2012 ADSA – AMPA – ASAS –
CSAS – WSASAS JAM
July 15-19 Phoenix, Arizona

Use of milk fatty acids to substitute for body condition score in breeding purposes

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Body condition score *vs.* fatty acids

- Body condition score = subjective measurement of the stored energy reserves of a dairy cow
  - used worldwide as an indicator of the energy balance status → fertility management and selection
  - but not readily available, generally not routinely collected
- (Changes of) fatty acid contents in milk have been associated with energy balance status and fertility of dairy cows.
  - mid-infrared prediction of fatty acid contents: potentially routinely available within milk recording schemes

Van Haelst et al., 2008, J. Dairy Sci.
Stoop et al., 2009, J. Dairy Sci.
Bastin et al., 2012, J. Dairy Sci.

Objectives

Could fatty acid contents in milk substitute for body condition score as an indirect indictor of fertility in genetic evaluations?

- Genetic correlations among BCS, FA and fertility
  - among FA
  - FA – fertility

  } Obtained from previous research
  - BCS – fertility
  - BCS – FA

  Objective 1
- What proportion of the genetic variance in fertility is explained either by BCS, FA, or both?
  - selection index theory

  Objective 2

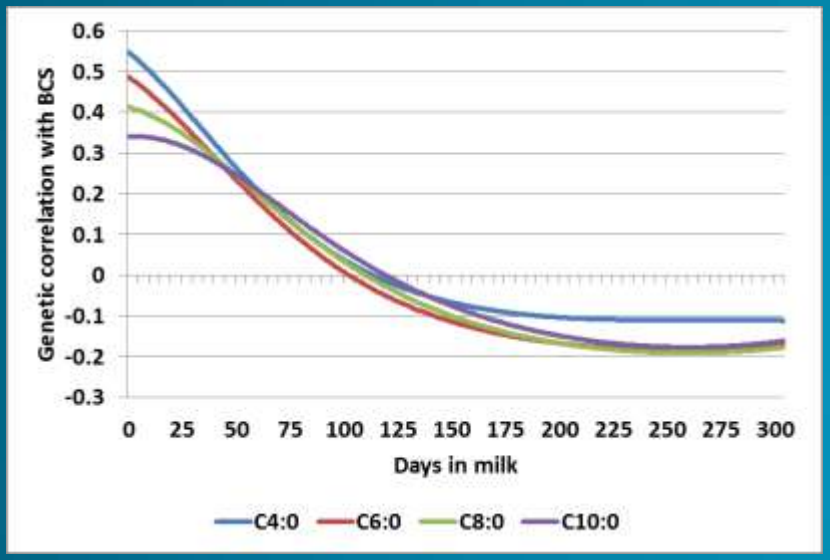
Correlations among traits: data

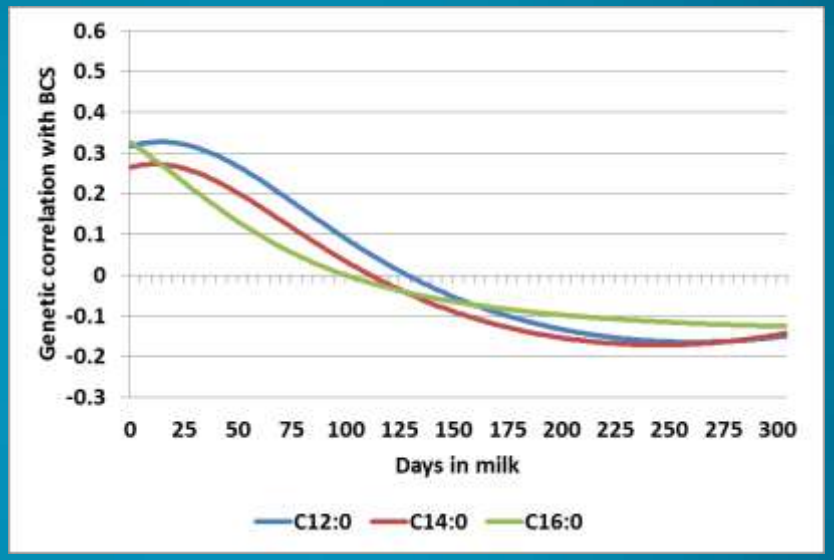
Traits	Recording
BCS	• Monthly collected by milk recorder in 85 herds • April 2006 – June 2010
FA contents (g/dL of milk)	• Mid-infrared prediction for several FA → 10 major individual FA included in this study • MIR spectra collected since January 2007 within milk recording schemes
Days open (DO)	• No. of days from calving to conception • Sole fertility trait available

