

# Interpreting methane: Accounting for biology and behaviour

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# Applicability of short-term emission measurements for on-farm quantification of enteric methane

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# Measurement and number of animals

- Animal recording-Greenfeed - 4 yrs (2022-2026)
- 6 breeds, extensively recorded for other key traits (birth, growth, carcass, reproduction)
- Steers in Tullimba feedlot (feed intake and methane)
  - ~650-750 Multibreed steers measured per yr
  - ~ 4-500 Angus steers measured from Angus Sire Benchmarking Program
- Heifers measured on pasture across 5 sites in NSW
  - ~650-750 Multibreed heifers per yr





20 Greenfeed Machines for recording + 8 for training

# Low Methane Beef project

System	Animals tested	Valid Records	Sires	CH <sub>4</sub> Records	mean (SD)
Feedlot	3 389	2 985	472	193 538	170 (76)
Pasture	2 996	2 023	362	131 781	173 (61)
<b>Total</b>	<b>6 686</b>	<b>5 008</b>	<b>523</b>	<b>325 319</b>	<b>171 (70)</b>

# Multibreed analysis

Model:  $y = Xb + Za + e$

X= Fixed effects/covariates:

Breed

Contemporary group

Age

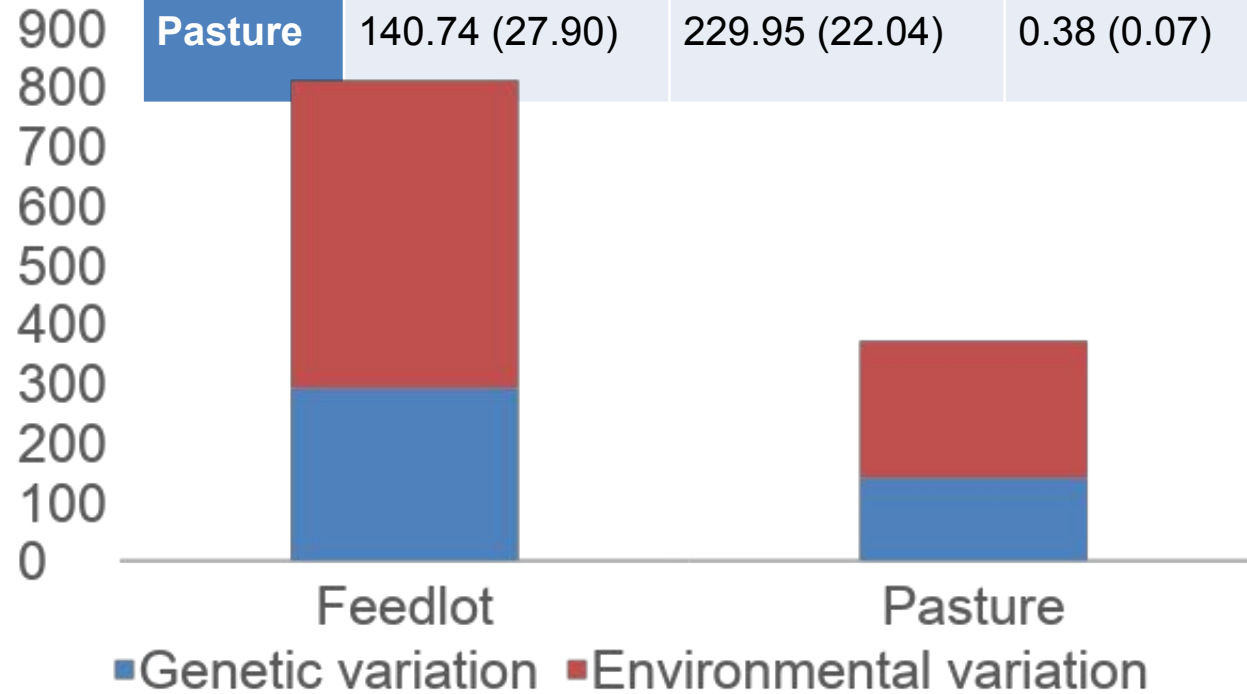
Z = Random

Animal effects

Genomic relationships

Genomic estimated breeding values (gEBV's) (research)

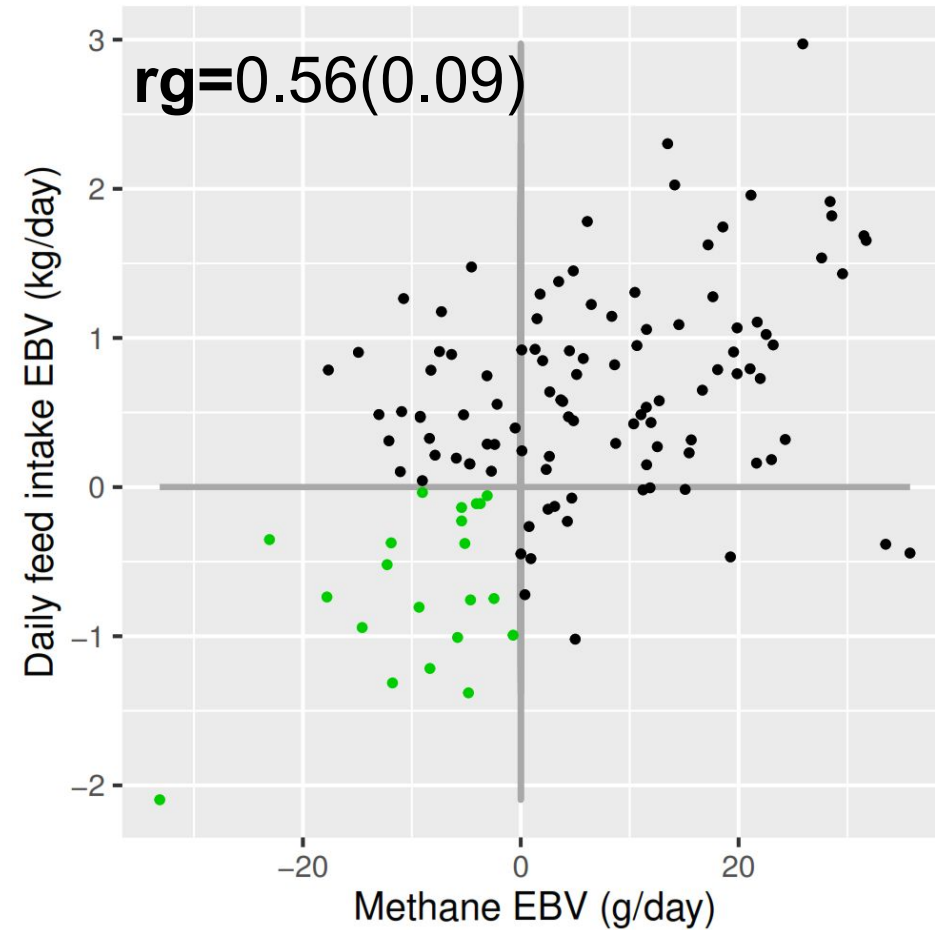
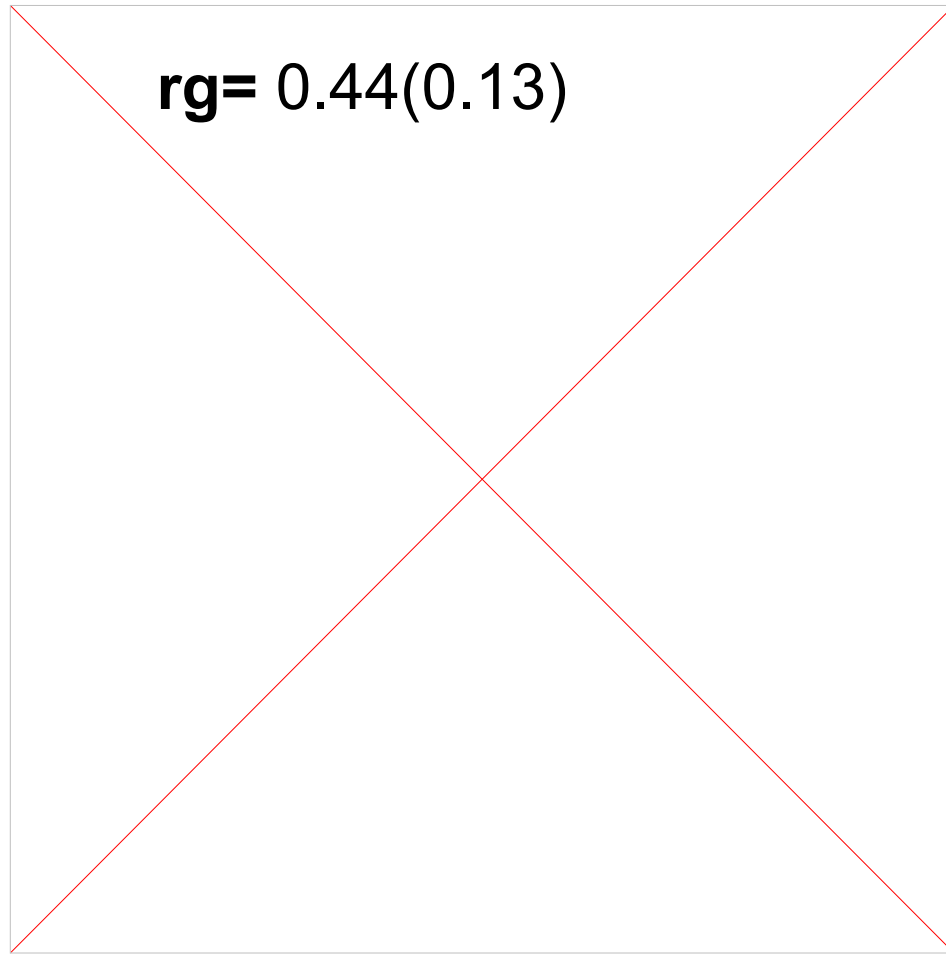
CH4 (g/day)	Genetic variation (SD)	Environmental variation (SD)	$h^2$	rg
Feedlot	291.86 (45.49)	518.65 (36.19)	0.36 (0.04)	0.58 (0.13)
Pasture	140.74 (27.90)	229.95 (22.04)	0.38 (0.07)	



