Estimation of genetic parameters for methane indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle

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Introduction

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- CH_4 is the largest contributor to total GHG emitted by the dairy sector
- 0.2 million tonnes CH_4 per year from enteric fermentation of livestock in Belgium
- CH_4 is 21 times more potent to CO_2 in greenhouse effect
- Generally CH_4 is measured by respiration chamber or Sulphur hexafluoride (SF_6) method in animals

IPCC (2007), FAO (2010), EU (1998), Johnson (1994)

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Methane (CH_4)

CH_4

CH_4 prediction from milk FA profile

- The fermentation of feed in rumen is essentially a digestion process of ruminants and CH_4 is produced
- Many fatty acids (FAs) are synthesized and degraded in rumen during this process
- These FAs are absorbed in blood; some FAs are secreted directly to milk and others are produced by *de novo* synthesis in mammary gland
- Therefore, a link between milk FAs and CH_4 production seems to exist → prediction equations

Chilliard et al.,2000 & 2009; Moss et al., 2000; Dijkstra et al., 2011

Mid-infrared (MIR) CH_4 indicators

Milk samples

MIR CH_4 indicators

Milk samples

MIR spectra

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MIR CH_4 indicators

Milk samples

MIR spectra

FA analysis
(gas chromatography)

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MIR CH_4 indicators

Milk samples

MIR spectra

FA analysis
(gas chromatography)

CH_4 predicted by FA contents
(Chilliard et al. 2009 and Dijkstra et al. 2011)

CH_4 predicted by FA contents

Prediction	Equation	R^2	Reference
Methane1 *g/day*	9.97 x (C8:0 to C16:0) - 80	**0.88**	Chilliard et al., 2009
Methane2 *g/day*	-8.72 x C18:0 + 729	**0.88**	
Methane3 *g/day*	282 x C8:0 + 11	0.81	
Methane4 *g/day*	16.8 x C16:0 - 77	0.82	
Methane5 *g/kg DM, 17.7 kg DM/day*	24.6 + 8.74 x C17:0 anteiso – 1.97 x trans-10+11 C18 :1 – 9.09 x C18 :1 cis-11 + 5.07 x C18 :1 cis-13	0.73	Dijkstra et al., 2011

R^2 *represents the relationship between the* SF_6 CH_4 *data and the predictors*

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MIR CH_4 indicators

Milk samples

MIR spectra

FA analysis
(gas chromatography)

CH_4 predicted by FA contents
(Chilliard et al. 2009 and Dijkstra et al. 2011)

Development of equations for MIR CH_4 indicators

MIR CH_4 indicators

g/day	N	Mean	SD	R^2cv
Methane1	597	446.75	68.50	**0.92**
Methane2	602	421.52	60.71	0.91
Methane3	595	368.53	43.23	0.72
Methane4	588	459.55	88.11	**0.92**
Methane5	592	368.38	51.33	0.69

Mean= mean of reference values; SD= SD of reference values;
R^2cv= *cross-validation coefficient of determination*

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MIR CH_4 indicators

Milk samples

MIR spectra

FA analysis
(gas chromatography)

CH_4 predicted by FA contents
(Chilliard et al. 2009 and Dijkstra et al. 2011)

Development of equations for MIR CH_4 indicators

Spectral database (11,999 records from 1,602 Dual Purpose Belgian Blue cows in their first three lactations)

