Evaluation of Diurnal Patterns of Methane Emissions

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Science and Engineering at Work

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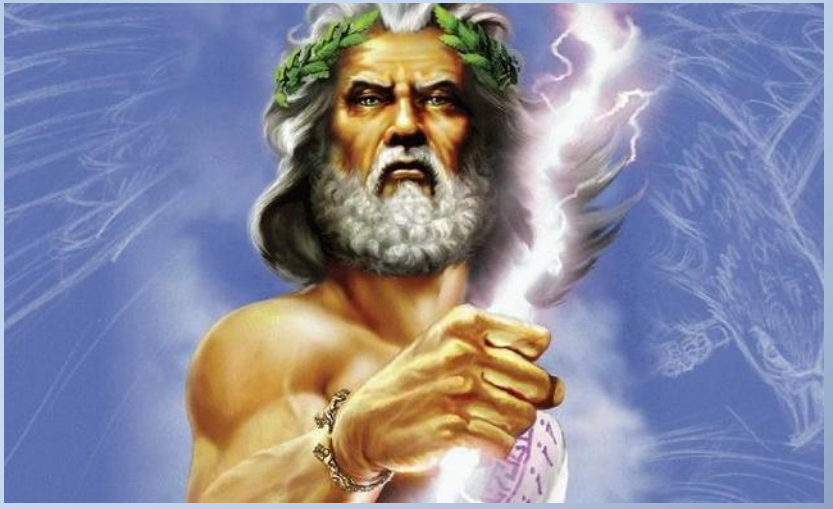
“Mythology”



- Common statements which are not usually true:
  - *Cows fart methane!*
  - *Cattle only emit methane while ruminating!*
  - *Cattle don’t emit methane while sleeping!*
  - ***Methane emissions vary by 5-fold over the day!***

Cattle Rumen

- Gas is produced in the rumen at about 0.5-2.0 L/mi
- Most is CO_2 (69%) and CH_4 (29%)
- The animals have no ability to directly control the microflora and turn them on or off
  - Can control intake and timing, “fuel”
  - Can control rumen contractions to stimulate growth

From: http://matronofhusbandry.wordpress.com/2009/06/11/i-want-to-die-with-my-cud-in-my-mouth/

“Diurnal Pattern” of Methane?

- A diurnal pattern of methane describes how methane changes over the day.
- The definition of “pattern” is, “something that happens in a regular and repeated way”

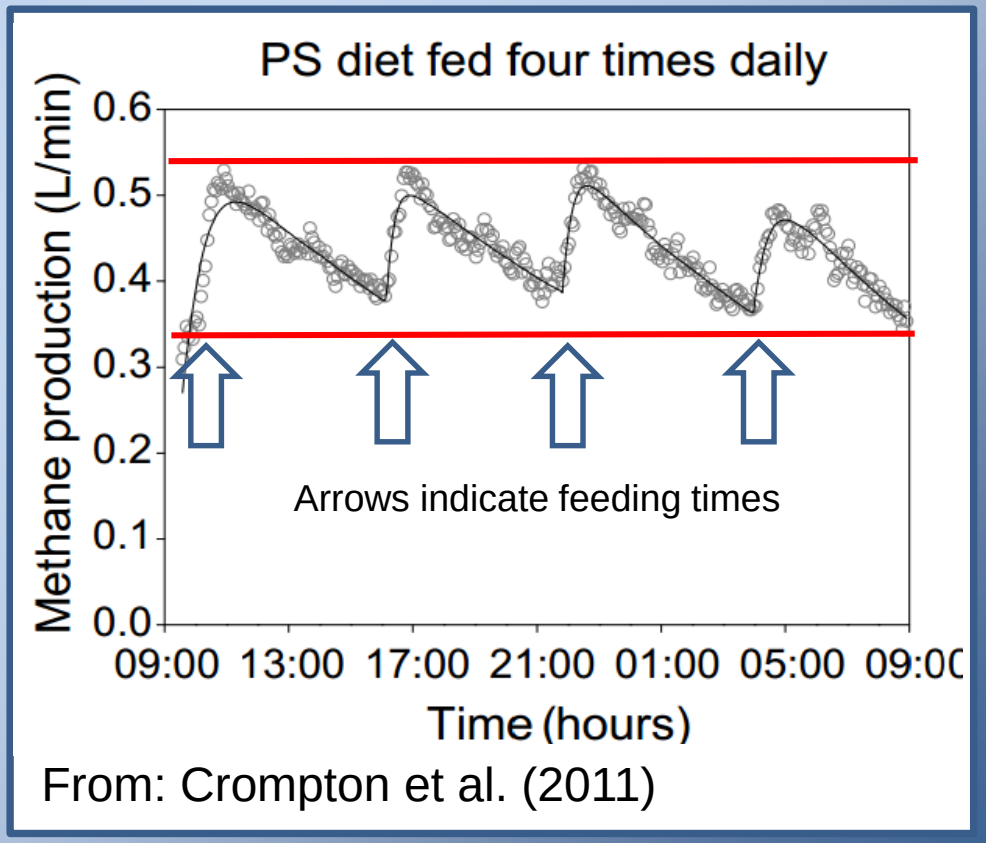
Methane diurnal patterns are a function of:

Size of the meals

Timing of the meals

Diet composition

Individual animal factors



From: Crompton et al. (2011)

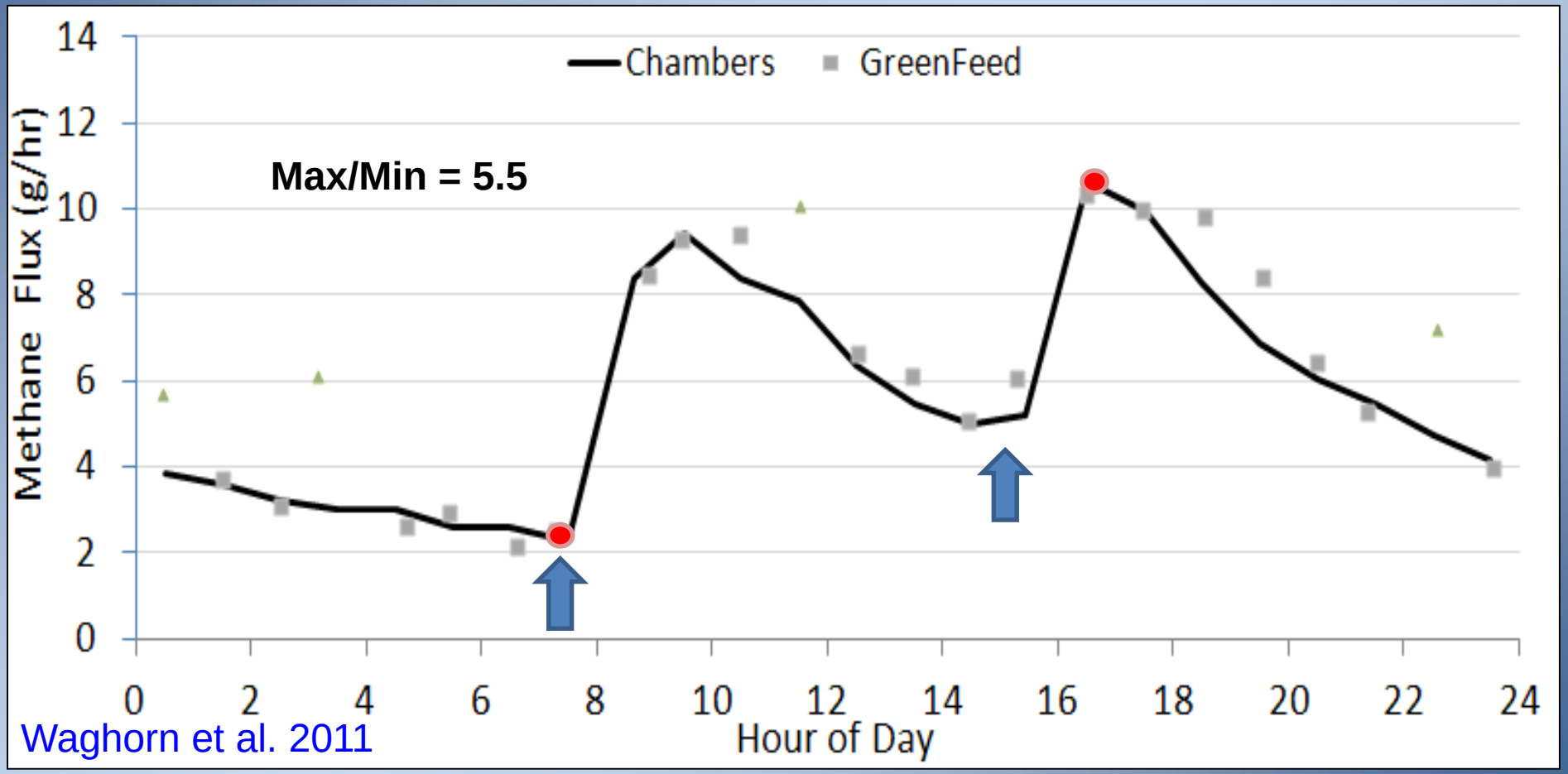
Objectives

- The diurnal variance in methane is a consideration for the sampling strategy needed to sample methane with GreenFeed
  - More variability = more samples needed, timing critical
  - Less variability = fewer samples need, timing not as critical
- The objective: To determine the variability of diurnal patterns of methane in different conditions

Methods

- The diurnal variance in methane over the day is rarely directly reported in the literature.
- Chamber data or GreenFeed data– When time of day vs methane emissions are reported the diurnal variance can be evaluated, usually graphical.
- Diurnal variance can not be evaluated using normal SF_6 data
- Simple statistic is:
    - Maximum/minimum emissions

