Variability among individual young beef bulls in methane emissions

Renand G., Ricard E., Maupetit D. Thouly J.C.

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INTRODUCTION

20% of GHG in France **originate from Agriculture**

and **60% of Agriculture GHG** in France **originate from Beef or Dairy Cattle production**

Enteric Methane emissions markedly contribute to GHG emissions in:

Dairy cattle production: 43% of GHG

Beef cattle production: 52% of GHG

Methane warming properties:

High Global Warming Potential (x25)

Short Atmospheric Half-Life (7 years)

are primary arguments for research efforts in Mitigation of Cattle Enteric Methane emissions

Several strategies are currently explored for mitigating Enteric Methane emissions:

- **Increased herd productivity** (less replacement heifer needed) **=> less GHG/kg product**
- **Increased production *** (through feeding level or genetics) **=> less CH_4/kg product**

  **** Possible conflicting effects with other GHG** (CO_2 N_2O) **emissions***

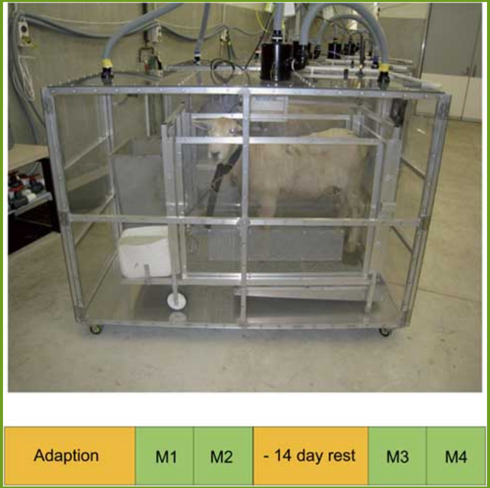
- **Diet composition** (Celluloses vs Starch; Lipid supply)
- **Feed additives or biotechnologies** (Modulation of rumen microbial methanogens)
- **Breeding cattle for lower RFI ?** (phenotypic correlations of +0.44 and +0,35 in beef steers) (*Nkrumah et al. 2006; Hegarty et al. 2007*)
- **Breeding cattle that emits less methane ?**

Individual variability of Methane emissions does exist among animals fed the same ration:

- **Coefficient of Variation: 10% to 20% of the mean**

Arguments on the animal genetic determinism of Methane emissions:

- **h^2=0.29 and repeatability=0.55 with 1225 sheep measured** (2 x 2 days) **in Respiratory Chambers** (*Pinares-Patino et al., 2013*)



Genetic studies require a large number of phenotypes :

the measure of daily Methane emission rate of cattle is difficult however

- **Respiratory Chamber are the “golden standard” where <u>gas concentrations & air flow rate</u> are continuously measured all over the 24 hours a day.**

✓a very limited number of cattle can be measured

✓1 or 2 days maximum measurement

✓the confinement may modify the feeding behavior

- **The SF6 tracer technique allow measuring the whole day methane emission through a <u>continuous sampling of expired air</u>.**

