Holsteins: good or bad for greenhouse gas emissions?

Conrad Ferris

European Holstein and Red Holstein Confederation
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Introduction

- Our climate is changing!'
- Part of this change is believed to be due to Greenhouse gases (GHG) 'trapping' the suns heat within the earths atmosphere
- GHG are produced from many sources, including agriculture
- Globally agriculture contributes approximately 10-12% of total anthropogenic GHG (IPCC)
- Within the UK agriculture contributes 7% of total GHG emissions
- Within Northern Ireland agriculture contributes 23% of total GHG emissions
- The main agricultural GHG are:
  - Carbon dioxide
  - Methane
  - Nitrous oxide

- How are these gases produced?

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Sources of methane

Enteric fermentation

Manure storage

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Sources of Nitrous oxide

‘nitrification’ and ‘de-nitrification’ of nitrogen by microbes




Soils



Manure storage

Why is there is pressure to reduce GHG….?

(I) Why reduce GHG emissions from Agriculture?

Global impact if we do not take action could be disastrous

(II) Why reduce GHG emissions from Agriculture?

- Legislation
  - UK Climate Change Act (2008) requires a 80% reduction in GHG emissions by 2050

- To increase biological efficiency
  - 6-8% of the energy consumed by a cow is lost as methane
  - Nitrous oxide represents a loss of nitrogen from agriculture

- Retailer pressure

So are Holsteins good or bad for GHG emissions?

- Holsteins compared to other breeds
- Effect of milk yield and longevity
- Whole system effect

Measuring methane production from enteric fermentation

Indoor diets – via respiration calorimeters

Grazing – using SF6

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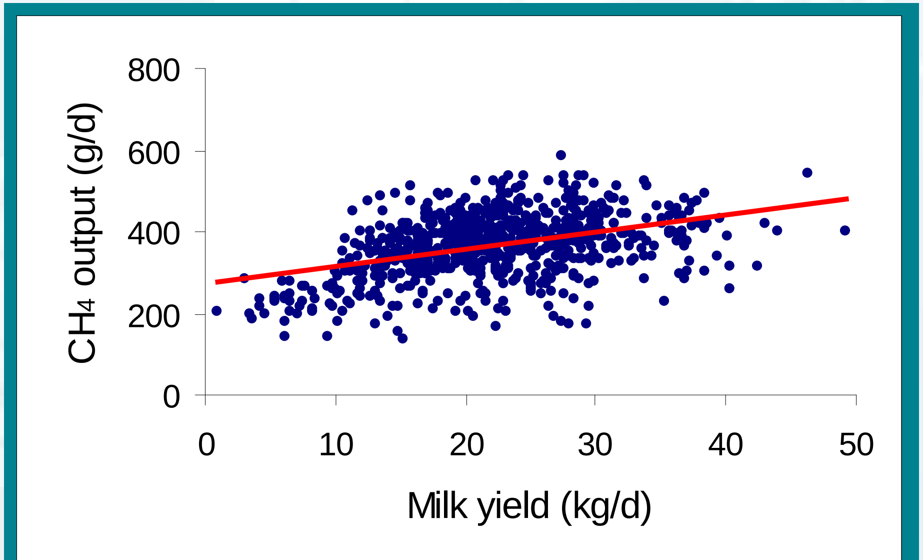
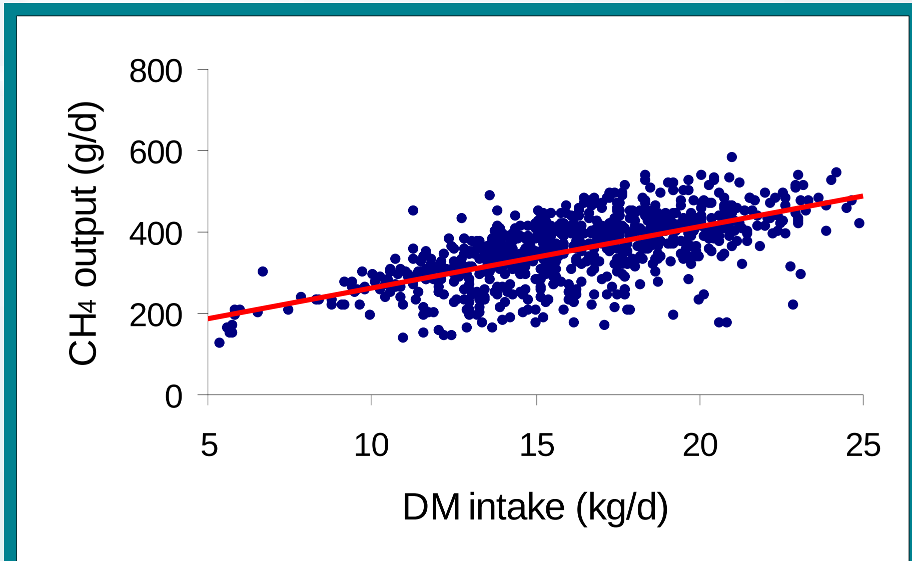
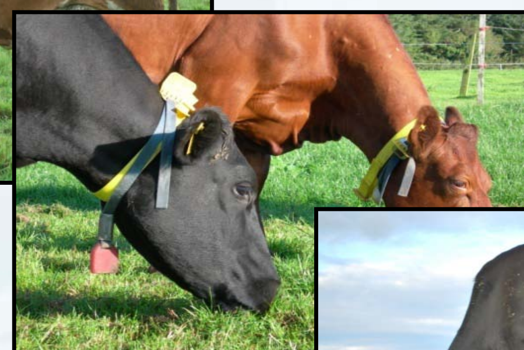
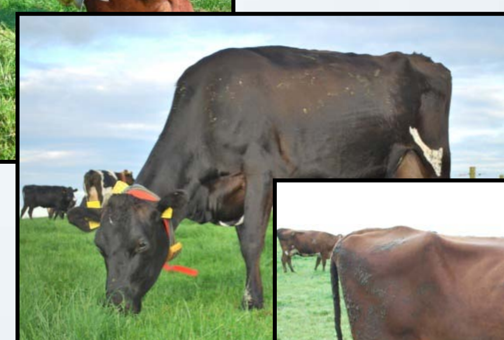
What are the key animal factors that affect methane production?

