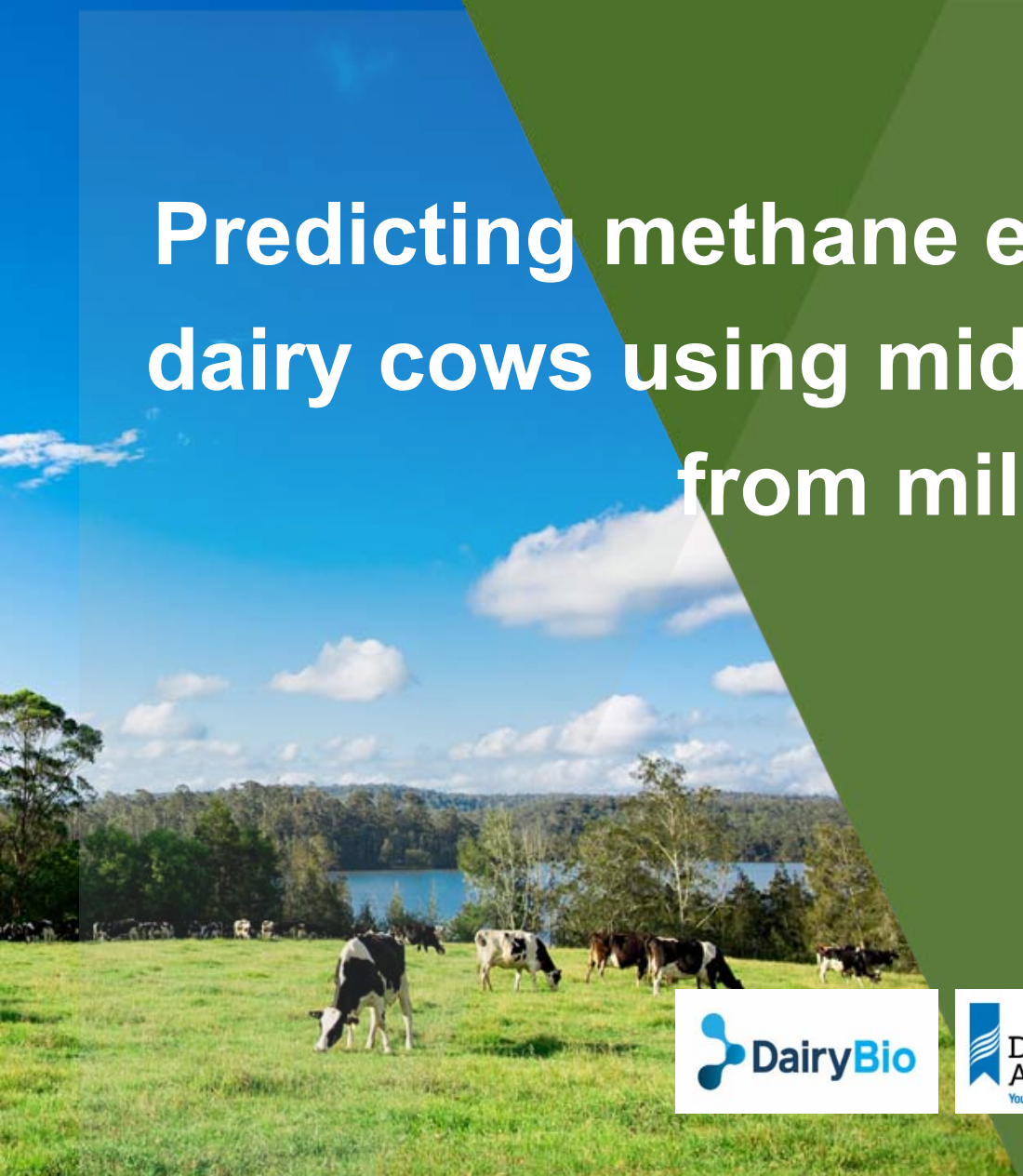
Predicting methane emissions of Australian dairy cows using mid-infrared spectroscopy from milk samples



P.N. Ho, F. Almasi, L.C. Marret, S.R.O. Williams, J.L. Jacobs and J.E. Pryce

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Potential of milk mid-infrared spectra for predicting methane emissions

Animal (2012), 6:10, pp 1694–1701 © The Animal Consortium 2012
doi:10.1017/S1751731112000456

animal

Potential use of milk mid-infrared spectra to predict individual methane emission of dairy cows

