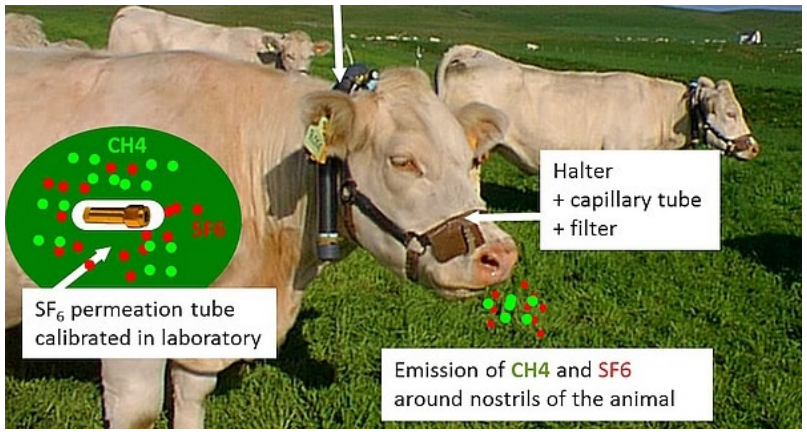
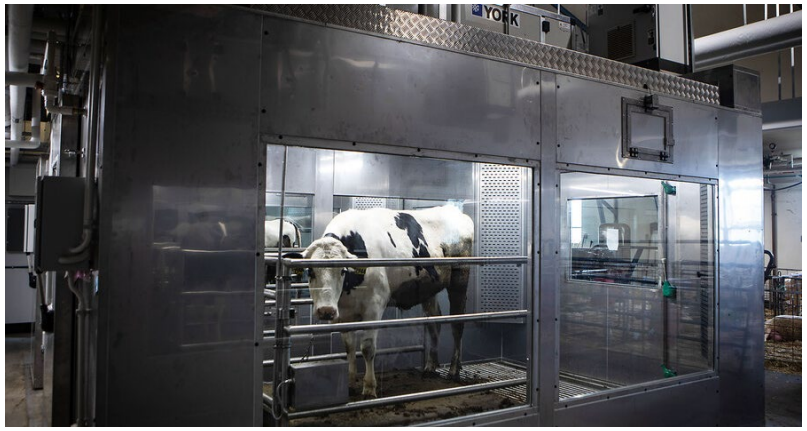
Milk mid-infrared prediction of methane emission

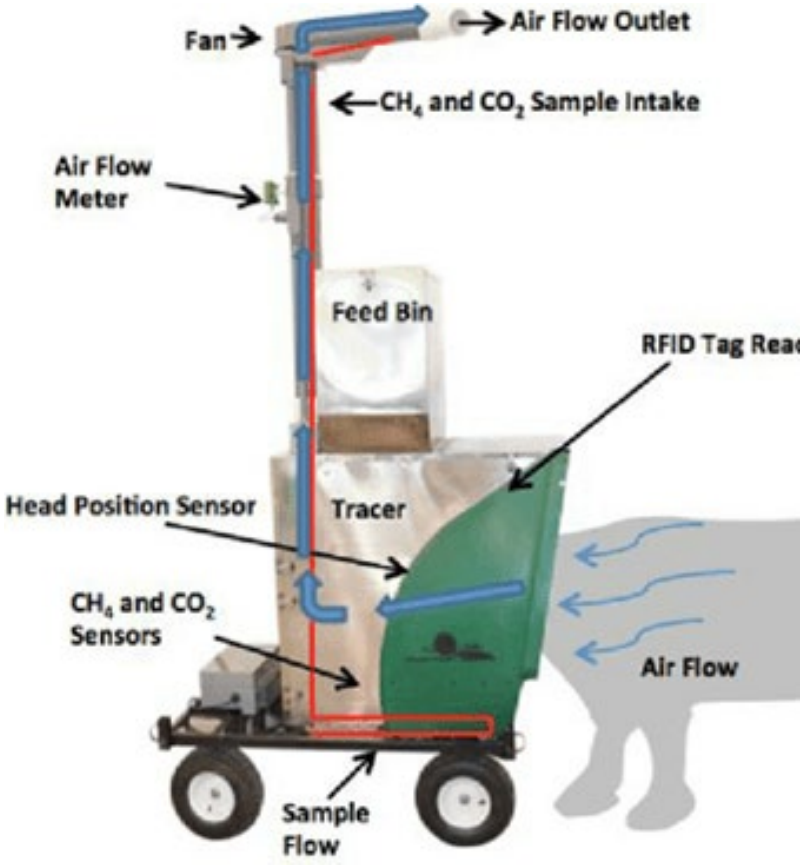
recorded using handheld laser methane detector in small holders' dairy cattle.

Alireza Ehsani

EAAP-2024







CH4 measuring technologies

Method	Purchase Cost	Running Cost	Labour	Repeatability	Behaviour Alteration	Throughput
Respiration chamber	High	High	High	High	High	Low
SF_6 tracer gas technique	Medium	High	High	Medium	Medium	Medium
Breath analysers ("sniffers")	Low	Low	Low	Medium	None	High
GreenFeed	Medium	Medium	Low	Medium	Low	Medium
Laser methane detector	Low	Low	High	Low	Low–medium	Medium

Sorge 2022

Purchase Cost	Running Cost	Labour	Repeatability	Behaviour Alteration	Throughput
Low	Low	High	Low	Low–medium	Medium


FINLAND
ESTONIA
KAZAKHSTAN
Ethiopia
Capital: Addis Ababa
ALGERIA
LIBYA
EGYPT
INDIA
MALI
NIGER
CHAD
SUDAN
ERITREA
SOMALIA
UGANDA
KENYA
TANZANIA
INDIAN OCE
South Atlantic
OCEAN