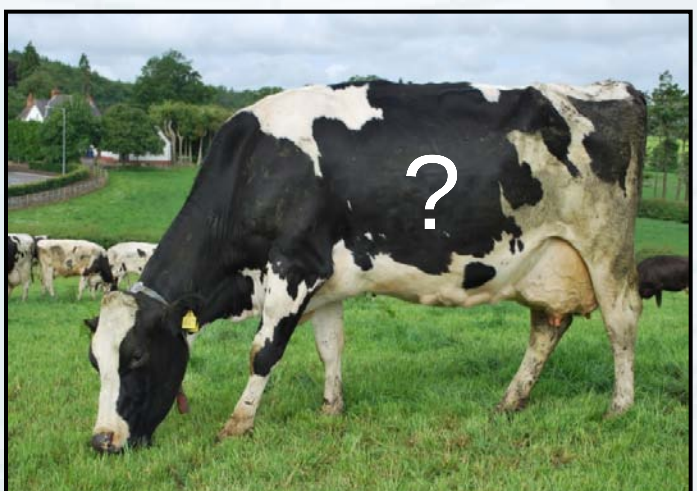




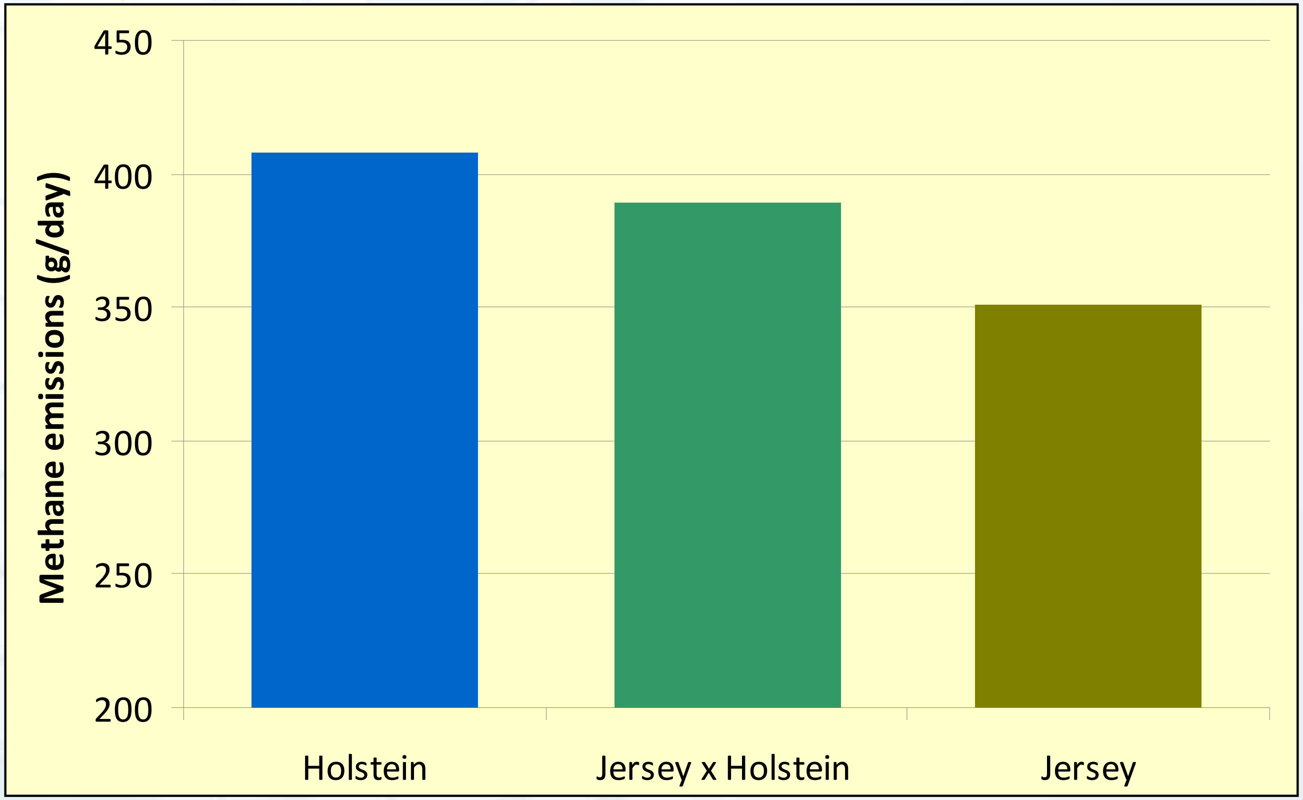
Do Holsteins produce more methane than cows of other breeds?





