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Differences in milk composition associated with enteric methane emissions

Suzanne Rowe, Melanie Hess, Timothy Bilton, Tricia Johnson, Sharon Hickey, Cesar Pinares, Arjan Jonker, Rudiger Brauning, Peter Janssen & John McEwan

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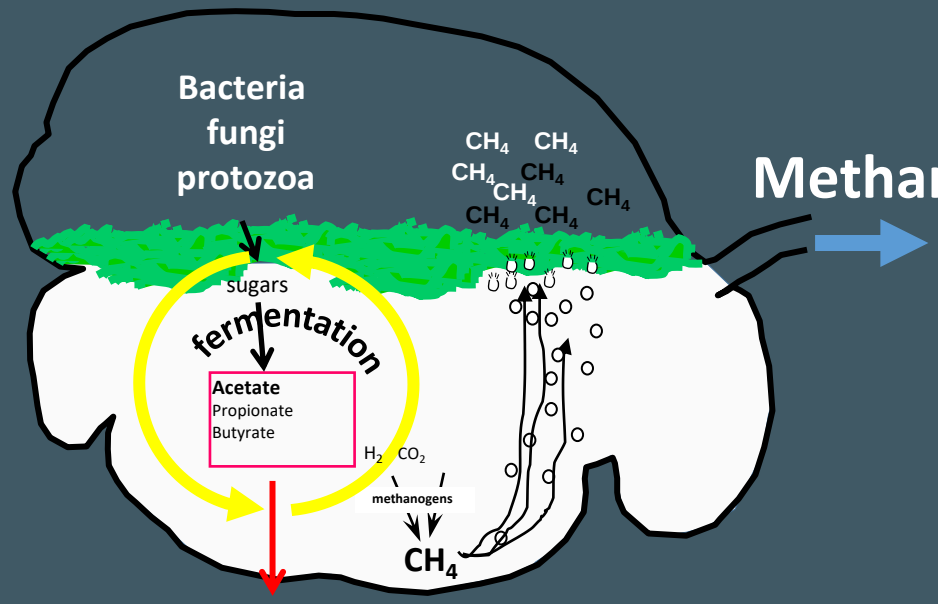
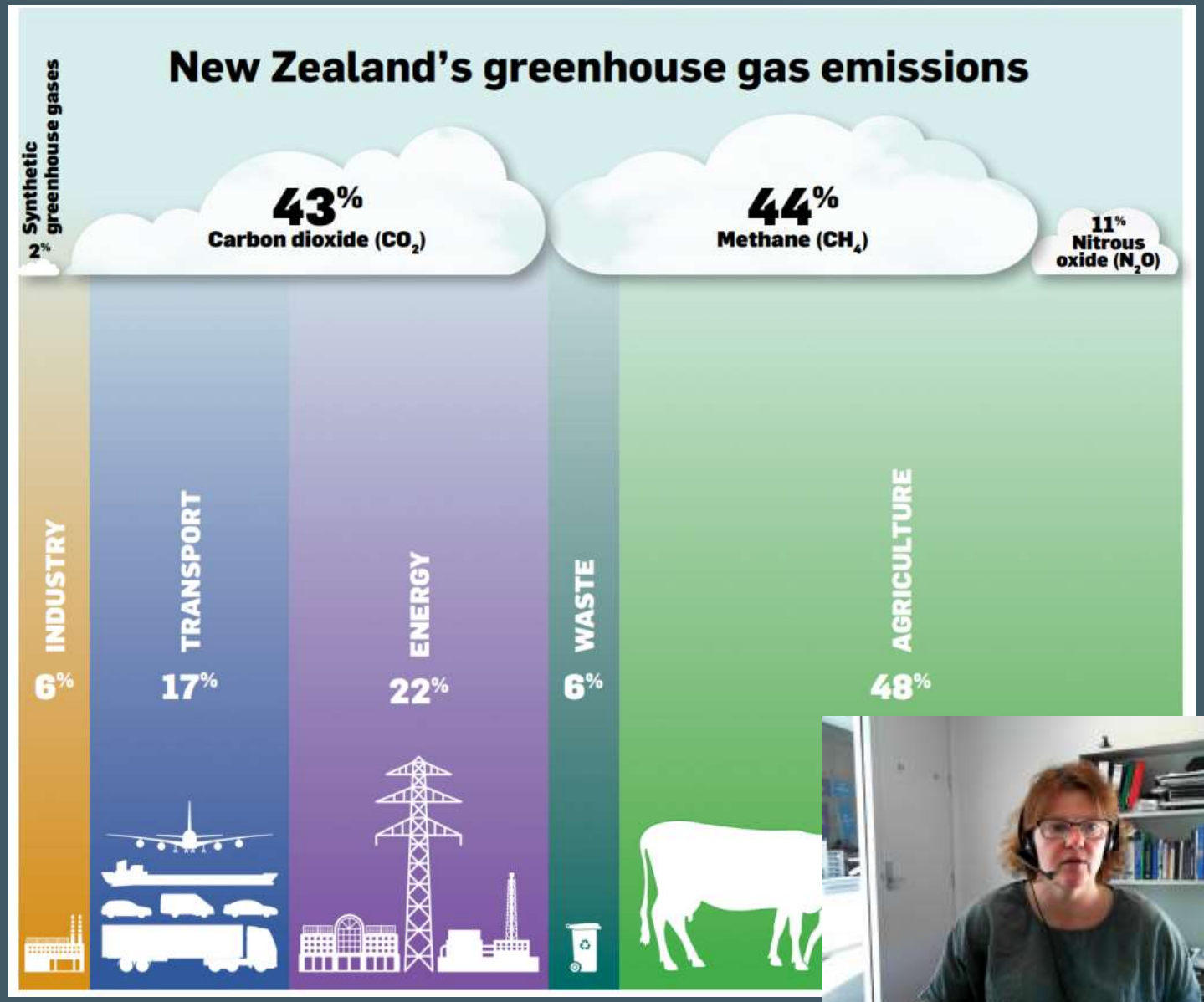
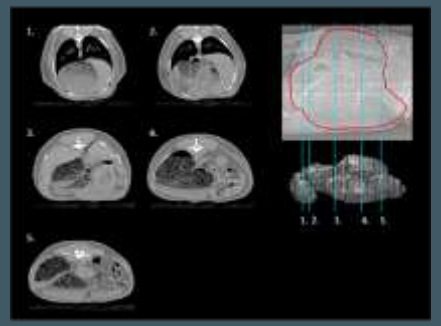


