Re-Livestock

RESILIENT FARMING SYSTEMS

Definition of Methane Phenotypes in Cattle

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INIA CSIC

Zaragoza, February 25th, 2025

Data from GreenFeed and C-Locks

Lisanne Koning

30’ presentation

10’ discussion

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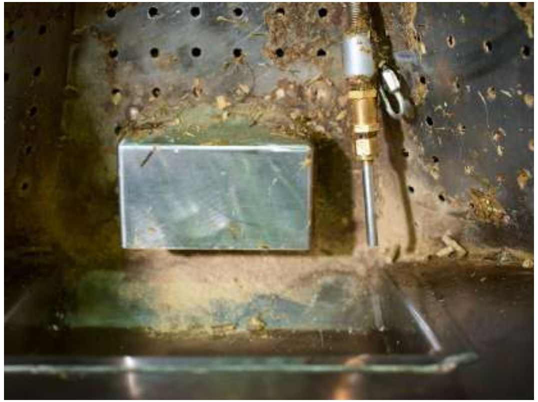
Overview

1. Introduction
2. Background/baseline approaches
3. Methane concentration phenotypes (ppm)
4. Methane production phenotypes (g/d)
5. Other methane phenotypes (residuals and ratios)
6. Pros and cons methane phenotypes
7. Overlook of entire process Netherlands and Spain examples

Introduction

- Sniffers are used widely to measure CH_4 for genetic purposes
- Lack of harmonization in the process
- Suggested phenotypes for CH_4
- or convert it to CH_4 g/d
- or use another derived phenotype



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Raw CH4 data from sniffer

File Edit Search View Encoding Language Settings Tools Macro

output.txt

```
cow,date,ch4,co2
59,2022/18/02 00:00:01,0.042,0.512
59,2022/18/02 00:00:02,0.042,0.52
59,2022/18/02 00:00:03,0.041,0.521
59,2022/18/02 00:00:04,0.041,0.526
59,2022/18/02 00:00:05,0.041,0.527
59,2022/18/02 00:00:06,0.041,0.529
59,2022/18/02 00:00:07,0.041,0.533
59,2022/18/02 00:00:08,0.041,0.534
59,2022/18/02 00:00:09,0.04,0.532
59,2022/18/02 00:00:10,0.04,0.534
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59,2022/18/02 00:00:28,0.047,0.562
59,2022/18/02 00:00:29,0.047,0.565
59,2022/18/02 00:00:30,0.048,0.566
59,2022/18/02 00:00:31,0.048,0.567
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59,2022/18/02 00:00:33,0.048,0.569
59,2022/18/02 00:00:34,0.049,0.567
```

Background approaches

1. Within the visit (milking period)
   a. Average of the 3-5 lowest values (Spain, Italy, Re-Livestock)
   b. 0.001 quantile (NL; van Breukelen, et al. 2022) 10.3168/jds.2021-21420
   c. median, mode.
2. Outside the visit (non-milking periods)
   a. using plateau (Poland)
   b. using a function with sin and cos (Lovendahl, et al. 2024)

https://doi.org/10.1016/j.compag.2024.109559

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Plateau approach

Methane records in non-milking time are divided in plateau regions

Thresholds for defining a plateau region can be:

Difference between two consecutive records

Min and max methane values

Number of records in a plateau

Finding the most stable plateaus depending on the quantile values in each plateau

First quantile of CH_4 value for each plateau is the background CH_4 value

Background is subtracted from the CH_4 values in the preceding milking events

Lovendahl approach

Methane values in idle periods should be screened out for outliers based on moving averages of CH_4 values at each time point

Threshold is set for the duration of each non-milking event

Records in initial and final parts of each non-milking event are discarded

Methane records are analysed using a linear mixed model

Background values can be predicted using the linear model for each milking event

Shariff's work

Diurnal and nocturnal adjustments

1. Daily phenotype ⟶ Needed
   - Using fourier series (Lovendahl et al. 2006, Lassen et al. 2012)

     https://doi.org/10.3168/jds.S0022-0302(06)72404-3; https://doi.org/10.3168/jds.2011-4544

   - can be done in ASReml
2. Weekly phenotype ⟶ No needed

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Methane phenotypes

Methane concentration

(MeC)

CH_4 ppm

Methane production

(MeP)

g/d

Residuals and Ratios

RMet, MeI, MeY

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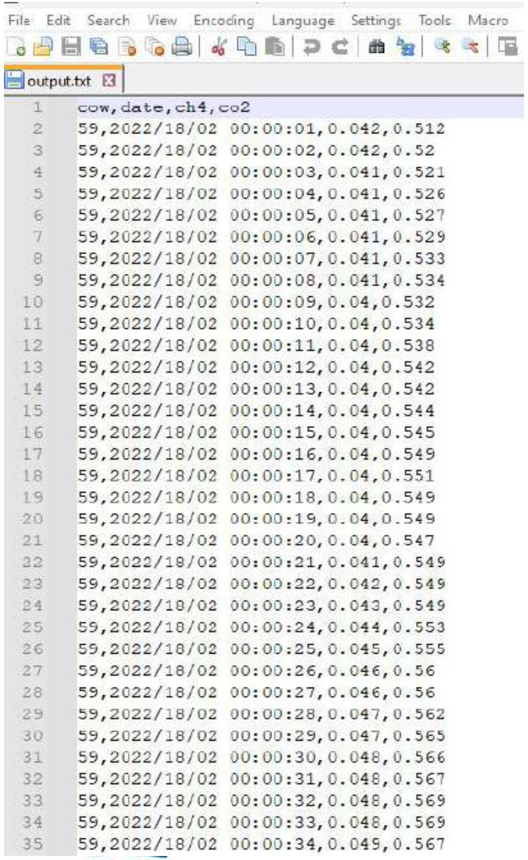
Phenotypes for CH_4 concentration

- average methane
  - per visit or minute
  - moving average (dif window size)
- peaks (eructation events)
  - sum/average of max 2 values peaks
  - sum of max peaks
  - number of peaks
- area under the curve

- ratio

Raw CH4 data from sniffer (Spain)

