Early Stage Researcher Network Meeting

13-14 Feb 2012, Edinburgh, UK

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Part I

Technical Report

Genetic parameters for methane indicator traits based on milk fatty acids in cows

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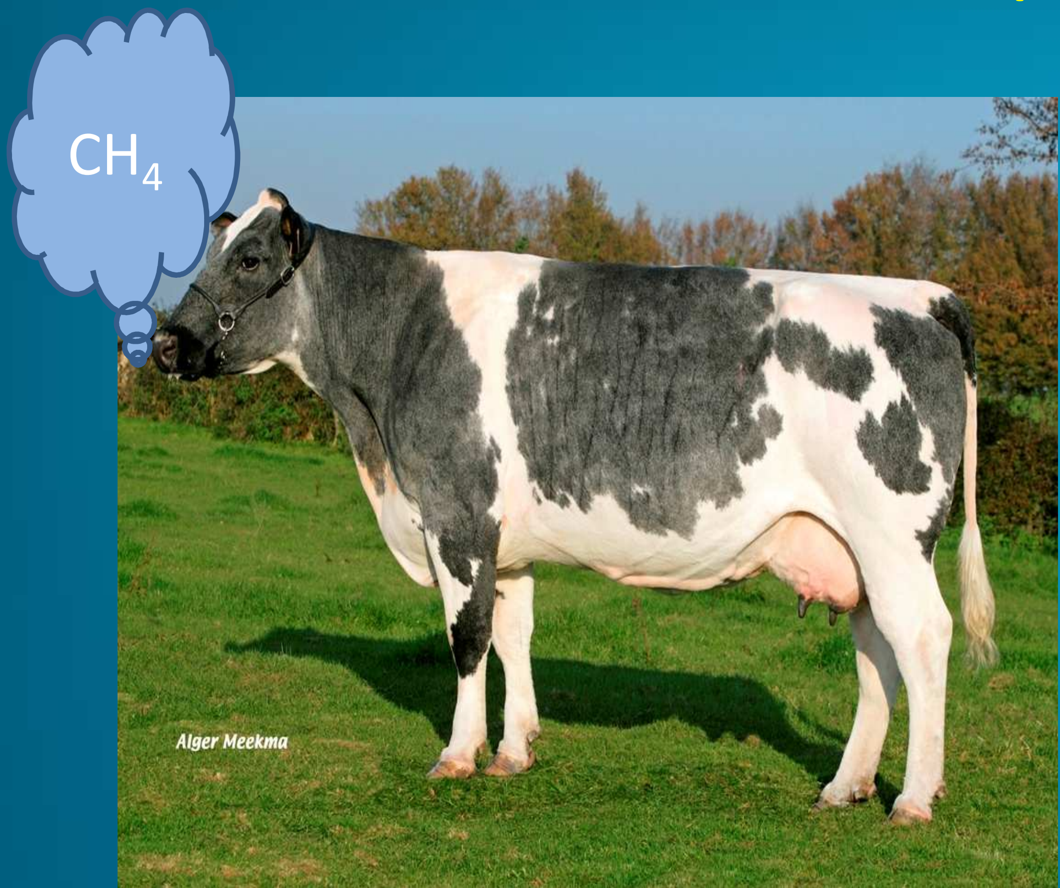
Early Stage Researcher Network Meeting; 13-14 Feb 2012, Edinburgh, UK

Introduction

- CH_4 is the largest contributor to total GHG emitted by the dairy sector
- 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)

Methane (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

www.foss.dk

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)