Methane

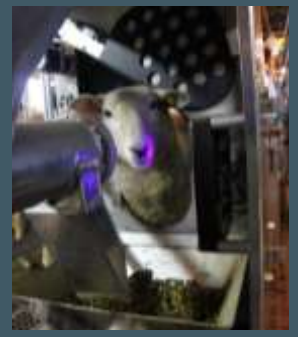


Breeding for Lower emissons



Detailed measures

Short term measures plus genomic prediction



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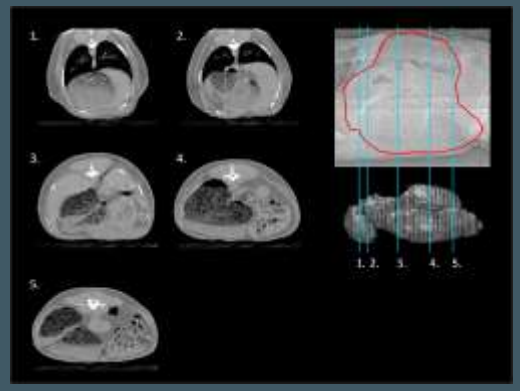
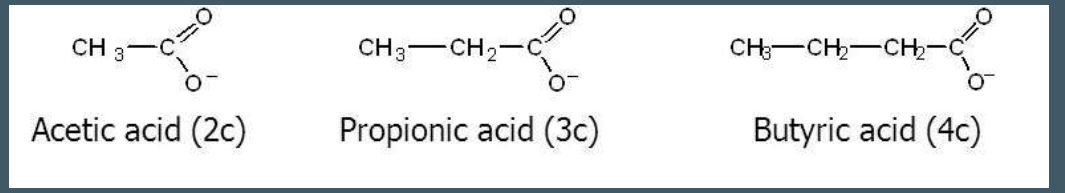
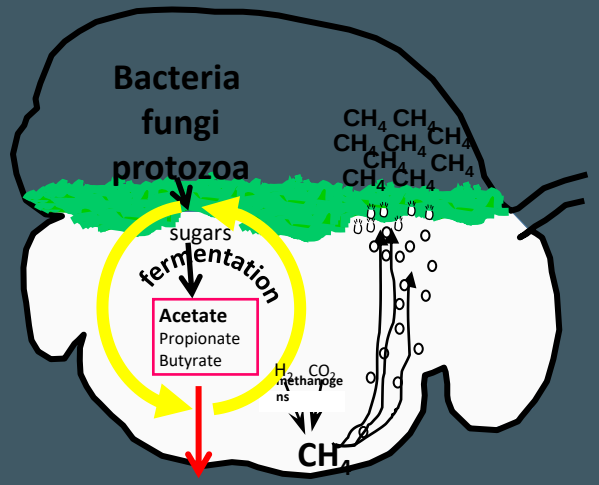
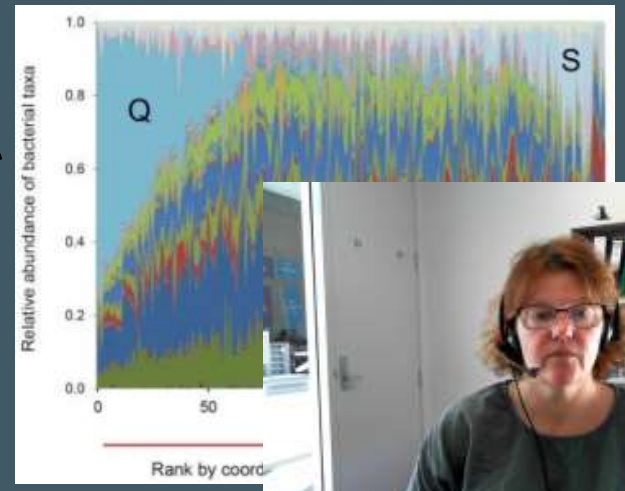
Low Methane animal