✓ require burdensome handling

✓ few days measurement

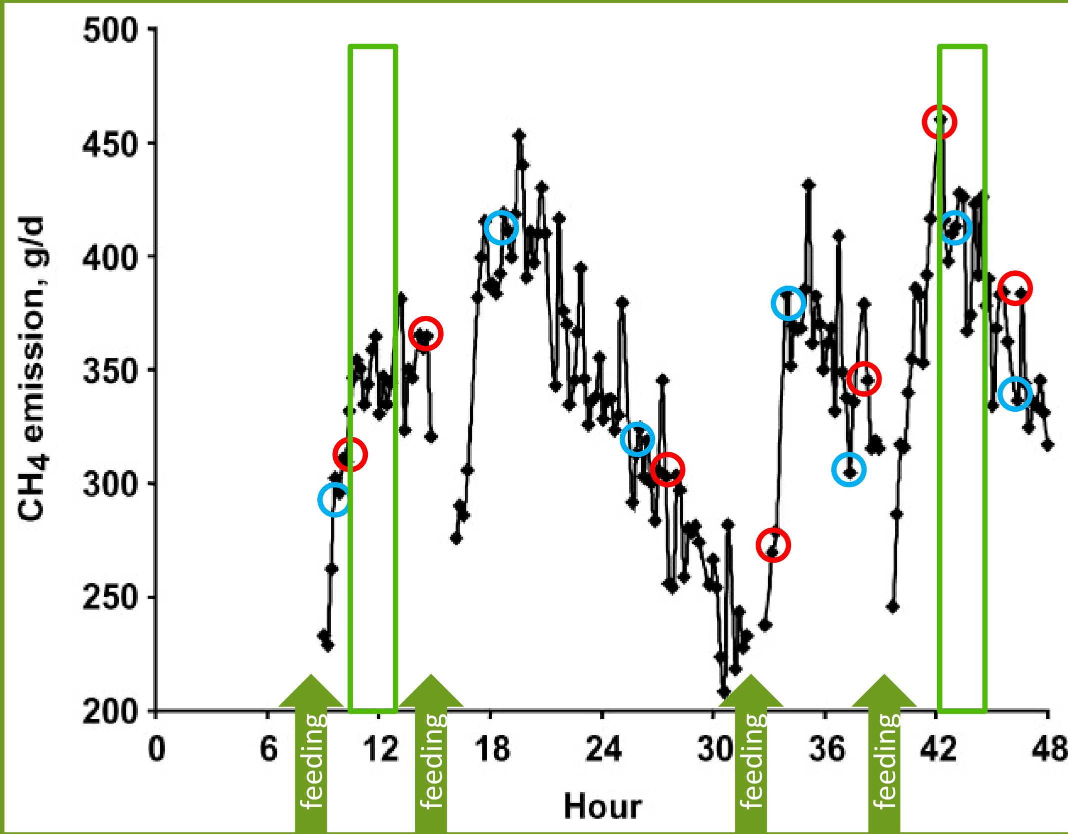
✓may modify the feeding behavior

INRA SCIENCE & IMPACT

- **Short period sampling**

Methane emission highly fluctuates along day and night in relation with the feeding behavior.

- ✓**<u>1 hour whole CH4 emission</u> measured in Portable Accumulation Chambers (sheep)**
- ✓**<u>CH4 emission rates</u> measured in GreenFeed® systems (cattle)**



Grainger et al., 2007

Objective of the experiment:

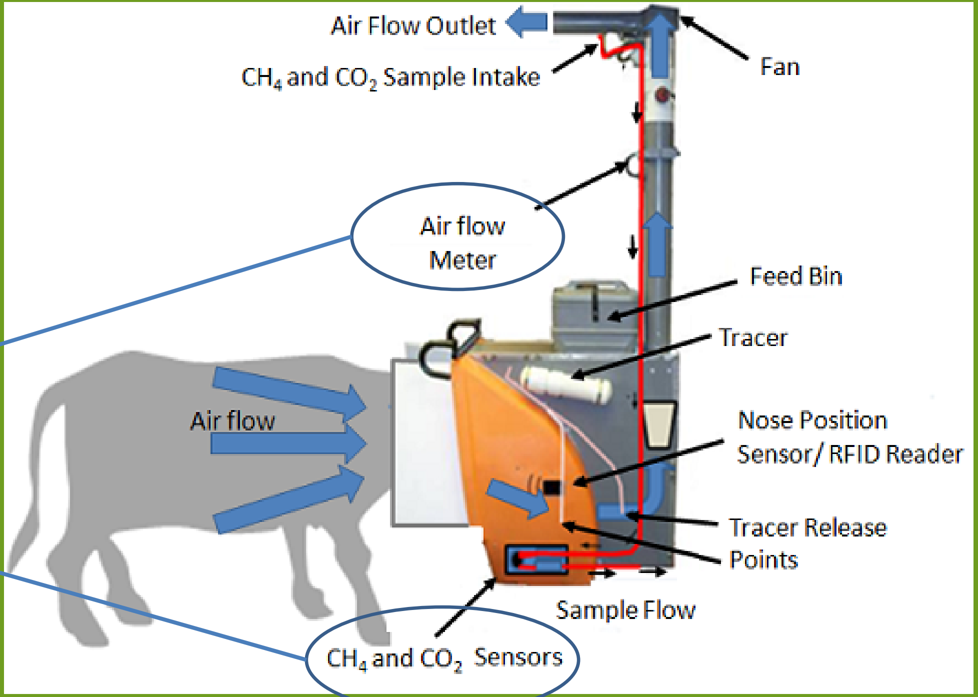
Estimating variability and repeatability of CH4 and CO2 emission rates measured with GreenFeed® systems

