Genetic relationships between methane, dry matter intake, bodyweight, and milk traits

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Introduction - Climate smart cattle breeding

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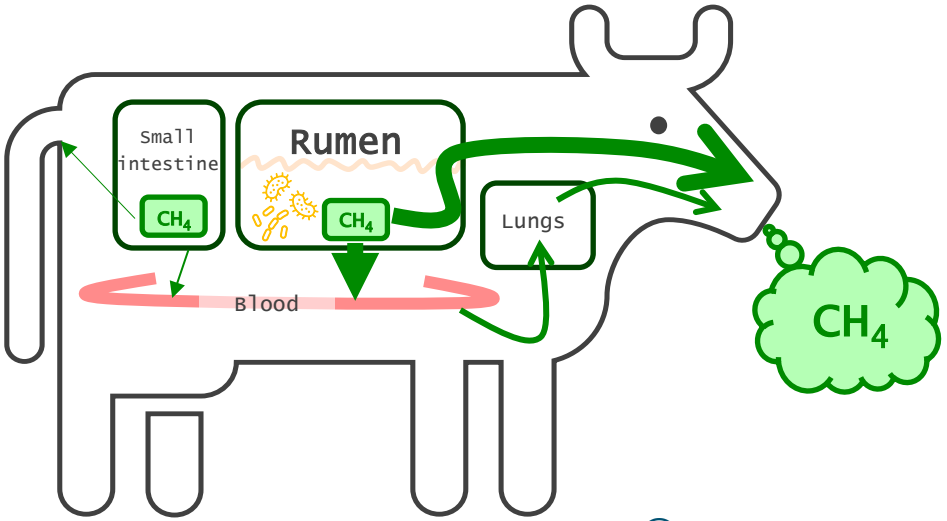
Research objective

- Estimate **genetic correlations** between CH_4 emissions, dry matter intake (DMI), bodyweight (BW), and milk yield traits in Dutch Holstein dairy cows

Materials – Methane recording



Sniffer

- ☺ High throughput
- ☺ Non-invasive
- ☺ Cost-effective
- ☹ Lower precision

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Materials - Dataset

- CH_4 concentration (ppm) recorded with sniffers on 60 farms, of which:
  - 11 farms with BW recorded (1,378 cows), of which one farm with also DMI recorded (53 cows)

	Number of records			Number of cows		
Trait[1]	Original data	Weekly means	After filtering	Original data	Weekly means	After filtering
CH_4c	882,632	74,569	**71,572**	9,274	7,139	**6,901**
Dry matter intake	727,458	210,865	**206,491**	7,547	7,546	**7,399**
Milk yield	544,562	544,562	**532,905**	9,549	9,550	**9,366**
Protein yield	454,187	450,822	**440,570**	9,542	9,542	**9,358**
Fat yield	452,151	450,034	**439,785**	9,544	9,544	**9,360**
Body weight	698,325	195,361	**192,440**	7,049	7,049	**6,885**

Methods

- **Bivariate repeatability animal models** in ASReml 4.2
  - 8,194 genotyped animals with 55K SNPs
  - H^{-1} matrix including 106,641 animals

Fixed effects:
- Herd x Experiment
- Breed x Breed fraction
- Days in milk
- Parity

Random effects:
- Additive genetic
- Parity x Permanent environment
- Residual

Results - Heritability and Repeatability

- CH_4
  - Heritability 0.21 ± 0.04 to 0.27 ± 0.03
  - Repeatability 0.65 to 0.73
- Dry matter intake
  - Heritability 0.29 to 0.22
  - Repeatability 0.69 to 0.67
- Milk yield
  - Heritability 0.43 to 0.45
  - Repeatability 0.72 to 0.69

