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Genetic approaches for methane mitigation strategies

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Why is genetics a PART of the solution?

› No economic value for farmer

› Effect of selection is permanent and cumulative.

› Progress for traits with low heritability

› Mastitis: 5% best vs 5% worst -10 treatments dif/100 cows

Measuring methane for genetic analysis

- A well defined trait…

- Methane / day
- Methane / output
- Methane / input
- Residual methane

- Selection trait vs breeding goal trait

Measuring methane for genetic analysis

- **Precise** measurements in **large** numbers
- Respiratory chambers are ”Golden Standard”
- Greenfeed
- Snapshot methods
- SF_6 methods
- ”All models/methods are wrong – but some are usefull”

Geneticists vs Nutritionists

- Acceptance by both disciplines
- Accurate, repeatable measures
- Same ranking of animals between methods

Sheep/Beef vs Dairy cattle

- Data from commercial farms are inevitable
- No training can be allowed
- Hard to individualise cows for long periods
- Expensive to have staff to handle equipment
- Useful phenotype for the farmer

Laser

Good and bad

- High capacity
- Non-invasive
- Small investment

- Spot samples
- No control of breath
- Quantification is a challenge

Quantifying methane production

- Measure methane and carbon dioxide concentrations
- Heat producing units (HPU) = 5.6 *live weight^{0,75} + 22*FPCM + 1.6*10^{-5}*days carried calf
- CH4_LITERS = CH4_RATIO*180*24*HPU
- Highly influenced by milk production
- Ignoring variation in CO_2 production

Madsen et al., 2010

Danish data

Trait	Units	#	Mean	SD	Min	Max
CH4_RATIO		3121	0.087	0.012	0.043	0.109
CH4_LITERS	L / day	1745	381	41.2	283	548
CH4_MILK	L/kg/day	1745	10.41	1.34	8.43	13.7
FPCM	L / day	3121	36.6	7.9	19.2	62.7
Weight	Kg	1745	647	68.4	467	890

Results

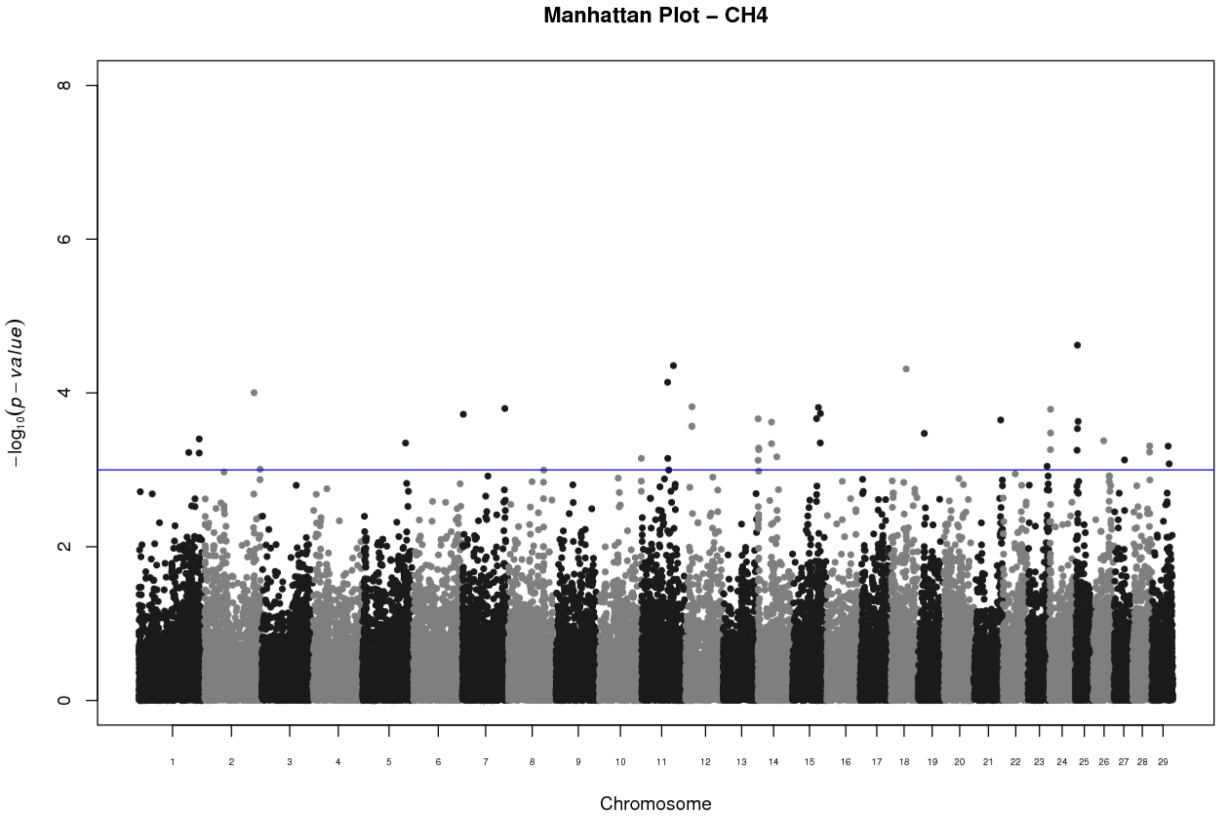
Trait	CH4_RATIO	CH4_LITERS	CH4_MILK	FPCM	Weight
CH4_RATIO	0.16	0.83	0.23	0.37	-0.16
CH4_LITERS	0.18	0.21	0.07	0.43	-0.18
CH4_MILK	0.21	0.11	0.21	0.15	-0.10
FPCM	0.04	0.12	0.21	0.27	-0.10
Weight	-0.12	-0.05	-0.05	0.04	0.35