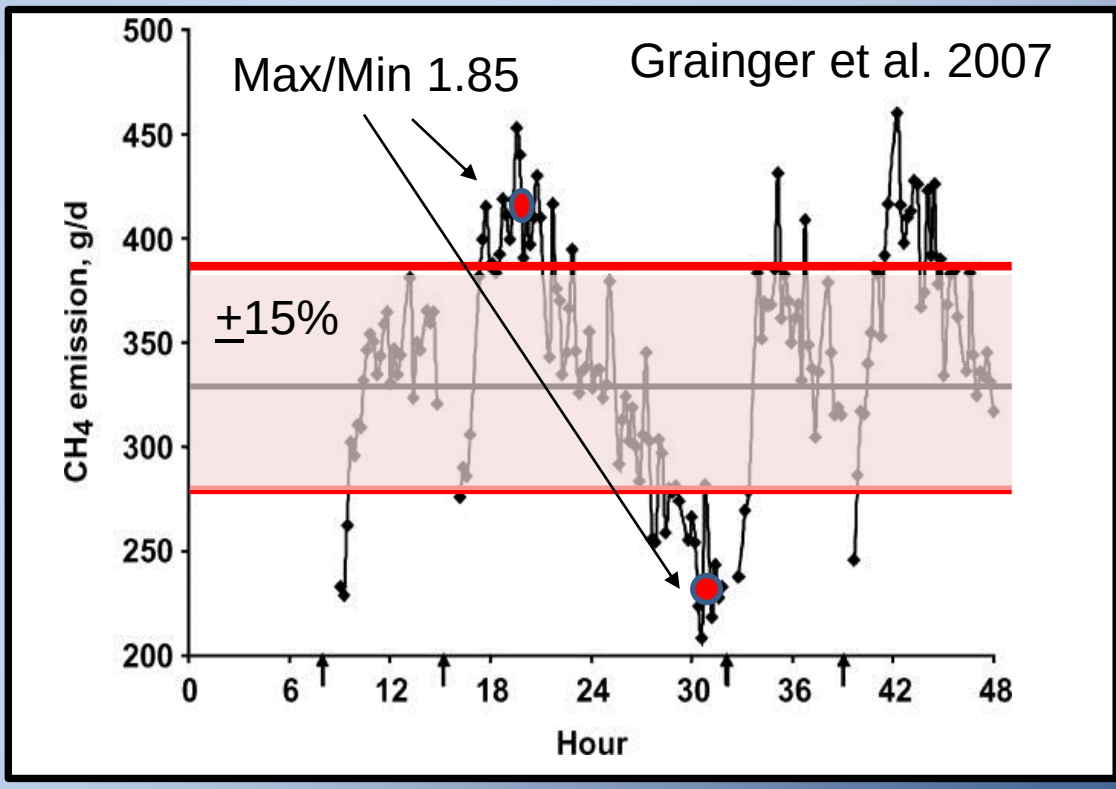
Chambers and GreenFeed Can Measure Diurnal Patterns Restricted Feed, Waghorn et al. 2011



“Rough” Rule of Thumb

- Diurnal methane variance compared to the percent of day within ± 15%:

Max/Min	% of day within ±15% of mean
1.0	100%
1.2	100%
1.4	90-95%
1.6	80-85%
1.8	72-76%
2.0	67-72%



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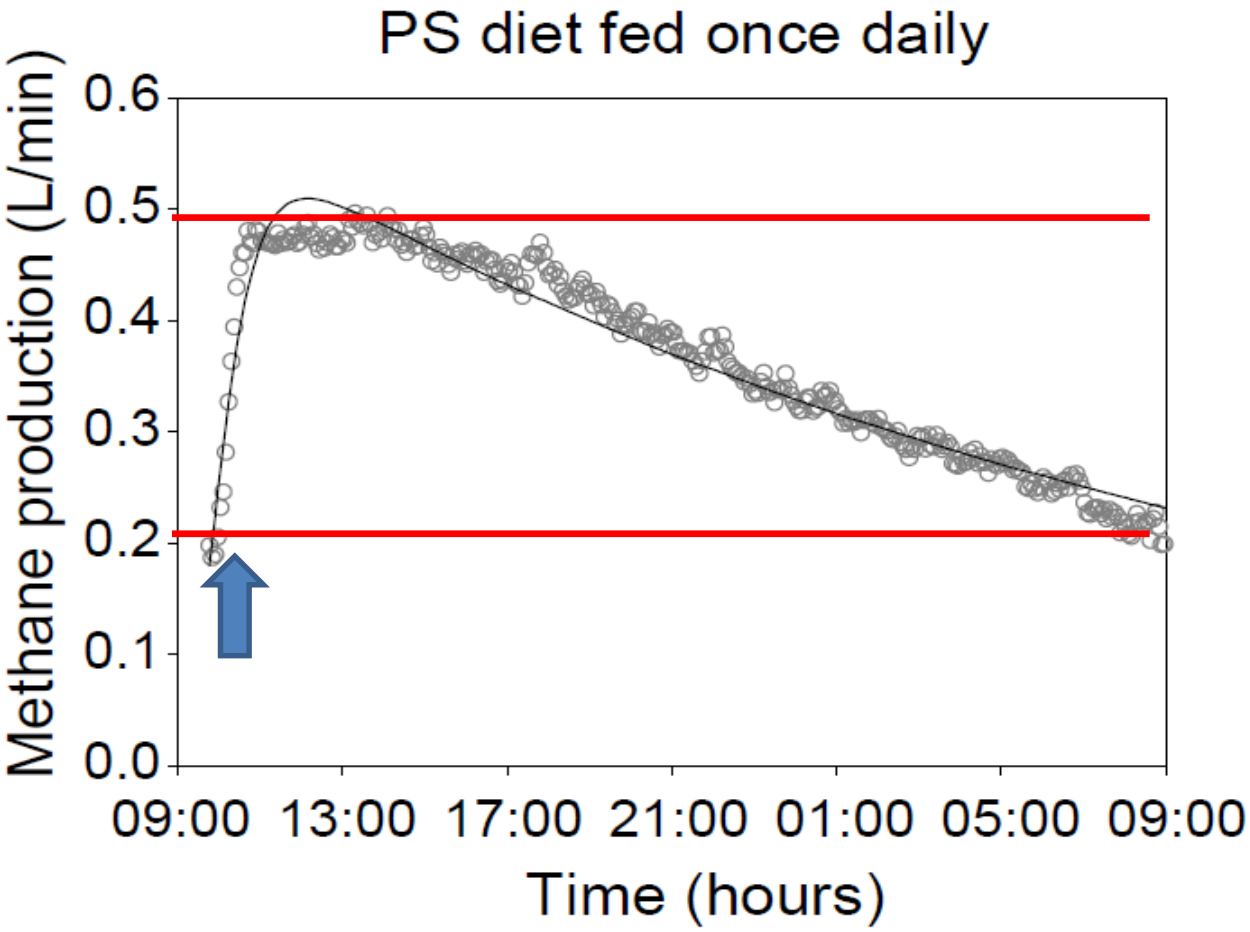
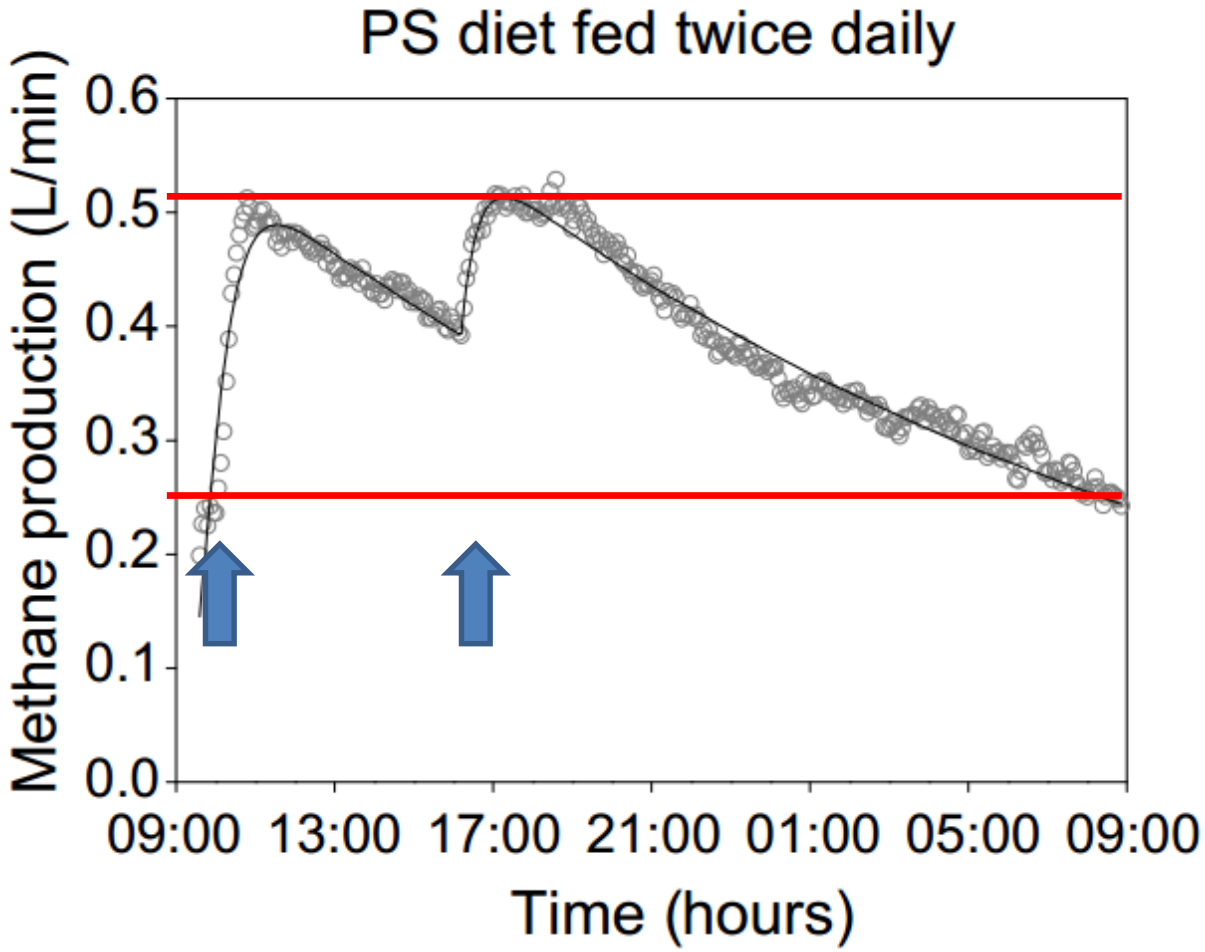
Once Per day Feeding (Crompton et al 2011)



