Ways to reduce GHG emissions of dairy cows by genetic selection

Yvette de Haas – Wageningen Livestock Research

Anouk van Breukelen, Michael Aldridge

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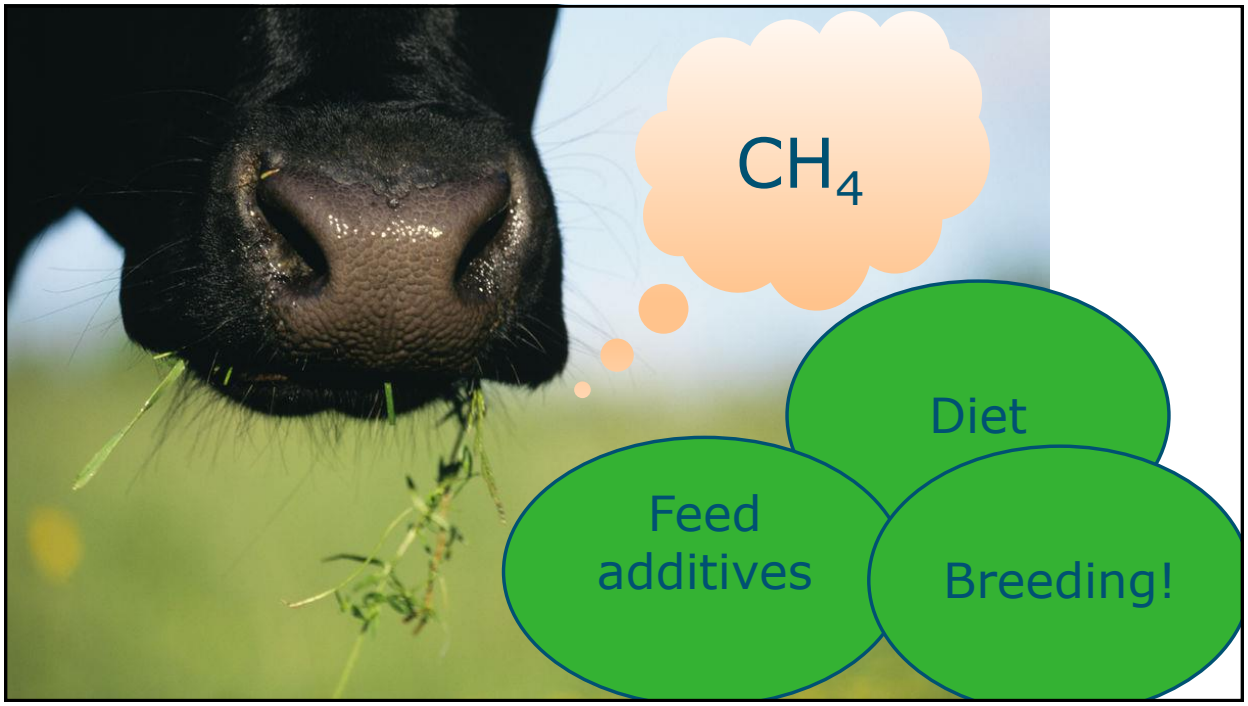

2

Why animal breeding as a mitigation tool?

Permanent change

Cumulative

No additional costs
(for the farmer)

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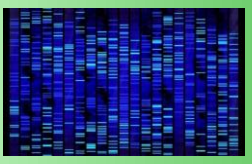
Developments in animal breeding

1980's	1990's	2000's	2010's
			
Solely on production	Fertility/ Health	Genomic selection	Feed efficiency / methane

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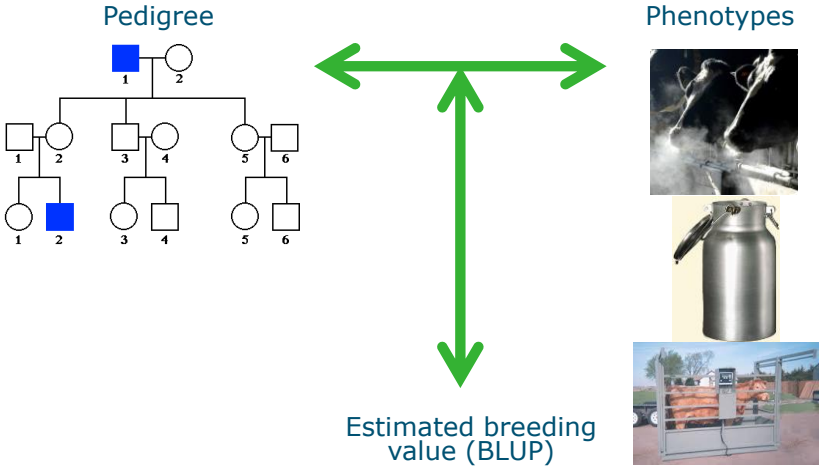
Traditional breeding (<2000's)