*All other SEs are 0.01

Results – First parity

	CH_4C	DMI	MY	PY	FY	P%	F%	BW
CH_4C		0.02 ± 0.03	0.05 ± 0.10	0.02 ± 0.10	0.06 ± 0.10	-0.25 ± 0.09	-0.04 ± 0.09	0.03 ± 0.04
DMI	0.06 ± 0.10							
MY	-0.04 ± 0.08							
PY	<0.01 ± 0.08							
FY	0.12 ± 0.08							
P%	0.10 ± 0.09							
F%	**0.21 ± 0.08**							
BW	-0.04 ± 0.10							

Genetic correlations below diagonal, and phenotypic correlations above diagonal

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Results – First parity

	CH_4C	DMI	MY	PY	FY	P%	F%	BW
CH_4C		0.02 ± 0.03	0.05 ± 0.10	0.02 ± 0.10	0.06 ± 0.10	-0.25 ± 0.09	-0.04 ± 0.09	0.03 ± 0.04
DMI	0.06 ± 0.10		0.50 ± 0.01	0.54 ± 0.01	0.43 ± 0.01	0.06 ± 0.01	-0.16 ± 0.01	0.21 ± 0.02
MY	-0.04 ± 0.08	0.62 ± 0.03		0.92 ± <0.01	0.75 ± <0.01	-0.30 ± 0.01	-0.49 ± 0.01	0.10 ± 0.02
PY	<0.01 ± 0.08	0.66 ± 0.03	0.93 ± <0.01		0.80 ± <0.01	0.08 ± 0.01	-0.30 ± 0.01	0.17 ± 0.02
FY	0.12 ± 0.08	0.62 ± 0.03	0.73 ± 0.02	0.81 ± 0.01		0.04 ± 0.01	0.18 ± 0.01	0.16 ± 0.01
P%	0.10 ± 0.09	0.11 ± 0.05	-0.40 ± 0.03	-0.02 ± 0.03	0.06 ± 0.04		0.54 ± 0.01	0.14 ± 0.01
F%	**0.21 ± 0.08**	-0.19 ± 0.04	-0.63 ± 0.02	-0.42 ± 0.03	0.08 ± 0.03	0.65 ± 0.02		0.03 ± 0.02
BW	-0.04 ± 0.10	0.25 ± 0.02	0.15 ± 0.04	0.21 ± 0.04	0.19 ± 0.05	0.16 ± 0.04	-0.06 ± 0.04	

Genetic correlations below diagonal, and phenotypic correlations above diagonal

Results – Third and later parities

	CH_4C	DMI	MY	PY	FY	P%	F%	BW
CH_4C		0.02 ± 0.02	0.07 ± 0.04	0.08 ± 0.04	0.13 ± 0.04	0.02 ± 0.03	0.06 ± 0.03	0.06 ± 0.03
DMI	0.09 ± 0.10							
MY	0.03 ± 0.06							
PY	0.03 ± 0.06							
FY	**0.15 ± 0.07**							
P%	0.03 ± 0.06							
F%	0.14 ± 0.06							
BW	0.06 ± 0.06							

Genetic correlations below diagonal, and phenotypic correlations above diagonal

Results – Third and later parities

	CH_4C	DMI	MY	PY	FY	P%	F%	BW
CH_4C		0.02 ± 0.02	0.07 ± 0.04	0.08 ± 0.04	0.13 ± 0.04	0.02 ± 0.03	0.06 ± 0.03	0.06 ± 0.03
DMI	0.09 ± 0.10		0.52 ± 0.01	0.53 ± 0.01	0.43 ± 0.01	-0.01 ± 0.01	-0.11 ± 0.02	0.27 ± 0.02
MY	0.03 ± 0.06	0.72 ± 0.03		0.91 ± <0.01	0.74 ± <0.01	-0.34 ± 0.01	-0.45 ± 0.01	0.06 ± 0.02
PY	0.03 ± 0.06	0.75 ± 0.03	0.91 ± <0.01		0.81 ± <0.01	0.08 ± 0.01	-0.22 ± 0.01	0.15 ± 0.02
FY	**0.15 ± 0.07**	0.77 ± 0.03	0.68 ± 0.01	0.83 ± 0.01		0.04 ± 0.01	0.24 ± 0.01	0.12 ± 0.02
P%	0.03 ± 0.06	0.03 ± 0.05	-0.30 ± 0.02	0.14 ± 0.02	0.27 ± 0.03		0.57 ± 0.01	0.14 ± 0.02
F%	0.14 ± 0.06	-0.08 ± 0.05	-0.54 ± 0.02	-0.26 ± 0.02	0.24 ± 0.02	0.72 ± 0.01		0.06 ± 0.02
BW	0.06 ± 0.06	0.48 ± 0.04	0.09 ± 0.03	0.17 ± 0.03	0.16 ± 0.03	0.17 ± 0.03	0.06 ± 0.03	