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Hot topic: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra

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J. Dairy Sci. 100:9052–9060
https://doi.org/10.3168/jds.2017-13014

Predicting methane emissions of lactating Danish Holstein cows using Fourier transform mid-infrared spectroscopy of milk

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J. Dairy Sci. 101:1–17
https://doi.org/10.3168/jds.2017-13052

Predicting enteric methane emission of dairy cows with milk Fourier-transform infrared spectra and gas chromatography–based milk fatty acid profiles

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J. Dairy Sci. 105:8272–8285
https://doi.org/10.3168/jds.2021-21176

Predicting methane emission in Canadian Holstein dairy cattle using milk mid-infrared reflectance spectroscopy and other commonly available predictors via artificial neural networks

Saeed Shadpour,[1] Tatiane C. S. Chud,[1] Dagnachew Hailemariam,[2] Graham Plastow,[2] Hinayah R. Oliveira,[1] Paul Stothard,[2] Jan Lassen,[3] Filippo Miglior,[1,4] Christine F. Baes,[1] Dan Tulpan,[1] and Flavio S. Schenkel[1]*
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J. Dairy Sci. 107:978–991
https://doi.org/10.3168/jds.2023-23577

Predicting methane emissions of individual grazing dairy cows from spectral analyses of their milk samples

S. McParland, M. Frizzarin, B. Lahart, M. Kennedy, L. Shalloo, M. Egan, K. Starsmore, and D. P. Berry*
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$R^2 \approx 0.04 – 0.79$

JDS Communications®
TBC:TBC
https://doi.org/10.3168/jdsc.2023-0431
Symposium Review
Genetics

Symposium Review: Development of genomic evaluation for methane efficiency in Canadian Holsteins

Hinayah R. Oliveira,12 Hannah Sweett,[1] Saranya Narayana,[1] Allison Fleming,[1] Saeed Shadpour,[3] Francesca Malchiodi,34 Janusz Jamrozik,13 Gerrit Kistemaker,[1] Peter Sullivan,[1] Flavio Schenkel,[3] Dagnachew Hailemariam,[3] Paul Stothard,[3] Graham Plastow,[3] Brian Van Doormaal,[1] Michael Lohuis,[4] Jay Shannon,[4] Christine Baes,36 and Filippo Miglior13

MIR prediction equations derived overseas are usually not readily applicable to local data

Objectives

- Evaluate the ability of milk FT-IR spectra for predicting methane emissions of dairy cows in Australia
  - Methane production (g/d)
  - Methane yield (g/kg of dry matter intake)
  - Methane intensity (g/kg of milk)
- Compare the prediction accuracy of independent versus dependent lactation stage approaches

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Animal data

- 32-d experiments conducted on 240 cows at Ellinbank Dairy Research Farm (2016-2017)
- Cows were fed with Lucerne cubes plus grain supplements
- Methane production was measured by modified SF6 tracer technique during the last 5 days (*Deighton et al., 2014*)
- Other records : milk yield, milk composition, dry matter intake…
- MIR: milk samples (4-6 times /week) were analyzed using Bentley Instruments NexGen Series FTS Combi machines
  - *Methane production (g/d), methane yield (g/kgDMI), methane intensity (g/kgMY)*

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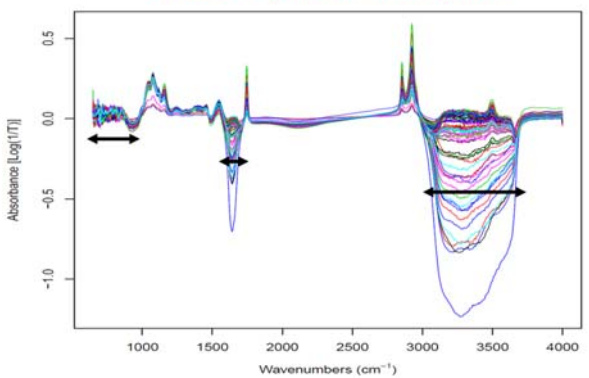
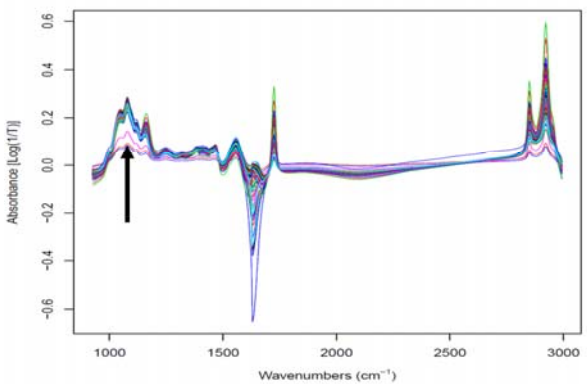
Mathematical treatments of spectra