861 LMD
3-5 min length
25 farms in Ethiopia
July to December 2023
318 animals
age, parity, lactation stage, breed and management

MIR ±3 days
931 wavelength
LMD CH_4 concentration range 21-106 ppm/m

$$CH_4\left(\frac{g}{min}\right) = CH_4\,peak \times V \times R \times \alpha \times \beta \times 10^{-6}$$

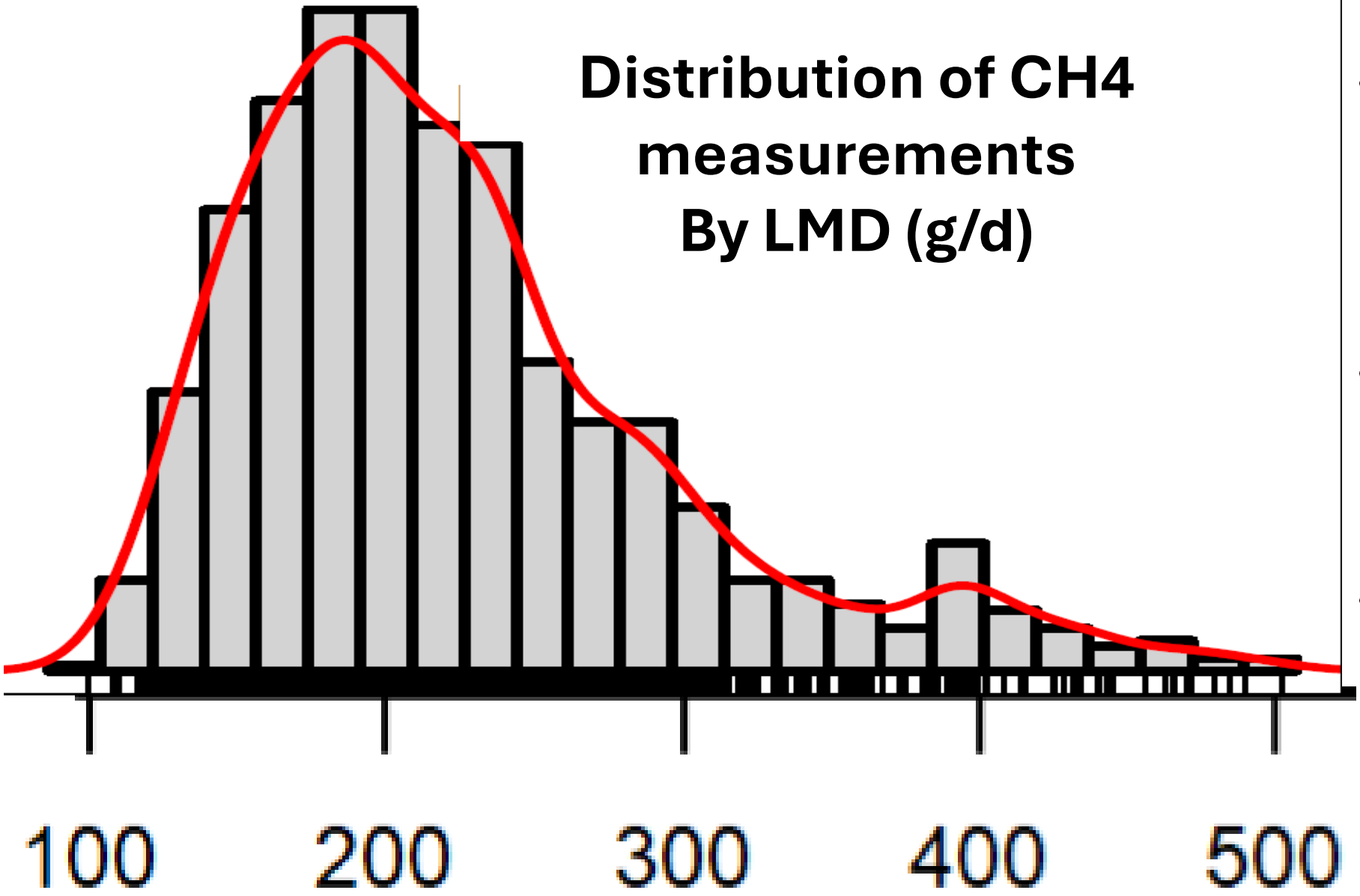
$$CH_4\left(\frac{g}{day}\right) = CH_4\left(\frac{g}{min}\right) \times 1440$$

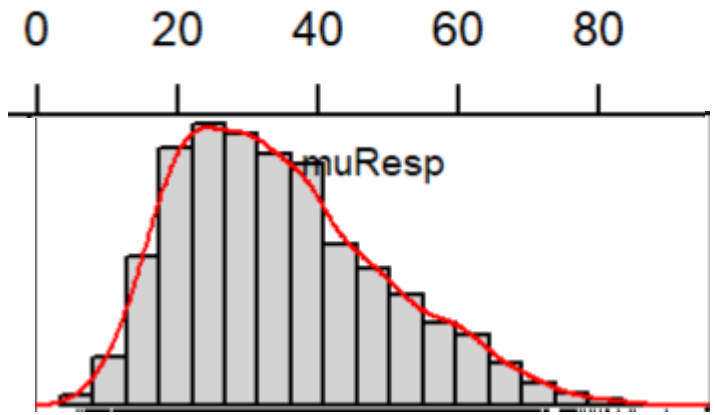
Lanzoni et. al. (2022)