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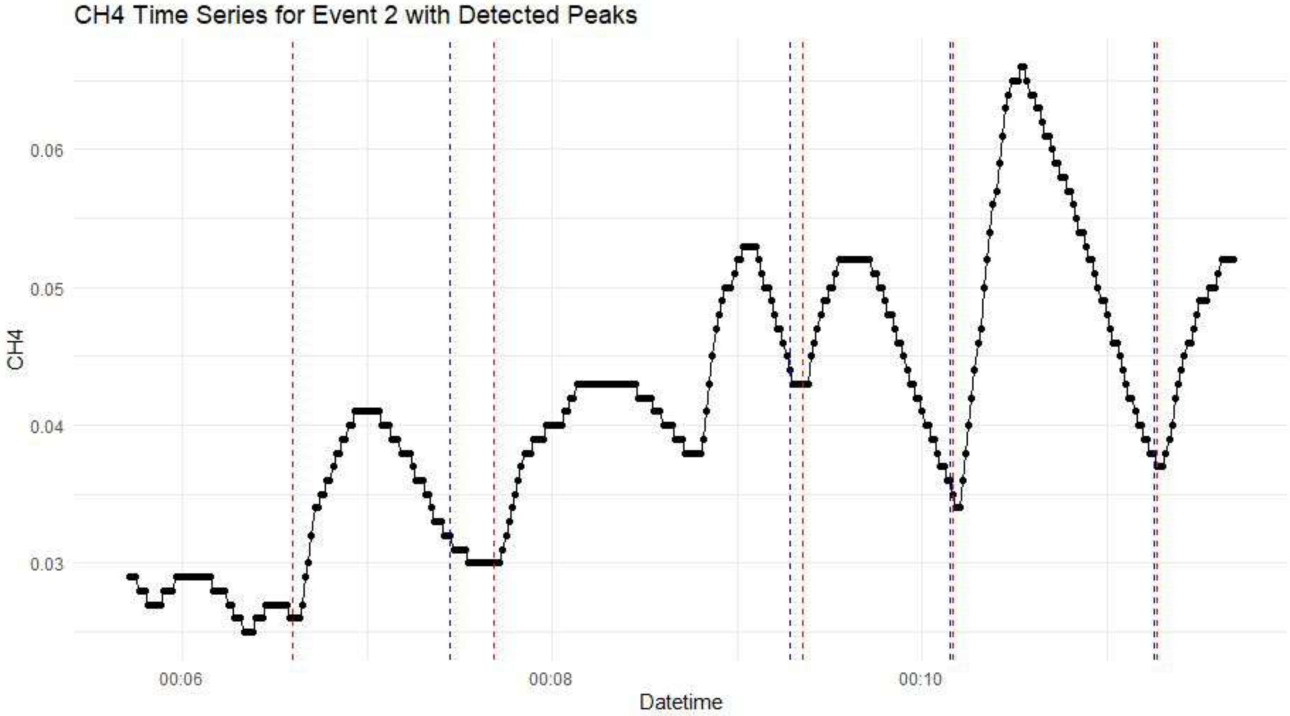
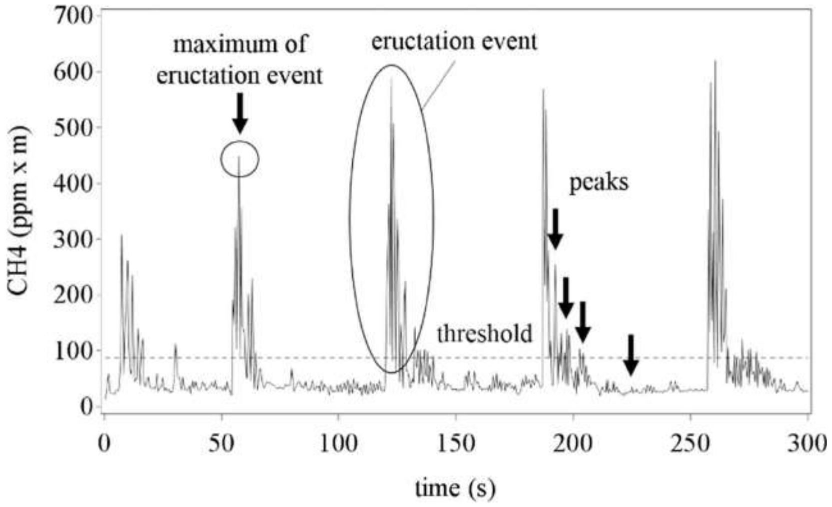
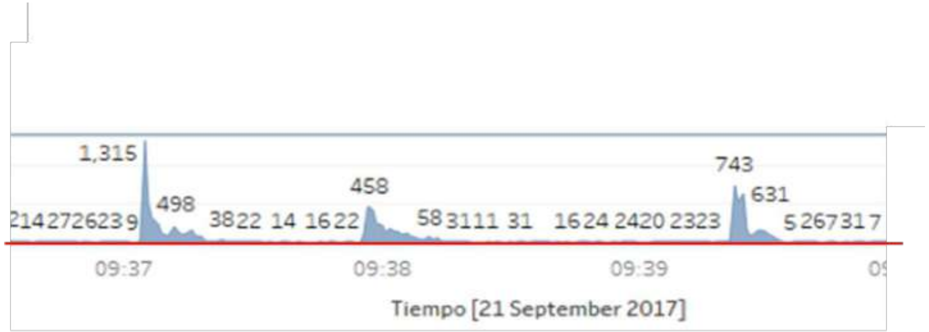


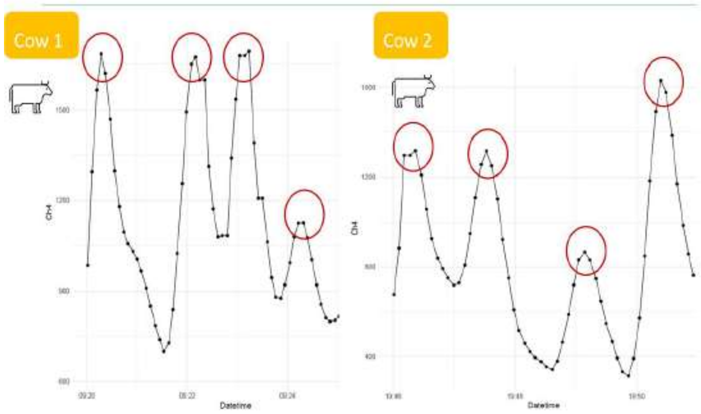
Methane concentration phenotypes



Sorg, et al. 2018



Methane concentration phenotypes



Overview of the process

Editing steps after alignment

Background
- Measuring or estimating

Creating event
- Per animal and visit

Discard first 20-60 sec or sincronice AMS and sniffer events
- Accounting for the time the gas takes to travel through the tube

Discard records with less 200 sec
- Keeping homogen eous visits

Keep between 60-300 sec
- Head cow in the AMS

New generation sniffers can detect head presence

Create mean per visit per animal per day
- Delete outliers

Example (2 months/600 cows)

17.6 millions CH_4/sec/cow

Final CH4 conc phenotype

24,723 weekly individual CH_4 records

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Methane phenotypes

Methane concentration

(MeC)

CH_4 ppm

Methane production

(MeP)

g/d

Residuals and Ratios

RMet, MeI, MeY

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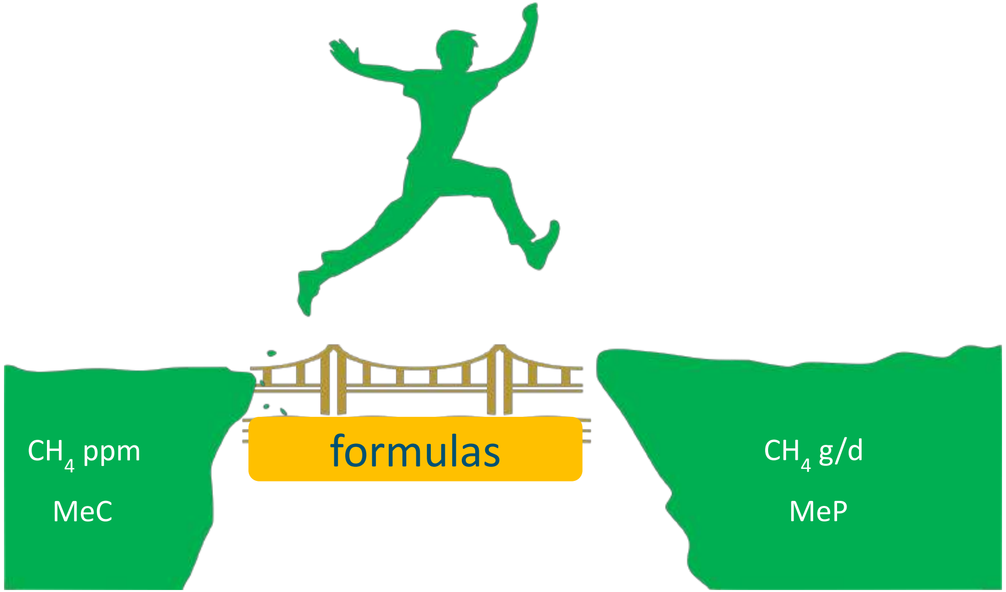
From Methane Concentration to Methane Production



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Methane Production Phenotypes

- With sniffer input
  - Using Ratio: between CH_4 and CO_2 concentrations
    - Madsen, Pedersen, Kjeldsen
  - Using CH_4 concentration
    - Chagunda
- Without sniffer input
  - Based only on DMI, BW and ECM
    - Tier formulas (1,2,3)

Formulas that predict CO_2

- Madsen *et al.* (2010) equation https://doi.org/10.1016/j.livsci.2010.01.001

  CO_2 g/d= 180 × 24 × (5.6 MBW + 22 ECM + 1.6*10-5 * num days in gestation)

  (ßMilkCF, parity × Milk CF)

* CH_4 g/d= ratio x predicted CO_2

Formulas that predict CO_2

Kjeldsen et al. 2024 10.3168/jds.2023-24414

* CH_4 g/d= ratio x predicted CO_2

- Kjeldsen equation 1

CO2 (g/d) = ß0 + (ß1 × DMI) + (ß2 × MBW) + (ß3 × Diet CP) + breed + (bDMI, breed × DMI) + (ßDMI, parity × DMI) + (MBW, breed × MBW)

- Kjeldsen equation 2

CO_2 g/d = ß0 + (ß1 × ECM) + (ß2 × MBW) + (ß3 × Milk CF) + (ß4 × DIM) + breed + (ßDIM, Diet CF × DIM × Diet CF) + (ßECM, DIM × ECM × DIM) + (ßECM, MBW × ECM × MBW) + (ßMilkCF, MBW × Milk CF × MBW) + (ßMBW, breed × MBW) + (ßDIM, breed × DIM) + (ßMBW, parity × MBW)

- Kjeldsen equation 3

CO_2 g/d = ß0 + (ß1 × ECM) + (ß2 × DIM) + breed + parity + (ßbreed, parity) + (ßDIM, Diet CF × DIM × DietCF) + (ßECM, DIM × ECM × DIM) + (ßDIM, breed × DIM) + (ßMilkCF, parity × Milk CF)