h^2, r_g, r_e

Genomic prediction and GWAS

- 1739 Holstein cows
- Illumina 50 K SNP beadchip

Genome wide association study



From G Sahana

Genomic prediction

- Five-fold cross validation procedure
- Whole data randomly into five subsets
- Reliability = $(r_{ebv,y_c})^2/h^2$
- Regression of y_c on estimated breeding values

- Compares BLUP, GBLUP and $GBLU_w$

Genomic prediction

Model	**Validation set**	
	Reliability	Regression
BLUP	0.171	1.025
GBLUP	0.175	1.002
GBLU$_w$	0.183	1.003

MILK

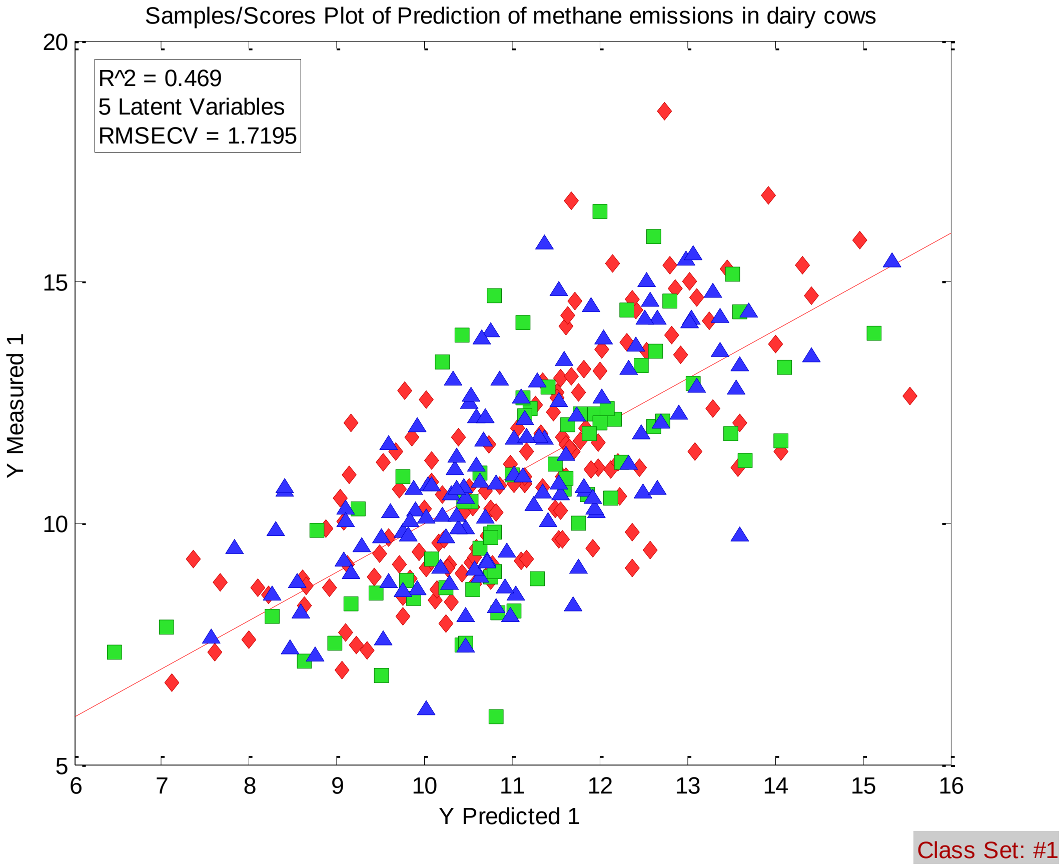
Milk as predictor

- Milk is measured routinely
- Milk spectra is available in many countries
- Many very optimistic results predicting phenotypes from milk spectras: Feed efficiency (McPharland et al 2014), Methane emission (Dehareng et al., 2012)

Design description

- 340 genotyped Holstein cows
- 3 herds