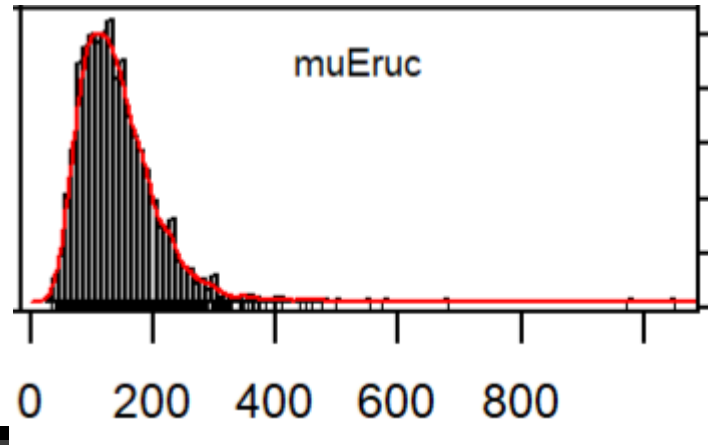
$$CH_4\left(\frac{g}{min}\right) = \int LMD(ppmm/m) \times R \times \alpha \times \beta \times 10^{-6}$$

$$CH_4\left(\frac{g}{day}\right) = CH_4\left(\frac{g}{min}\right) \times 1440$$

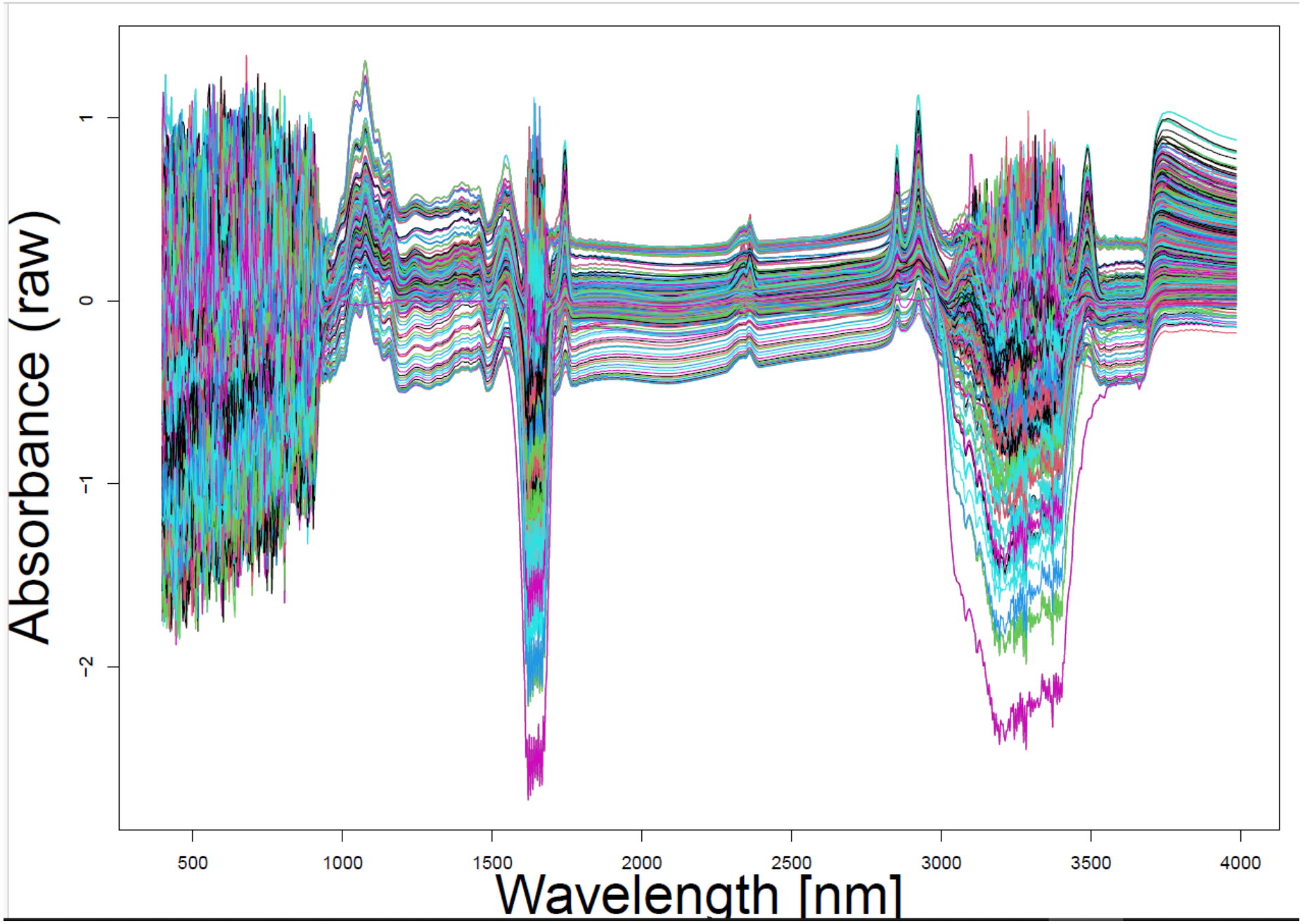
Distribution of CH4 measurements By LMD (g/d)