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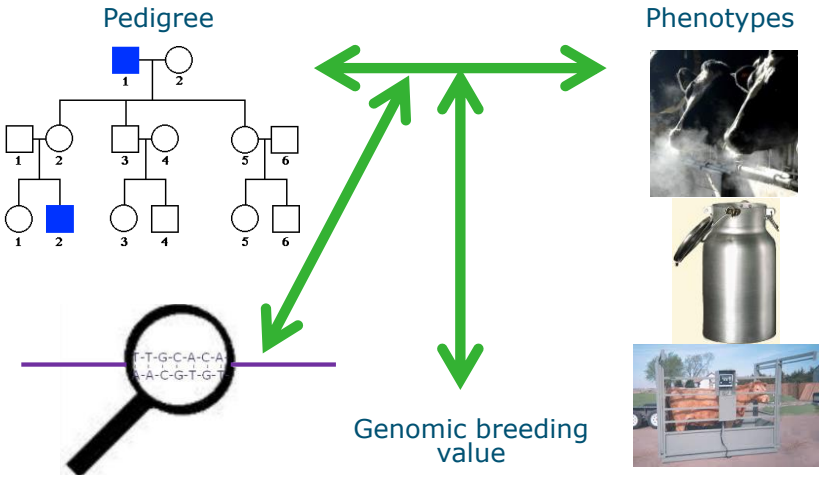
Genomic selection (>2000's)



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Dutch breeding goal

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Traits in breeding goal

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 MILK	lactose	**0.43**														
2	fat	0.38	**0.58**													
3	protein	0.88	0.58	**0.5**												
4 LONG	longevity	0.36	0.35	0.42	**0.12**											
5 MAST	udder health	-0.03	-0.02	-0.06	0.36	**0.09**										
6 FERT	int. 1st-last insemination	-0.34	-0.24	-0.29	0.25	0.27	**0.08**									
7	calving interval	-0.44	-0.33	-0.37	0.11	0.21	0.85	**0.15**								
8 CONFORM	udder	-0.08	-0.04	-0.10	0.11	0.27	-0.05	0.00	**0.34**							
9	legs	0.02	0.04	0.05	0.25	0.21	0.00	0.00	0.19	**0.17**						
10 BIRTH	direct calving ease	0.07	0.15	0.11	0.24	0.15	0.20	0.24	0.00	0.00	**0.07**					
11	maternal calving ease	0.00	0.00	0.00	0.16	0.09	0.25	0.24	0.10	0.10	0.19	**0.05**				
12	direct vitality	0.05	0.09	0.02	0.14	0.05	0.10	0.14	0.00	0.00	0.60	0.14	**0.04**			
13	maternal vitality	-0.04	-0.07	0.03	0.16	0.07	0.32	0.24	0.00	0.00	0.11	0.34	-0.16	**0.09**		
14 CLAW	claw health	0.00	0.15	0.07	0.33	0.09	0.10	0.14	0.15	0.65	0.16	0.06	0.03	0.10	**0.18**	
15 EFF	feed saved	0.20	0.35	0.30	0.50	-0.03	-0.10	-0.30	-0.09	-0.29	0.41	-0.20	0.17	-0.05	0.11	**0.25**

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CRV, 2018

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What if we add methane to the breeding goal?

