Re-Livestock

RESILIENT FARMING SYSTEMS

Discussion: Estimation of genetic parameters for methane emissions

Birgit Gredler-Grandl, Coralia Manzanilla-Pech, Ester Teran and Oscar González-Recio

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INIA CSIC

Zaragoza, February 26th, 2025

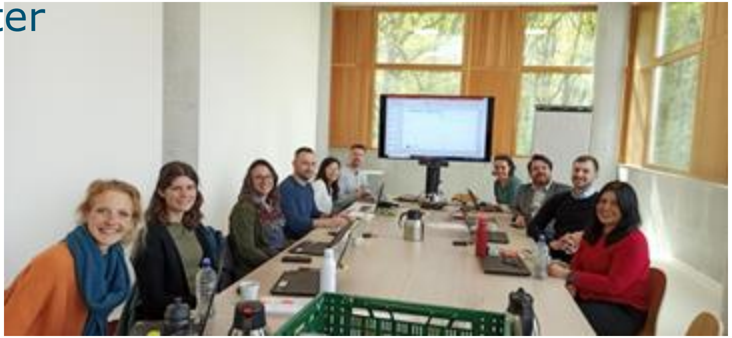
Examples of variance components for methane traits: Relivestock

Birgit Gredler-Grandl, Coralia Manzanilla-Pech, Ester Teran and Oscar González-Recio

Zaragoza, February 25th, 2025

Standardizing the phenotype

- Weekly records, no correction diurnal variation
- Minimum number of visits per week = 5
- Average all visits within a calendar week R lubridate (epidemiological week) epiyear(x) + epiweek(x)
- Background correction within visit: average 5 lowest measurements per visit
- Duration of visit: each partners keeps own filter
- Max duration: 5min
- Lactation grouping 1,2,3+
- Lactation stage: 3 levels in Spain:
    - 0-90,91-150,151-365
    - DIM max 365 days



Methane phenotypes

METHANE CONCENTRATION

1. conc Average *methane concentration* per visit (ppm)
2. #peaks *Number* of *methane peaks* per minute
3. Sumpeaks Sum of 2 maximum values within each peak
4. CO2 conc Average *carbon dioxide concentration* per visit (ppm)
5. ratio between *methane* and *carbon dioxide* concentration

METHANE PRODUCTION (g/d)

6. Madsen Based on Madsen et al. 2010 equation
7. Chagunda Based on Chagunda et al. 2009 equation
8. Kjeldsen Based on Kjeldsen et al. 2024 equation2
9. Kjeldsen Based on Kjelsen et al. 2024 equation3
10. Tier2 Based on Tier2 (IPCC) equation

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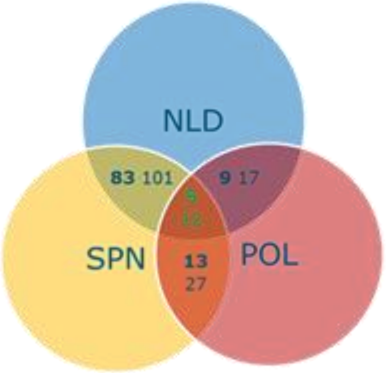
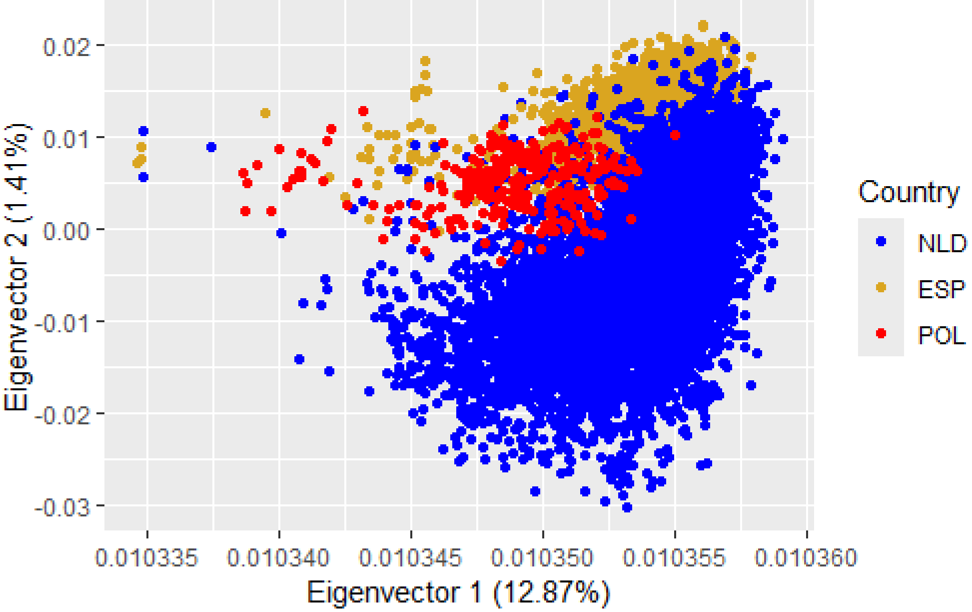
Pedigree and Genotypes per country