Range = 0.21 - 0.49 L/min

Max/Min Ratio = 2.5

Twice Per day Feeding (Crompton et al. 2011)

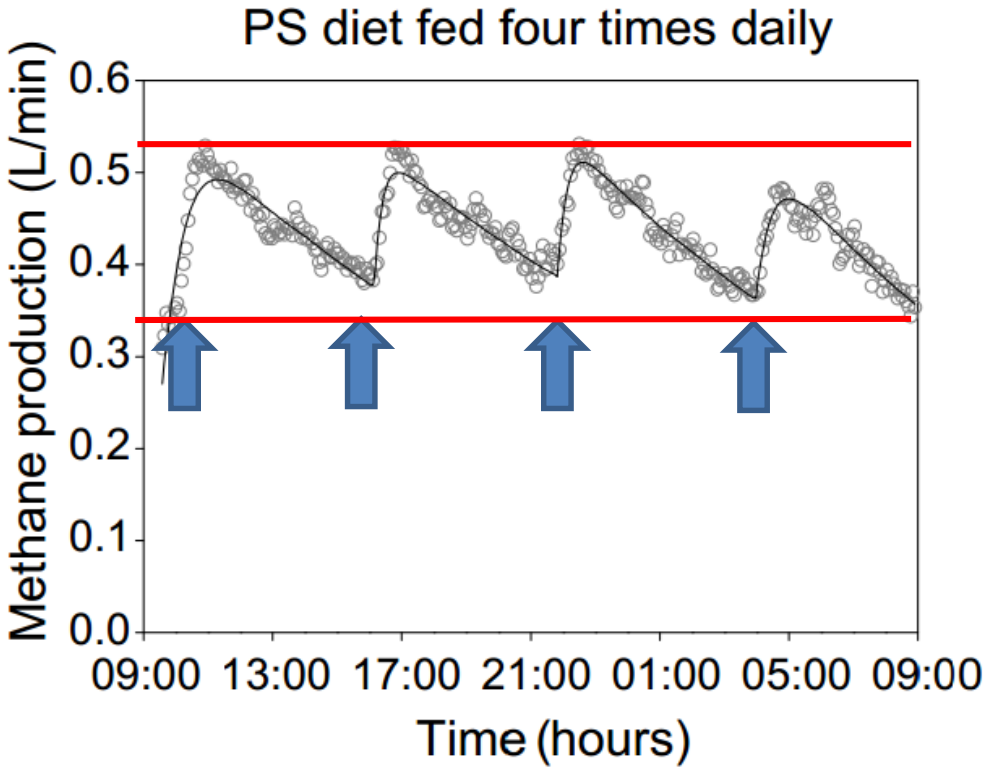


Range = 0.26 - 0.51 L/min

Max/Min Ratio = 2.0

Methane and Feeding

- Methane increase and decrease over the day according to food intake…

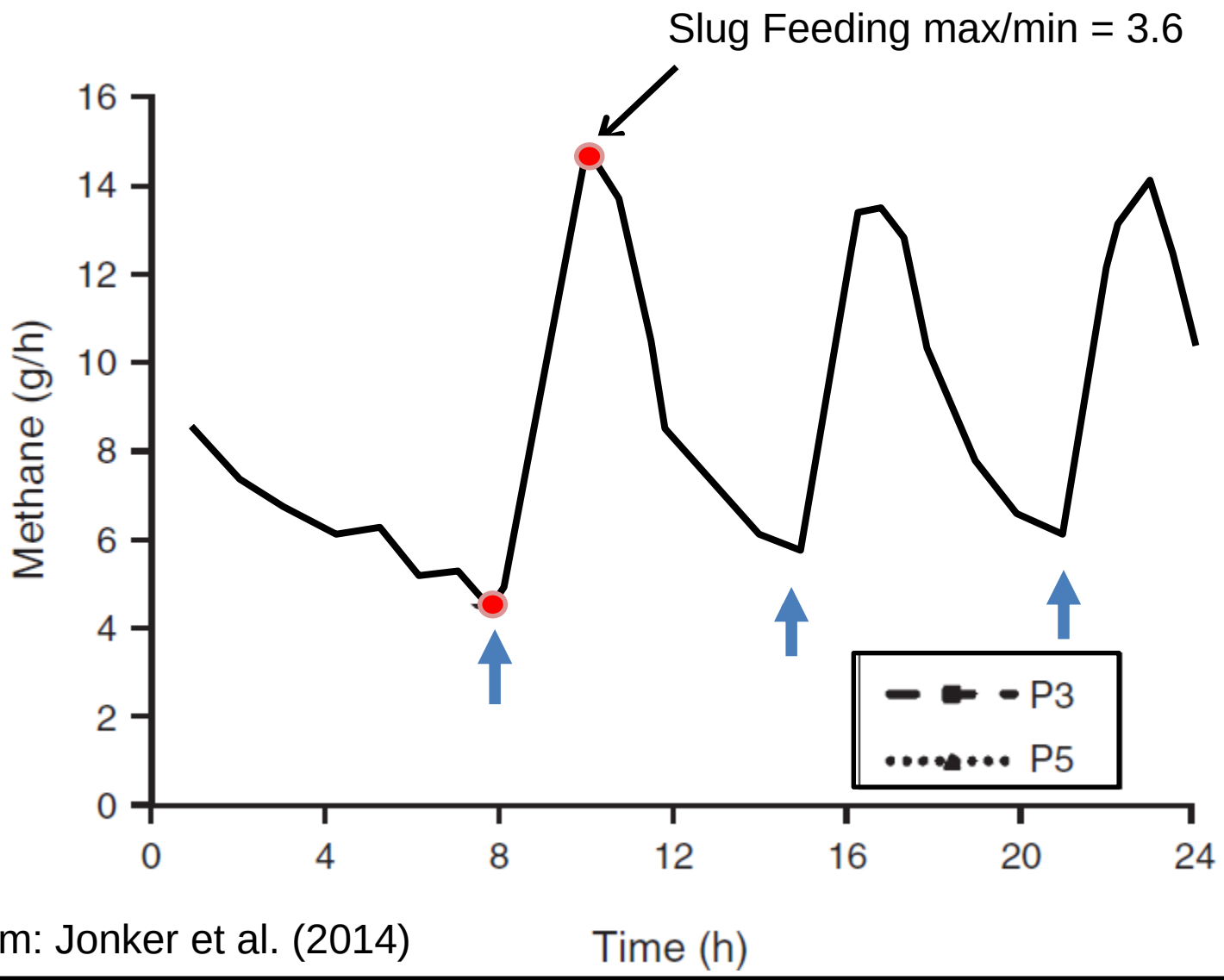


Range = 0.37 - 0.51 L/min

Max/Min Ratio = 1.45

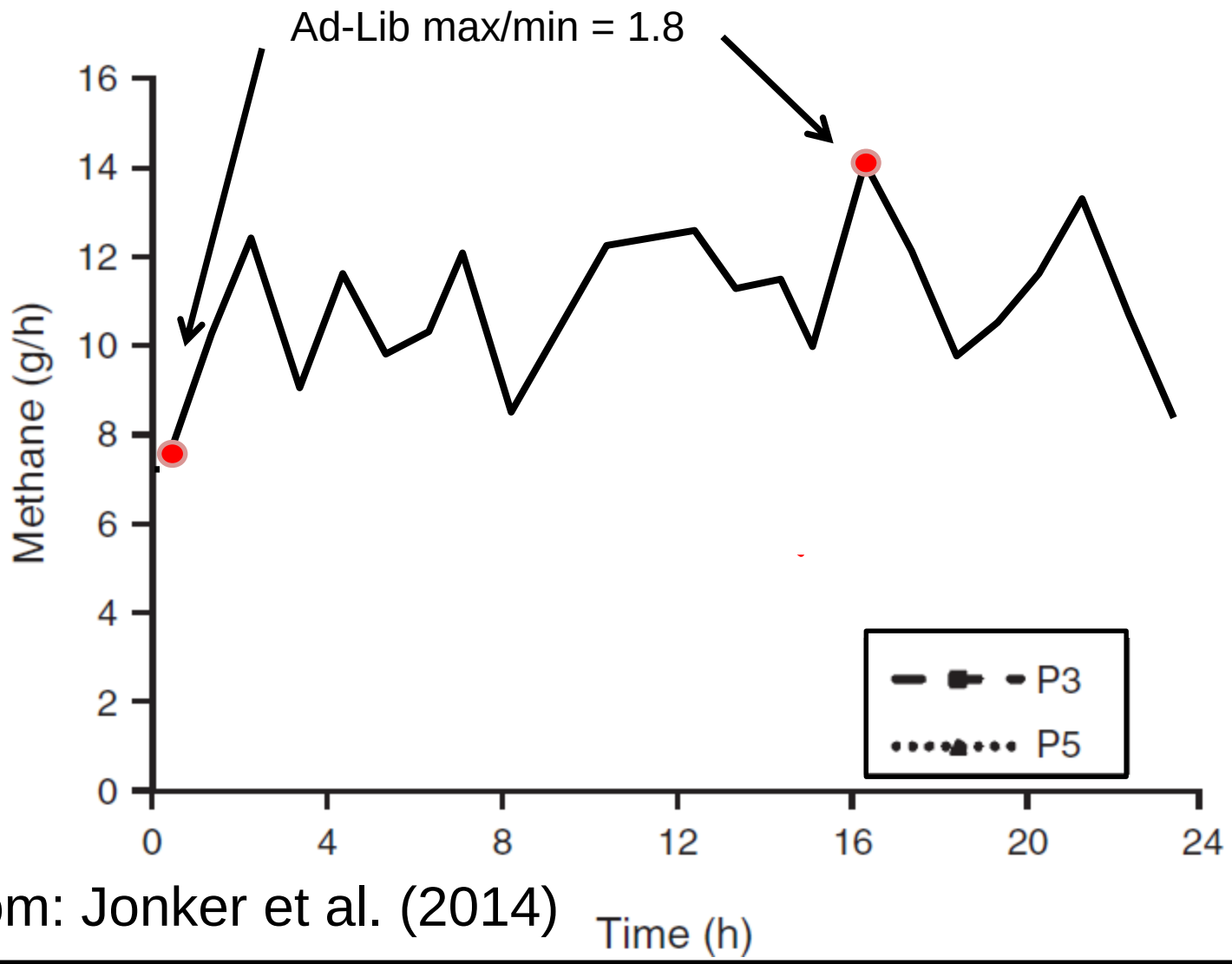
As animal's eat more often, CH_4 varies less over the day