- ~11% less methane per kg feed eaten
- 20% smaller rumens but same surface area
- Eats more, eats little and often
- Different microbial fermentation
- Different energy profile – more propionate
- More lean growth, less fat, more wool
- Healthy and profitable









Meat – fatty acid profiles

	HighGHG	LowGHG	P value
GR	16.5 ± 1.06	14.8 ± 1.28	0.0853
IMF%	4.67 ± 0.39	4.84 ± 0.46	0.0673
SFA	3.86 ± 0.01	3.84 ± 0.01	0.0196
MUFA	3.77 ± 0.01	3.76 ± 0.01	0.4728
PUFA	2.07 ± 0.02	2.16 ± 0.03	0
BC	0.84 ± 0.02	0.87 ± 0.02	0.0232
C10:0	0.05 ± 0.00	0.04 ± 0.00	0.0676
Artifact:1	0.05 ± 0.00	0.05 ± 0.00	0.8649
C12:0	0.03 ± 0.00	0.03 ± 0.00	0.6162
iso C14	0.01 ± 0.00	0.01 ± 0.00	0.2387
C14:0	0.43 ± 0.01	0.43 ± 0.01	0.9527
iso C15	0.06 ± 0.00	0.06 ± 0.00	0.1388
anteiso C15	0.06 ± 0.00	0.07 ± 0.00	0.0185
C14:1	0.01 ± 0.00	0.01 ± 0.00	0.1821
C15:0	0.12 ± 0.00	0.13 ± 0.01	0.0499
Artifact:2	0.24 ± 0.01	0.26 ± 0.01	0.3848
iso C16	0.05 ± 0.00	0.05 ± 0.00	0.0235
Unknown 3	0.02 ± 0.00	0.02 ± 0.00	0.0578
Unknown 4	0.03 ± 0.00	0.03 ± 0.00	0.0666
C16:0	1.38 ± 0.01	1.37 ± 0.01	0.5731
Unknown 5	0.03 ± 0.00	0.04 ± 0.00	0.0538
Unknown 6	0.01 ± 0.00	0.01 ± 0.00	0.6384
Unknown 7	0.01 ± 0.00	0.02 ± 0.00	0.1102
C16:1t	0.04 ± 0.00	0.05 ± 0.01	0.0014
iso C17	0.15 ± 0.00	0.16 ± 0.00	0.053
Unknown 8	0.13 ± 0.00	0.13 ± 0.00	0.1536
C16:1	0.28 ± 0.01	0.29 ± 0.01	0.0099
anteiso C17	0.17 ± 0.00	0.18 ± 0.01	0.0298
Unknown 9	0.02 ± 0.00	0.01 ± 0.00	0.3494
C17:0	0.28 ± 0.00	0.28 ± 0.00	0.2142
Artifact:3	0.27 ± 0.01	0.26 ± 0.01	0.5595
Unknown 10	0.06 ± 0.00	0.06 ± 0.00	0.2063
Unknown 11	0.04 ± 0.00	0.04 ± 0.00	0.2563
C17:1	0.14 ± 0.00	0.15 ± 0.00	0.0384
Unknown 12	0.01 ± 0.00	0.02 ± 0.00	0.0622
Unknown 13	0.04 ± 0.00	0.04 ± 0.00	0.9629
C18:0	1.30 ± 0.01	1.28 ± 0.01	0.0023
Unknown 14 C18:1t	0.05 ± 0.00	0.06 ± 0.00	0.0159
C18:1 t9	0.08 ± 0.00	0.08 ± 0.00	0.0056

	HighGHG	LowGHG	P value
C18:1 t11	0.56 ± 0.03	0.62 ± 0.03	0.0046
C18:1c9	1.58 ± 0.01	1.57 ± 0.01	0.0136
C18:1c11	0.27 ± 0.00	0.28 ± 0.00	0
Unknown 15	0.06 ± 0.00	0.06 ± 0.00	0.0002
Unknown 16	0.02 ± 0.00	0.02 ± 0.00	0.1392
Unknown 17	0.13 ± 0.00	0.13 ± 0.00	0.0009
Unknown 18	0.05 ± 0.00	0.06 ± 0.00	0.0138
Unknown 19	0.04 ± 0.00	0.04 ± 0.00	0.7978
C18:2tt n6	0.12 ± 0.00	0.13 ± 0.00	0.0001
Unknown 20	0.06 ± 0.00	0.07 ± 0.00	0
Unknown 21	0.01 ± 0.00	0.01 ± 0.00	0.2926
Unknown 22	0.10 ± 0.00	0.12 ± 0.01	0
C18:2 n6	0.48 ± 0.01	0.52 ± 0.01	0.0001
Unknown 23	0.03 ± 0.00	0.03 ± 0.00	0.1553
Unknown 24	0.01 ± 0.00	0.01 ± 0.00	0.3738
Unknown 25	0.02 ± 0.00	0.02 ± 0.00	0.8705
Unknown 26	0.01 ± 0.00	0.01 ± 0.00	0.7695
C20:0	0.03 ± 0.00	0.02 ± 0.00	0.1941
C18:3 n3	0.43 ± 0.01	0.46 ± 0.01	0
9 11 CLA	0.29 ± 0.02	0.33 ± 0.02	0.001
Unknown 27	0.01 ± 0.00	0.02 ± 0.00	0.0723
Unknown 28	0.01 ± 0.00	0.01 ± 0.00	0.5364
Unknown 29	0.01 ± 0.00	0.01 ± 0.00	0.7318
Unknown 30	0.07 ± 0.00	0.09 ± 0.00	0
Unknown 31	0.07 ± 0.00	0.06 ± 0.00	0.0001
Unknown 32	0.03 ± 0.00	0.04 ± 0.00	0.173
C20:4 n6	0.19 ± 0.01	0.20 ± 0.01	0.5907
C22:1	0.01 ± 0.00	0.01 ± 0.00	0.3251
Unknown 33	0.02 ± 0.00	0.02 ± 0.01	0.3411
Unknown 34	0.01 ± 0.00	0.01 ± 0.00	0.7671
Unknown 35	0.01 ± 0.00	0.01 ± 0.00	0.673
Unknown 36	0.02 ± 0.00	0.02 ± 0.00	0.706
C20:5 n3	0.20 ± 0.01	0.21 ± 0.01	0.55
C22:2	0.01 ± 0.00	0.02 ± 0.00	0.06
Unknown 37	0.01 ± 0.00	0.01 ± 0.00	0.465
C22:5	0.17 ± 0.01	0.17 ± 0.01	0.992
C22:6 n3	0.08 ± 0.00	0.07 ± 0.01	0.309