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	MILK	lactose	**0.43**														
2		fat	0.38	**0.58**													
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9		legs	0.02	0.04	0.05	0.25	0.21	0.00	0.00	0.19	**0.17**						
10	BIRTH	direct calving ease	0.07	0.15	0.11	0.24	0.15	0.20	0.24	0.00	0.00	**0.07**					
11		maternal calving ease	0.00	0.00	0.00	0.16	0.09	0.25	0.24	0.10	0.10	0.19	**0.05**				
12		direct vitality	0.05	0.09	0.02	0.14	0.05	0.10	0.14	0.00	0.00	0.60	0.14	**0.04**			
13		maternal vitality	-0.04	-0.07	0.03	0.16	0.07	0.32	0.24	0.00	0.00	0.11	0.34	-0.16	**0.09**		
14	CLAW	claw health	0.00	0.15	0.07	0.33	0.09	0.10	0.14	0.15	0.65	0.16	0.06	0.03	0.10	**0.18**	
15	EFF	feed saved	0.20	0.35	0.30	0.50	-0.03	-0.10	-0.30	-0.09	-0.29	0.41	-0.20	0.17	-0.05	0.11	**0.25**
16	CH4	methane emission	*0.40*	*0.40*	*0.40*	?	?	?	?	?	?	?	?	?	?	?	*-0.40*

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CRV, 2018

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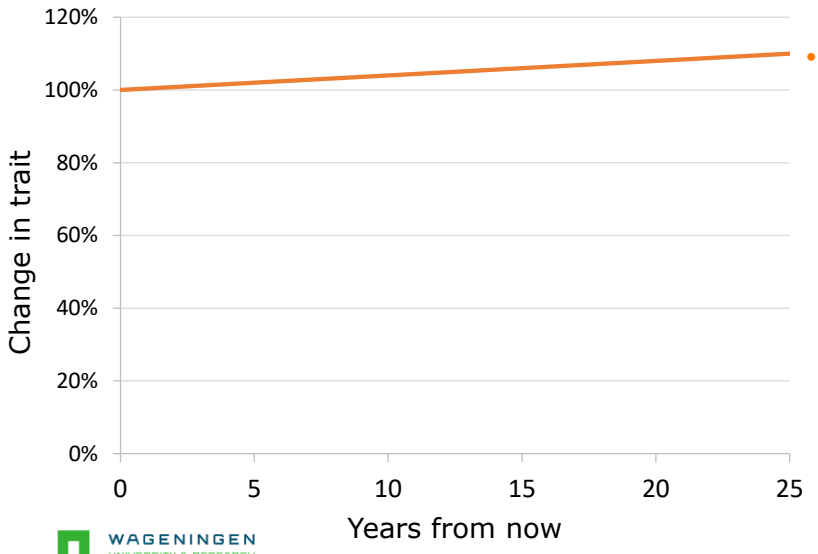
Impact current breeding goal



Current population:

CH_4: 392 g/d
Milk: 9000 kg (305 d)
Methane intensity:
16g CH_4/kg milk

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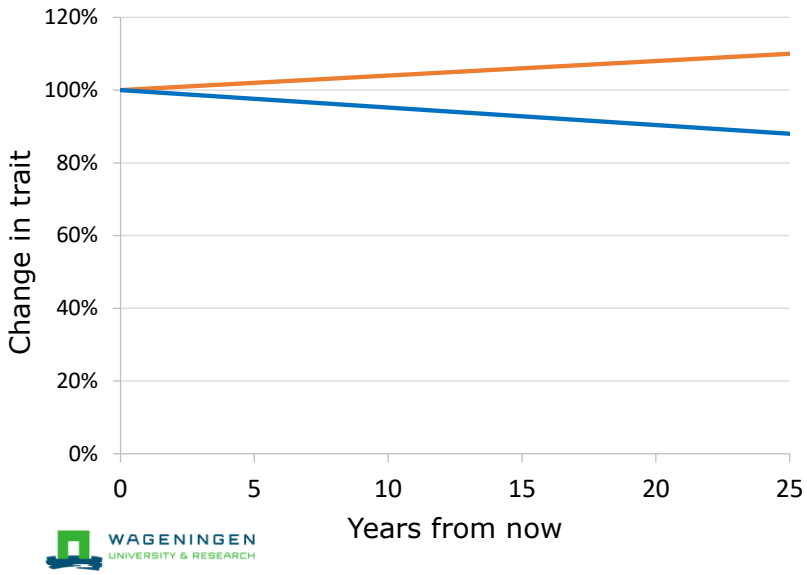
Impact current breeding goal



- Methane, g/d
- Methane, g/kg milk

Current population:

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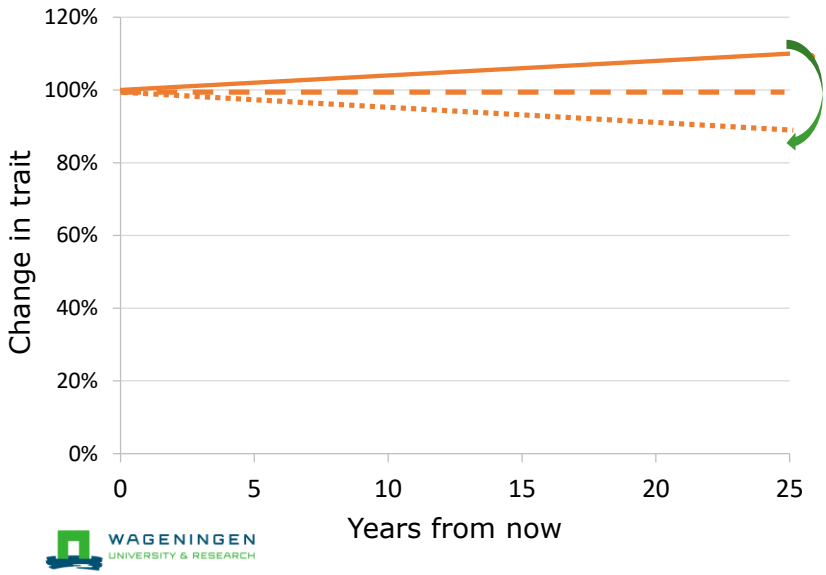
What if we can reduce methane through breeding?



Methane, g/d

Current population:

CH_4: 392 g/d
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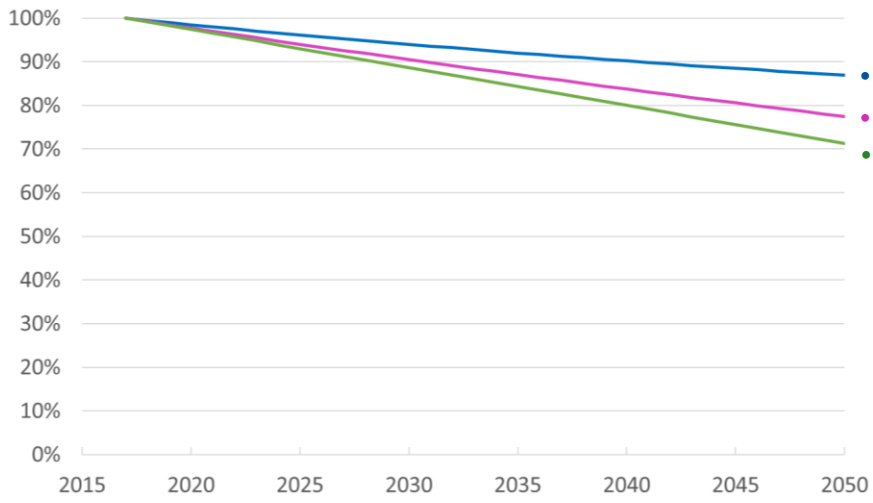
Impact breeding goal with methane



- Current (g/kg milk)
- Selective breeding
- Strong selection

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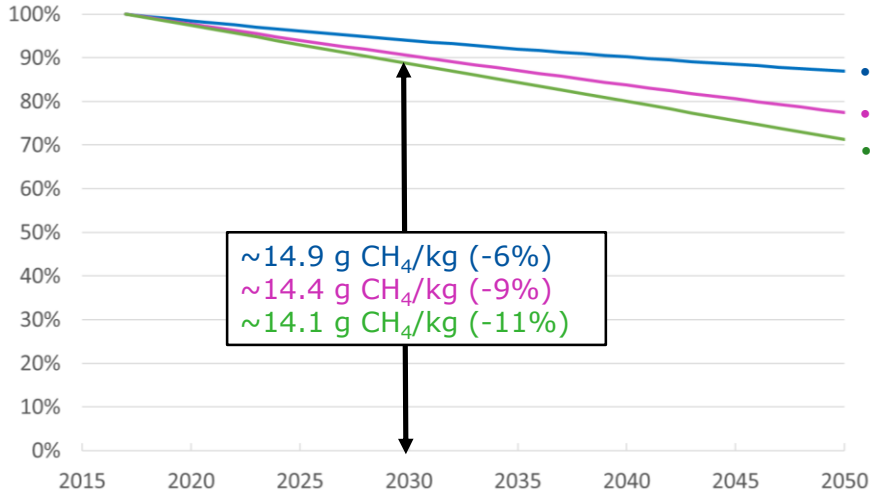
Impact breeding goal with methane