Restricted Feed Intake Pattern, Slug Feeding



From: Jonker et al. (2014)

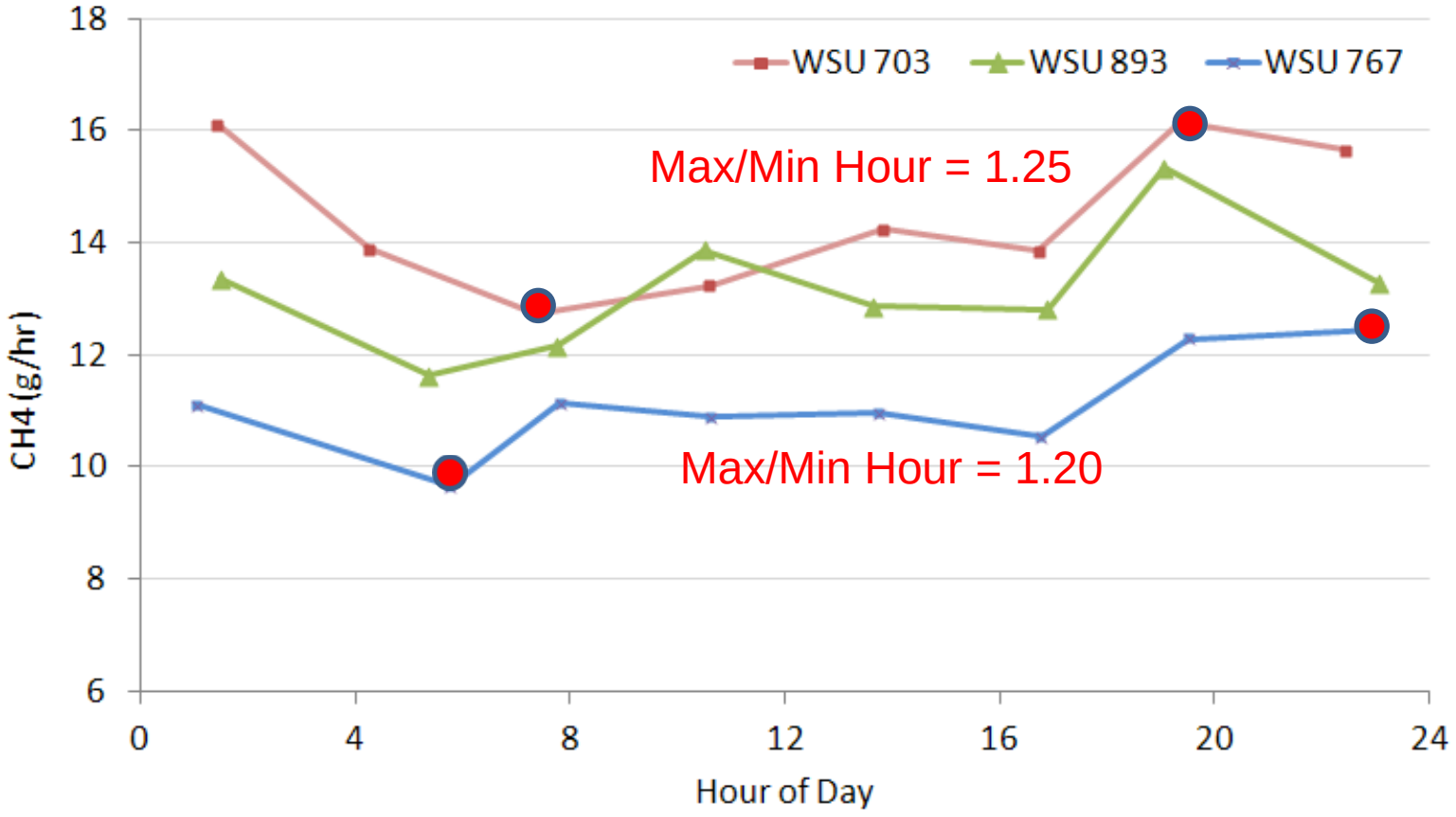
Ad Lib vs Restricted Feed Intake Pattern



From: Jonker et al. (2014)

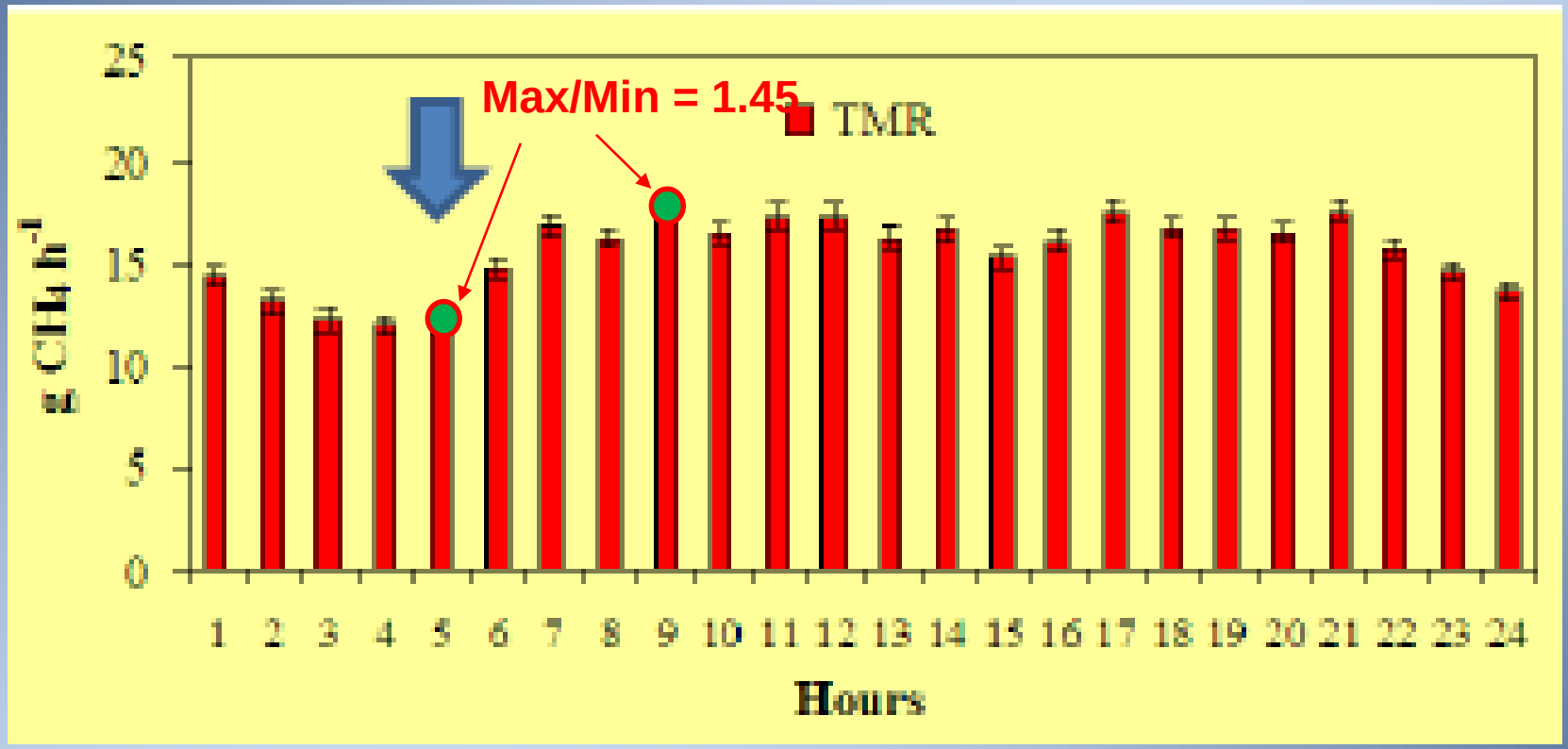
Forage Diets – Production Systems

Beef Cattle, Grazing Wheat Grass (Zimmerman et al. 2013), Three Animals

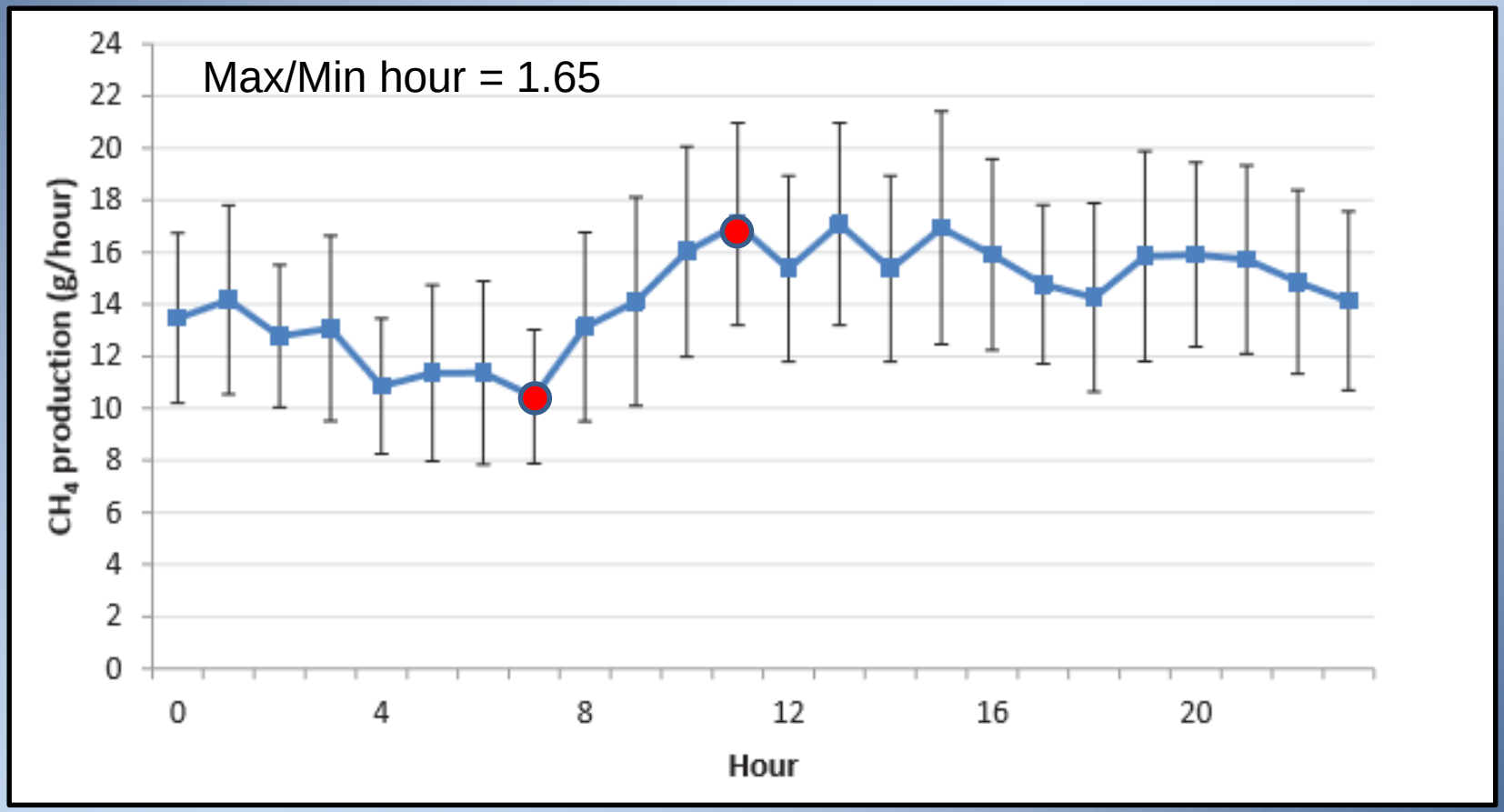


Each Line is one animal's diurnal pattern

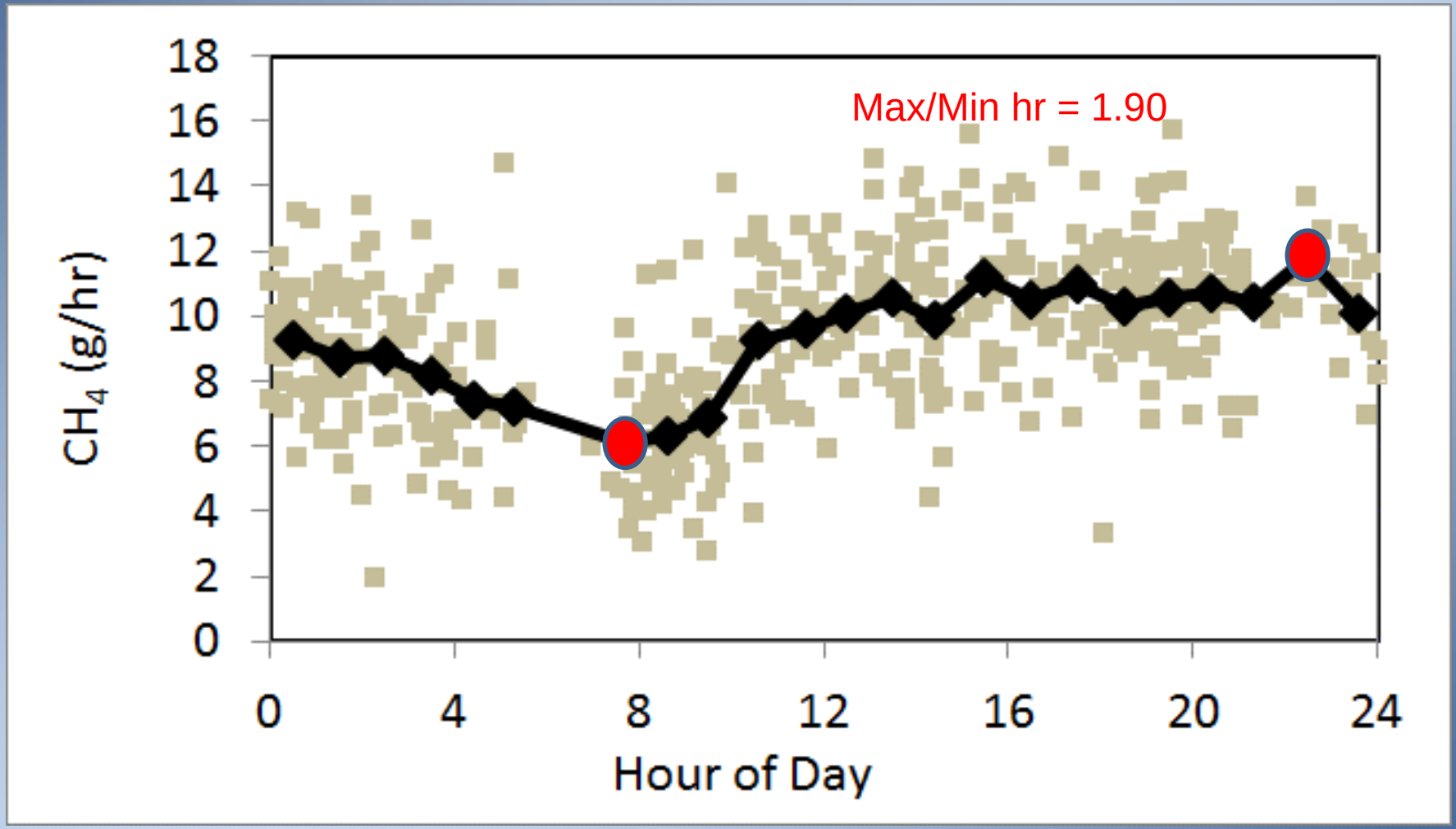
Ad-Lib Lactating Dairy Animals, TMR, Utsumi et al (2013)



Intensive Grazing Diurnal Pattern, New Zealand Lactating Milk Cows, Garnett (2012)



Beef Forage, Free-Stall
Manafiazar et al. (2015)



Diurnal Min/Max CH_4 Patterns in Production Systems – Forage Diets

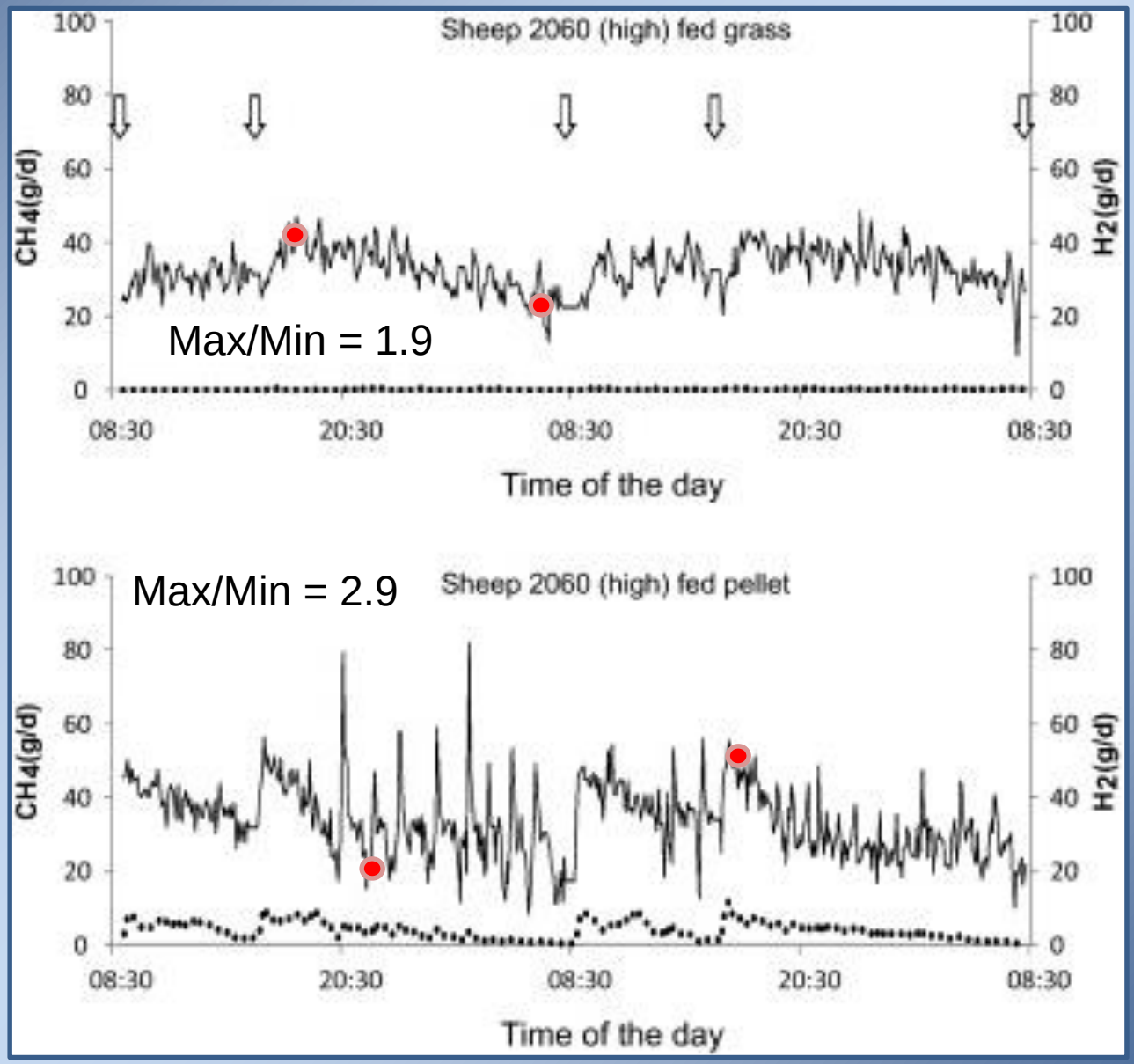
Type	Location	Breed, Type, DIM[1]	Diet	H_d CH_4
Milk	US, MI	H[4], L[5], 157	TMR	1.3
Milk	Sweden	SR[6], L, 120	TMR	1.2
Milk	NZ[7]	F[8], L, 93	Past[9]	1.5
Milk	US, NH	J_o[10], L, 215	Past	1.6
Beef	WA, US	A[11], Hr[12]	TMR	1.3
Beef	WA, US	A, C[13]	Past	1.2