- **Short period sampling :**

Limited feed distributed for attracting the animal in the feeder for few minute visits

- **Measure of CH4 emission rates during visits :**

$$CH4 = F°\{(CH4_t - CH4_{base}) \times Q_{air}\}$$



Material and Methods

➢ **Animals:**

18 young bulls (3 pens)

- mean age = 10 months

- mean LW = 323 kg

6 weeks measurements

- pellet ration distributed in trough equipped with Calan gate

- restricted feeding : increase 2 to 5 kg/day

- straw bedding

Material and Methods

➢ **1 GreenFeed equipment / pen**

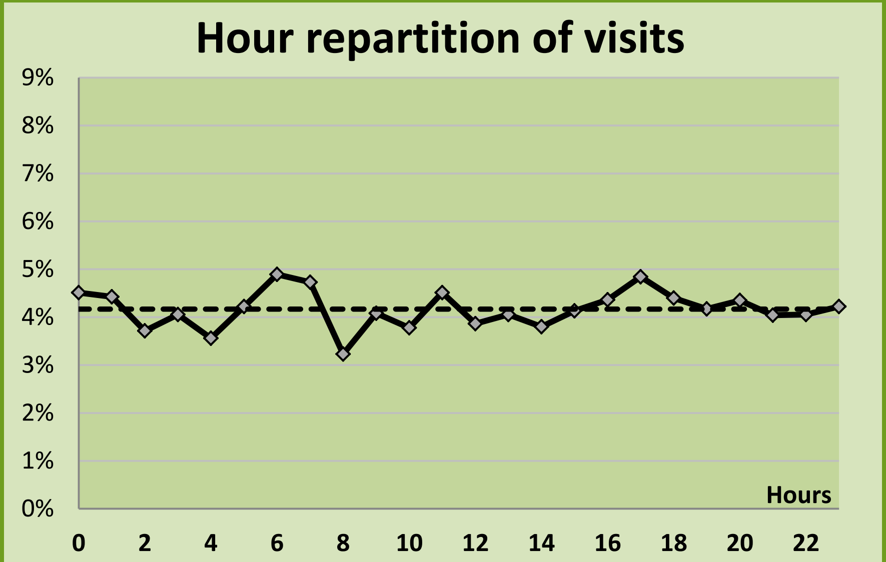
- **Distribution of 6 drops** (60 g each) **at each visit** (45 seconds between 2 drops)
- **Minimum interval between 2 visits: 2 hours**

Material and Methods

- **Analysis of data**
  - ✓ **Dependent variables :**
    - **visit CH4 emission rate measures** (g/d)
    - **daily CH4 emission rate estimates** (g/d)
    - **daily DMI** (kg/d)
  - ✓ **Environment effects**
    - **pen group of animals** (3)
    - **experiment day** (42)
    - **visit hour** (24)
  - ✓ **Animal effect** (18)

