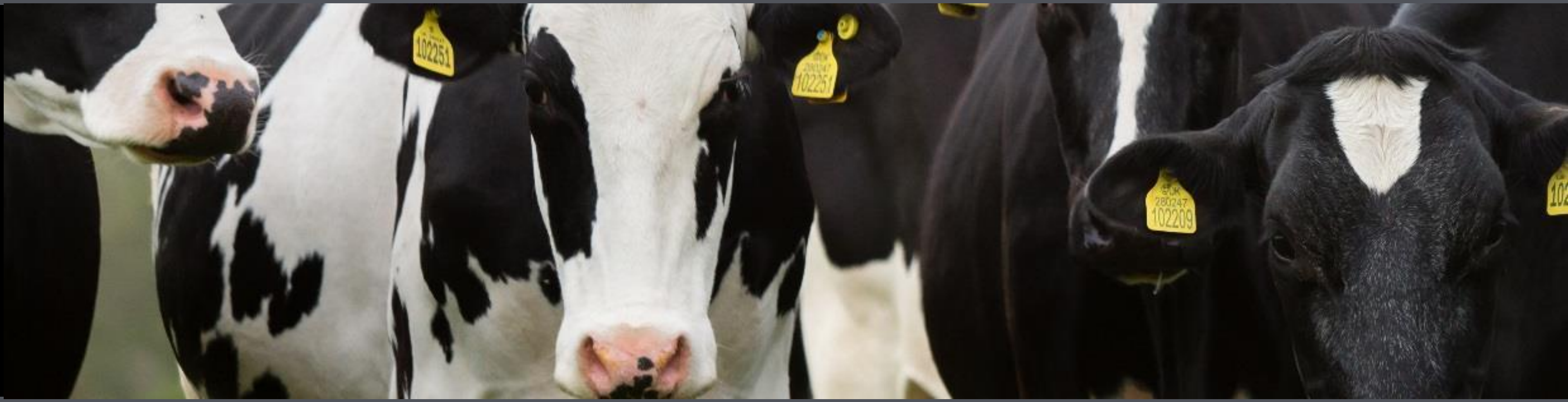
DEFRA Project ACO122

University of Reading

PROTEIN SUPPLY – TOO MUCH OF A GOOD THING?

REDUCING ENVIRONMENTAL IMPACTS OF DAIRY PRODUCTION SYSTEMS



University of Reading, Aberystwyth University, SRUC, Rothamsted Research North Wyke

ROTHAMSTED RESEARCH

1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY

SRUC

AHDB DAIRY

Department for Environment Food & Rural Affairs

LIMITLESS **POTENTIAL** | LIMITLESS **OPPORTUNITIES** | LIMITLESS **IMPACT**

NITROGEN USE EFFICIENCY

University of Reading

FW | LATEST | KNOW HOW | MARKETS | 8° Sutton

Farmers face restrictions to tackle ammonia emissions

Philip Case
14 January 2019

More in

Compliance | Environment | Farm policy | News

Recommended

Gove's new farm pollution controls: The details and reaction

© Tim Scrivener

Farms will face new restrictions on spreading manure and slurry under the government's "world-leading" plan to tackle air pollution.

The government plans to regulate to reduce ammonia emissions from farming, including a requirement to spread slurries and digestate using low-emission spreading equipment (trailing shoe or trailing hose or injection) by 2025.

In the UK, agriculture is responsible for 88% of all ammonia emissions – one-quarter of which comes from ammonia lost in the atmosphere when nitrogen fertiliser is made and spread on farmland.

~25%

e

NH3

ser

J Moorby

IMPACT

Energy-Proofing Using Symbiotic N_2-Fixation

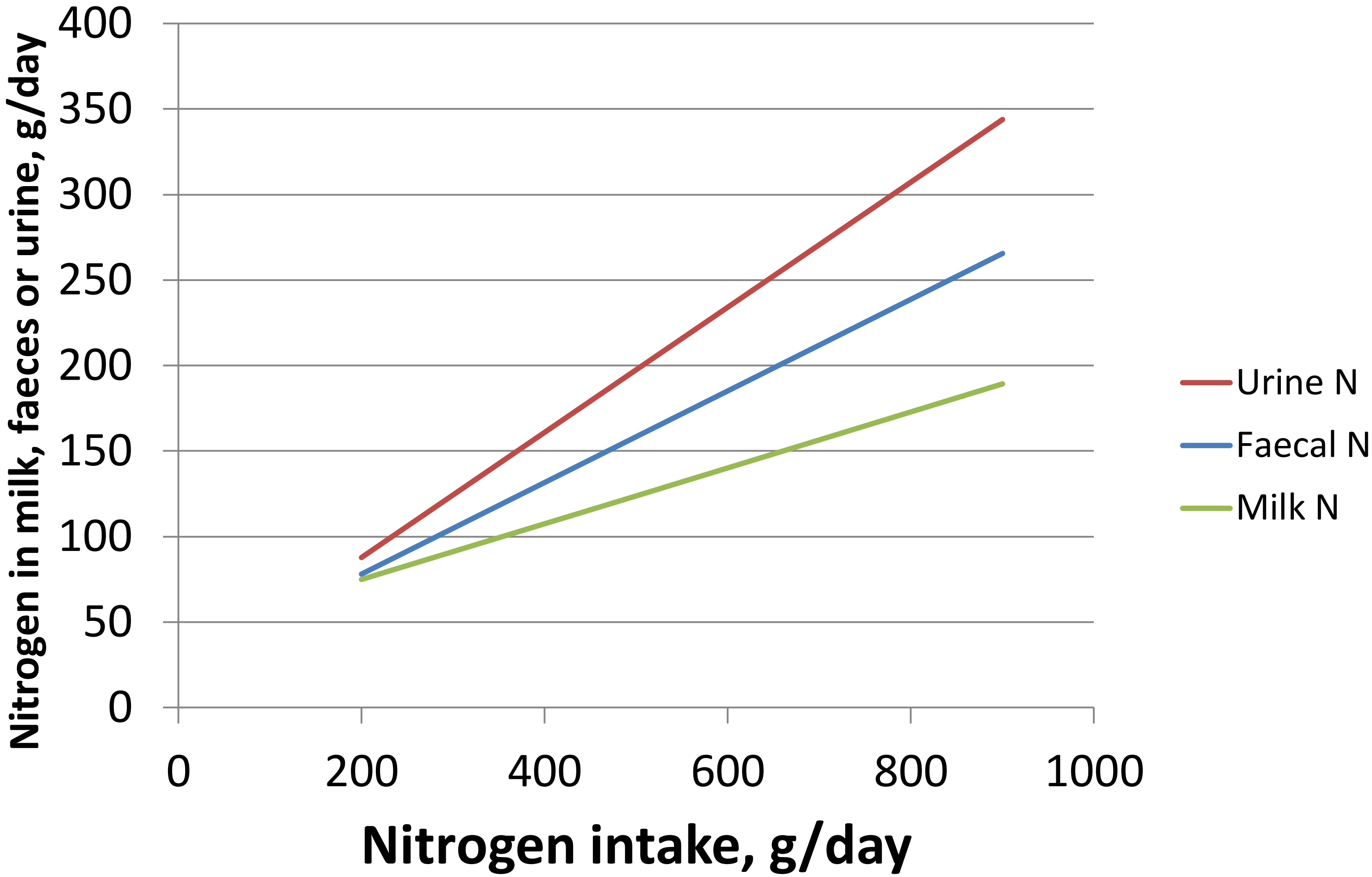
- **Productive grass-clover mixtures fix about 200 kg N ha^{-1} yr^{-1}**
  - The corresponding energy to produce 200 kg N fertiliser = fuel needed to drive 10,000 km in a small car