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Milking Trial

200 ewes, 100 highs and 100 lows

3 Timepoints 2, 4 and 6 weeks post lambing.

Separated from lambs for 2 hours.

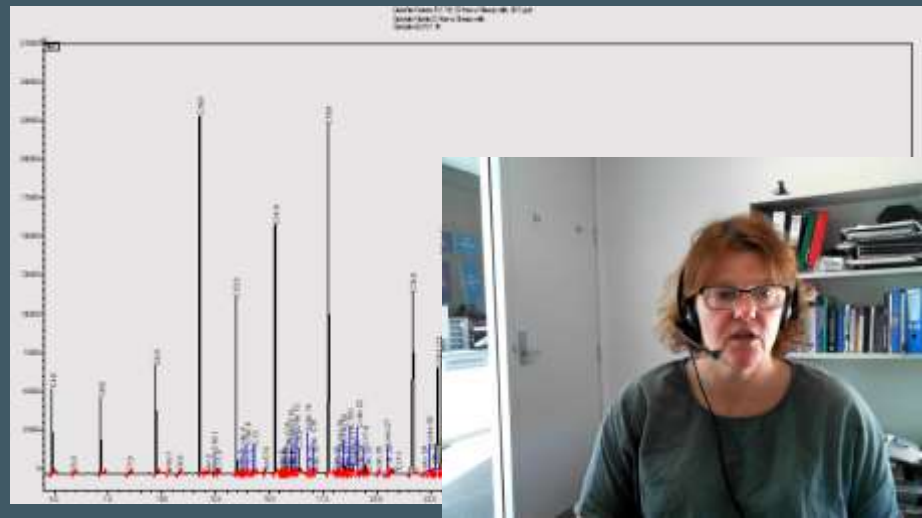
From each Ewe took

- Milk
- Blood
- Rumen fluid
- Methane emissions

Testing

- A standard milk herd test profile
- fat, protein, lactose, SCC
- Milk fatty acids
- Blood Plasma volatile fatty acids
- Rumen microbial profile
- Rumen volatile fatty acids
- A methane yield breeding value

LIC, Christchurch, NZ



Agnew et al., 2019; Jonker et al.,2019, Hess et al.,2020

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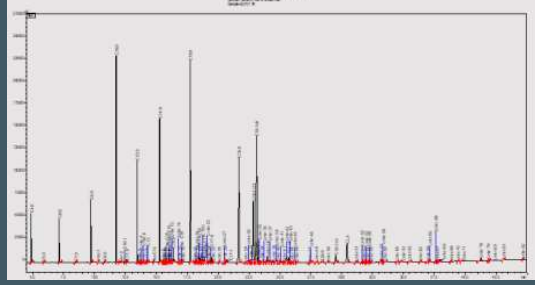
Results



$$\log_{10}(y) = \mu + \text{date*lamb\_group} + \text{Ewe Age} + \text{nlambs} + \text{lwt} + \text{line} + p_e$$

Milk			
Constituent	Low	High	p-value
Fat (%)	5.07	5.00	0.910
Protein (%)	5.04	5.14	0.169
Lactose (%)	5.79	5.78	0.451
Total Solids (%)	16.28	16.28	0.797
Somatic Cell Count '000	260	182	<.001*
Methane Yield g/kg DMI	-1.22	+1.14	<.001

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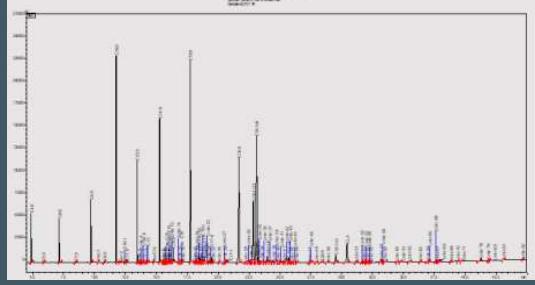


