Breeding Sheep with a lower carbon footprint

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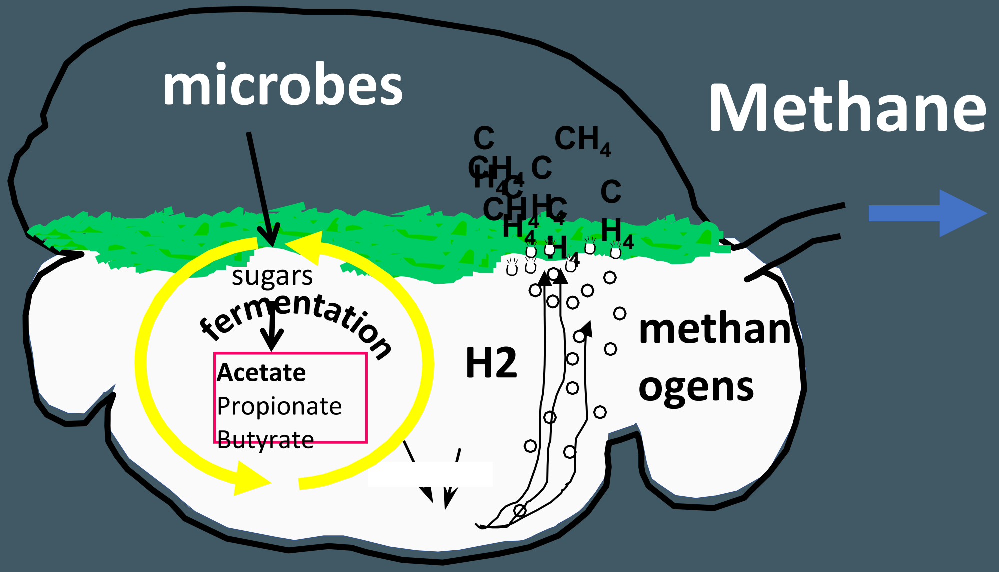

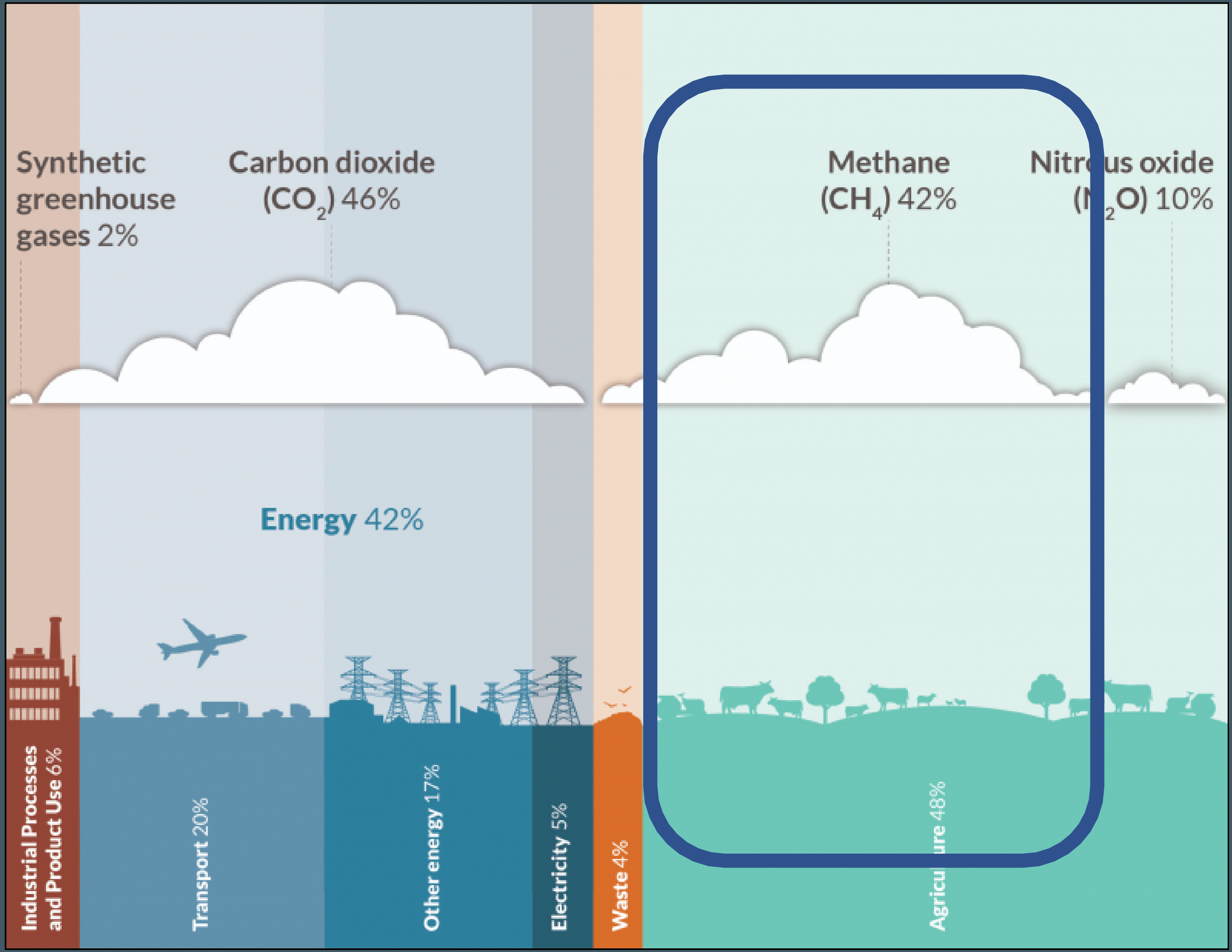

Enteric methane

80% Agricultural Emissions 35 % NZ GHG

Biogenic Methane is challenging

likely require significantly lower agricultural production from livestock and more land-use change.

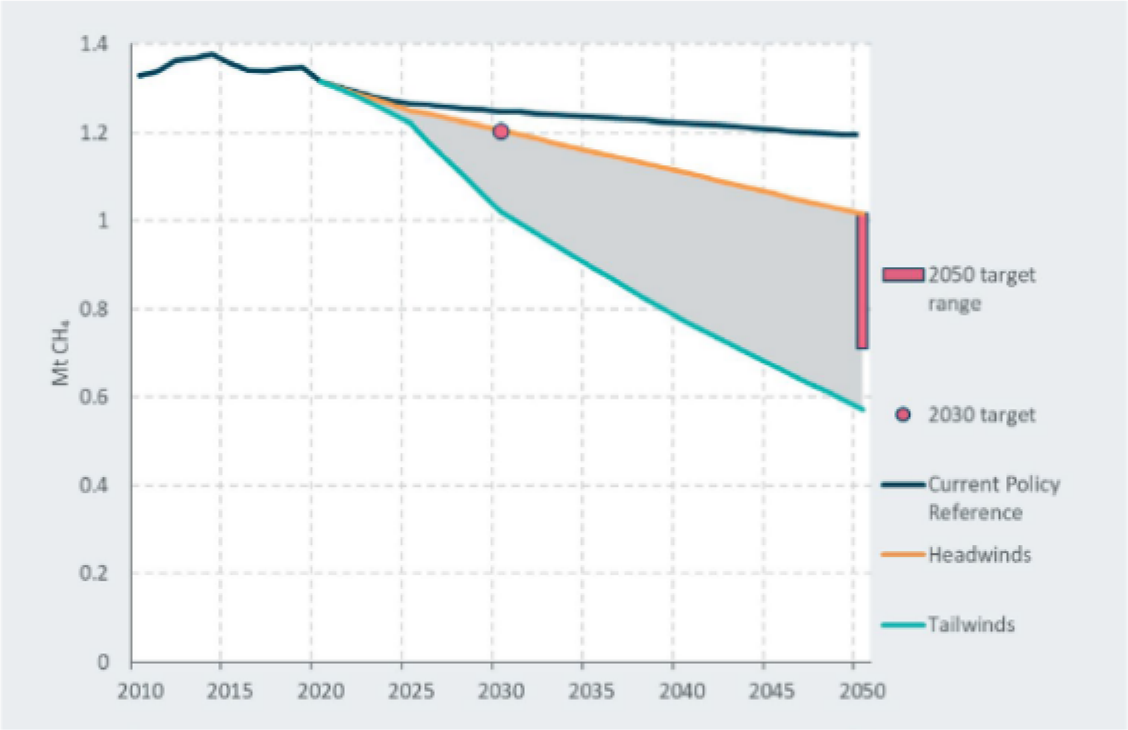

Figure 6.8: The path for biogenic methane emissions in the Headwinds and Tailwinds scenarios.
Source: Commission analysis.

- More Uncertainty
- Technology unknown
- 10% by 2030
- 24-47% by 2050

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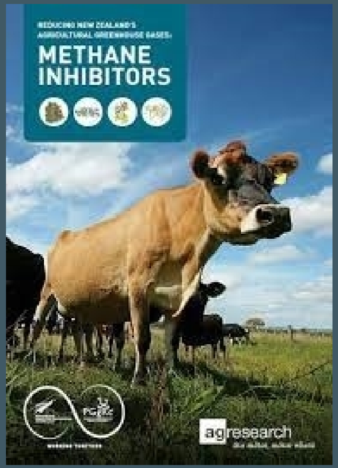
Mitigation Technologies for grazing livestock



Targets 10% by 2030   24-47% by 2050
mix of charges and incentives

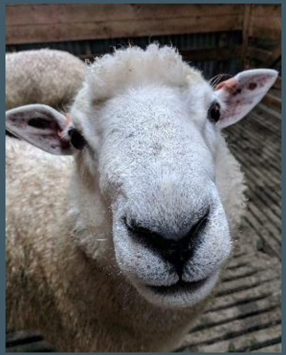
Major Questions

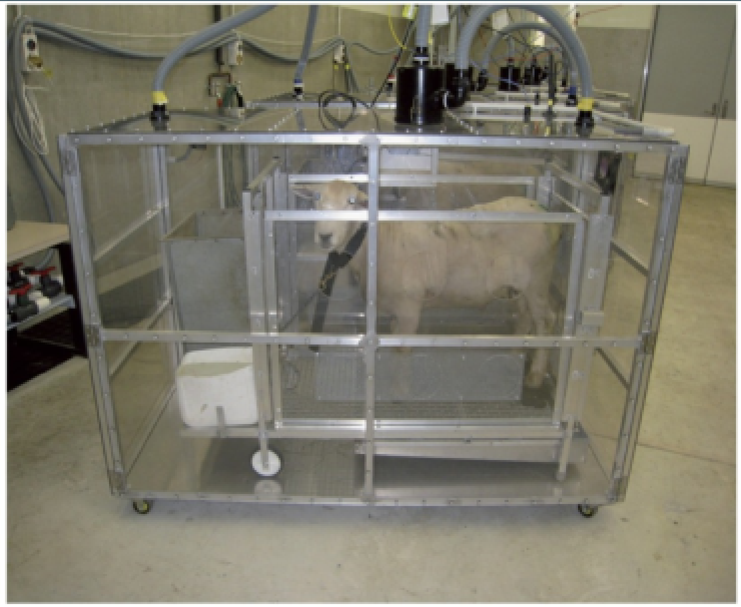
- Performance
- Feed efficiency
- Rumen size
- Economics

Research

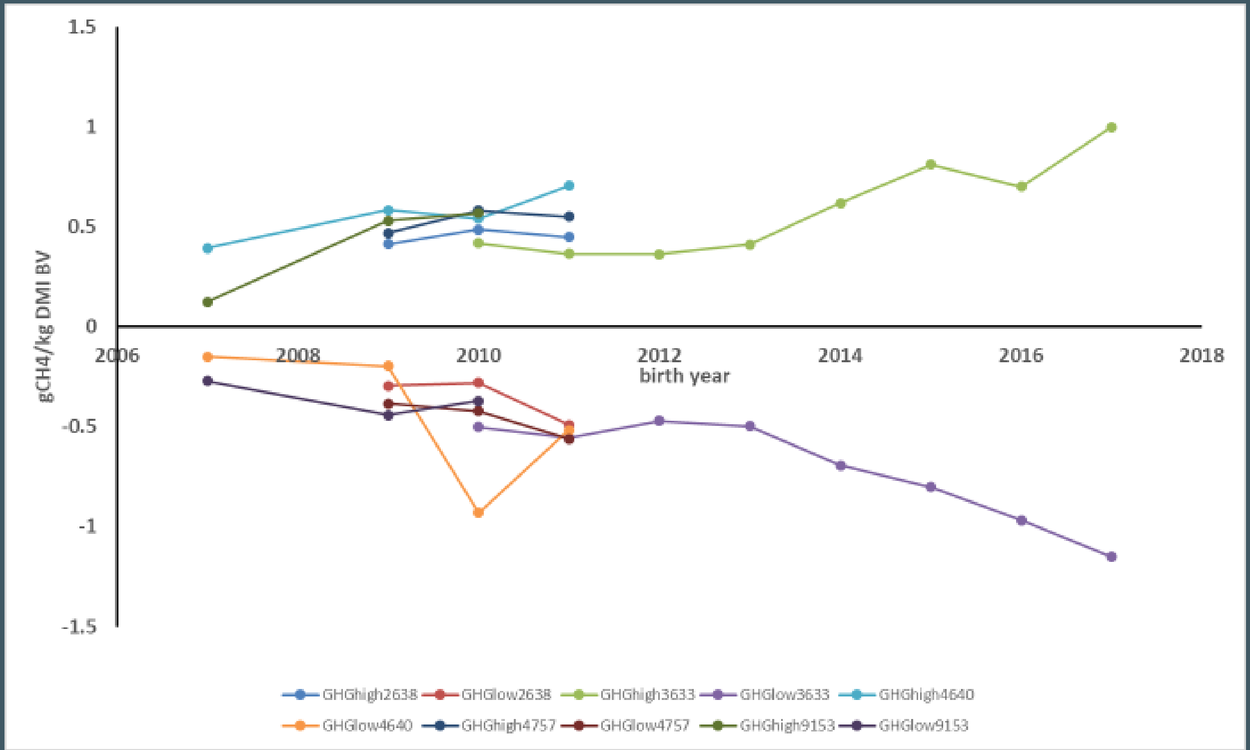
- Methane selection lines monitored annually – 200 ewes
- Ram used in research flock – 750 ewes monitored annually
- Central progeny test flocks
- National records

The quest for individual variation……





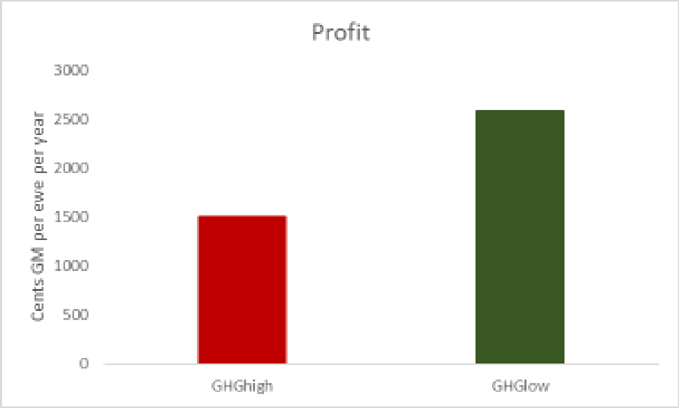
Adaption	M1	M2	- 14 day rest	M3	M4



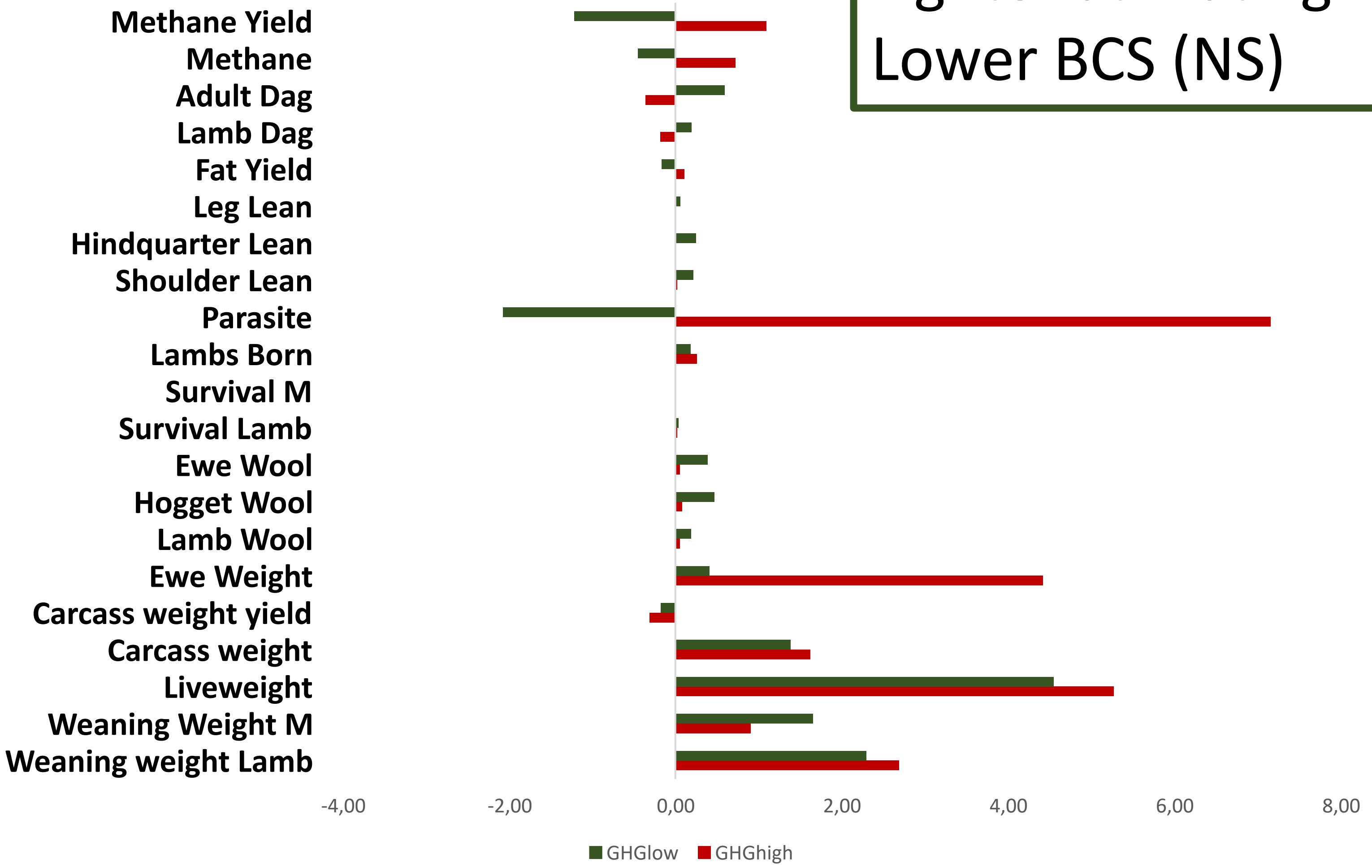
Spot the difference.....



