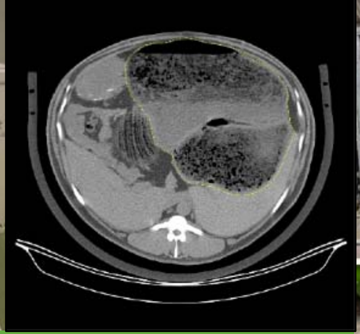



SRUC

GrassToGas

Smarter

SMAll RuminanTs breeding for Efficiency and Resilience

An international approach to reduce greenhouse gas emissions from sheep

Joanne Conington

& many others..

ICAR session 8, 24 May 2024

Leading the way in Agriculture and Rural Research, Education and Consulting

Strategies to mitigate greenhouse gas emissions from pasture-based sheep: 'Grass To Gas'

GrassToGas

Norway

Norwegian University of Life Sciences

NSG Norsk Sau og Geit

UK

SRUC

TEXEL SHEEP SOCIETY

NZ

agresearch

Ireland

teagasc Agriculture and Food Development Authority

Sheep Ireland www.sheep.ie

France

RÉPUBLIQUE FRANÇAISE Liberté Égalité Fraternité

INRAE

Turkey

REPUBLIC OF TURKEY MINISTRY OF AGRICULTURE AND FORESTRY INTERNATIONAL CENTER FOR LIVESTOCK RESEARCH AND TRAINING

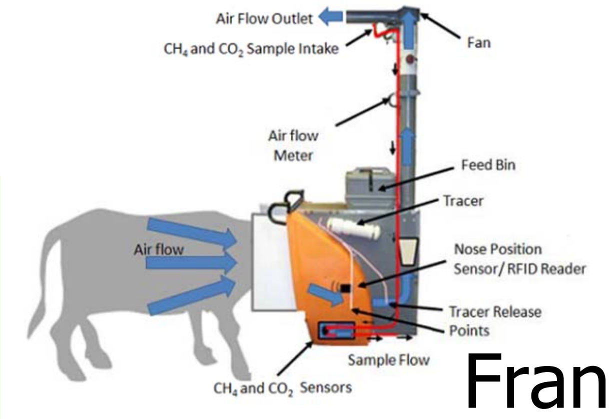
Uruguay

INIA Instituto Nacional de Investigación Agropecuaria URUGUAY

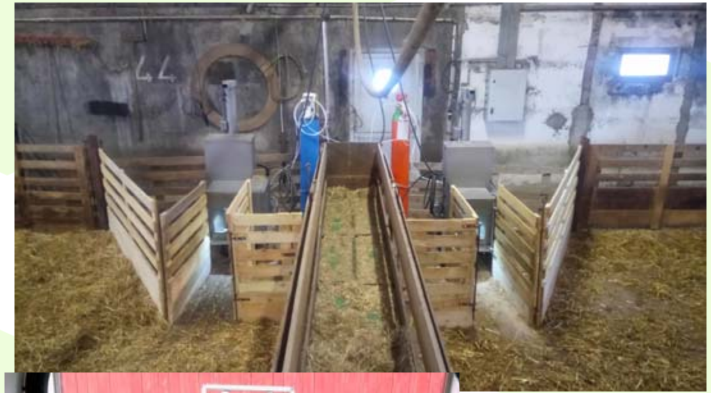
International Project, 10 partners from 7 countries, 2019-2023

** New project 2024-2027 'Sustain Sheep' **

Previously?



France

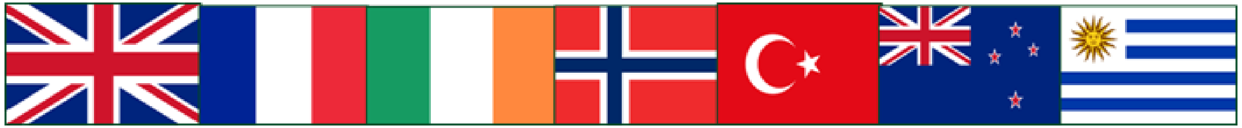


UK

Uruguay

NZ

Norway



Key Aims

1. Validate predictors of feed intake, feed efficiency and methane emissions

Key Aims

2. Compare indoor vs outdoor feed efficiency and methane emissions

Key Aims

3. Investigate the opportunity to use genetics and genomics to reduce methane (CH_4) emissions
   - genetic control – feed efficiency and methane?
   - impact of genetic selection on CH_4?
   - genomic diversity of rumen microbial communities?
   - links between phenotypes and host genome?