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Item	Model 1	Model 2	Model 3
Intercept	956	−6,134	8,781
DMI (kg/d)	122		
ECM (kg/d)		213	80.3
MetaBW (kg)	60.4	126	
Diet CP (g/kg DM)	3.44		
Milk CF (g/kg)		52.5	
DIM (d)		−5.13	−4.66
Breed			
Ayrshire	0	0	0
Holstein	−777	2,117	−49.0
Jersey	1,103	1,364	−2,321
Others/crossbreeds	1,501	4,083	−1,237
Parity			
First			0
Second			511
Third and higher			1,587
DIM × Diet CF		- 0.122	−0.149
ECM × DIM		0.386	0.338
ECM × metaBW		−1.18	
Milk CF × metaBW		−0.614	
DMI × Ayrshire	0		
DMI × Holstein	206		
DMI × Jersey	204		
DMI × others/crossbreds	225		
DMI × first parity	0		
DMI × second parity	7.53		
DMI × third parity	15.7		
MetaBW × Ayrshire	0	0	
MetaBW × Holstein	−18.5	−5.96	
MetaBW × Jersey	−37.3	−1.03	
MetaBW × others/crossbreds	−43.2	−33.4	
DIM × Ayrshire		0	0
DIM × Holstein		2.06	6.05
DIM × Jersey		2.49	6.02
DIM × others/crossbreds		8.94	11.3
MetaBW × first parity		0	
MetaBW × second parity		3.66	
MetaBW × third parity		4.01	
First parity × milk CF			−4.18
Second parity × milk CF			−10.5
Third parity × milk CF			−28.8
Ayrshire × first parity			0
Ayrshire × second parity			0
Ayrshire × third parity			0
Holstein × first parity			0
Holstein × second parity			775
Holstein × third parity			803
Jersey × first parity			0
Jersey × second parity			608
Jersey × third parity			1,307
Others/crossbreds × first parity			0
Others/crossbreds × second parity			791
Others/crossbreds × third parity			659

[1]Diet CF = dietary crude fat (g/kg DM), diet CP = dietary crude protein (g/kg DM), DIM = days in milk (d), DMI = dry matter intake (kg/d), ECM = energy-corrected milk yield (kg/d), milk CF = milk crude fat (g/

Coefficients for the different models

Formulas that predict CH_4

- Chagunda *et al.* (2009) equation https://doi.org/10.1016/j.compag.2009.05.008
  CH_4 g/d = 0.000576 x M_{TV} x TV_r
  M_{TV} = CH_4 conc x TV_r

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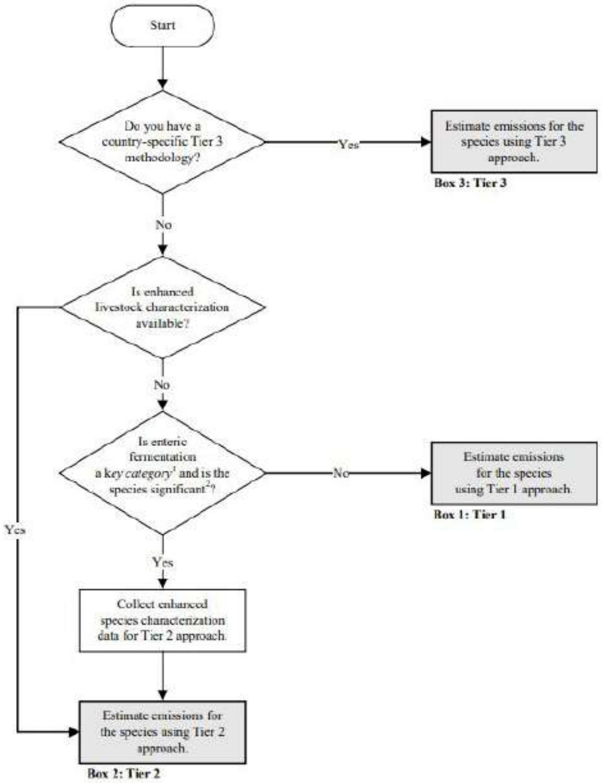
Formulas that predict CH_4: TIERs

Figure 10.2 **Decision Tree for CH_4 Emissions from Enteric Fermentation**



IPCC, 2019

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf

EQUATION 10.21

CH_4 EMISSION FACTORS FOR ENTERIC FERMENTATION FROM A LIVESTOCK CATEGORY

$$EF = \left[\frac{GE \bullet \left(\frac{Y_m}{100} \right) \bullet 365}{55.65} \right]$$

ere:

EF = emission factor, kg CH_4 head^{-1} yr^{-1}

GE = gross energy intake, MJ head^{-1} day^{-1}

Y_m = methane conversion factor, per cent of gross energy in feed converted to methane

The factor 55.65 (MJ/kg CH_4) is the energy content of methane

EQUATION 10.16
GROSS ENERGY FOR CATTLE/BUFFALO AND SHEEP

$$GE = \left[\frac{\left(\frac{NE_m + NE_a + NE_l + NE_{work} + NE_p}{REM} \right) + \left(\frac{NE_g + NE_{wool}}{REG} \right)}{\frac{DE\%}{100}} \right]$$

ere:

GE = gross energy, MJ day^{-1}

NE_m = net energy required by the animal for maintenance (Equation 10.3), MJ day^{-1}

NE_a = net energy for animal activity (Equations 10.4 and 10.5), MJ day^{-1}

NE_l = net energy for lactation (Equations 10.8, 10.9, and 10.10), MJ day^{-1}

NE_{work} = net energy for work (Equation 10.11), MJ day^{-1}

NE_p = net energy required for pregnancy (Equation 10.13), MJ day^{-1}

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed (Equatio 10.14)

NE_g = net energy needed for growth (Equations 10.6 and 10.7), MJ day^{-1}

NE_{wool} = net energy required to produce a year of wool (Equation 10.12), MJ day^{-1}

REG = ratio of net energy available for growth in a diet to digestible energy consumed (Equation 10.15)

DE%= digestible energy expressed as a percentage of gross energy

MeP

- ✓ Easy to merge with other countries that use other methods
- ✓ Easy to explain and compare with other traits with the same unit

- ✗ Total dependency on ECM and BW
- ✗ Problems with double counting

MeC

- ✓ No induced correlation with ECM and BW

- ✗ Difficult to compare with other traits
- ✗ Concentration does not account for size and production of the animal

Methane phenotypes

Methane concentration

(MeC)

CH_4 ppm

Methane production

(MeP)

g/d

Residuals and Ratios

RMet, MeI, MeY

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Other Methane Phenotypes

RESIDUAL

RMeP

RMeC

1. Regression on MBW and DMI and fixed effects
2. Regression on MBW and ECM and fixed effects
3. Regression on MBW, DMI and ECM and fixed effects

RATIO

Methane intensity (MeI) — g CH_4 / kg ECM

Methane yield (MeY) — g CH4 / kg DMI
g CH4 / kg BW

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Residual traits

- ✓ It is independent of ECM and BW
- ✓ Easy to rank animals
- ✓ Could be use with MeC to account for ECM and BW
- ✓ Easy and effective to include in the breeding goal

- ✗ Can be seen as an index inside an index
- ✗ Not easy to explain to farmers

Ratio traits

- ✓ Nutritionist and farmers prefer it
- ✓ Easy to explain in terms of g CH_4 per kg of milk, feed or body weight

- ✗ Dependency with the numerator
- ✗ Correlation with ECM, DMI, or BW

Calculation of baseline and merging data with milk recording: The Netherlands example

Downloading data from Azure database

Recording

Anouk's work

Sniffers (Carltech BV):
- WD-WUR v1.0 + Arduino (KE)
- WD-WUR v2.0 (PPS CSCB)

Connect sniffer to database with MethaanWatcher azurewebsite

Twice a week visually check if the sniffers work correctly with wlrsniffer azurewebsite (wlrsniffer.azurewebsites.net)

Microsoft Azure database:
euwstkemethanedatap -> container newdata
(csv file per farm per day with CH_4, CO_2, and time of day)

Milkingrobot data from CRV (cow ID and date and time of milking) and cow information (Parity, Breed, calving date)

Python script to download the data to a local computer or HPC, filter out bad data, and connect to cow ID

Python script to prepare data for genetic evaluation by adding cow information

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Data processing 1

Pipeline_part1.sh, runs scripts:

Python Script number	**Function**
1	Makes a subfile of the AMS data per farm, to increase computational efficiency
2	Make a list of all the farms that are in the Azure database with sniffer data, to download them one by one for each farm
3	Processes the .csv files in the Azure database one by one, and calls functions to filter the data, and to align the filtered data to the AMS data

Data processing 2

Pipeline_part2.sh, runs scripts:

Script number	Function
4	Calculates the mean emissions per milking robot visit, including some filtering criteria of which records to include in a visit
5	This script combines the methane data with data on other cow traits for genetic analyses. Based on the animals in the combined dataset the pedigree is then pruned

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Data processing 3

Run_diu.sh, runs scripts:

Script name	Function
1.R	Runs ASReml to precorrect visit means for diurnal variation, before averaging to daily means. The model includes a random genetic and permanent environmental effect

Data processing 4

Pipeline_part3.sh, runs scripts:

Script name	Function
6.py	Add the diurnal corrected trait from the ASReml output, and summarize traits as weekly means

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Data filtering criteria for CH_4 – Raw sniffer data

- Groups data by farm, date and hour, NA if:
  - Interquartile larger than 200
  - Less than 30% of data should be within 10 ppm (2 first modes)
  - Not measurements above 3500 ppm
- Individual measurements below the 0.001 quantile and above the 0.999 quantile = NA
- Within-day scaled and centred phenotype is made
- Data is matched to the AMS data, AMS times are shifted by one minute because of the delay in when concentrations reach the sniffer

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Data filtering criteria for CH_4 – Visit means

- Background concentrations as the 0.001 lowest quantile per farm per day
- Summarises the data and calculate means by milking robot visit
- Keep only records between 60 and 300 seconds of milking
- Remove records of less than 150 seconds during milking
- A file used for diurnal correction in ASReml is made, including:
  - Parity and calf dates (not necessary anymore when not analysing visits, may remove later)

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Data filtering criteria – Genetic analyses

- Adds cow information (e.g. calving info) and other traits
- Prune the pedigree
- After running ASReml the fixed effect solutions are subtracted from the CH_4 trait
- Week records with less than 7 CH_4 records = NA
- Records = means per calendar week
- Keep records up to 405 DIM
- Discard records of cows < 25% HF
- Data is standardized within project (KE or PPS)
- Discard lactations with less than 3 weekly records

Methane Team at ABG WUR

Present at this course







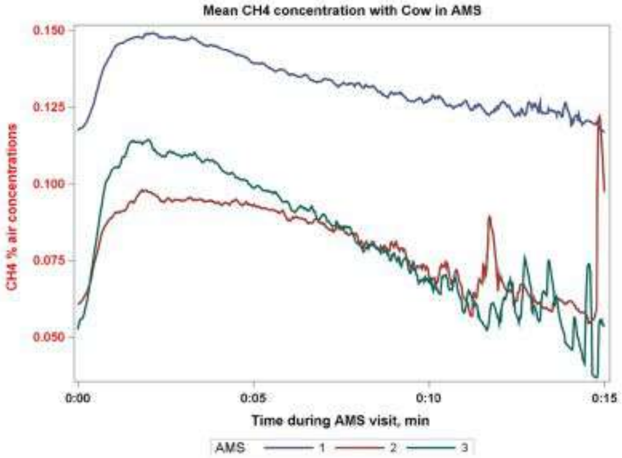


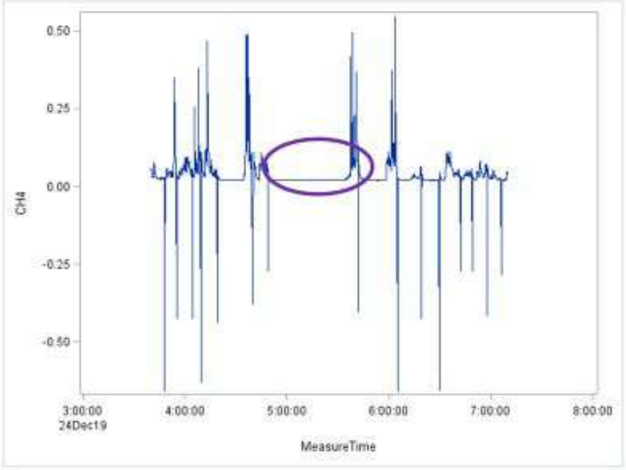


Calculation of baseline and merging data with milk recording: The Denmark example

Aligning the data and setting a background

Variation in CH_4 conc across minutes





Identify cleaning time of AMS

Aligning the data (Developed software)

Computers and Electronics in Agriculture
Volume 201, October 2022, 107299

Data synchronization for gas emission measurements from dairy cattle: A matched filter approach

Viktor Milkevych, Trine Michelle Villumsen, Peter Løvendahl, Goutam Sahana

Computers and Electronics in Agriculture
Volume 227, Part 1, December 2024, 109559

A data-driven approach to the processing of sniffer-based gas emissions data from dairy cattle

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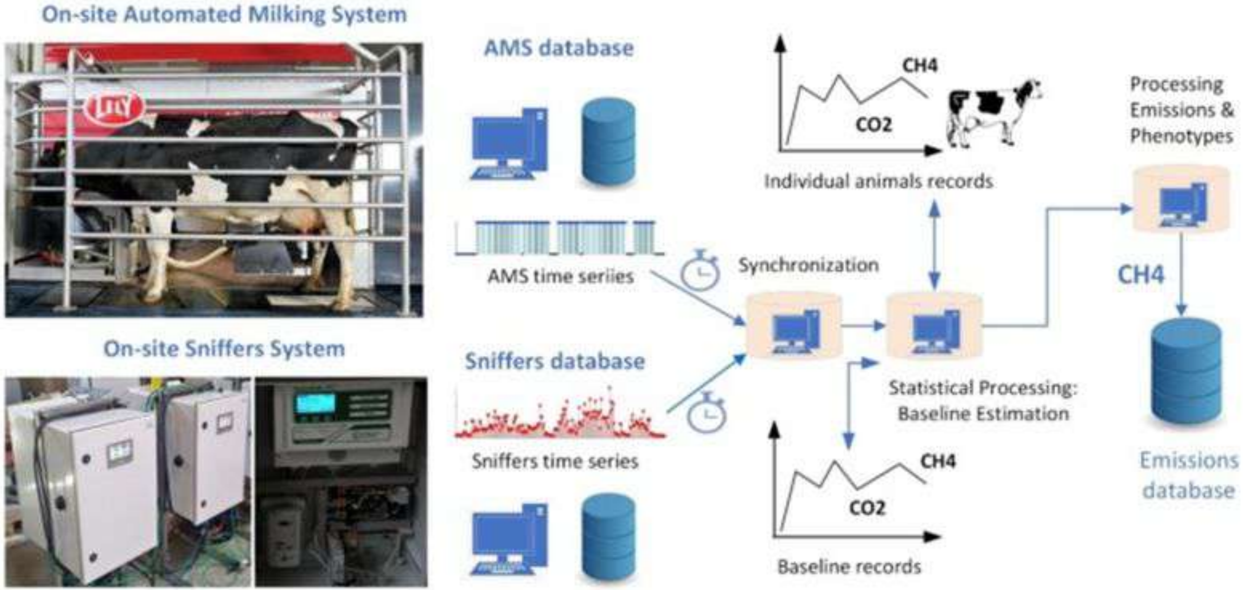