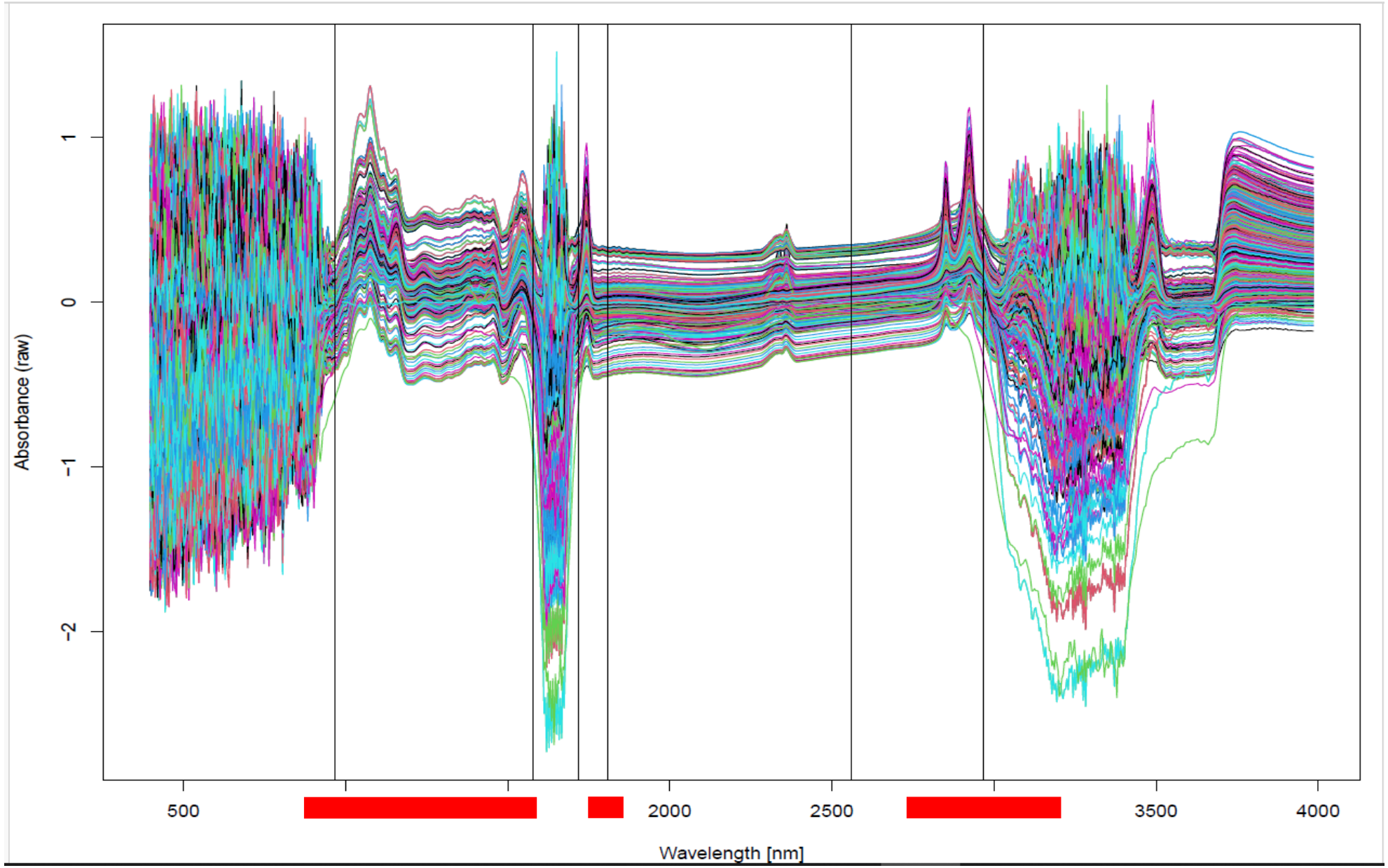






MIR data


Absorbance (raw)
1
0
-1
-2
500
1000
1500
2000
2500
3000
3500
4000
Wavelength [nm]


Absorbance (raw)
1
0
−1
−2
500
2000
2500
3500
4000
Wavelength [nm]