1. Remove noisy and noninformative areas caused by water absorption

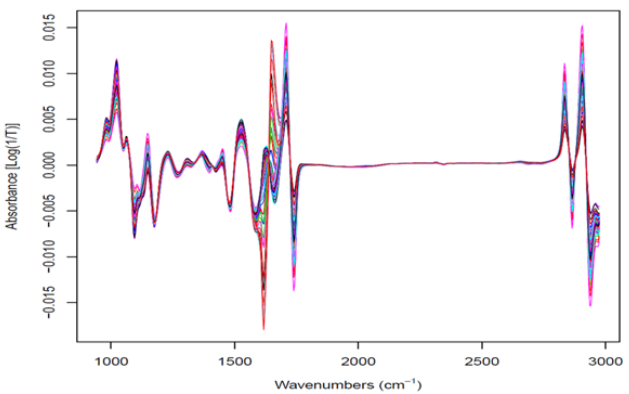


2. Remove possible outliers using *global Mahalanobis* distance



The **Mahalanobis distance** is a measure of the distance between a point P and a distribution D, introduced by P. C. Mahalanobis in 1936.

3. Enhance peak resolution by applying first derivative



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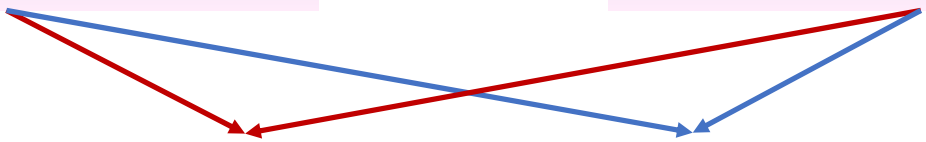
Model development and evaluation

Day 0 (937 records)

Methane Day$_i$ ↔ MIR Day$_i$

Day 1 (350 records)

Methane Day$_i$ ↔ MIR Day$_{i+1}$



LACTATION STAGE INDEPENDENCE

LACTATION STAGE DEPENDENCE

J. Dairy Sci. 98:5740–5747
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***Hot topic*: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra**

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To obtain the DLS calibration equation, each first derivative value of the spectrum was multiplied by (1) a constant (i.e., 1), (2) a linear $\left(\sqrt{3} \times x\right)$, and (3) a quadratic $\left[\sqrt{5/4} \times \left(3x^2 - 1\right)\right]$ modified Legendre polynomial (Gengler et al., 1999), where

$$x = -1 + 2[(\mathrm{DIM} - 5)/(365 - 5)].$$

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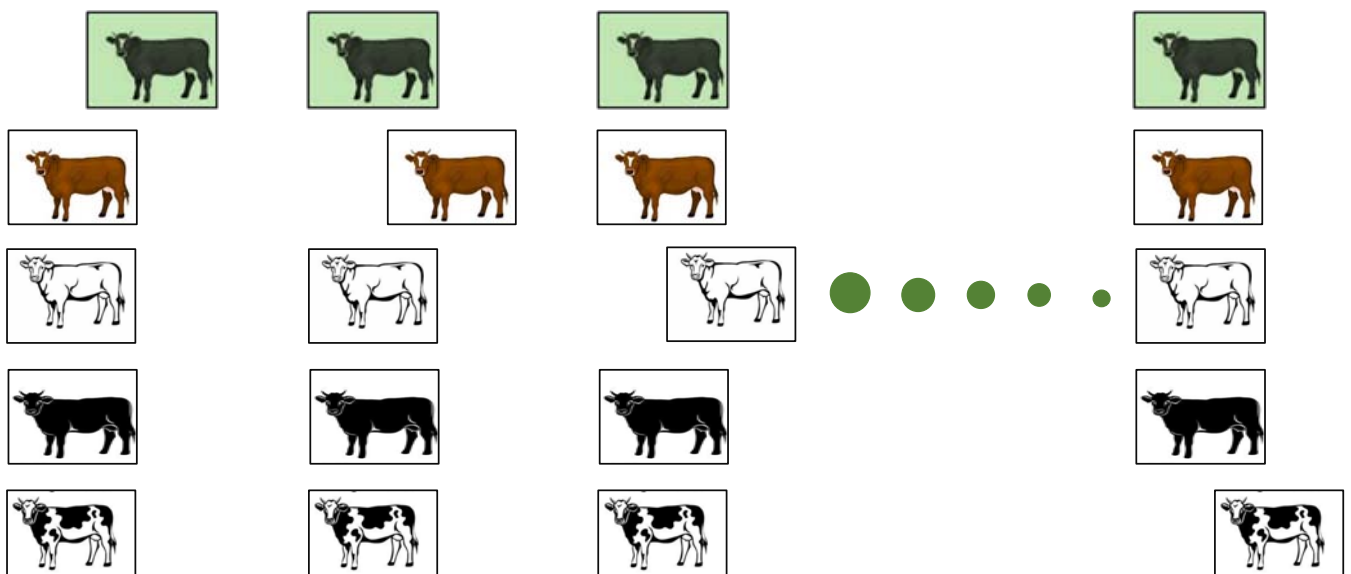
7