Key Aims

4. Quantify economic and environmental benefits of more feed-efficient and lower GHG-emitting sheep

Identify / quantify potential trade-offs via modelling approaches

Ensure relevance from farm to international impact scale

Our focus

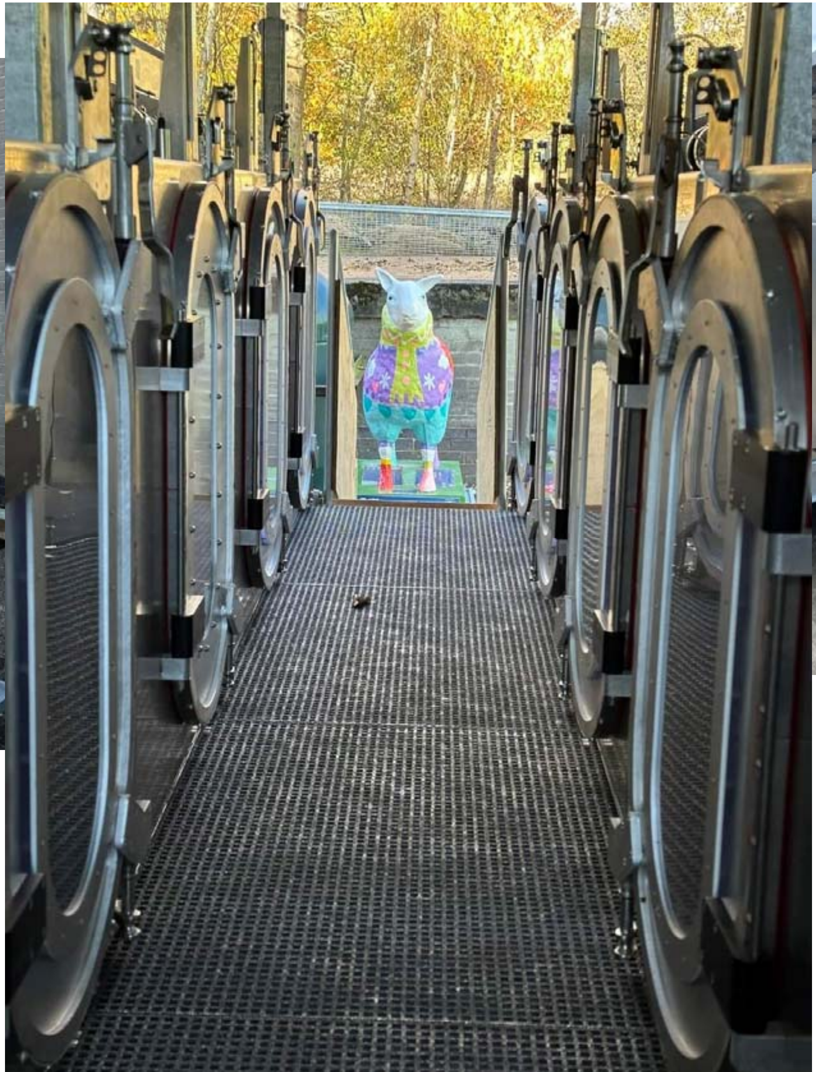
- Focus on measuring methane emissions, feed efficiency, potential predictors, animal performance

Direct measurement of methane emissions

Norway, Ireland, France, Uruguay, NZ (& UK 2022+)

Computation of methane emissions, oxygen consumption, CO_2 emission /kg LWT /hr

Mini ‘boxes’ (PACs) to measure CH4 from individual sheep



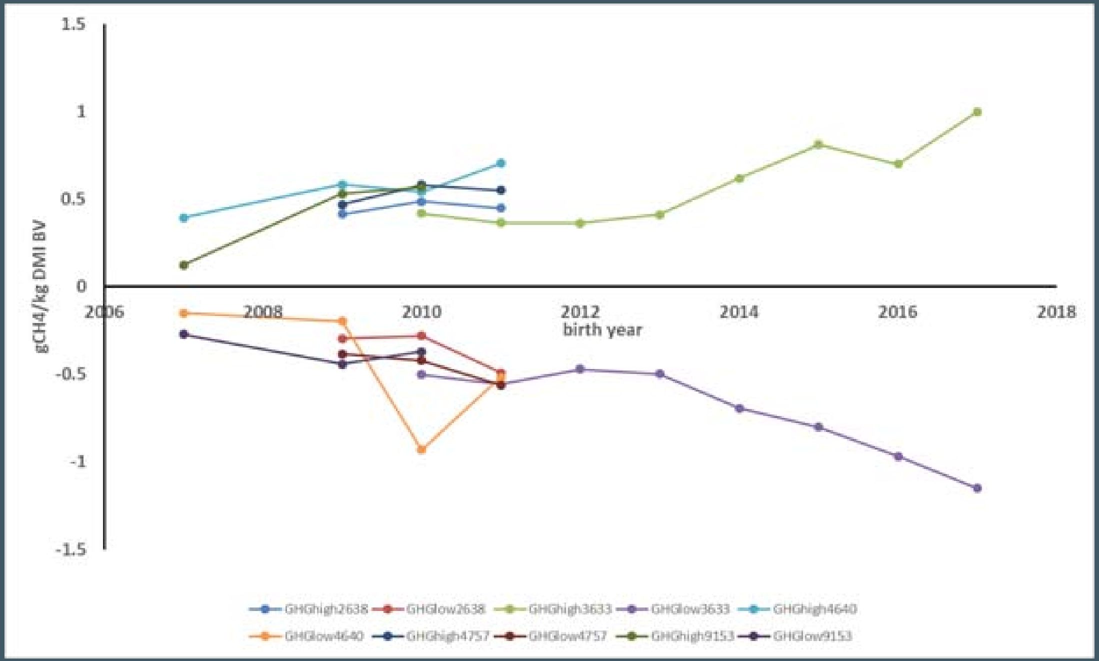
Traits measured

TRAIT	France	UK	Uruguay	Ireland	Norway	NZ	ICLRT
Feed intake (concentrate)	X						
Feed intake (forage)	X	X	X	X	X	X	
Feed intake (water)	X						
GHG emissions	X		X	X	X	X	
Body weights – ADG	X	X	X	X	X	X	X
Body composition: ultrasound	X	X	X	X		X	
Body composition: CT-scanning and MRI	X	X				X	
Body composition: MRI	X						
Carcass traits		X	X	X		X	
Body condition scores	X		X	X	X	X	
Rumen volume (CT scan)	X	X			X	X	
Blood metabolites	X			X			
Genetic markers	X		X		X		
NIRS on faeces	X						
Ruminal datasets	X		X	X	X	X	
RumiWatchSystem				X			
Feed quality	X	X	X	X	X	X	X