`Plsr` from `pls` package

`LMD_CH4 ~ MIR`

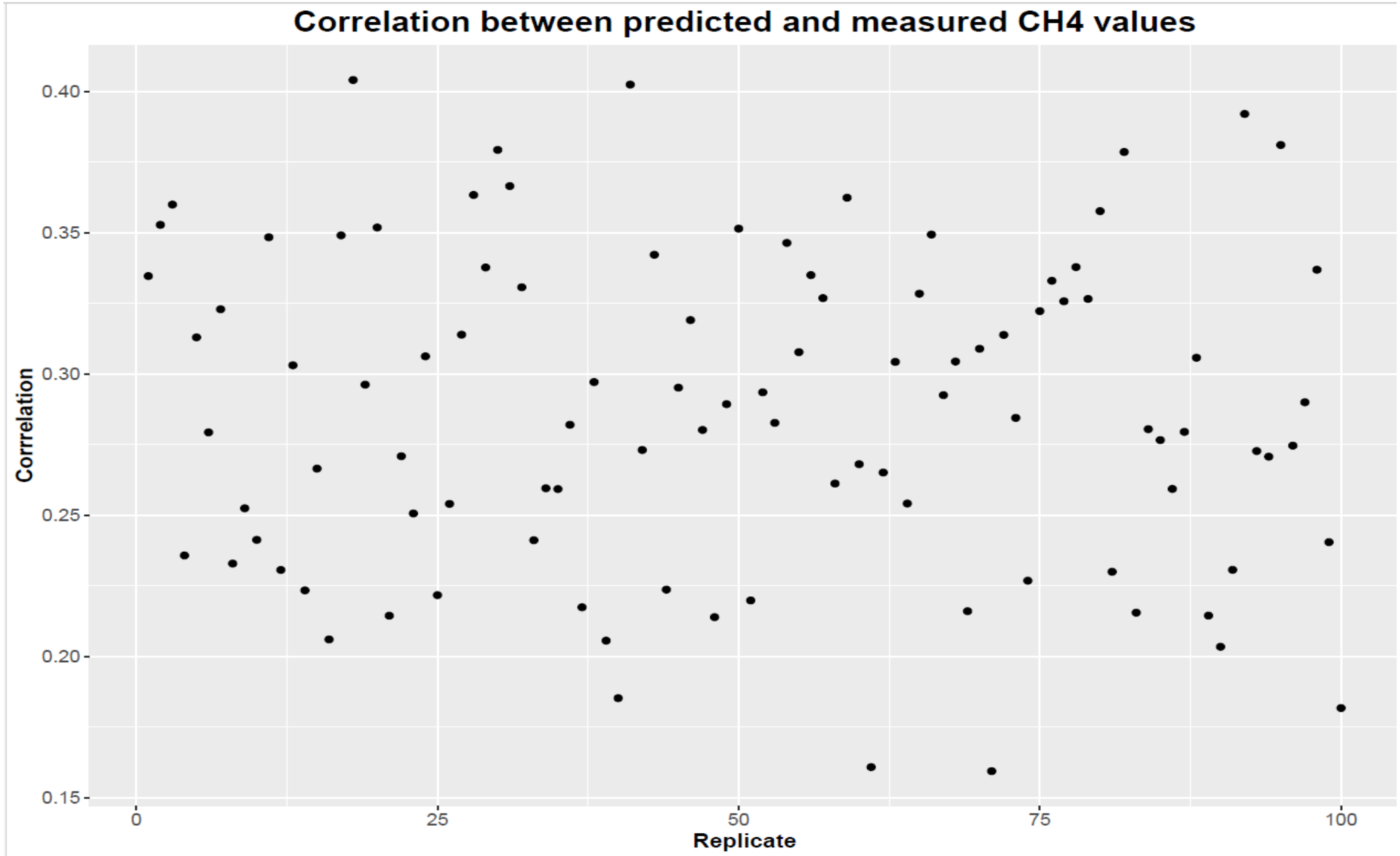
5 fold cross validation

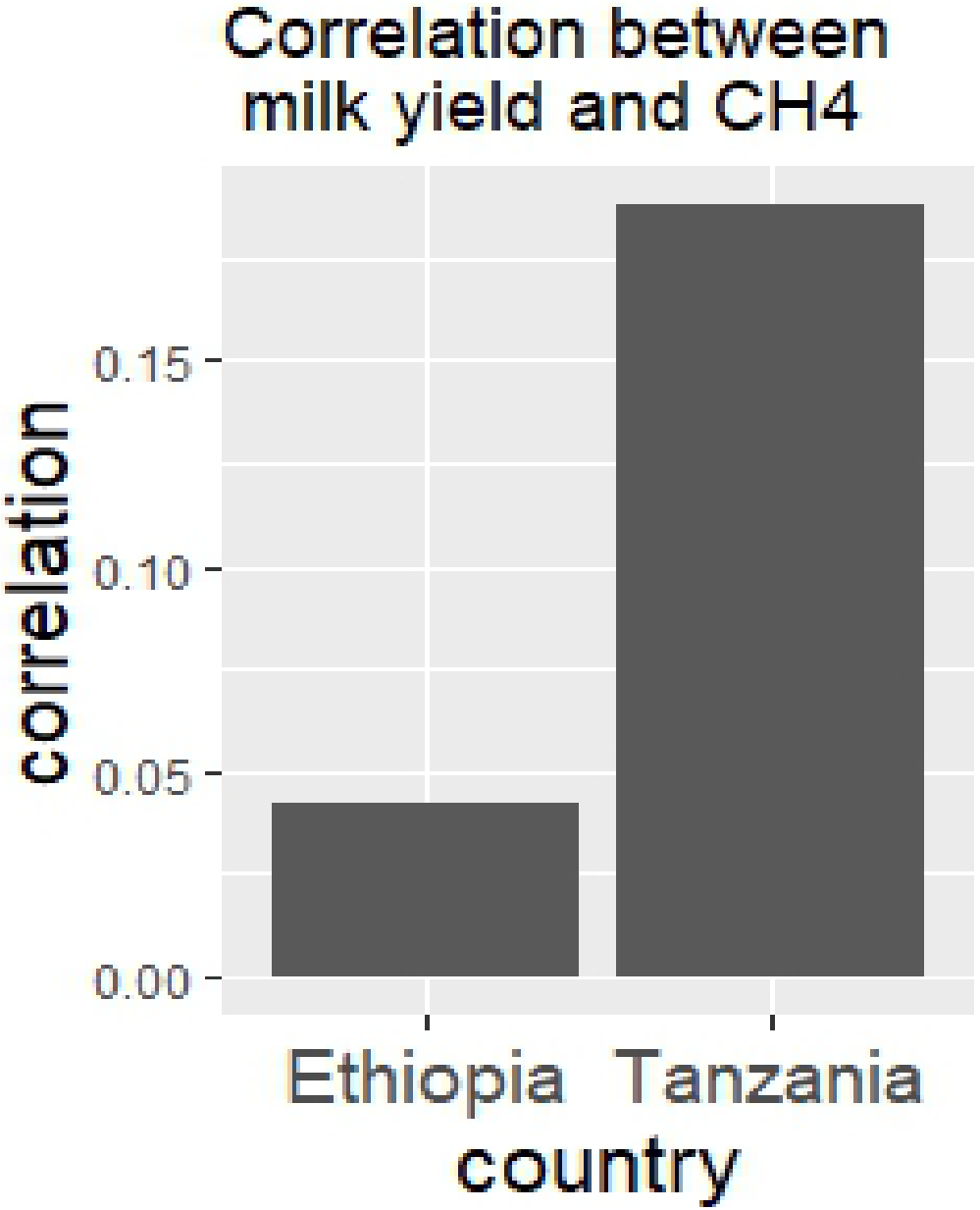
100 replicates

