Estimation of heritability and genetic correlation of methane phenotypes and yield traits in the Spanish Holstein population

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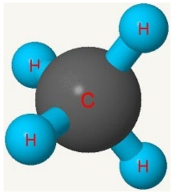
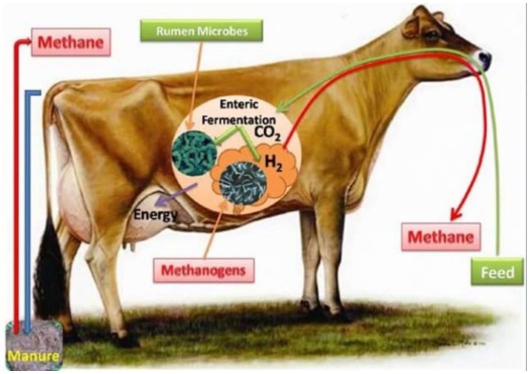
Ruminants and climate change



METHANE

Global warming

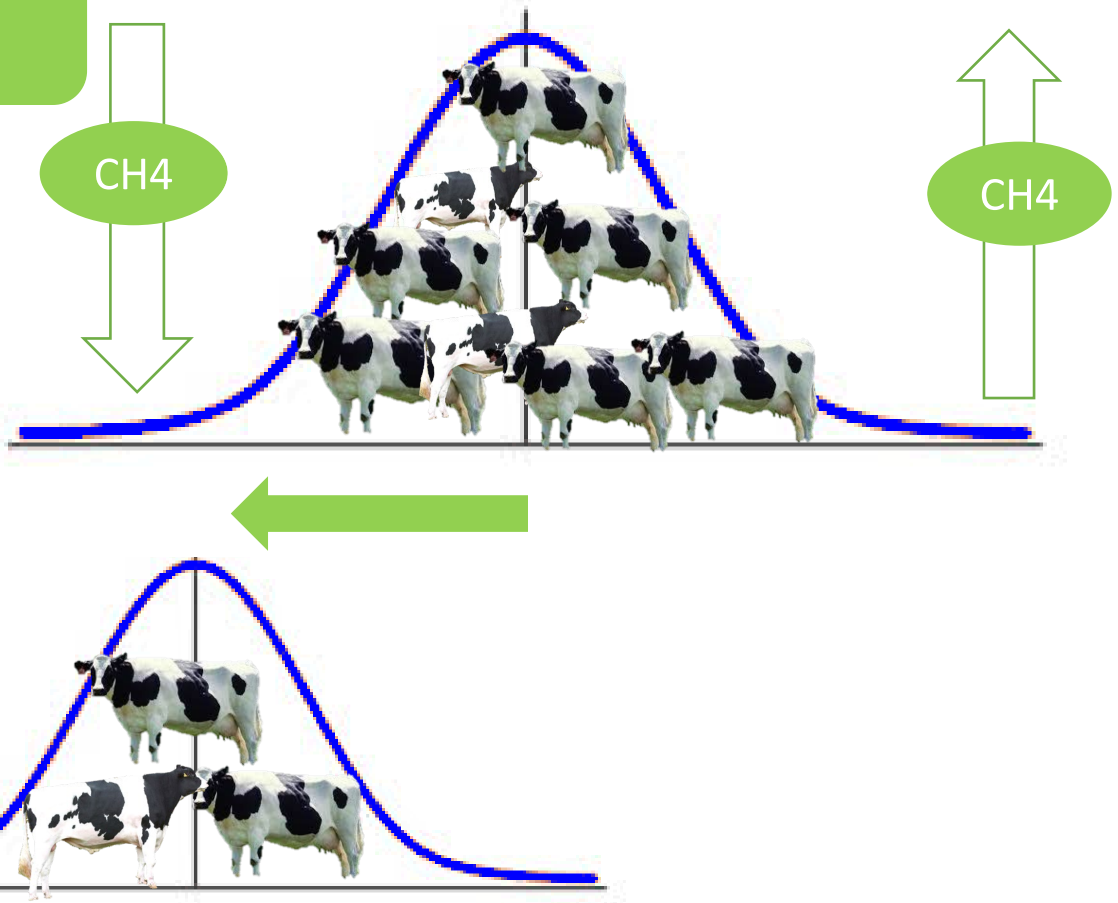
-Cattle is the main methane emitter from agricultural sector (6 % of anthropogenic greenhouse gas emissions)



Energy loss

What can we do?