Evaluation of model performance (R^2 and RMSE)

leave-one (animal)-out cross-validation



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Prediction accuracy – Day 0

		CH_4 production (g/d)		CH_4 intensity (g/kgMY)		CH_4 yield (g/kgDMI)	
		R^2	RMSE	R^2	RMSE	R^2	RMSE
IDLS	Day 0	0.25	72.0	0.24	6.4	0.20	4.5
DLS	Day 0	0.29	70.2	0.33	3.6	0.24	6.4

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Prediction accuracy – Day 0 vs. Day 1

		CH_4 production (g/d)		CH_4 intensity (g/kgMY)		CH_4 yield (g/kgDMI)	
		R^2	RMSE	R^2	RMSE	R^2	RMSE
IDLS	Day 0	0.25	72.0	0.24	6.4	0.20	4.5
	Day 1	0.33	68.5	0.38	3.5	0.53	3.1
DLS	Day 0	0.29	70.2	0.33	3.6	0.24	6.4
	Day 1	0.39	65.1	0.42	3.3	0.55	3.0

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Our results are comparable with the literature: 0.04 – 0.79

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Conclusions

- Promising prediction accuracy for methane emissions of Australian dairy cows using MIR from milk samples
- Significant impact of incorporating lactation stage effect on MIR spectra to the prediction accuracy
- More and diverse data are needed for improving accuracy and robustness of the models

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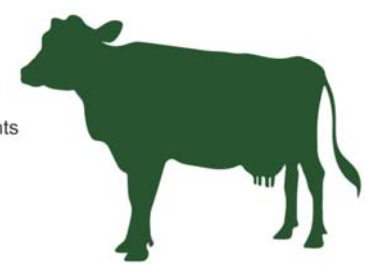
Green Cow project – developing a methane ABV

- **Phenotyping methane at-scale on commercial dairy farms**
- **3-year project (commenced Nov 2023)**
- **AVR AgriBio and Ellinbank collaboration**
- **Year 1:**
  - Recruitment
  - Existing data
  - Validating sensors and proxies
  - Preliminary on-farm measurements
  - Securing funding
- **Years 2 & 3:**
  - Commercial herd phenotyping
  - Development of methane ABV



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Comparison of technology Agriculture Victoria has tested for measuring methane

Methodology	Strength	Cost	Throughput	AVR Tested
Respiration chamber	5	5	1	Gold-standard
SF6	5	4	2	Gold-standard
GreenFeed	4	5	3	(✓)
Sniffers	4	2	4	✓
Sensor	3	3	3	(✓)
Rumen microbiome	4	3	3	✓
MIR	3	1	5	✓
Faecal microbiome	Early results now	2	4	Current
???				

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Acknowledgements

ARC Training Centre in Predictive Breeding for Agricultural Futures

- The world's first centre dedicated to ***training the next generation of plant and animal breeders*** is being established at The University of Queensland
- The Centre consists of seven University Nodes and over 30 industry and government partners
- 38 PhD studentships and postdoctoral positions are available within the Centre and projects focus on ***21 agriculturally important species/commodities***
- Projects include a ***placement with our leading industry partners***, access to ***short courses***, and an opportunity to learn and apply ***cutting-edge technologies*** to help solve real world problems
- ***Recruitment*** will commence shortly – email predictivebreeding@uq.edu.au to be part of this exciting new Centre!