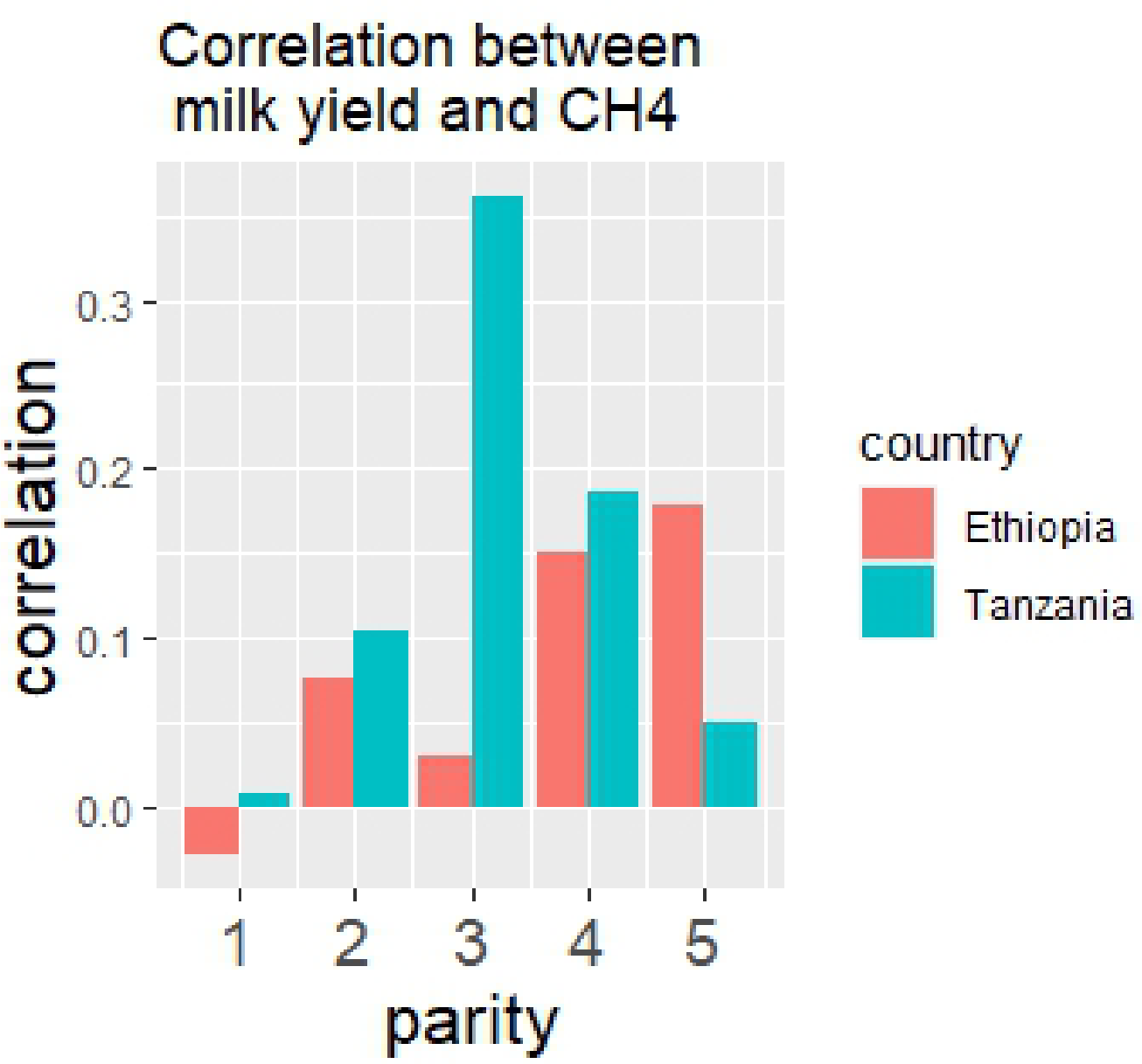
Correlation range from 0.16 to 0.41

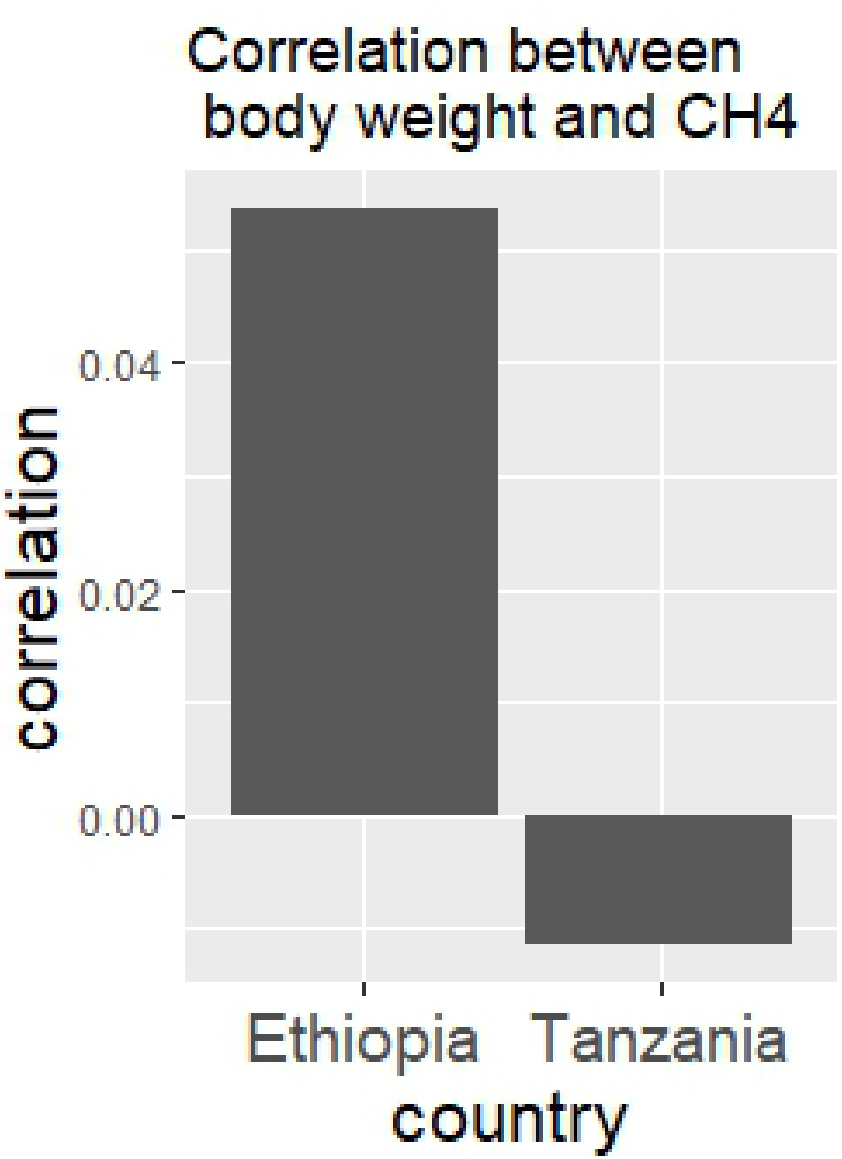
Average 0.29

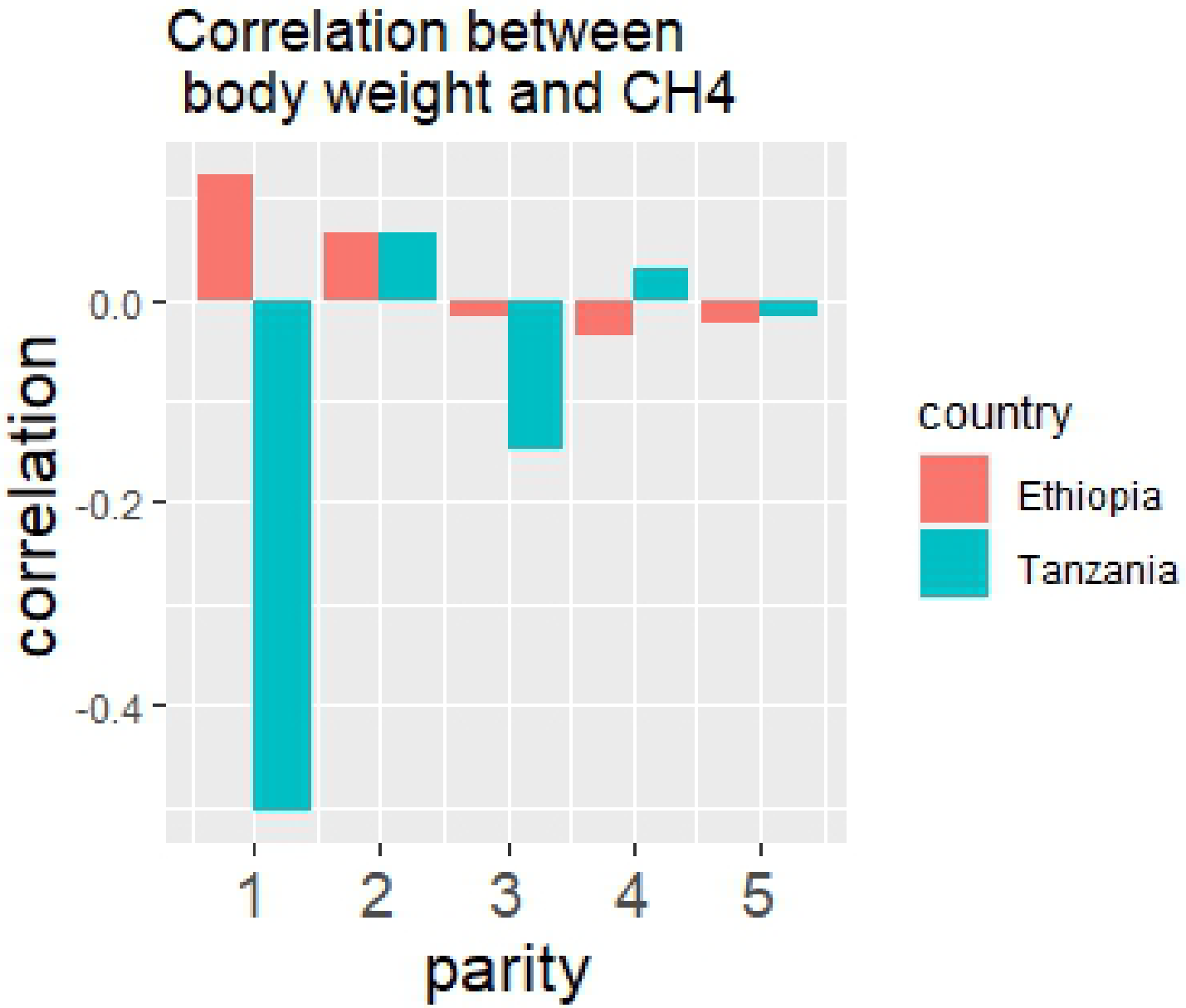
Accuracy = 0.29/sqrt(0.2) = 0.65


Correlation between predicted and measured CH4 values
Correlation
0.40
0.35
0.30
0.25
0.20
0.15
0
25
50
75
100
Replicate