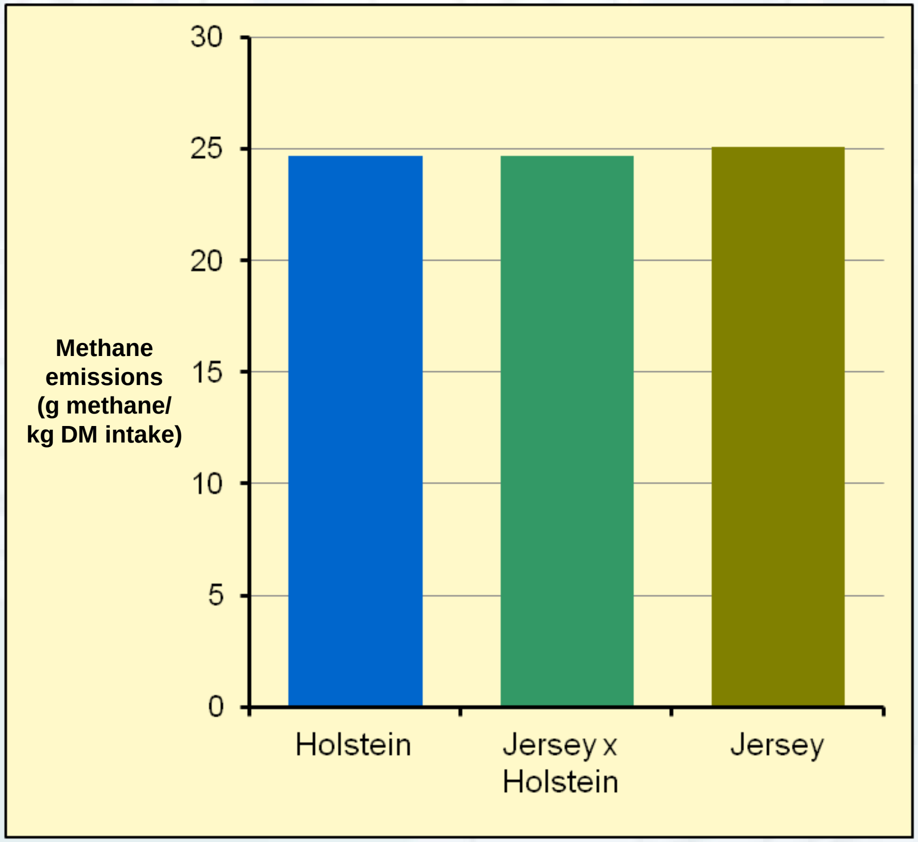


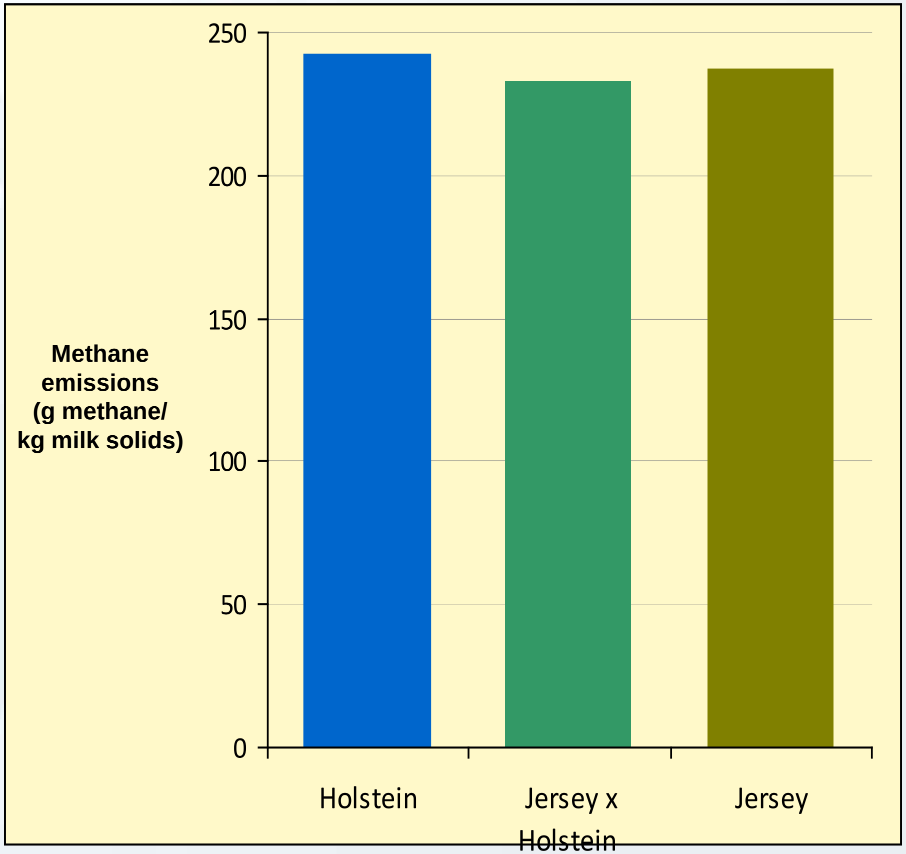
Effect of dairy cow breed on methane production (I)



Deighton et al. (2011)

Effect of dairy cow breed on methane emissions (II)

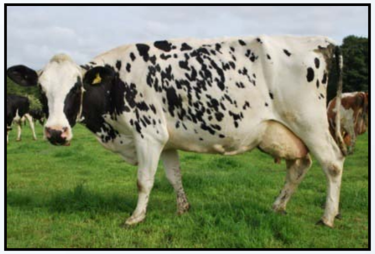




Deighton et al. (2011)

Are there genetic differences between individual cows in methane production

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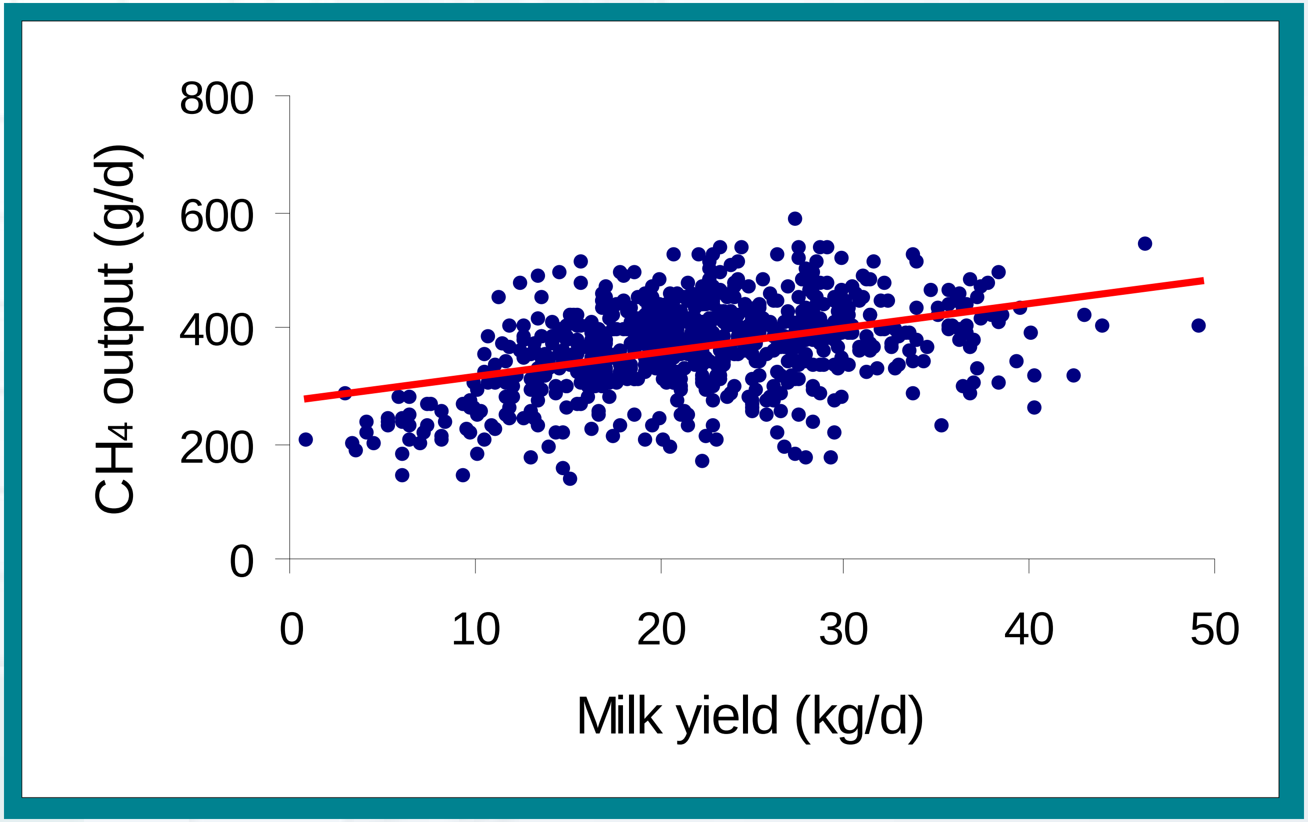
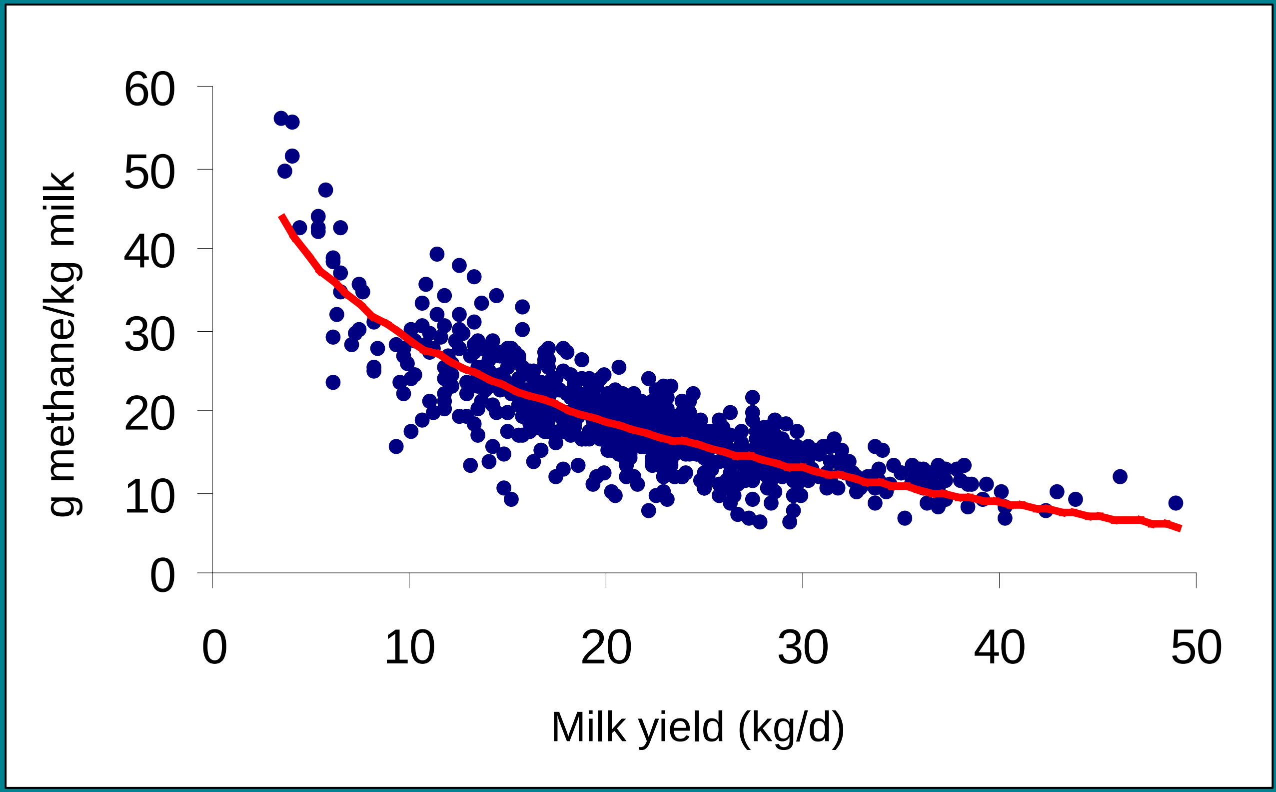
- There is evidence of cow-to-cow variation in methane production
- Some cows are low emitters
- Might it be possible to select cows with low methane emissions?

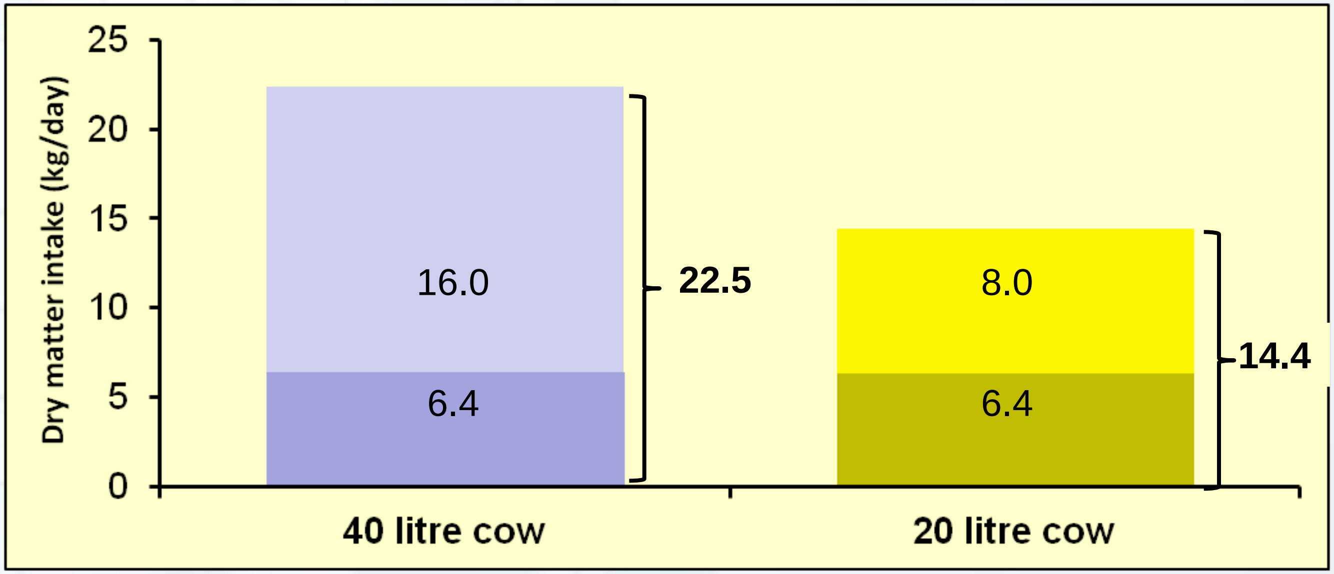
Are there benefits to be gained with increasing milk yields/cow? (I)



Are there benefits to be gained with increasing milk yields/cow? (II)



Why does methane production per litre of milk decrease with higher milk yields?



448 g CH_4/day
(28% due to maintenance)

11.2 g CH_4/litre milk

288 g CH_4/day
(44% due to maintenance)

14.4 g CH_4/litre milk

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Holsteins: good or bad for GHG emissions?

- If higher yields result in reduced methane production per litre of milk……Holsteins must be good for GHG emissions?

- This is true, PROVIDED….
  - Functional traits do not decline!
  - Higher yields do not result in the adoption of systems with higher GHG!

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Functional performance of Holsteins vs other breeds

- Until recently, selection goals within the Holstein breed focused primarily on milk production traits

- This resulted in a:
  - Decline in fertility performance
  - Increased health problems
  - Increased culling and poorer longevity

- Other breeds, for example the Scandinavian breeds, have adopted broader selection goals

- A number of studies have compared the performance of Holstein cows with Scandinavian cows

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Comparison of the performance of Holstein and Norwegian Red cows in Northern Ireland over 5 lactations

	Holstein-Friesian	***Norwegian Red***
Average milk yield (kg)	7140	6950
Mean SCC (000/ml)	271	164
Conception to 1st AI	45 %	61 %
Cows culled as infertile	28 %	12 %
Cows culled due to mastitis	9 %	4 %
Cows surviving to lactation 6	16 %	27 %

Ferris et al., (2008)

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Why does a decline in functional traits increase GHG emissions?

- Increased number of heifers on the farm
- Cows do not achieve their mature milk yield potential

GHG associated with heifer rearing

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Birth | 12 months | 24 months | 36 months

GHG associated with heifer rearing
to 24 months approximately
4200 kg $CO_2{}^e$/heifer

23% of emissions on average Northern Ireland systems are due to heifer rearing

Effect of replacement rate and age at first calving on total GHG production

	Scenario 1	Scenario 2	Scenario 3
Replacement rate (%)	15	30	30
Age 1st calving (months)	24	24	36
Number of replaced heifers on farms	30	60	90
GHG associated with heifer rearing/year (kg CO_2 equivalent)	60, 000	120, 000	315, 000

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Effect of improving fertility on GHG emissions from dairy systems

Current level	
Days to 1st AI	= 78
Oestrous detection rate	= 50%
Conception to 1st AI	= 38%
Conception to subsequent AI	= 37%

Ideal level	
Days to 1st AI	= 70
Oestrous detection rate	= 70%
Conception to 1st AI	= 65%
Conception to subsequent AI	= 60%

Improving fertility would reduce which farm methane emissions by 24%

Garnsworthy *et al*, 2004

Any strategy which will improve longevity, without reducing cow performance, will reduce both methane and nitrous oxide emissions

Use of indices such as £PLI (United Kingdom) will allow cows with good functional performance to be selected

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Do GHG emissions differ with different milk production systems?

- As the genetic potential for milk production of Holstein cows has increased, farmers have modified their management systems

- Concentrate feed levels in Northern Ireland increased from 1.2 t/cow/year 1998 to 2.2 t/cow/year in 2008

- A move to partial or total confinement systems in many countries

- What impact do these changes have on total GHG emissions?

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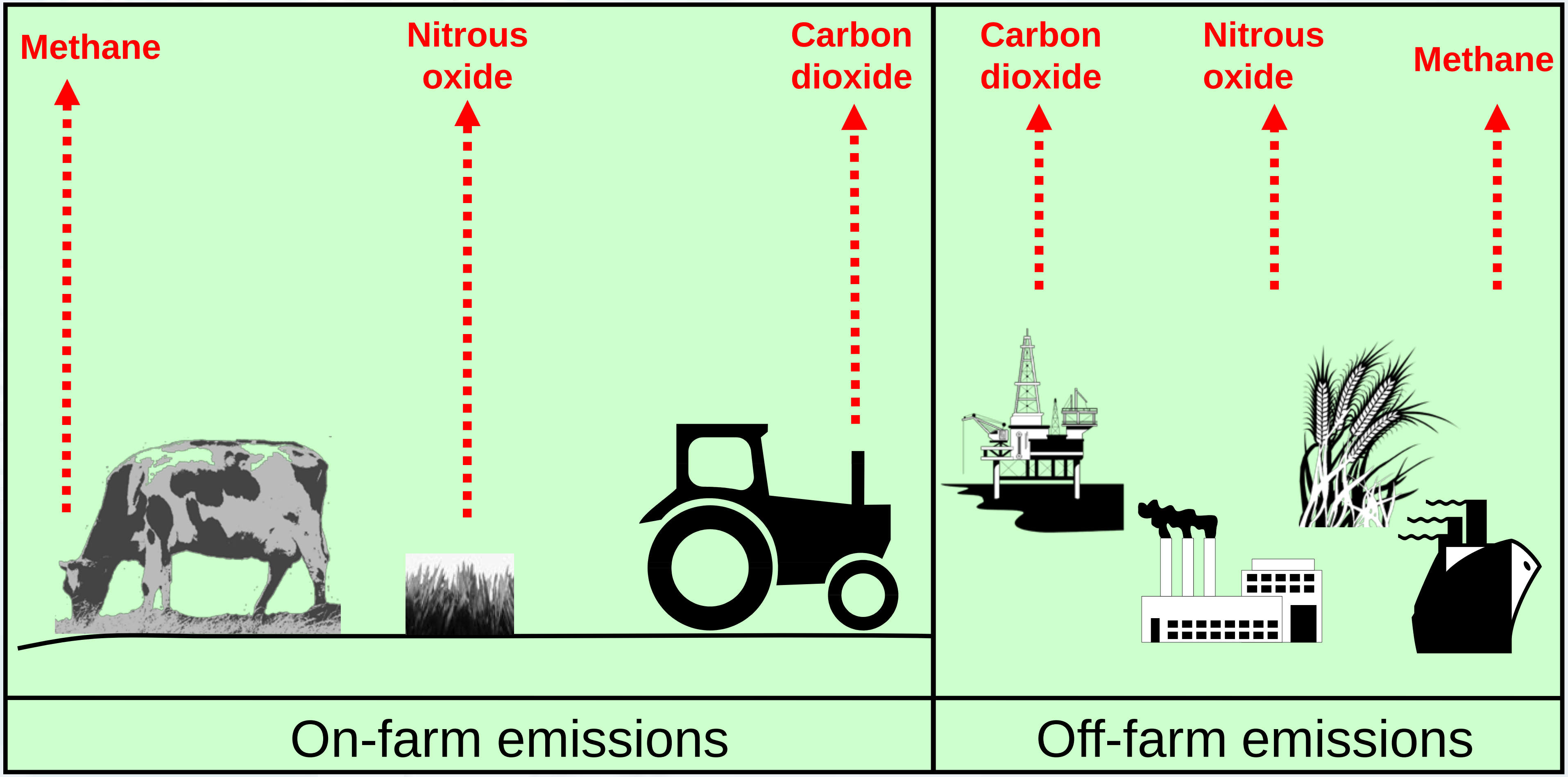
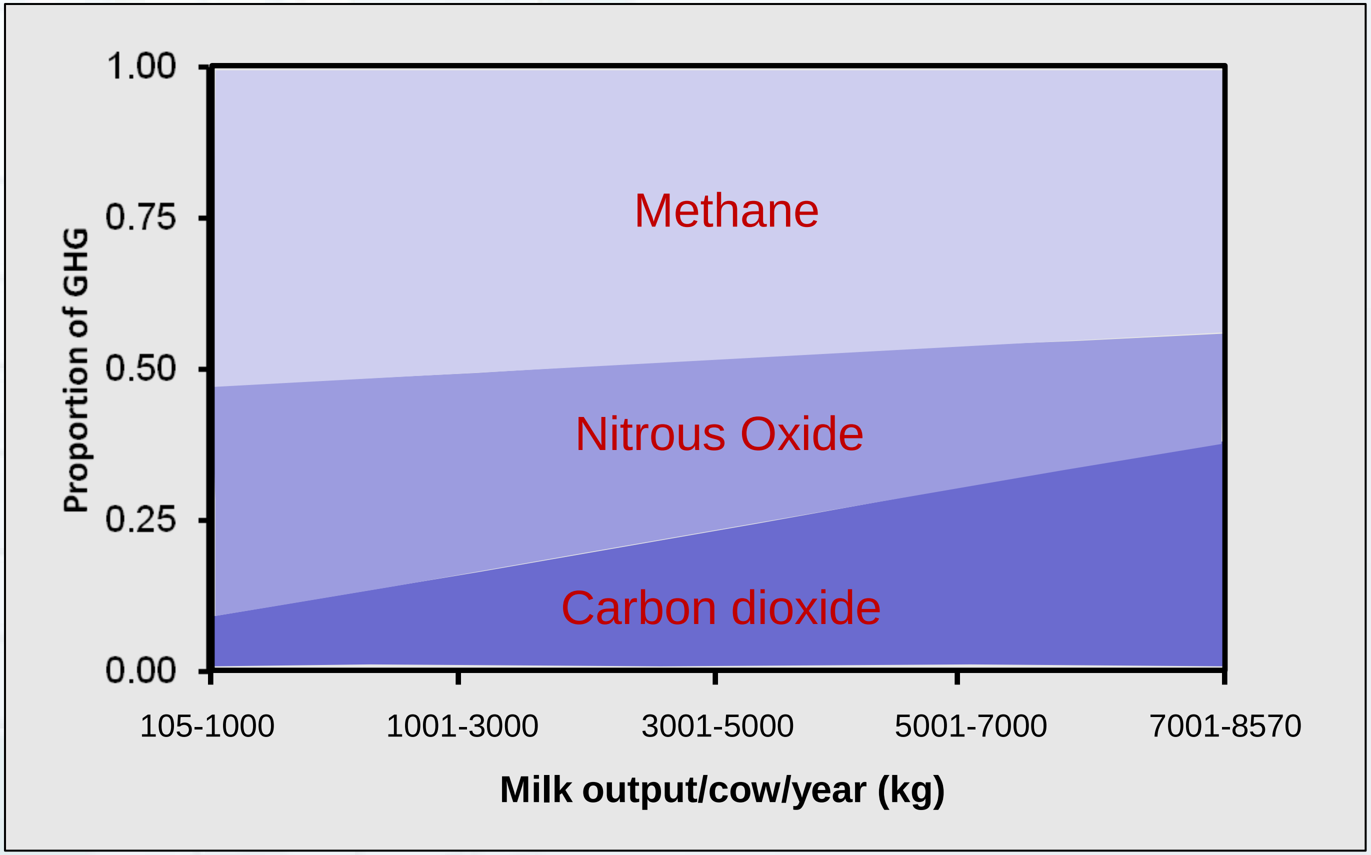
Must consider whole system



Relationship between milk output per cow per year and the relative contribution of methane, nitrous oxide and carbon dioxide in total GHG emissions



Gerber et al. (2011)

Published values for GHG emissions per litre of milk from different countries

Country	GHG footprint (kg CO_2e/litre milk)	Reference	Comments on methodology
Northern Ireland	1.13	Woods *et al*. (2010)	Average milk production system (5894 litre milk/year) to farm gate. No CO_2 from fossil fuels. 100% allocation milk
Republic of Ireland	1.5 (ECM)	Casey and Holden (2005)	Average dairy unit (4822 litre milk/290 day lactation). Cradle to farm gate. 100% allocation milk
Republic of Ireland	1.03	Lovett *et al*. (2006)	Cradle to farm gate. Medium pedigree index. 1403kg concentrate/head/year
United Kingdom	1.14	Foster *et al*. (2007)	LCA, 100% allocation milk
New Zealand	0.74 (ECM) 0.86* (ECM)	Barber (2010)	Partial LCA to farm gate. Conventional system. Allocation=86% milk, 14% meat
Sweden	1.02 (ECM) 1.2* (ECM)	Cederberg *et al*. (2009)	LCA to farm gate in 2005. Allocation=85% milk, 15% meat

*If 100% allocation to milk

Conclusions

- There is little evidence of differences between breeds in methane production, but genetic differences between individual cows within a breed do exist
- Methane production per litre of milk declines with higher milk yields….this places the Holstein at an advantage
- However this advantage could be easily lost due to poorer longevity of Holstein cows
- Effect of system on total GHG emissions is still unclear!
- A common methodology to calculate the carbon footprint of milk is needed

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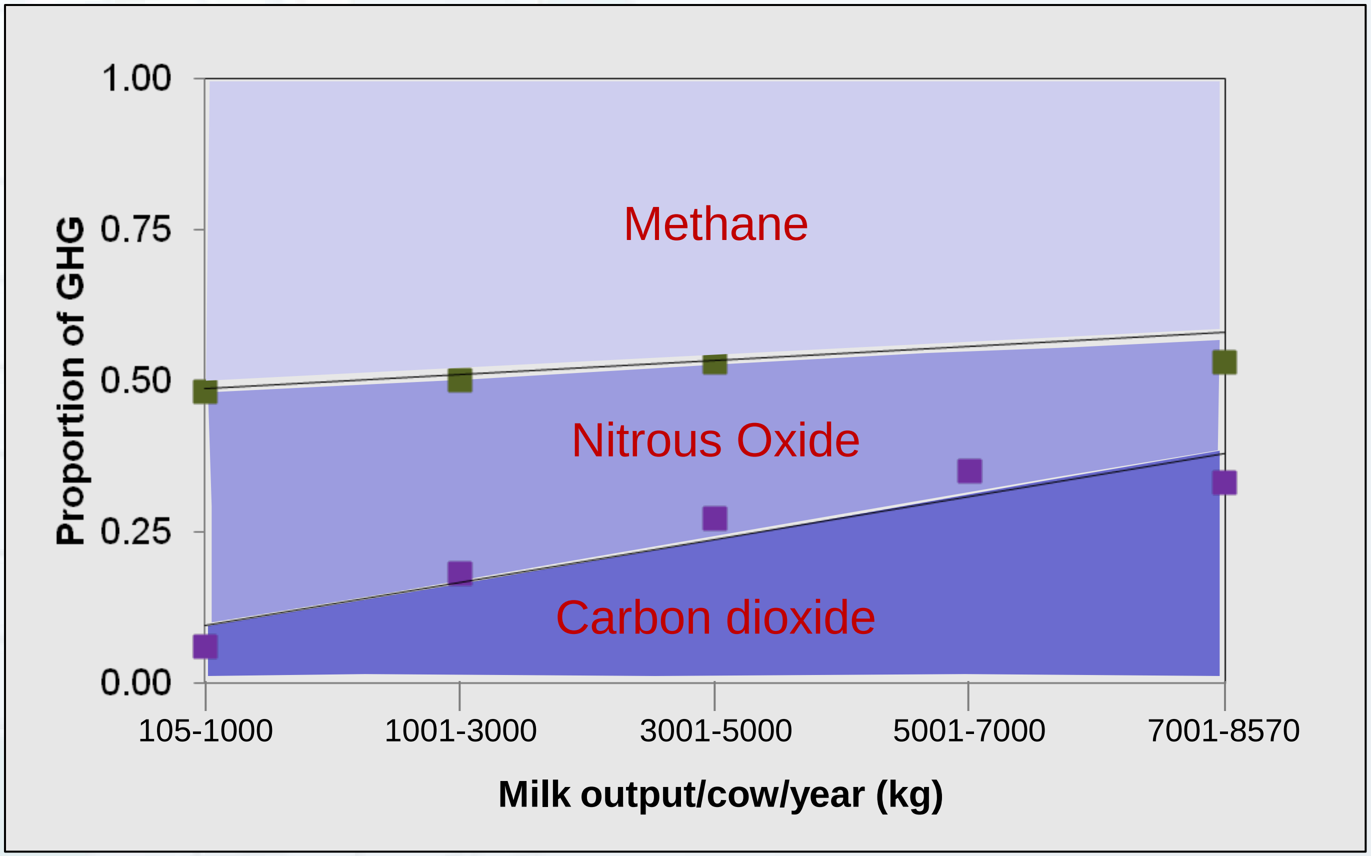
THANK YOU

Relationship between milk output per cow per year and the relative contribution of methane, nitrous oxide and carbon dioxide in total GHG emissions



Are there genetic differences between individual cows in methane production

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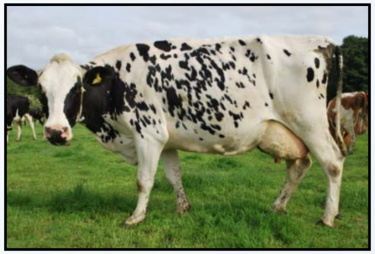

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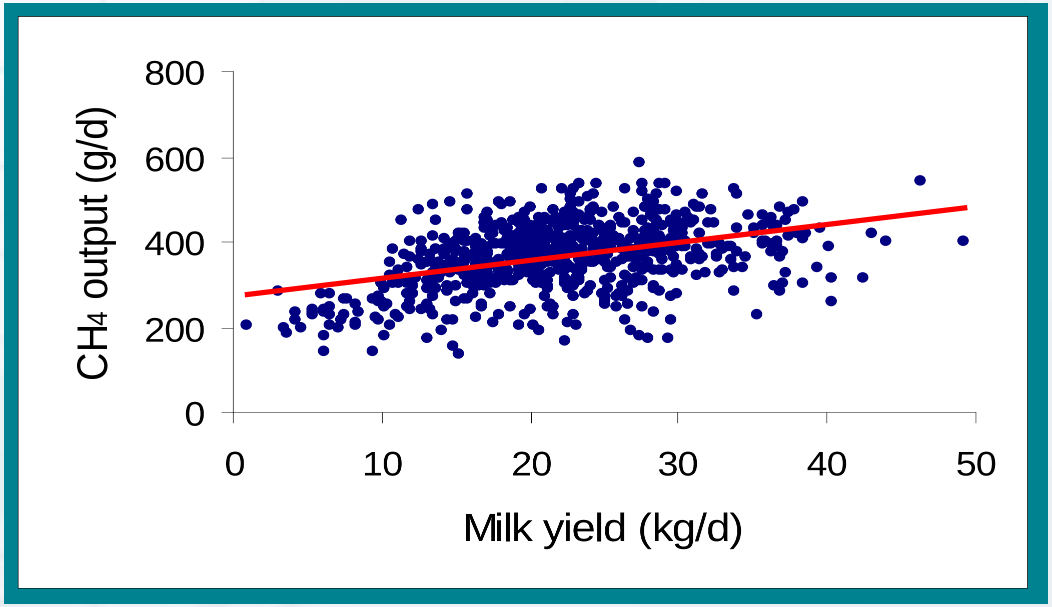
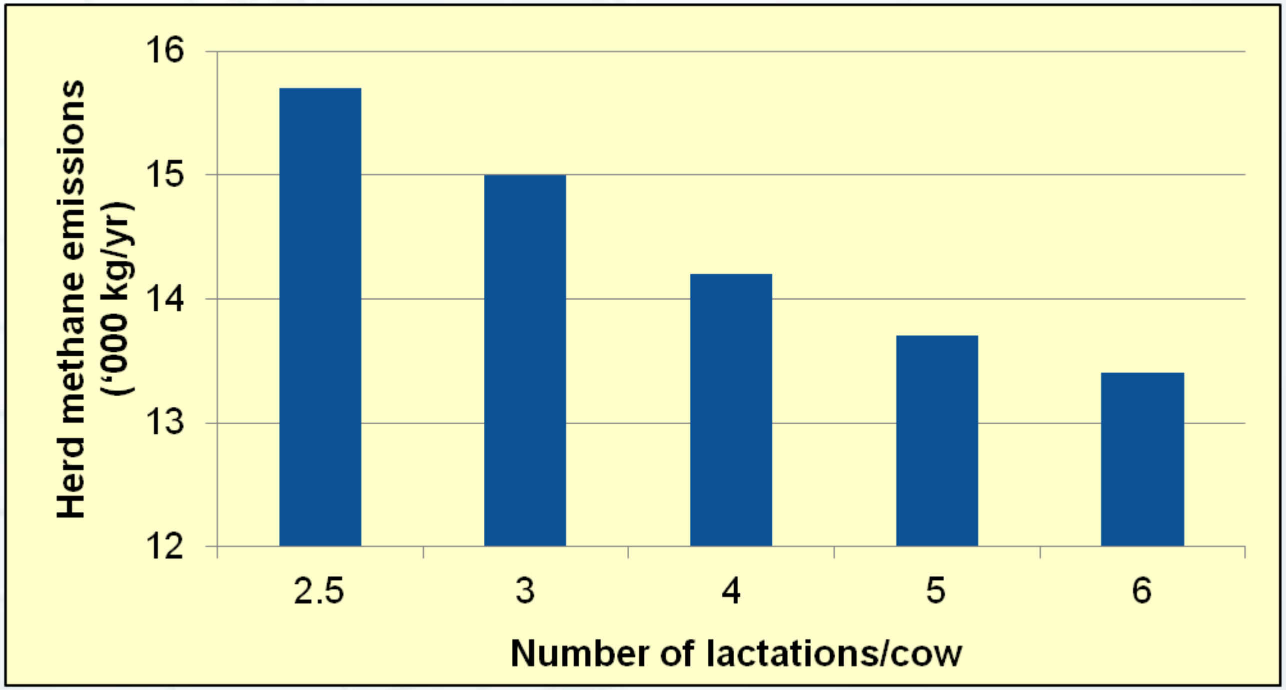


Effect of number of lactations per cow on annual total herd emissions of methane



13% reduction in whole farm methane emissions