Calculation of baseline and merging data with milk recording: Spain example

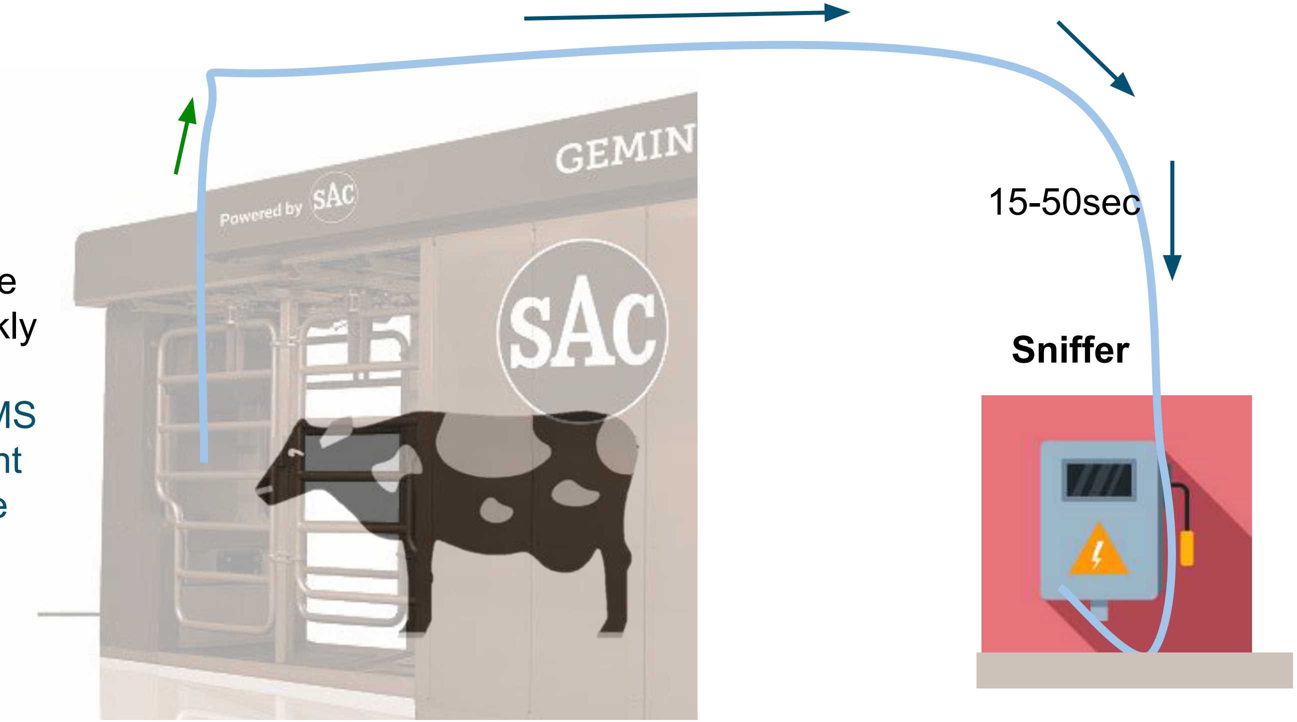
Installation and lag calculation

-Lag: Calculate the time that the eructation takes to arrive in the sensor.

-Longer tubes, longer lag.

-Tube obturation may change the lag period. Monitorize daily/weekly

-Synchronize clocks from the AMS and Sniffer, and take into account the lag to assign the event to the right cow (*in-house software*).



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Recording

Lag is calculated
Download data files from sniffer and AMS on site.

Combine files.

Raw Data

Sincronize

SANCHEZdic21_101_Loggy_42

Date and time	CH4	CO2
03/12/2021 11:50:00	0,018	0,095
03/12/2021 11:50:01	0,018	0,095
03/12/2021 11:50:02	0,018	0,093
03/12/2021 11:50:03	0,018	0,094
03/12/2021 11:50:04	0,018	0,093
03/12/2021 11:50:05	0,018	0,095
03/12/2021 11:50:06	0,018	0,093
03/12/2021 11:50:07	0,018	0,095
03/12/2021 11:50:08	0,018	0,095
03/12/2021 11:50:09	0,018	0,095
03/12/2021 11:50:10	0,018	0,095
03/12/2021 11:50:11	0,018	0,095
03/12/2021 11:50:12	0,019	0,095
03/12/2021 11:50:13	0,019	0,095
03/12/2021 11:50:14	0,019	0,094
03/12/2021 11:50:15	0,019	0,093
03/12/2021 11:50:16	0,019	0,094
03/12/2021 11:50:17	0,02	0,095
03/12/2021 11:50:18	0,02	0,095
03/12/2021 11:50:19	0,02	0,095
03/12/2021 11:50:20	0,02	0,095
03/12/2021 11:50:21	0,02	0,095
03/12/2021 11:50:22	0,02	0,097
03/12/2021 11:50:23	0,02	0,096
03/12/2021 11:50:24	0,021	0,095
03/12/2021 11:50:25	0,021	0,095

SUAREZ_102

Numero vaca	Addres	Fecha/Hora de visita	tiempo en cubiculo	Produccion de leche	Tiempo	Descripcion	CIB
161	102	22/11/2021 0:02:00	4:26	18.8	6:04	Correcto	ES031112194660
148	102	22/11/2021 0:15:00	10:08	10.9	11:39	Correcto	ES021112642431
193	102	22/11/2021 0:23:00	6:01	15.8	7:38	Correcto	ES091111967021
110	102	22/11/2021 0:28:00	3:45	14.4	5:04	Correcto	ES041112449478
136	102	22/11/2021 0:35:00	5:37	15.1	7:11	Correcto	ES091112194713
158	102	22/11/2021 0:43:00	5:42	15.9	7:29	Correcto	ES031112449535
257	102	22/11/2021 0:48:00	3:41	11.3	5:20	Correcto	ES091112642438
178	102	22/11/2021 0:54:00	3:44	14.6	5:24	Correcto	ES061112449527
142	102	22/11/2021 1:01:00	5:01	15	6:35	Correcto	ES031112194693

Java

OUTPUT

SUAREZ_102output

CIB	cow	date	kgm	time	meanCH4	meanCO2	meanRatioCH4_CO2	peaks	Sum_of_PeaksCH4	Sum_of_PeaksCO2	Sum_of_PeaksRatio	AUC_CH4	AUC_Ratio	Mean_of_PeaksCH4	Mean_of_PeaksRatio	validity
ES041112449525	230	Mon Nov 22 19:48:33 CET 2021	17.1	398.0	388.52	5224.3	0.08	6	1482.8071148459383	36504.70058512293	0.20990055440186733	9978.99	1.37	247.1345191409897	0.03498342573364455	0
ES071112449528	121	Mon Nov 22 19:59:33 CET 2021	0.7	218.0	143.03	4209.27	0.07	3	392.1966794380587	13818.945593869732	0.14540231828572295	4879.82	1.9	130.7322264793529	0.048467439428574316	11
ES021112449545	186	Mon Nov 22 20:06:54 CET 2021	15.7	257.0	77.83	3027.98	0.07	3	227.29635854341737	11562.271820728292	0.125719661192007‌1	2248.25	1.19	75.76545284780579	0.04190655373066903	10
ES041111966965	275	Mon Nov 22 20:13:10 CET 2021	12.0	301.0	159.91	3662.45	0.11	5	485.00529320666624	18271.3391350576‌7	0.530705232770315‌1	3715.61	4.02	97.00105864133324	0.1061410465540630‌2	10
ES011112449533	368	Mon Nov 22 20:19:49 CET 2021	10.4	322.0	383.1	5698.58	0.09	5	943.7062980030722	35488.7873015873	0.11710308352325392	6333.54	0.8	188.74125960061446	0.02342061670465078‌4	0
ES061112449505	160	Mon Nov 22 20:25:13 CET 2021	0.0	418.0	173.68	4022.3	0.09	6	996.6991341991343	33887.80194805195	0.20150781394808717	5467.46	1.23	166.1165223665224	0.03358463565801452‌6	0
ES051112449526	30	Mon Nov 22 20:34:27 CET 2021	14.2	284.0	58.84	1541.71	0.13	1	39.7752808988764	1414.1573033707866	0.10767299876464806	1470.42	4.0	39.7752808988764	0.10767299876464806	10
ES091112194724	259	Mon Nov 22 20:40:59 CET 2021	9.6	312.0	[illegible]	[illegible]	0.05	[illegible]	[illegible]	15736.551503094608	0.17945967803194526	4218.08	1.7	113.20883068081345	0.04486491950798631‌6	1
ES061112449516	168	Mon Nov 22 20:48:18 CET 2021	20.6	353.0	[illegible]	[illegible]	0.07	5	[illegible]	18021.85005574136	0.315294328670491‌7	4330.2	2.38	115.59647309212525	0.0630588657340983‌3	10
ES041112194694	123	Mon Nov 22 20:56:29 CET 2021	14.0	342.0	84.08	[illegible]	[illegible]	4	[illegible]	9928.445993265992	0.4332130926953546	2649.12	3.33	82.44612794612794	0.1083032731738386‌4	0
ES081112642404	364	Mon Nov 22 21:25:18 CET 2021	17.7	353.0	124.63	2983.51	0.12	3	416.18426501035196	11718.46149068323	0.16710207260913496	2575.07	1.12	138.728088336784	0.05570069086971165‌4	10
ES071112642447	253	Mon Nov 22 21:33:45 CET 2021	16.4	386.0	143.62	3937.58	0.1	5	638.1588738059327	20841.785816728847	0.38961611552911024	6160.1	3.95	127.63177476118653	0.07792322310582205	10
ES051112642398	179	Mon Nov 22 21:42:08 CET 2021	12.1	603.0	187.48	2412.15	0.23	7	1207.601986249045	21018.304430863256	1.353011447947969	6426.87	9.86	172.51456946414928	0.1932873497068527	0
ES081112642437	153	Mon Nov 22 21:54:12 CET 2021	12.3	239.0	93.29	3023.13	0.11	2	211.1122661122661‌3	9635.074844074843	0.0683787351519707‌8	3180.75	1.03	105.55613305613306	0.0341893675759853‌9	0
ES081111967020	233	Mon Nov 22 22:00:32 CET 2021	12.4	459.0	65.35	1708.46	0.12	5	349.9339738923324	11015.28748938095	0.42803751793536104	3556.86	4.5	69.98679477846648	0.0856075035870722‌1	0
ES011112194715	243	Mon Nov 22 22:10:03 CET 2021	21.5	308.0	232.21	5241.77	0.06	4	866.969696969697	24427.121212121212	0.234282059318597‌1	8578.83	2.08	216.74242424242425	0.0585705148296492‌8	10
ES011111966973	135	Mon Nov 22 22:16:43 CET 2021	11.1	268.0	220.28	5748.11	0.06	4	569.2437160540609	25125.016420361248	0.17554566167125346	6377.46	2.02	142.31092901351522	0.04388641541781336‌5	10
ES051112194684	180	Mon Nov 22 22:22:57 CET 2021	10.8	674.0	140.17	6116.57	0.04	11	1423.3539729111376	72146.39184785487	0.3804216924355346	6294.48	1.72	[illegible]	[illegible]	[illegible]
ES091112449542	189	Mon Nov 22 22:36:04 CET 2021	13.2	307.0	128.16	4759.58	0.06	4	376.9674621709726	22420.723981900454	0.10450932553531182	3536.29	1.02	[illegible]	[illegible]	[illegible]
ES031112449535	158	Mon Nov 22 22:43:15 CET 2021	18.3	416.0	103.82	2997.8	0.09	4	434.45247897642264	15196.337130475158	0.2580819528163808	4414.04	2.94	[illegible]	[illegible]	[illegible]
ES091111966982	246	Mon Nov 22 22:52:00 CET 2021	16.4	671.0	134.73	3133.5	0.11	6	878.4542245194419	24473.33101922232	0.5466706894738621	4159.94	[illegible]	[illegible]	[illegible]	[illegible]