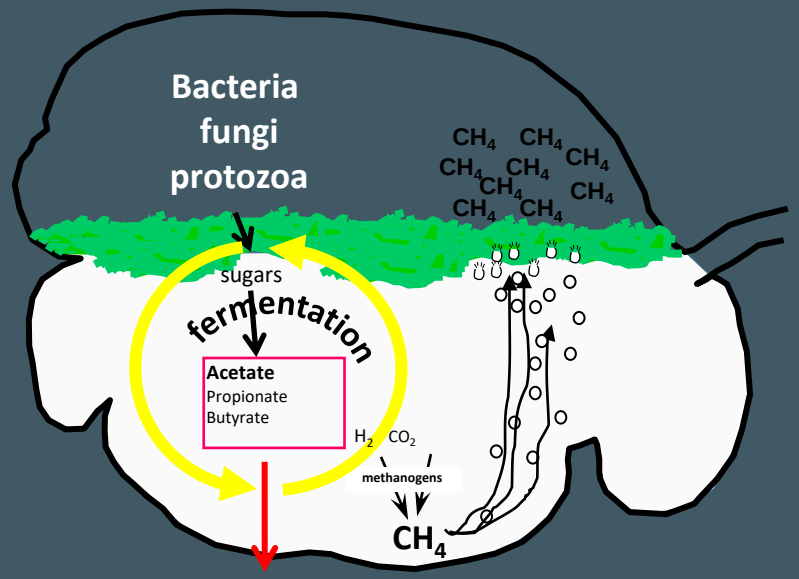
Results

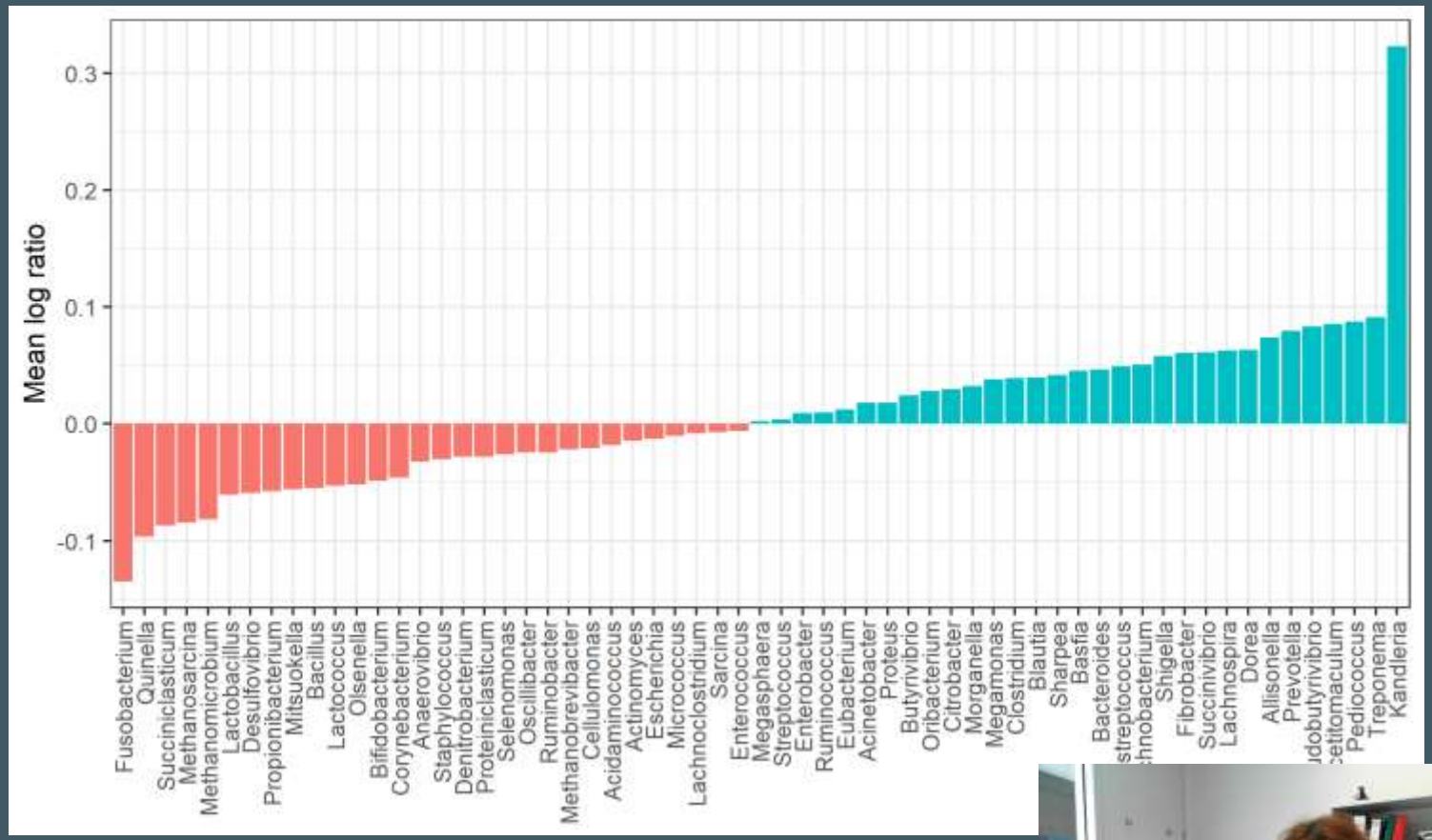
$\log_{10}(y) = \mu + \text{date*lamb\_group} + \text{Ewe Age} + \text{nlambs} + \text{lwt} + \text{line} + p_e$

