Diurnal variation and correlation between methane and new feed efficiency metric in Nordic Red dairy cows

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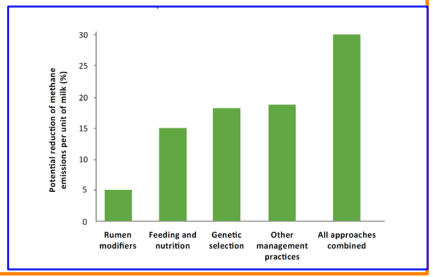
Background

- ✓ **Environmental sustainability**
  - ✓ Carbon neutrality commitments
    - ➢ EU : 2050
    - ➢ Finland : 2035
- ✓ **Reducing livestock systems emissions**
  - ✓ has been one of the priorities in different countries

- ➢ **Livestock systems emissions** - two main areas:
- ✓ **Methane measurement**

- ✓ **Mitigation options**

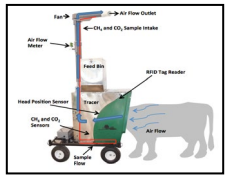


- ✓ **Methane measurement**
  - ✓ National inventory
  - ✓ Mitigation strategies
- ✓ **Quantifying CH_4 on an individual animal basis is difficult & expensive**
  - ✓ Different techniques over the last several years
  - ✓ This work still on-going



- ✓ **Finland**
  - ✓ Since 2012 invested in various techniques



- ✓ **Currently we are working on greenfeed units**
  - ✓ Accounting for all effects to ensure accurate measurement is still challenging

✓ Mitigation

- ✓ Depends on ability to accurately measure CH_4
  - ✓ Can be both direct or indirect
    - ✓ Indirect – FE traits
- ✓ Long been working on FE traits
  - ✓ Lately developing new & cost-effective FE metric : **RCO_2**
    - ✓ Its association with MeP traits & its comparison with RFI not reported

Objectives

- ➢ To assess CH_4 diurnal variation and measurement duration on methane quantification
- ➢ Association between methane and a new feed efficiency trait

Data

1. Gaseous Traits: CH_4 & CO_2

- Two GreenFeed units (C-Lock, USA)
- 2021-23, 105 1st lactation Nordic Red cows
- 71,000 CH_4 & CO_2 RPT daily records

➢ CH_4 traits

- Methane production (MeP, g/day)
- Methane intensity MeI, (gCH_4/kg milk)
- Methane yield (MeY, gCH_4/kg DMI)
- Residual Methane Production (RMP, g/d)

$$\mathbf{MeP} = b_1 DMI + b_2 Milk + b_3 mBW + \varepsilon$$
$$\mathbf{RPM} = \hat{\varepsilon}$$

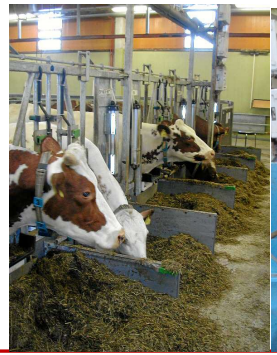
➢ RCO_2 : Chegini et al. (EAAP, 2024)

RCO2 = **Actual**_CO_2 – **Predicted**_CO_2

2. Feed intake & production traits

- Daily records from 870 1st lactation cows
- This data combined with CH_4 & CO_2 data
- 19,000 combined daily average records
  - adjusted for Time, mDur
- RFI