# **CORRELATIONS**

# Methane is associated with ADG and DFI

## Research gEBVs for Angus Sires

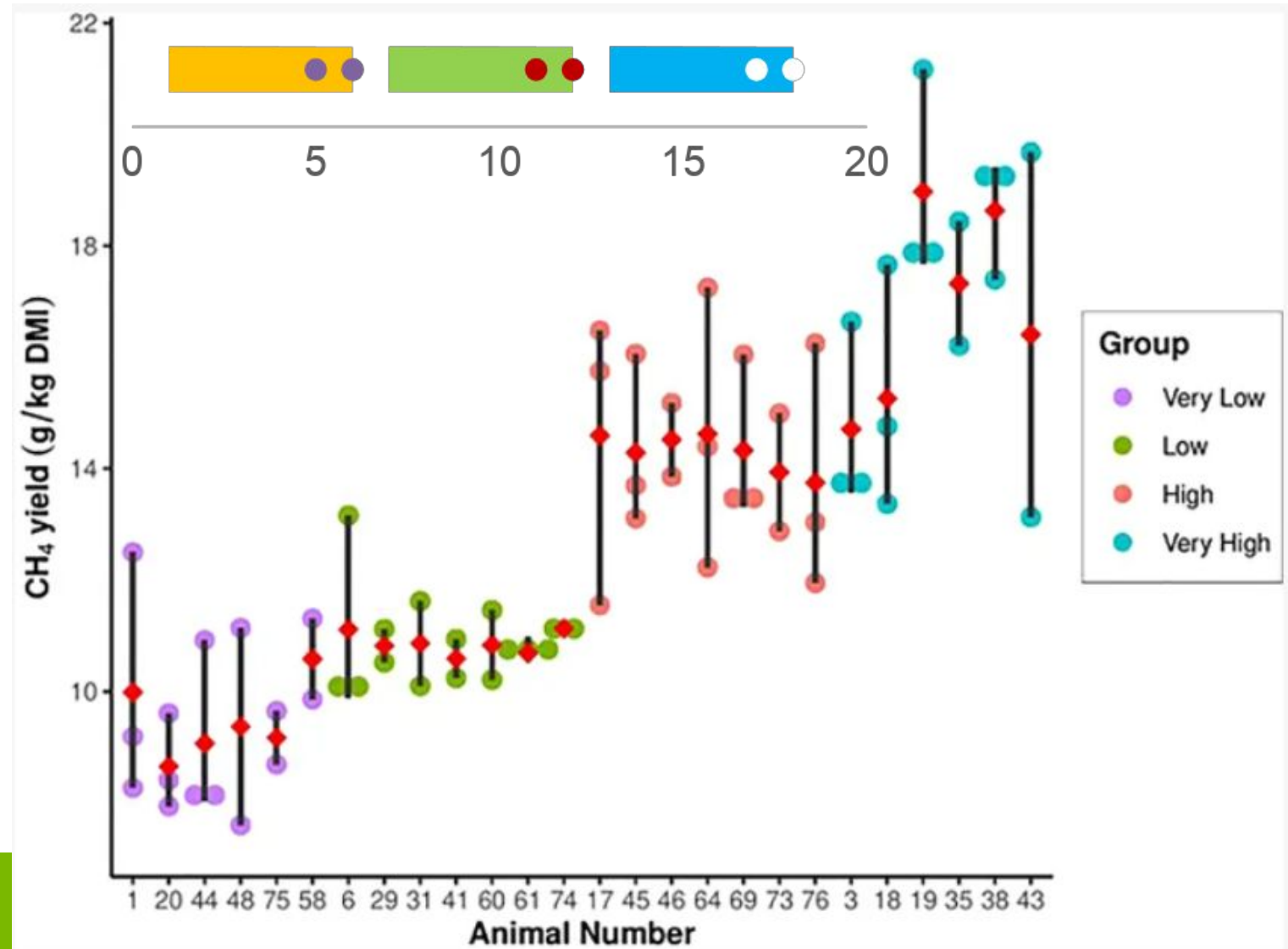


How do we find the green animals? measure CH<sub>4</sub> or genotype

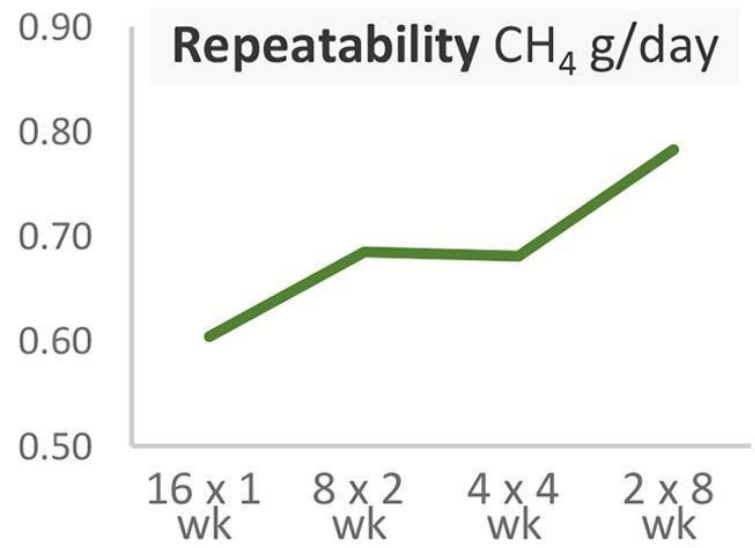
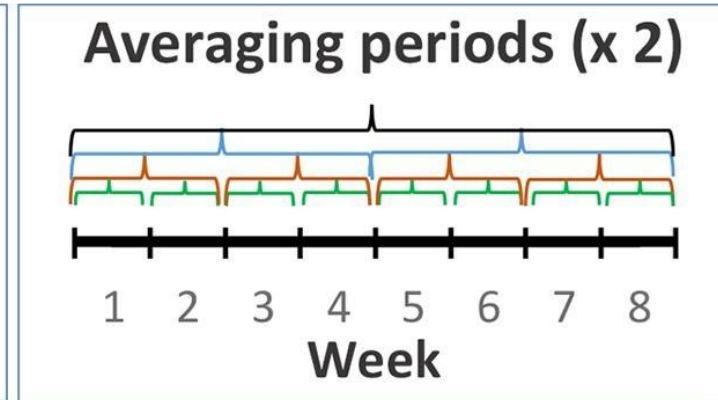
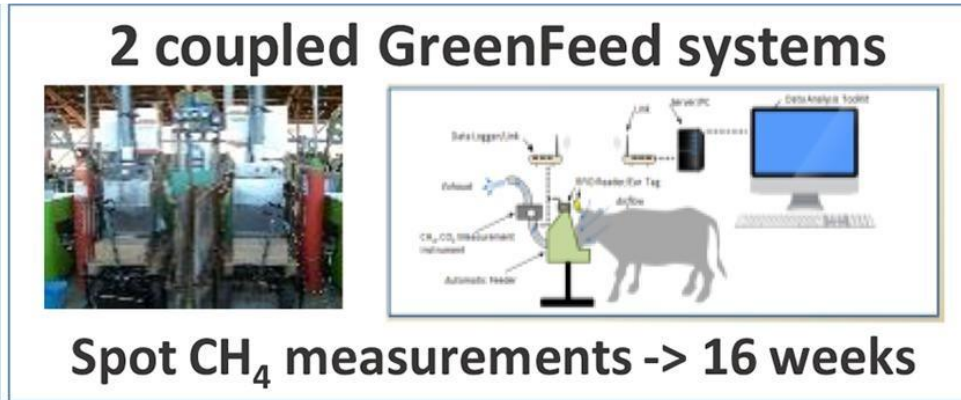
# Consistency of Methane Yield Rank (Beef)

- Differences in MY groups is due to MP, not diet
- Able to use MP solely, if standardised diet, BW and growth stage
- MY differences correlated with tVFA, but not DMI

Is a single 2-week period sufficient?



# Consistency of Methane Production Rank (Dairy)



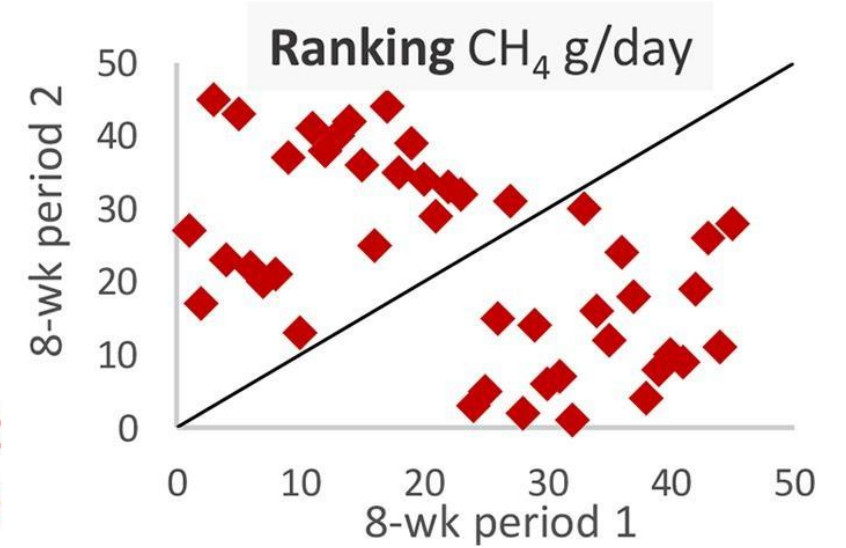
Good prerequisite for phenotyping



BUT

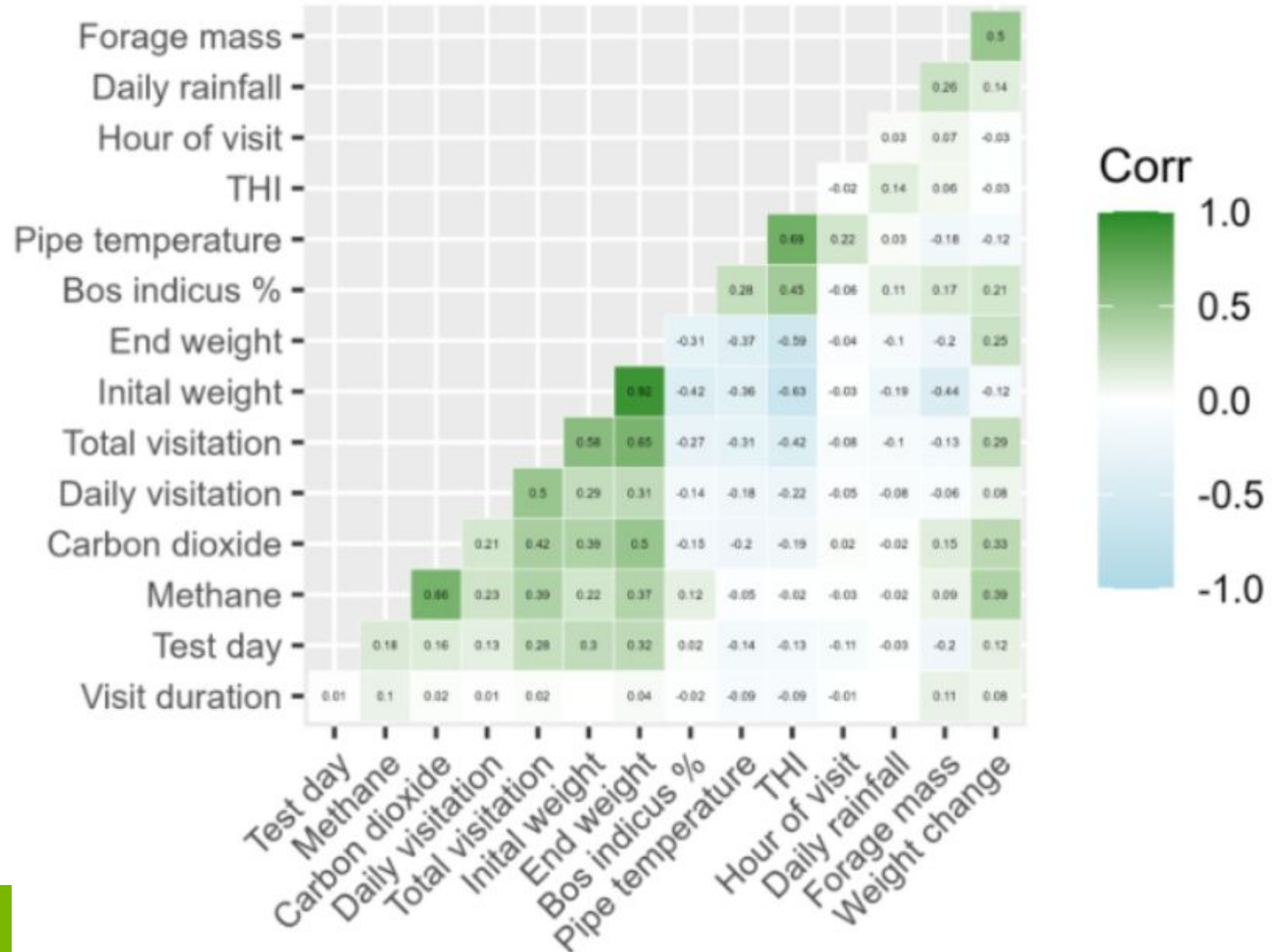


Individual ranking not stable over time



- CH<sub>4</sub>:
  - Initial weight (11.8%)
  - Total visitation (5.6%)
  - Trial (4.0%)
- Visitation
  - Initial weight
  - Climate (negative)
  - Daily visitation

