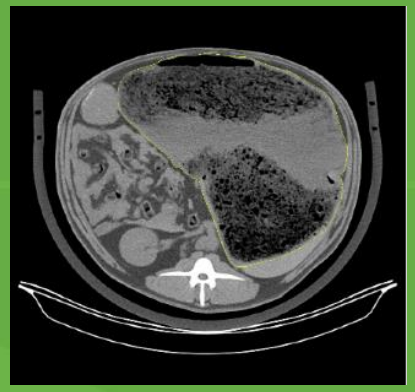
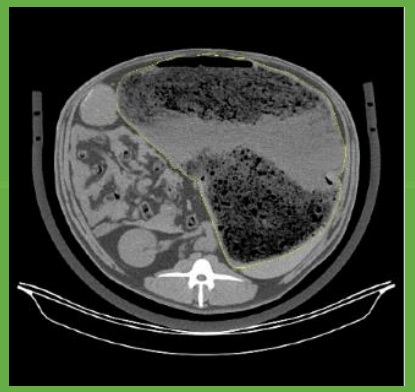




Big or small rumens?

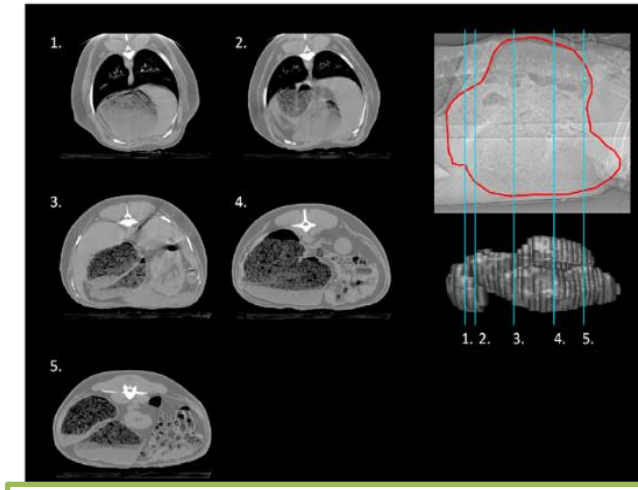
Observations from research projects to investigate breeding for low methane emissions

Introduction

- CT scanning is routine for elite UK terminal sire sheep
  - accelerated gains in carcass composition
  - potential for new traits
  - related to sustainability / environmental impact?

- Different rumen morphology in sheep divergent for methane emissions
  - New Zealand (Bain et al., 2014)
  - Australia (Goopy et al., 2014)

- What can our CT images tell us about methane emissions or other sustainability traits in UK sheep?

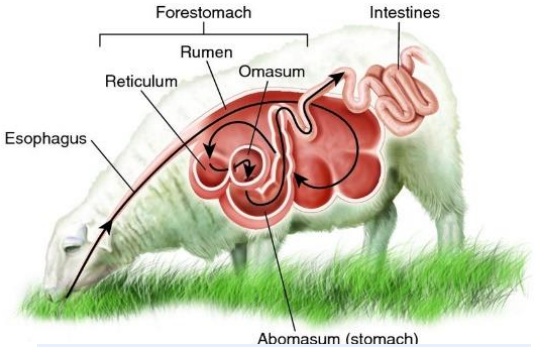


Bain et al. 2013. AABG 2013.

Research questions:

- Can CT rumen measurements predict methane emissions?
- Can CT identify differences in rumen dimensions that could affect methane emissions between different types of sheep?
- Are these predictors under genetic control?
- Would there be unfavourable consequences of breeding for rumen measurements?

…or for methane emissions, if that changes rumen traits?



Background: rumen volume vs CH4

Low vs high methane emission lines

- Goopy et al, 2014 – Australia
- Bain et al. 2014; Elmes *et al.* 2014; Waite *et al.* 2018 - NZ

- ewes and slaughter lambs
- CT and abattoir data
- rumen size (not shape) affects methane yield

Bigger rumen
= more methane

Progeny of sires divergent for methane emissions

- Bond *et al.* 2019; Oddy *et al.* 2019

- ewes 12 – 28 months
- high correlation: rumen size v methane

Rumen-canulated sheep

- Pinares-Patino *et al.* 2003

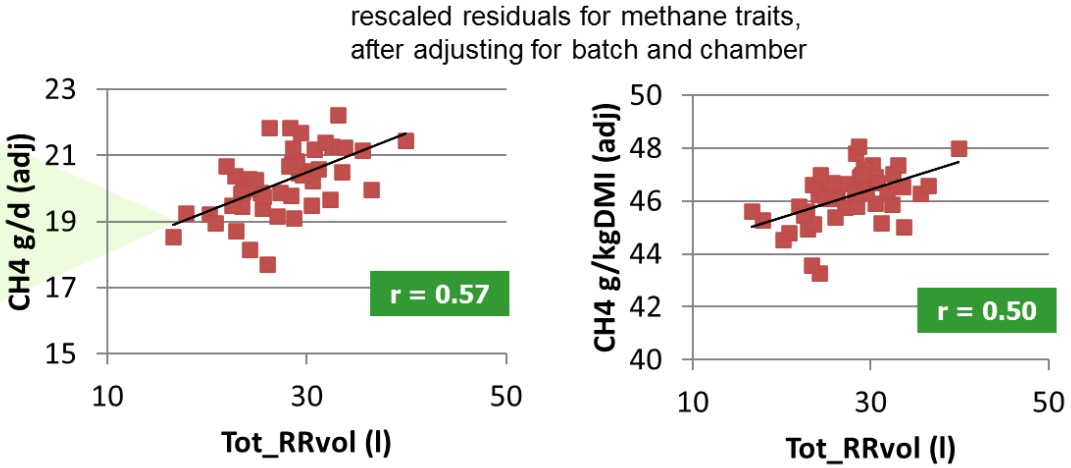
- longer rumen retention =
- larger rumen fill =
- higher methane yields

Maternal selection lines

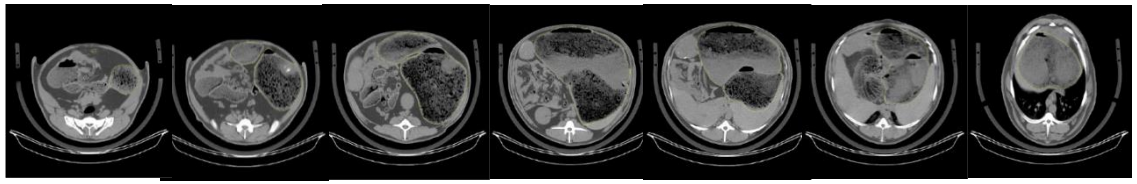
- Lambe et al. 2019

Background: rumen volume vs CH_4

Lambe, Miller, McLean, Gordon and Dewhurst 2019. Prediction of methane emissions in sheep using computed tomography (CT) measurements of rumen volume. British Society of Animal Science.



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



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Objectives using SRUC CT archive

Use archived CT images of sheep to investigate

variation in rumen volumes between and within breeds

Breed effect on reticulo-rumen (RR) volume

CT archive data set from 220 lambs CT scanned pre-slaughter:

- Scottish Blackface (n = 151) and Texel (n = 119)
  - reared together on low-ground grass birth-slaughter
- Entire male and female
- Age 3 - 6 months (average 20 weeks old)
- No standardisation of time off feed

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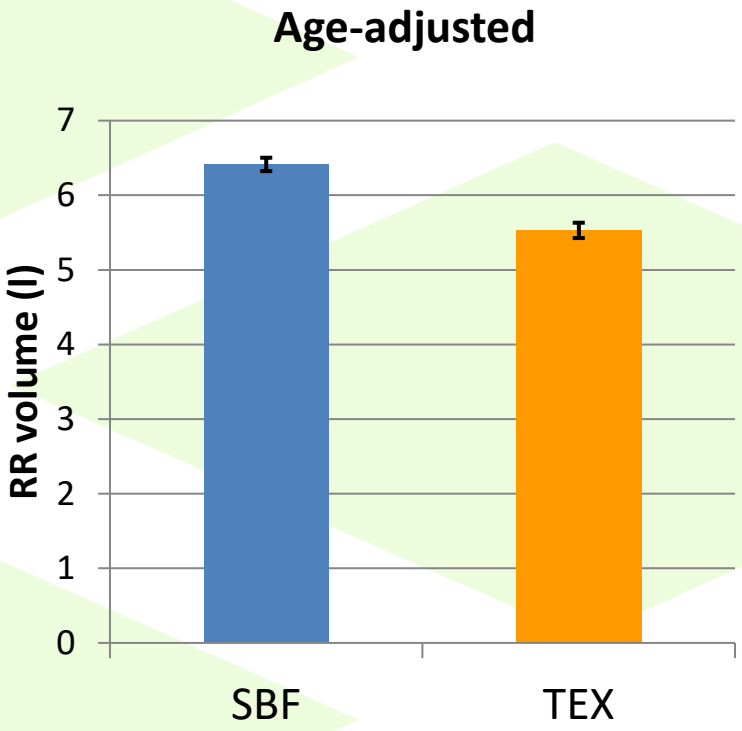
CT image analysis

CT image analysis

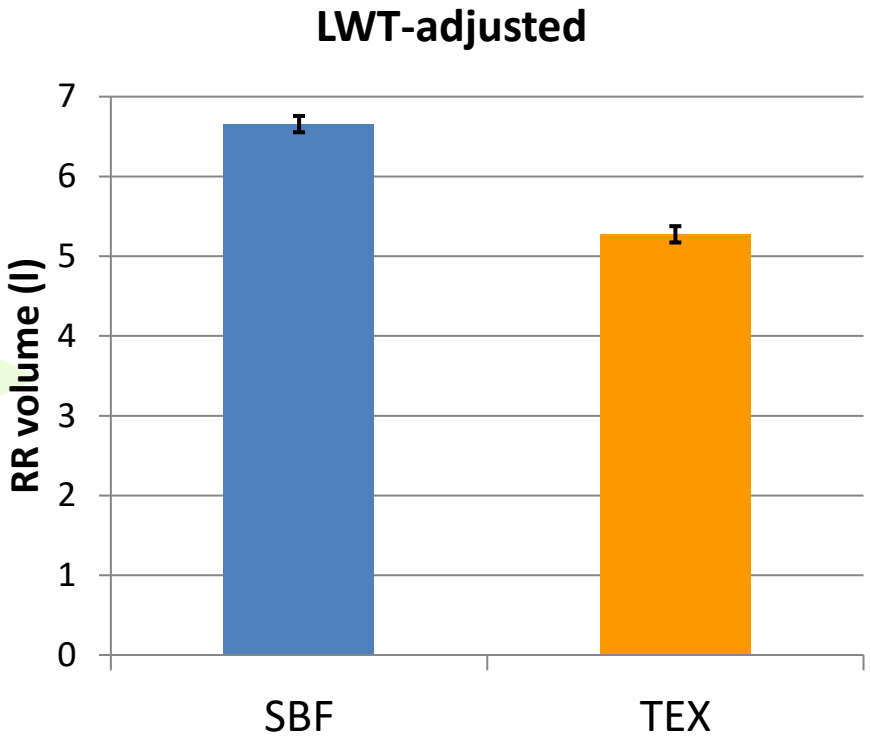
- Methods refined on first 50 lambs
  - mixed breed & sex
- Cross-sectional images every 8mm
  - measure areas every 6th image: ∑(area*thickness)

  → **Reticulo-rumen volume (RRvol)**
  - highly accurate and repeatable

Breed effect on RR volume



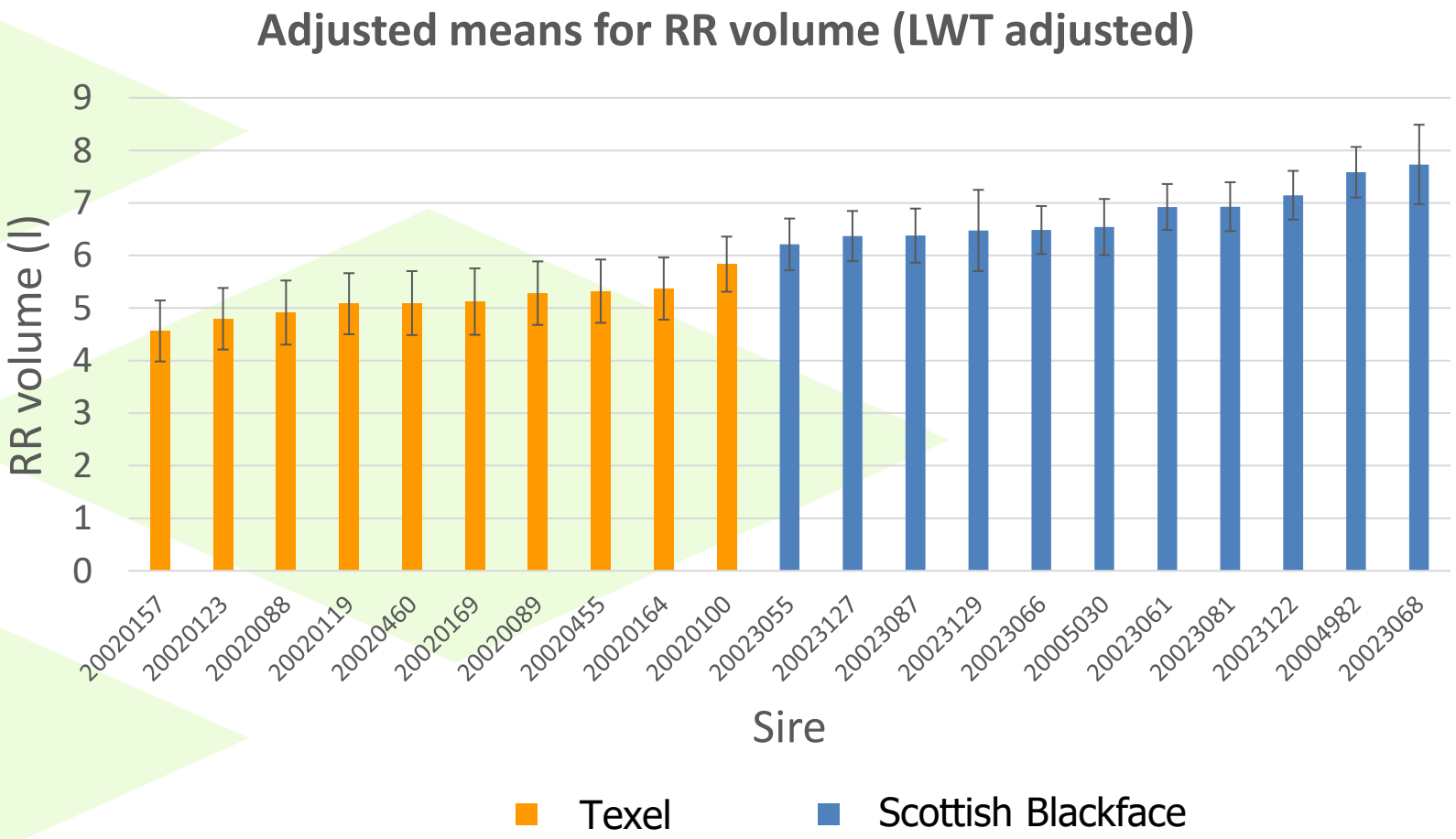
16% higher*



26% higher*

* P<0.001

Sire effect on RR volume

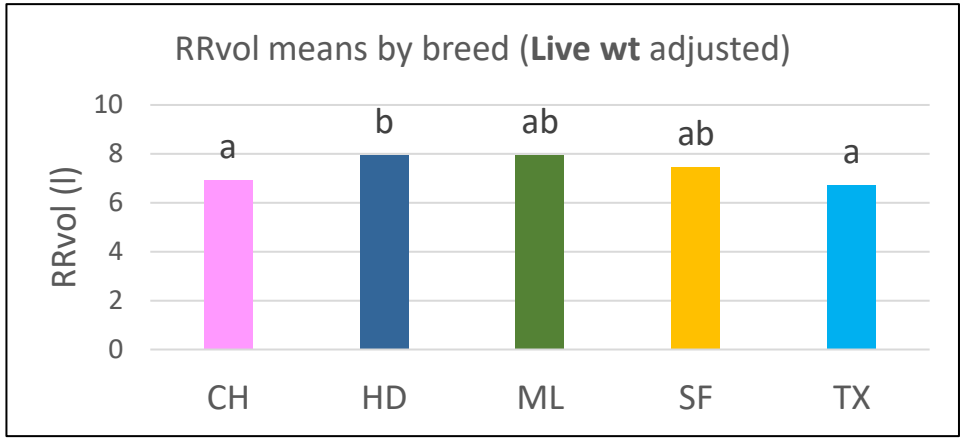


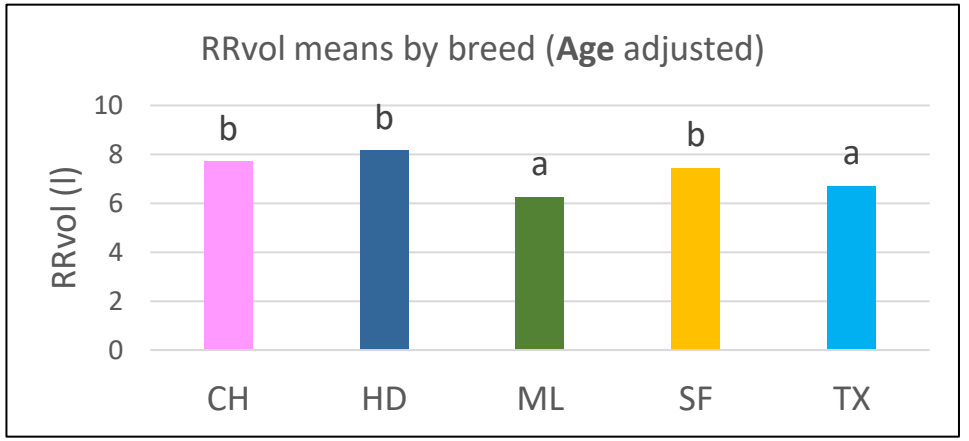
- Significant sire differences, even within breed

Terminal sire breed differences in RRvol

Breed	n	
	lambs	flocks
Charollais (CH)	129	16
Hampshire Down (HD)	102	15
Meatlinc (ML)	98	4
Suffolk (SF)	106	14
Texel (TX)	265	34

- Significant terminal sire breed differences (10-23%) in RRvol, at same age or live weight





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Genetic effects on RR volume

CT archive data set from 649 commercial Texel ram lambs:

- Scanned 2017-2019 for national breeding programme
- From 36 flocks (2 - 38 lambs/flock) and 188 sires (1 – 25 lambs/sire)
- Age 2 - 7 months (average 20 weeks old)
- Live weight 36 – 86 kg (average 55 kg)
- No standardisation of diet or time off feed

Genetic effects on RR volume

- Rumen volume measured from routine CT images
- Moderately heritable in Texel lambs ($h^2 = 0.45$)
  - potential for genetic selection within-breed

- Genetic relationships with production traits?
  - Favourable CH_4 vs carcass traits (lean yield, dressing %) in literature

Genetic relationships with other traits

Correlations of growth and carcass traits in Texel with total reticulo-rumen volume (RRvol)

Trait	Genetic correlation[1]	Phenotypic correlation
8 week weight	0.18	0.003
Scan weight	0.03	0.08
Ultrasound fat depth	-0.37	-0.25
Ultrasound muscle depth	-0.31	-0.19
CT lean weight	-0.47	-0.28
CT fat weight	-0.26	-0.21
CT carcass weight	-0.69	-0.40
CT muscularity	-0.67	-0.10

[1] standard errors 0.17-0.30

In general:

Higher RRvol →

- lower fat
- lower muscle
- lower muscularity
- little assoc. with growth

At the genetic and phenotypic levels

Terminal sire breed RRvol vs production trait EBVs

Significant changes in RRvol (l) per EBV unit increase

EBV	CH	HD	ML	SF	TX
Scan weight					
Ultrasound fat depth	↓		↓		↓
Ultrasound muscle depth	↓				↓
CT Fat weight	↓				
CT Lean weight					
CT Muscularity		↓			
CT Eye muscle area	↓				↓
Terminal Sire Index	↓				↓

- Generally, lower EBVs for fat, muscle and muscularity traits associated with higher RRvol
- Not significant in all breeds / traits

Considerations

- Valuable additional measurement from routine CT
- Potential to use for breeding?
- Genetic relationships with wider economic / environmental traits?
  - Animals inefficient at digesting fibre produce less CH_4 (Cabezas-Garcia et al., 2017)
  - Different priorities in different production systems?

Further research required

Further understanding required of the complex relationships between:

- rumen function
- methane emissions
- feed efficiency
- production
- resilience

…across different types of sheep systems

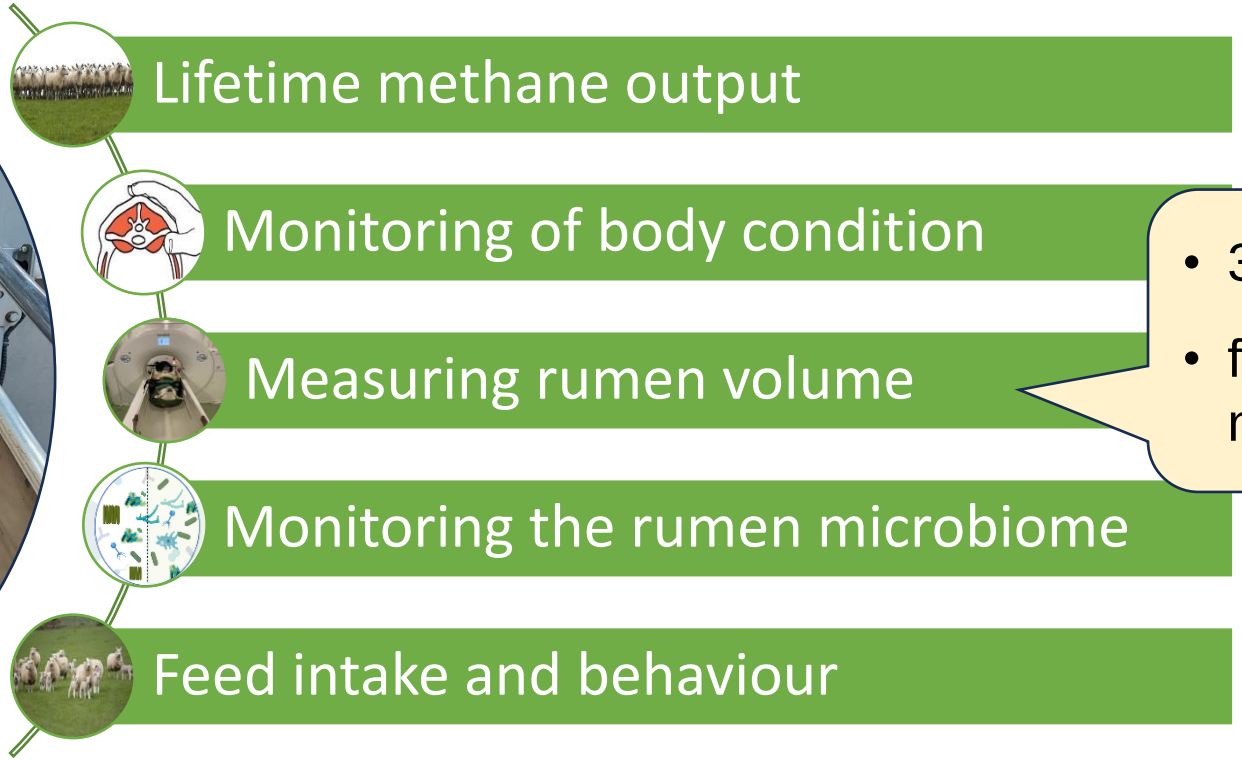
Measuring related phenotypes including methane output….

BREED FOR CH4NGE

BREEDING LOW METHANE SHEEP

AHDB · Centurion · Elana · Harper Adams University · innovis · NSA · Performance Recorded Lleyn Breeders · Pilgrim's · Signet Breeding Services · SRUC · Waitrose · Agri-Tech Centre · UKRI Innovate UK

Informed decisions on breeding strategy…



- 360 sheep so far
- further 250 lambs/yr in next 2 years

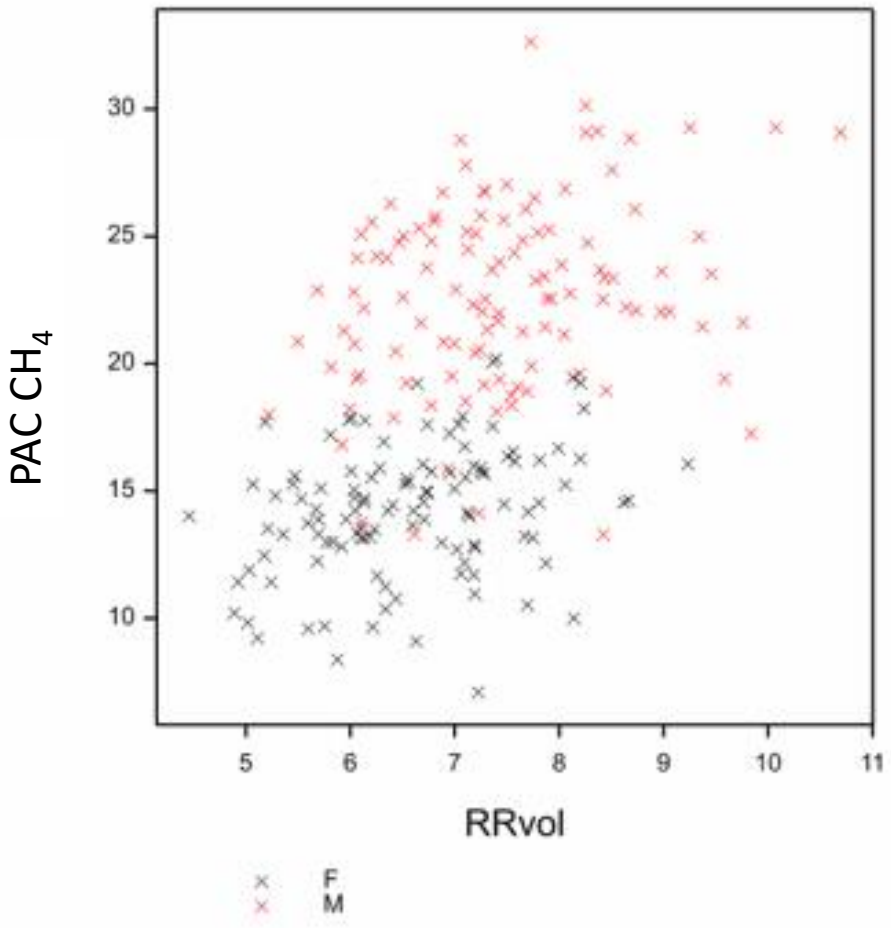
BREED FOR CH4NGE
BREEDING LOW METHANE SHEEP

innovis

SRUC

BREED FOR CH4NGE

BREEDING LOW METHANE SHEEP



Will allow us to investigate:

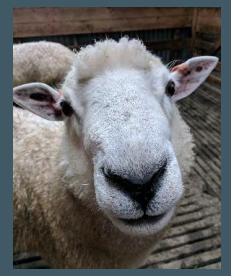
- Genetic correlations
  - RRvol vs PAC-measured methane
  - RRvol vs feed efficiency
- Relationships with microbiome
- Consequences of genetic seln.

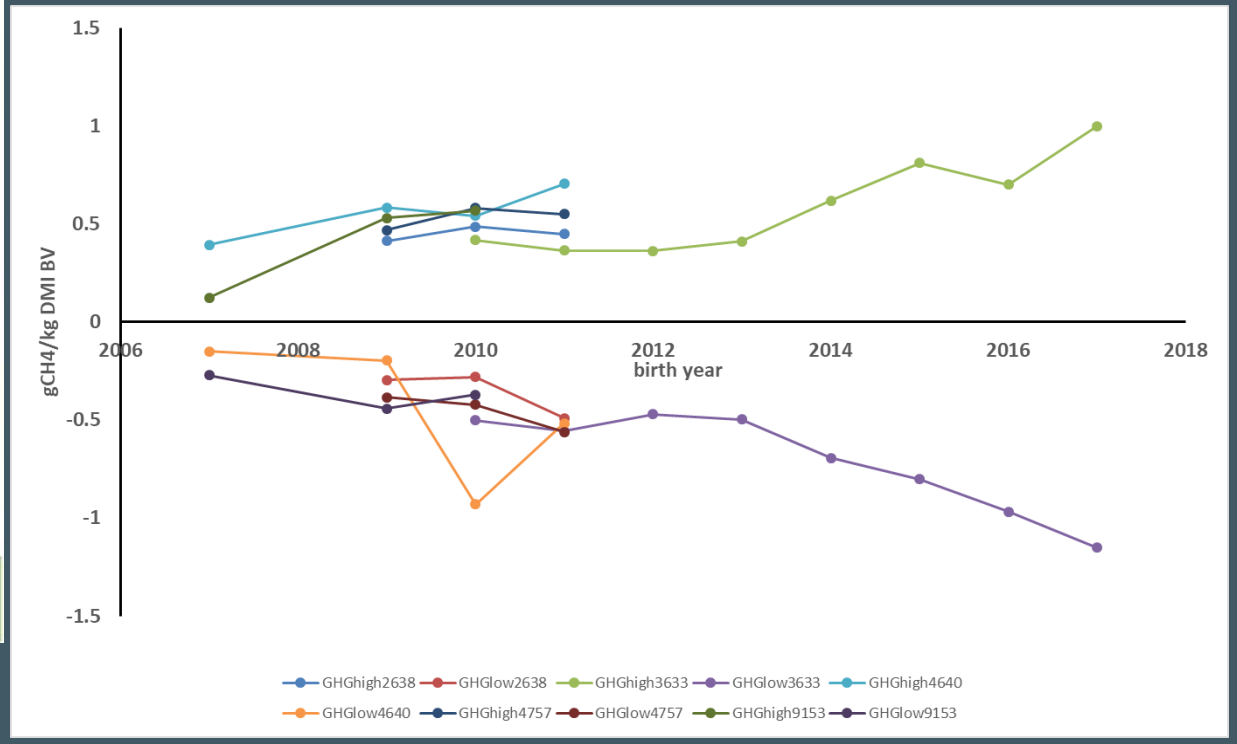
…in relevant UK maternal breeds

agresearch
āta mātai, mātai whetū

NZ - selection for divergent CH_4

Adaption	M1	M2	- 14 day rest	M3	M4

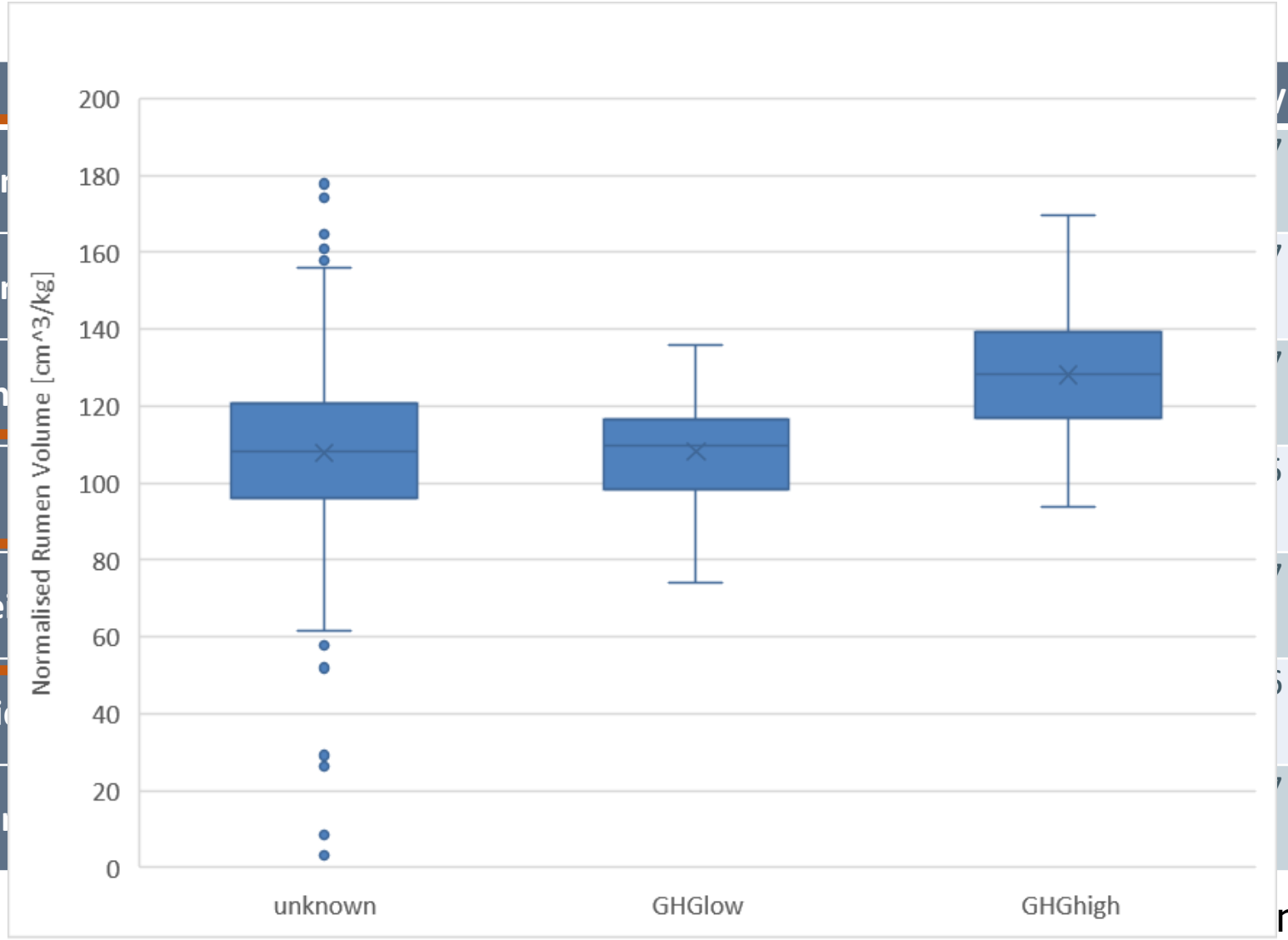




Suzanne Rowe, pers. comm

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

Trait
Reticulo-rumen
Reticulo-rumen
Est. rumen con
Papillae count
Av. papillae hei
Av. papillae wi
Av. papillae su



ne Rowe, pers. comm

Breeding sustainable hill sheep

Aim: productive and efficient genetics and management strategies → adapt to future challenges, promote climate change resilience & biodiversity

2022-2027:

- High index Scottish Blackface ewes n = 200
- Crossbred SBF x Lleyn ewes as comparison n = 400

Genetic selection for:

- production
- health and welfare
- resilience
- efficiency
- reduced environmental impact

Monitor:

- grazing resource
- animal location
- biodiversity
- environmental parameters (sensors)

~120 lambs/yr x 4 years

~120 lambs/yr x 5 years

Sustain Sheep
Green Breading

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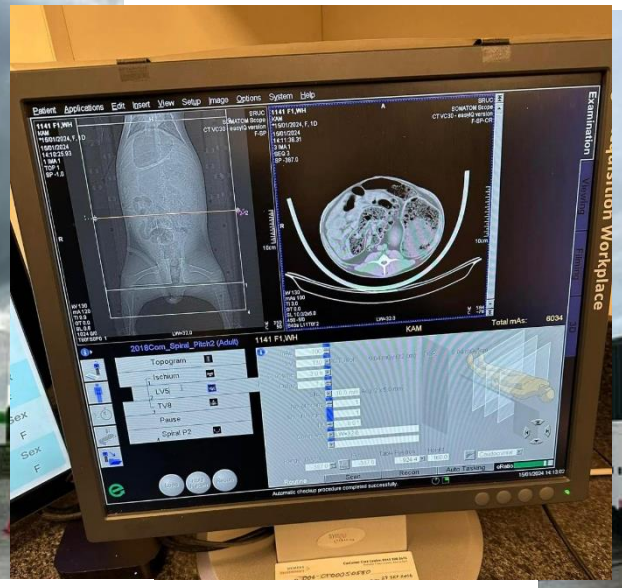
defra
Department for Environment Food and Rural Affairs