agresearch
ātaa mātai, mātai whetū

NZ- selection for divergent CH_4

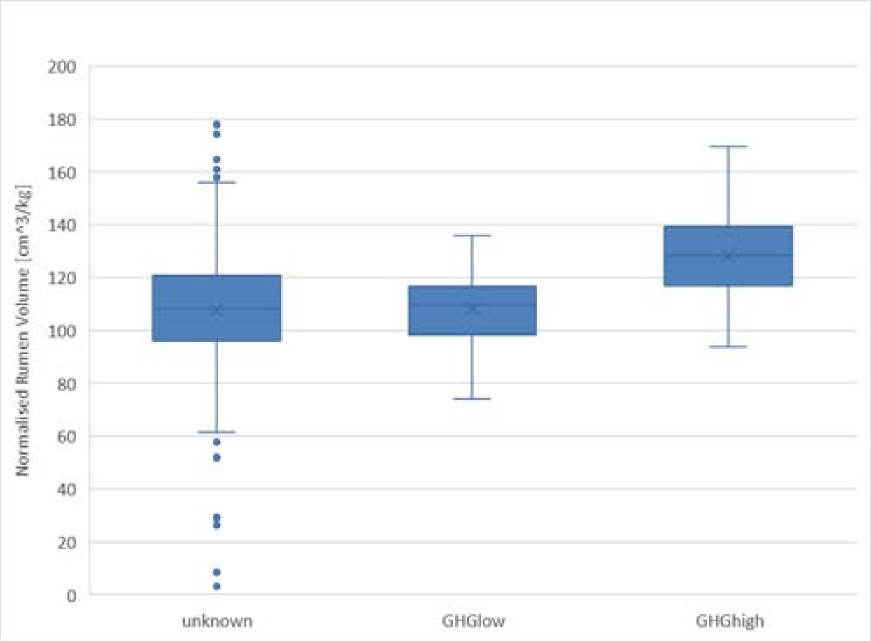
Adaption	M1	M2	- 14 day rest	M3	M4



Suzanne Rowe, pers. comm

Differences between High vs low CH4 lines NZ provides evidence of how animals differ

Trait	High CH_4	Low CH_4	P-value	Diff.[1]	Heritability
Reticulo-rumen full (g)	[illegible]	[illegible]	[illegible]	[illegible]	0.19 ± 0.07
Reticulo-rumen empty (g)	[illegible]	[illegible]	[illegible]	[illegible]	0.16 ± 0.07
Est. rumen contents (g)	[illegible]	[illegible]	[illegible]	[illegible]	0.20 ± 0.07
Papillae count (per cm^2)	[illegible]	[illegible]	[illegible]	[illegible]	0.09 ± 0.05
Av. papillae height (mm)	[illegible]	[illegible]	[illegible]	[illegible]	0.25 ± 0.07
Av. papillae width (mm)	1.94 ± 0.04	1.95 ± 0.04	[illegible]	[illegible]	0.10 ± 0.06
Av. papillae surface area	26.6 ± 1.0	28.5 ± 1.1	0.21	-7%	0.22 ± 0.07



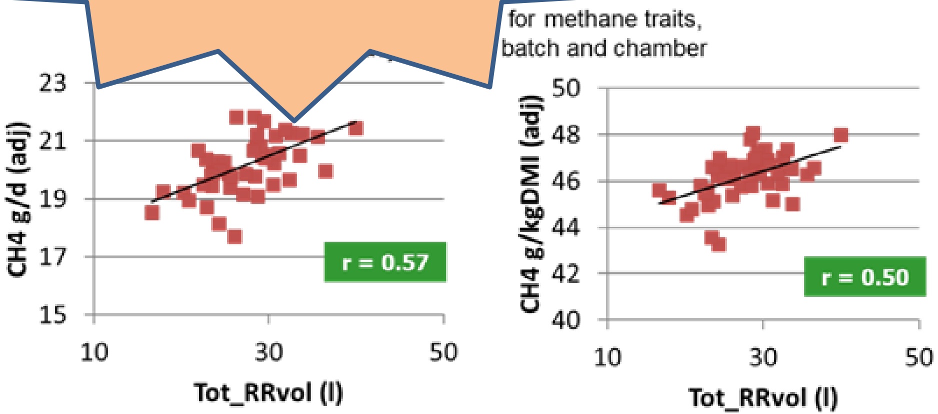
Suzanne Rowe, pers. comm

The rumen volume story cont'd..

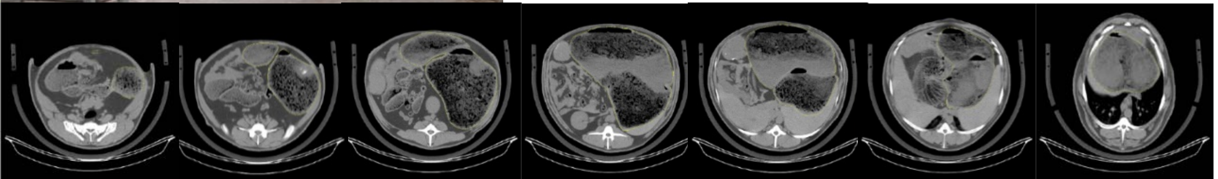
NZ - 3 generations of sel (Rowe, 2021)