Milk Fatty Acid	% Diff	P-value
C18:1 t9	5.6	0.034
C18:1 t11	8.7	0.001
C18:1 c9	-2.3	0.206
C18:1 c11	8.2	0.024
C18:2 n6	9.5	<.001
C18:3 n3	12.7	<.001
C20:0	-4.9	0.007
CLA	12.3	<.001
SFA[2]	-2.7	<.001
PUFA[3]	11.9	<.001

Rumen VFAs	% diff	p-value
Concentrations		
Acetic (mM)	-7.9	0.009*
Butyric (mM)	-7.0	0.060
Caproic (mM)	6.1	0.243
Isobutyric (mM)	-9.4	0.012*
Isovaleric (mM)	-10.2	0.030*
Propionic (mM)	-5.2	0.122
Valeric (mM)	-6.5	0.113
SCFA (mM)	-7.9	0.009*
Proportions[1]		
Butyric	-0.8	0.073
Caproic	4.6	0.013*
Propionic	1.1	0.003*
Ratios		
Acetic/Propionic	-2.9	0.012*
(A + B)/(P + V)[2]	-2.7	0.009*

The next generation of predictors





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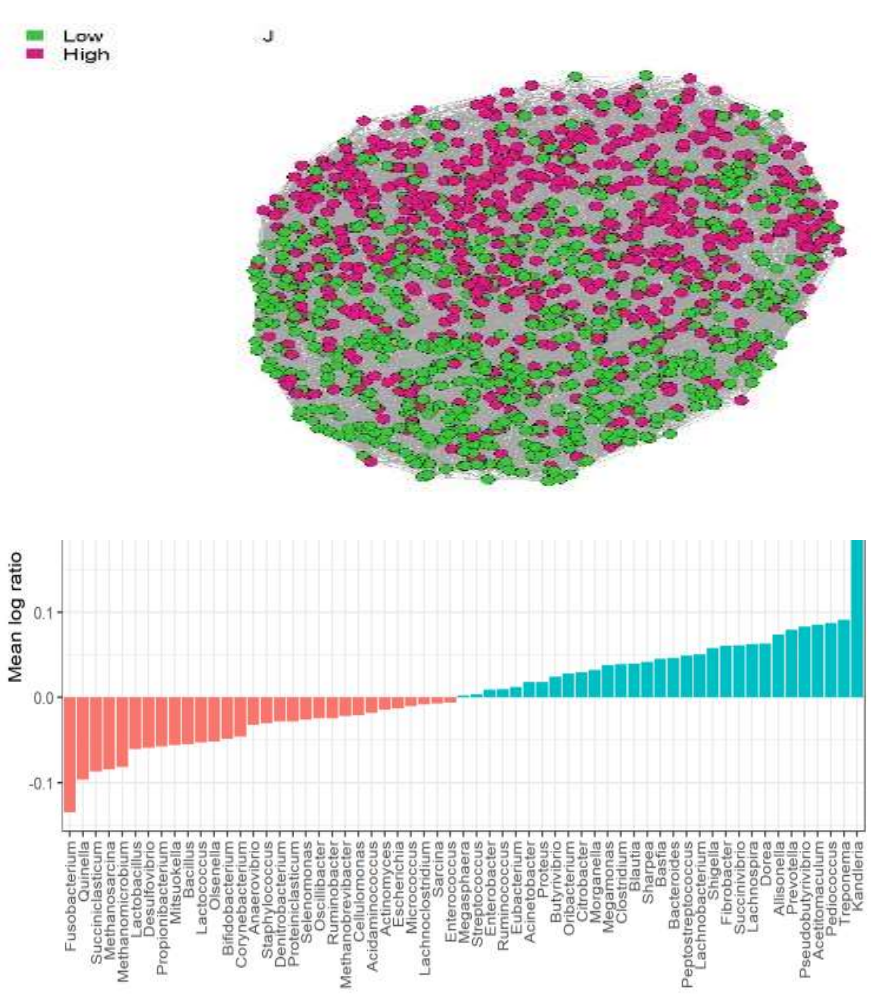
$$\log_{10}(y) = \mu + \text{date*lamb\_group} + \text{Ewe Age} + \text{nlambs} + \text{lwt} + \text{line} + \mathbf{M}$$