Averages and standard deviations

Phenotypes		Pooled dataset	Netherlands	Spain	Poland
		Average (SD)			
CH_4 concentration	average	**397.1** (181.4)	388.1 (167.8)	377.0 (186.2)	534.9 (142.2)
	#peaks	**1.4**(0.5)	1.5 (0.4)	0.57 (0.1)	1.00 (0.1)
	speaks	**902.6** (471.4)	931.3 (442.0)	464.8 (318.9)	716.8 (210.1)
CO_2 concentration	average	**5543.0** (1844.0)	5637.0 (1812.0)	5115.0 (1736.0)	7037.0 (1707.0)
Ratio*	CH_4/CO_2	**0.07** (0.02)	0.07 (0.02)	0.07 (0.02)	0.08 (0.01)
CH_4 production	Madsen	**311.9** (122.9)	296.4 (131.9)	344.3 (102.0)	379.4 (94.6)
	Chagunda	**139.5** (103.2)	180.9 (97.2)	65.2 (45.0)	94.3 (31.3)
	Kjeldsen2	**299.3** (117.8)	309.3 (135.1)	287.8 (84.9)	354.2 (62.4)
	Kjeldsen3	**321.7** (127.0)	318.5 (128.8)	356.5 (103.4)	358.3 (61.5)
	Tier2	**402.6** (89.31)	356.7 (68.8)	468.7 (77.3)	334.5 (54.7)
CH_4 Intensity**	CH_4/MY	**9.9** (4.7)	9.9 (4.8)	9.2 (3.3)	10.5 (2.8)

Variation between the phenotypes' averages

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Genetic correlations between countries

Phenotype		Netherlands-Spain	Netherlands-Poland	Spain-Poland
		Genetic correlations		
CH_4 concentration	average	0.53 (0.14)	0.67 (0.20)	0.56 (0.28)
	#peaks	-0.52 (0.07)	0.99 (0.25)	0.18 (0.27)
	speaks	-0.34 (0.12)	0.74 (0.16)	0.10 (0.27)
CO_2 concentration	average	0.82 (0.91)	0.86 (0.28)	0.99 (1.00)
Ratio*	CH_4/CO_2	0.50 (0.17)	0.34 (0.22)	0.48 (0.46)
CH_4 production	Madsen	0.98 (0.72)	0.30 (0.81)	0.48 (0.46)
	Chagunda	0.17 (0.24)	0.35 (0.33)	-0.28 (0.31)
	Kjeldsen2	0.47 (0.19)	0.22 (0.22)	0.80 (0.36)
	Kjeldsen3	0.47 (0.19)	0.29 (0.22)	0.84 (0.35)
	Tier2	0.73 (0.29)	0.57 (0.42)	0.36 (0.42)
CH_4 Intensity**	CH_4/MY	0.69 (0.17)	0.81 (0.23)	0.88 (0.41)