- 20% difference in R
- associated with 11% d issions

Bigger rumen
= more methane

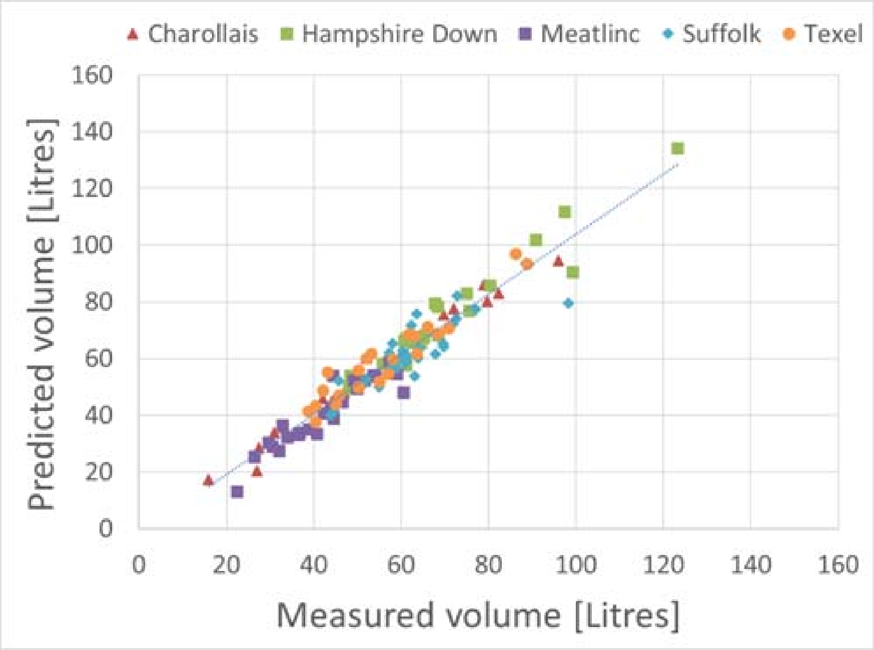


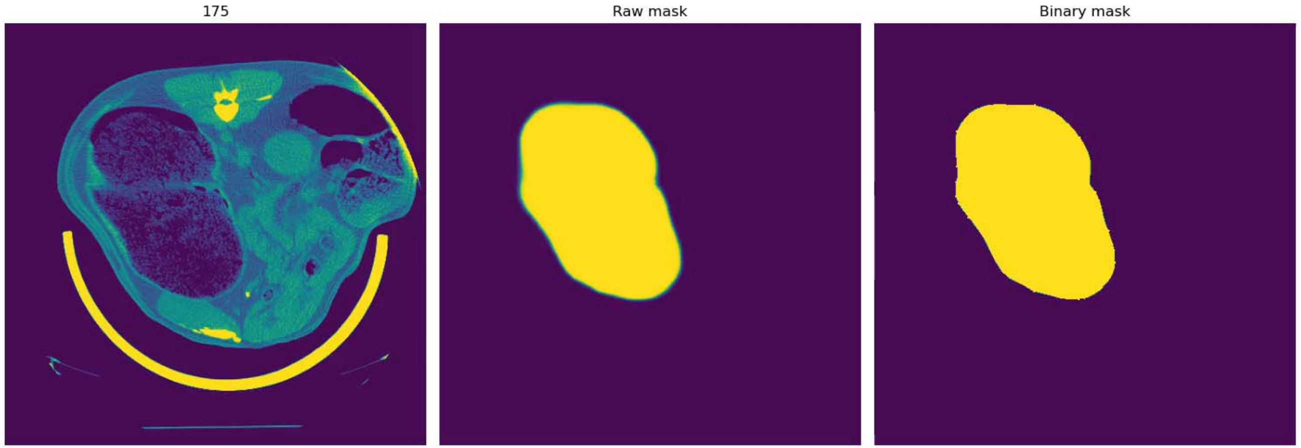
CT reticulo-rumen (RR) volume related to CH_4 emissions



Using CT images to predict rumen volume

Testing out on Computer-Tomography (CT)* images from UK breeds





Sam Hitchman et al., 2023 EAAP Session 15, paper 14

*CT is already routinely used in sheep breeding programmes in some countries for near-perfect estimates of body composition (fat, muscle etc)

Feed intake & efficiency

Feed efficiency:

•Protocols and models further developed and shared (Residual Feed Intake; RFI)

•Between and within-breed variation confirmed

•Moderate h^2 RFI France = 0.45, NZ = 0.42, Uruguay 0.37 (0.08)




Residual Feed Intake (RFI)
= actual feed intake - predicted feed intake
(due to growth, metabolism, composition changes etc.)