GENETIC SELECTION



- Many precise records to obtain reliable estimation of genetic components

- Relation with productive traits

How can we estimate methane emissions?

Repeatability of enteric methane determinations from cattle using either the SF_6 tracer technique or the GreenFeed system

M. Arbre [A], Y. Rochette [A], J. Guyader [A], C. Lascoux [A], L. M. Gómez [A], M. Eugène [A], D. P. Morgavi [A], G. Renand [B], M. Doreau [A] and C. Martin [A C]

+ Author Affiliations

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ELSEVIER

Journal of Dairy Science
Volume 95, Issue 6, June 2012, Pages 3166-3180

On-farm methane measurements during milking correlate with total methane production by individual dairy cows

P.C. Garnsworthy, J. Craigon, J.H. Hernandez-Medrano, N. Saunders

animals MDPI

Article

Comparison Between Non-Invasive Methane Measurement Techniques in Cattle

Jagoba Rey [1,*], Raquel Atxaerandio [1], Roberto Ruiz [1], Eva Ugarte [1], Oscar González-Recio [2,3], Aser Garcia-Rodriguez [1] and Idoia Goiri [1,*]

ORIGINAL ARTICLES

Ranking cows' methane emissions under commercial conditions with sniffers versus respiration chambers

G. F. Difford, D. W. Olijhoek, A. L. F. Hellwing, P. Lund, M. A. Bjerring, Y. de Haas, ...show all

Pages 25-32 | Received 25 Oct 2018, Accepted 14 Jan 2019, Published online: 08 Feb 2019

AMS

Non-dispersive infrared methane detector

Objective

- Our aim was to estimate the genetic components of different methane phenotypes and to evaluate the genetic correlations between them and with production traits

Methodology : Samples and data collection

Samples= 3281 dairy cows in 34 farms

CH4

CH4

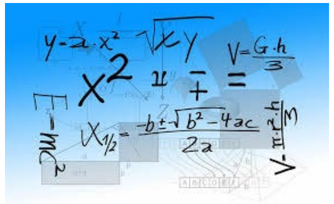
CH4

CH4

Metane emissions =15-30 days – 1 s interval
Productive data= monthly test day records

Methodolody: Phenotype definition

Equations



Concentration (ppm)

1. Mean CH_4 (by second and every 5 s)
2. Sum of peaks CH_4 (by second and every 5 s)
3. Sum of max peaks CH_4
4. Area under the curve (AUC CH_4)
5. Ratio of (mean) CH_4/CO_2

Production (g/d)

6. Grams per day (Madsen et al., 2010)

$$\text{Prod } CH_4\left(\frac{g}{d}\right) = 0.714 * \boldsymbol{ratio(ppm)} * 180 * 24 * 0.001 * (5.6 * kg\ body\ mass^{0.75}) + 22 * \boldsymbol{ECM} + 1.6{*}10^{-5} * days\ in\ pregnancy$$

Weekly averages were used for all phenotypes

Methodolody: genetic estimations

Bayesian approach

GIBBSF90+

Genetic components

Genetic correlations

Bivariate

$$\mathbf{y_1\text{-}y_2 = Xb + Z_h h + Z_u u + Z_p p + e}$$

y= Phenotype

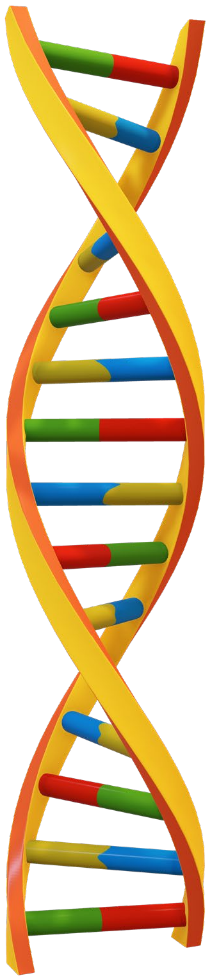
b= Fix effects(stage of lactation, number of calving, month of calving)

h= Random effect Herd-Robot-week-year

u= Genetic effect, where u ~ N $(0,H\sigma^2_a)$

p= Permanent environmental effect

e= Residuals



Results and discussion

Results: Descriptive statistic

Traits	N	Mean	SD	Min	Max
Mean CH_4	12,400	**356**	196	30.85	1,062
Mean CH_4 5 sec	12,400	357	196	30.86	1,071
Sum of peaks CH_4	12,400	12,783	9,512	504.80	41,967
Sum of peaks CH_4 5 sec	12,400	25,431	15,872	962.50	83,485
Sum of max peaks	12,400	450	334	12.29	1,739
AUC CH_4	12,400	25,297	15,815	993.20	83,183
Ratio CH_4/CO_2	7,505	0.07	0.01	0.01	0. 14
G/d	6,017	**345**	103	41	689