- Similar feeding regime
- Milk spectra from sample from morning milking
- Methane using CO_2 method

Predicted vs measured methane



Fatty acids

- Methane / Kg Milk
- Pedigree based
- SNP based

	Correlations pedigree	Correlations genomic
C6	-0.65	-0.71
C8	-0.80	-0.60
C10	-0.82	-0.51
C12	-0.63	-0.17
C13	-0.66	0.57
C14	0.09	0.13
C15	0.40	0.50
C16	-0.05	0.23
C17	0.39	0.28
C18	0.18	-0.06
C18:1trans11	-0.70	0.03
C18:2n6cis	0.33	0.22
Fat	0.59	0.11
Protein	0.78	0.46
Mean se	0.61	0.43

Milk as predictor

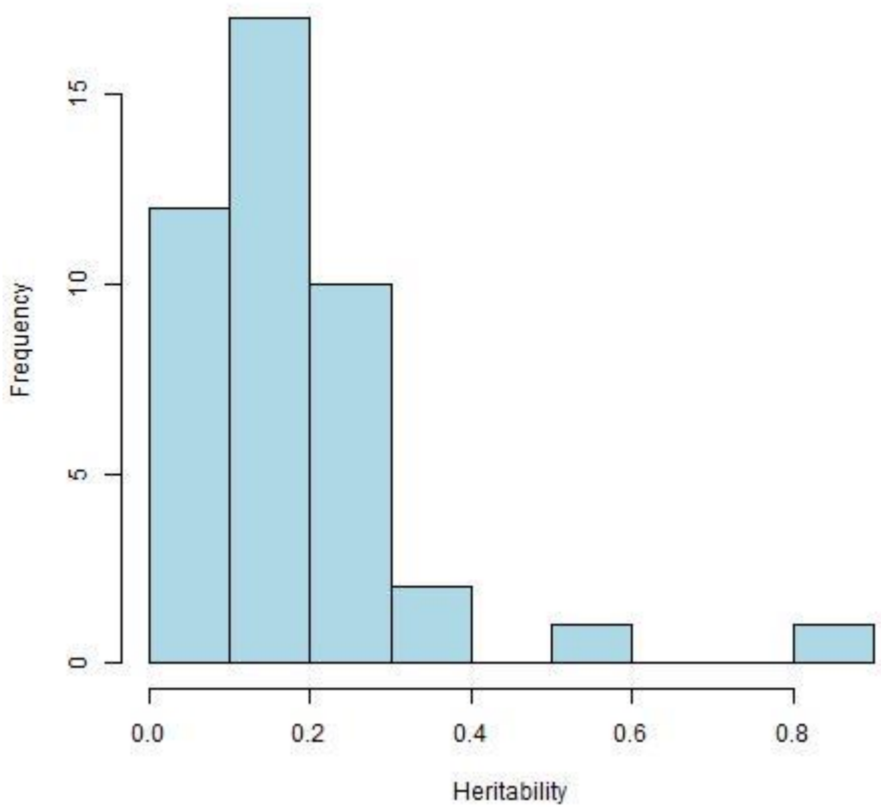
- Not as optimistic as other studies
- Less accurate methane measurements – but many
- Room to learn and understand more on underlying biology

RUMEN MICROBIOME

Host microbiome interaction

- 1000 cows genotyped and phenotyped
- Milk, rumen samples
- Methane measurements
- 16s analysis of bacteria and archcea