0.53-0.66 r_a between countries for CH_4 conc

High r_a for CO_2 conc

Moderate to high r_a for some Methane Production

High r_a for Methane Intensity

Genetic correlations with CH_4 concentration average

Phenotype		Pooled database	Netherlands	Spain	Poland
		Genetic correlations with CH_4 average			
CH_4 concentration	#peaks	0.32 (0.04)	0.74 (0.05)	0.72 (0.22)	0.80 (0.31)
	speaks	0.78 (0.02)	0.76 (0.03)	0.73 (0.07)	0.99 (0.03)
CO_2 concentration	average	0.82 (0.03)	0.82 (0.03)	0.78 (0.19)	0.85 (0.07)
Ratio*	CH_4/CO_2	-0.10 (0.08)	0.86 (0.03)	0.38 (0.66)	-0.03 (0.67)
CH_4 production	Madsen	0.47 (0.10)	0.65 (0.13)	0.94 (0.08)	0.43 (0.24)
	Chagunda	0.74 (0.05)	0.70 (0.08)	0.95 (0.05)	0.58 (0.12)
	Kjeldsen2	0.77 (0.07)	0.81 (0.10)	0.99 (0.07)	0.70 (0.14)
	Kjeldsen3	0.84 (0.03)	0.85 (0.03)	0.99 (0.06)	0.80 (0.12)
	Tier2	-0.02 (0.11)	-0.16 (0.12)	0.38 (0.20)	-0.03 (0.24)
CH_4 Intensity**	CH_4/MY	0.70 (0.05)	0.62 (0.08)	0.38 (0.59)	0.43 (0.52)

Moderate to high r_a with num peaks and sum of max peaks

High r_a with CO_2 conc

High r_a with ratio (NL)

High correlation with all Methane Production phenotypes except Tier2

Moderate correlation with Methane Intensity

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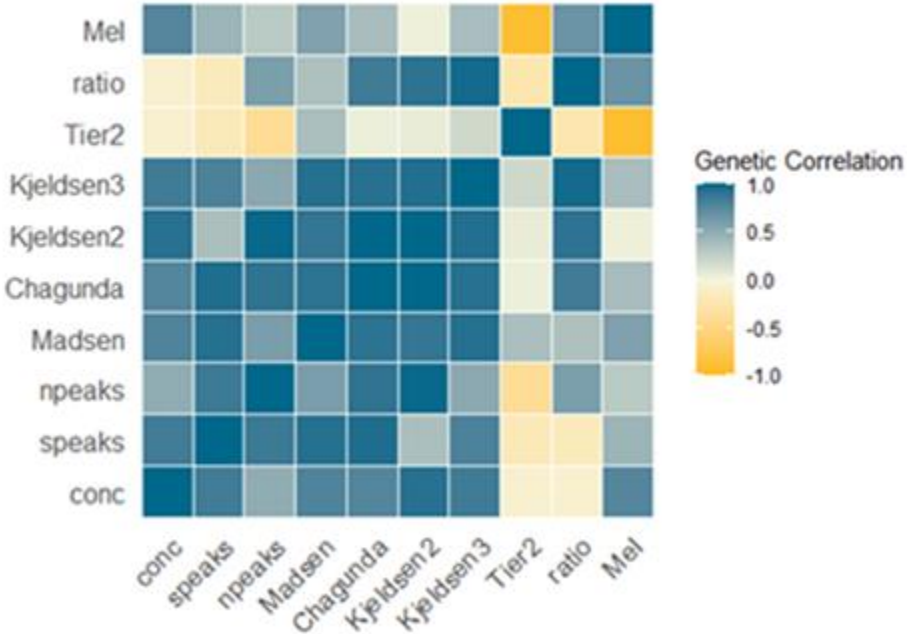
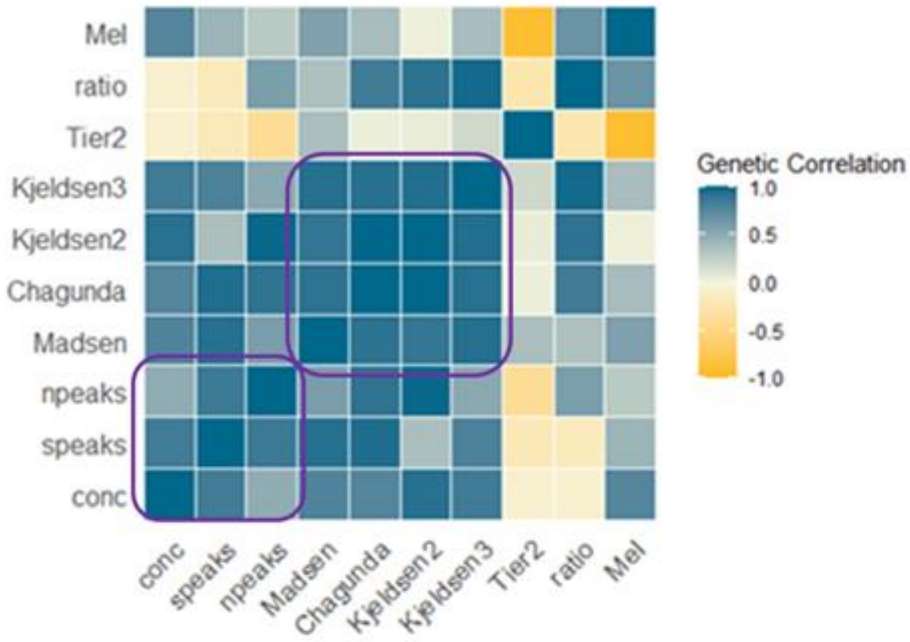
Genetic correlations all phenotypes for Netherlands