RFI = Actual_DMI – Predicted_DMI



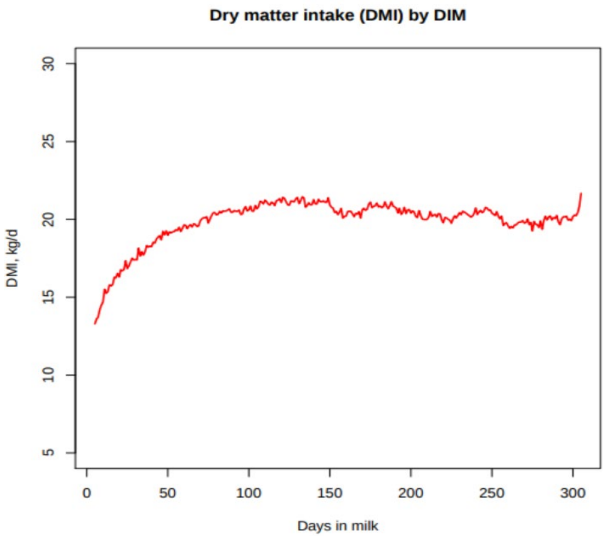
Data analysis

- **Univariate & bivariate repeatability animal models**
- **Fixed**
  - Fixed reg, TestYear*month
- **Random**
  - rec date and animal effects
- **Note: the no animals is not high**
  - Difficult to disentangle PE & add genetic effects
  - Animal correlations and animals solutions calculated

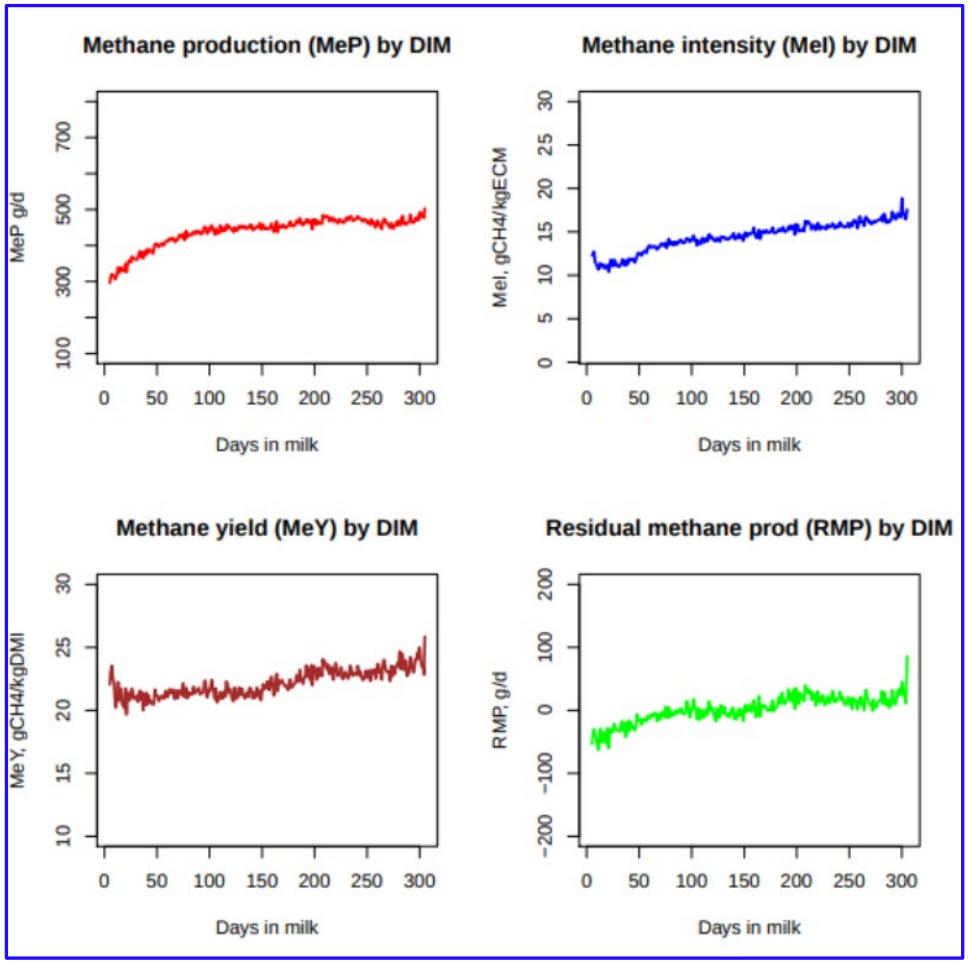
Production Traits		
Traits	Mean	SD
ECM	30.9	4.3
mBW	119.2	9.5
DMI	19.9	2.7
RFI	0.0	1.9

CH_4 & RCO2 traits		
Traits	Mean	SD
MeP	439.4	80.8
MeI	14.3	3.1
MeY	22.0	3.6
RMP	0.0	66.9
RCO_2	0.5	1269.1