- Current (g/kg milk)
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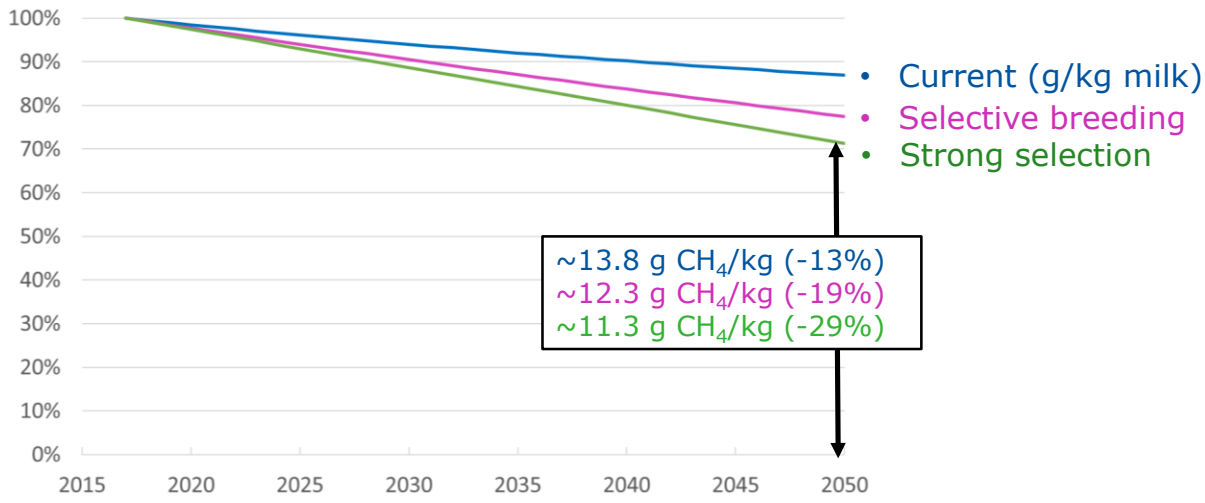
Impact breeding goal with methane



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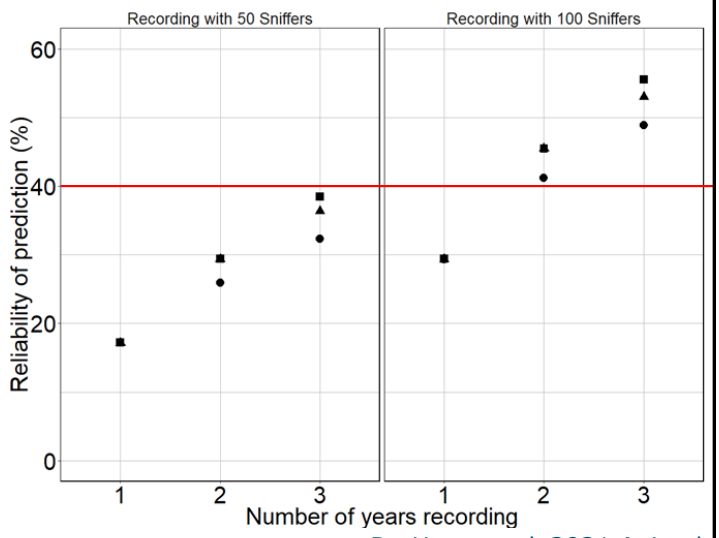
What do we need for breeding? Records!