## Correlation matrix of numeric factors

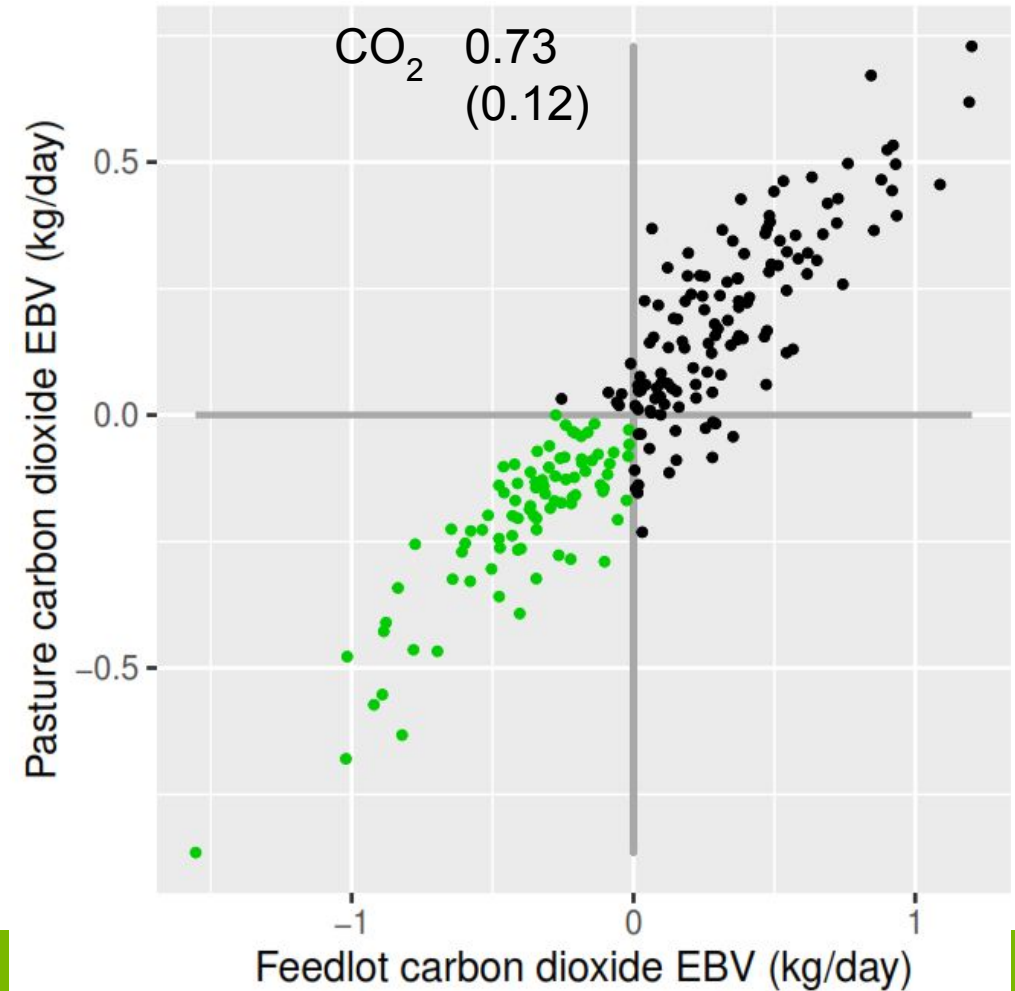
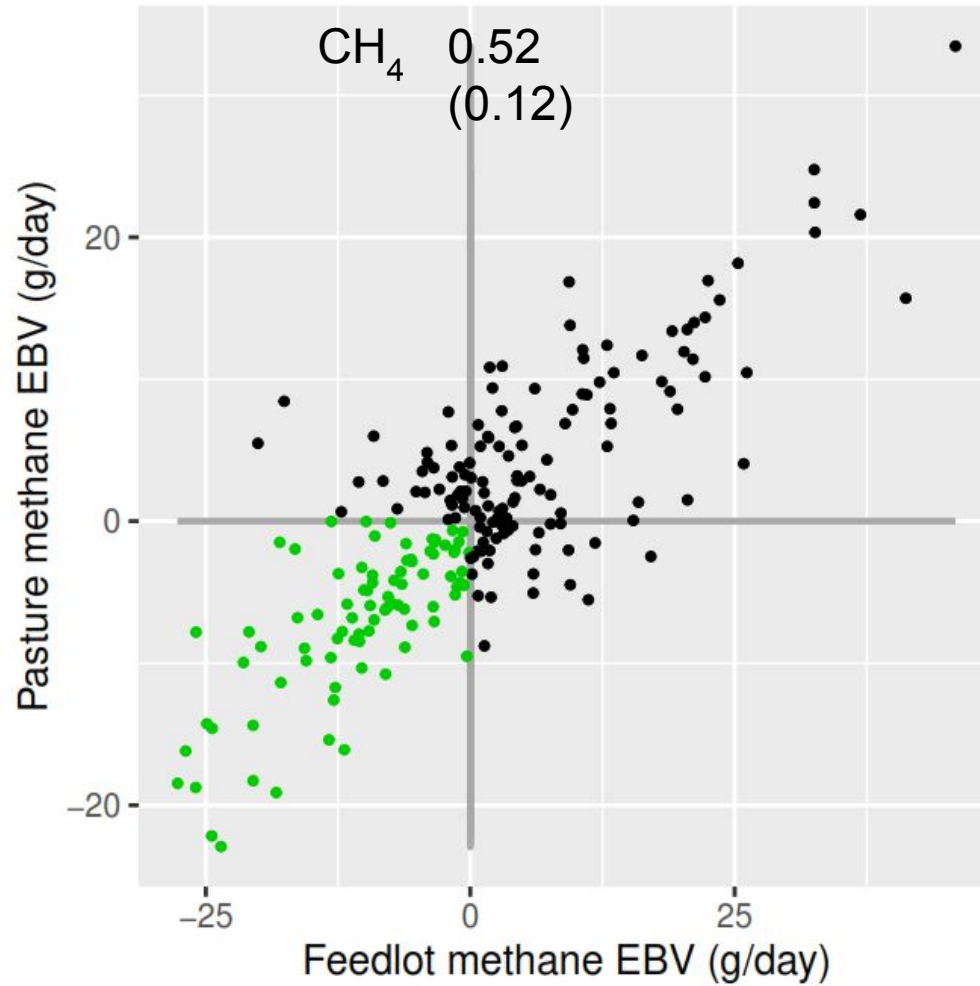


Whistler et al (2025)

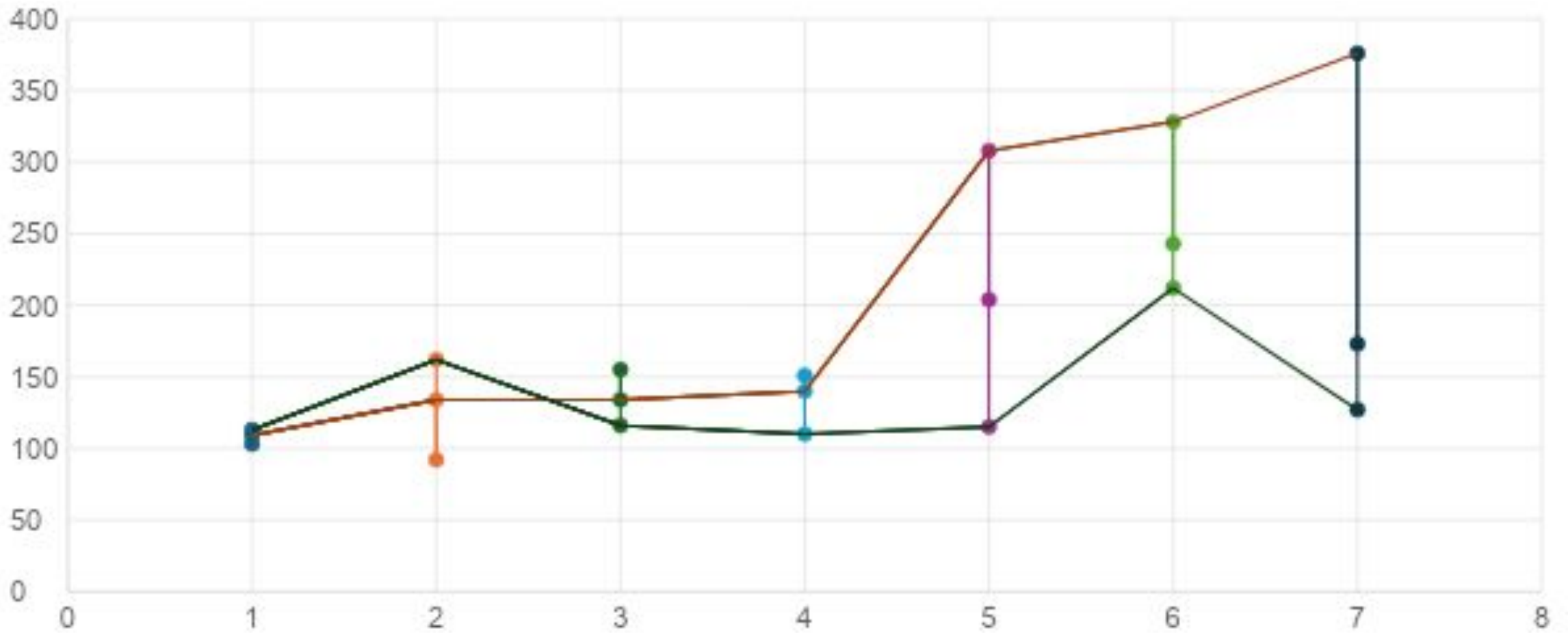
# DIET

# Preliminary results - rEBVs

## Correlations between pasture and feedlot emissions

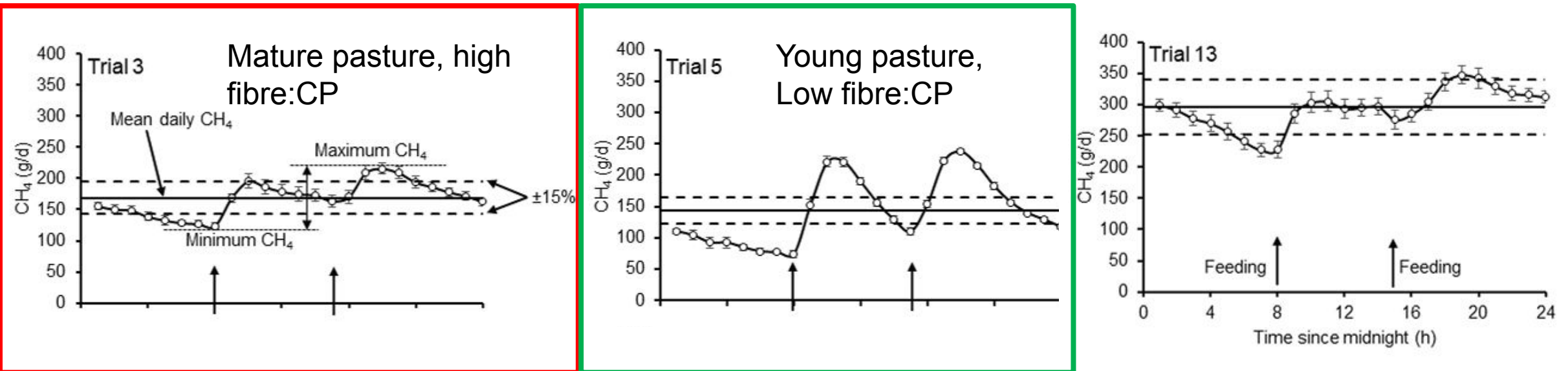


# Consistency across diets

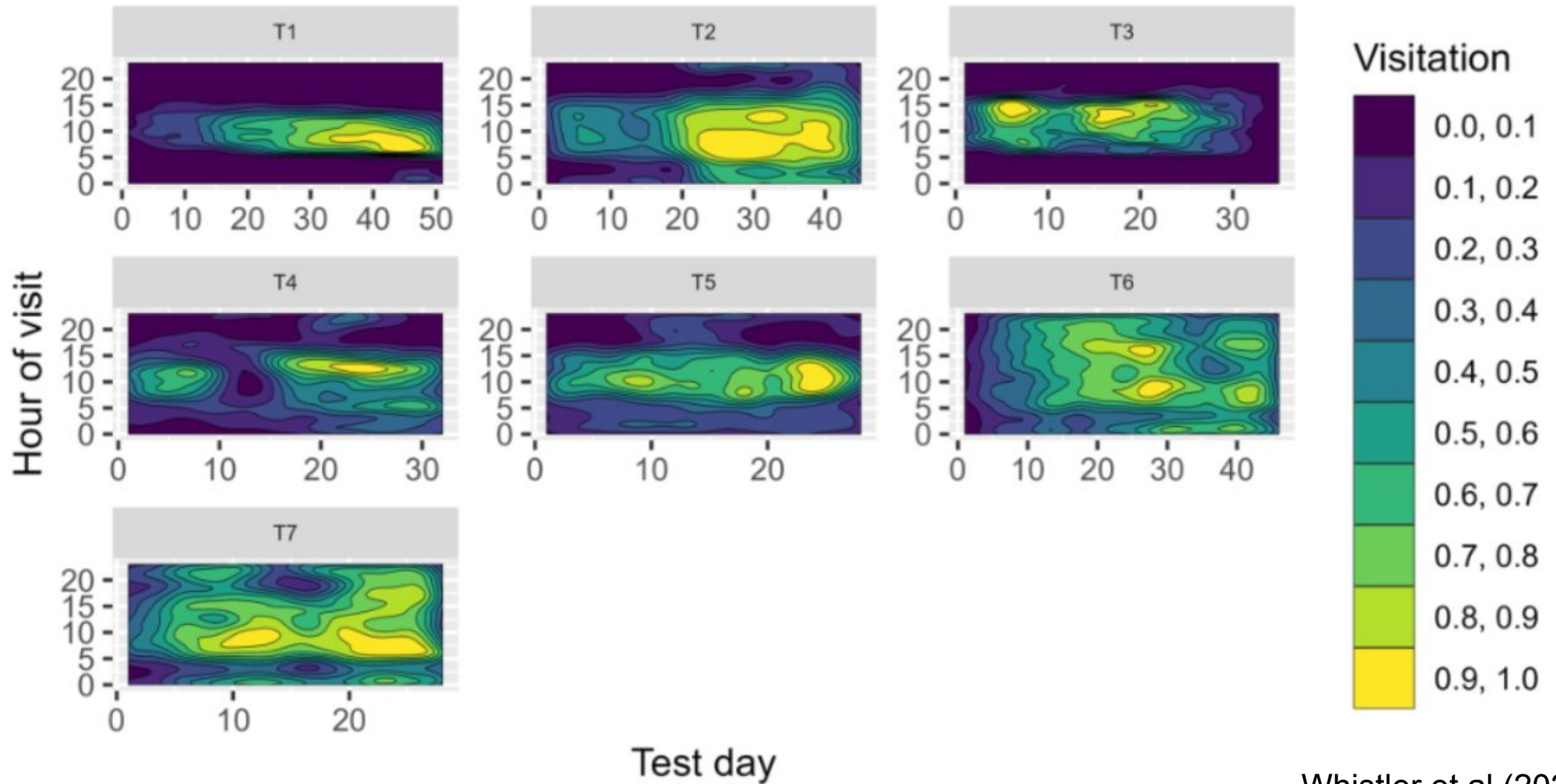


# Diurnal pattern of methane emission

- Cut ryegrass: digestibility affects diurnal variability
- Methane emission is lowest before AM feeding and highest after PM feeding
- Within-day CV =  $\pm 15\%$  (pasture-fed)
- Circadian variation moderately increased with decreased feeding level



# Distribution of visitation across trials



Whistler et al (2025)

Relative visitation across trial day and hour of visit per trial



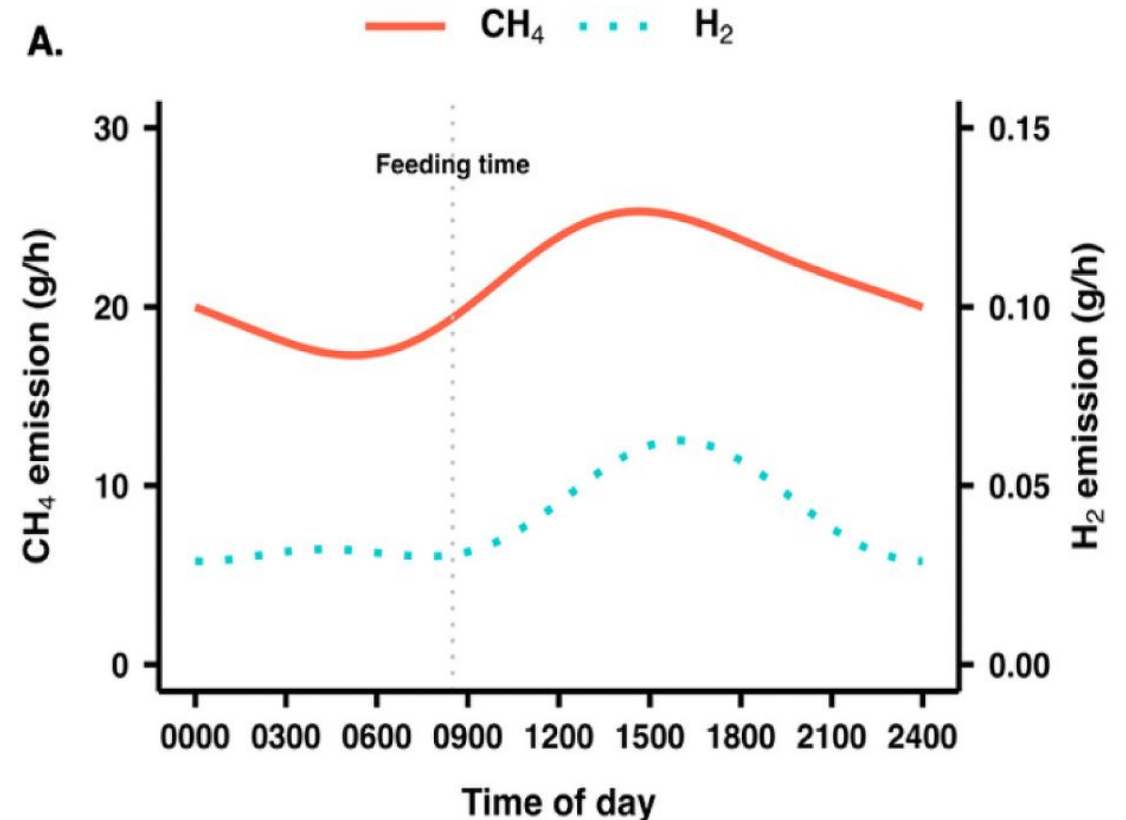
# **FEEDING PATTERN**

# Methane emissions have a circadian rhythm

- Feeding pattern
  - Meal timing
  - Feed delivery time
  - Meal frequency
  - Meal size
- Diet
  - Fermentability
  - Passage rate
- Animal physiology
  - Rumination pattern
  - Activity

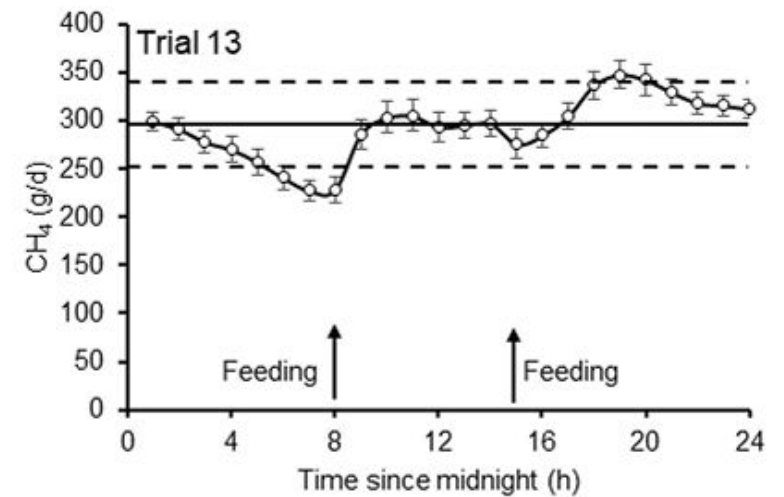
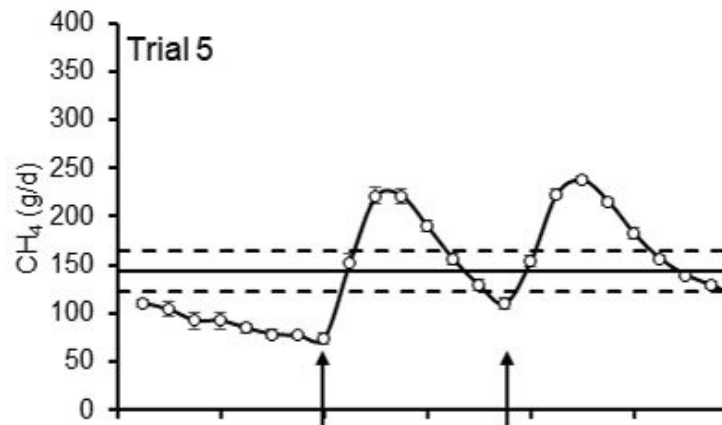
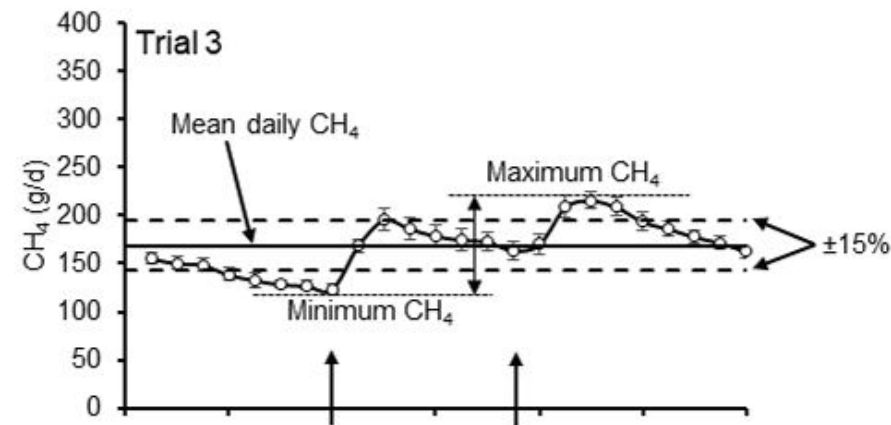
# Feeding pattern

- Centrally regulated
  - Hunger, satiety, physiological state, environment, endogenous circadian rhythms
  - Strong natural drive to feed in early afternoon and evening
- Grazing cattle
- Fed cattle
  - Slug-eating
  - Feed delivery, pushup
    - Strong stimulus, for 1-2 h

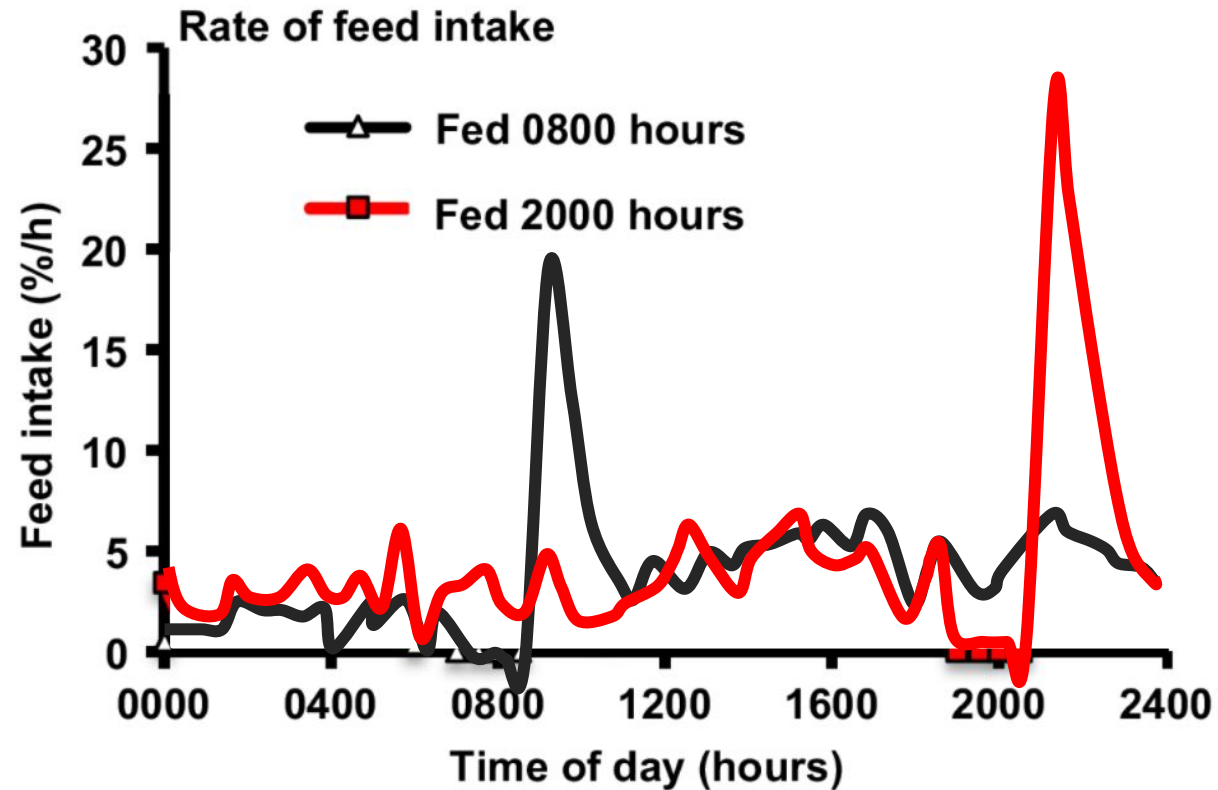


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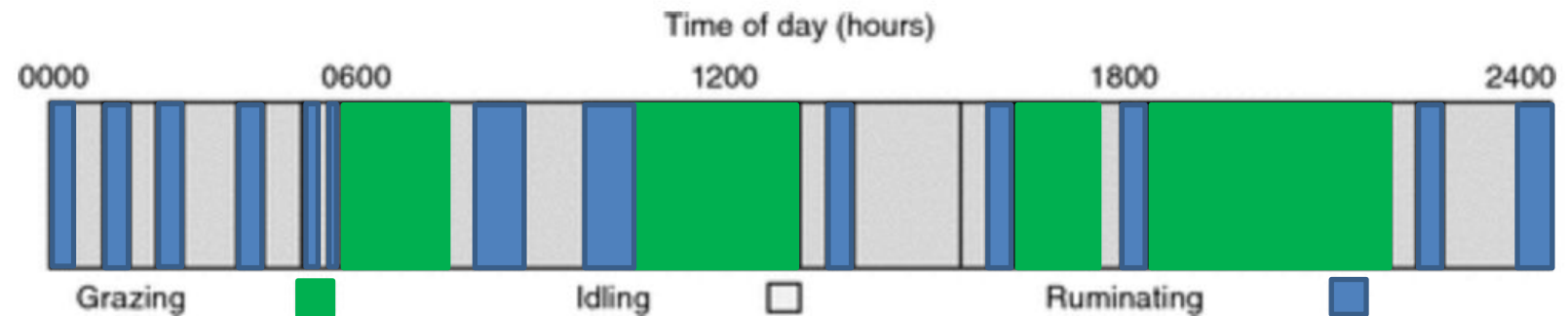


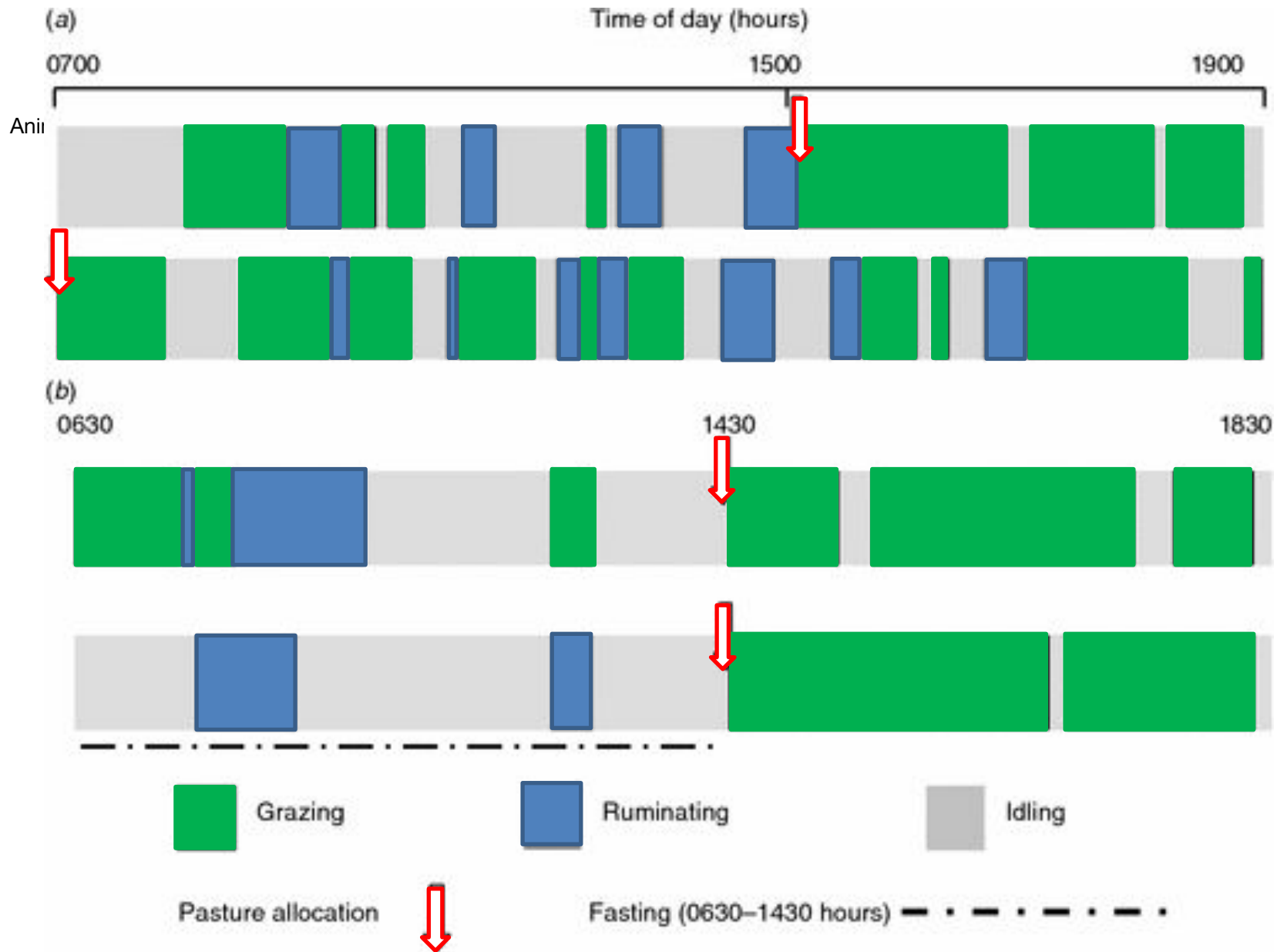
# Effect of feeding frequency on diurnal intake pattern



# Grazing intake patterns

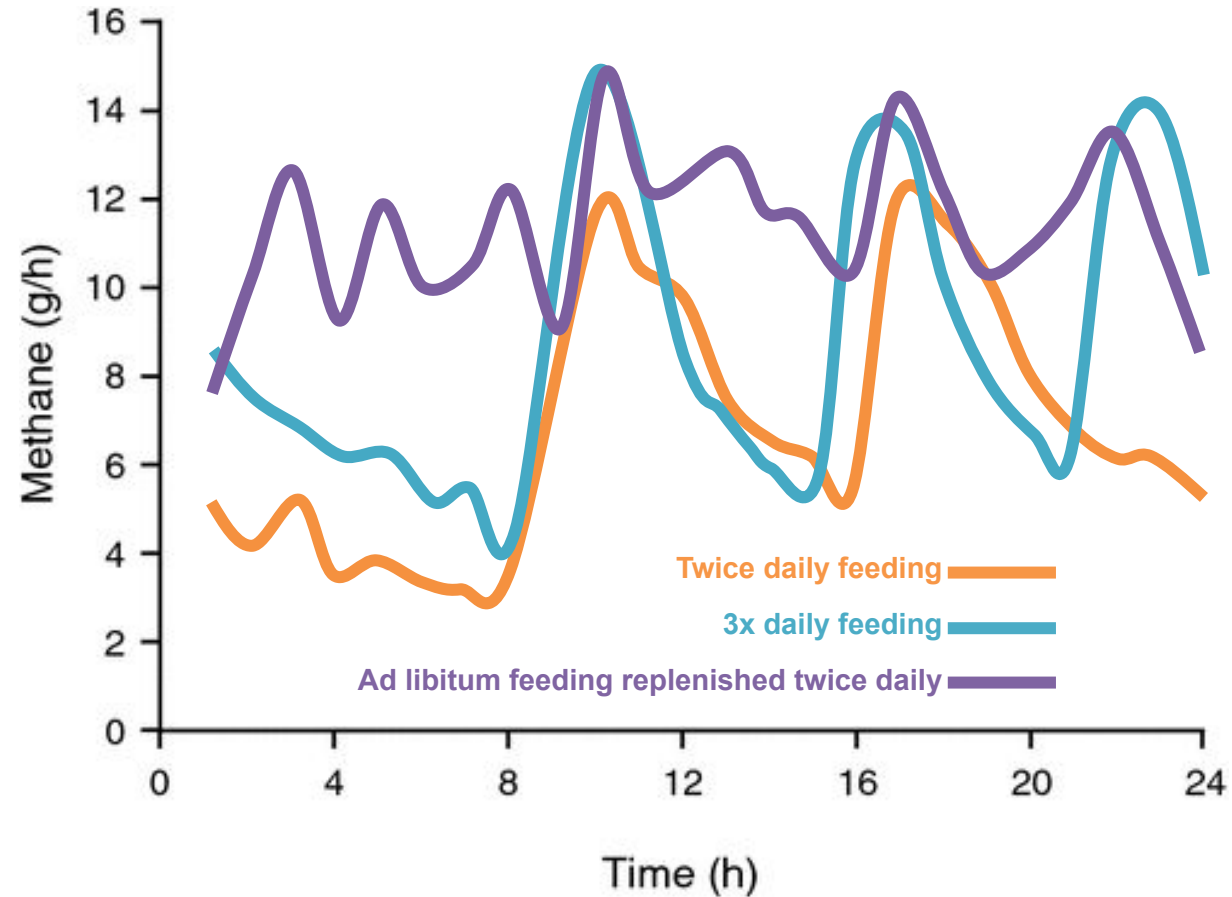
Example of the typical diurnal grazing pattern of dairy cows under set stocking grazing method (adapted from [Gibb 2006](#)).





(a) Effect of timing of pasture allocation (morning versus afternoon) and (b) 9 h of fasting before afternoon pasture allocation on the diurnal grazing pattern of beef heifers (adapted from [Gregorini et al. 2006b, 2007b](#)).

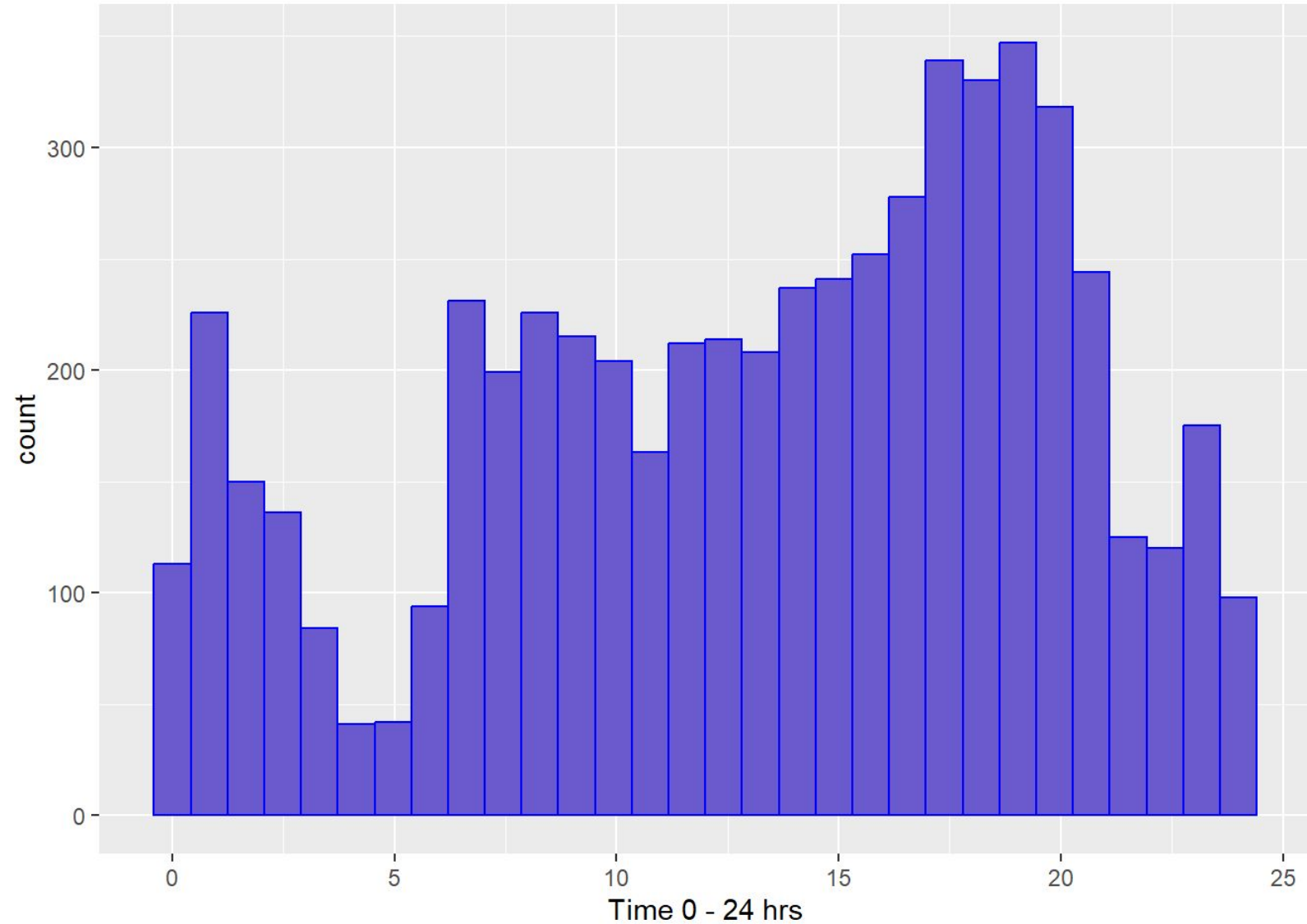
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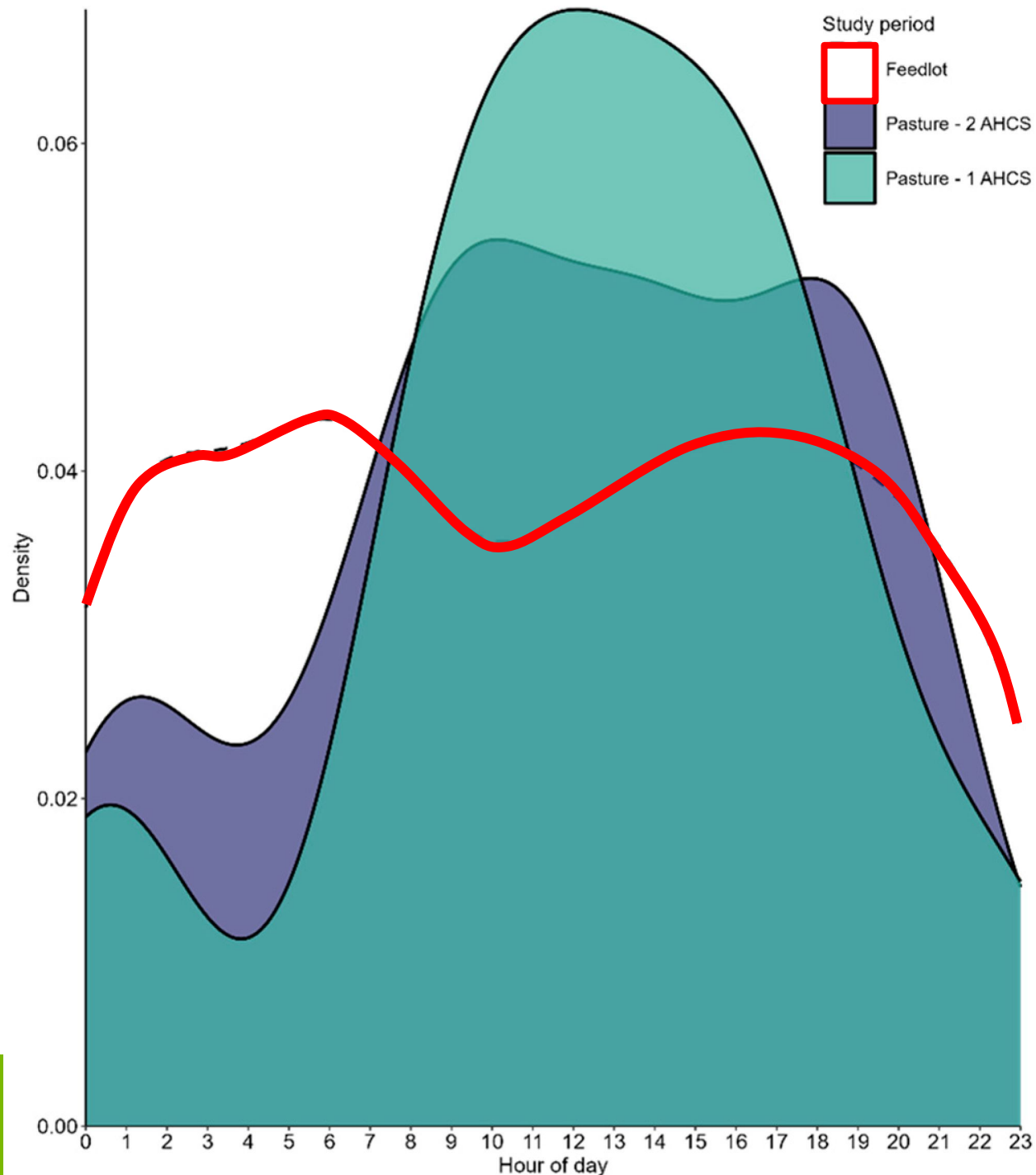


# Day to day variation within an animal

- Over a lactation and across different diets, cows tend to show the same diurnal pattern of intake (Bell et al, 2018)
  - Dairy cows
  - Fed PMR once daily
- Animal to animal diurnal pattern variation is greater than within animal diurnal pattern variation

# Timing of visits to Greenfeed



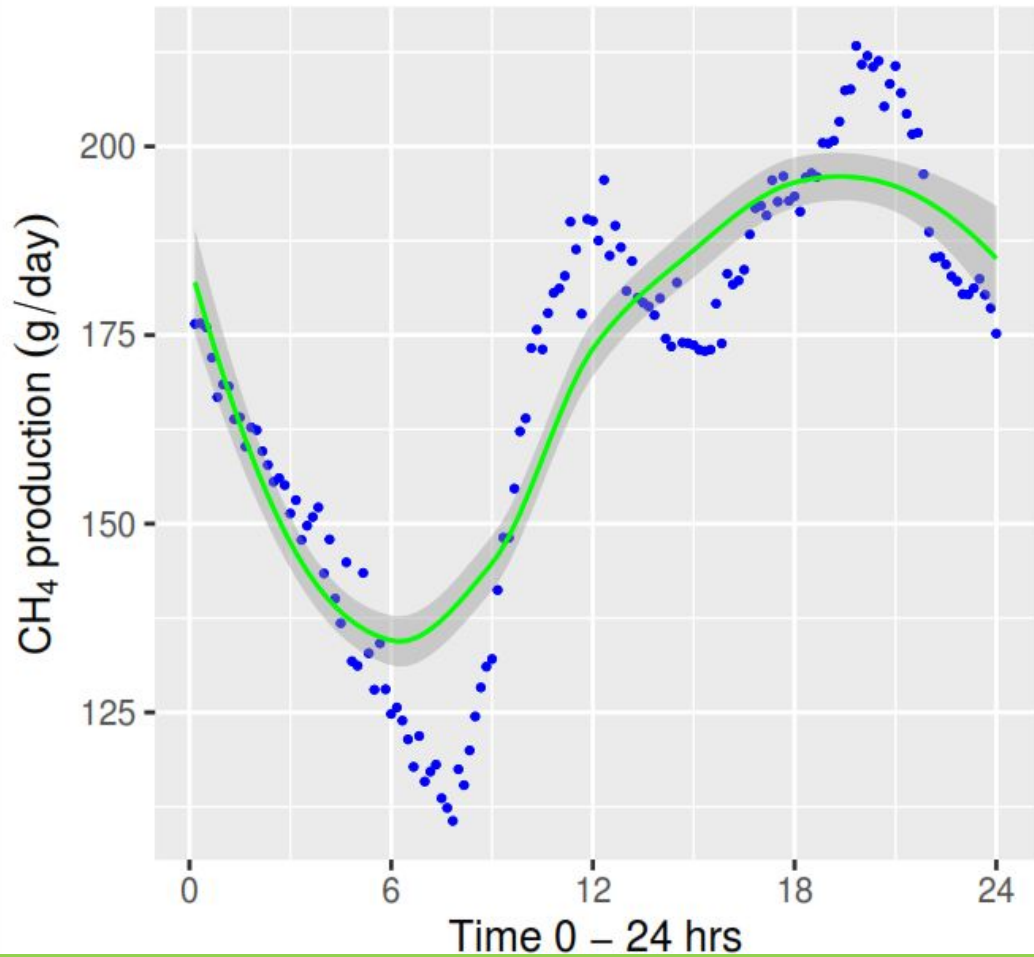


Density plot illustrating the probability of a Greenfeed visit.