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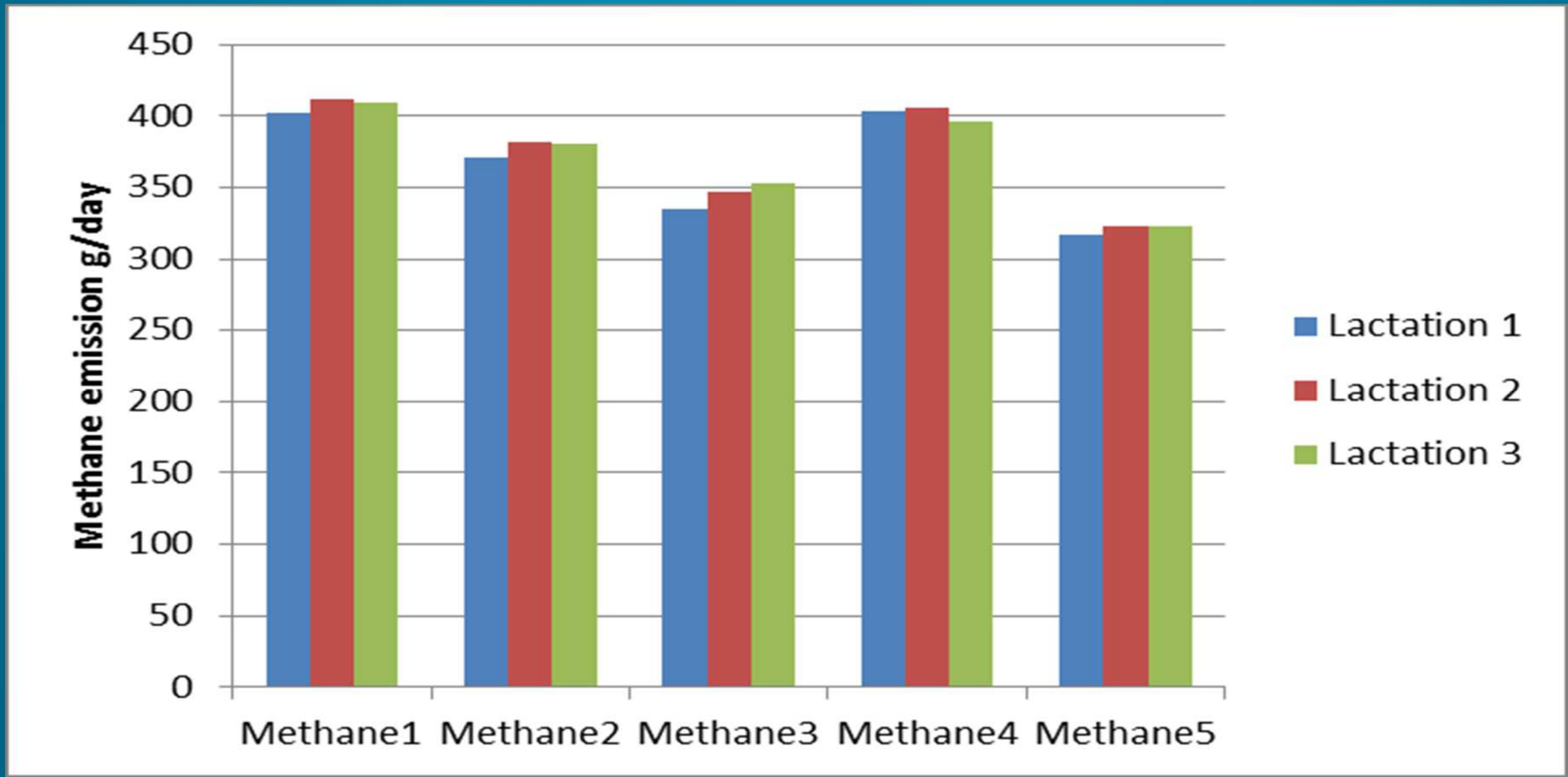
Objectives