Results: h^2 and r^2

Trait	h^2	r^2
Mean CH4	0.08 (0.05-0.11)	0.54 (0.52-0.56)
Mean CH4 5 s	0.08 (0.05-0.11)	0.54 (0.53-0.56)
Sum of peaks CH4	0.09 (0.06-0.12)	0.55 (0.53-0.57)
Sum of peaks CH4 5s	0.10 (0.06-0.13)	0.55 (0.53-0.57)
Sum of max peaks	0.08 (0.05-0.11)	0.52 (0.50-0.54)
AUC CH4	0.10 (0.07-0.13)	0.55 (0.53-0.57)
Ratio CH4/CO2	0.10 (0.05-0.16)	0.42 (0.39-0.45)
Grams per day (g/d)	0.12 (0.06-0.17)	0.51 (0.48-0.54)

!

Low to moderate heritabilities and large repeatibility

Results: Genetic correlations between methane traits

Traits	Mean CH_4	Mean CH_4 5 s	Sum of peaks CH_4	Sum of peaks CH_4 5s	Sum of max peaks	AUC CH_4
Mean CH_4	0.08	0.99	0.82 (0.74-0.90)	0.82 (0.75-0.90)	0.77 (0.67-0.85)	0.83 (0.74-0.89)
Mean CH_4 5 s		0.08	0.82 (0.73-0.89)	0.84 (0.76-0.92)	0.72 (0.57-0.85)	0.84 (0.76-0.90)
Sum of peaks CH_4			0.09	0.99	0.99	0.99
Sum of peaks CH_4 5 s				0.10	0.99	0.99
Sum of max peaks					0.08	0.99
AUC CH_4						0.10

1

0

!

High correlations between phenotypes

INIA

Results
Genetic correlations between methane concentration and production

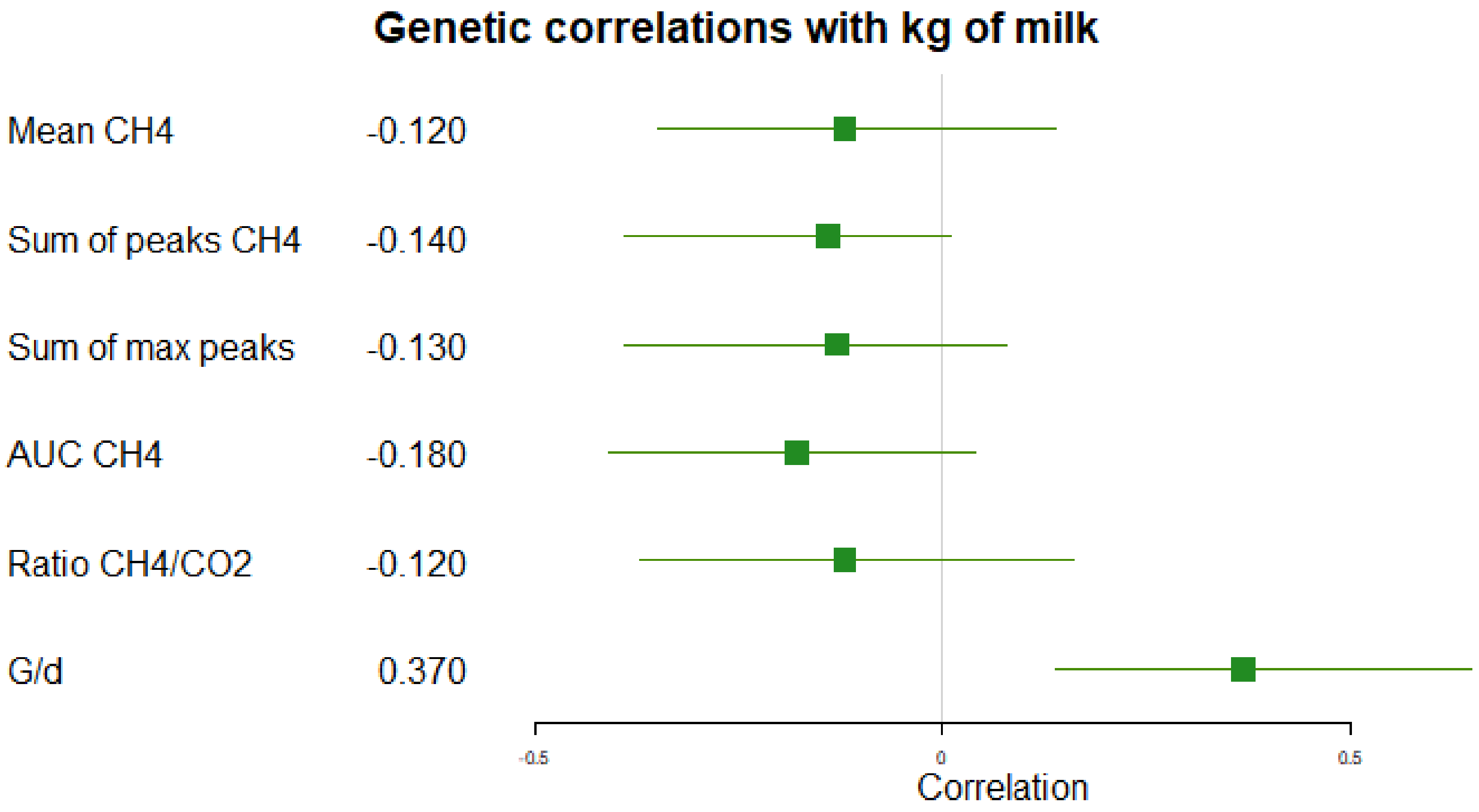
Traits	Ratio CH_4/CO_2	G/d
Mean CH_4	0.95 (0.89-0.99)	0.92 (0.81-0.98)
Sum of peaks CH_4	0.71 (0.56-0.85)	0.75 (0.50-0.97)
Sum of max peaks	0.65 (0.46-0.84)	0.58 (0.31-0.76)
AUC CH_4	0.68 (0.52-0.81)	0.62 (0.38-0.84)
Ratio CH_4/CO_2	0.10	0.98
G/d		0.12