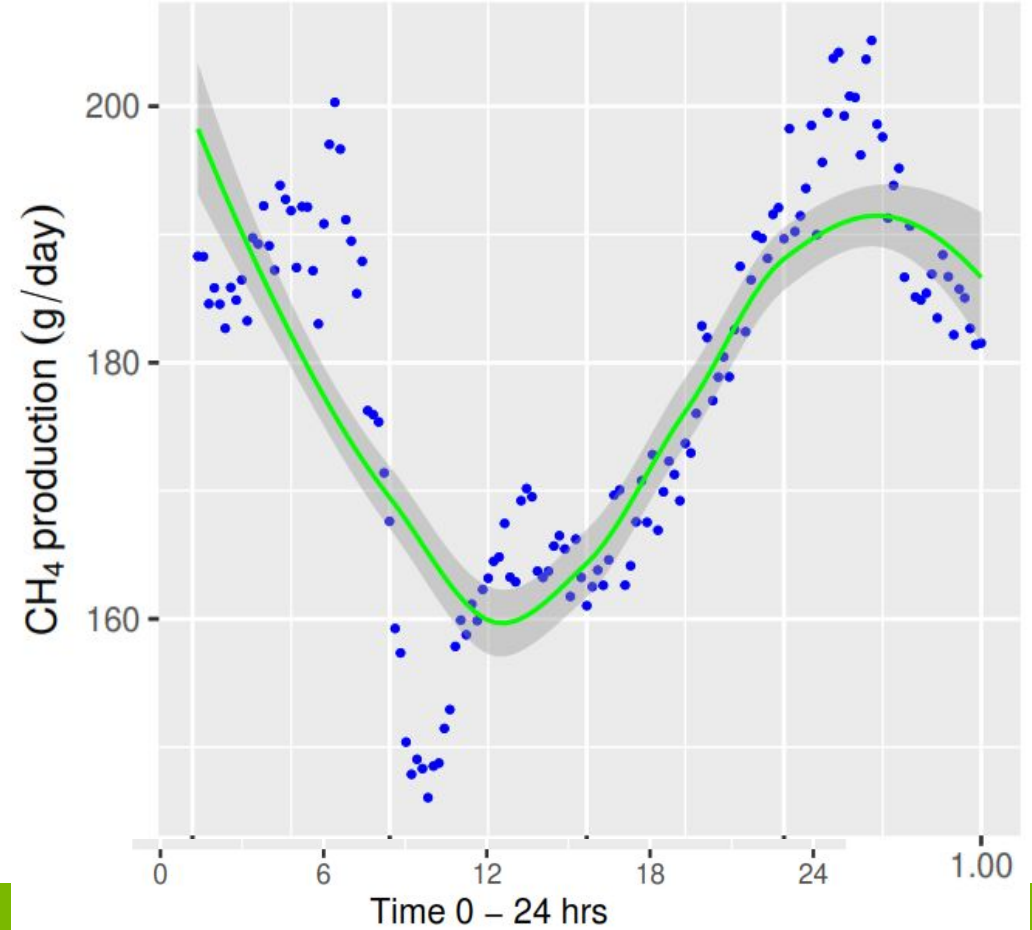
Raynor et al 2025

# Diurnal pattern

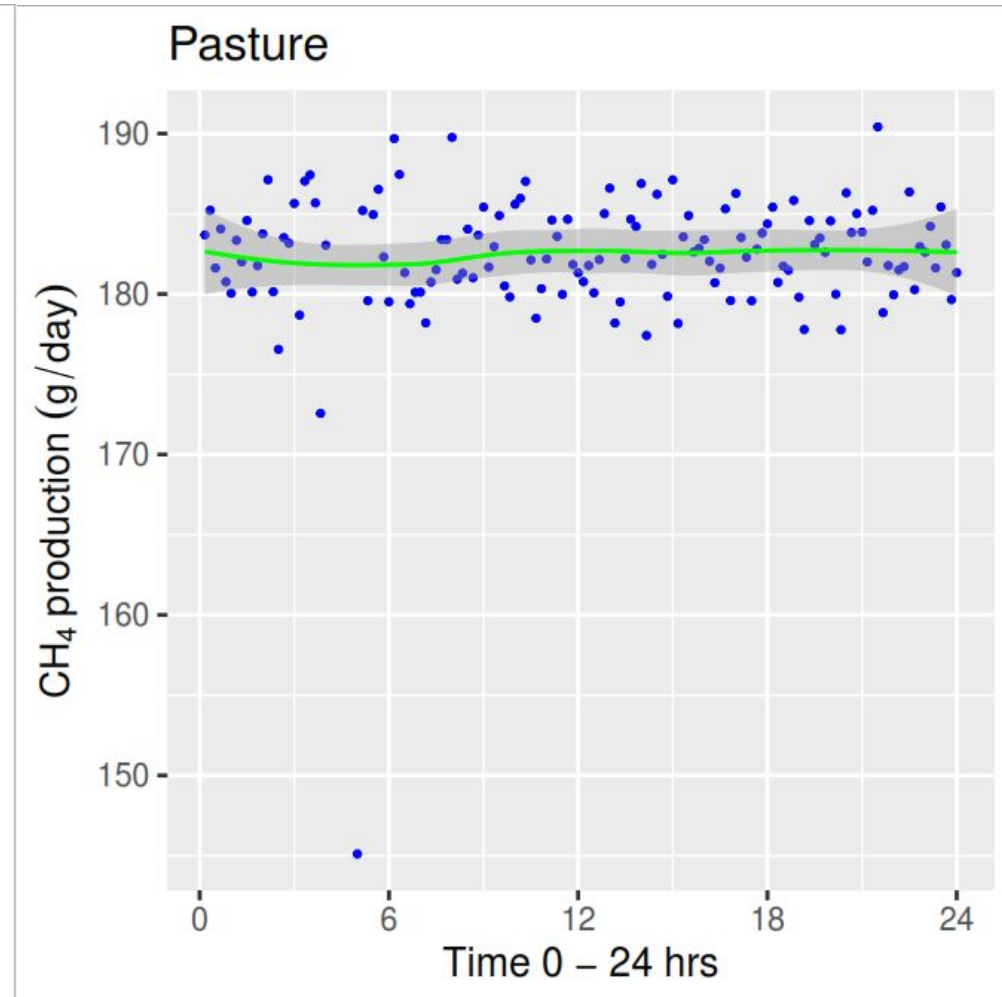
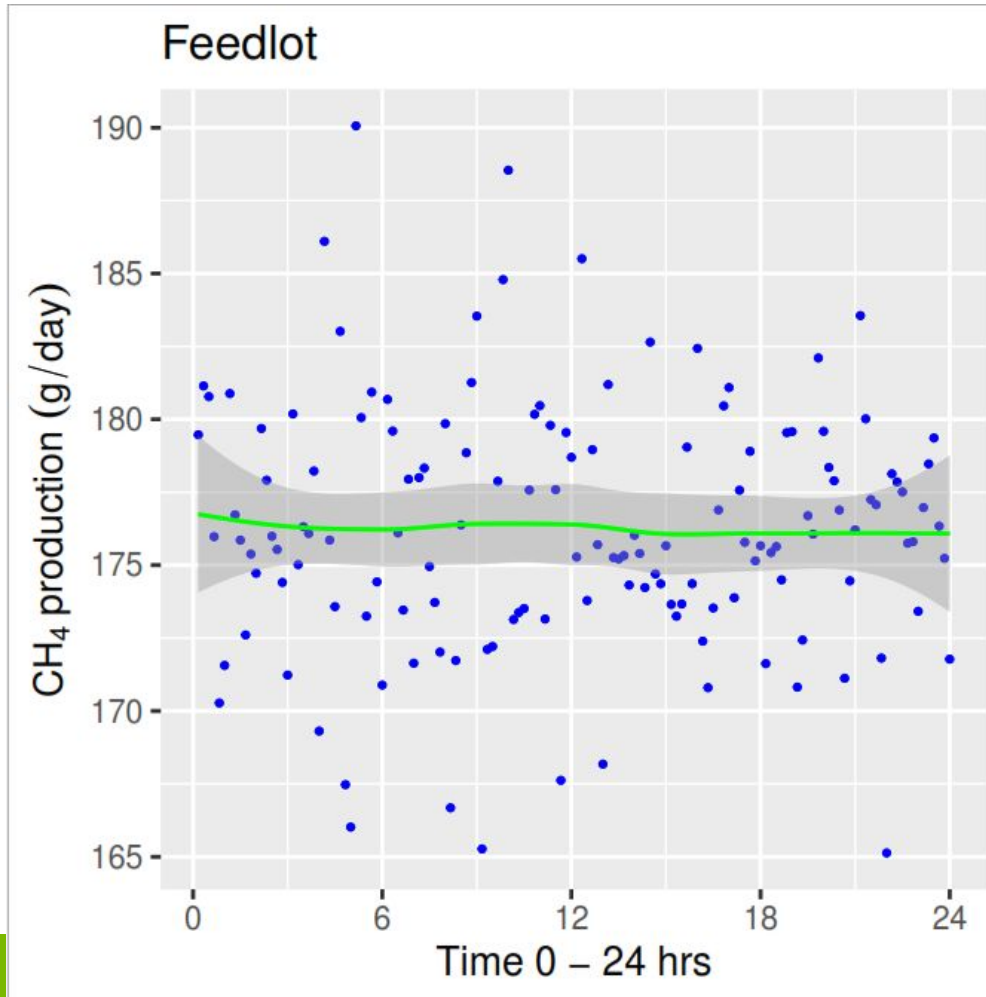
Feedlot