Feed intake and efficiency

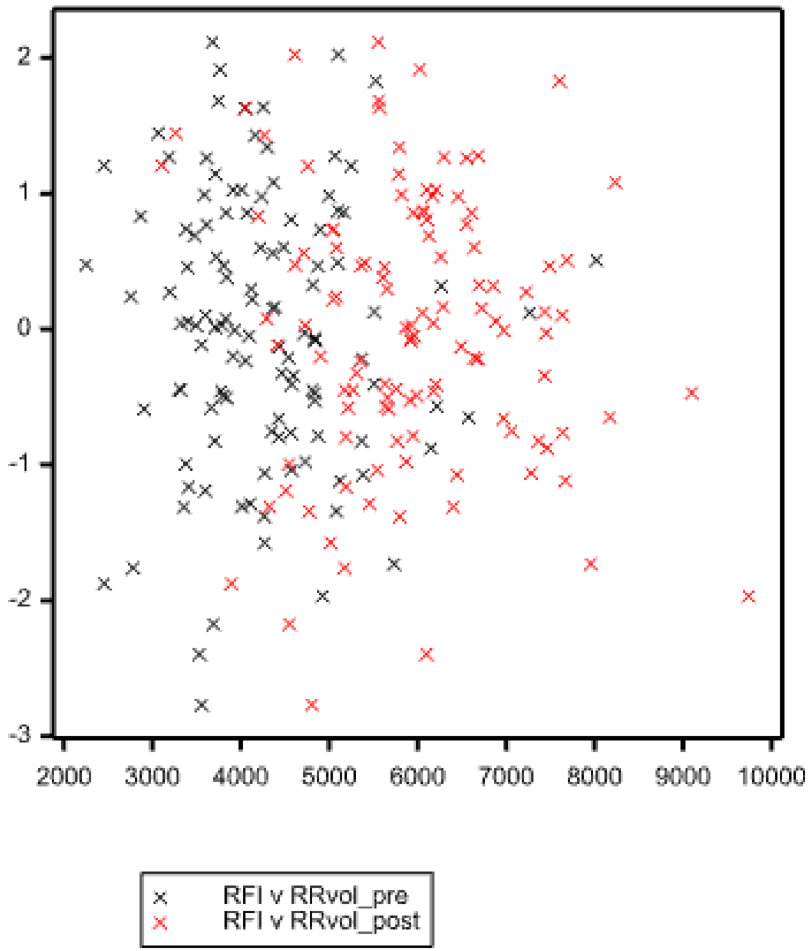
Feed efficiency:

- Differences between forage-based diets (grass / silage of differing quality) (Ireland)
- Positive correlations between indoor concentrate intake, indoor forage intake and RFI (Norway)
- Feed intake at grazing (n-alkane technique) highly correlated with intake measured indoors (Ireland)

Indoor/outdoor trial - UK

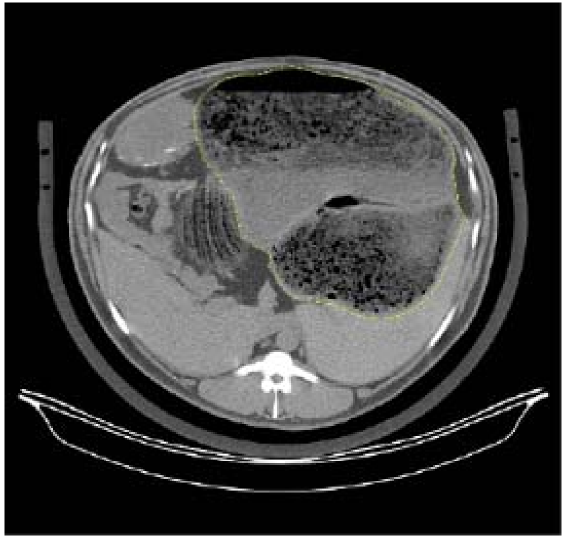
- **Lambs grazed outdoors (vs indoors)**
  - lower weights, growth, fat and muscle levels
  - greater RR volume
- **Feed efficiency (RFI) measured indoors**
  - Significant sire differences
  - No clear relationship with RR volume

RFI vs rumen volume?



x = RFI vs pre-trial rumen vol

x = RFI vs post-trial rumen vol



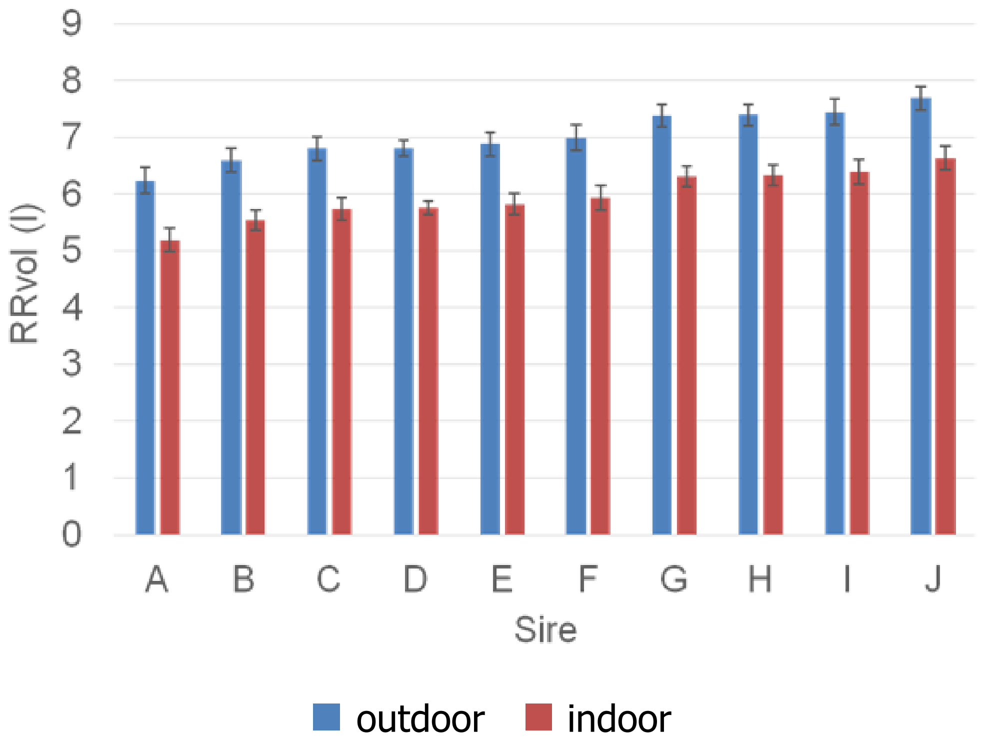
No clear relationship

Results – indoor vs outdoor (UK)