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OUTPUT

SUAREZ_102output

CIB	cow	date	kgm	time	meanCH4	meanCO2	meanRatioCH4_CO2	peaks	Sum_of_PeaksCH4	Sum_of_PeaksCO2	Sum_of_PeaksRatio	AUC_CH4	AUC_Ratio	Mean_of_PeaksCH4	Mean_of_PeaksRatio	validity
ES041112449525	230	Mon Nov 22 19:48:33 CET 2021	17.1	398.0	388.52	5224.3	0.08	6	1482.8071148459383	36504.70058512293	0.20990055440186733	9978.99	1.37	247.1345191409897	0.03498342573364455	0
ES071112449528	121	Mon Nov 22 19:59:33 CET 2021	0.7	218.0	143.03	4209.27	0.07	3	392.1966794380587	13818.945593869732	0.14540231828572295	4879.82	1.9	130.7322264793529	0.048467439428574316	11
ES021112449545	186	Mon Nov 22 20:06:54 CET 2021	15.7	257.0	77.83	3027.98	0.07	3	227.29635854341737	11562.271820728292	0.1257196611920071	2248.25	1.19	75.76545284780579	0.04190655373066903	10
ES041111966965	275	Mon Nov 22 20:13:10 CET 2021	12.0	301.0	159.91	3662.45	0.11	5	485.00529320666624	18271.33913505767	0.5307052327703151	3715.61	4.02	97.00105864133324	0.10614104655406302	10
ES011112449533	368	Mon Nov 22 20:19:49 CET 2021	10.4	322.0	383.1	5698.58	0.09	5	943.7062980030722	35488.7873015873	0.11710308352325392	6333.54	0.8	188.74125960061446	0.023420616704650784	0
ES061112449505	160	Mon Nov 22 20:25:13 CET 2021	0.0	418.0	173.68	4022.3	0.09	6	996.6991341991343	33887.80194805195	0.20150781394808717	5467.46	1.23	166.1165223665224	0.033584635658014526	0
ES051112449526	30	Mon Nov 22 20:34:27 CET 2021	14.2	284.0	58.84	1541.71	0.13	1	39.7752808988764	1414.1573033707866	0.10767299876464806	1470.42	4.0	39.7752808988764	0.10767299876464806	10
ES091112194724	259	Mon Nov 22 20:40:59 CET 2021	9.6	312.0	125.06	3196.0	0.05	4	452.8353227232538	15736.551503094608	0.17945967803194526	4218.08	1.7	113.20883068081345	0.044864919507986316	1
ES061112449516	168	Mon Nov 22 20:48:18 CET 2021	20.6	353.0	182.54	3645.61	0.07	5	577.9823654606263	18021.85005574136	0.3152943286704917	4330.2	2.38	115.59647309212525	0.06305886573409833	10
ES041112194694	123	Mon Nov 22 20:56:29 CET 2021	14.0	342.0	84.08	1892.72	0.18	4	329.7845117845118	9928.445993265992	0.4332130926953546	2649.12	3.33	82.44612794612794	0.10830327317383864	0
ES081112642404	364	Mon Nov 22 21:25:18 CET 2021	17.7	353.0	124.63	2983.51	0.12	3	416.18426501035196	11718.46149068323	0.16710207260913496	2575.07	1.12	138.728088336784	0.055700690869711654	10
ES071112642447	253	Mon Nov 22 21:33:45 CET 2021	16.4	386.0	143.62	3937.58	0.1	5	638.1588738059327	20841.785816728847	0.38961611552911024	6160.1	3.95	127.63177476118653	0.07792322310582205	10
ES051112642398	179	Mon Nov 22 21:42:08 CET 2021	12.1	603.0	187.48	2412.15	0.23	7	1207.601986249045	21018.304430863256	1.353011447947969	6426.87	9.86	172.51456946414928	0.1932873497068527	0
ES081112642437	153	Mon Nov 22 21:54:12 CET 2021	12.3	239.0	93.29	3023.13	0.11	2	211.11226611226613	9635.074844074843	0.06837873515197078	3180.75	1.03	105.55613305613306	0.03418936757598539	0
ES081111967020	233	Mon Nov 22 22:00:32 CET 2021	12.4	459.0	65.35	1708.46	0.12	5	349.9339738923324	11015.28748938095	0.42803751793536104	3556.86	4.5	69.98679477846648	0.08560750358707221	0
ES011112194715	243	Mon Nov 22 22:10:03 CET 2021	21.5	308.0	232.21	5241.77	0.06	4	866.969696969697	24427.121212121212	0.2342820593185971	8578.83	2.08	216.74242424242425	0.05857051482964928	10
ES011111966973	135	Mon Nov 22 22:16:43 CET 2021	11.1	268.0	220.28	5748.11	0.06	4	569.2437160540609	25125.016420361248	0.17554566167125346	6377.46	2.02	142.31092901351522	0.043886415417813365	10
ES051112194684	180	Mon Nov 22 22:22:57 CET 2021	10.8	674.0	140.17	6116.57	0.04	11	1423.3539729111376	72146.39184785487	0.3804216924355346	6294.48	1.72	129.39581571919433	0.03458379022141223	10
ES091112449542	189	Mon Nov 22 22:36:04 CET 2021	13.2	307.0	128.16	4759.58	0.06	4	376.9674621709726	22420.723981900454	0.10450932553531182	3536.29	1.02	94.24186554274316	0.026127331383827956	10
ES031112449535	158	Mon Nov 22 22:43:15 CET 2021	18.3	416.0	103.82	2997.8	0.09	4	434.45247897642264	15196.337130475158	0.2580819528163808	4414.04	2.94	108.61311974410566	0.0645204882040952	10
ES091111966982	246	Mon Nov 22 22:52:00 CET 2021	16.4	671.0	134.73	3133.5	0.11	6	878.4542245194419	24473.33101922232	0.5466706894738621	4159.94	2.15	146.40903741990698	0.09111178157897702	0