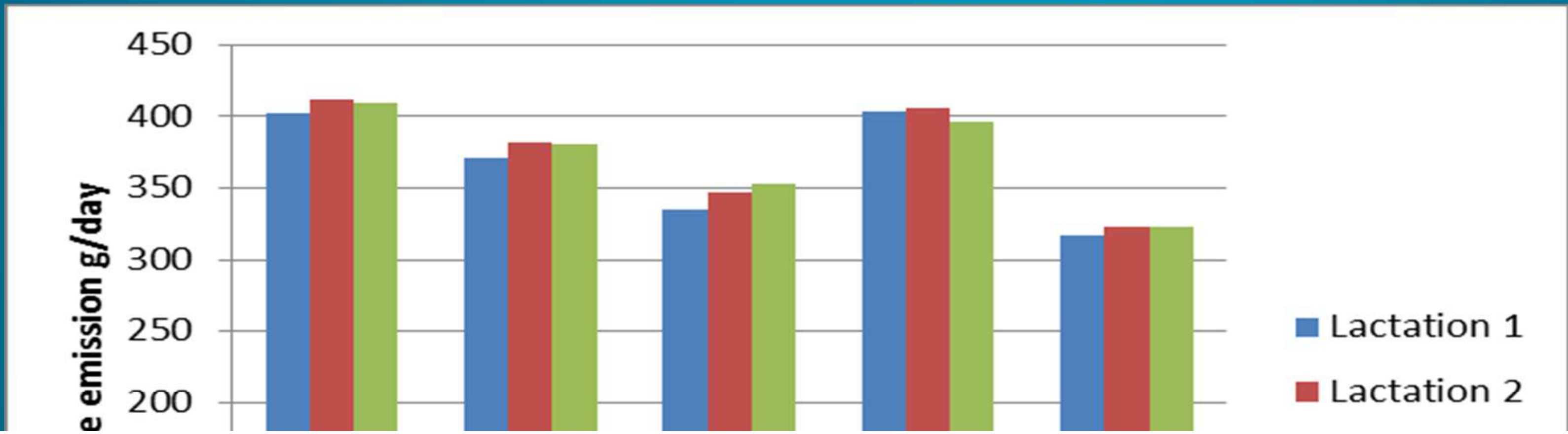
- Estimation of genetic parameters of MIR CH_4 indicators
  - Heritability
  - Genetic correlations
- Study of the genetic variability of MIR CH_4 indicators

Estimated CH_4 production from MIR CH_4 indicators



Estimated CH_4 emission 115 to 150 kg /year from one cow

Estimated CH_4 production from MIR CH_4 indicators



Breed	CH_4 (g/day)	Method	Reference
Holstein	371-453	Respiration chamber	van Zijderveld et al., 2011
Holstein	403	SF_6	Deighton et. al.2011
Jersey	356	SF_6	
Jersey*Holstein	311 (151-497)	SF_6	Cavanagh et al., 2008

Model : Single trait random regression test day

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

y: separate 5 MIR CH_4 indicators

β: herd x test day, 24 classes of days in milk, and 3 classes of age at calving → fixed effects

p: random permanent environmental effects

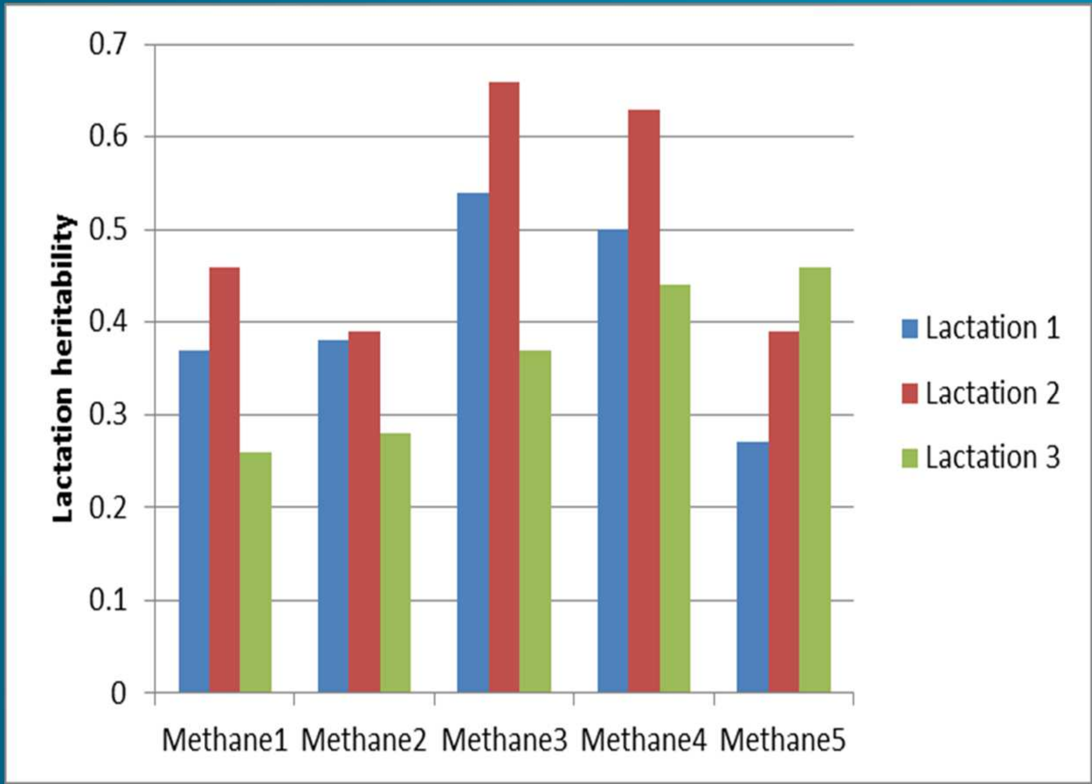
u: additive genetic effects, e: random residual effect