DMI & methane output traits by days in milk



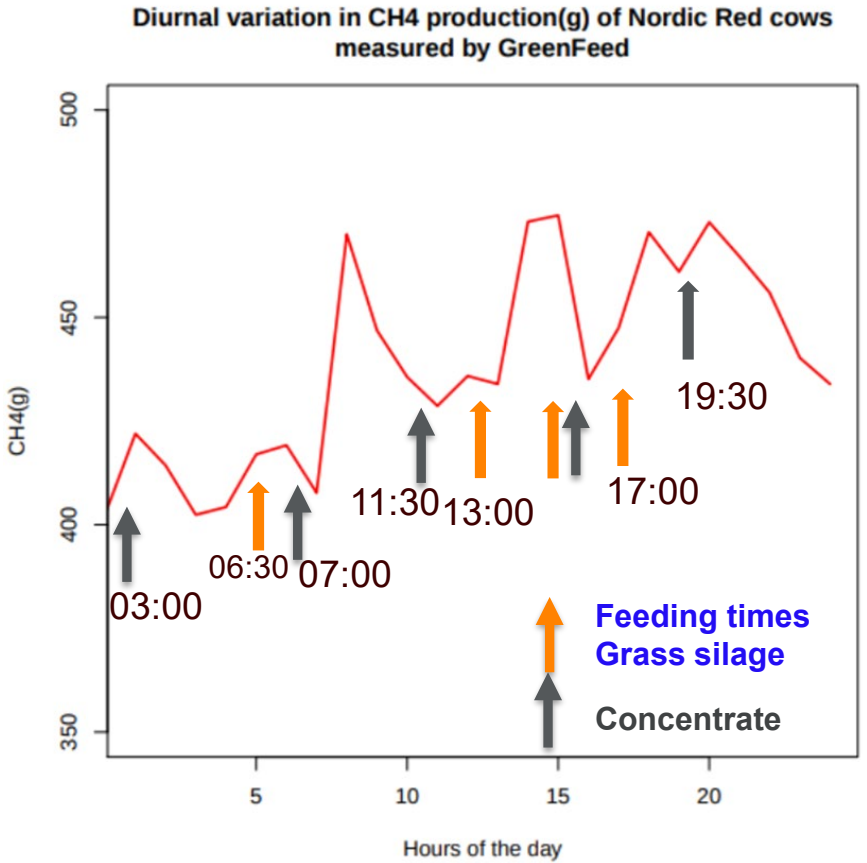
- CH4 traits follow the DMI intake trend
- The decrease in early lactation & a gentle increase in mid to late lactation as expected



Diurnal variation in Methane production

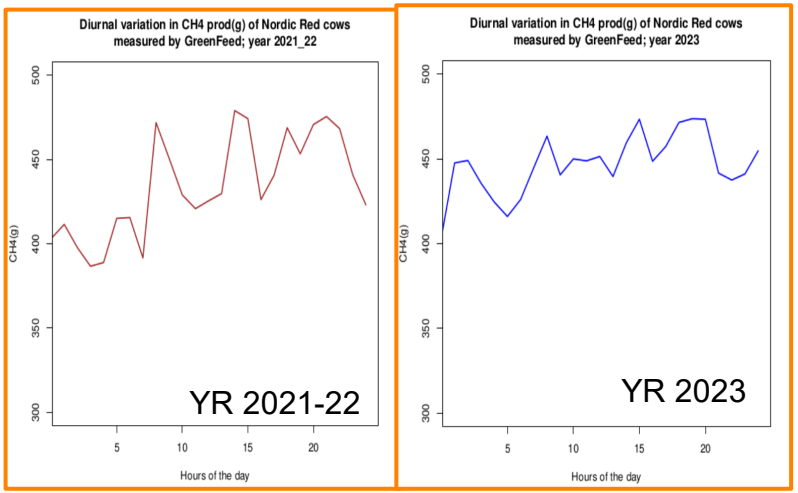
CH4 measurement

- **Total measurement of true cows** emission is difficult
  - Techniques are not available
- **Most of the techniques are spot sampling techniques**
  - CH_4 emissions change overtime (day, month, years)
  - Accounting for potential sources of variation essential