- Minimal reliability of prediction is 40%
- At least 100 farms
- On avg ~150 cows/farm
- Recording for 2 years



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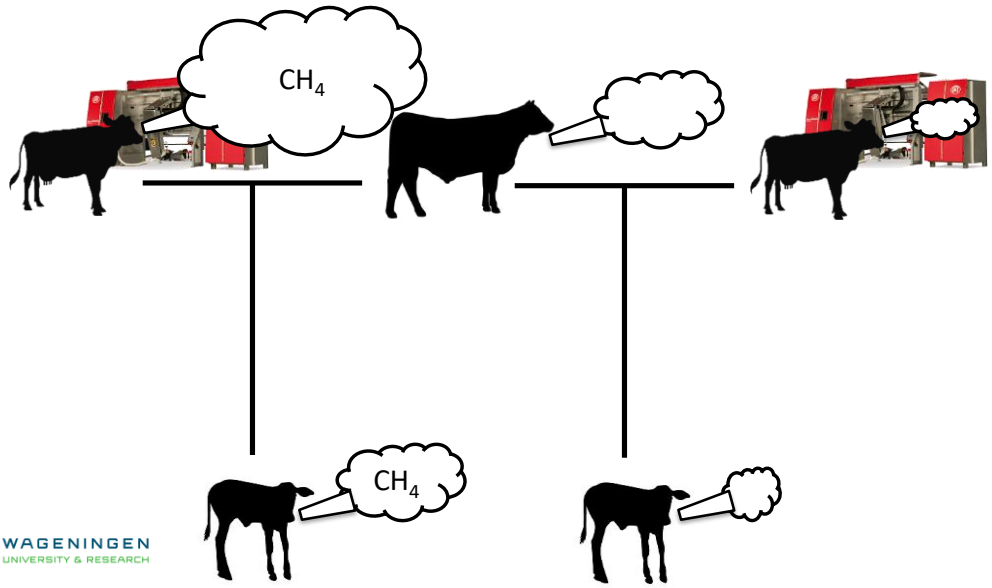
Ultimate aim



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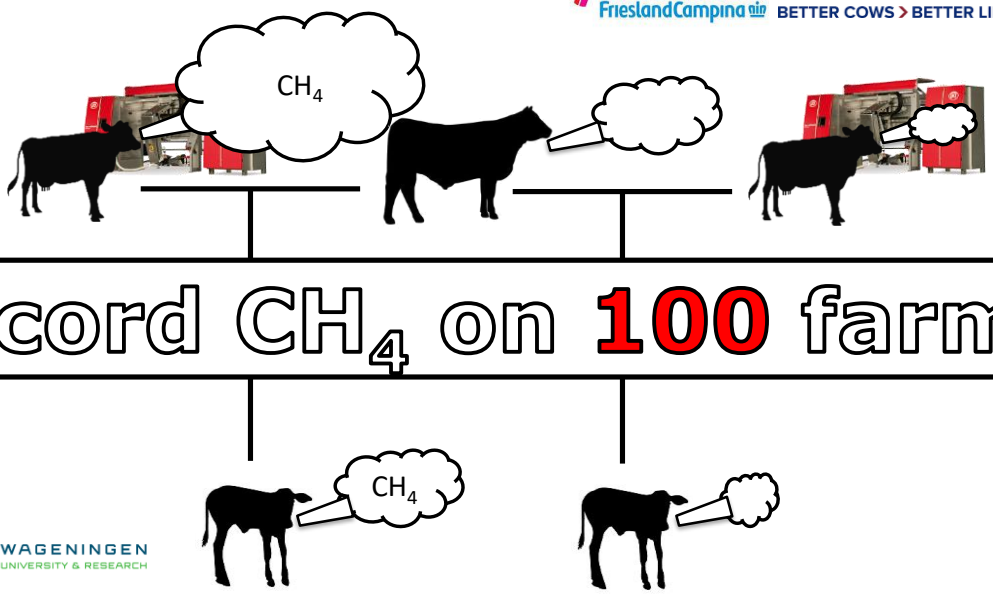
Ultimate aim

FrieslandCampina BETTER COWS > BETTER LIFE



record CH_4 on **100** farms

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Measuring enteric emissions

Sniffer

- Spot sampling method, installed in feed bin of a milking robot, measures concentration (ppm)

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

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Experience with sniffer

- 14 herds, March 2019 to September 2020
- CH_4 and CO_2 concentration (ppm)
  - Mean, median, log, ratio
- 308,968 visits from 1,746 Holstein cows
- 17,320 weekly records from 1,579 Holstein cows

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Results: Genetic parameters

	Visit		Week	
	heritability	repeatability	heritability	repeatability
mean CH_4 (ppm)	0.13	0.30	0.32	0.68
median CH_4 (ppm)	0.13	0.29	0.32	0.68
logCH_4	0.09	0.18	0.23	0.65
CH_4/CO_2	0.01	0.08	0.02	0.15