Genetic correlations below diagonal, and phenotypic correlations above diagonal

Results – Correlations between parities

	CH_4 parity 1	CH_4 parity 2	CH_4 parity 3+
CH_4 parity 1		0.51 ± 0.04	0.12 ± 0.03
CH_4 parity 2	0.97 ± 0.15		0.20 ± 0.03
CH_4 parity 3+	0.86 ± 0.20	0.96 ± 0.14	

Genetic correlations below diagonal, and phenotypic correlations above diagonal

Take home messages

- CH_4 concentrations measured with sniffers have **weak genetic correlations** with milk production traits, DMI, and BW
- Feasible to select for lower CH_4c, while improving other economically important traits like milk production
- The results are used to set up Dutch national breeding value estimations for CH_4

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Trait[1]	Parity	N cows	N records	Unit	Mean	SD	Min	Max	CV (%)
CH_4c	1	2,084	17,936		515	259	12	2,369	50
	2	1,843	15,265	ppm	557	282	7	2,095	51
	3+	3,743	38,364		592	305	5	2,087	51
CO_2c	1	385	2,369		4,168	1,685	7	9,483	40
	2	390	2,090	ppm	4,324	1,711	13	9,511	40
	3+	758	5,389		4,315	1,730	6	9,837	40
DMI	1	4,998	87,306		19.7	3.6	8	51	18
	2	3,500	54,660	kg/d	22.1	4.2	8	53	19
	3+	2,943	64,525		22.5	4.5	8	50	20
MY	1	8,891	179,469		27.4	7.1	1.0	59.1	26
	2	7,553	139,875	kg/d	31.6	9.6	1.0	59.4	31
	3+	5,776	213,539		32.1	10.3	0.9	59.4	32
ECM	1	8,889	139,295		27.5	6.0	3.1	56.4	22
	2	7,529	112,539	kg/d	32.4	8.6	3.8	60.3	27
	3+	5,760	186,581		33.6	9.5	3.2	59.3	28
PY	1	8,889	139,317		0.9	0.2	0.2	1.9	24
	2	7,539	112,996	kg/d	1.09	0.3	0.2	1.9	27
	3+	5,772	188,235		1.11	0.3	0.2	1.9	28
FY	1	8,889	139,328		1.13	0.3	0.1	2.5	22
	2	7,538	112,990	kg/d	1.34	0.4	0.1	2.5	27
	3+	5,767	187,445		1.40	0.4	0.1	2.5	29
P%	1	8,889	139,314		3.56	0.4	1.3	18.7	11
	2	7,539	112,850	%	3.61	0.4	0.4	12.4	12
	3+	5,768	187,801		3.55	0.4	1.0	14.6	12
F%	1	8,889	139,326		4.39	0.8	1.3	22.5	17
	2	7,536	112,778	%	4.47	0.8	0.6	14.5	17
	3+	5,763	186,934		4.50	0.7	0.5	18.6	17
BW	1	5,919	119,523		600	72	306	988	12
	2	4,532	91,817	kg	667	75	301	995	11
	3+	4,194	164,715		713	71	310	1,000	10