Correlation between
milk yield and CH4
correlation
0.15
0.10
0.05
0.00
Ethiopia
Tanzania
country


Correlation between
milk yield and CH4
correlation
0.3
0.2
0.1
0.0
1
2
3
4
5
parity
country
Ethiopia
Tanzania


Correlation between
body weight and CH4
correlation
0.04
0.02
0.00
Ethiopia
Tanzania
country


Correlation between
body weight and CH4
correlation
0.0
-0.2
-0.4
1
2
3
4
5
parity
country
Ethiopia
Tanzania

LMD_CH4 ~ MIR + Fat+ Lactose+ Prot.

LMD_CH4 ~ MIR
+ Fat+ Lactose+
Prot. + BW + MY +
Feed components + …

No improvements

Herd-wise prediction

Herd-wise prediction

5-fold cross validation

20 herds as training

5 herds as validation

100 replicates

Accuracy 0.03

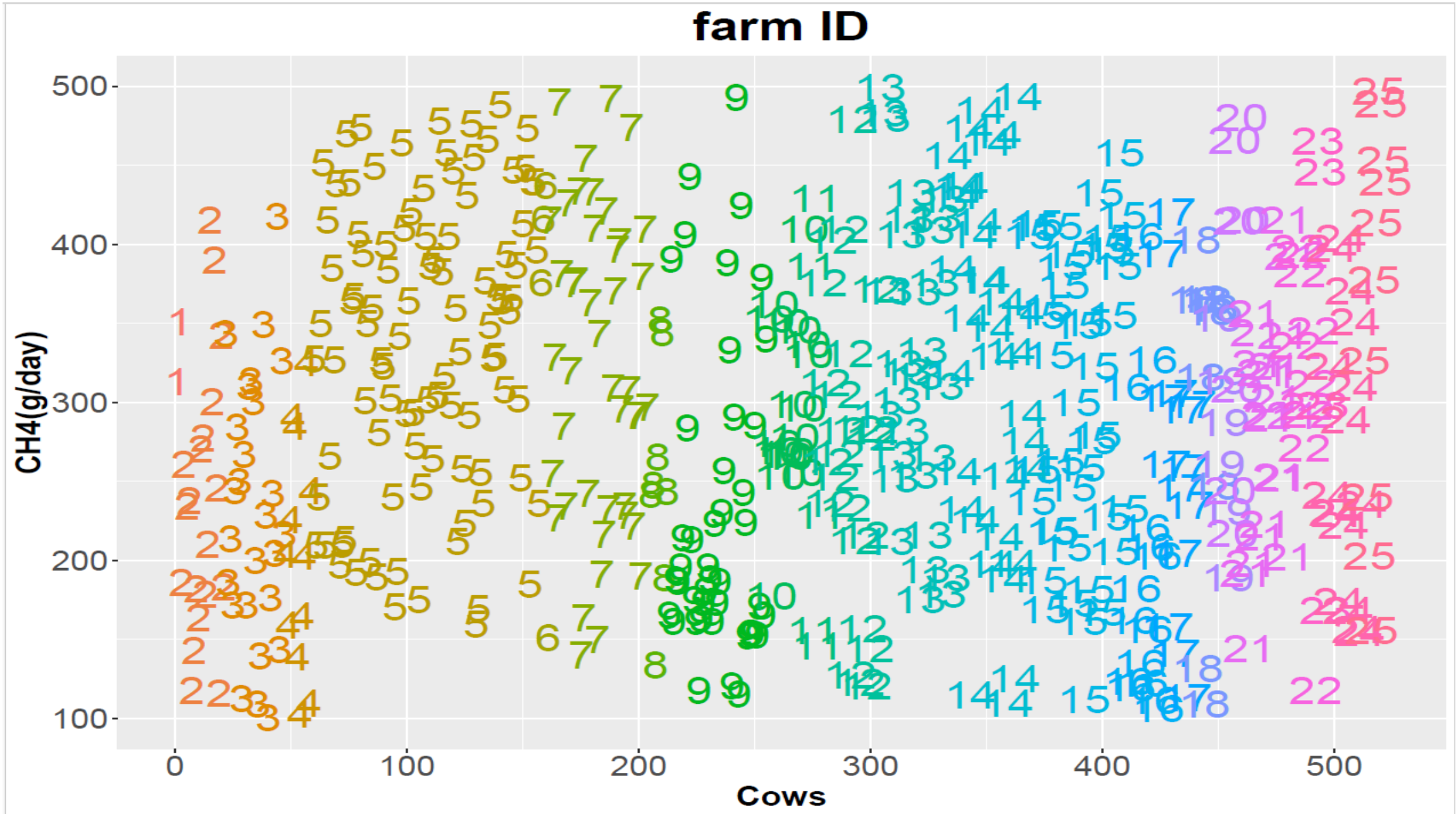
Herd-wise prediction

age, parity, lactation stage, breed and management

Herd-wise prediction

age, parity, lactation stage, breed and management

Farm sizes 2 - 99


farm ID
CH4(g/day)
Cows
500
400
300
200
100
0
100
200
300
400
500

- ✓Reducing the heterogeneity of population is a key
- ✓Prediction of CH4 measured by LMD is promising

BILL & MELINDA GATES foundation

SRUC

ILRI

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE