Methane emissions and RFI

Repeatability of short-term spot measurement of CH_4 and CO_2 from beef cattle using GEM system

Ghader Manafiazar, Scott Zimmerman and John A. Basarab
University of Alberta, c-lock Inc., Alberta Agriculture & Forestry

Workshop on metabolic gas emission measurements and GreenFeed, Melbourne, Australia, 13-14 February 2016

ALMA Alberta Livestock and Meat Agency Ltd.

CCEMC

Alberta Innovates Bio Solutions

Alberta Freedom To Create. Spirit To Achieve.

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Improving feed efficiency, product quality, profitability, environmental impact and food security

Canadian Opportunities and Global Challenges

Canadian Opportunities

- $20 B/year industry
- Increasing global demand for meat
- $1 to $2.3B profit over 15yr
- Reduce GHG emissions and environmental impact
- Improve image and demand for Canadian beef
- GE[3]LS shows increased willingness to pay for sustainable beef using genomics

Global Challenges

- Continually improve efficiency to be globally competitive
- safe, affordable, and environmentally responsible beef
- Limited vertical integration
- many breeds, crossbreeding, natural mating
- Leading to weak genetic linkage among populations
- Traits difficult and expensive to measure

Livestock are a producer of man-made Greenhouse Gases (GHG) through the belching of methane from cattle, sheep and goats. Methane is 25 times more powerful as a GHG than CO_2.

Environmental Sustainability

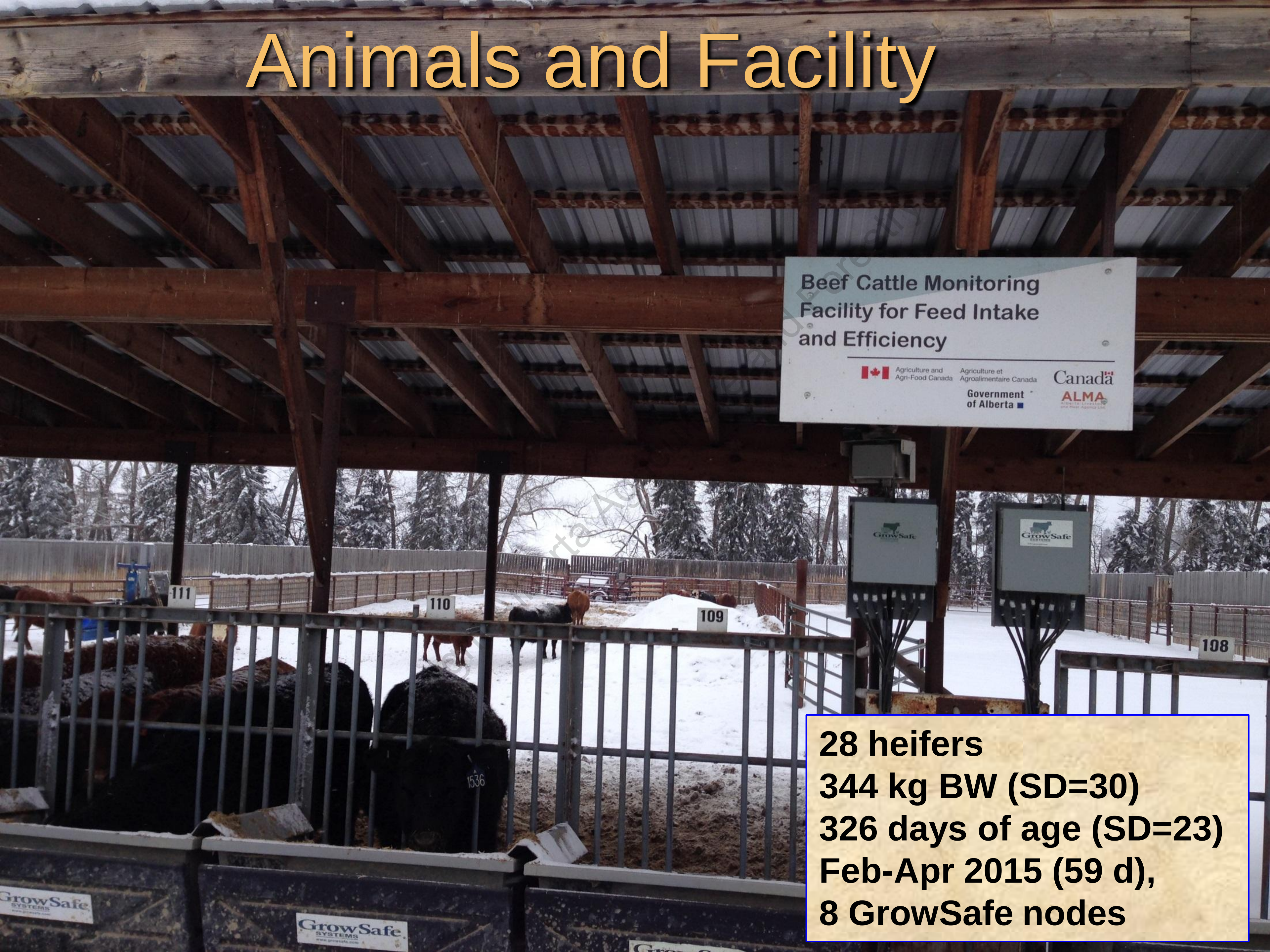
- **Global livestock production is <u>14.5%</u> of global man-made GHG**
- **Global beef production is <u>5.95%</u> of global man-made GHG (41%)**
- **Canada's beef production is <u>0.072%</u> of global man-made GHG,**
- **Canada's beef production is <u>3.6%</u> of Canada's man-made GHG and while lands that grow grasses and legumes for cattle sequester carbon**

Repeatability of short-term spot measurement of CH_4 and CO_2 from beef cattle using GEM system

Hypothesis

How many individual animal daily visit fluxes and days of sampling will be required to obtain moderate repeatability (0.5-0.7) and certainty of estimating daily CH_4 and CO_2 emission and yield

Animals and Facility



28 heifers
344 kg BW (SD=30)
326 days of age (SD=23)
Feb-Apr 2015 (59 d),
8 GrowSafe nodes


Lacombe Research Centre
GreenFeed 69

Experimental Design

Two Daily Averaging Methods:

Mean and Time of Day (4 h bins, 6 per day; starting at 00:00-04:00h)

Four Averaging Periods:

1 day (max n=1652); 3 day (max n=532)

7 day (max n=224); 14 day (max n=112)

Repeatability of each trait was calculated as:

$$r = \sigma^2_{within\ indvidual} / (\sigma^2_{within\ indvidual} + \sigma^2_{among\ indvidual})$$

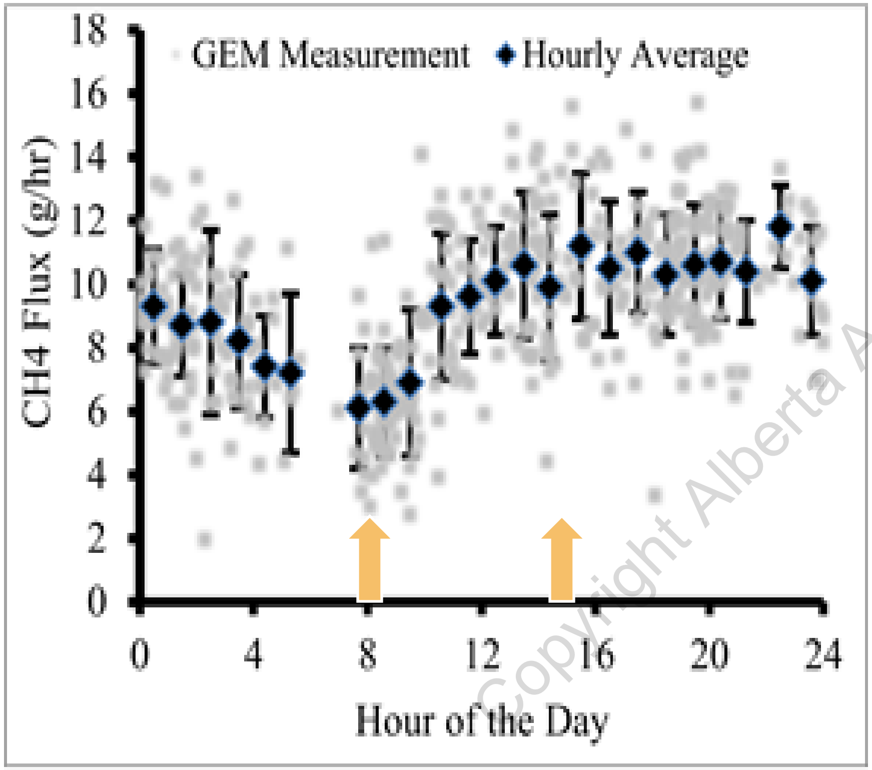
where σ2 is variance.

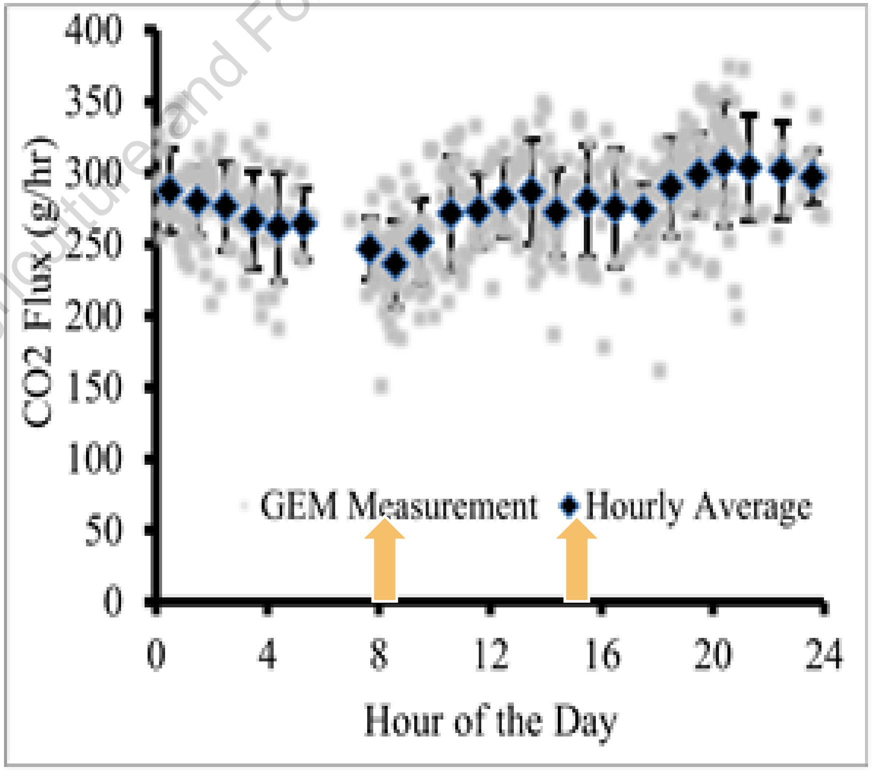
Mean daily CH_4 and CO_2 emission (±SD) by averaging period and averaging method

Averaging Period	Arithmetic Mean		Averaging Diurnal Pattern	
	CH_4 (g/d)	CO_2 (g/d)	CH_4 (g/d)	CO_2 (g/d)
1d	204.7±49.6	6532±915	204.7±49.5	6535±914
3d	203.5±37.6	6479±815	201.3±39.3	6453±824
7d	201.8±34.8	6456±812	199.2±36.4	6425±822
14d	201.4±33.7	6422±780	196.8±33.8	6377±778

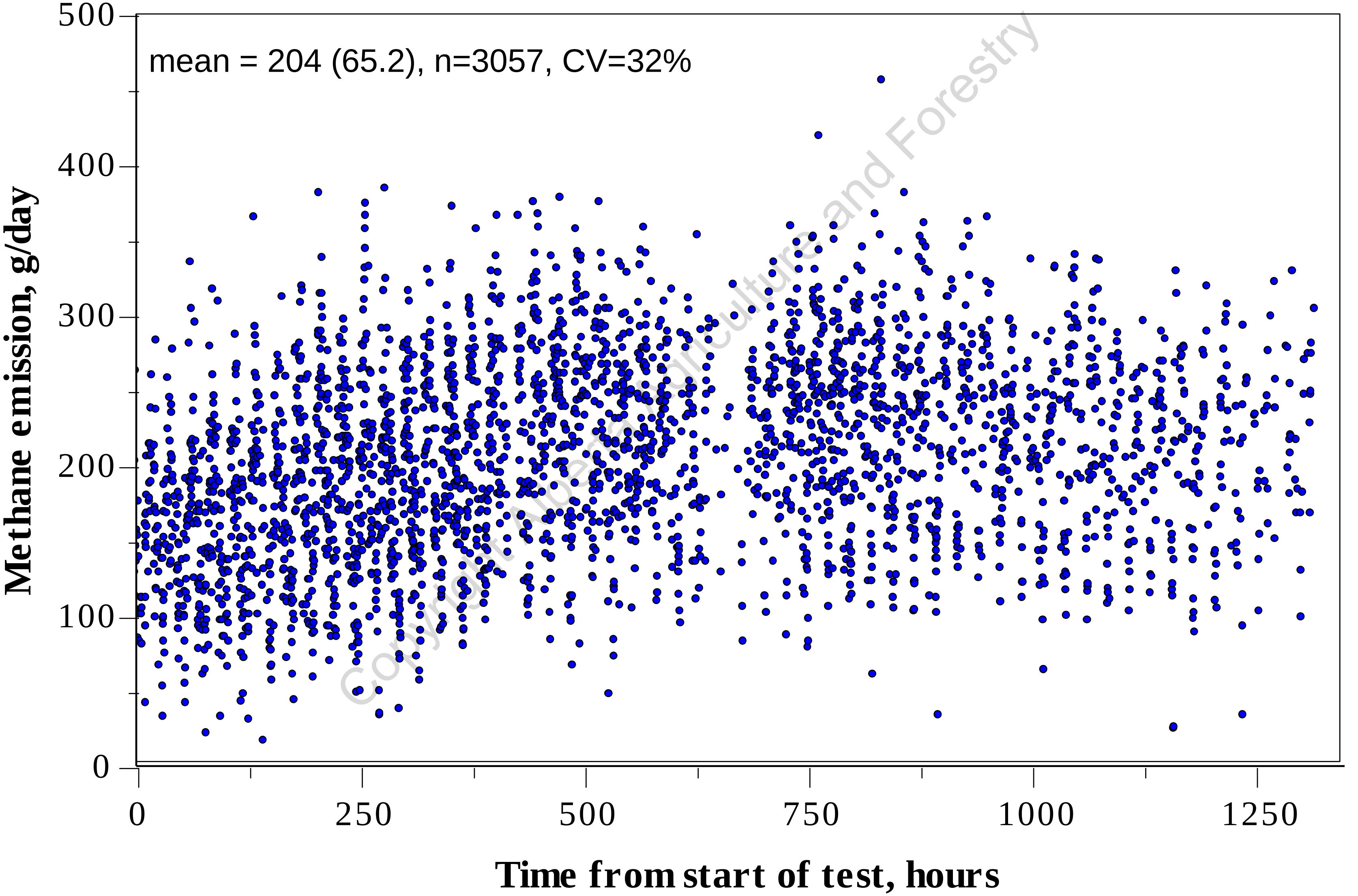
R^2 between averaging method: 0.968-0.998

Diurnal pattern of CH_4 and CO_2 emissions in beef heifers fed (↑) twice per day

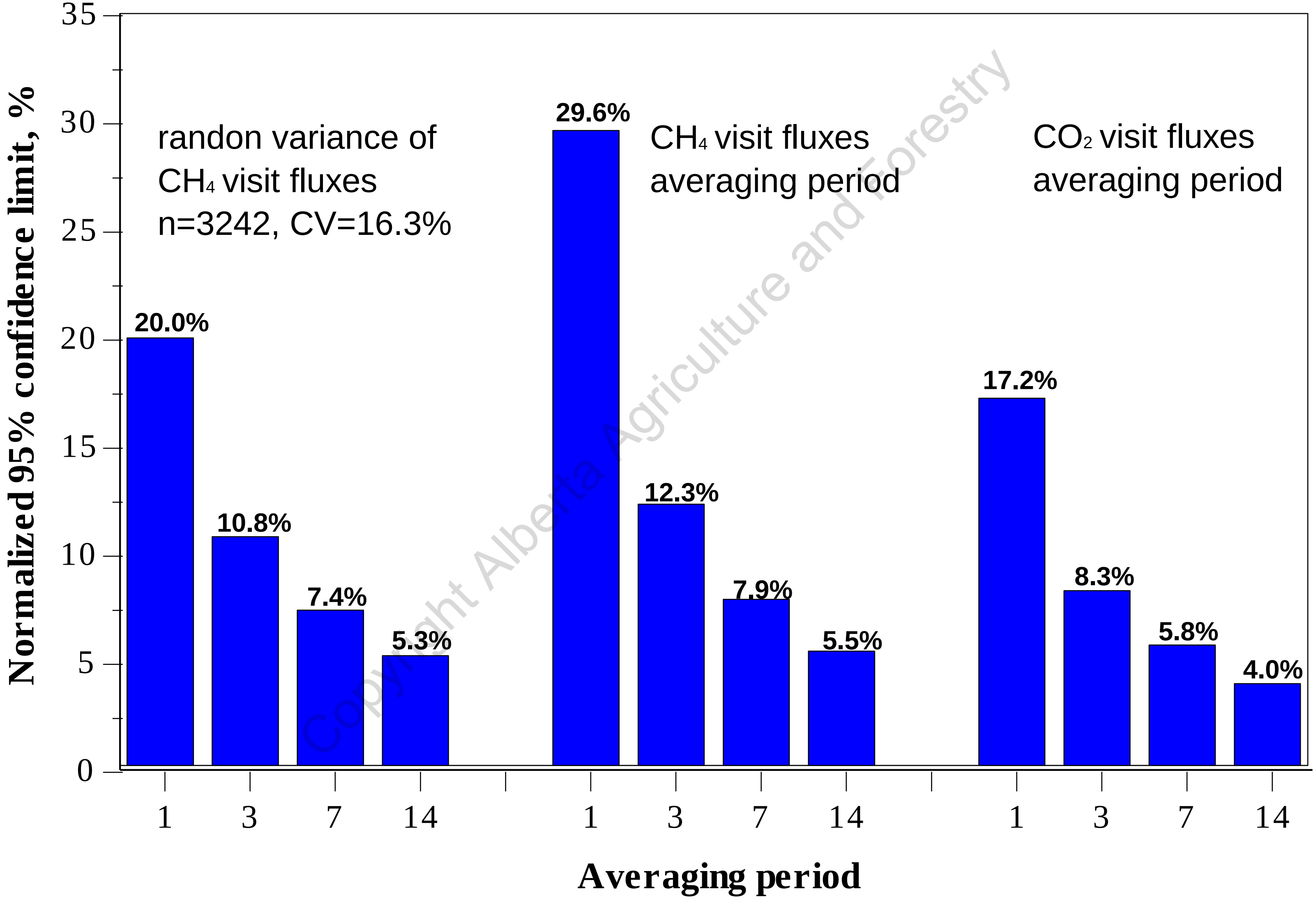




Enteric methane visit fluxes by hour of feed intake test period for 28 beef heifers



Uncertainty of CH_4 and CO_2 visit fluxes

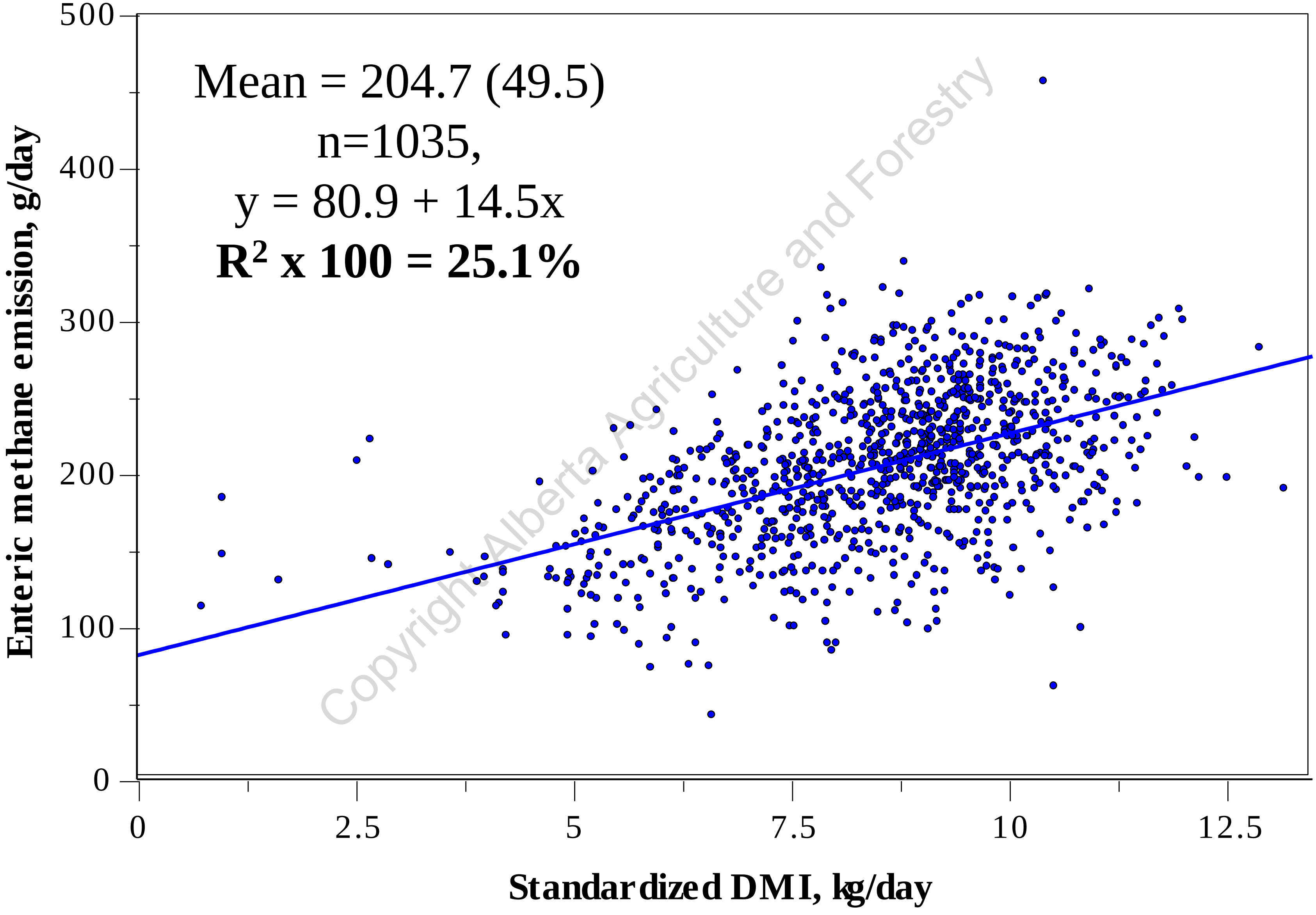


Normalized 95% CI = (CV/square root of n) x 1.96

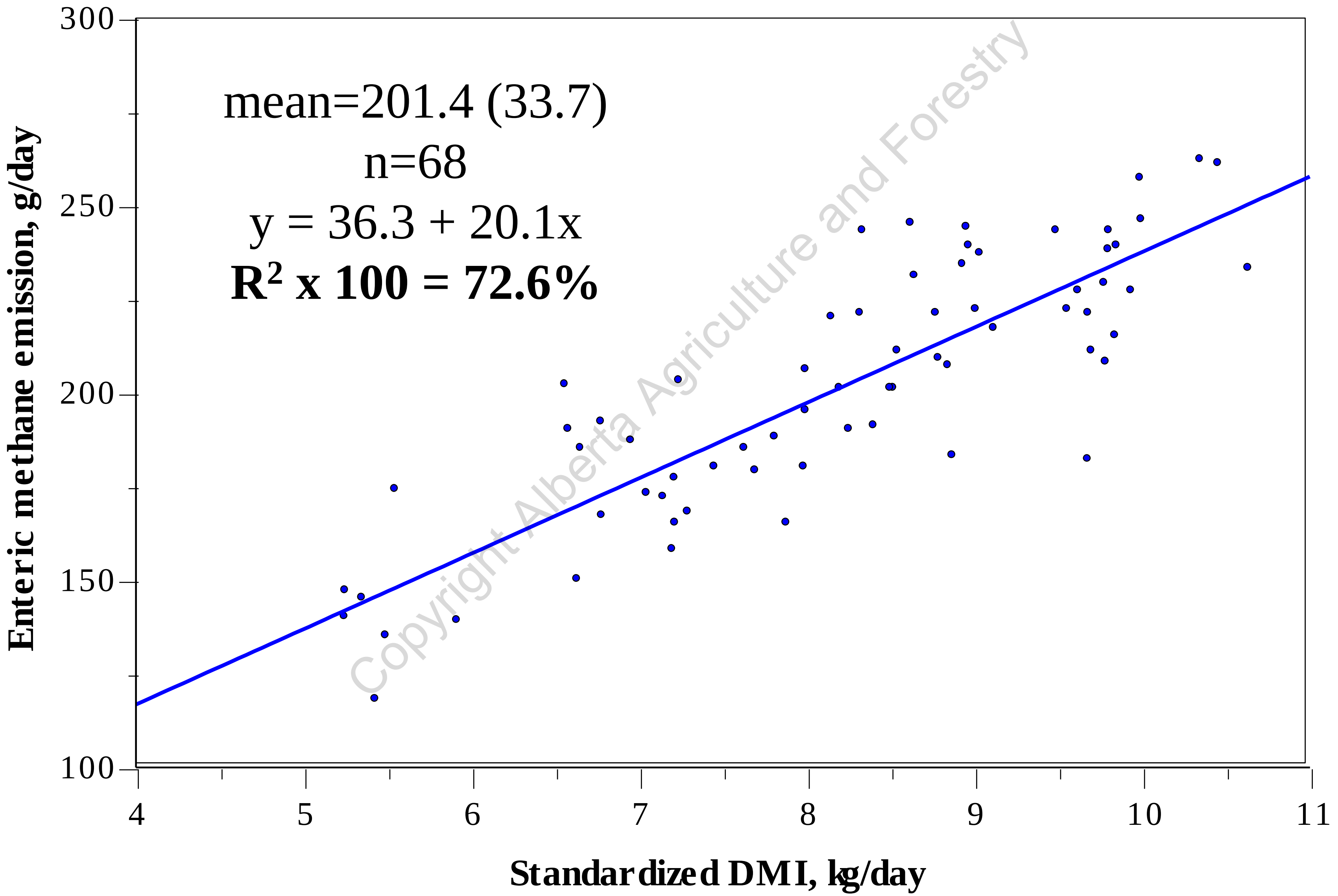
Repeatability of SDMI, and CH_4 and CO_2 emission and yield for different averaging periods

Averaging Period	n	SDMI kg/d	CH_4 g/d	CO_2 g/d	CH_4 yield g/kg SDMI	CO_2 yield g/kg SDMI
Mean (SD)	1035-1652	8.55 (1.72)	204.7 (49.6)	6532 (915)	24.77 (9.59)	799 (301)
			Repeatability			
1d	1035	0.36	0.33	0.58	0.08	0.06
3d	272	0.52	0.62	0.78	0.28	0.20
7d	137	0.67	0.69	0.82	0.40	0.33
14d	68	0.71	0.79	0.86	0.51	0.28

Relationship of standardized DMI on enteric methane emission for a 1 day averaging period in beef heifers

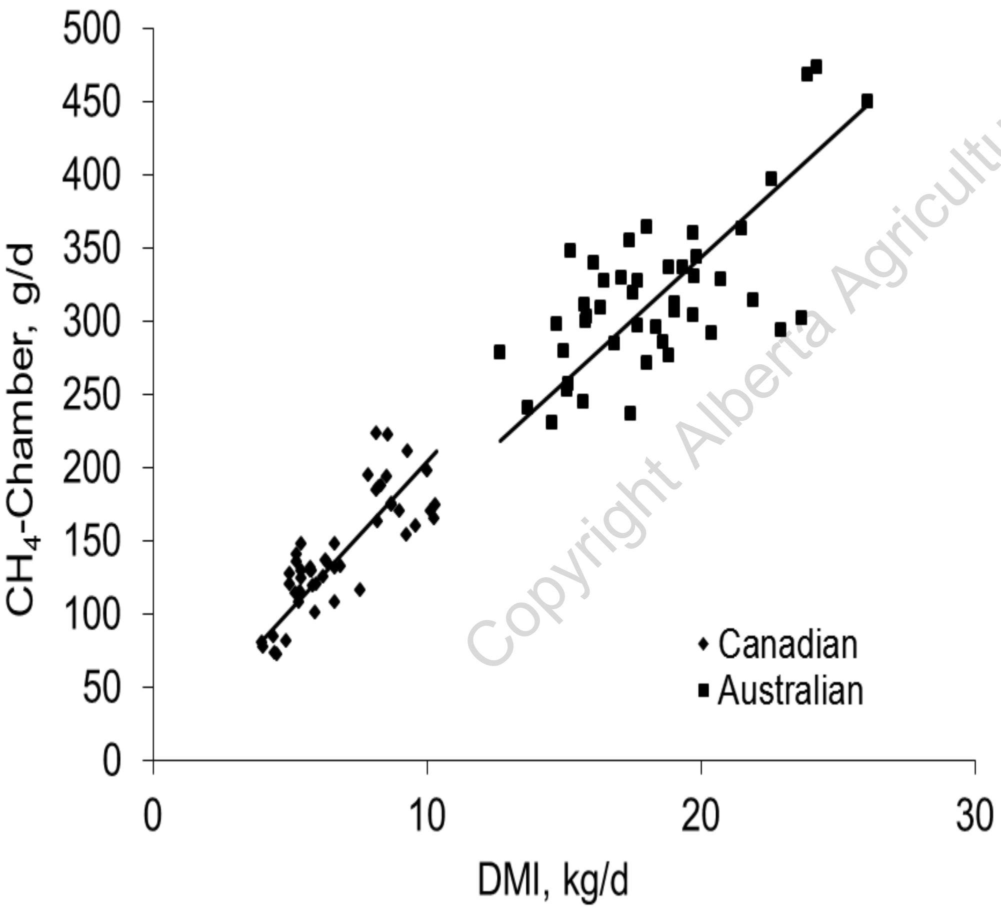


Relationship of standardized DMI on enteric methane emission for a 14 day averaging period in beef heifers



Two basic hypotheses: low RFI & low CH_4

<u>Feed intake driven</u> low RFI, lower DMI and lower CH_4 production (g/day) but no effect on digestibility or CH_4 yield (g/kg DMI)



Relationship between CH_4 emission and DMI

Aus $r^2 = 0.454$; Can $r^2 = 0.677$
Grainger et al. (2007), J. Dairy Sci.

<u>IPCC 2006:</u> CH_4 production =

((DMI, kg DM/day *18.45 MJ/kg DM) x (6.5%/100))/0.05565 MJ/g CH_4

Two basic hypotheses: low RFI & low CH_4

Inherent differences in feeding behaviours, lower feed intake, longer rumen retention time ➡ differences in rumen microbial communities, increased digestibility, more H^+ and increased **?** CH_4 yield (g/kg DMI)

What did we observe?

LOW RFI heifers

consumed 7.1% less feed

8.09±0.26 vs. 8.71±0.21 kg DM/day

emitted 6.5% less daily CH_4

196±1.4 vs. 210±1.4 g/day

BUT

emitted 2.7% more CH_4/kg DMI compared to HIGH RFI heifers

Methane Emissions

WINTER DRYLOT

SUMMER GRAZING

SUMMER GRAZING

Fall SWATH GRAZING

Conclusion

Multiple short-term visit fluxes averaged over 14 days, with 20+ visit fluxes per animal and 28+ animals per group,

- **produced moderate repeatability for CH_4 and CO_2 emissions,**
- **moderate to high correlations with DMI, and**
- **may consistently represent individual animal CH_4 and CO_2 emissions, and to a lessor extent, yield.**

However, different production environments (i.e., grazing, feedlot) will likely require different GEM sampling intensities.