[1]DIM = Average days in milk, [2]N = Number NZ = New Zealand, [8]F = Friesian, [9]Past = Pasture, [10]J_o = J

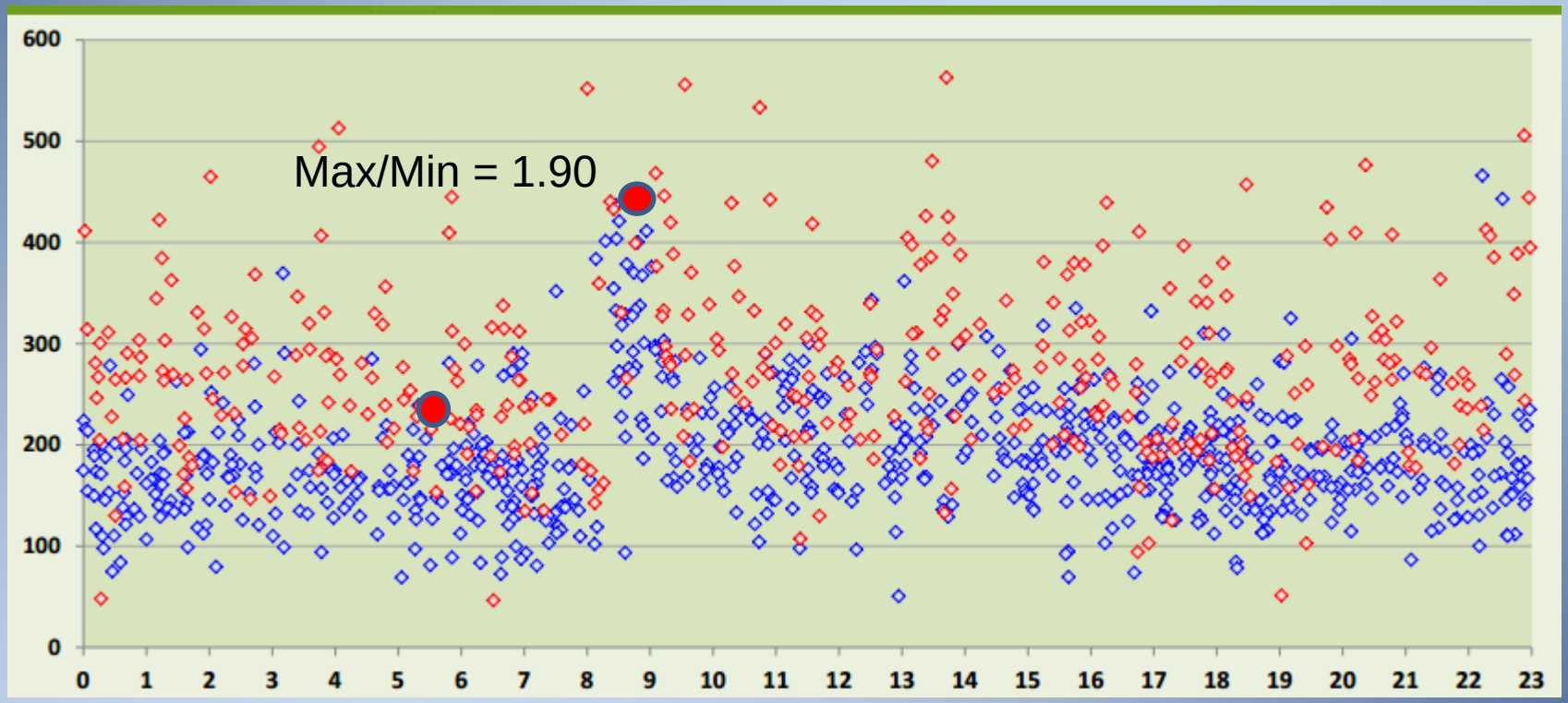
From: Zimmerman et al, 2013

High Energy Diets

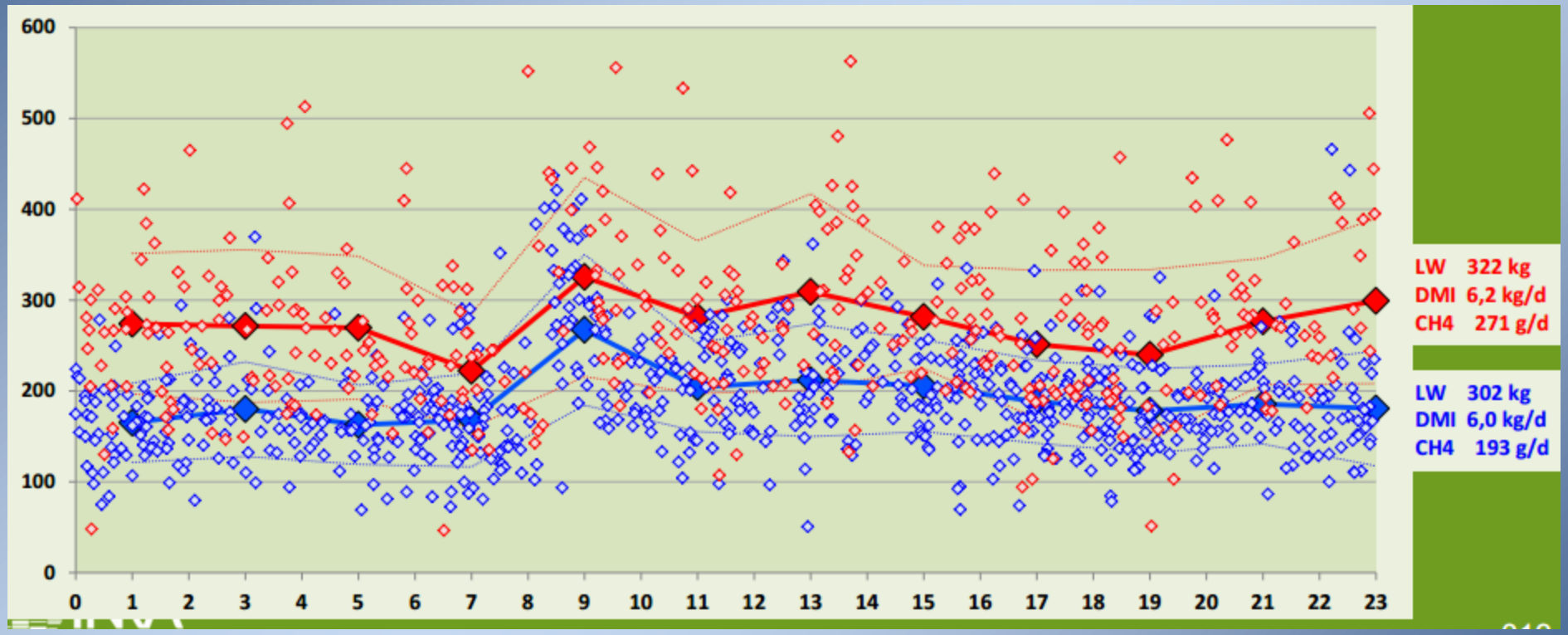
Sheep, Grass or 40/60 pellet (Pinares-Patino et al. (2011)) (Restricted intake)