FA (%)		FA (%)	
SFA	0.18 ± 0.07	PUFA	0.33 ± 0.09
C12:0	0.11 ± 0.07	C18:2 n6	0.21 ± 0.09
C14:0	0.04 ± 0.05	C18:3 n3	0.28 ± 0.09
C15:0	0.01 ± 0.04	CLA	0.26 ± 0.08
C16:0	0.16 ± 0.07	VFA (%)	
C17:0	0.07 ± 0.07	Acetic	0.38 ± 0.09
C18:0	0.07 ± 0.06	Butyric	0.48 ± 0.08
C20:0	0.07 ± 0.06	Caproic	0.32 ± 0.08
MUFA	0.08 ± 0.08	Isobutyric	0.54 ± 0.09
C14:1	0.00 ± 0.00	Isovaleric	0.52 ± 0
C16:1	0.01 ± 0.05	Propionic	0.28 ± 0
C17:1	0.15 ± 0.09	Valeric	0.41 ± 0
C18:1 c9	0.16 ± 0.09	A/P	0.31 ± 0
C18:1 c11	0.41 ± 0.10	(A+B)/(P+V)	0.30 ± 0

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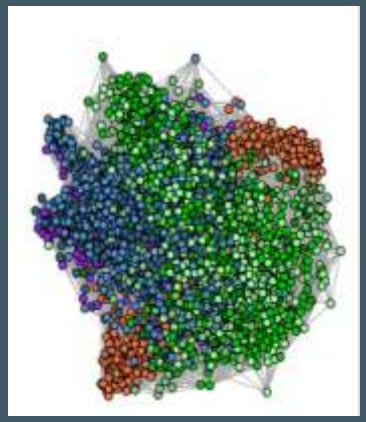
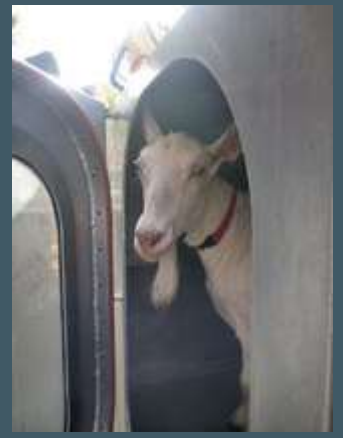
Proposal for NZ Ruminants

- Measure Sires
  - Direct methane measures
  - Rumen samples, Blood, DNA





- Screen wider population

Use milk profiles to identify breeding candidates

SFA and PUFA

Rumen profiles

propionic

Validation

Acknowledgements

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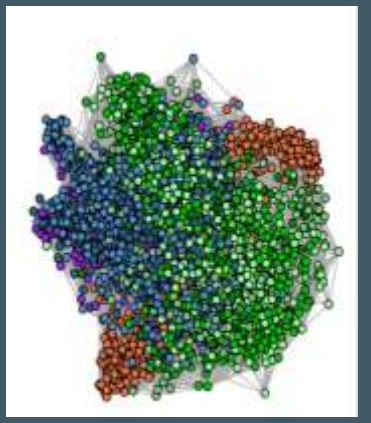
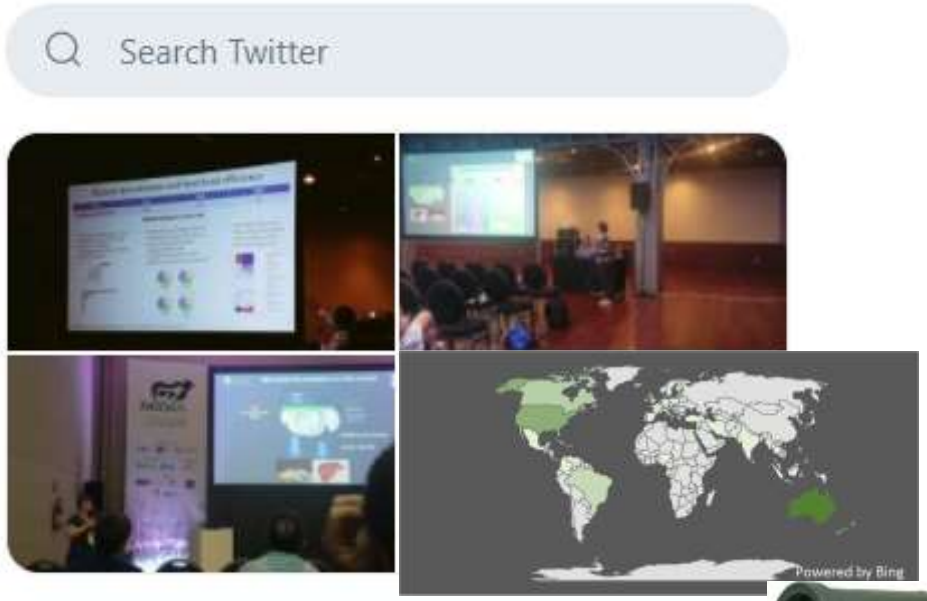
- Pastoral Greenhouse Gas Research Consortium
- New Zealand Agricultural Greenhouse Gas Research Centre
- Ministry for Primary Industries
- Ministry for Business, Innovation and Enterprise
- Global Research Alliance
- AgResearch
- Beef and Lamb New Zealand Genetics