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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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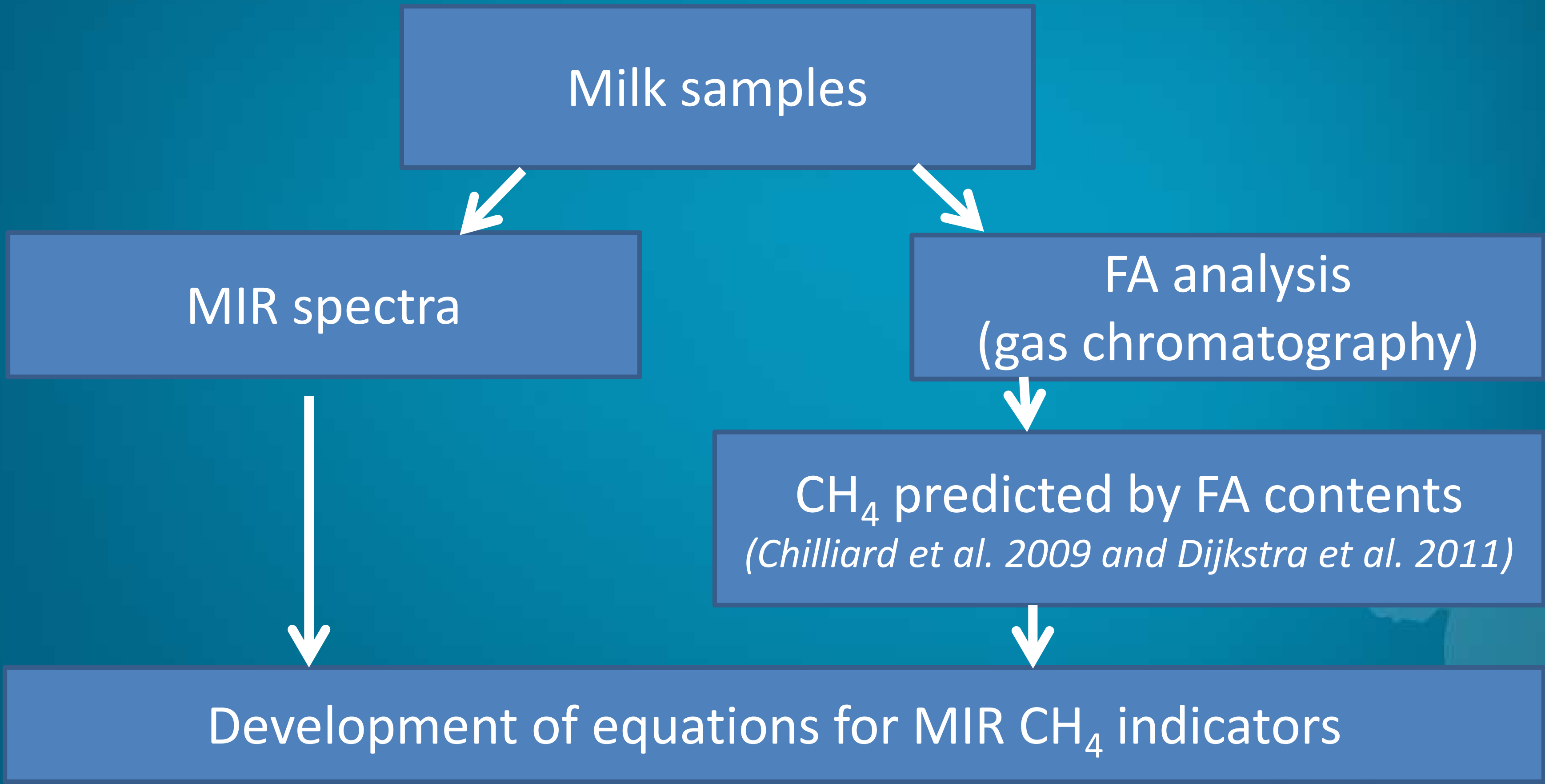
MIR CH_4 indicators