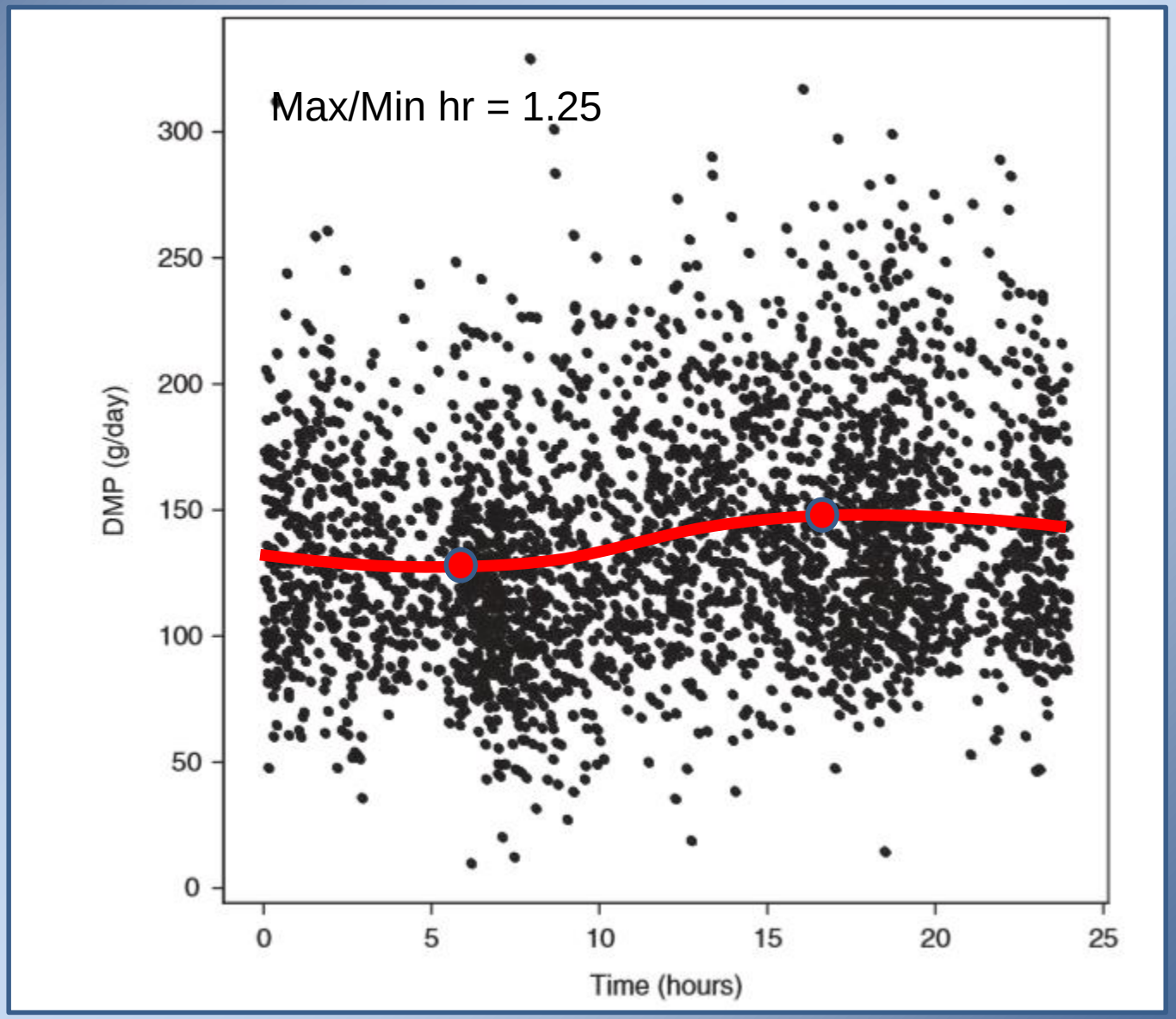
Beef Cattle, Concentrate Pellets, Renand et al. (2013)



Beef Cattle, Concentrate Pellets, Renand et al. (2013)