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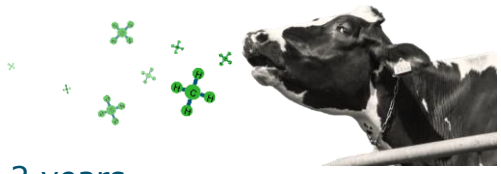
Next steps



- Longitudinal recording on 100 farms for 2 years
  - Creating a reference population of CH_4 with >13,000 cows
- Update genetic parameters
  - Heritability
  - Genetic correlations with other traits in breeding goal
- Select best index to actively breed for lower emitting cows

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In summary

- Breeding results in a continuous improvement of traits
- It is generally a slow process, so it should go hand in hand with other mitigation strategies

- It is high on the agenda in many countries
  - A lot is still unknown (e.g. correlations with other traits)
  - Currently simulations are with assumptions (*guestimates*), but more and more pieces are added to the puzzle

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Thank you for your attention

Yvette.deHaas@wur.nl

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twitter @Yvette_deHaas

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h^2 en m^2

PLOS GENETICS

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Host genetics and the rumen microbiome jointly associate with methane emissions in dairy cows

Gareth Frank Difford, Damian Rafal Plichta, Peter Løvendahl, Jan Lassen, Samantha Joan Noel, Ole Højberg, André-Denis G. Wright, Zhigang Zhu, Lise Kristensen, Henrik Bjørn Nielsen, Bernt Guldbrandtsen, Goutam Sahana

Version 2 Published: October 12, 2018 https://doi.org/10.1371/journal.pgen.1007580

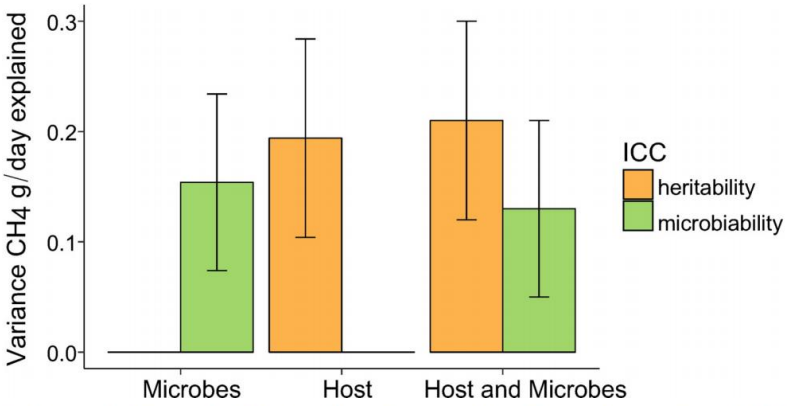

Fig 5. Proportion of variance in CH4 explained by different sources (Intra-class correlation coefficients, ICC) due to additive genetic effects (heritability) and rumen microbe content (microbiability), with respective standard errors when fit separately or jointly.

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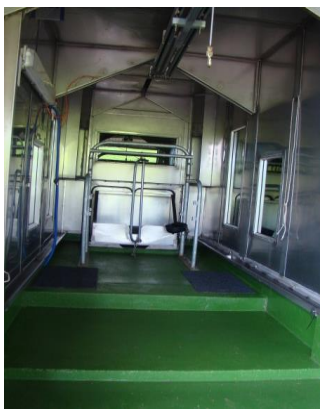
Measuring equipments (1/3)



Respiration chamber
Gold (*or bronze…*) standard!

SF_6

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Measuring equipments (2/3)

Laser

Sniffers (FTIR)

GreenFeed

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Measuring equipments (3/3)

Head hoods

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Features of equipments

- Robustness
- Intrusiveness
- Costs of 1 measurement
- Throughput
- Total time in life that animal can be recorded
- Labour intensity
- Automated matching with animal ID (risk on mistakes)
- Flow / Flux
- Concentration

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Conclusion of METHAGENE consortium

Best device

- No method is fully ideal for large scale monitoring
- Need to be aware of limitations
- All methods (used properly) provide valuable information
- All methods provide variable information
- *For animal breeding: Ranking of the animals is most important! Not necessarily (always) the most accurate measurement needed*

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