Results

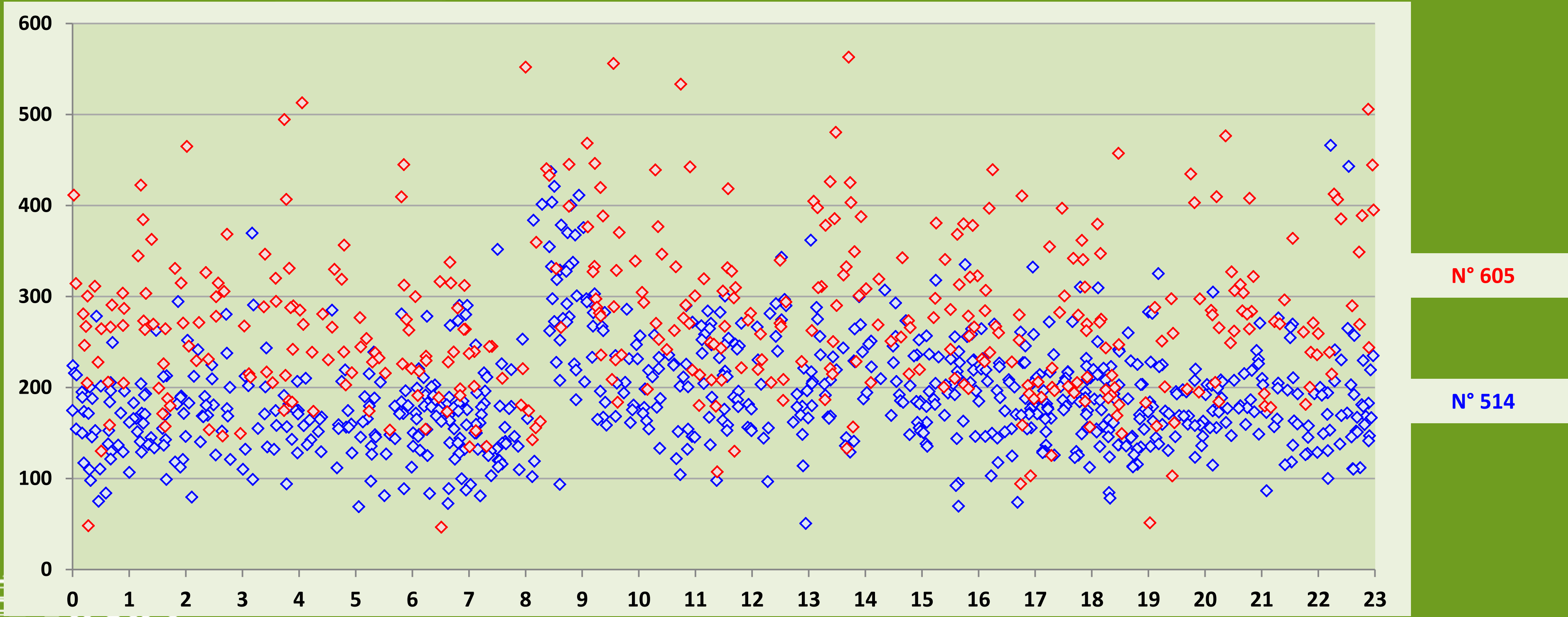
- **Number and duration of the 7,860 visits:**
  - ✓ **number = 9.1 ± 3.6** visits / animal*day
  - ✓ **duration = 5.1 ± 1.4** minutes/ animal*day
  - ✓ **even hour repartition among animals**



Results: variability among visit CH4 emission rate measures

CH4 : 233 ± 85 (g/j) CV = 0.36

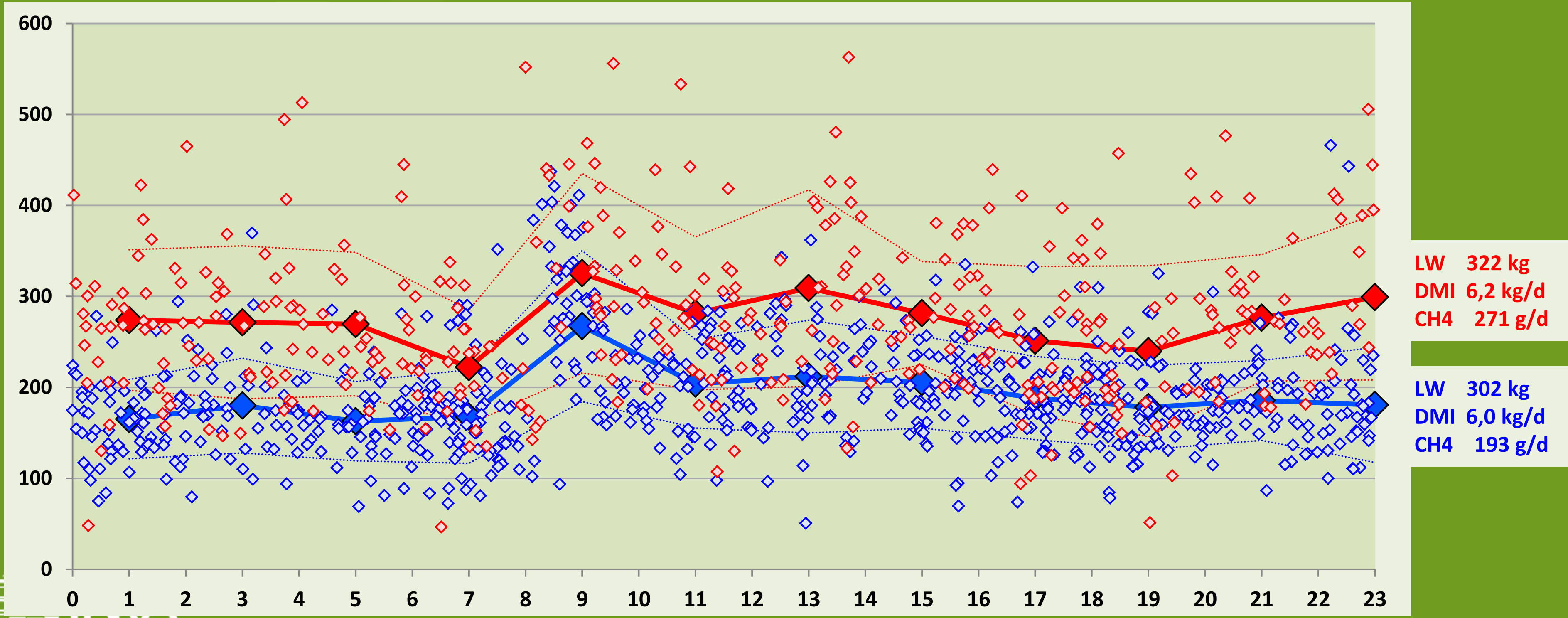
σ^2_{resid} = 63% **σ^2_{animal} = 22%** **σ^2_{date} = 8%** **σ^2_{hour} = 7%**