1

0

Lower correlations but still high

Results: Genetic correlation with milk production



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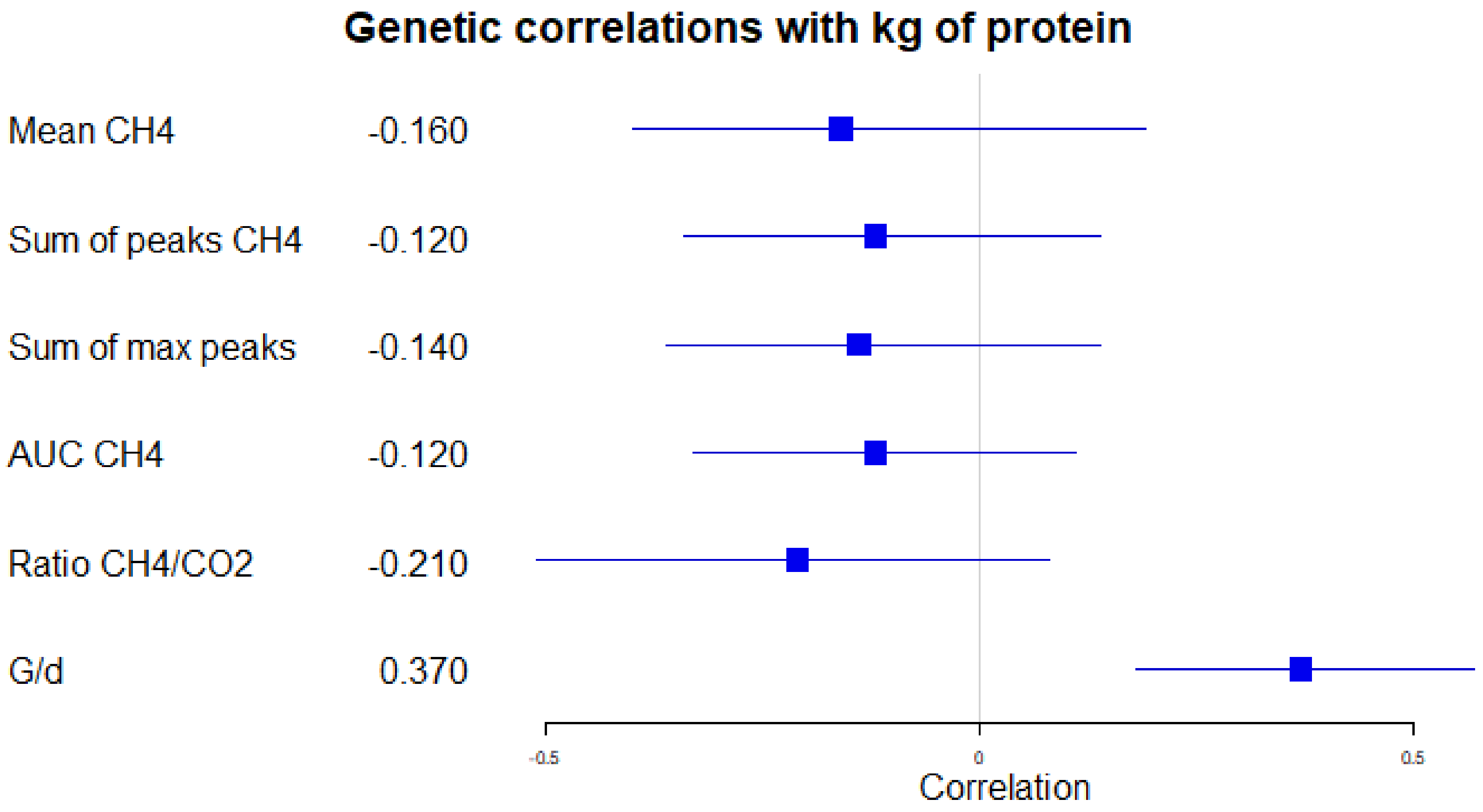