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)*

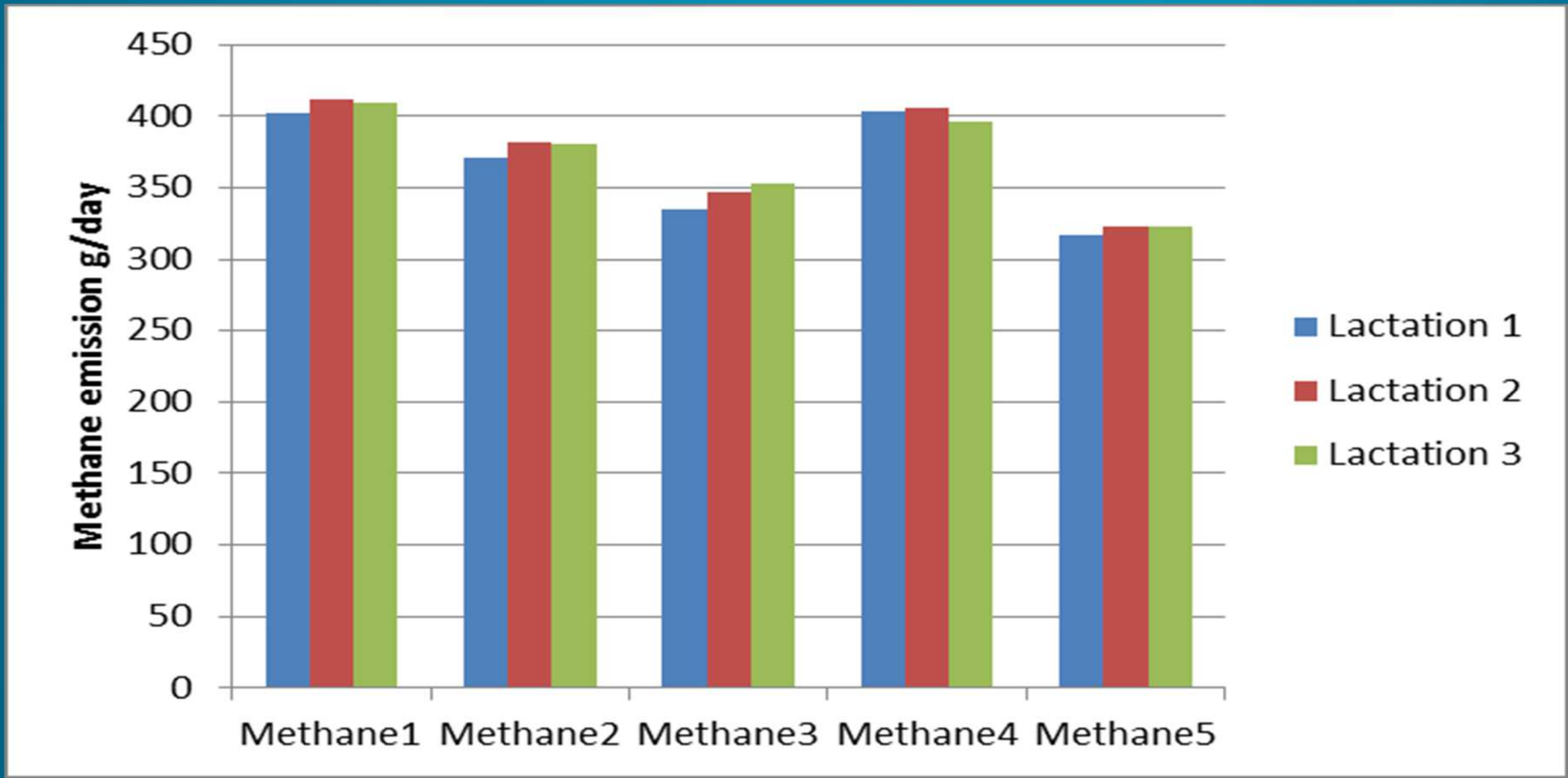
Development of equations for MIR CH_4 indicators