Significant sire effects (all traits)

Lambs from the same sires ranked similarly in each system for LWT, RFI, reticulo-rumen volume

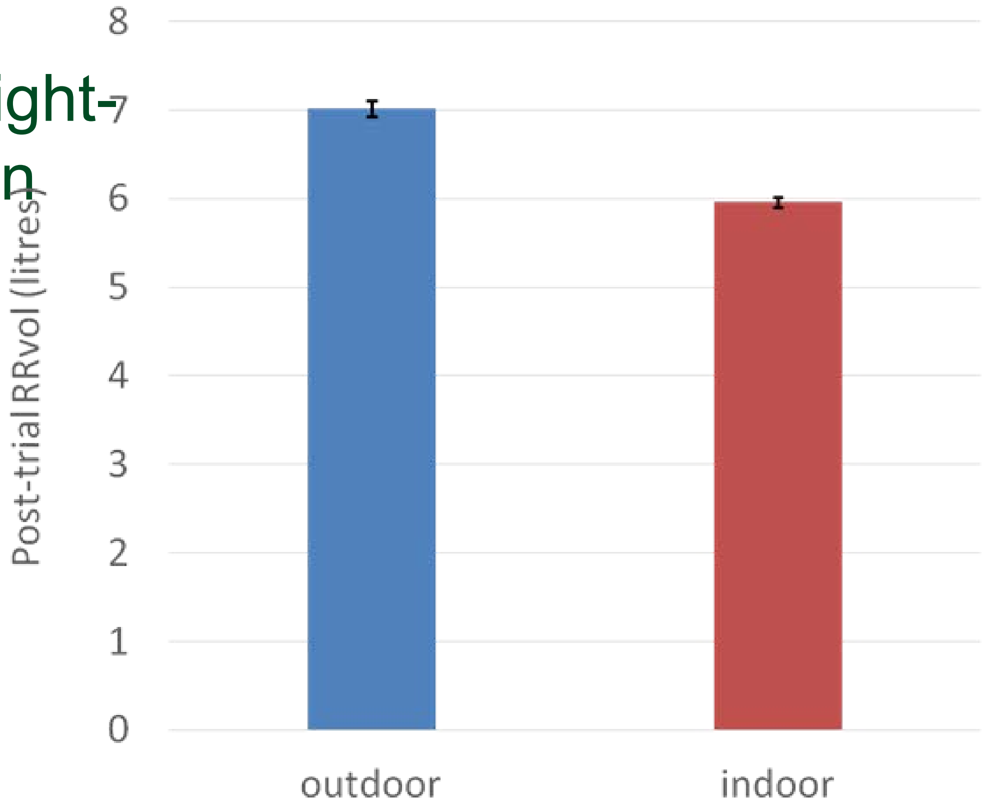
Feed intake behaviour (no. meals, meal duration etc.) explained large % RFI variation



Results – system/diet effects on RR volume

Lambs grazed outdoors post-trial were:-

•significantly larger (P<0.001) liveweight-adjusted reticulo-rumen volume (RRvol)



Key results – CH_4

- Ranking of animals same PAC vs respiration chambers high
- Between and within-breed variation confirmed
- h^2 CH_4 g/d = 0.32; $CH_4/(CH_4+CO_2)$=0.29 NZ* n= 1000

  CH_4 g/hr = 0.17 Norway **(n=4500)

  CH_4 g/d = 0.34(0.09) Uruguay *** (n-930)

*Johnson et al 2022
Front. Genet. Aug 22
https://doi.org/10.3389/fgene.2022.911639

** Jakobsen et al WCGALP
https://doi.org/10.3920/978-90-8686-940-4_34

*** Marques et al 2022
https://www.wageningenacademic.com/doi/10.3920/978-90-8686-940-4_28

Results RFI vs CH_4

Less efficient animals (high RFI) emit more CH_4(g/day & g/kg LWT)

r_g RFI - CH_4 = 0.43(0.19)

r_g FI - CH_4 = 0.75 (0.12)