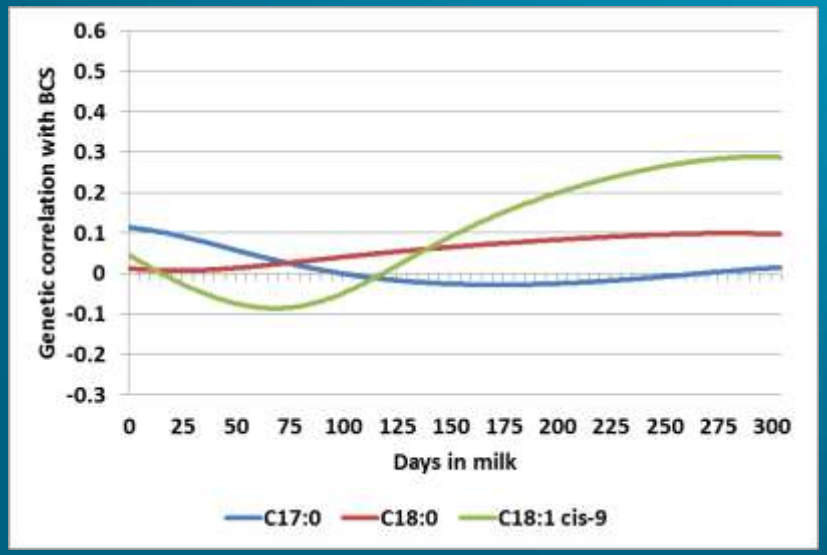
Correlations BCS – FA: data

- After edits:
  - 7,623 first-parity Walloon Holstein cows
    - ✓ of which 4,061 with both observations
    - ✓ in 85 herds
  - > 36,000 records for FA traits
  - > 30,000 records for BCS
  - BCS and FA generally recorded at the same day
- 10 two-trait random regression animal test-day models

Correlations BCS – FA





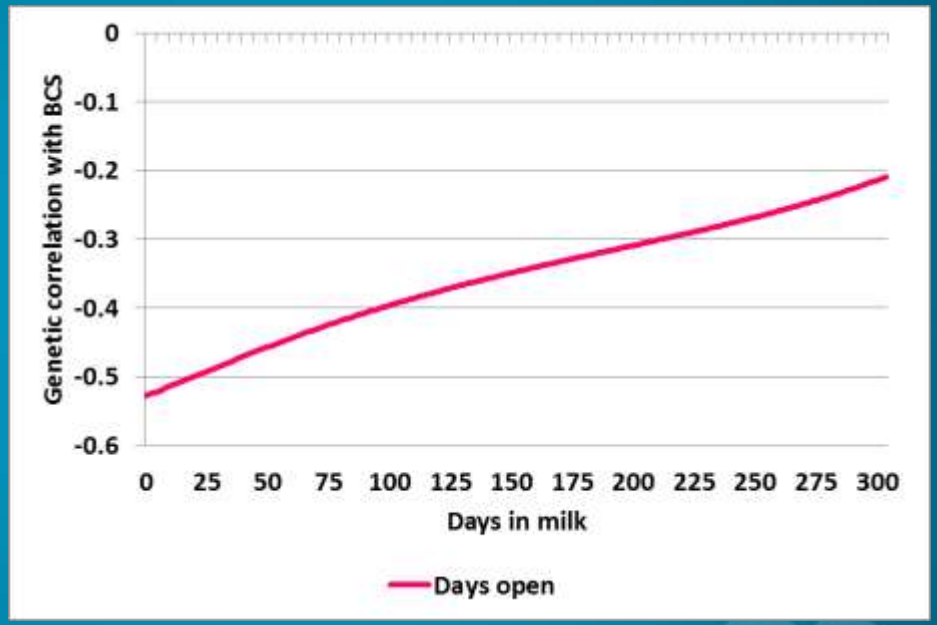


Body fat mobilization in early lactation:

- **BCS loss (↘)**
- **release of C18:0 and C18:1 *cis-9* (↗)**
- **consequent inhibition of *de novo* synthetized FA (C4:0 to C16:0) (↘)**