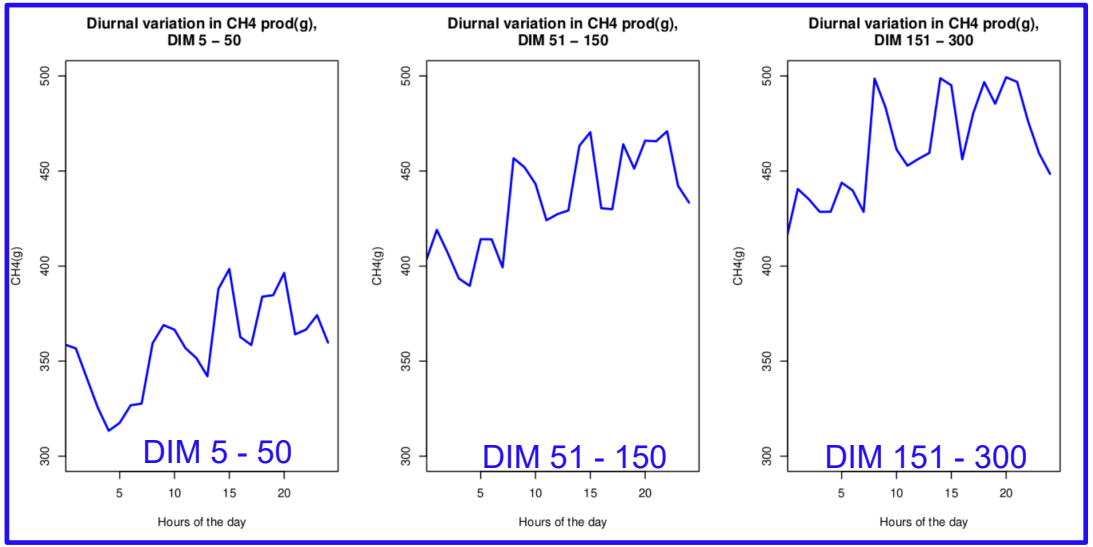


Diurnal variation

- By year of data collection



- By stages of lactation



Fitting a general average curve or fixed effect of time to account for diurnal variation may not be optimal