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

Dual-Purpose Belgian Blue

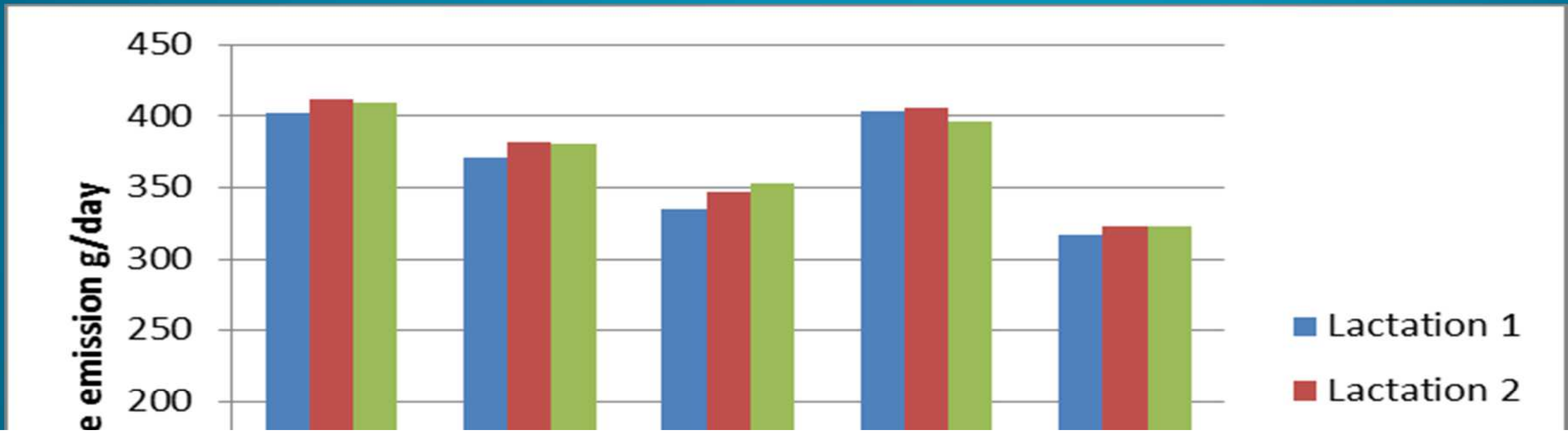
- Study of the genetic variability of MIR CH_4 indicators
- Estimation of genetic parameters of MIR CH_4 indicators
  - Heritability
  - Genetic correlations
- Estimation of breeding values using same data

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

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

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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 (619,272 records from 71,188 Holstein cows in their first three lactations)

Holstein

- Study of the genetic variability of MIR CH_4 indicators on a sub-sample:
  - 210,280 records from ~25,000 cows
- Estimation of genetic parameters of MIR CH_4 indicators
  - Heritability
  - Genetic correlations
- Estimation of breeding values using same data

Prelimenary Results (Holstein)

Methane1

Lactation	Daily heritability		Lactation heritability	
	Mean	SD	Mean	SD
First	0.35	0.01	0.67	0.02
Second	0.35	0.01	0.72	0.02
Third	0.32	0.02	0.62	0.03

EBV for sires which have daughters with MIR CH_4 indicator records

kg/lactation (305 days)

Indicator	Lactation 1 (1,542 bulls)			Lactation 2 (1,230 bulls)			Lactation 3 (1,303 bulls)		
	SD	Range	Range/SD	SD	Range	Range/SD	SD	Range	Range/SD
Methane1	3.3	**21.8**	6.6	3.5	**22.8**	6.5	3.5	**24.9**	6.9
Methane2									
Methane3									
Methane4									
Methane5									

Appreciable genetic difference was observed

EBV for cows with MIR CH_4 indicator records

kg/lactation (305 days)

Indicator	Lactation 1 (18,805 cows)			Lactation 2 (14,069 cows)			Lactation 3 (9,949cows)		
	SD	Range	Range/SD	SD	Range	Range/SD	SD	Range	Range/SD
Methane1	3.5	**31.0**	8.8	4.1	**34.5**	8.4	3.8	**31.8**	8.4
Methane2									
Methane3									
Methane4									
methane5									