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Raw Data

OUTPUT

SUAREZ_102output

CIB	cow	date	kgm	time	meanCH4	meanCO2	meanRatioCH4_CO2	peaks
ES041112449525	230	Mon Nov 22 19:48:33 CET 2021	17.1	398.0	388.52	5224.3	0.08	6
ES071112449528	121	Mon Nov 22 19:59:33 CET 2021	0.7	218.0	143.03	4209.27	0.07	3
ES021112449545	186	Mon Nov 22 20:06:54 CET 2021	15.7	257.0	77.83	3027.98	0.07	3
ES041111966965	275	Mon Nov 22 20:13:10 CET 2021	12.0	301.0	159.91	3662.45	0.11	5
ES011112449533	368	Mon Nov 22 20:19:49 CET 2021	10.4	322.0	383.1	5698.58	0.09	5
ES061112449505	160	Mon Nov 22 20:25:13 CET 2021	0.0	418.0	173.68	4022.3	0.09	6
ES051112449526	30	Mon Nov 22 20:34:27 CET 2021	14.2	284.0	58.84	1541.71	0.13	1
ES091112194724	259	Mon Nov 22 20:40:59 CET 2021	9.6	312.0	125.06	3196.0	0.05	4
ES061112449516	168	Mon Nov 22 20:48:18 CET 2021	20.6	353.0	182.54	3645.61	0.07	5
ES041112194694	123	Mon Nov 22 20:56:29 CET 2021	14.0	342.0	84.08	1892.72	0.18	4
ES081112642404	364	Mon Nov 22 21:25:18 CET 2021	17.7	353.0	124.63	2983.51	0.12	3
ES071112642447	253	Mon Nov 22 21:33:45 CET 2021	16.4	386.0	143.62	3937.58	0.1	5
ES051112642398	179	Mon Nov 22 21:42:08 CET 2021	12.1	603.0	187.48	2412.15	0.23	7
ES081112642437	153	Mon Nov 22 21:54:12 CET 2021	12.3	239.0	93.29	3023.13	0.11	2
ES081111967020	233	Mon Nov 22 22:00:32 CET 2021	12.4	459.0	65.35	1708.46	0.12	5
ES011112194715	243	Mon Nov 22 22:10:03 CET 2021	21.5	308.0	232.21	5241.77	0.06	4
ES011111966973	135	Mon Nov 22 22:16:43 CET 2021	11.1	268.0	220.28	5748.11	0.06	4
ES051112194684	180	Mon Nov 22 22:22:57 CET 2021	10.8	674.0	140.17	6116.57	0.04	11
ES091112449542	189	Mon Nov 22 22:36:04 CET 2021	13.2	307.0	128.16	4759.58	0.06	4
ES031112449535	158	Mon Nov 22 22:43:15 CET 2021	18.3	416.0	103.82	2997.8	0.09	4
ES091111966982	246	Mon Nov 22 22:52:00 CET 2021	16.4	671.0	134.73	3133.5	0.11	6

CIB	Sum_of_PeaksCH4	Sum_of_PeaksCO2	Sum_of_PeaksRatio	AUC_CH4	AUC_Ratio	Mean_of_PeaksCH4	Mean_of_PeaksRatio	validity
ES041112449525	1482.8071148459383	36504.70058512293	0.20990055440186733	9978.99	1.37	247.1345191409897	0.03498342573364455	0
ES071112449528	392.1966794380587	13818.945593869732	0.14540231828572295	4879.82	1.9	130.7322264793529	0.048467439428574316	11
ES021112449545	227.29635854341737	11562.271820728292	0.1257196611920071	2248.25	1.19	75.76545284780579	0.04190655373066903	10
ES041111966965	485.00529320666624	18271.33913505767	0.5307052327703151	3715.61	4.02	97.00105864133324	0.10614104655406302	10
ES011112449533	943.7062980030722	35488.7873015873	0.11710308352325392	6333.54	0.8	188.74125960061446	0.023420616704650784	0
ES061112449505	996.6991341991343	33887.80194805195	0.20150781394808717	5467.46	1.23	166.1165223665224	0.033584635658014526	0
ES051112449526	39.7752808988764	1414.1573033707866	0.10767299876464806	1470.42	4.0	39.7752808988764	0.10767299876464806	10
ES091112194724	452.8353227232538	15736.551503094608	0.17945967803194526	4218.08	1.7	113.20883068081345	0.044864919507986316	1
ES061112449516	577.9823654606263	18021.85005574136	0.3152943286704917	4330.2	2.38	115.59647309212525	0.06305886573409833	10
ES041112194694	329.7845117845118	9928.445993265992	0.4332130926953546	2649.12	3.33	82.44612794612794	0.1083032731738[illegible]	0
ES081112642404	416.18426501035196	11718.46149068323	0.16710207260913496	2575.07	1.12	138.728088336784	0.0557006908[illegible]	[illegible]
ES071112642447	638.1588738059327	20841.785816728847	0.38961611552911024	6160.1	3.95	127.63177476118653	0.0779232[illegible]	[illegible]
ES051112642398	1207.601986249045	21018.304430863256	1.353011447947969	6426.87	9.86	172.51456946414928	0.19328734970[illegible]	[illegible]
ES081112642437	211.11226611226613	9635.074844074843	0.06837873515197078	3180.75	1.03	105.55613305613306	0.034189367575985[illegible]	0
ES081111967020	349.9339738923324	11015.28748938095	0.42803751793536104	3556.86	4.5	69.98679477846648	0.08560750358707221	0
ES011112194715	866.969696969697	24427.121212121212	0.2342820593185971	8578.83	2.08	216.74242424242425	0.05857051482964928	10
ES011111966973	569.2437160540609	25125.016420361248	0.17554566167125346	6377.46	2.02	142.31092901351522	0.043886415417813365	10
ES051112194684	1423.3539729111376	72146.39184785487	0.3804216924355346	6294.48	1.72	129.39581571919433	0.03458379022141223	10
ES091112449542	376.9674621709726	22420.723981900454	0.10450932553531182	3536.29	1.02	94.24186554274316	0.026127331383827956	10
ES031112449535	434.45247897642264	15196.337130475158	0.2580819528163808	4414.04	2.94	108.61311974410566	0.0645204882040952	10
ES091111966982	878.4542245194419	24473.33101922232	0.5466706894738621	4159.94	2.15	146.40903741990698	0.09111178157897702	0

ControlDiciembre2021SUAREZ

nes	numero	collar	nupadre	numpar	DEL	metodo	leche	grasa	proteina	lactosa	fcontrol	fpar	cib	ultimaFCubDespuesUltParto	PesoVivo
12	ESPH1504697451	4663	ESPM1504153910	1	318	n1	49,90	3,62	3,26	5,01	07/12/2021 0:00:00	23/01/2021 0:00:00	ES061112194663	10/09/2021 0:00:00	690,925
12	ESPH1504739508	9480	840M3130915852	1	170	n1	49,70	2,19	3,21	5,01	07/12/2021 0:00:00	20/06/2021 0:00:00	ES051112449480	24/08/2021 0:00:00	657,413
12	ESPH1504739622	9478	840M3130915852	1	98	n1	40,50	3,23	3,16	5,21	07/12/2021 0:00:00	31/08/2021 0:00:00	ES041112449478	04/11/2021 0:00:00	578,523
12	ESPH1504739623	9479	840M3130915852	1	274	n1	35,50	3,32	3,47	4,85	07/12/2021 0:00:00	08/03/2021 0:00:00	ES051112449479	21/05/2021 0:00:00	647,866
12	ESPH1504745968	4692	CANM0011993494	1	482	n1	19,20	4,44	4,47	4,73	07/12/2021 0:00:00	12/08/2020 0:00:00	ES021112194692	24/06/2021 0:00:00	590,568
12	ESPH1504781420	4723	ESPM9204487906	1	339	n1	28,70	4,53	3,97	4,66	07/12/2021 0:00:00	02/01/2021 0:00:00	ES081112194723	21/05/2021 0:00:00	615,612
12	ESPH1504787246	9492	GBRM838050D583	1	339	n1	33,90	4,55	3,79	5,02	07/12/2021 0:00:00	02/01/2021 0:00:00	ES061112449492	21/05/2021 0:00:00	658,032
[illegible]	[illegible]H1504790998	9499	840M3008461593	1	382	n1	34,90	3,22	3,40	4,99	07/12/2021 0:00:00	20/11/2020 0:00:00	ES031112449499	19/11/2021 0:00:00	623,461
[illegible]	[illegible]504790999	9501	840M3008461593	1	291	n1	38,90	4,10	3,51	4,70	07/12/2021 0:00:00	19/02/2021 0:00:00	ES021112449501	08/07/2021 0:00:00	632,368
12	[illegible]PH1504795200	9514	840M3014562212	1	223	n1	33,60	4,42	3,79	4,99	07/12/2021 0:00:00	28/04/2021 0:00:00	ES041112449514	10/09/2021 0:00:00	641,056
12	ESPH1504828783	9522	840M3130915852	1	309	n1	40,50	2,22	3,34	4,97	07/12/2021 0:00:00	01/02/2021 0:00:00	ES011112449522	21/04/2021 0:00:00	657,193
12	ESPH1504828785	9524	840M3132349851	1	257	n1	30,20	4,73	3,69	5,10	07/12/2021 0:00:00	25/03/2021 0:00:00	ES031112449524	30/05/2021 0:00:00	564,904
12	ESPH1504828786	9525	840M3130915852	1	305	n1	39,00	3,44	3,38	5,04	07/12/2021 0:00:00	06/02/2021 0:00:00	ES041112449525	20/04/2021 0:00:00	673,949
12	ESPH1504828787	9529	840M3132349851	1	270	n1	40,70	4,46	3,79	4,99	07/12/2021 0:00:00	12/03/2021 0:00:00	ES081112449529	28/05/2021 0:00:00	632,988
12	ESPH1504828789	9531	840M3130915852	1	163	n1	45,20	3,00	3,35	5,14	07/12/2021 0:00:00	27/06/2021 0:00:00	ES091112449531	23/11/2021 0:00:00	631,529