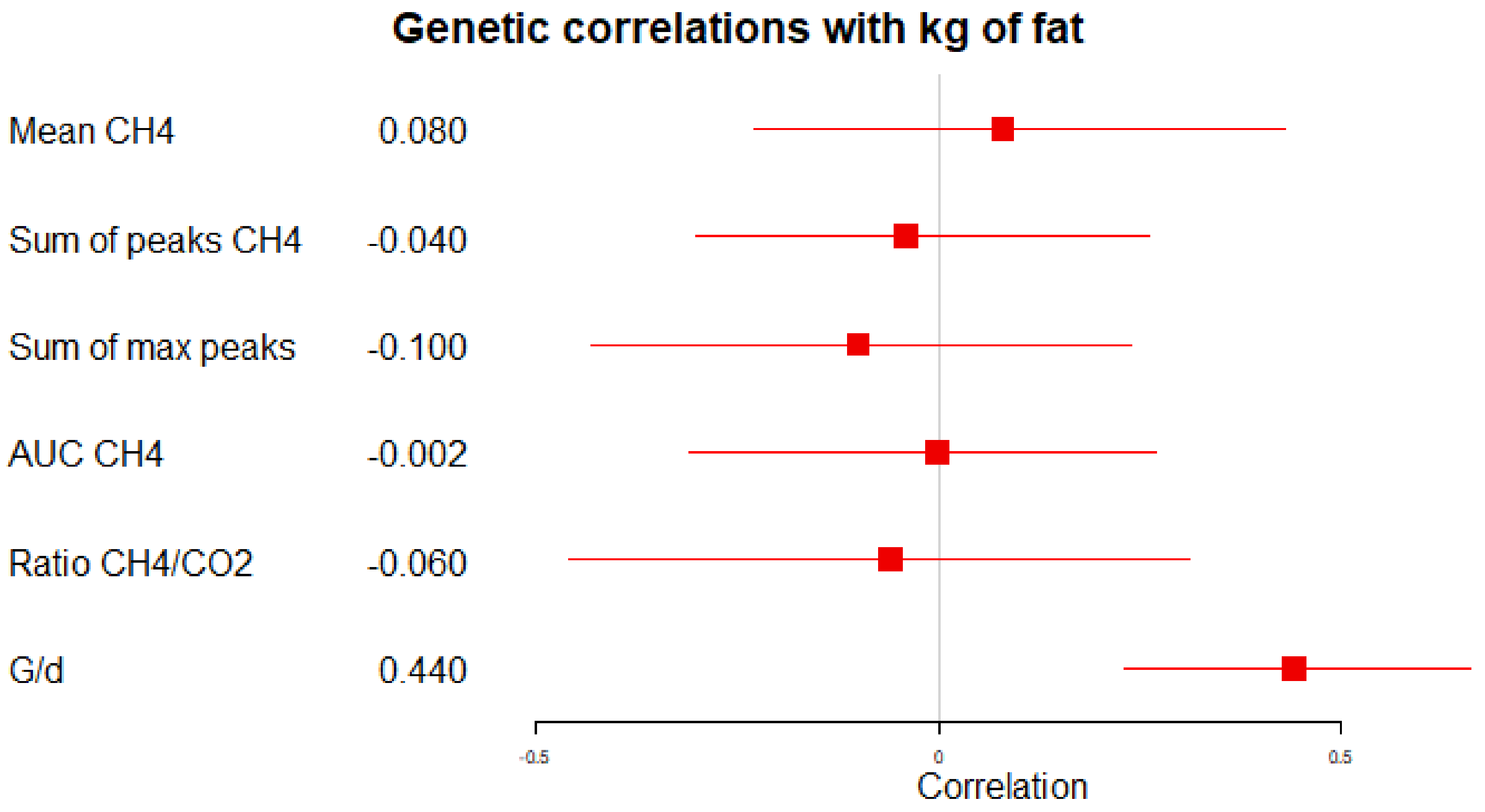
Most correlations were negative (favorable) with large posterior standard deviations (except g/d)