Appreciable genetic difference was observed

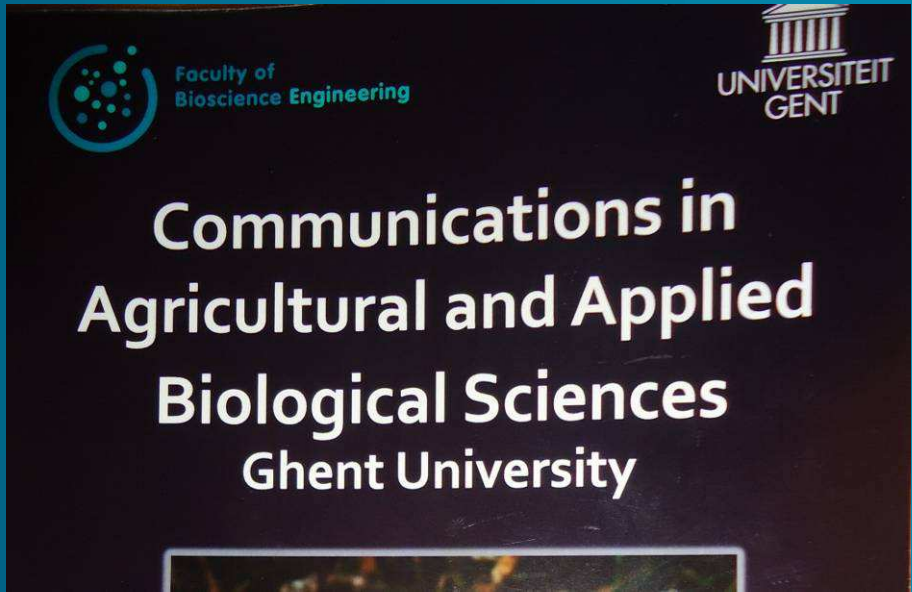
Conclusions

- MIR predictions of MIR CH_4 indicators possible
- Given current results, more relevant MIR CH_4 indicators could be:
  - Methane1:
    - The best relation between SF_6 data and the predictor (R^2= 0.88)
    - The highest R^2cv (0.92) of MIR prediction
  - Methane5:
    - Low genetic correlation with other MIR CH_4 indicators
- Preliminary heritability estimates sufficient to select animals
- Genetic variability of CH_4 production seems to exist

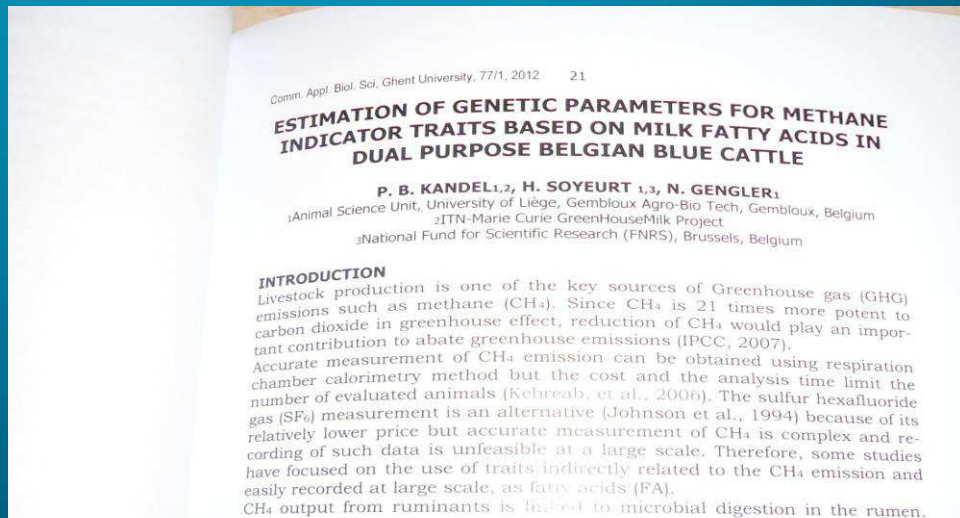
Part II

Publication/Training /Exchange

Publication



Published Extended Abstract in Communications in Applied Biological Science Vol:77(1)



Comm. Appl. Biol. Sci, Ghent University, 77/1, 2012 21

ESTIMATION OF GENETIC PARAMETERS FOR METHANE INDICATOR TRAITS BASED ON MILK FATTY ACIDS IN DUAL PURPOSE BELGIAN BLUE CATTLE

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INTRODUCTION

Livestock production is one of the key sources of Greenhouse gas (GHG) emissions such as methane (CH_4). Since CH_4 is 21 times more potent to carbon dioxide in greenhouse effect, reduction of CH_4 would play an important contribution to abate greenhouse emissions (IPCC, 2007).