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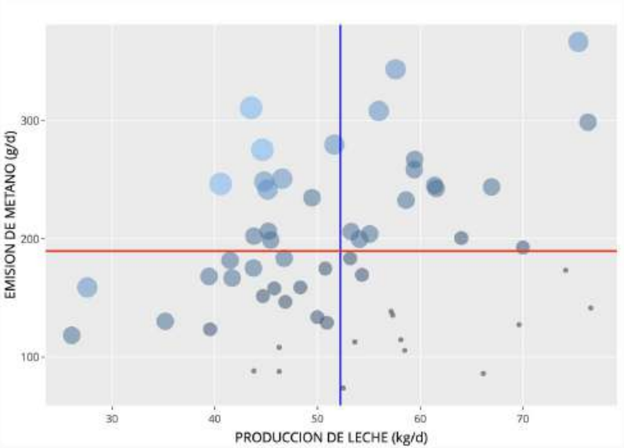
// 1.2. Emision de metano expresada en gramos/dia (g/d) por produccion de leche.

En la siguiente grafica se muestra la produccion de metano en funcion (gramos/dia) de la produccion de leche (kg/d) de las vacas de la ganaderia dividida en 4 cuadrantes, siendo aquellas que menos metano emiten y producen mayor cantidad de leche las situadas en el **cuadrante inferior derecho.**



Se divide la tabla en 4 cuadrantes, la linea horizontal (roja) indica la media de la ganaderia para emisiones de CH4 y la linea vertical (azul) indica la media de la produccion de leche de la ganaderia.

/ 2. DIFERENCIA ENTRE LAS VACAS CON MENORES Y MAYORES PERDIDAS POR METANO POR LITRO DE LECHE PRODUCDIDO:

La diferencia entre el 10% de vacas con mayores y menores perdidas por emisiones fue de **3.86 g de METANO por cada kg de leche producido**

POSIBILIDADES DE MEJORA DEL APROVECHAMIENTO DE LA RACION: Esta diferencia equivale a 0.028 UFL perdidas **por litro de leche que es la energÃa que proporcionan 28 gramos de pienso**, lo que supondria un total de 538 kg de pienso por vaca al aÑO.

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3. RESULTADOS DE LAS VACAS DE LA GANADERIA EN FUNCION DE LA EMISION DE METANO POR KG DE LECHE (GRAMOS AL DIA POR LITRO DE LECHE).

La siguiente tabla muestra el ranking de las vacas de la ganaderia **ordenadas segun menores emisiones de METANO por cada kg de leche** producido (el valor por cada vaca estÃ¡ corregido por dias en lactacion, numero de lactacion, mes de parto y robot).

numero	n.establo	n.parto	dias en leche	EMISIONES DE METANO (g/d)	EMISIONES DE METANO POR KG DE LECHE	RANKING POR EXPLOTACION
ESPH1703944464	251	3	152	100.88	1.69	10% MENOS EMISIONES POR KG DE LECHE
ESPH1704129715	293	1	383	139.48	1.75	10% MENOS EMISIONES POR KG DE LECHE
ESPH1704365573	317	1	232	131.59	1.88	10% MENOS EMISIONES POR KG DE LECHE
ESPH1703611386	200	4	173	101.79	2.15	10% MENOS EMISIONES POR KG DE LECHE
ESPH1704129714	292	2	145	235.82	5.29	10% MAS EMISIONES POR KG DE LECHE
ESPH1704371619	336	1	56	313.08	5.49	10% MAS EMISIONES POR KG DE LECHE
ESPH1704129712	290	2	27	291.49	5.67	10% MAS EMISIONES POR KG DE LECHE
ESPH1704323433	311	2	12	186.24	6.04	10% MAS EMISIONES POR KG DE LECHE
ESPH1704236543	301	2	21	298.76	6.96	10% MAS EMISIONES POR KG DE LECHE

4. INDICES GENETICOS TOROS

La siguiente tabla muestra la valoracion genetica de los toros con hijos/as en la ganaderia para los indices ICO, ICAP, y kg de leche, grasa y proteina, y emisiones de metano expresadas en produccion, g/d (MeP) y en concentracion, ppm (MeC).

nombre	animal	ICO	MeC	MeP	kl	kg	kp	ICU	ICAP
COOKIECUTTER MOM HUNTER ET	840M3000540481	2958	31.22	7.80	663	34	33	0.63	0.51
LONG-LANGS OMAN OMAN 2 ETN	840M3006030062	2764	107.63	17.13	332	39	40	0.17	-0.16
S-S-I MONTROSS JEDI ET	840M3123886035	4237	-2.94	-0.13	1942	32	72	2.08	0.70
GILLETTE WINDBROOK ET	CANM0007816429	2420	-0.72	-1.67	158	33	16	1.00	1.68
MAPLE-DOWNS-I G W ATWOOD ET	CANM0008956379	2762	53.83	8.22	-22	28	6	2.07	1.16
GENERVATIONS EPIC ET	CANM0011104016	3395	103.25	21.09	810	27	31	1.42	0.83
SNOWBIZ LITTLETON ETM	CANM0108251028	3475	14.78	7.90	2031	50	51	1.03	0.26
BURANO ET	DEUM0357970606	3380	36.14	5.92	917	2	32	2.05	0.32

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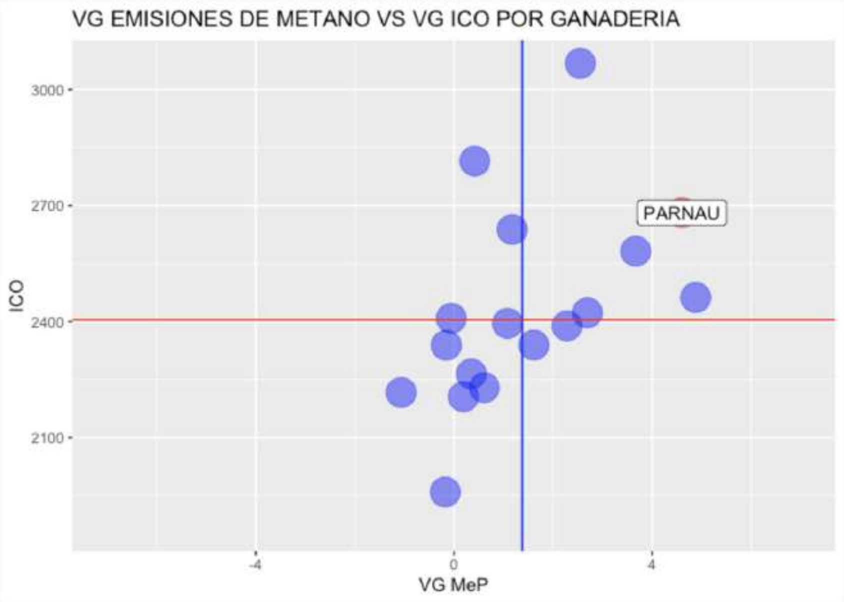
// 5.2. EMISIONES DE METANO - ICO

En la siguiente grafica se muestra la comparativa entre explotaciones para la media del valor genetico de ICO y la media del valor genetico de emisiones de metano. Siendo el **objetivo** situarse en el **CUADRANTE SUPERIOR IZQUIERDO**.



Data processing

Java Program	Function
SnifferAnalyzer.jar	1. Assign events to cows according to time footprint and lag
	2. Calculate background (average of 5 lowest measurements from opening of the AMS gate to cow exit).
	3. Detect eructation peaks
	4. Calculate traits
	5. Write output

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Data processing

R script	Function
	Combine output from SnifferAnalyzer with test day records and ID information