*** Marques et al 2022

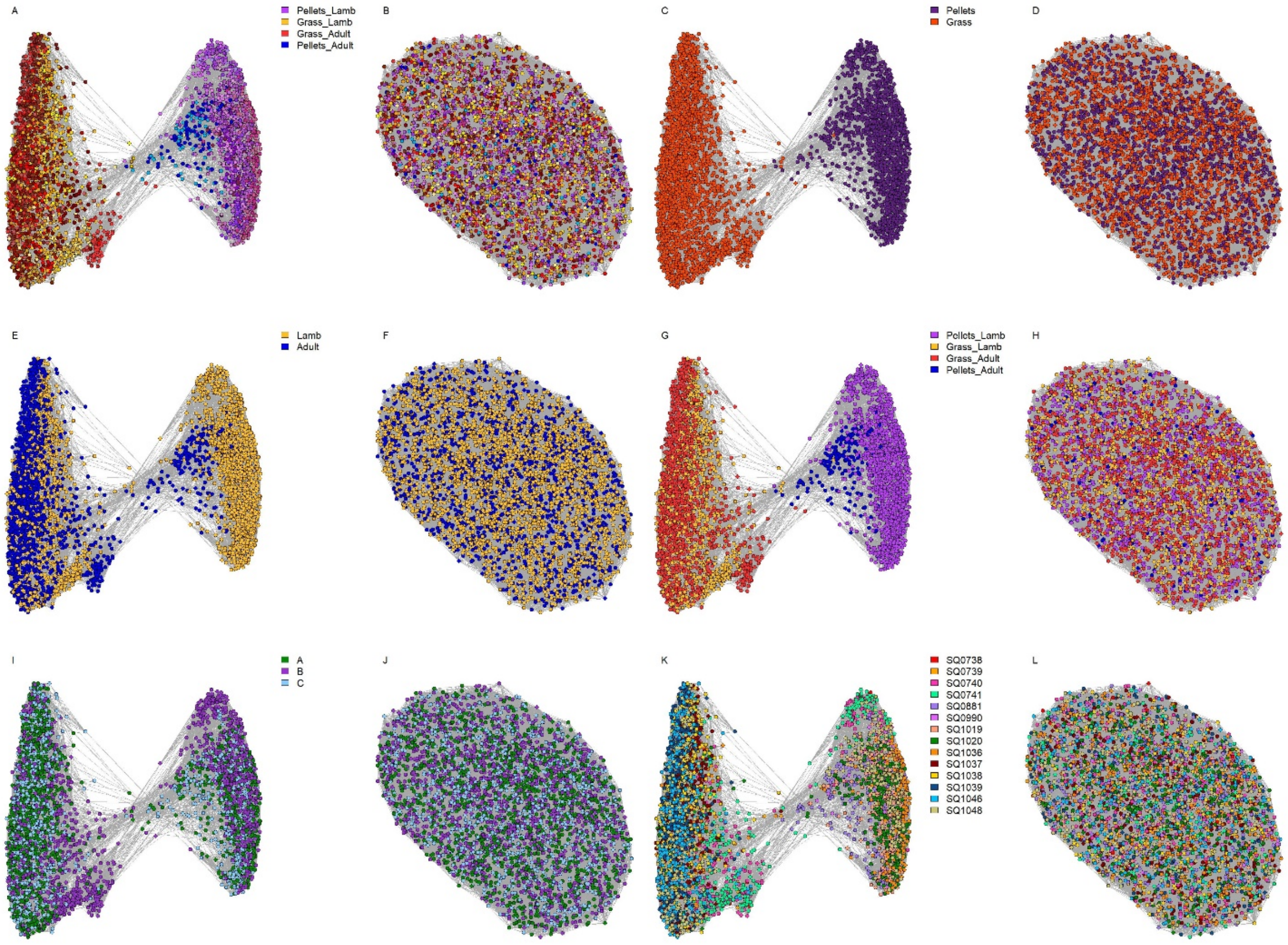
Results RFI vs CH_4 ?

r_g RFI … Co_2) … 0.13(0.03)

… (0.15)

The Jury is still out!

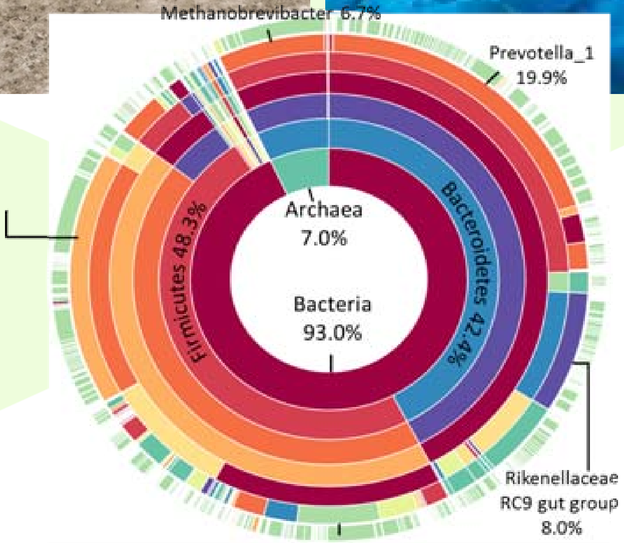
Microbiome predictor of CH_4



Rumen microbial (genomic) profiles

Hess MK, Rowe SJ, Van Stijn TC, Henry HM, Hickey SM, Brauning R, et al. (2020) A restriction enzyme reduced representation sequencing approach for low-cost, high-throughput metagenome profiling. PLoS ONE 15(4): e0219882. https://doi.org/10.1371/journal.pone.0219882

Results – not always consensus



Ruminal microbiota – France: no clear relationships

NZ

~4K sheep: r_g 0.64 feed intake

r_g CH_4 (PAC) vs RMC= 0.66(.13) - 0.76(.14)

Bilton et al., 2022

4th Aim: Cost effectiveness (CE) and abatement potential (AP) of mitigation measures applied to UK sheep systems

Name	Applied to	CE (£/tCO2e)	AP (ktCO2e)	AP as %
Bio N fixation in grasslands	Managed grass	-1034	250	2.5%
Optimising pH for grass growth	Managed grass	-31	278	2.8%
Breeding for improved productivity	All sheep	-10	504	5.0%
Breeding for lower CH4	All sheep	20	252	2.5%
Better health planning for sheep	All sheep	38	391	3.9%
3NOP*	Non-grazing sheep	119	99	1.0%
3NOP*	All sheep	158	925	9.2%
Total			2699	27%