Accurate measurement of CH_4 emission can be obtained using respiration chamber calorimetry method but the cost and the analysis time limit the number of evaluated animals (Kebreab, et al., 2006). The sulfur hexafluoride gas (SF_6) measurement is an alternative (Johnson et al., 1994) because of its relatively lower price but accurate measurement of CH_4 is complex and recording of such data is unfeasible at a large scale. Therefore, some studies have focused on the use of traits indirectly related to the CH_4 emission and easily recorded at large scale, as fatty acids (FA).

CH_4 output from ruminants is linked to microbial digestion in the rumen.

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Presentation

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ACTIVITY	DESCRIPTION	DATES	LOCATION	KEY OUTCOMES
Oral Presentation	Estimation of CH_4 and its variation across different breeds of cattle predicted from milk fatty acids	2 Dec 2011	GHM meeting, Paris	Presented research work
Oral Presentation	Estimation of genetic parameters for CH_4 indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle	10 Feb 2012	Symposium on Applied Biological Sciences, Leuven, Belgium	Presented research work
Poster Presentation	Relationships between CH_4 emission of dairy cattle and farm management*	10 Feb 2012	Symposium on Applied Biological Sciences, Leuven, Belgium	Presented research work
Oral Presentation	GreenHouseMilk meeting	14 Feb 2012	SAC, Scotland	Research work presentation

*M.-L. Vanrobays, A. Vanlierde, P. B. Kandel, E. Froidmont, F. Dehareng, H. Soyeurt & N. Gengler

Submitted abstracts

DESCRIPTION	DATES	LOCATION	KEY OUTCOMES (inc any weblink)
Estimation of genetic parameters for methane indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle	3 Feb 2012	Fourth International Conference of Quantitative Edinburgh, UK	Research work will be presented http://www.icqg4.org.uk/
Genetic parameters for methane indicator traits based on milk fatty acids in cows	12 Feb 2012	ADSA® ASAS Joint Annual Meeting, Phoenix, USA	Research work presentation http://www.jtmtg.org/2012/

Training

DESCRIPTION	DATES	LOCATION	KEY OUTCOMES (inc any weblink)
French Language Course	20 Sept 2011- 23 Feb 2012	Gembloux, Belgium	Learned basic French to communicate
Training for users of computing devices and mass storage	25 Sept 2011 – 15 Dec 2011	University Catholique Louvain	Linux operations High memory computing http://goo.gl/i9OSH
Dairy cow lactations, profiles, nutrient allocation and energy balances	5 Dec 2011 – 9 Dec 2011	Aarhus University, Viborg, Denmark	Lactation profile , energy use and genetic basis of negative energy balance http://goo.gl/ouudy
Training on infrared spectroscopy and chemometrics	27 Feb 2012 - 2 Mar2012	CRA-W, Belgium	Sampling and analysis skill of infrared spectroscopy http://goo.gl/zYe6Q
Mixed Models in Quantitative Genetics Advanced R programming for Bioinformatics	11 Jun 2012- 16 Jun 2012	Edinburgh, UK	Advanced Knowledge of Mixed Model and R for Genetic analysis will be learned http://goo.gl/VioJf

Conferences

DESCRIPTION	DATES	LOCATION	KEY OUTCOMES (inc any weblink)
Healthy Food from Healthy Animals	23 Apr 2012- 26 Apr 2012	University of Nottingham, UK	Latest development in livestock research and industry Learning soft skills http://goo.gl/MoUxe
ICAR and IINTERBULL meeting	28 May 2012 -2 June 2012	Cork, Ireland	Animal recording system skills; Interaction with dairy industry people http://goo.gl/5uU1m

Exchange

Partner Visited	Description	Period	Objective/Outcome
TEAGSAC, Ireland (Proposed)	Experiment , Report, Publication	Apr 2012 to Aug 2012	• Compilation of performance data from herds with SF6 CH4 measures • study the phenotypic and genetic variability of CH4 indicators predicted by MIR on Irish Data • model the SF6 data (e.g., test-day mixed model)

Acknowledgement

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Thank you for your attention!