Differences



Greater profit
Parasite resistant
Smaller adult ewe
More meat & wool



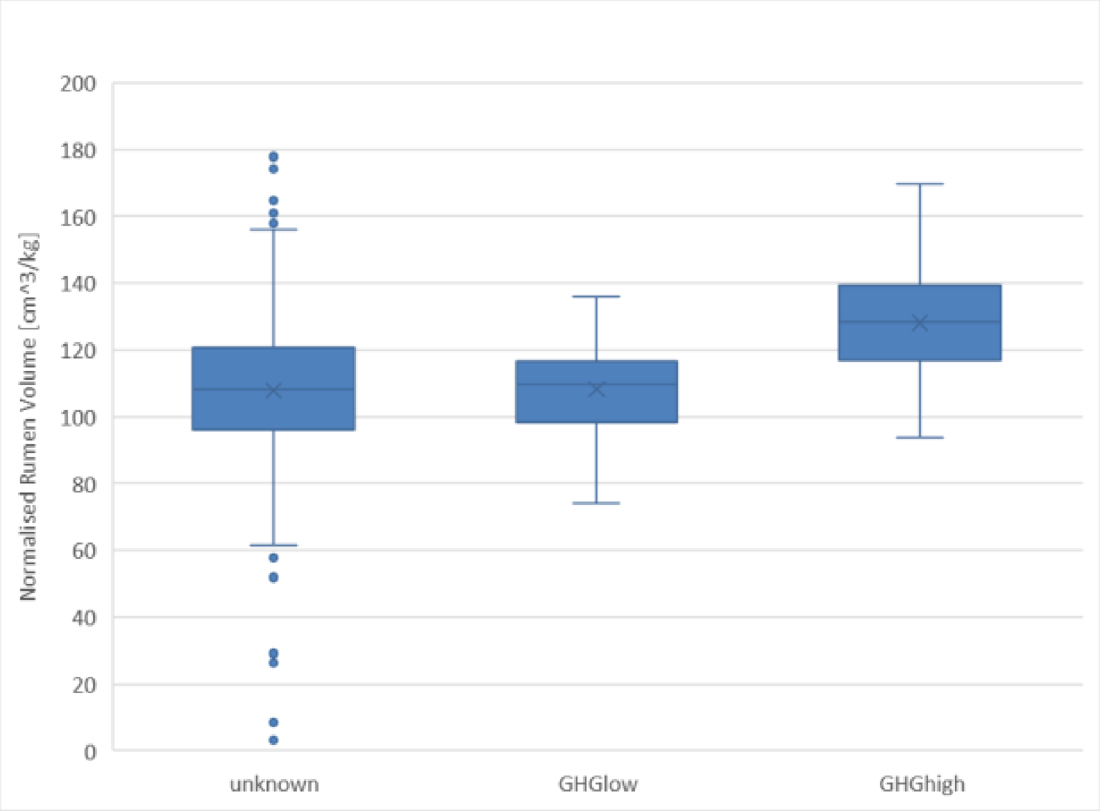
Lighter at mating
Lower BCS (NS)

Rumen Differences

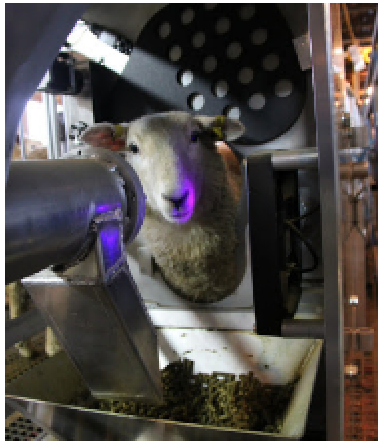
Trait	High CH_4	Low CH_4	P-value	Diff.[1]	Heritability
Reticulo-rumen full (g)	5358 ± 82	5052 ± 83	0.01*	6%	0.19 ± 0.07
Reticulo-rumen empty (g)	988 ± 8	956 ± 8	0.01*	3%	0.16 ± 0.07
Est. rumen contents (g)	4370 ± 81	4096 ± 82	0.02*	6%	0.20 ± 0.07
Papillae count (per cm^2)	32 ± 1	31 ± 1	0.61	2%	0.09 ± 0.05
Av. papillae height (mm)	3.69 ± 0.09	3.92 ± 0.09	0.06	-6%	0.25 ± 0.07
Av. papillae width (mm)	1.94 ± 0.04	1.95 ± 0.04	0.85	0%	0.10 ± 0.06
Av. papillae surface area	26.6 ± 1.0	28.5 ± 1.1	0.21	-7%	0.22 ± 0.07

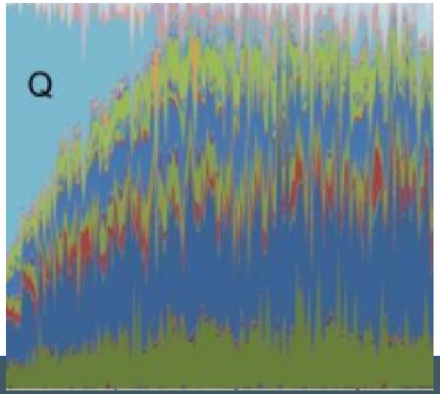
[1] Percentage difference between high and low CH_4 as a proportion of the high.

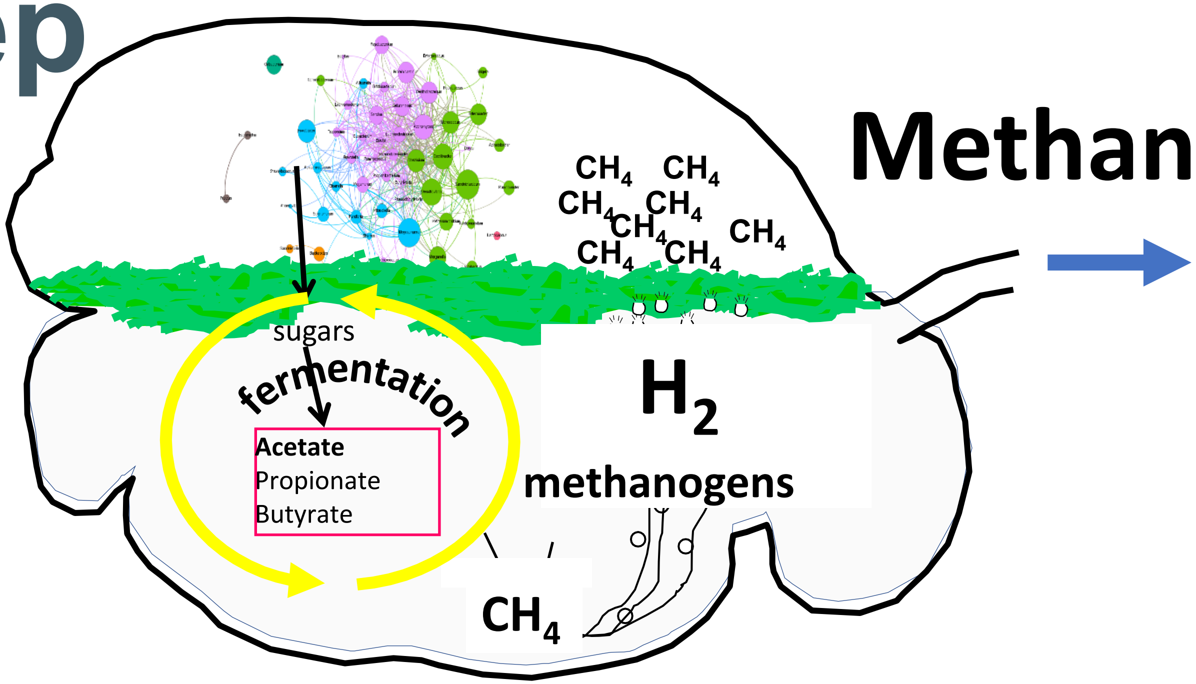
AI for rumen volume (unpublished)

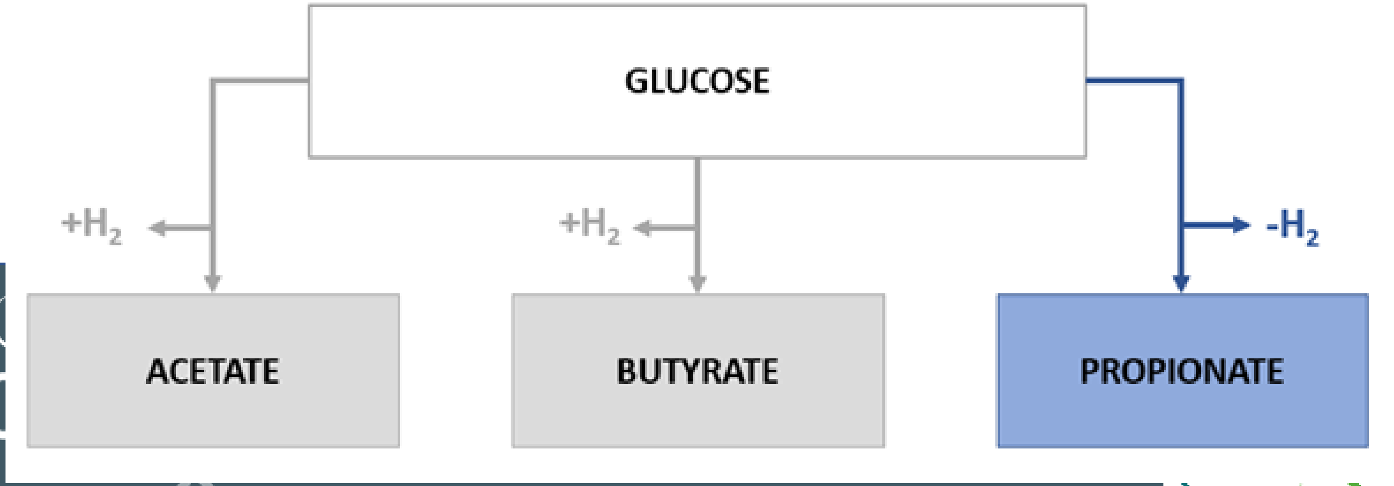


Low methane sheep

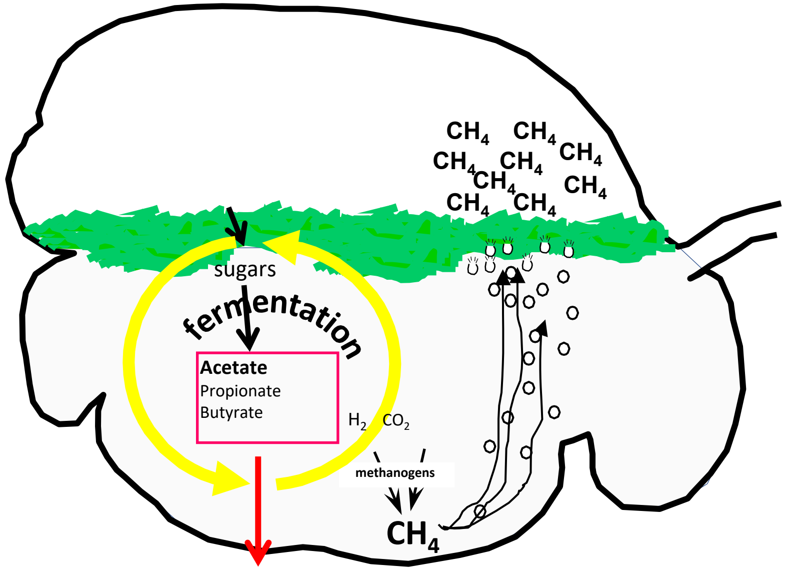


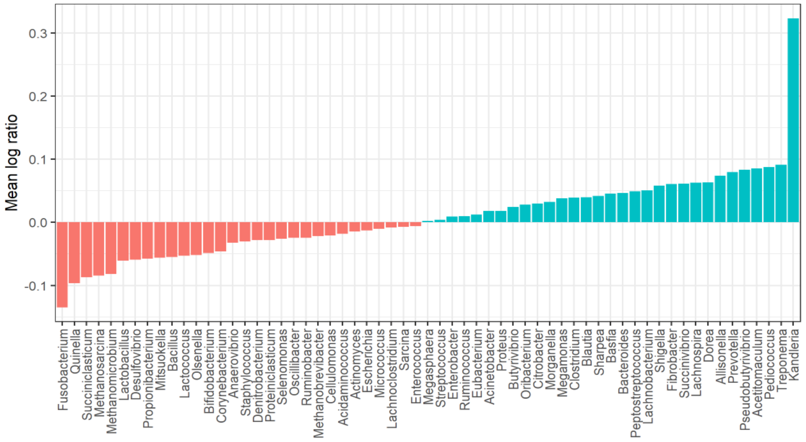


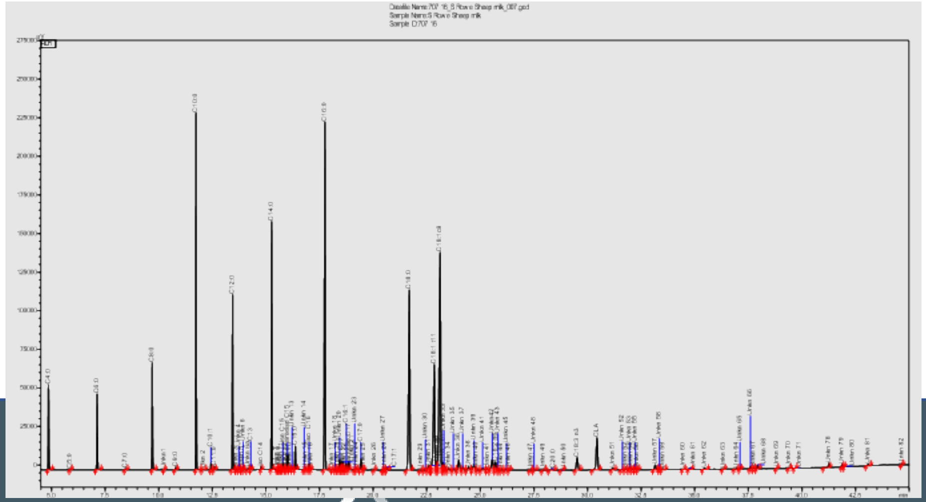




The next generation of predictors ?