Results: Genetic correlation with protein production



Most correlations were negative (favorable) with large posterior standard deviations (except g/d)

Results: Genetic correlation with fat production



Correlations clore to zero with large posterior standard deviations (except mean CH4 and g/d)

Final remarks

To summarize…

- **Heritability values were moderate** and repeatability within lactations was large, suggesting that methane concentration estimates obtained with sniffers can be used for genetic selection towards lower emissions
- There is **high correlation between different methane phenotypes.** Nonetheless there should be an standardization based on ICAR guidelines (to be developed)
- **Correlations with productive traits were low and negative** in general indicating that selection for methane would not affect milk production. However, it should be considered that the HDP 95% was large. Caution with fat yield.
- The use of **ratio CH_4/CO_2** may be of interest as it showed **high correlation with methane phenotypes** and is proposed to calculate g/day
- It is necessary to **carefully consider transformations from concentration (ppm) to methane production (g/d)** that depend on productive or type traits, and thus avoid biased genetic correlation estimates

Future perspectives

- The results of this analysis will be used to define the best phenotype to be included in the **index of CONAFE**
- The adoption of a **multi-country analysis** (RE-LIVESTOCK, RDGP and NET ZERO projects) would strengthen the trait's definition, allowing it to be implemented in other countries

Thanks for your attention

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Results: Genetic correlation

Traits	Kg milk	Kg fat	Kg protein
Mean CH_4	-0.12 (-0.35 ; 0.14)	0.08 (-0.23 ; 0.43)	-0.16 (-0.40 ; 0.19)
Mean CH_4 5 sec	-0.11 (-0.30 ; 0.13)	0.10 (-0.21 ; 0.36)	-0.11 (-0.47 ; 0.16)
Sum of peaks CH_4	-0.14 (-0.39 ; 0.01)	-0.04 (-0.30 ; 0.26)	-0.12 (-0.34 ; 0.14)
Sum of peaks CH_4 5 sec	-0.20 (-0.41 ; 0.02)	-0.006 (-0.31 ; 0.3)	-0.12 (-0.37 ; 0.16)
Sum of max peaks	-0.13 (-0.39 ; 0.08)	-0.10 (-0.43 ; 0.24)	-0.14 (-0.36 ; 0.14)
AUC CH_4	-0.18 (-0.41 ; 0.04)	-0.002 (-0.31 ; 0.27)	-0.12 (-0.33 ; 0.11)
Ratio CH_4/CO_2	-0.12 (-0.37 ; 0.16)	-0.06 (-0.46 ; 0.31)	-0.21 (-0.51 ; 0.08)
G/d	**0.37** (0.14 ; 0.65)	**0.44** (0.23 ; 0.66)	**0.37** (0.18 ; 0.57)

!

Most of correlations were negative
Except mean CH_4 and g/d

Results: Variance components

Traits	σ^2_p	σ^2_h	σ^2_{pe}	σ^2_g	σ^2_r
Mean CH_4		27,424.0	7,208.1	1,149.8	7,001.6
Mean CH_4 5 sec		26,344.0	7,288.5	1,207.1	7,048.1
Sum of peaks CH_4					
Sum of peaks CH_4 5 sec					
Sum of max peaks					
AUC CH_4					
Ratio CH_4/CO_2					
G/d					