Results: variability among visit CH4 emission rate measures according to visit hours

CH4 : 233 ± 85 (g/j) CV = 0.36

σ^2_{resid} = 63% σ^2_{animal} = 22% σ^2_{date} = 8% σ^2_{hour} = 7%



Results: **variability of daily measures during the whole experiment period** (n=750)

➢ **Daily CH_4 emission rate variability**

✓**CH_4 :** **233 ± 55** (g/d) CV = 0.24

σ^2_{resid} **= 31%** σ^2_{animal} **= 48%** σ^2_{date} **= 20%** **rep = 0,61**

➢ **Daily DMI variability**

✓**DMI:** **6.06 ± 1.14** (kg/d) CV = 0.19

σ^2_{resid} **= 10%** σ^2_{animal} **= 3%** σ^2_{date} **= 87%** **rep = 0,22**

Results: variability within and across weeks

(splitting the experiment in 6 one-week periods)

- **Within week daily CH4 emission rate variability**

  ✓ **CH4 : 233 ± 51** (g/d) CV = 0.22

  σ^2_{resid} = 26% σ^2_{animal} = 70% σ^2_{date} = 4% **rep = 0,73**

- **Within week DMI variability**

  ✓ **DMI: 6.06 ± 0.58** (kg/d) CV = 0.10

  σ^2_{resid} = 36% σ^2_{animal} = 16% σ^2_{date} = 49% **rep = 0,30**

- Correlations across 6 weekly averages of CH_4 emission rate or DMI

CH4	week 1	week 2	week 3	week 4	week 5	Aver.
+1	0,82	0,88	0,86	0,86	0,91	**0,87**
+2	0,75	0,89	0,66	0,75		**0,76**
+3	0,65	0,73	0,55			**0,64**
+4	0,47	0,63				**0,55**
+5	0,35					**0,35**

DMI	week 1	week 2	week 3	week 4	week 5	Aver.
+1	0,76	0,67	0,56	0,53	0,68	**0,64**
+2	0,67	0,46	0,29	0,03		**0,36**
+3	0,38	0,52	-0.02			**0,29**
+4	0,15	0,31				**0,23**
+5	0,05					**0,05**

Conclusions:

Is GreenFeed accurate enough for detecting individual differences among cattle in CH4 emission rate ?

- **Visit CH4 emission rate is highly variable due to sampling and measurement errors**
- **Visit hour has a significant effect => should be taken into account**
- **With 9 visits per day, the daily average is fairly repeatable (rep= 0,61)**
- **A two week average will provide highly repeatable estimate (rep>0,85)**

  and can be used for ranking animals on their CH4 emission rate capacity.