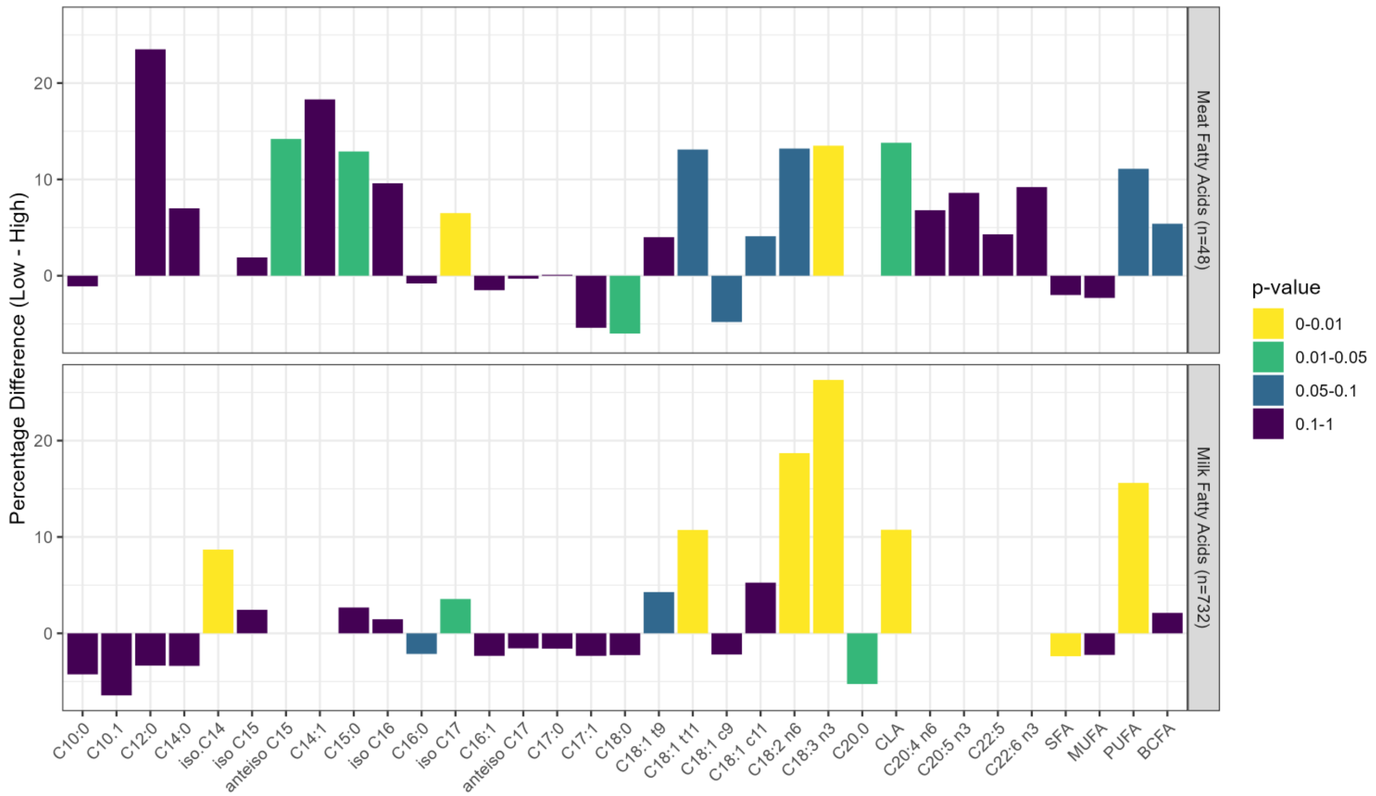


Fatty Acid	% Diff	P-value
C18:1 t9	5.6	0.034
C18:1 t11	8.7	0.001
C18:1 c9	-2.3	0.206
C18:1 c11	8.2	0.024
C18:2 n6	9.5	<.001
C18:3 n3	12.7	<.001
C20:0	-4.9	0.007
CLA	12.3	<.001
SFA[2]	-2.7	<.001
PUFA[3]	11.9	<.001

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

GENETICS

Fatty Acid Profiles



Low Methane

Less short chain
More branched chain
More polyunsaturated
More CLA

Meat & Milk

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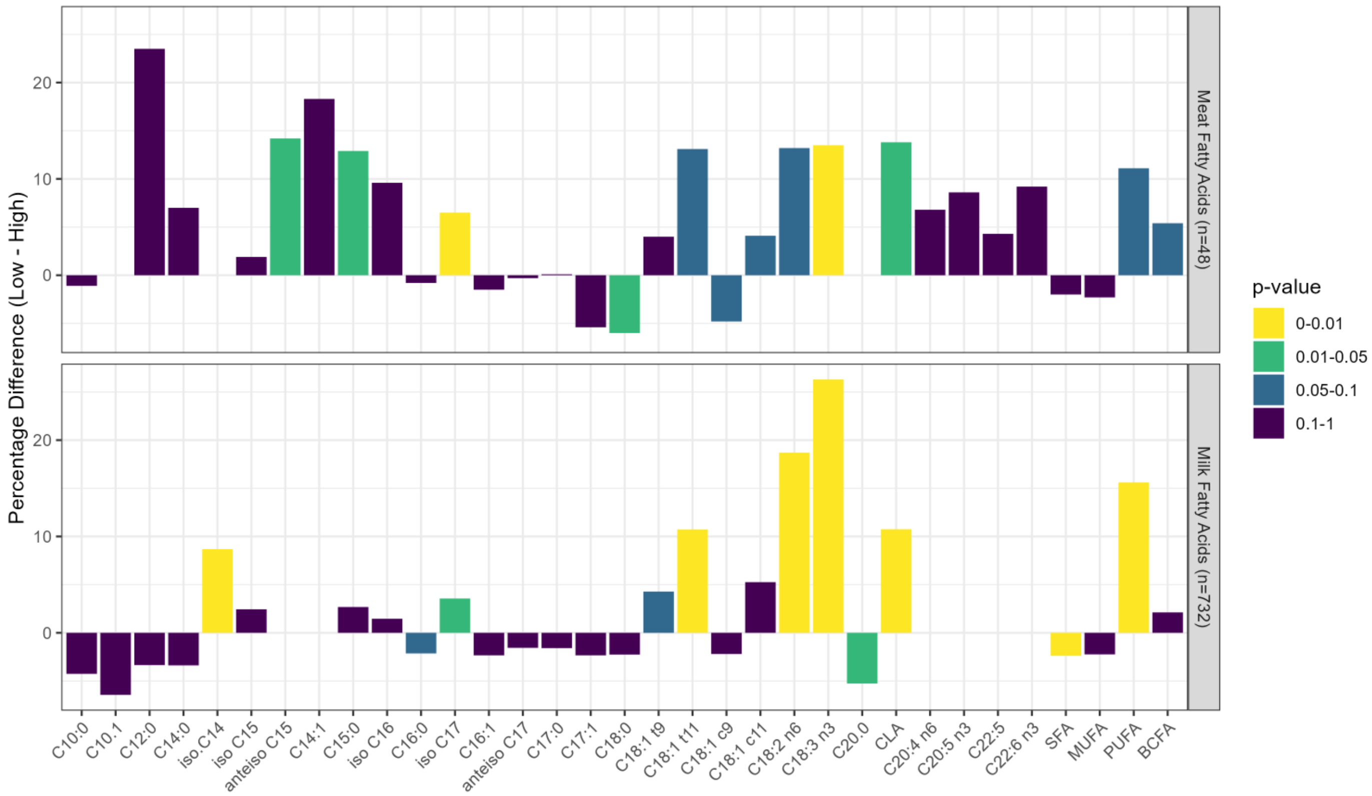
beef+lamb new zealand GENETICS

PGgRc

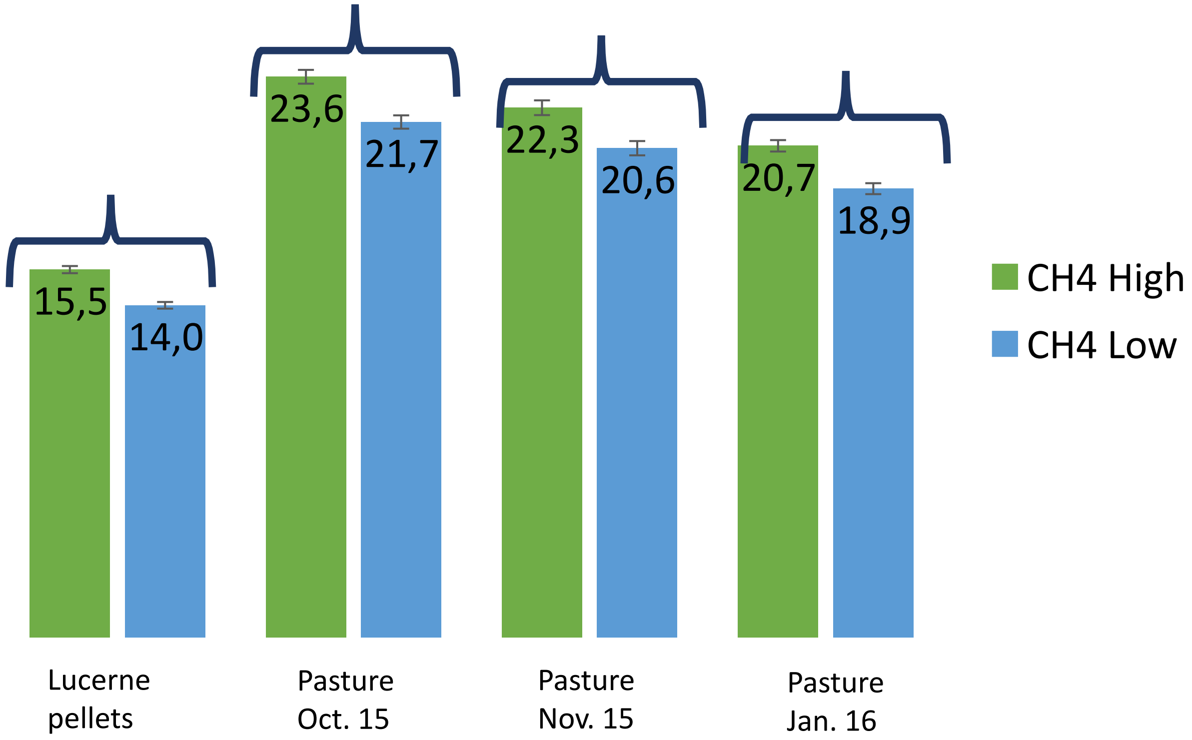
Low Methane Sheep



Lower fat : lean ratio
Greater Meat yield

- Less short chain
- More branched chain
- More polyunsaturated
- More CLA

Respiration chamber - cut pasture



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In Sheep – Portable Accumulation chambers

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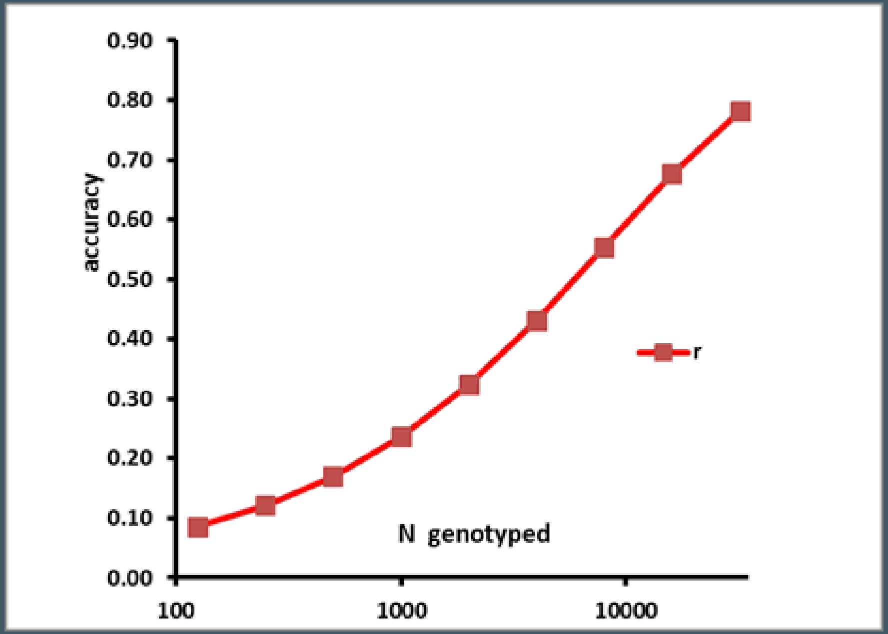
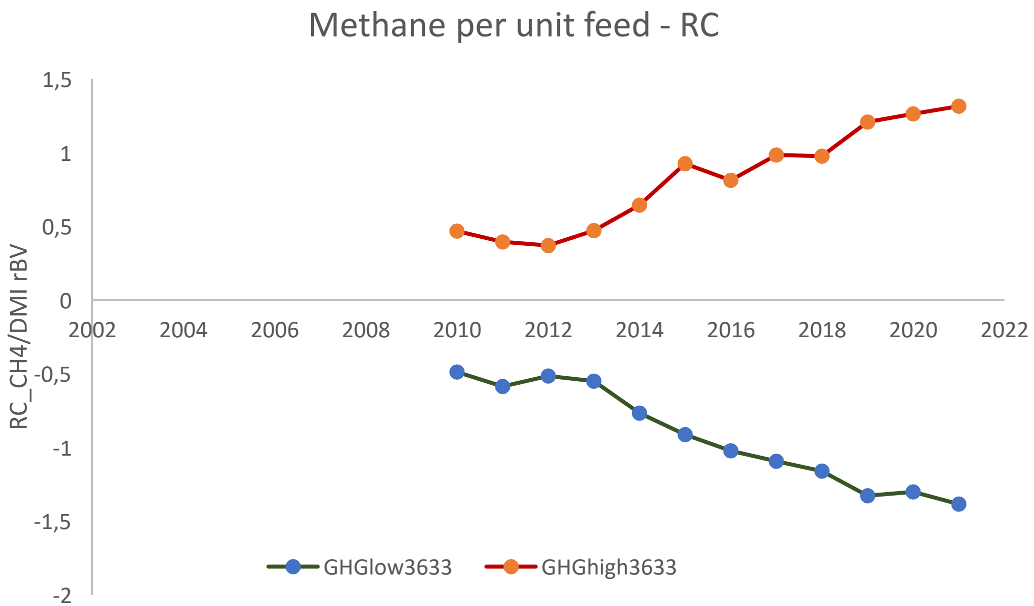
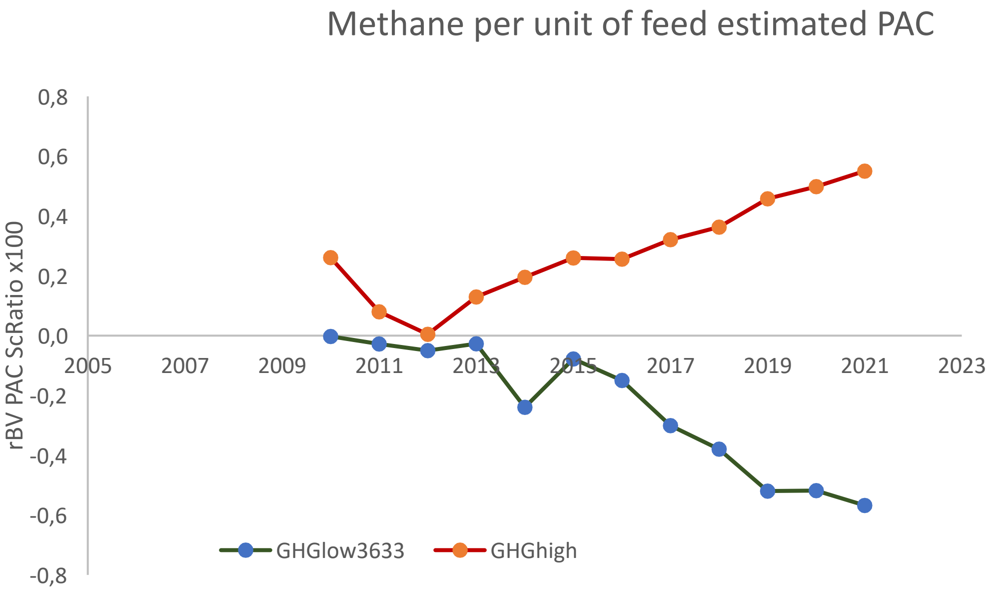
Thousands of measures are needed for breeding schemes



Total gas predicts methane yield g CH4/kg DMI





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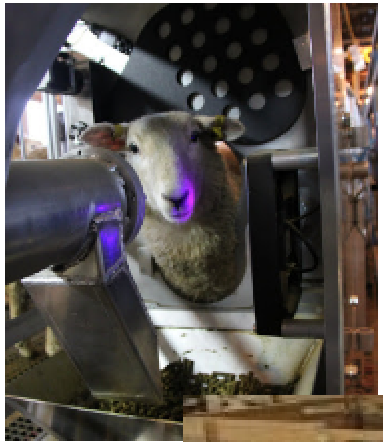

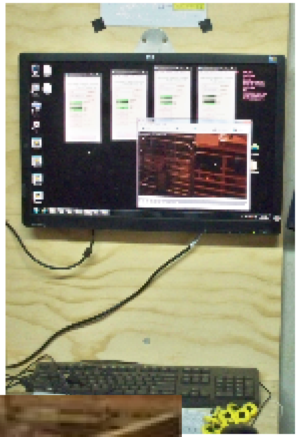

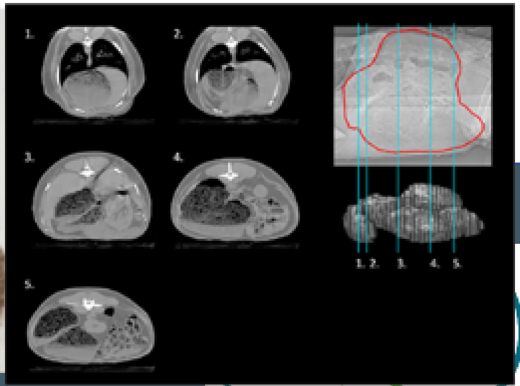

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TICS

Adult ewe traits (n=9-20k)

	CH_4 /DMI, g/kg/d	
	r_g	r_p
Faecal egg	0.13 ± 0.11	**0.05 ± 0.02**
LW Mating	**0.30 ± 0.09**	**0.07 ± 0.02**
BCS Mating	0.21 ± 0.11	0.01 ± 0.02
PREG scan	0.11 ± 0.13	-0.02 ± 0.02
Lambs born	0.06 ± 0.13	-0.01 ± 0.01
Wool	**-0.21 ± 0.10**	**-0.07 ± 0.02**

Low Methane

Lighter at mating
Lower BCS (NS)
More wool

Feed traits (1-2k)

	$CH_4/(CH_4+CO_2)$
	r_g
Residual feed intake (MJ/day)	-0.41 ± 0.15
Traits in Residual feed intake Model	
Feed intake (MJ/day)	-0.24 ± 0.09
Mid-trial metabolic live weight (kg)	-0.06 ± 0.08
Feeding behaviour	
Average feeding time per feeding event	0.02 ± 0.15
Average intake per feeding event	0.21 ± 0.08
Average number of daily feeding events	-0.38 ± 0.15
Average feeding rate per feeding event	0.27 ± 0.11

Low Methane

Eat more often
Eat more total

Eat less per meal
Eat slower

CT Scan – Carcass traits

		$CH_4/(CH_4+CO_2)$
	r_p	r_g
Visceral fat (kg)	0.31 ± 0.15	0.07 ± 0.04
Subcutaneous fat (kg)	0.19 ± 0.17	**0.11 ± 0.04**
Intermuscular fat (kg)	0.24 ± 0.17	**0.09 ± 0.04**
Carcass lean (kg)	-0.03 ± 0.17	-0.05 ± 0.04
Carcass fat (kg)	0.24 ± 0.18	**0.12 ± 0.04**
Total fat (kg)	0.33 ± 0.17	**0.11 ± 0.04**
Total bone (kg)	-0.72 ± 0.26	**-0.09 ± 0.03**
Non-fat visceral components (kg)	-0.03 ± 0.18	-0.03 ± 0.04
Fat:lean	0.30 ± 0.16	**0.10 ± 0.04**
Carcass weight (kg)[2]	-0.28 ± 0.16	-0.04 ± 0.04
Dressing-out-percent (%)[3]	-0.33 ± 0.15	**-0.11 ± 0.04**

Low Methane

Lower fat:lean ratio

Greater Meat yield

Microbiomes for prediction

- Collect a rumen sample
- Sequence 1% of microbial genomes
- Predict merit using microbial and host DNA

Hess et al, 2023, GSE

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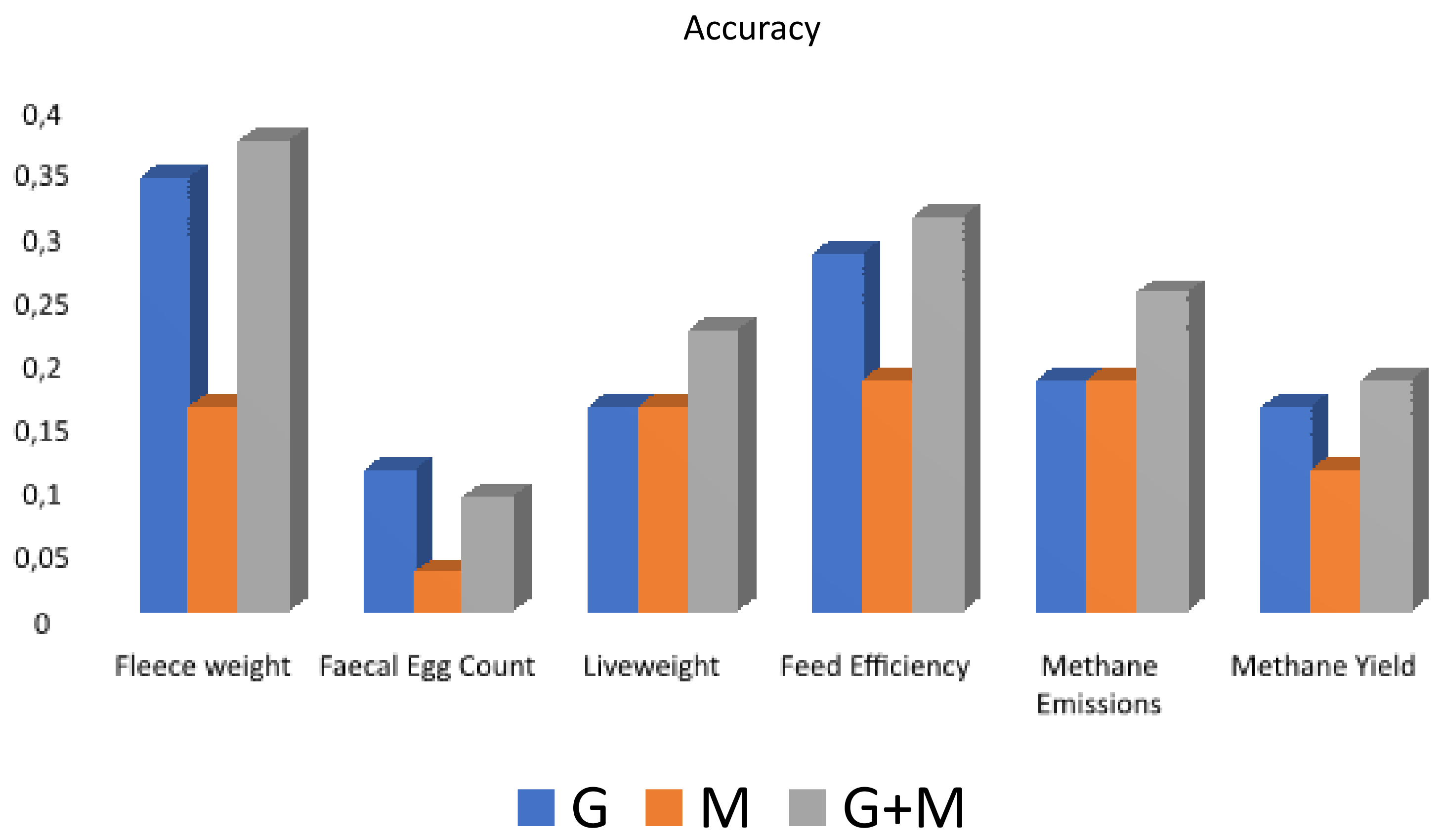
Bivariate Analysis

Methane traits
(Bilton *et al.* 2022)

Parameter	MidIntake		RFI		$ScCH_4$	
	Feeders	**RMC**	**Feeders**	**RMC**	**PAC**	**RMC**
Heritability	0.44 ± 0.16	0.15 ± 0.11	0.45 ± 0.14	0.26 ± 0.13	0.19	**0.19**
Phenotypic variance	78785 ± 6610	7772 ± 606	19166 ± 1625	1094 ± 87	3.01	**0.43**
Genetic correlation	**0.64** ± 0.30		**0.46** ± 0.26		**0.76** ± 0.14	
Phenotypic correlation	0.33 ± 0.05		0.30 ± 0.05		0.35 ± 0.03	

Bilton *et al.* (2022) WCGALP **12**:168

Microbiomes add to Genomic prediction



Hess et al., 2023 GSE

Cool Sheep program

- Offset phenotyping costs for breeders
- Breeders pay for genotyping (60k for <15 euros)
- Measure 8-12 per sire
- Minimum 120 sheep

Breeding Values & Economic weights

- BVs expressed in g/d for CH_4 and CO_2
- Based on PAC emissions for a ~40kg animal removed from pasture ~1-4 hours
  - Corrected for contemporary group (flock sex year) and “lot” in PAC chambers
  - Traits used in prediction
  - Scaled mean 7.5 g/h/d
  - Fixed effects Flk*yr*sex lot brr aod

Ranking for all

Methane Sire Summary - Flocks

Year - born 2019

Report Flocks			
Flock Prefix		Number of Sires	32
Flock Owner		Date Report Run	9-Apr-2020 14:41
Flock Sire/Dam Breeds	Romney	Report No.	1912020
Report Sorted By	rk CH4	Report Birth Period	2019 to 2019
Genetic Analysis No.		Date Breeding Values Created	28-Mar-2020 18:00
Analysis Birth Period		Base Year	1995
Analysis Flocks	Too many Flocks to list (1283 Flocks in the analysis)		
Goal Trait Groups	Bare Points; Body Condition Score; CarLA; Dag Score; Facial Eczema; Fine Wool; Growth; Hgt Lambing; Meat Yield; Reproduc		
Genetic Analysis Codes	Pregscan in Reproduction (if no NLB); Reproduction excludes LW8; Trait data excluded from GE; GBVs calculated		
Data Exclusion Set	Permanent		

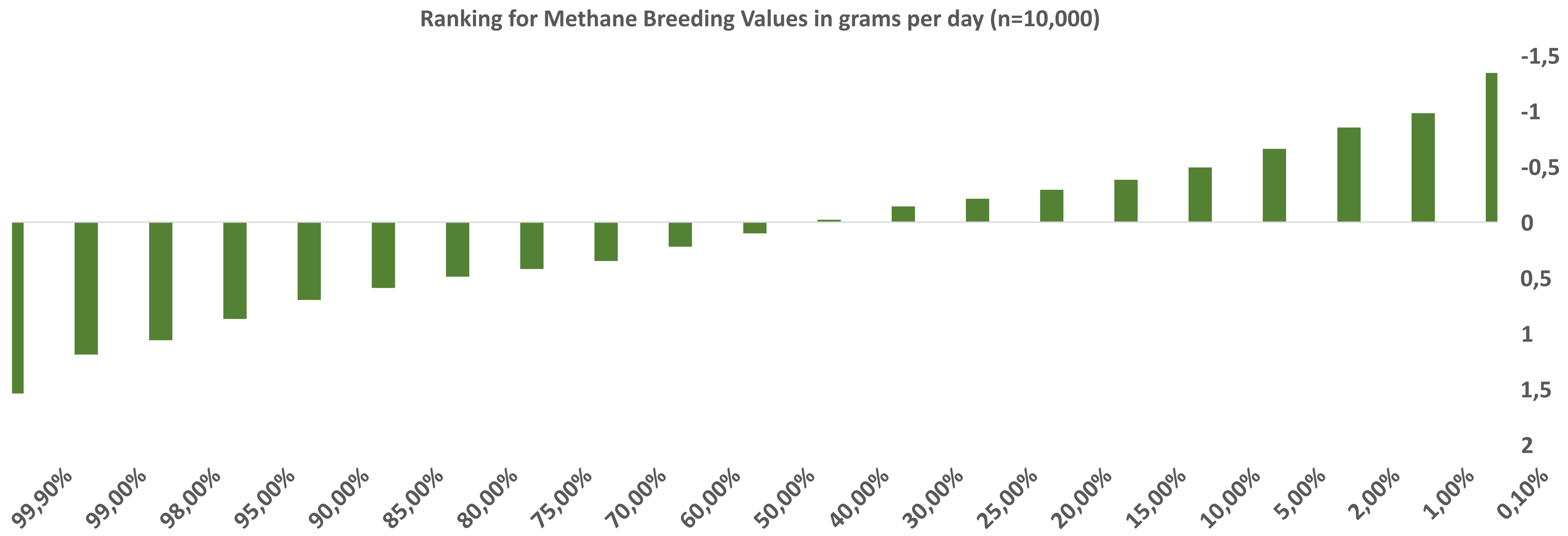
† Genomic information included

Explanatio
NZ Standa
PS) + (* DPW)
67 x CWgBV
467 x CWgBV - 147 x EWTgBV
EFWgBV
EWTgBV = Ewe live weight gBV
PACCH4gBV (CH4 gBV) = PAC methane emission gBV
SURMgBV = Survival maternal gBV
eny in Report Years with Traits
geny in Report Years with Traits

Sire Id	CH4 gBV	rk CH4	CH4 gAcc
1189/14	†-0.409	1	62
791/17	†-0.228	2	63
214/18	†-0.168	3	59
1600/18	†-0.056	4	63
1189/18	†0.101	5	65
2895/17	†0.193	6	63
600/18	†0.215	7	29
360/18	†0.229	8	65

Sire Id	CH4 gBV	rk CH4	CH4 gAcc
698/18	†0.534	24	36
825/18	†0.553	25	27
2230/18	†0.630	26	64
1020/17	†0.758	27	65
1368/18	†0.806	28	38
17/17	†0.826	29	63
899/17	†0.838	30	64
645/18	†0.843	31	23
318/18	†1.175	32	64

What do methane breeding values look like?



Flock 2638 – Select top ram lamb per sire
22 ram lambs selected from ~700 male progeny

	Select 22 best sons ranked by Maternal index		Select 22 best sons ranked by Maternal plus methane index	
	Ave index		Ave	Average Index + Methane ($100 per tonne CO_{2e})
Average Economic ($)	36.65		35.63	37.63
Change ($)			-1.03	+0.98
Change in CH4 per generation (%)	+1.69			-3.69

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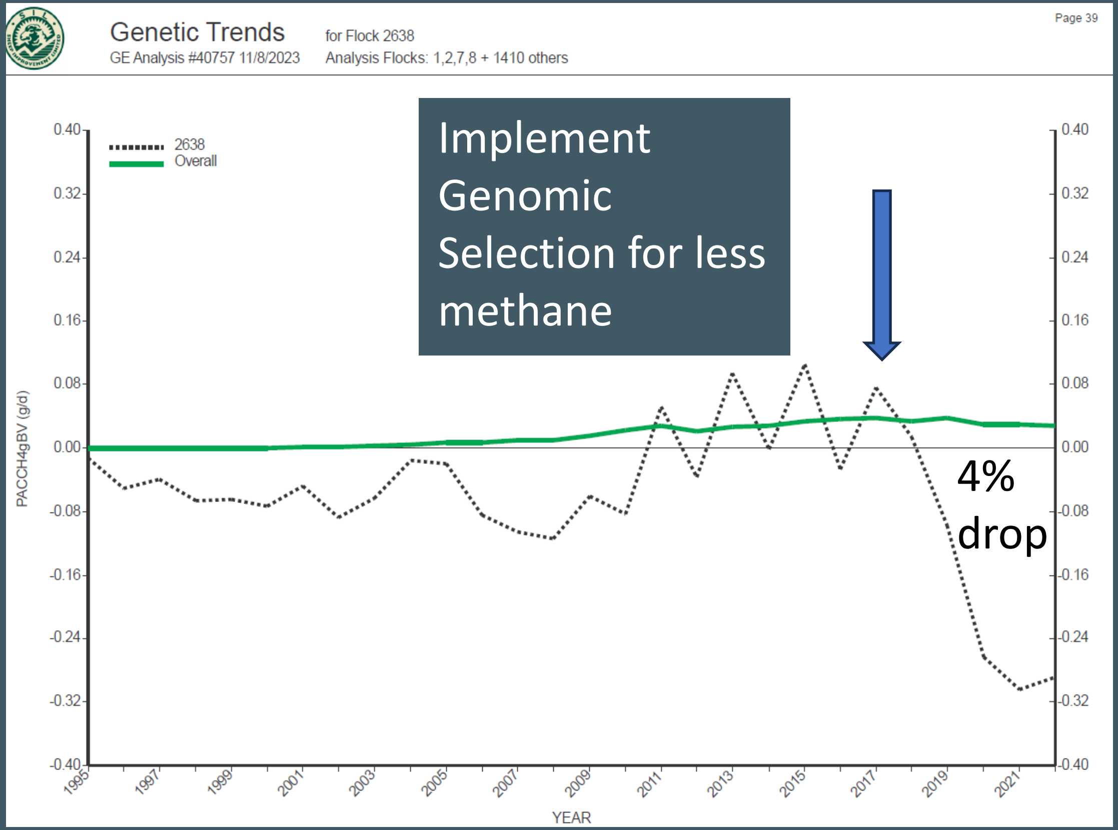
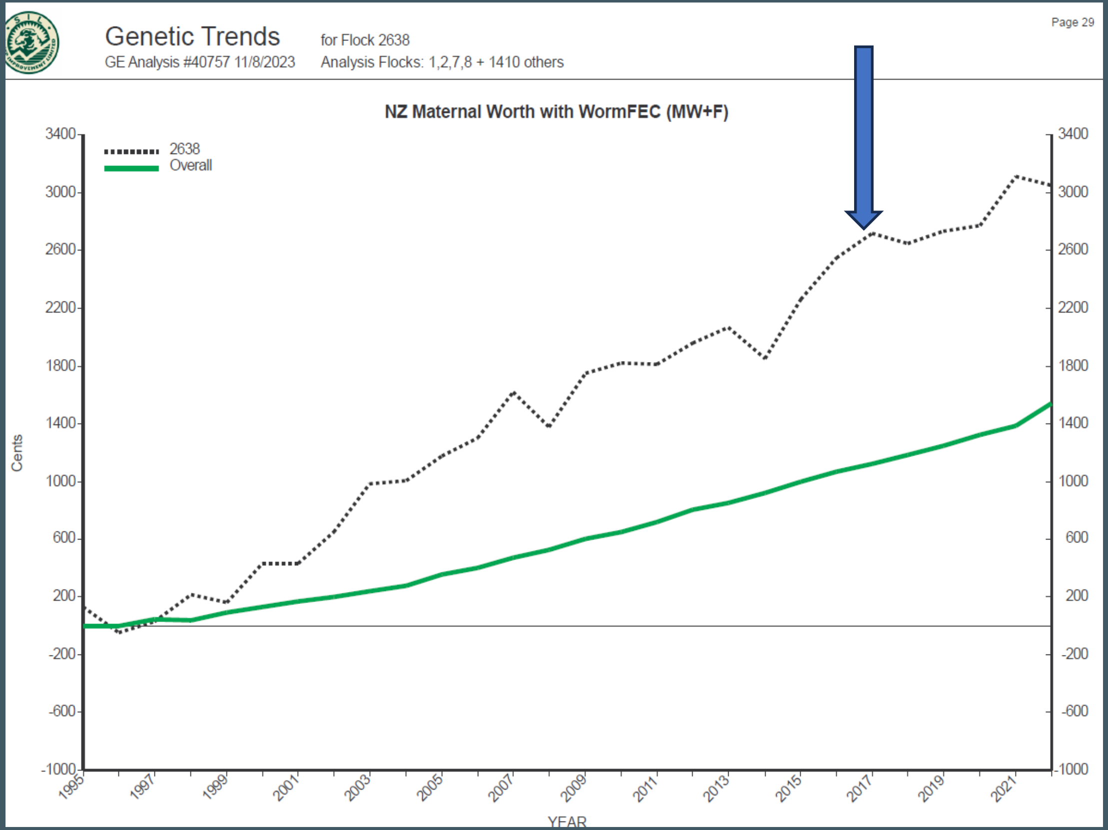
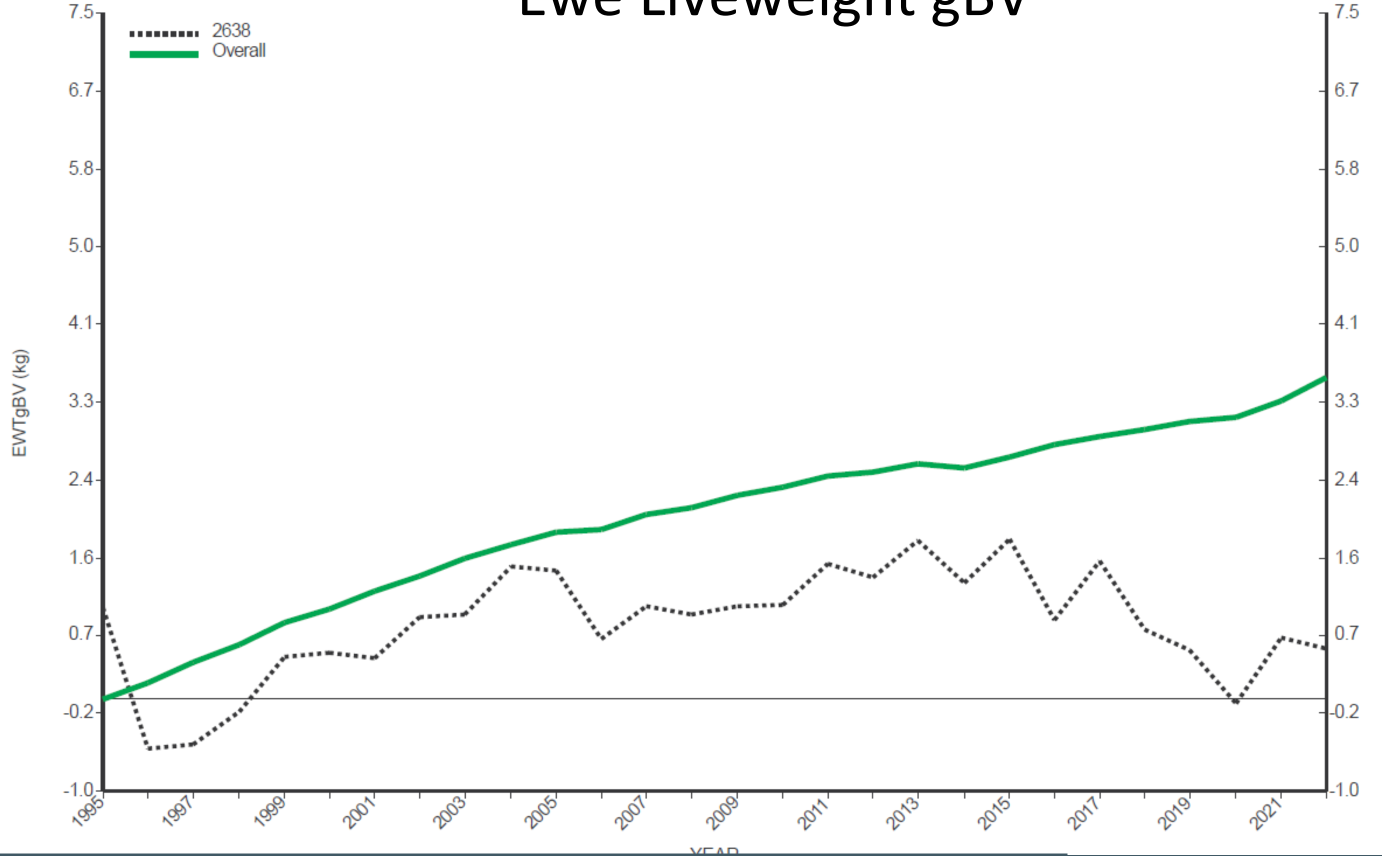
In practice g CH_4 x $6.81 ($100 CO2e equiv)



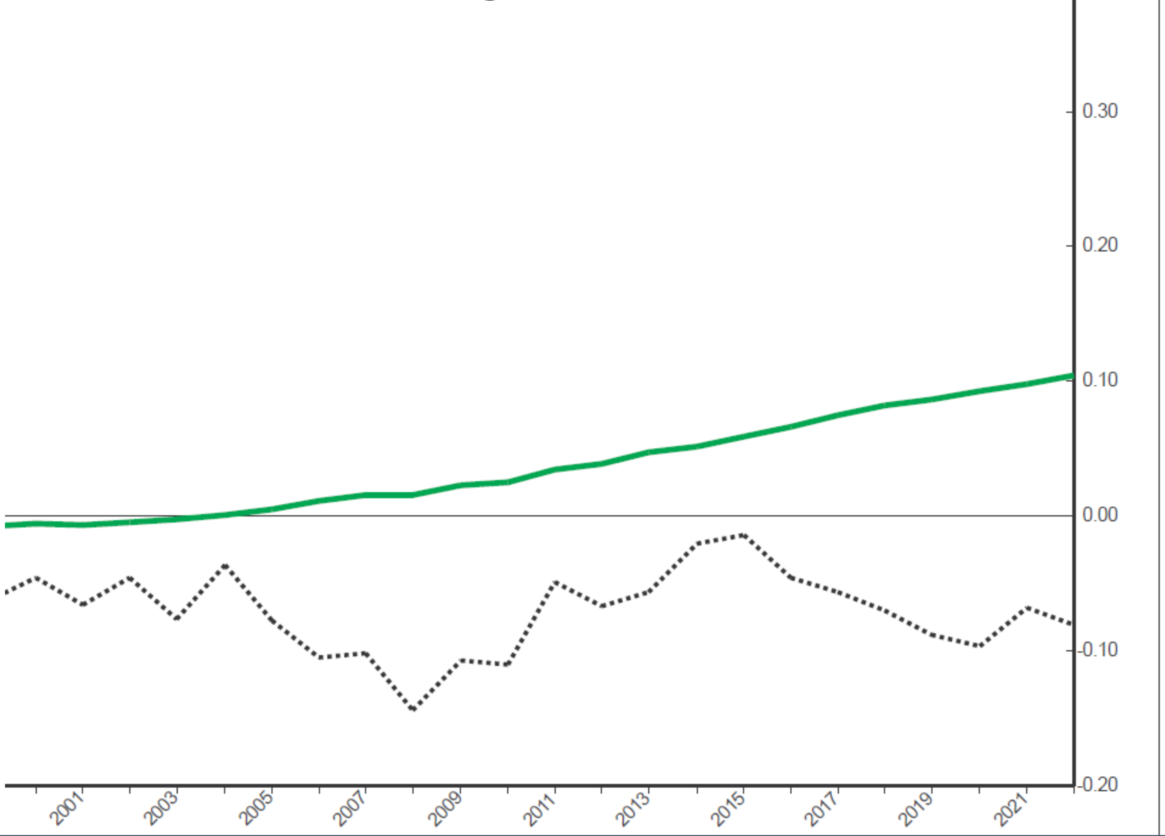


Ewes

Ewe Liveweight gBV



Ewe BCS gBV



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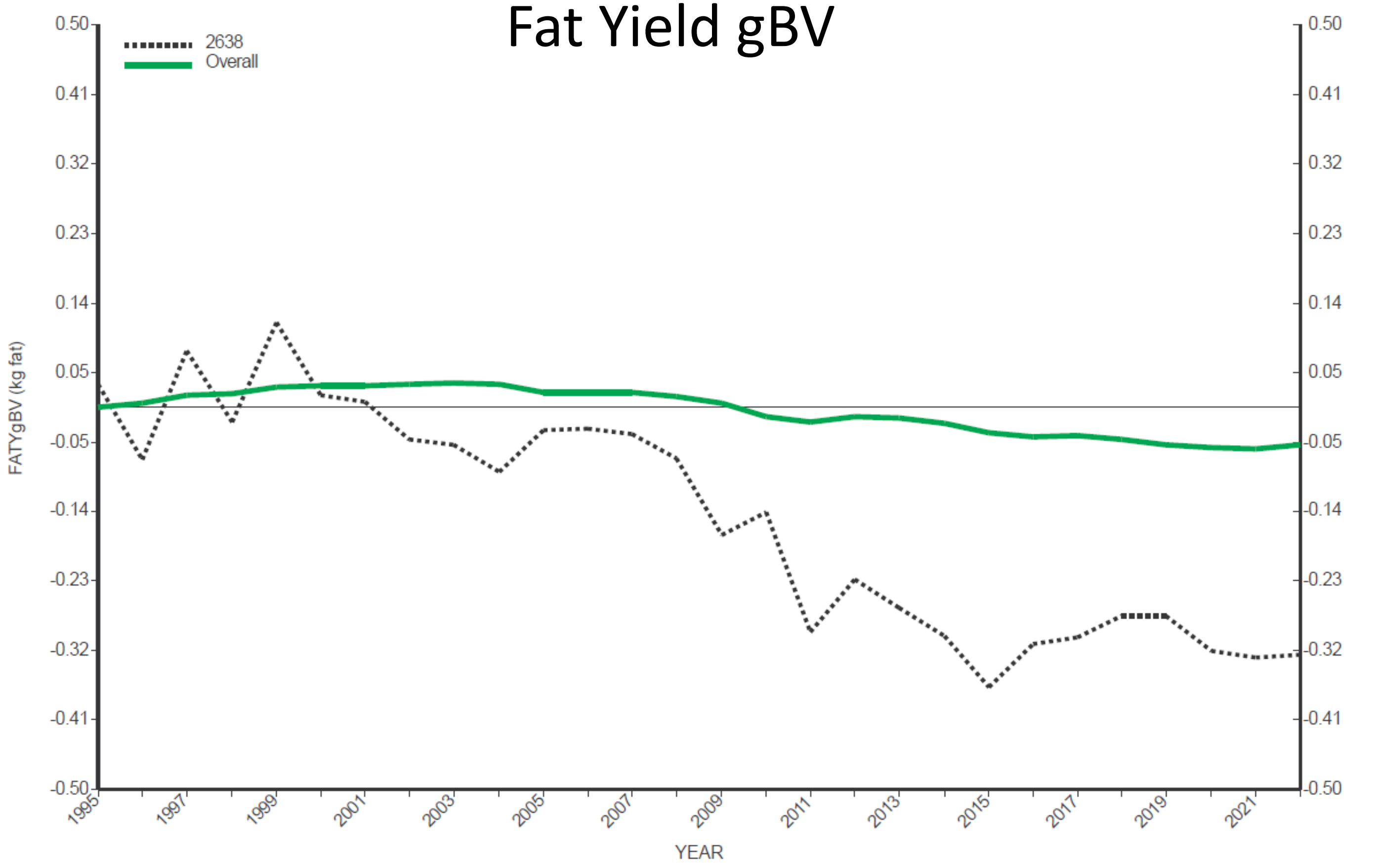
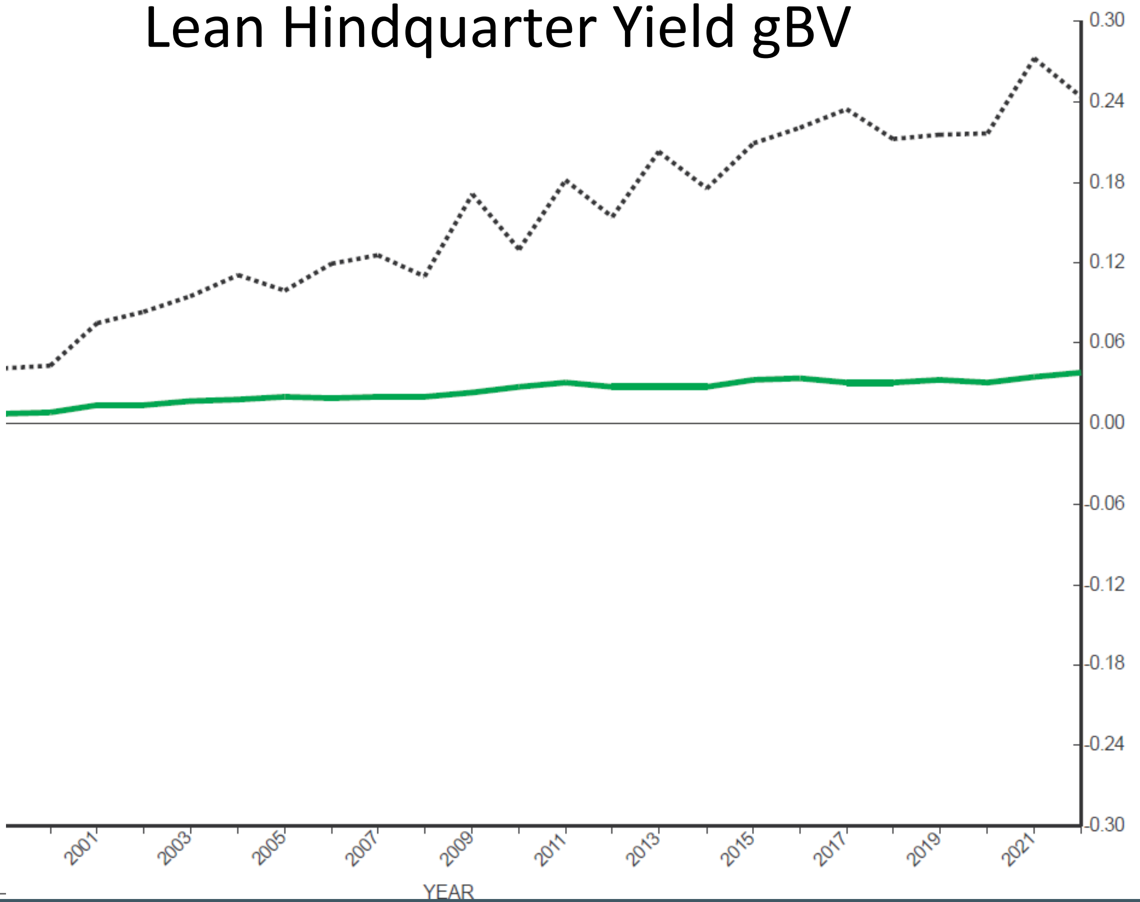
Fat and Meat Yield

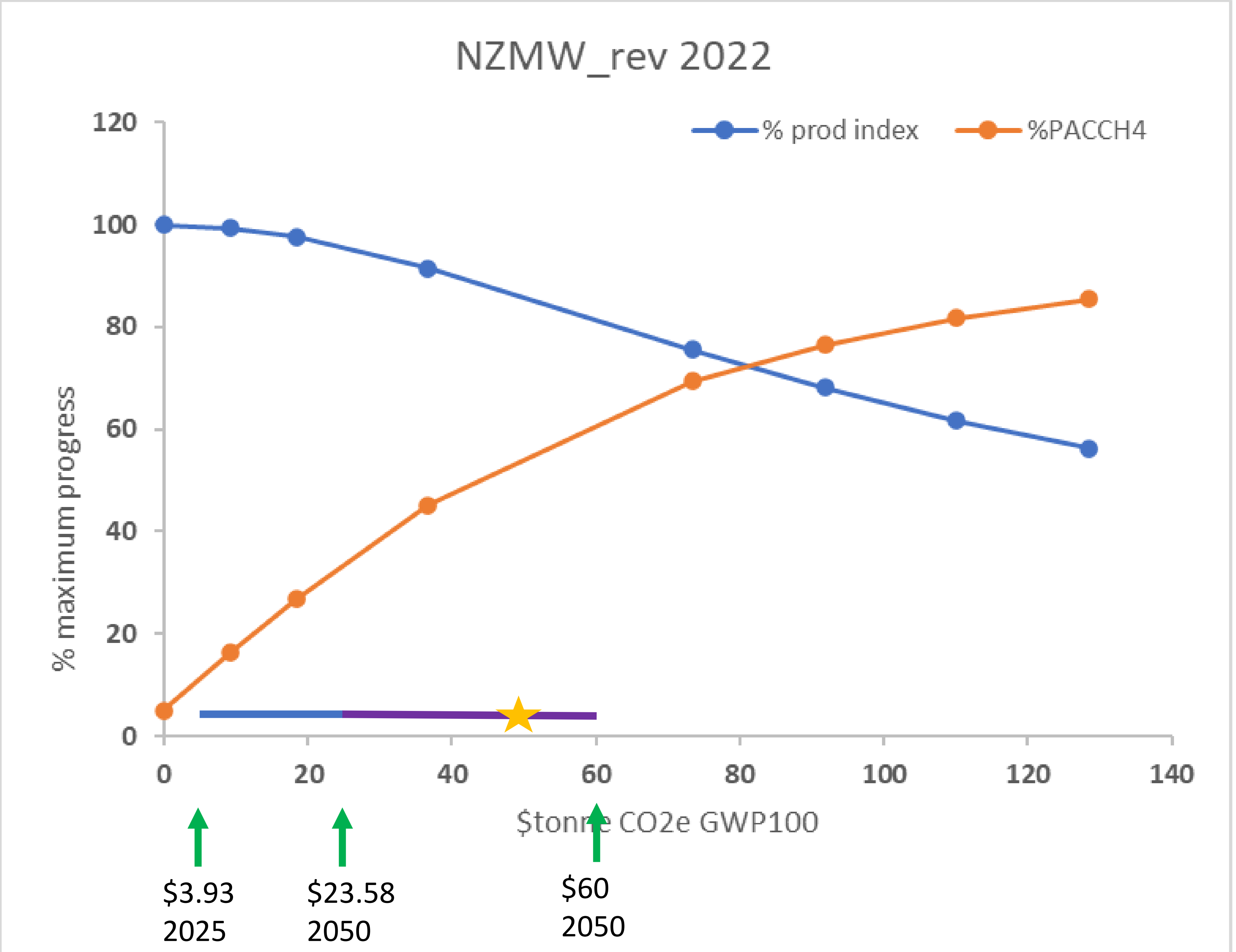
Fat Yield gBV



Lean Hindquarter Yield gBV



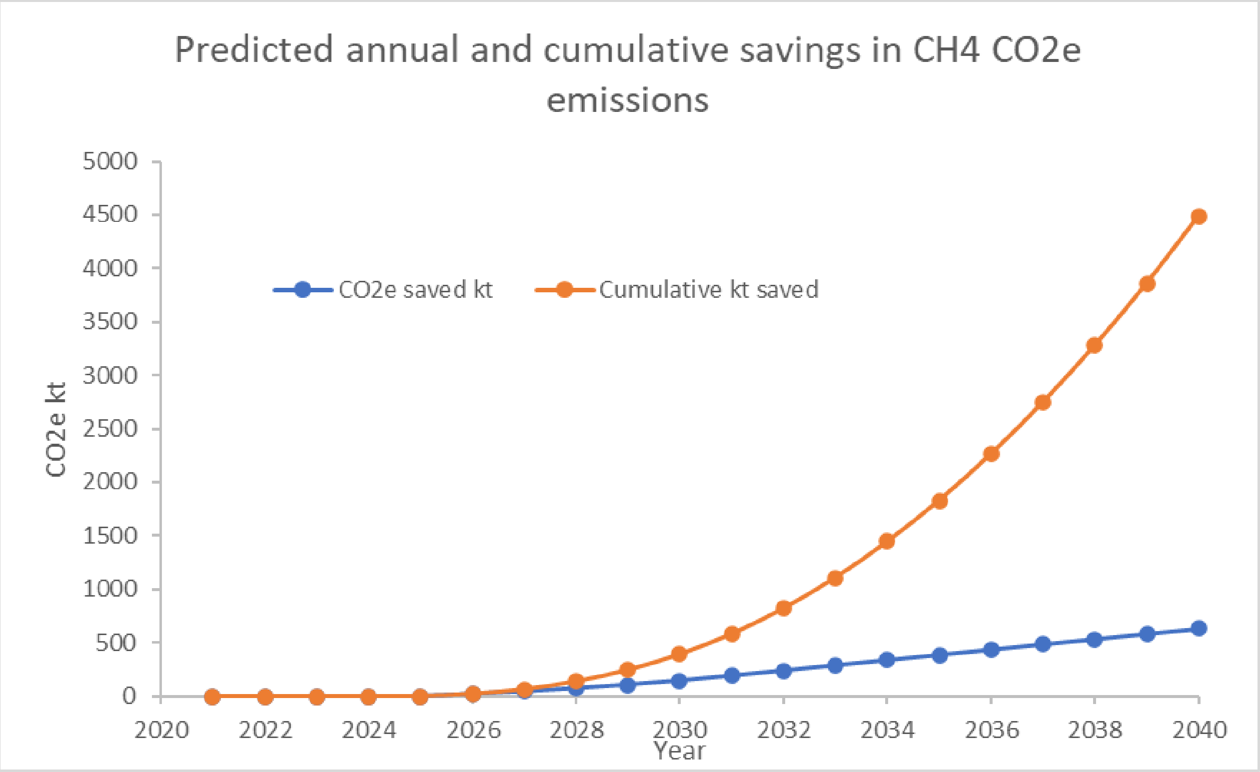
- Included likely range of prices from existing reports



Gains by trait for selection intensity

PACCH4 weight		0	0.1	0.2	0.4	0.8	1	1.2	1.4
Tonne CO2e $	Units	0	9.18	18.36	36.71	73.42	91.78	110.14	128.49
WWT	kg	0.731	0.702	0.666	0.582	0.412	0.343	0.284	0.235
WWTM	kg	0.006	0.006	0.006	0.006	0.005	0.004	0.004	0.003
CW	kg	0.492	0.485	0.473	0.437	0.351	0.312	0.279	0.251
EWT	kg	0.082	0.066	0.049	0.018	-0.030	-0.047	-0.060	-0.070
LFW	kg	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
FW12	kg	0.043	0.041	0.038	0.032	0.020	0.016	0.012	0.009
EFW	kg	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013
SUR	lambs	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
SURM	lambs	0.005	0.005	0.005	0.004	0.003	0.003	0.003	0.002
NLB	lambs	0.046	0.046	0.047	0.045	0.040	0.038	0.035	0.033
AFEC	loge	0.016	0.014	0.013	0.011	0.006	0.004	0.003	0.002
FEC1	loge	0.028	0.023	0.018	0.008	-0.007	-0.013	-0.017	-0.020
FEC2	loge	0.040	0.038	0.036	0.031	0.021	0.017	0.014	0.011
BCS	score	-0.028	-0.037	-0.046	-0.060	-0.076	-0.080	-0.083	-0.085
HNLB	lambs	0.022	0.022	0.021	0.020	0.016	0.014	0.013	0.012
HFER	score	0.023	0.023	0.023	0.021	0.017	0.016	0.014	0.013
PACCH4	g/day	-0.058	-0.185	-0.305	-0.514	-0.788	-0.870	-0.929	-0.971
PACCo2	g/day	6.389	4.318	2.268	-1.506	-7.044	-8.891	-10.297	-11.378
FI	MJ/day	0.253	0.140	0.029	-0.171	-0.459	-0.553	-0.624	-0.678
LW8	kg	1.003	0.848	0.688	0.379	-0.112	-0.287	-0.424	-0.532

Breeding predicted reduction in emissions (kt)



- Slow start but exponential
- Delays are costly
- By 2040 predict 4.49M tonnes of CO_2e reduced
- $6M from government
- $1.75M from breeders
- ~$1.72/tonne CO_2e mitigated
- IRR – 80% GWP^{100}
- 111% $GWP^{w.e}$

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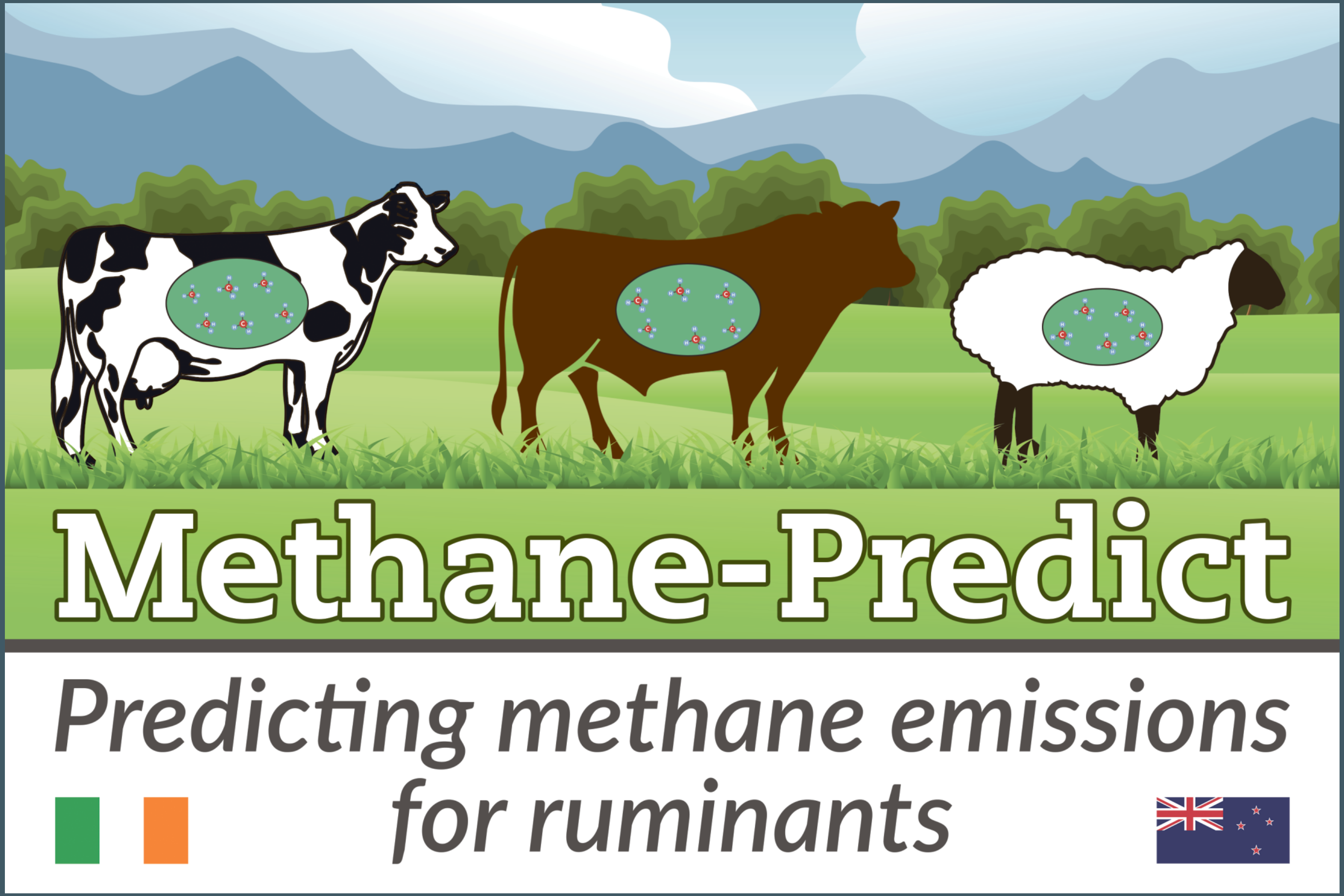

Fiona McGovern, Sinead Waters, Paul Smith

PĀMU
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LIC
CRV
GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES
PGgRc

Global Impact

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

GrassToGas

FACCE ERA-GAS

SUSAN

ICT-AGRI era-net

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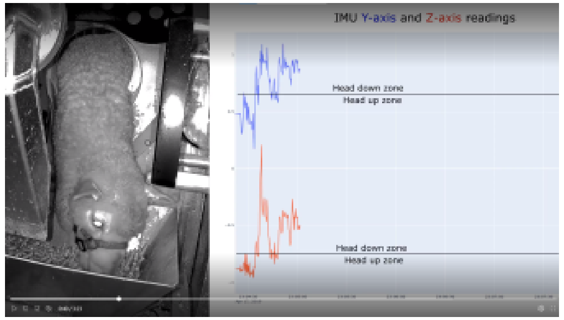
What next ?

- Economic models and national index
- Recognised in government calculations
- Continue to monitor flocks under challenge
- Fundamental model for rumen physiology
- Testing new technology
- Stackability of mitigation technologies



Acknowledgements

Funding

New Zealand Greenhouse Gas Centre

Pastoral Greenhouse Gas Research Consortium

New Zealand Government to support the Global Research Alliance on Agricultural Greenhouse Gases

Mapping the New Zealand Ruminotype Landscape (C10X1807)

Te Kāwanatanga o Aotearoa
New Zealand Government

Ministry for Primary Industries
Manatū Ahu Matua

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

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GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

Chris Smith
Ronan Jordan
Suzanne Rowe
John McEwan
Ken Dodds
Melanie Hess
Hannah Henry
Sharon Hickey
Patricia Johnson
Kathryn McRae
Timothy Bilton

Neville Amyes
Barry Veenvliet
Wendy Bain
Gerard Pile
Trevor Watson
Edgar Sandoval
Jacqui Peers-Adams
Brooke Bryson
Shannon Clarke
Fern Booker
Andrew Searle

Whats going on?

- Passage rate changes?
- Differences in rumen microbiota and substrate
- Changes in acetogenesis, methanogenesis
- Bottom line is looking at tens of thousands of animals very little impact on performance traits in selecting for low methane

What next

- Need a methane yield phenotype – feed intake
- Continue to monitor flocks
- Measure ewes all year on maintenance, different diets
- Fundamental work on rumen physiology

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Respiration chamber/Greenfeed

10s to 100s

<€2000

<€$200

PAC/Rumen Profiles

1000s

Breeding Values <€20

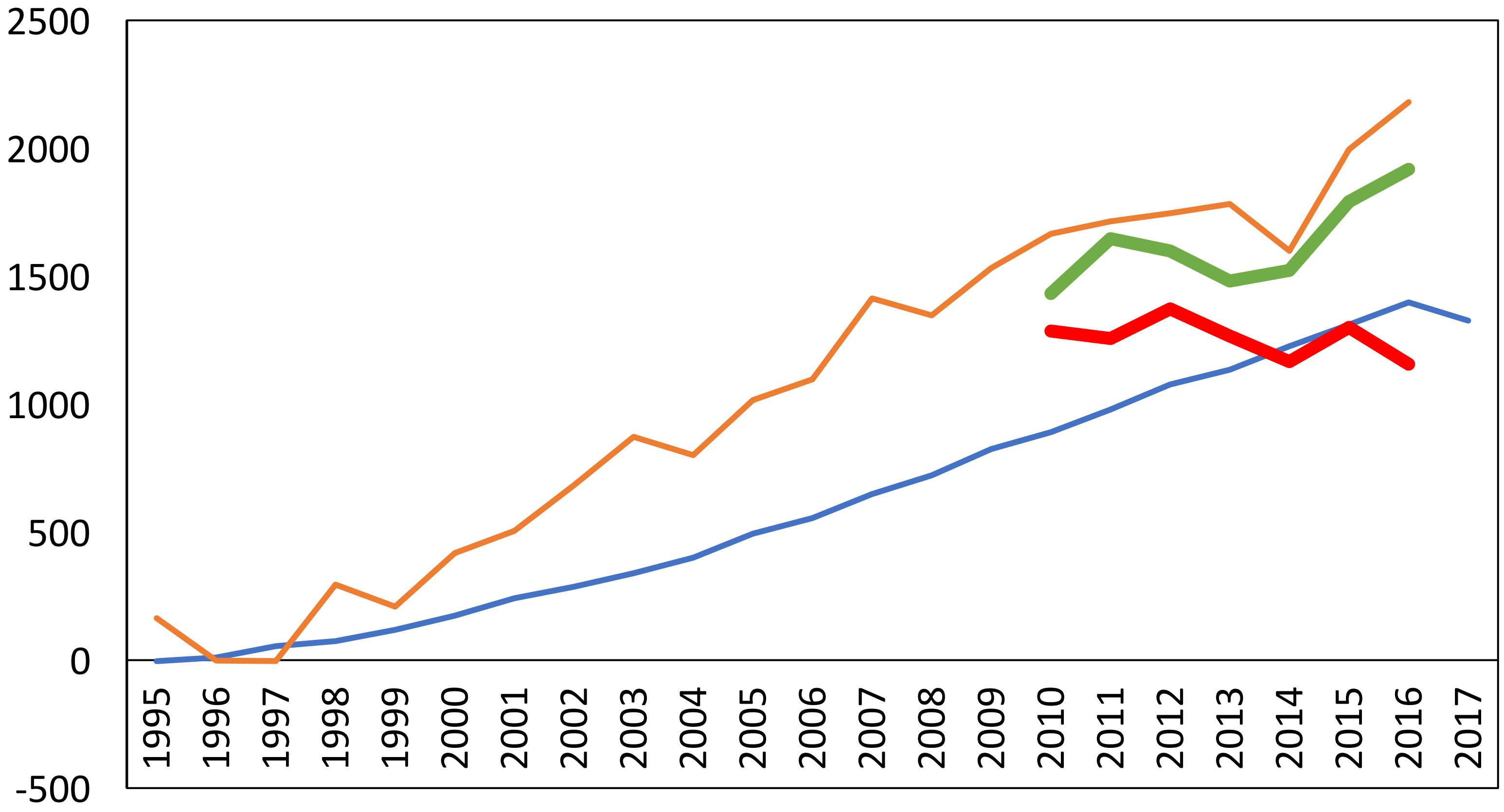
100,000s

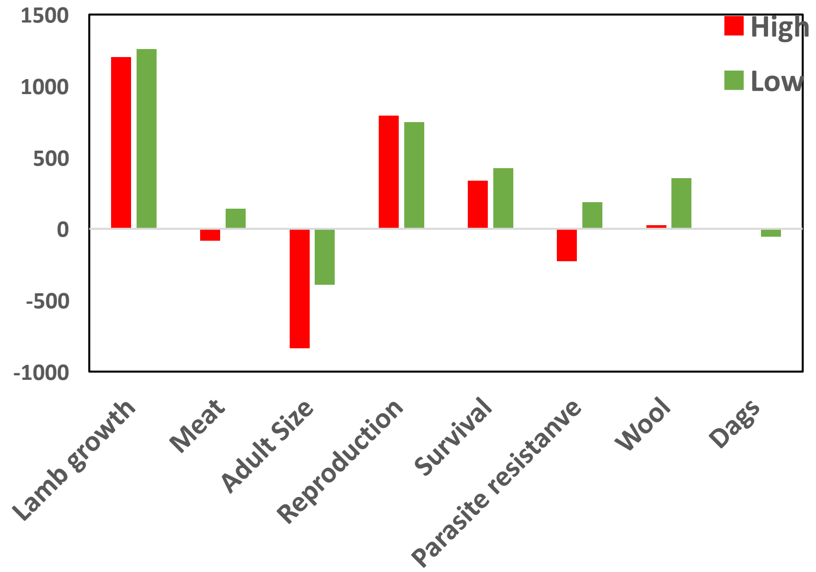
Milk Meat screening <€2

1,000,000 millions

Future plans

Maternal Worth Index





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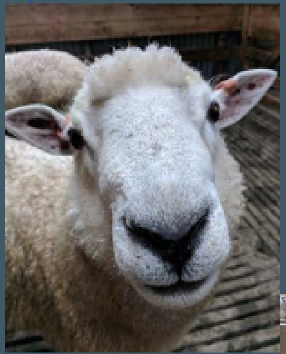
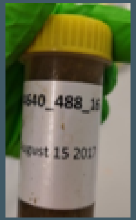
Conclusions

- There are small differences between highs and lows in the reticulo rumen
  - Potentially highs have big rumens
- Relationships between methane yield and performance traits
  - Wool is reduced, Fat is increased, Dressing out is decreased
- Feed traits
  - Eat less, more efficient, Eat less often, Eat bigger meals
- Low methane animals are more profitable – dress out better
- No evidence for detrimental effects – watching brief

Other trials



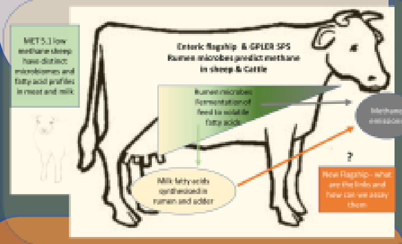


ASGGN The animal selection, genetics and genomics network.