Mike Macleod, Grass To Gas Final report December 2023

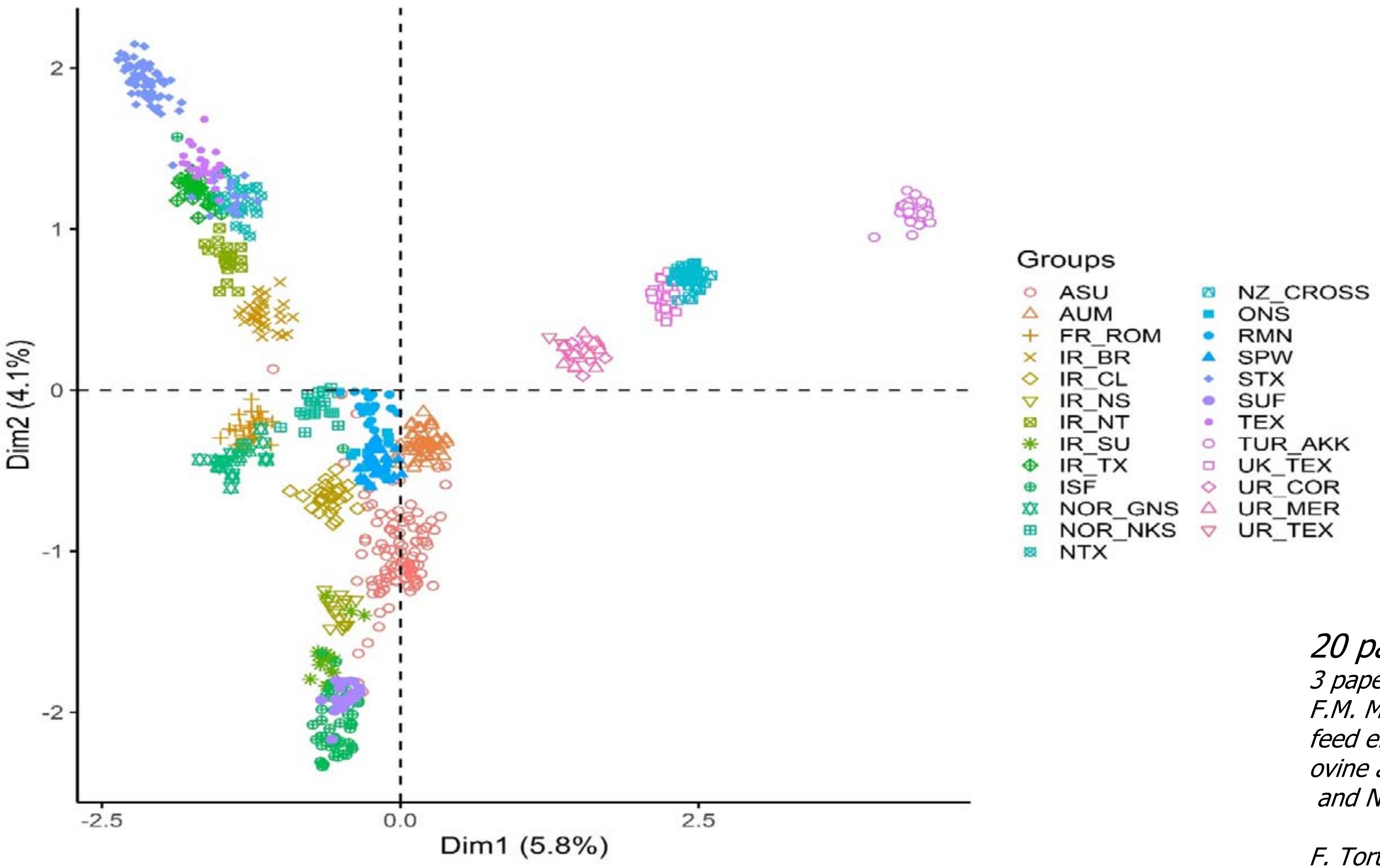
*3 Nitrooxyproponol=feed additive

Conclusions

- Promising tools have been developed to measure traits related to GHG emissions from sheep
- **Will enable genetic/ genomic selection** for reduced methane emissions which will have a direct favourable mitigation impact.
- **Improving productivity** and reducing inefficiencies in the production systems has direct favourable impact on methane intensity, however it may increase absolute emissions. But! selecting for low emitting animals has a positive impact on the reduction of total methane emissions.
- **Almost 30% of abatement potential from sheep can be realised through breeding strategies**
- **International collaboration is key:** Avoids duplication of research effort / funding, pools expertise, accelerates industry implementation, global problem requires global solution

Where are we going next?

International (genomic) comparisons



376 KTE outputs

20 papers published

3 papers in prep

F.M. McGovern, et al., Assessing methane production, feed efficiency and performance characteristics in ovine animals in six countries across Europe, S. America and New Zealand.

F. Tortereau, et al.,
Prediction of feed intake and feed efficiency in sheep: different proxies and models tested in different datasets.

Mehmet Kizilaslan

Acknowledgements

GrassToGas

FACCE ERA-GAS

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ICT-AGRI era-net

TEXEL SHEEP SOCIETY

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SMAll RuminanTs breeding for Efficiency and Resilience

Thanks for listening

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Suzanne Rowe
Elly Navajas
Flavie Tortereau
Fiona McGovern
+++ all G2G partners

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Some interesting facts

- 70 kg ewe emits 0.1 – 2.5g CH_4, 15 - 123g CO_2 *per hour*
- 70 kg ewe dry matter intake (DMI) / kg live weight =2.26 kg at pasture
- No difference in ewe CH_4 output / kg DMI between grass pellets vs haylage (fed indoors)
- Low- genetic merit for maternal ability ewes did not differ in CH_4 output between rough pasture & lowground pasture (in contrast to high-performing or lowground breed).

frontiers | Frontiers in Genetics

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Genetic parameters for residual feed intake, methane emissions, and body composition in New Zealand maternal sheep

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