Genetic correlations all phenotypes for Netherlands



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Examples of variance components for methane traits

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Heritabilities

Trait	h^2	r^2
Mean CH4 (ppm)	0.08 (0.05-0.11)	0.54 (0.52;0.56)
Mean CH4 5 s(ppm)	0.08 (0.05-0.11)	0.54 (0.53;0.56)
Sum of peaks CH4 (ppm)	0.09 (0.06;0.12)	0.55 (0.53;0.57)
Sum of peaks CH4 5s (ppm)	0.10 (0.06;0.13)	0.55 (0.53;0.57)
Sum of max peaks (ppm)	0.08 (0.05;0.11)	0.52 (0.50;0.54)
AUC CH4 (ppm)	0.10 (0.07;0.13)	0.55 (0.53;0.57)
CO_2 (ppm)	0.02 (0.004;0.04)	0.58 (0.56;0.60)
CO_2 (L/d)*	0.02 (0.004;0.05)	0.61 (0.59;63
Ratio CH4/CO_2	0.10 (0.05;0.16)	0.42 (0.39;0.45)
MeP (g/d) (Madsen eq)	0.12 (0.06;0.17)	0.51 (0.48;0.54)
MeP (g/d)*	0.10 (0.04;0.15)	0.55 (0.53;0.58)

Larger heritabilities with multicountry analyses

Results: Genetic correlations between methane traits

Traits	Mean CH_4	MeP (g/d)*	Sum of peaks CH_4	Sum of max peaks	AUC CH_4
Mean CH_4	0.08	0.99	0.82 (0.74;0.90)	0.77 (0.67;0.85)	0.83 (0.74;0.89)
MeP (g/d)*		0.10	-	-	-
Sum of peaks CH_4			0.09	0.99	0.99
Sum of max peaks				0.08	0.99
AUC CH_4					0.10

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High correlations between phenotypes

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METHANE ARTICLES… AND MANY MORE

http://pubmed.ncbi.nlm.nih.gov/31640130/

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https://pubmed.ncbi.nlm.nih.gov/32580811/

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