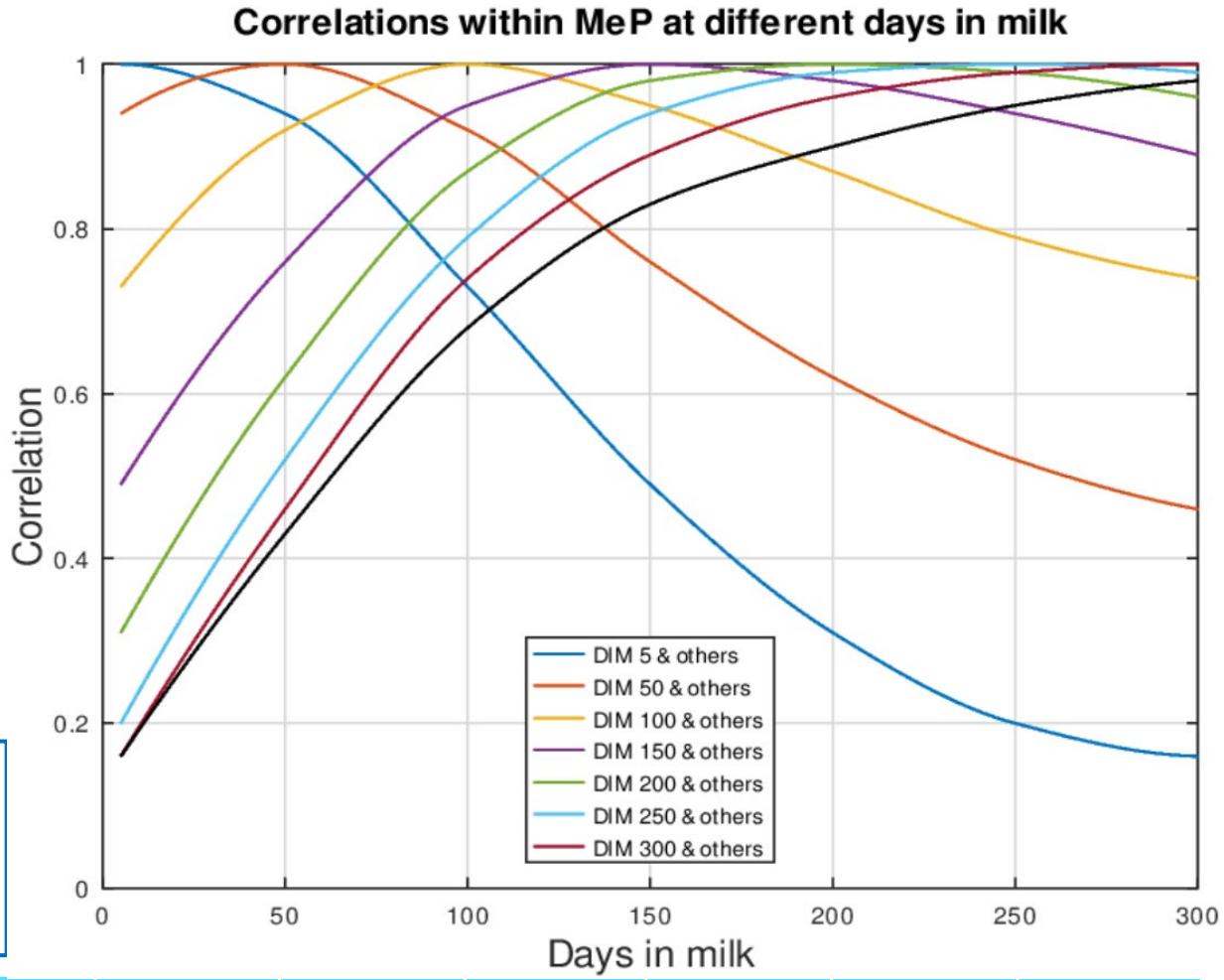
Methane measurement duration

Duration classes	Mean CH4	SD
Short (1 - 2 min)	399.9	120.4
Medium (3 - 6 min)	434.5	108.1
Long (7 - 10 min)	443.1	104.9
Very long (>11 min)	518.7	107.3

- ✓ **Ranking**
- ✓ Two animal model runs
  - **1) Adjusted for measurement Duration**
  - **2) Not adjusted**
- ✓ When top 10 and 20 cows ranked for lower CH4
  - ✓ Rank shifts were observed

- **In using spot sampling techniques, accounting for duration of measurement is important**

Correlations within MeP across days in milk



-MeP varied with lactation stages
-Mid lactation highly correlated with other days in milk
    -Important in designing recording strategies

Rrepeat.	0.48	0.35	0.39	0.42	0.43	0.48

Correlation of MeP with a new feed efficiency metric

Mitigation

- ✓ Indirect : selection for FE traits e.g., **RFI** vs **RCO2** **(Chegini et al. EAAP)**
  - ✓ Its effect on MeP depends on magnitude of correlation with the traits
    - ➢ Combined daily average MeP, RFI, RCO2 data used
      - ➢ 19,000 obs from 105 1st lactation cows
    - ➢ Bivariate analyses : **MeP & RFI** and **MeP & RCO2**
    - ➢ The bivariate model:
      - ➢ Fixed reg, YRmon, as fixed & rec date, animal random

Animal correlations between MeP and two FE traits RFI and RCO2

Traits	MeP	RFI
MeP		
RFI	0.53	
RCO_2	**0.71**	0.54

Ranking cows for RFI and RCO2 : its correlated effect on MeP

Animal Groups	Rankig for RFI	Common cows with lower MeP
Cows	Top 20	11
	Top 30	18

Animal Groups	Rankig for RCO_2	Common cows with lower MeP
Cows	Top 20	12
	Top 30	21

Conclusions

- When using spot sampling techniques for CH_4 measurement, accounting not only for diurnal variation but also for the duration of CH4 measurement is important for accurate estimation of CH4 emission.

- Higher correlation between MeP & RCO2 than between MeP & RFI. Indicates that better correlated response on MeP expected from RCO2 than from RFI.

Thank you!

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