Q: coefficients of 2nd order Legendre polynomials

X and Z: incidence matrices

Variance components were calculated by REML.

Lactation heritability



Cassandro et al. (2010)
0.12

de Haas et al. (2011)
0.38

The heritability values suggested a potential transmission from generation to generation of the capacity of the CH_4 eructation by dairy cattle.

Observed and genetic correlations

Indicator	1	2	3	4	5
Methane1		0.99	**0.51**	0.88	0.61
Methane2	0.96		**0.52**	0.88	0.65
Methane3	0.64	0.70		0.25	0.16
Methane4	0.81	0.71	0.35		0.65
Methane5	**0.62**	**0.61**	**0.24**	**0.66**	

Yellow color- Observed correlation among MIR indicators;

Green color- Genetic correlation approximated by correlation between EBVs

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EBV for sires which have daughters with MIR CH_4 indicator records

kg/lactation (305 days)

Indicator	Lactation 1 (127 bulls)			Lactation 2 (112 bulls)			Lactation 3 (97 bulls)		
	SD	Range	Range/SD	SD	Range	Range/SD	SD	Range	Range/SD
Methane1	1.9	**11.6**	6.1	2.0	**13.0**	6.4	1.1	**6.3**	5.6
Methane2	1.5	**9.4**	6.3	1.5	**9.0**	5.9	1.1	**5.3**	5.4
Methane3	3.7	**21.2**	5.8	3.0	**16.3**	5.4	2.1	**11.1**	5.4
Methane4	2.7	**13.4**	5.0	3.6	**18.9**	5.3	2.2	**12.2**	5.6
Methane5	0.6	**4.0**	7.2	0.8	**4.8**	5.9	0.8	**4.9**	5.8

Appreciable genetic difference was observed for e.g. Methane1- 11.6 kg per lactation

EBV for cows with MIR CH_4 indicator records

kg/lactation (305 days)

Indicator	Lactation 1 (1,301 cows)			Lactation 2 (880 cows)			Lactation 3 (581cows)		
	SD	Range	Range/SD	SD	Range	Range/SD	SD	Range	Range/SD
Methane1	2.1	**15.1**	6.9	2.1	**13.9**	6.4	1.3	**7.6**	6.1
Methane2	1.7	**11.6**	6.8	1.6	**9.6**	5.9	1.2	**6.9**	5.7
Methane3	4.3	**27.7**	6.5	3.6	**27.3**	7.5	2.2	**13.2**	6.1
Methane4	3.1	**22.8**	7.4	3.5	**25.4**	7.2	2.3	**14.6**	6.5
methane5	0.6	**4.8**	7.8	0.8	**5.0**	6.3	1.0	**7.2**	7.4

Appreciable genetic difference was observed for e.g. Methane1-15.1 kg per lactation

Conclusions

- The more relevant MIR CH_4 indicators could be:
  - Methane1:
    - The best relation between SF_6 data and the predicted ones (R^2=0.88)
    - The highest R^2cv (0.92)
  - Methane5:
    - Low genetic correlation with other MIR CH_4 indicators
- Possible predictions of MIR CH_4 indicators
- Preliminary heritability estimates were sufficient to select animals
- The genetic variability of CH_4 production seems to exist

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Thank you for your attention!