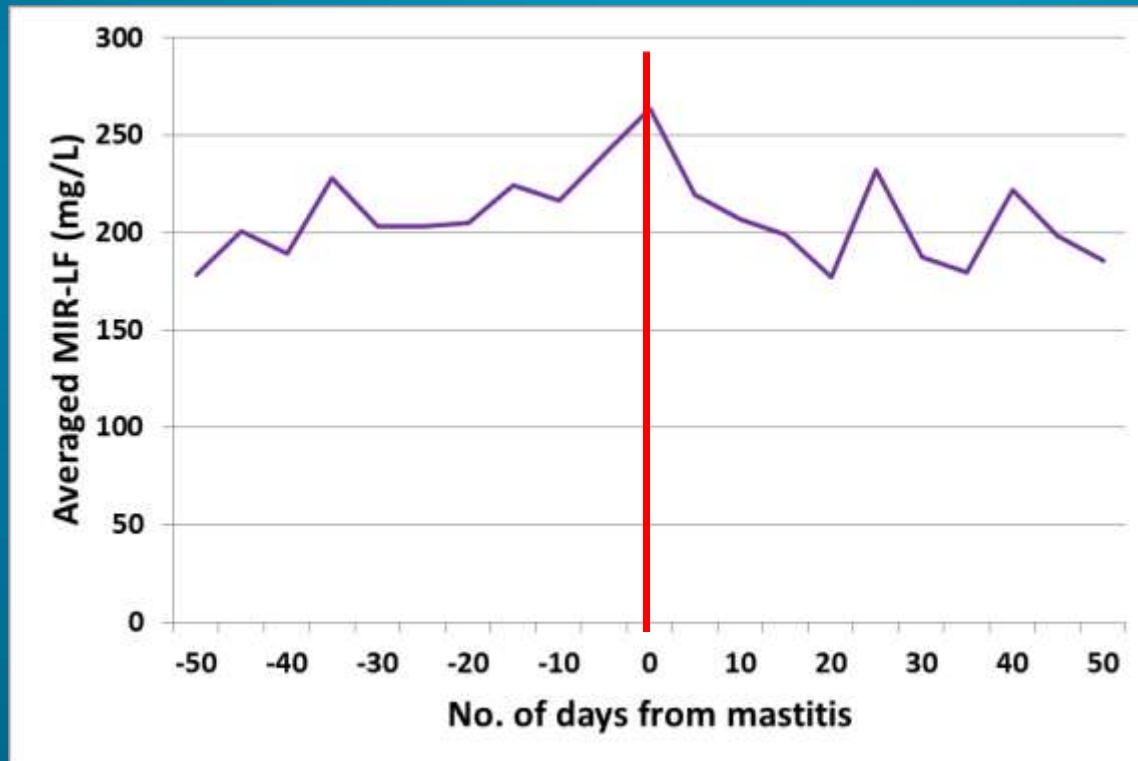
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MIR-LF and udder health

- Generally: lactoferrin level in **mastitic milk >>> normal milk**



- Mastitis and MIR-LF data from 26 Walloon herds since 2010
- 1497 lactations (of which 446 with mastitis) with at least 3 MIR-LF records

MIR-LF and udder health

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	N	Average MIR-LF over the lactation	
		Mean	SD
Non mastitic cows	1051	197.2	63.9
Mastitic cows	446	208.3	60.9

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Significantly higher for mastitic cow

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- But lactoferrin in mastitic milk **varies** according to **the pathogen and the pathogenicity** of the bacteria.
 - e.g. acute >< peracute mastitis caused by *E. coli*
- **Sufficient level of lactoferrin** necessary to prevent certain infections
 - Threshold of 200 mg/l to inhibit the growth of *E. coli*.

Kawai et al., 1999, Vet. Res. Commun.
Hagiwara et al., 2003, J. Vet. Med. Sci.
Lee et al., 2004, J. Vet. Med. Sci.

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- 
- ✓ lactoferrin = optimum trait
 - ✓ higher level: ability of the cow to fight infections vs. occurrence of mastitis
 - ✓ joint selection for improved SCS and mastitis resistance required

Conclusions

- The mid-infrared prediction of lactoferrin
 - = **indicator** of lactoferrin content in milk
 - **variable and heritable** especially in mid to late lactation
 - low and negative genetic correlation with milk yield
 - positive genetic correlations with fat, protein and fatty acid contents
- Selection for **improved MIR-LF feasible**
 - “nutraceutical properties of milk index”
 - “udder health index”





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