Grass to Gas Eranet
Susan 300k, Ire, SRUC, INIA, Norway, NZ, Turkey, France

Uruguay strategic alliance

Cattle
INZB LIC, CRV, DairyNZ, SDH

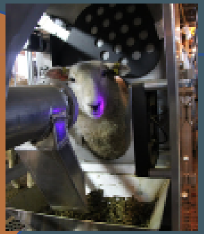


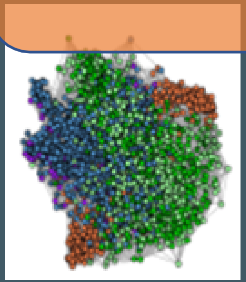
2638

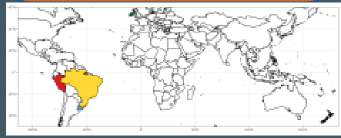
Sheep Microbes GPLER GRA

Enteric Fermentation Flagship Cattle

Proxy Review MPI







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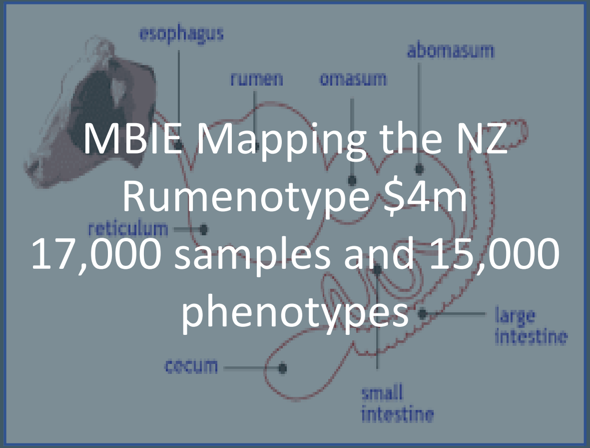
Low input

Future Farm

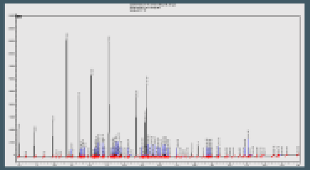
NZ-IRL Teagasc, LIC, CRV, INZB

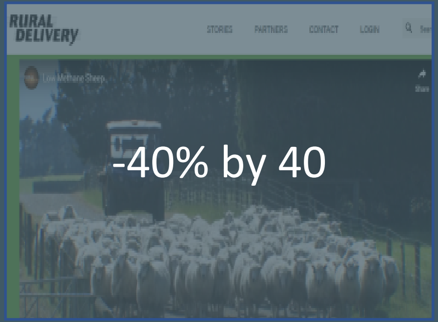
Methane BVs
Rumen Profiling



MBIE Mapping the NZ Rumenotype $4m
17,000 samples and 15,000 phenotypes

Buccal swabs and fatty acid assays





-40% by 40

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Conclusions

- No evidence to date for detrimental effects
- Relationships between methane yield and performance traits
  - Changes in digestion, microbes and fatty acids
  - Wool is reduced, Fat is increased, Dressing out is decreased
  - Low methane animals are more profitable – dress out better
  - Eat frequent smaller meals – eat more, less efficient,
- Small differences in the reticulo rumen

Impact

Table 1. Internal rate of return for 0.58% genetic gain per year expressed at a national level.

	\$tonne CO2e	ΔG/year%	NPV(10%) \$M[1]	IRR[2]
GWP_{100}	50	0.58	41.6	42%
	100	0.58	94.1	60%
	200	0.58	199.3	80%
GWPw.e.	25	0.58	111.3	64%
	50	0.58	233.6	85%
	100	0.58	478.3	111%

[1]NPV=Net Present Value, [2]IRR =Internal rate of return

Sire Id	CH4 gBV	rk CH4	CH4 gAcc
698/18	†0.534	24	36
825/18	†0.553	25	27
2230/18	†0.630	26	64
1020/17	†0.758	27	65
1368/18	†0.806	28	38
17/17	†0.826	29	63
899/17	†0.838	30	64
645/18	†0.843	31	23
318/18	†1.175	32	64

Methane Sire Summary - Flocks

Year - born 2019

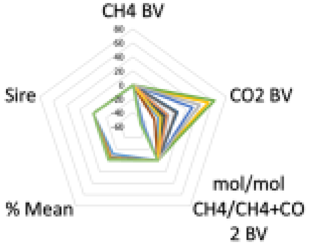
Number of Sires 32
Date Report Run 9-Apr-2020 14:41
Report No. 1912020
Report Birth Period 2019 to 2019
Flock Sire/Dam Breeds Romney
Report Sorted By rk CH4
Date Breeding Values Created 28-Mar-2020 18:00
Base Year 1995
Analysis Flocks: Too many Flocks to list (1283 Flocks in the analysis)
† Genomic information included

Explanation of Indexes

Explanation of Breeding Values

Explanation of count traits listed

Science Outputs



More than 50 publications
Hundreds of presentations, workshops and wool shed talks
Presented at every major meeting
 globally in the sector

Ameliorating the contribution of livestock to global greenhouse gas production: dream or deliverable?

R. Hegarty[1]* J.C. McEwan[2] and S.J. Rowe[2]

THE CONTRIBUTION ANIMAL BREEDING CAN MAKE TO INDUSTRY CARBON NEUTRALITY GOALS.

S.J. Rowe[1], S.M. Hickey[2], P.L. Johnson[1], T.P. Bilton[1], A. Jonker[3], W. Bain[1], B. Veenvliet[1], G. Pile[1], B. Bryson[4], K. Knowler[4], N.C. Amyes[2], S.A. Newman[1], and J.C. McEwan[1]

ENTERIC FERMENTATION FLAGSHIP PROJECT: RUMEN MICROBIOMES TO PREDICT METHANE

S7-SOW21-EFF-AGR-SR

Timothy Bilton, Larissa Zetouni, Melanie Hess, Juliana Budel, Gerlane Noronhe, Malou Bastiaanse, Hannah Henry, Allan McCulloch, John McEwan & Suzanne Rowe

21st July 2022

Impact of breeding for reduced methane emissions in New Zealand sheep on maternal and...
Article Sep 2022
Sharon M. Hickey · W E Bain · Timothy P. Bilton · [...] · Suzanne J Rowe
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Genetic parameters for residual feed intake, methane emissions, and body composition in New...
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Low-cost sample preservation methods for high-throughput processing of rumen...
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Can we have our steak and eat it: The impact of breeding for lowered environmental impact ...
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Low-cost sample preservation methods for high-throughput processing of rumen...
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Individual-level correlations of rumen volatile fatty acids with enteric methane emissions for...
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Breeding Low Emitting Ruminants: Predicting Methane from Microbes
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A restriction enzyme reduced representation sequencing approach for low-cost, high-...
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Melanie Kate Hess · Suzanne J Rowe · Tracey C van Stijn · [...]

Excreta emissions in progeny of the low and high enteric methane yield selection line sheep fed...
Article Sep 2019
Arjan Jonker · S. MacLean · Chernet Woyimo Woju · [...]

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Awards and Recognition

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Media

RURAL NEWS

NATIONAL WORLD OPINION AGRIBUSINESS MANAGEMENT FARM HEALTH MACHINERY & PRODUCTS

Thursday, 20 January 2022 08:55

Low methane livestock a reality

Written by Staff Reporters

font size Print | Em

AgResearch scientists' work to successfully breed low methane emitting sheep has the potential to help all NZ livestock farmers lower their carbon footprint.

Tuesday, November 22, 2022 FARMERSWEEKLY

HOME NEWS MARKETS POLITICS TECHNOLOGY PEOPLE OPINION

'Everyday' Subscription Digital Newspaper Weather Sector Leader

TECHNOLOGY

Planet's gain is no loss to sheep quality

Annette Scott

Researchers look at effect on meat quality of breeding for lower emissions.

Senior Scientist Suzanne Rowe on TVNZ 1's Breakfast

AgResearch
July 31, 2019
Following

Overview Comments

Senior Scientist, Dr Suzanne Rowe, spoke to Jehan Casinader on TVNZ 1's **Breakfast** about our research into lowering the methane emissions from ruminants and what it could mean for the future:

Most relevant

Author
AgResearch
"Farmers are just as worried about the environment and methane as anyone else and all of the top breeders and the people we would expect to come to us to be at the forefront of breeding, they're already knocking on our door..." - Dr Suzanne Rowe
Like Reply 3y Edited 4

Author
AgResearch
More details about this study, funded by the Pastoral

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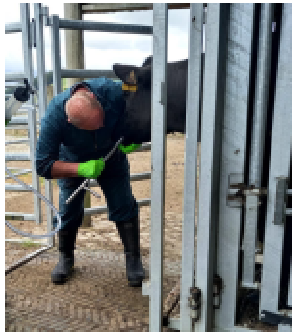
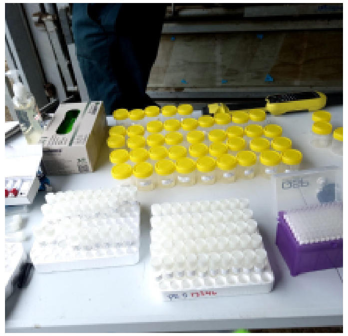
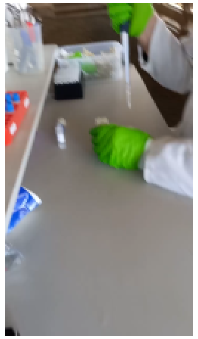
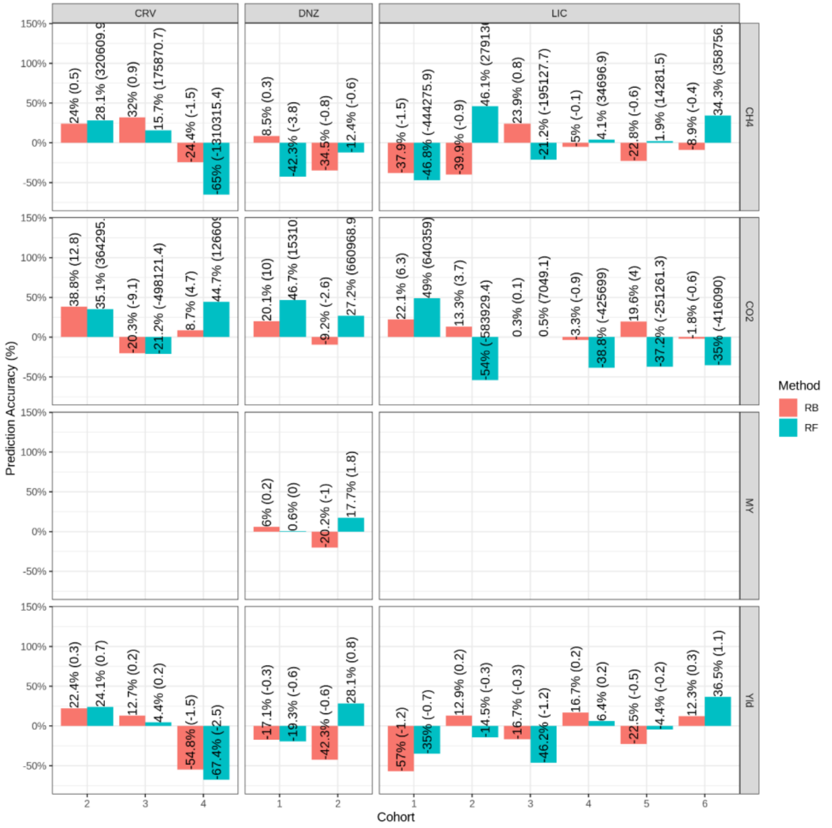
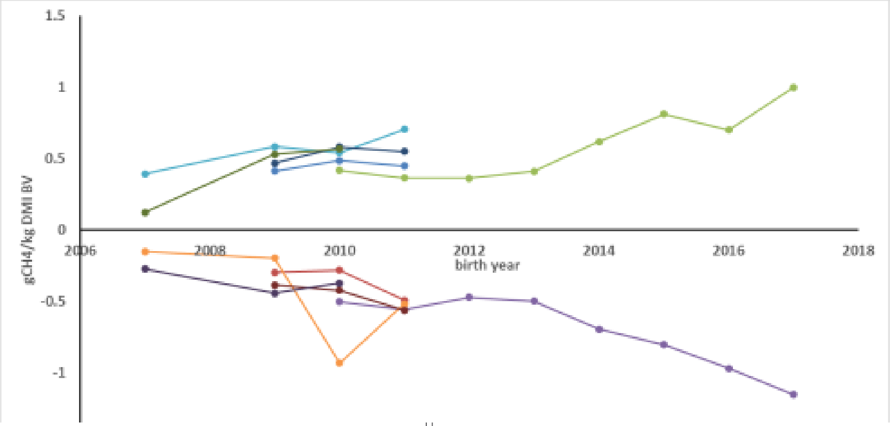
Developments

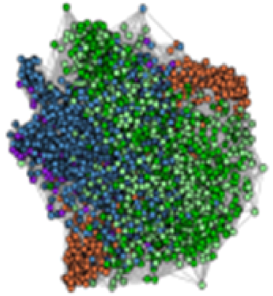


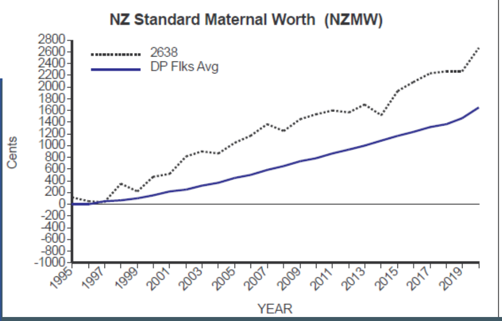


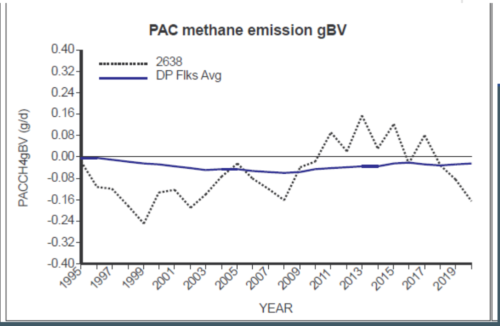












$$Trait_{ijkl} = \mu + Age_j + LWT_k + Breed_l + m_i +$$

Acknowledgements

Funding

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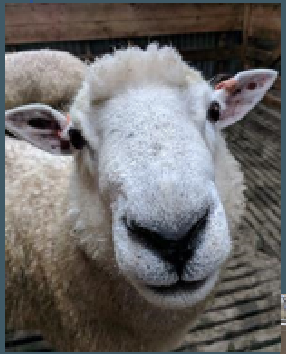

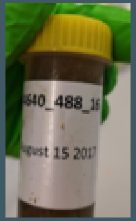

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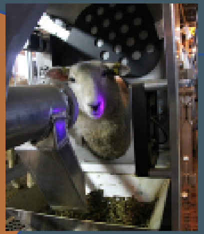

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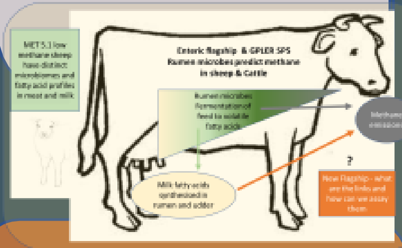

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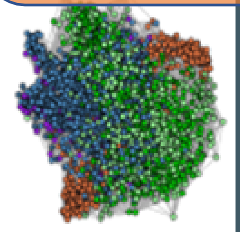
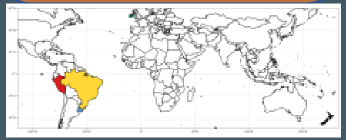
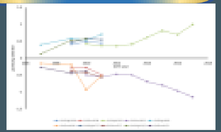




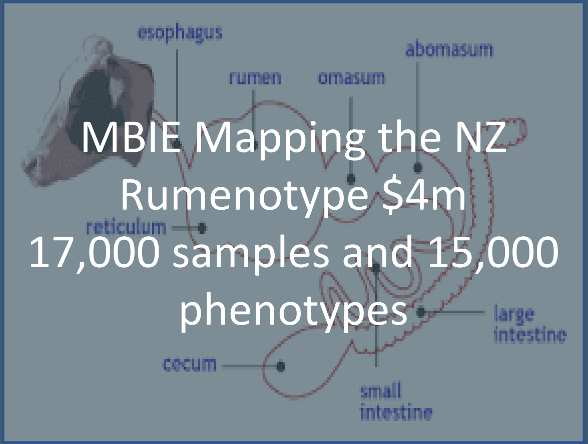
Low input

Future Farm

Methane predict
NZ-IRL



Methane BVs
Rumen Profiling



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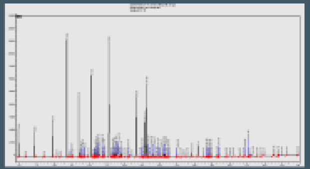

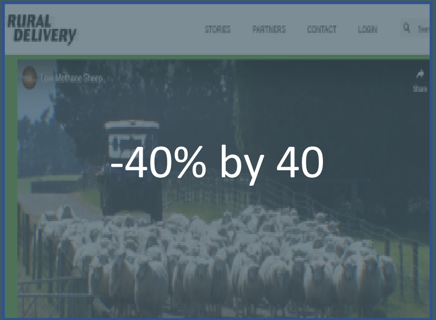

-40% by 40

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Genetic and phenotypic correlations between methane emissions (CH_4, g/d), methane yield traits (CH_4/DMI, g/kg/d) and adult ewe traits (n=9-20k).