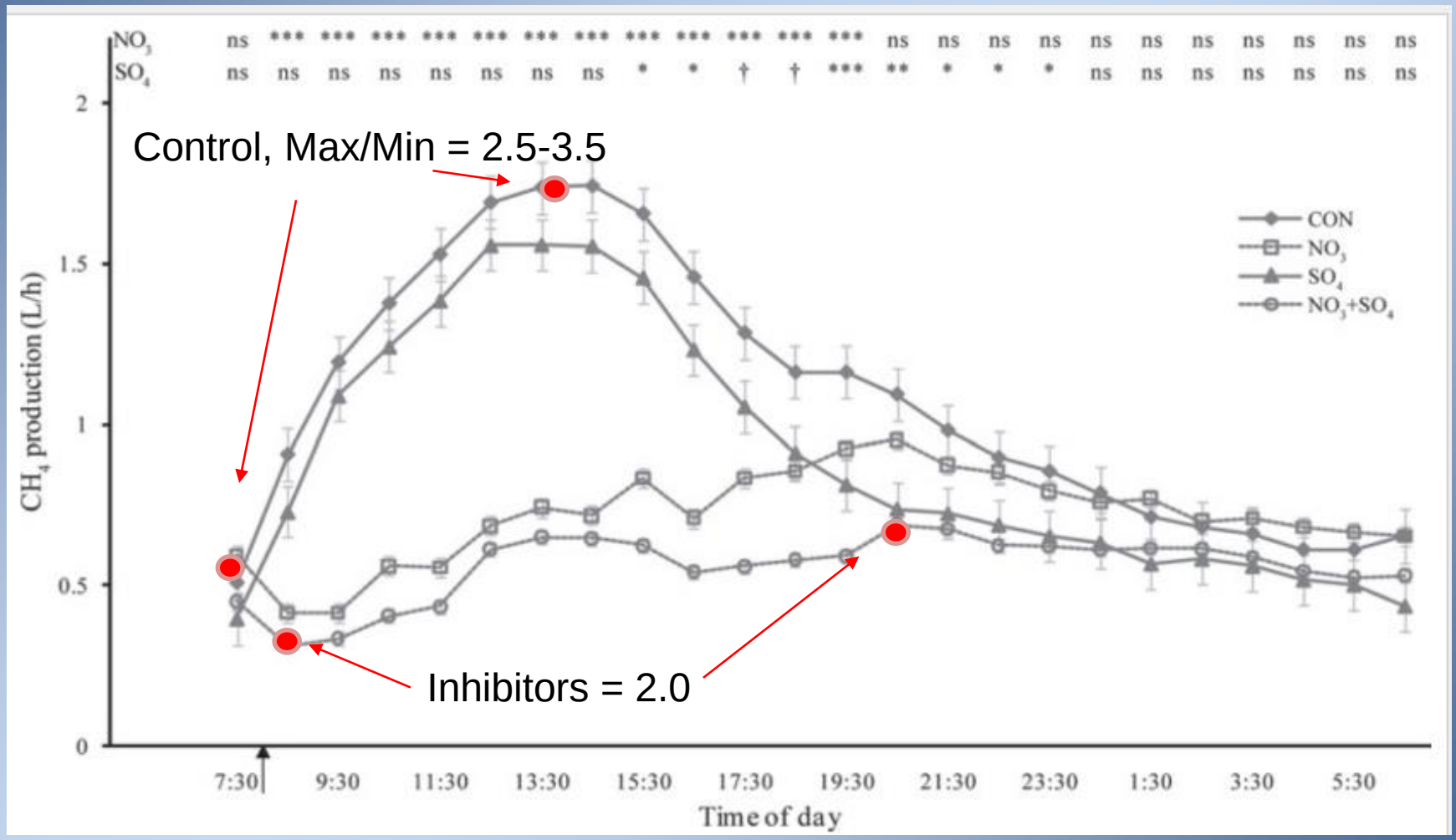


Cottle et al. (2015) Beef Feedlot Finisher Ration



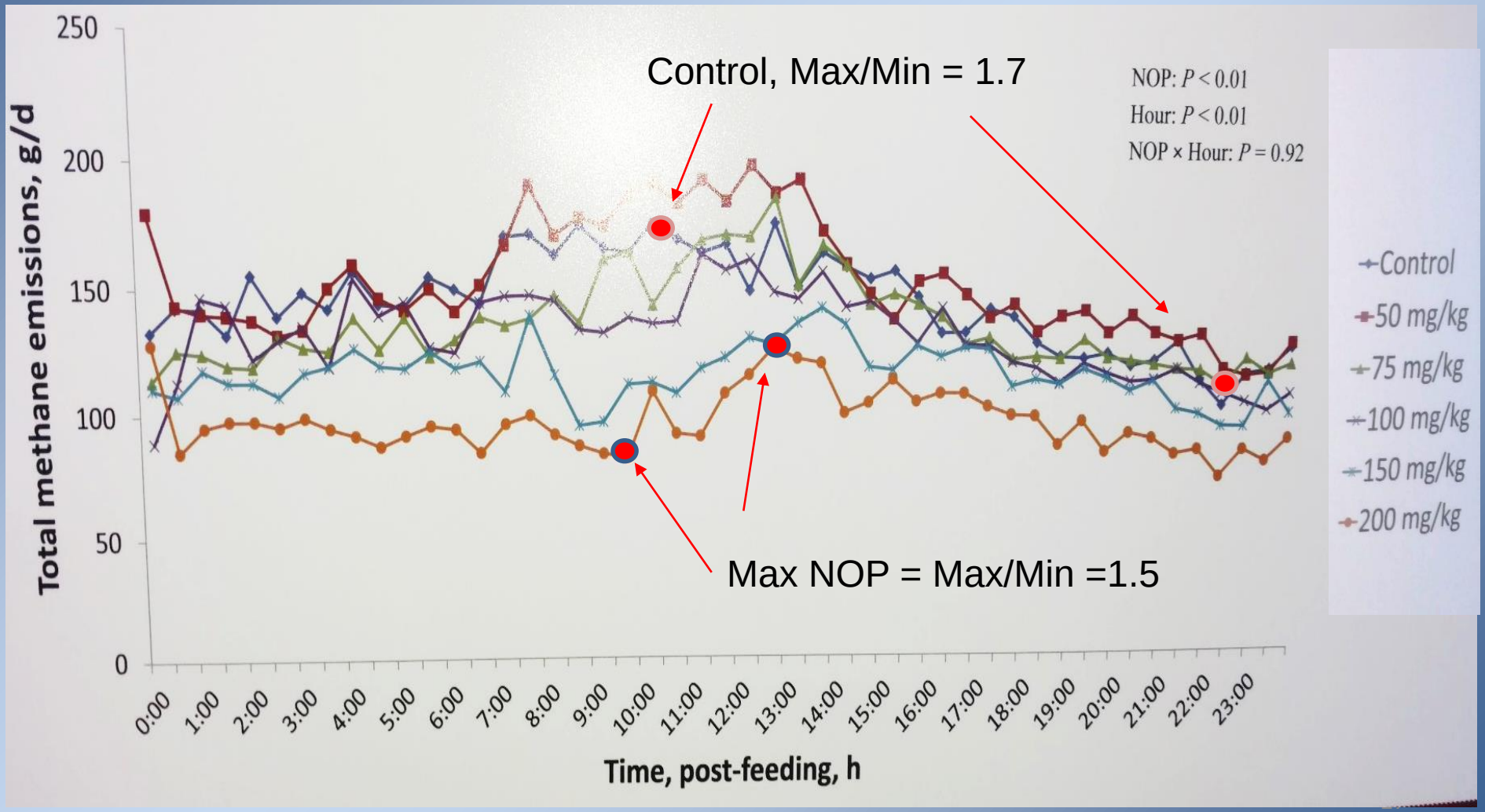
Methane Inhibitors

Methane Inhibitors, Restricted Intake, Lactating Milk Animals

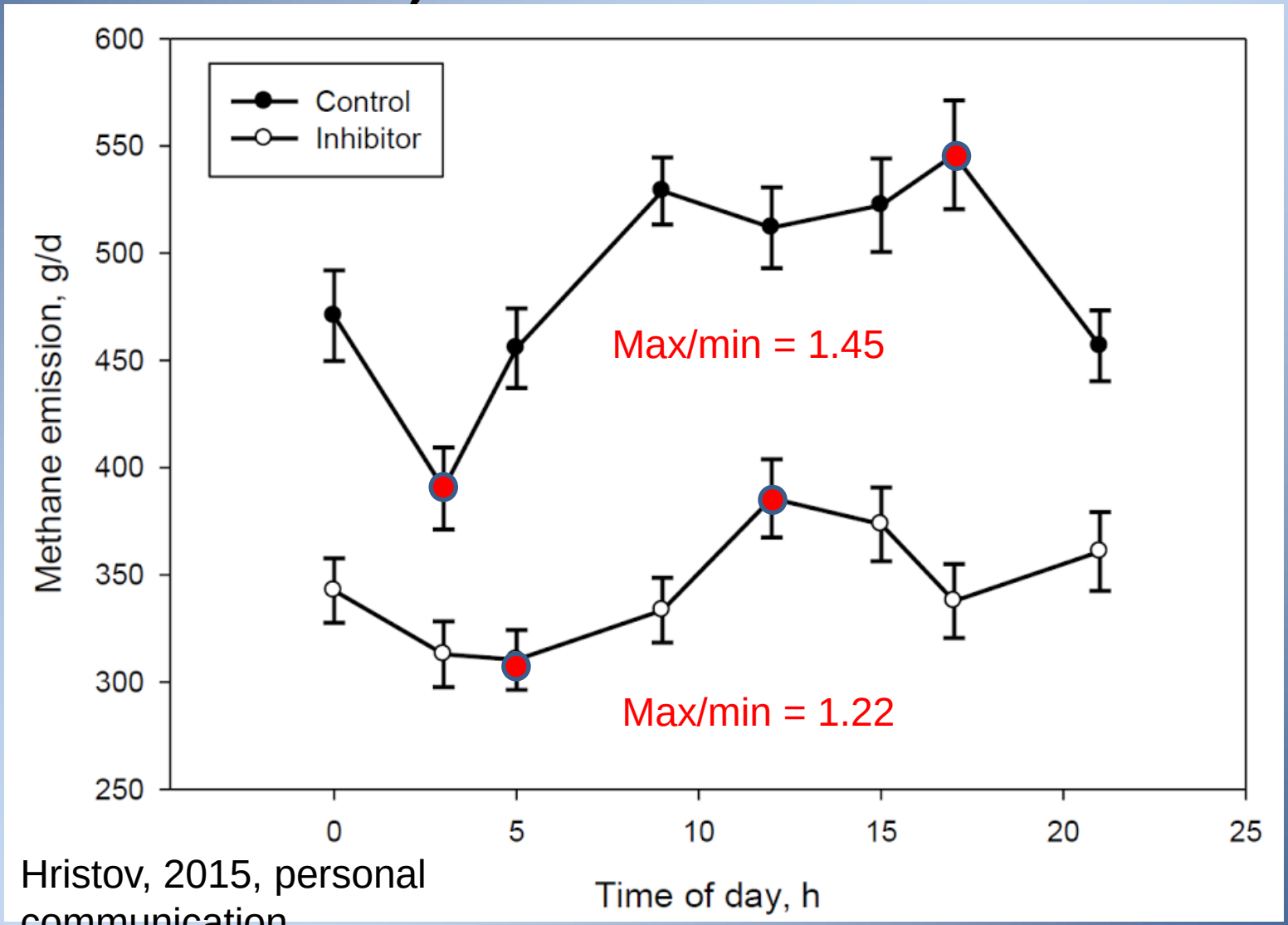


van Zijderveld et al. 2011

Ad-Lib Beef Cattle – Methane Inhibitors High Forage Diet control and NOP (Vyas et al. 2016)



Lactating Diary Animals, Ad Lib, Control, Methane Inhibitor



Hristov, 2015, personal communication

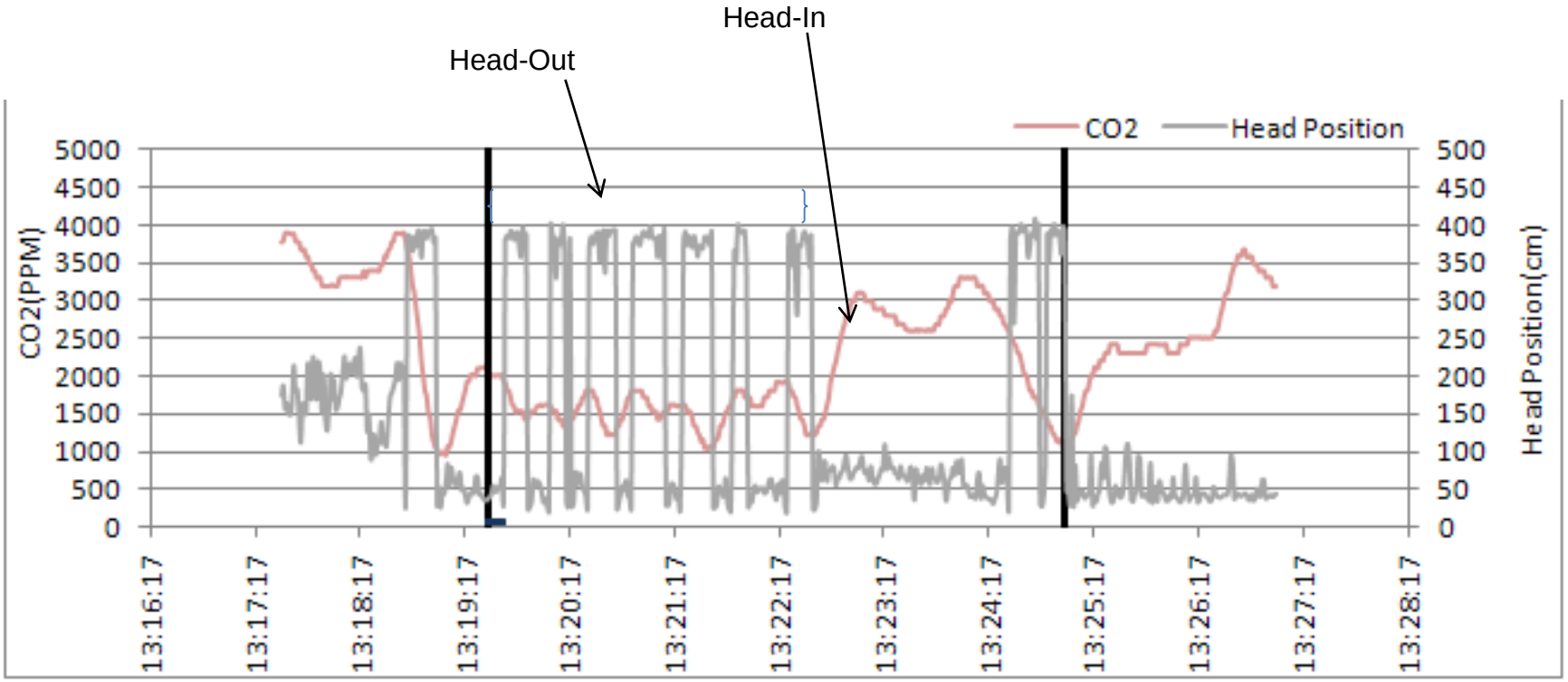
Summary

- Methane emissions diurnal patterns:
  - Most production systems
    - Max/Min ratio = 1.2 – 2.2 <- almost every GreenFeed application is in this range
    - The CH_4 emissions for a significant portion the day are within 10-15% of the daily averaged emissions
    - Gathering at least 20-50 samples to overcome the random variance is important. If this occurs, significant biases in GreenFeed from non-uniform visitation are < 5% in most cases
  - CH_4 inhibitors can produce LESS diurnal variability in methane
  - With concentrate diets, GreenFeed measurements can be more variable although averaged diurnal CH_4 patterns might be less variable.
  - Restricted intake or slug feeding, more variable:
    - Max/Min ratio = 2.0 - 6.0
    - GreenFeed is still useful, animals are hungry and will visit often if desired.

Thank you!

Questions?

Head Position and CO_2 Emissions (one Milking Period) High Movement



Attraction Flow = 1000 Times Sniffer Method

Head Position and Emissions (one Milking Period) High Movement