UK Research and Innovation



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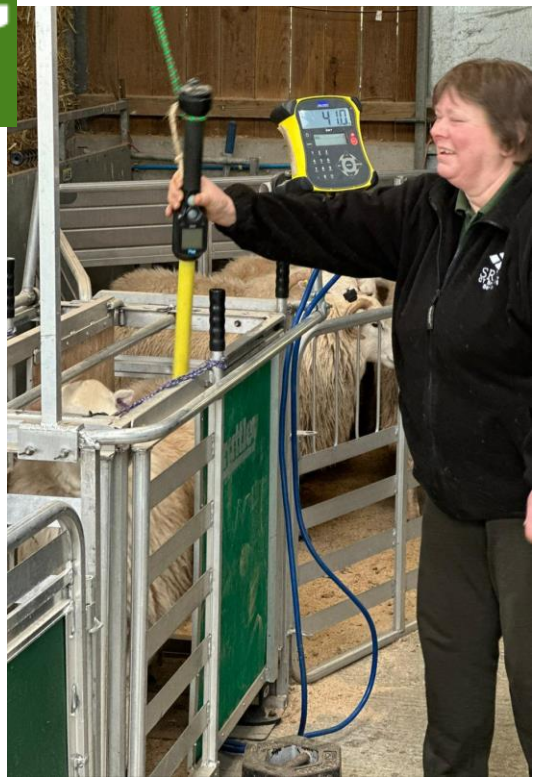
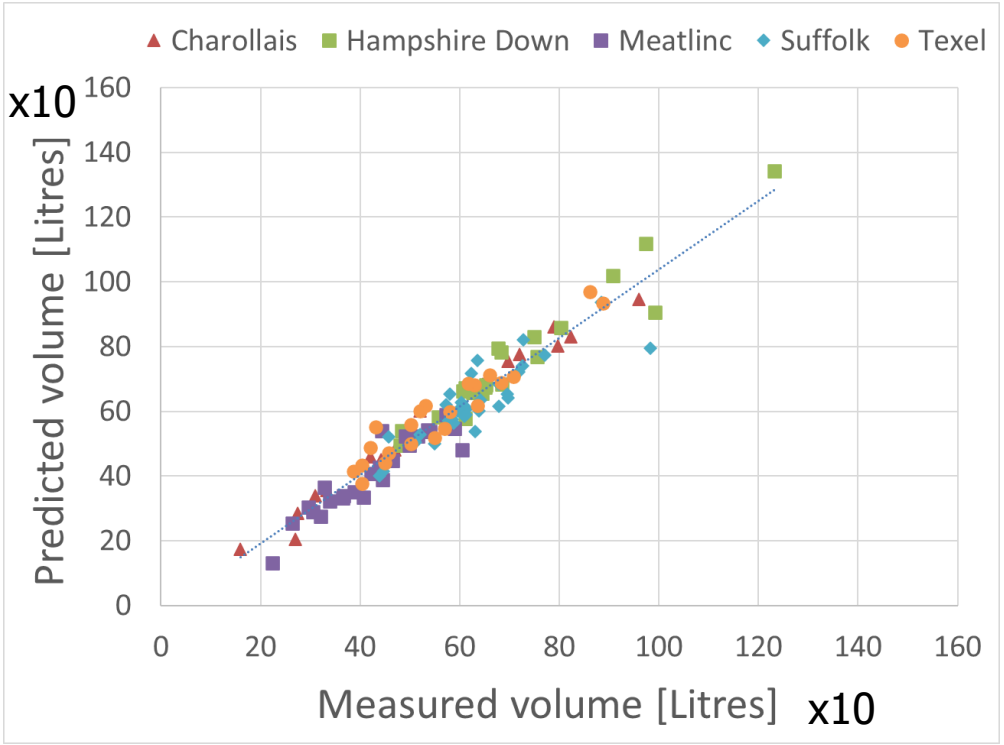


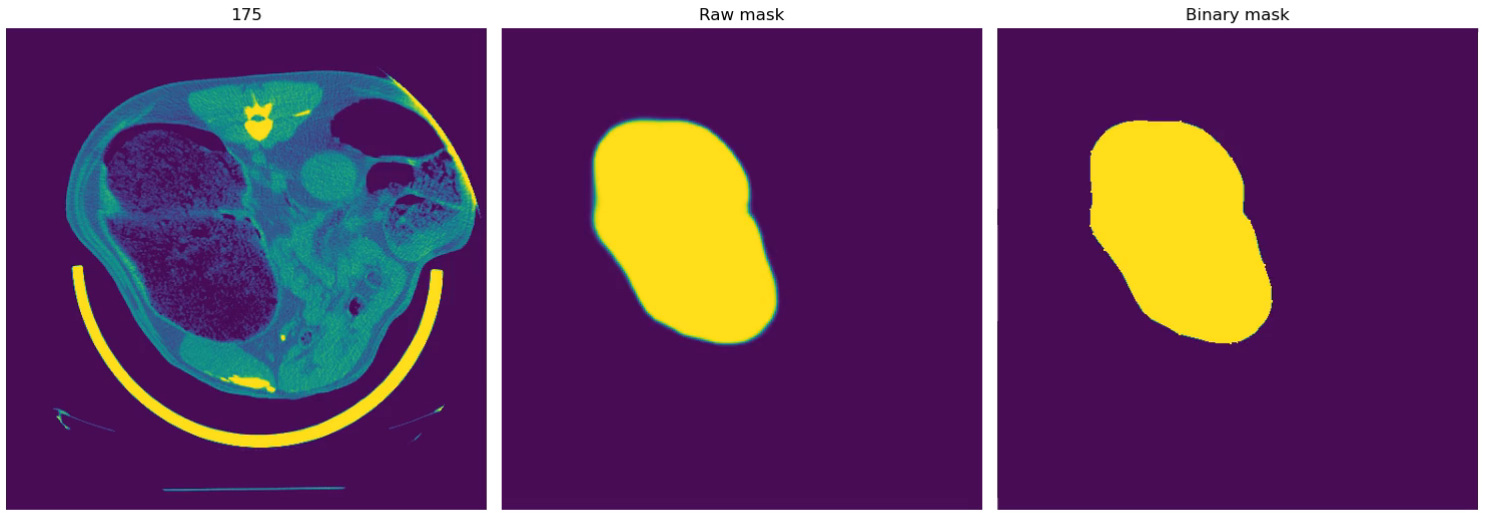
~900-1000 lambs per project across 2 years

CT scans (incl. RRvol) & PAC measurements

Using AI to predict phenotypes from CT scans

- Work underway at SRUC (EGENES), Abacusbio, AgResearch…
- Predicting rumen volume:





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

Testing an automated image analysis model on Computer-Tomography (CT) images from UK breeds

Conclusions

- Can CT rumen measurements predict methane emissions? ✓
- Can CT identify rumen differences between types of sheep? ✓
  - large differences between hill and terminal sire breed
  - differences between terminal sires
- Are these predictors under genetic control? ✓
  - significant differences between sires within-breeds
  - reticulo-rumen volume is heritable in Texel lambs
- Would there be unfavourable consequences of breeding for rumen measurements?

  …or for methane emissions? ?
  - Evidence emerging; under investigation in current projects

Acknowledgements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UK Research and Innovation

BREED FOR CH4NGE
BREEDING LOW METHANE SHEEP

GREEN ERA-HUB
on Agri-Food and Biotechnology

TEXEL
SHEEP SOCIETY

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