	CH_4, g/d		CH_4 /DMI, g/kg/d	
	r_g	r_p	r_g	r_p
Faecal egg	0.18 ± 0.09	**0.09 ± 0.03**	0.13 ± 0.11	**0.05 ± 0.02**
LW Mating	**0.77 ± 0.05**	**0.41 ± 0.02**	**0.30 ± 0.09**	**0.07 ± 0.02**
BCS Mating	**0.34 ± 0.09**	**0.12 ± 0.02**	0.21 ± 0.11	0.01 ± 0.02
PREG scan	-0.05 ± 0.12	0.01 ± 0.02	0.11 ± 0.13	-0.02 ± 0.02
Lambs born	-0.10 ± 0.11	0.01 ± 0.02	0.06 ± 0.13	-0.01 ± 0.01
Wool	-0.10 ± 0.08	-0.01 ± 0.02	**-0.21 ± 0.10**	**-0.07 ± 0.02**

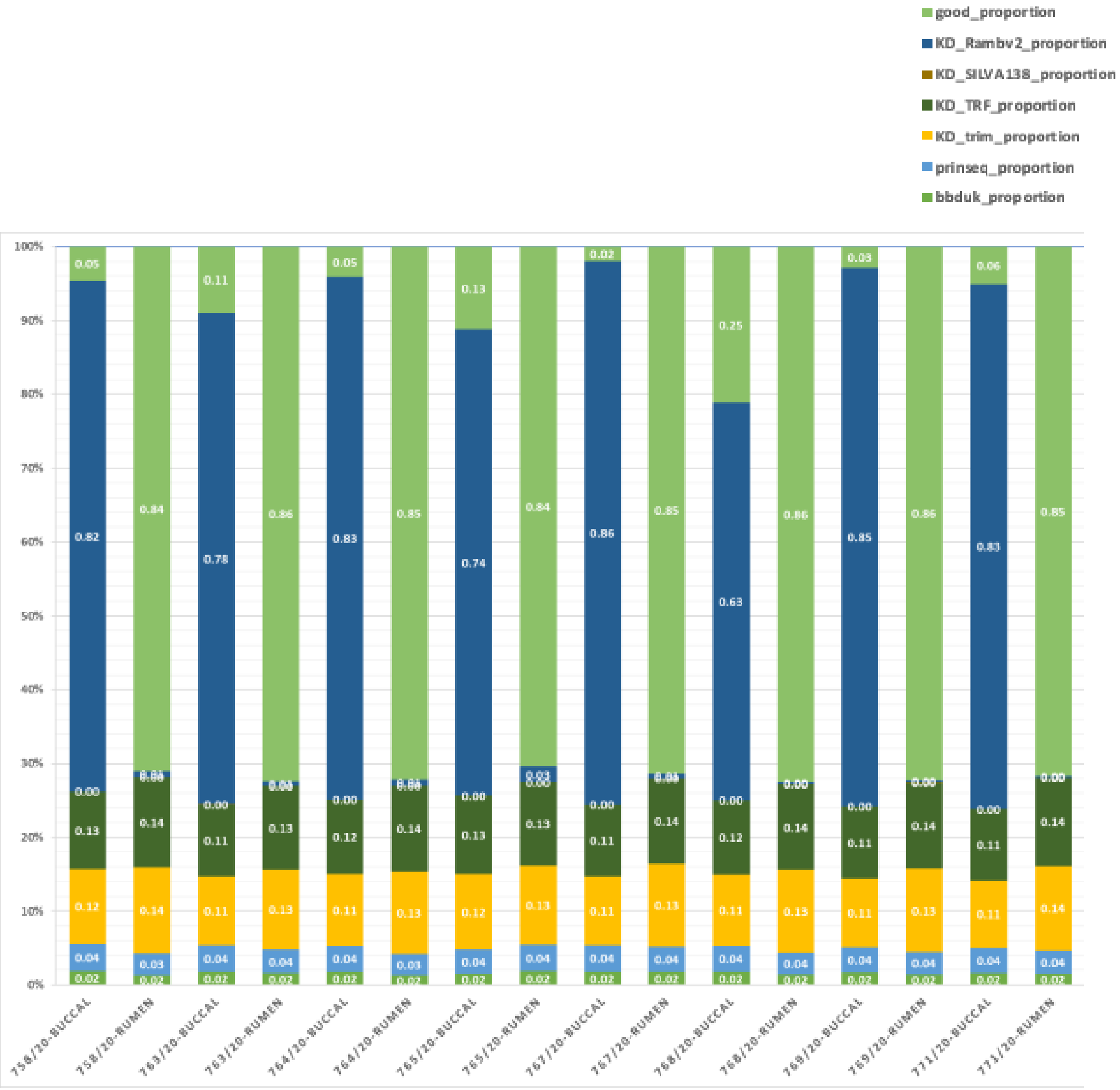
Feed traits

	CH_4 g_d		$CH_4/(CH_4+CO_2)$	
	r_g	r_p	r_g	r_p
Residual feed intake (MJ/day)	-0.28 ± 0.16	0.03 ± 0.03	**-0.41 ± 0.15**	-0.13 ± 0.03
<u>Traits in Residual feed intake Model</u>				
Feed intake (MJ/day)	0.33 ± 0.17	0.36 ± 0.02	**-0.24 ± 0.09**	-0.08 ± 0.03
Mid-trial metabolic live weight (kg)	0.68 ± 0.11	0.41 ± 0.02	-0.06 ± 0.08	-0.02 ± 0.03
<u>Feeding behaviour</u>				
Average feeding time per feeding event	0.04 ± 0.16	0.08 ± 0.03	0.02 ± 0.15	0.04 ± 0.03
Average intake per feeding event	0.41 ± 0.13	0.26 ± 0.03	**0.21 ± 0.08**	0.08 ± 0.03
Average number of daily feeding events	-0.28 ± 0.08	-0.10 ± 0.03	**-0.38 ± 0.15**	-0.10 ± 0.03
Average feeding rate per feeding event	0.55 ± 0.16	0.23 ± 0.03	**0.27 ± 0.11**	0.07 ± 0.03

		CH_4 g_d		$CH_4/(CH_4+CO_2)$
	r_p	r_g	r_p	r_g
Ultrasound assessed body composition				
Starting C (mm)[1]	-0.001 ± 0.13	-0.02 ± 0.03	0.27 ± 0.10	**0.08 ± 0.03**
Final C (mm)[1]	-0.04 ± 0.15	-0.01 ± 0.03	0.06 ± 0.08	**0.02 ± 0.03**
Change C (mm)[1]	-0.27 ± 0.23	-0.002 ± 0.03	-0.26 ± 0.13	**-0.06 ± 0.03**
Computed tomography assessed body comp.				
Visceral fat (kg)	-0.13 ± 0.16	-0.05 ± 0.04	0.31 ± 0.15	0.07 ± 0.04
Subcutaneous fat (kg)	-0.10 ± 0.19	0.03 ± 0.04	0.19 ± 0.17	**0.11 ± 0.04**
Intermuscular fat (kg)	-0.10 ± 0.18	0.04 ± 0.04	0.24 ± 0.17	**0.09 ± 0.04**
Carcass lean (kg)	0.54 ± 0.12	**0.28 ± 0.03**	-0.03 ± 0.17	-0.05 ± 0.04
Carcass fat (kg)	-0.11 ± 0.18	0.01 ± 0.04	0.24 ± 0.18	**0.12 ± 0.04**
Total fat (kg)	-0.13 ± 0.18	-0.01 ± 0.04	0.33 ± 0.17	**0.11 ± 0.04**
Total bone (kg)	-0.33 ± 0.25	-0.07 ± 0.04	-0.72 ± 0.26	**-0.09 ± 0.03**
Non-fat visceral components (kg)	0.36 ± 0.17	0.12 ± 0.04	-0.03 ± 0.18	-0.03 ± 0.04
Fat:lean	-0.12 ± 0.17	0.01 ± 0.04	0.30 ± 0.16	**0.10 ± 0.04**
Carcass weight (kg)[2]	-0.22 ± 0.16	-0.08 ± 0.04	-0.28 ± 0.16	-0.04 ± 0.04
Dressing-out-percent (%)[3]	-0.24 ± 0.16	**-0.20 ± 0.04**	-0.33 ± 0.15	**-0.11 ± 0.04**

Work trial 1 and 2

- Initial work n=96 evaluated swab types and results
  - Identified problems with: low DNA recovery and concentration <10ng/ul
  - Sample collection and DNA extraction ease
- Revised collection, preservative & extraction protocol tested n=8 buccal + 8 rumen
  - Concentrations and quantity still too low but adequate
  - Achieved same proportion of filtered good reads as rumen
  - Reads 79% sheep, 9% rumen, 11% buccal
  - Need 5-10X more reads to get same number of rumen microbe reads as rumen sample!
  - Buccal “rumen” read composition averages vs Rumen read composition averages encouraging



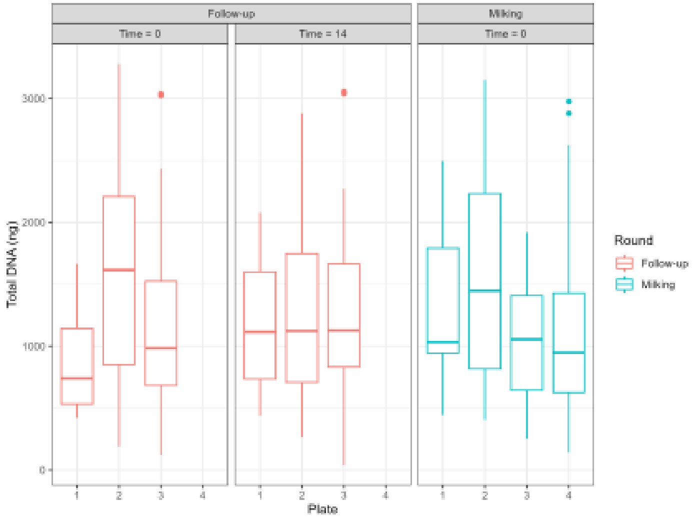
Work trial 3

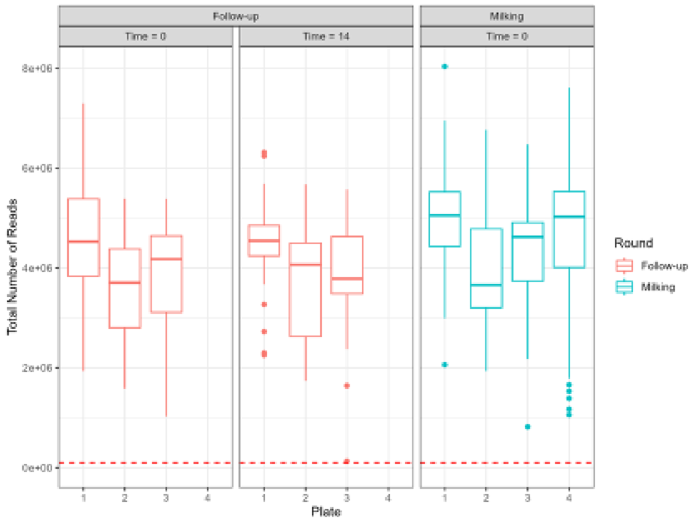
- Revised method to extract more DNA
- 5 X sequencing depth
- Test storage time
- Test repeatability of buccal samples
- Test correlation “buccal rumen reads” vs rumen reads
- Test SNP chip vs GBS host genotyping of buccal samples
-

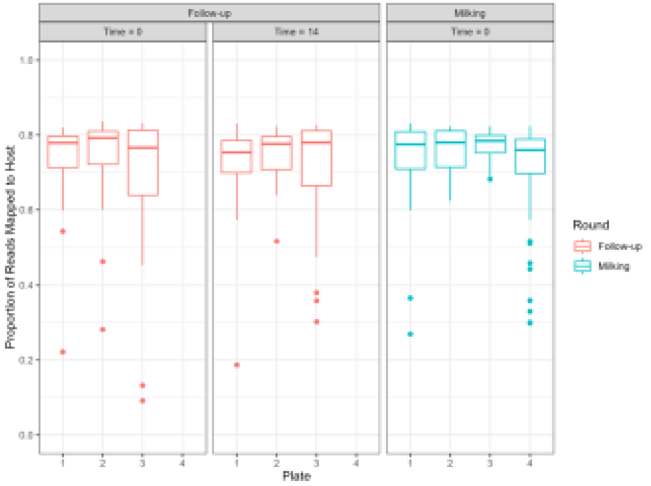
277 low & high methane ewes

- Rumen
- Buccal

- Buccal resample 96 ewes weaning
  - Balanced selection line and
  - Freeze 0 days or
  - Freeze 14 days







- DNA quantity + quality + concentration √
- Number of reads √
- 14 days storage √
- ~80% host reads
- ~5-10% rumen reads

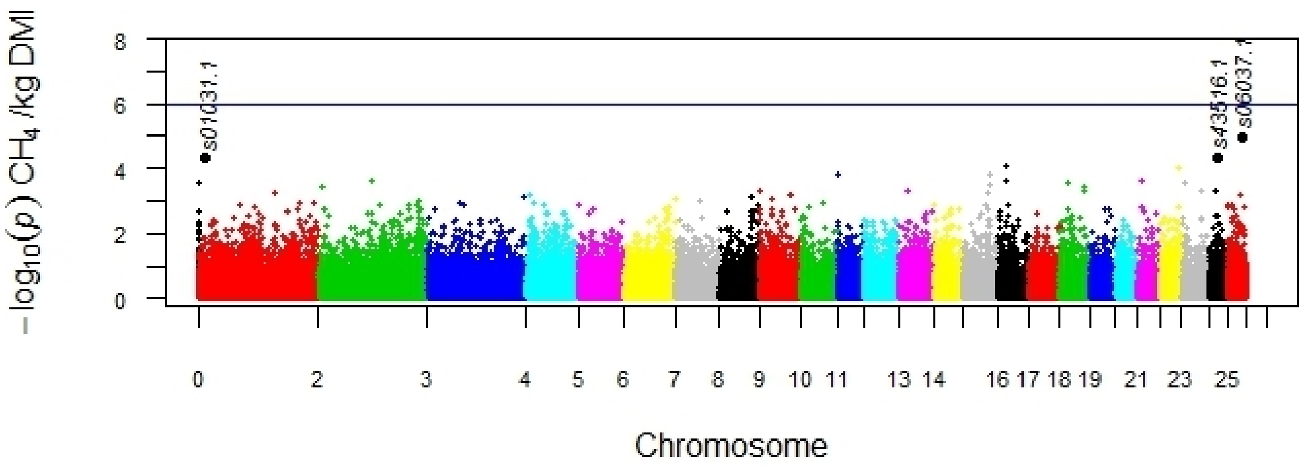
Going forward

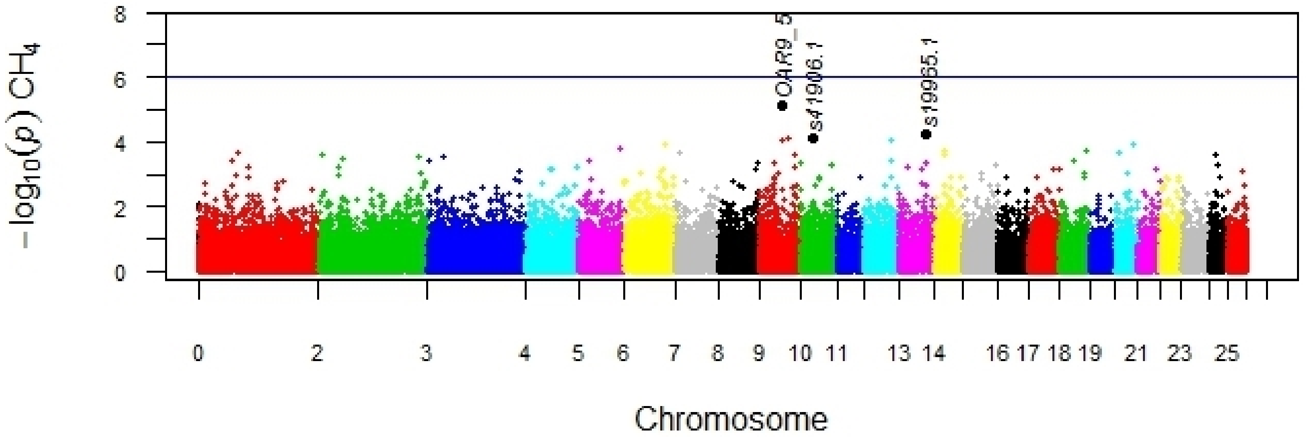
- Decision made to double sequencing depth to increase buccal rumen reads
- When complete analyse buccal rumen read correlation with rumen profiles
- Evaluate predictive ability with methane traits and RFI
- Do a rarefication analysis against predictive ability
- Test buccal DNA samples for use on host SNP chips (covers additional sequencing cost)
- At this stage trying for a method that is both discovery and profiling
- If suitable criteria achieved use method across species where rumen samples collected to evaluate in parallel (n = 500-1000 animals/species)

GWAS

- No big signals

- Unlikely linked to major traits





agresearch
āta mātai, mātai whetū

beef+lamb new zealand
GENETICS

PGgRc

Samples

- 444 sheep sampled
- 1258 herd test samples
- 997 full fatty acid samples
- 1138 Rumen microbial profiles
- 734 Rumen VFAs
- 473 Blood VFAs
- Methane Predict - 500 sheep and 500 beef cattle fatty acid profiles for meat