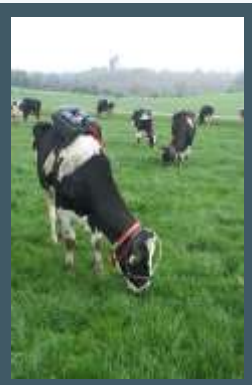
Looking Forward

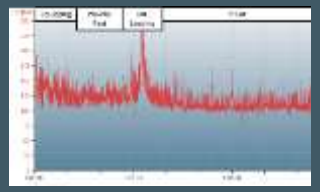
- Sheep selection lines
    - Pushing the envelope
- Nationwide breeding programs
- Transfer of technologies
- New ways to predict
- Impact analyses



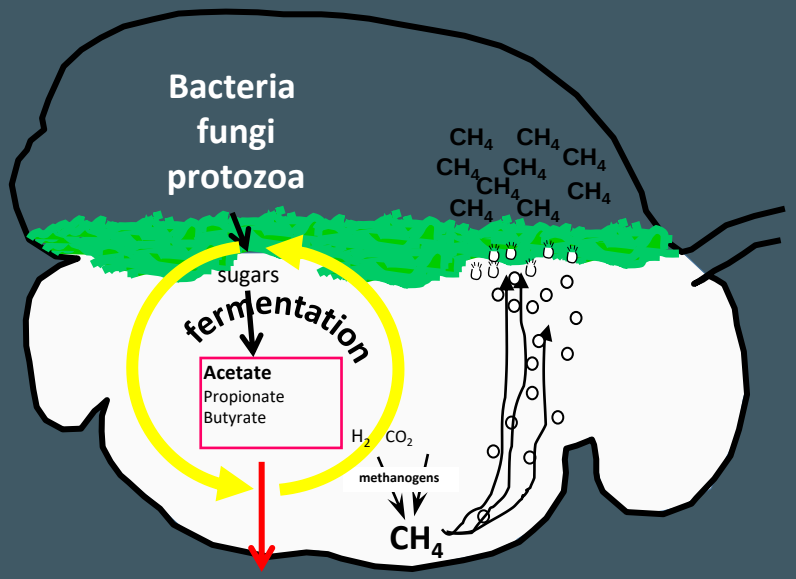


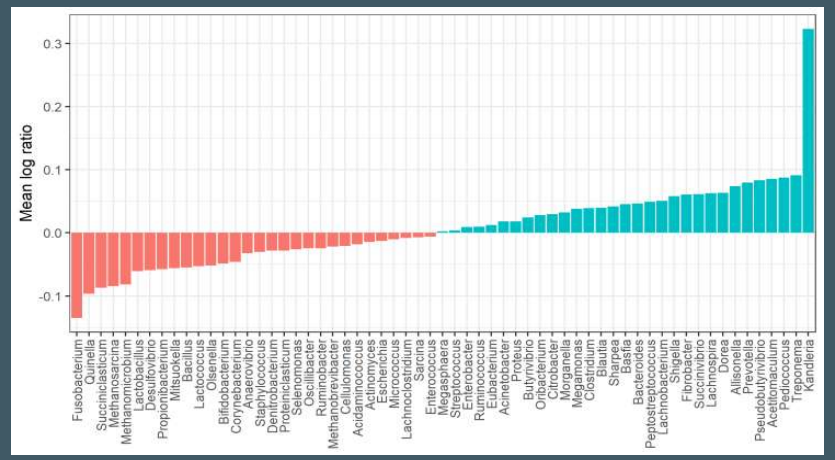
- Identification of new collaborations and connections
- Defining traits and breeding objectives
- Establishing the heritability of methane emissions and its genetic associations with other performance traits
- Sharing data, methods & protocols for prediction





The next generation of predictors





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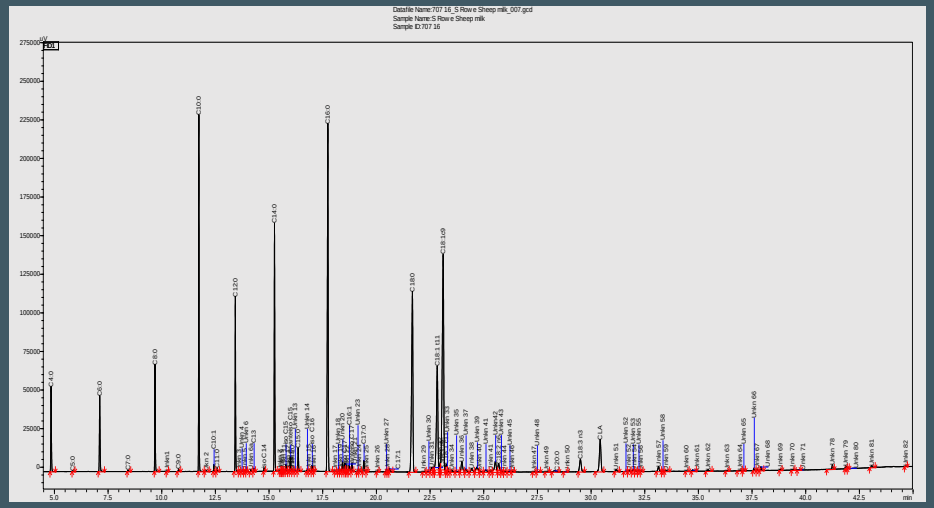

Variance explained		
Acetic/Propionic	0.28 ± 0.07	*
(A + B)/(P + V)	0.29 ± 0.07	*