Correlations BCS – DO

- Data:
  - 14,887 first parity Holstein cows of which 4,455 with both observations
  - 31,350 records for DO
  - 14,157 records for BCS
- Two-trait model including random regression for BCS



- Average genetic correlation = -0.35
- Lower BCS → higher DO
- Similar to previous estimates on interval fertility traits

Veerkamp et al., 2001 , J. Dairy Sci.; Berry et al., 2003, J. Dairy Sci

Fertility explained by FA and BCS: method

From the selection index theory:

$$\frac{\sigma^2_{\text{index}}}{\sigma^2_{\text{fertility}}}$$

- σ^2_{index}= variance of the index which is a linear combination of genetic merit of BCS and/or FA traits

  = $\sigma^2_{\text{index}} = \mathbf{G'P^{-1}G}$ where

  - G = genetic covariances between DO and BCS-FA
  - P = genetic (co)variances among BCS and FA

- $\sigma^2_{fertility}$= genetic variance of the DO

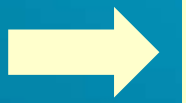
Fertility explained by FA and BCS: method

- Covariances among random regressions coefficients:
  - regression curves of the genetic effect for BCS and FA modelled using 2nd order Legendre polynomials
  - to account for the whole variation among traits over the lactation
- Standardization of estimates → correlations
- Complete correlation matrix among traits (34 x 34)
  - obtained from the combination of estimates from separate analyses
  - bending of the correlation matrix to make it positive definite

Proportion of genetic variance in fertility theoretically explained by …

One trait

BCS	0.12
C4:0	0.06
C6:0	0.20
C8:0	0.22
C10:0	0.31
C12:0	0.27
C14:0	0.22
C16:0	0.27
C17:0	0.05
C18:0	0.10
C18:1 *cis-9*	0.30



Most of the FA (except C4:0, C17:0 and C18:0) more informative than BCS only

Proportion of genetic variance in fertility theoretically explained by …

One trait		BCS and …
BCS	0.12	
C4:0	0.06	0.13
C6:0	0.20	0.25
C8:0	0.22	0.29
C10:0	0.31	0.38
C12:0	0.27	0.35
C14:0	0.22	0.27
C16:0	0.27	0.30
C17:0	0.05	0.25
C18:0	0.10	0.32
C18:1 *cis-9*	0.30	0.62

BCS combined with 1 FA more informative than 1 FA only

e.g. C18:1 *cis-9*

Proportion of genetic variance in fertility theoretically explained by …

Traits included in the index:	Ratio minimum	Ratio maximum
BCS + 1 FA	0.13	0.62
2 FA	0.17	0.69

… but BCS add as much information as 1 additional FA

Proportion of genetic variance in fertility theoretically explained by …

Traits included in the index:	Ratio minimum	Ratio maximum
BCS + 1 FA	0.13	0.62
2 FA	0.17	0.69
BCS + 2 FA	0.31	0.86
3 FA	0.29	0.84
BCS + 3 FA	0.44	0.94
4 FA	0.48	0.93
BCS + 4 FA	0.52	0.98
5 FA	0.52	0.99
10 FA	> 0.99	
10 FA + BCS	> 0.99	

And similarly for a higher number of FA …

Conclusions

- **Genetic correlations between FA and BCS**
  - **in early lactation: 0.30 to 0.60 for C4:0 to C16:0**
  - **relationships among body fat mobilization, BCS loss, release of long chain FA and consequent inhibition of *de novo* synthesis**
- **Genetic correlation between BCS and DO**
  - **-0.35 on average**
  - **low BCS → poor fertility**

Conclusions

- Theoretically, FA could replace BCS as an indicator of fertility in genetic evaluations …
  - The proportion of the genetic variance in fertility explained by BCS could be explained by FA.
  - Errors on the genetic correlation estimates

    → weighted bending
- In practice, both are indicators of body fat mobilization.
  - FA more readily available within milk recording schemes, several records per lactation but recorded since recently
  - FA could supplement BCS in breeding program to improve indirectly fertility.

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Study supported by:

- Public Service of Wallonia (SPW-DGARNE; project D31-1273)
- European Commission, Directorate-General for Agriculture and Rural Development, under Grant Agreement 211708 (project Robustmilk)

This study has been carried out with financial support from the Commission of the European Communities, FP7, KBBE-2007-1. It does not necessarily reflect its view and in no way anticipates the Commission's future policy in this area.

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