Heritability estimates of bacteria



From Goutam Sahana

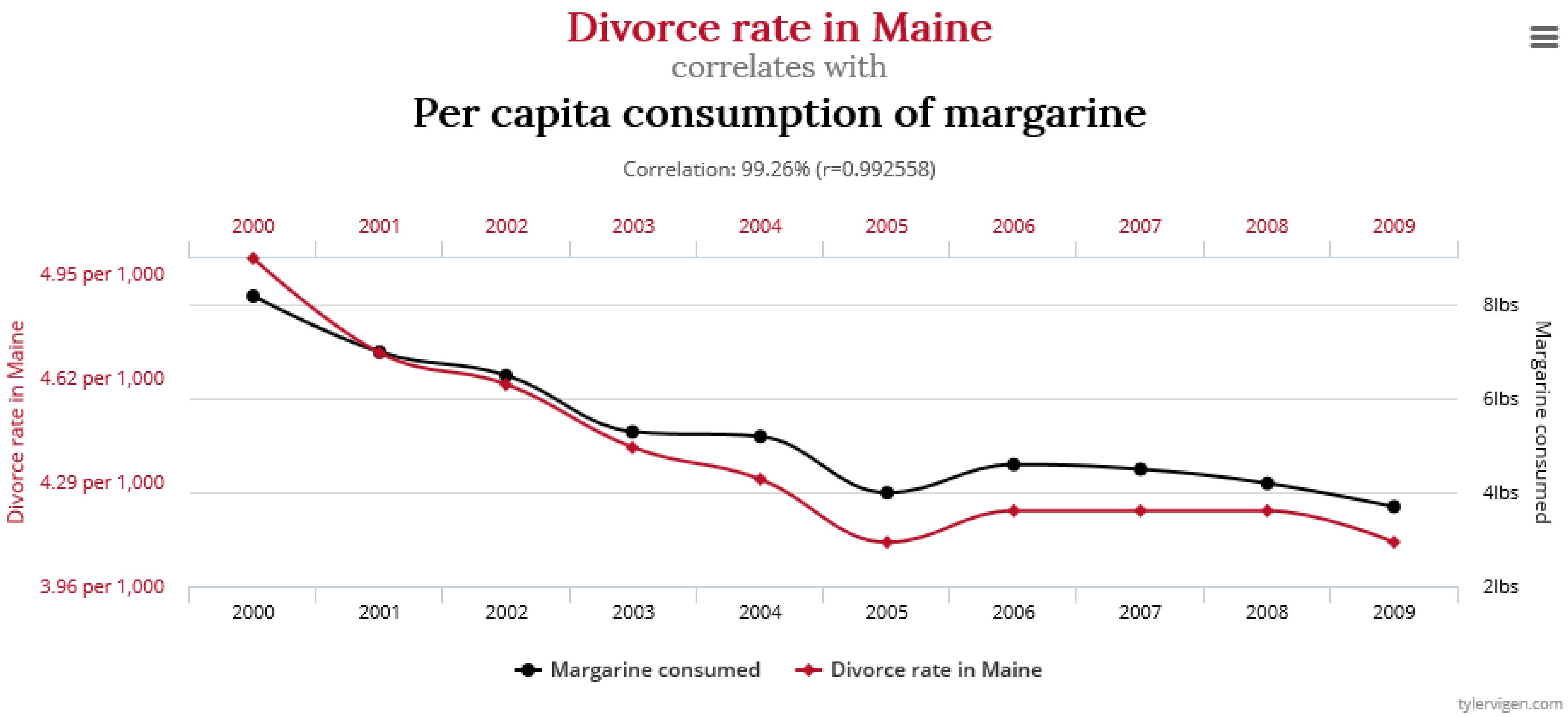
International collaboration

- Comparison and validation of methods
- Integration of methods for analysis across countries
- Estimation of genetic and genomic parameters
- Correlation to other traits

- METHAGENE, ICAR, RUMINOMICS and ASGGN

Black box biology

- Cross validations
- Independent data
- What is causal and what is just by chance?



Divorce rate in Maine
correlates with
Per capita consumption of margarine

Correlation: 99.26% (r=0.992558)

tylervigen.com

Conclusion

- Methane emission is under some genetic control
- Selection for increased milk yield will also increase methane production
- Our results on milk data is not as positive as other studies

Conclusion

› The rumen content is under some host genetic control

› International collaboration is needed an initiated

› There is still a lot to do…

Job openings at QGG – post docs

- Genomic prediction models for new phenotypes in dairy cattle
- Genetic and genomic relationship between methane, feed efficiency and cost reducing traits
- Welcome phd-students