Pasture



# Diurnal pattern removed

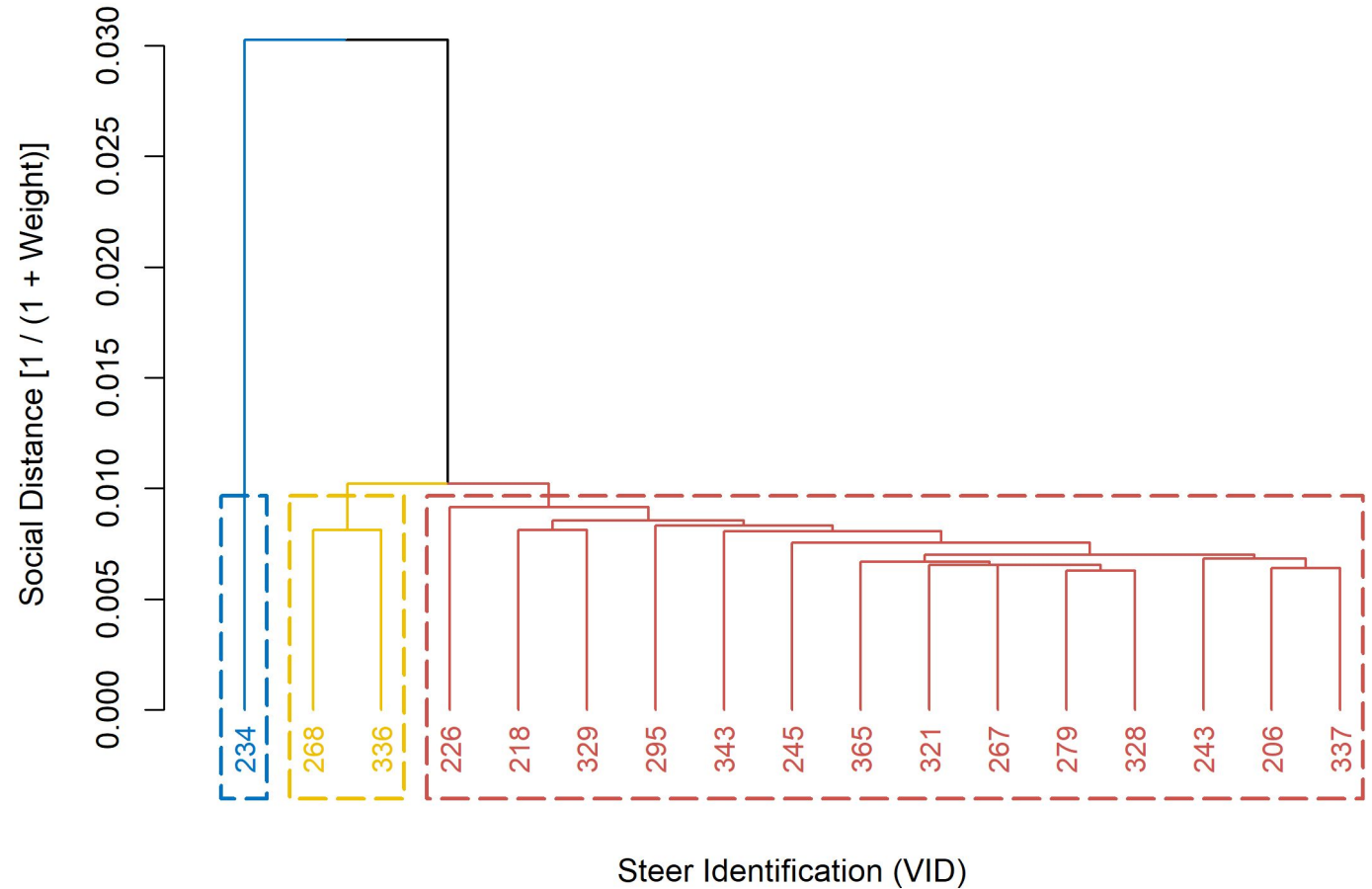


# **MOB EFFECTS**

# Shy visitors

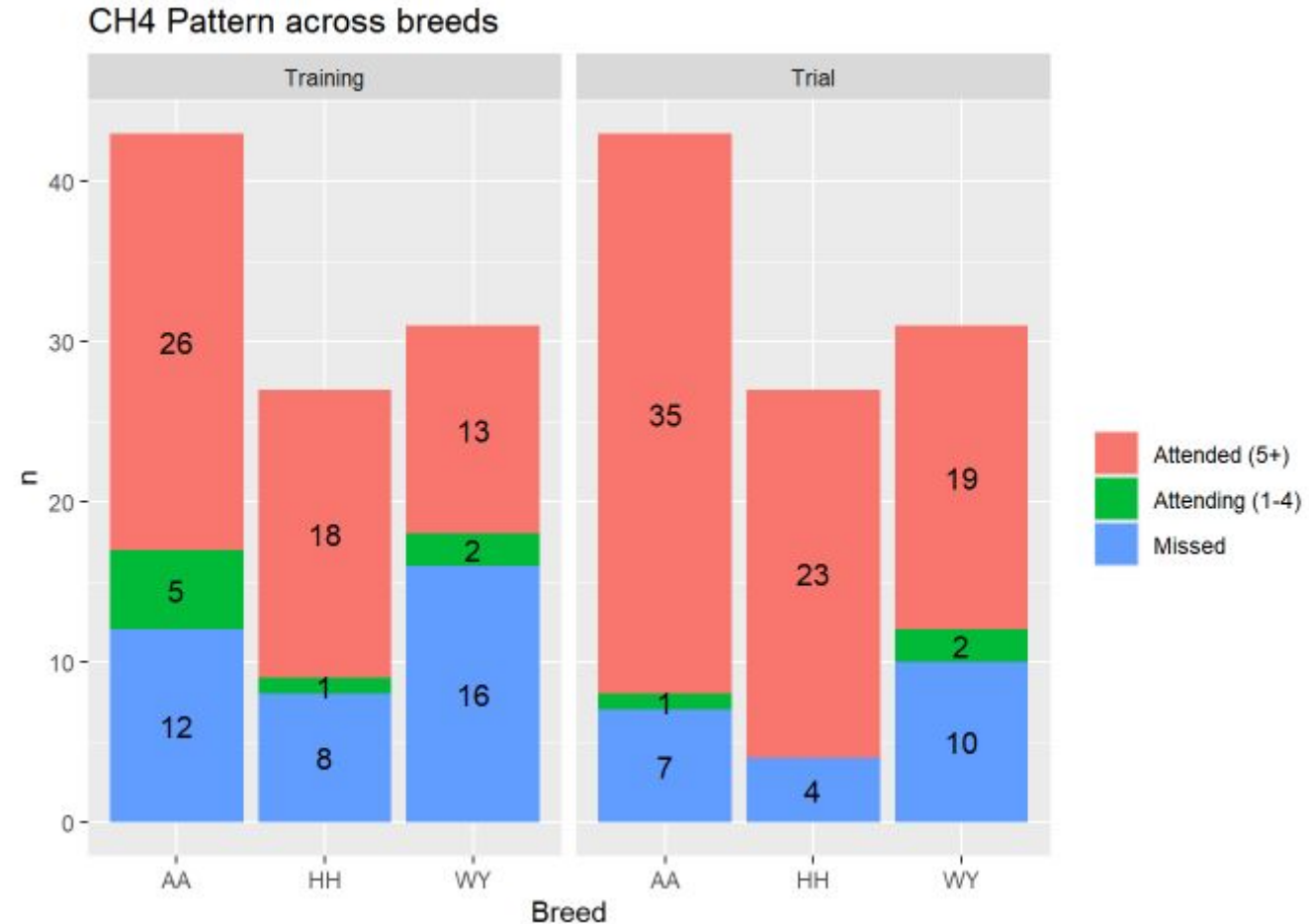
Hierarchical social clustering associations among grazing steers ( $n = 17$  &  $18$ ) based on GreenFeed visitation patterns.

Hierarchical Clustering ( $k = 3$ ) - Group 1



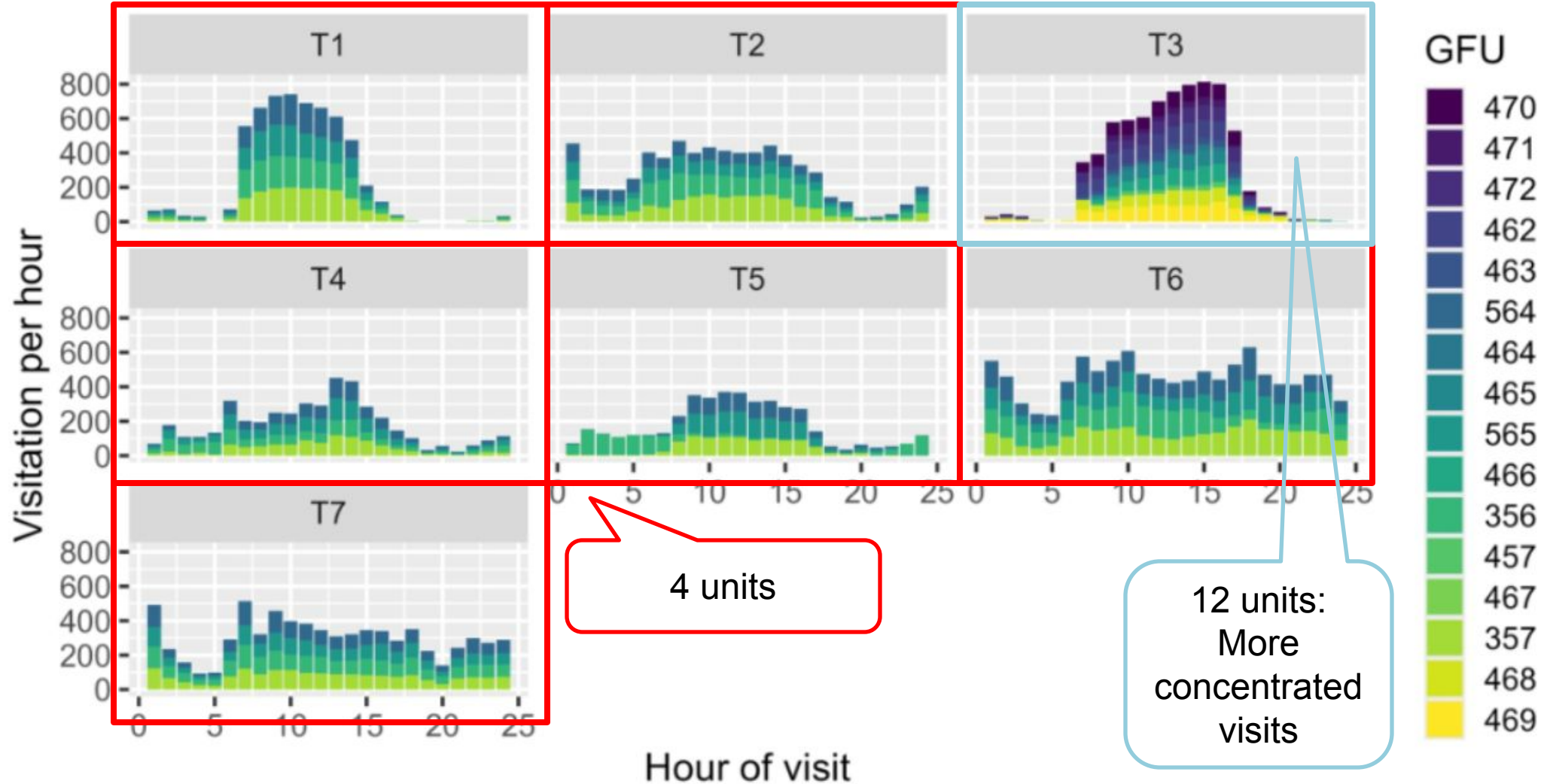
# Multi-breed groups

- Closing gate improved recording for some breeds
  - Reduces bullying (visual observations)
- Potential impacts:
  - Selection of animals for further study based on visitation during training can be skewed



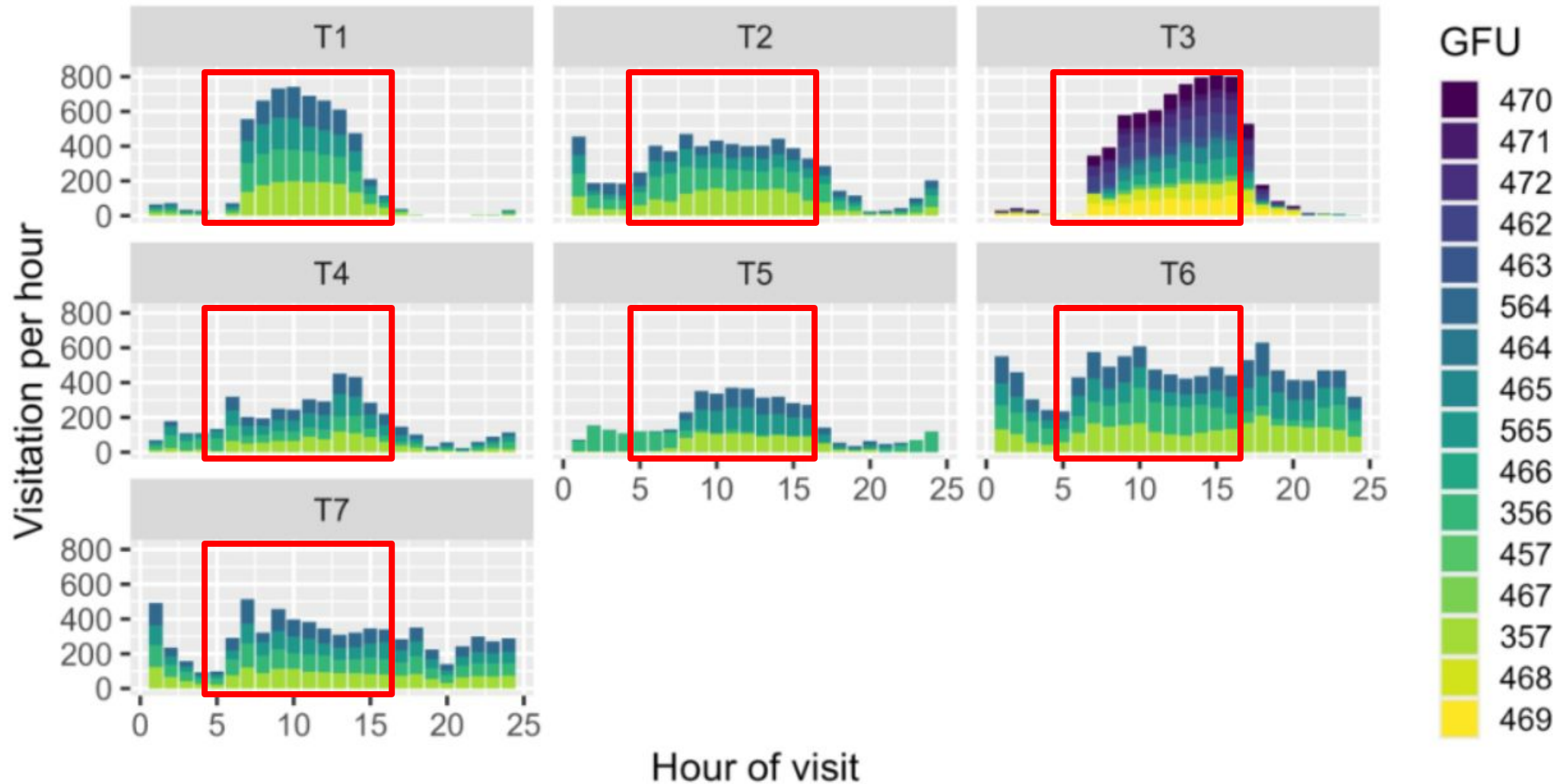
# **ENVIRONMENTAL CONDITIONS**

# Usage of GreenFeed units by hour of day for each trial



Counts of visit per hour across trial and by Greenfeed unit (GFU)

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Counts of visit per hour across trial and by Greenfeed unit (GFU)

# Recommendations

- Feed animals *ad libitum*
- Weight records for diurnal rhythm
- Recording period needs to be meaningful to the production system
- Training is key
- Manage herd dynamics, especially if herd is variable, or grazing area is large

# The takeaway?

- All methane measurement methodologies are but a glimpse into a dynamic biological system
- Data quality depends on how we sample
- Animal behaviour can drive systemic biases
- But! Even with imperfect measurement, genetic correlations are robust!