Slide courtesy of Dr John Finn, Johnstown Castle

Teagasc
Agriculture and Food Development Authority

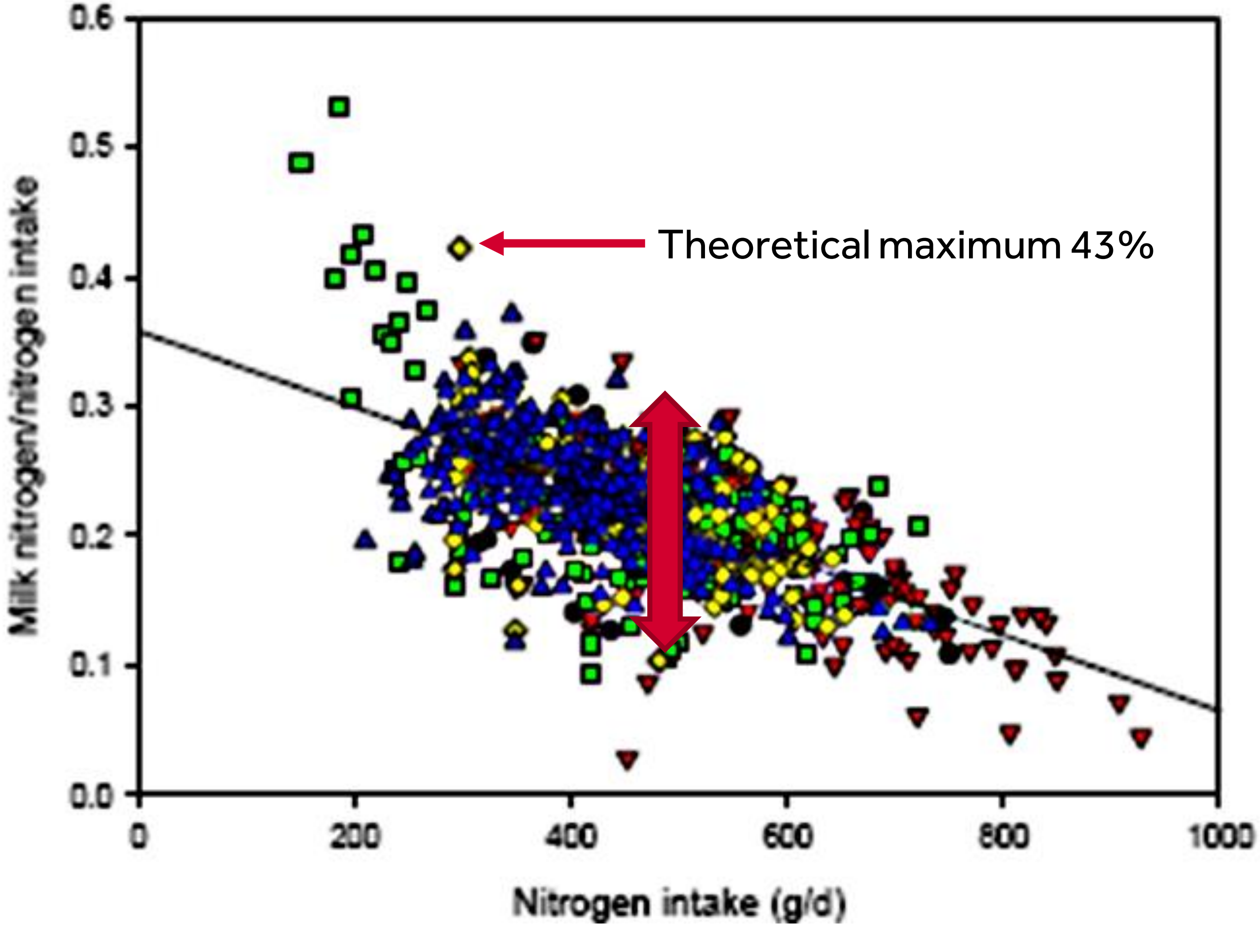
META-ANALYSIS OF N BALANCE TRIALS

University of Reading



Mills et al. (2009)

MILK N/INTAKE N VS. N INTAKE



Mills et al. (2009)

VARIATION IN N USE EFFICIENCY IN DAIRY CATTLE

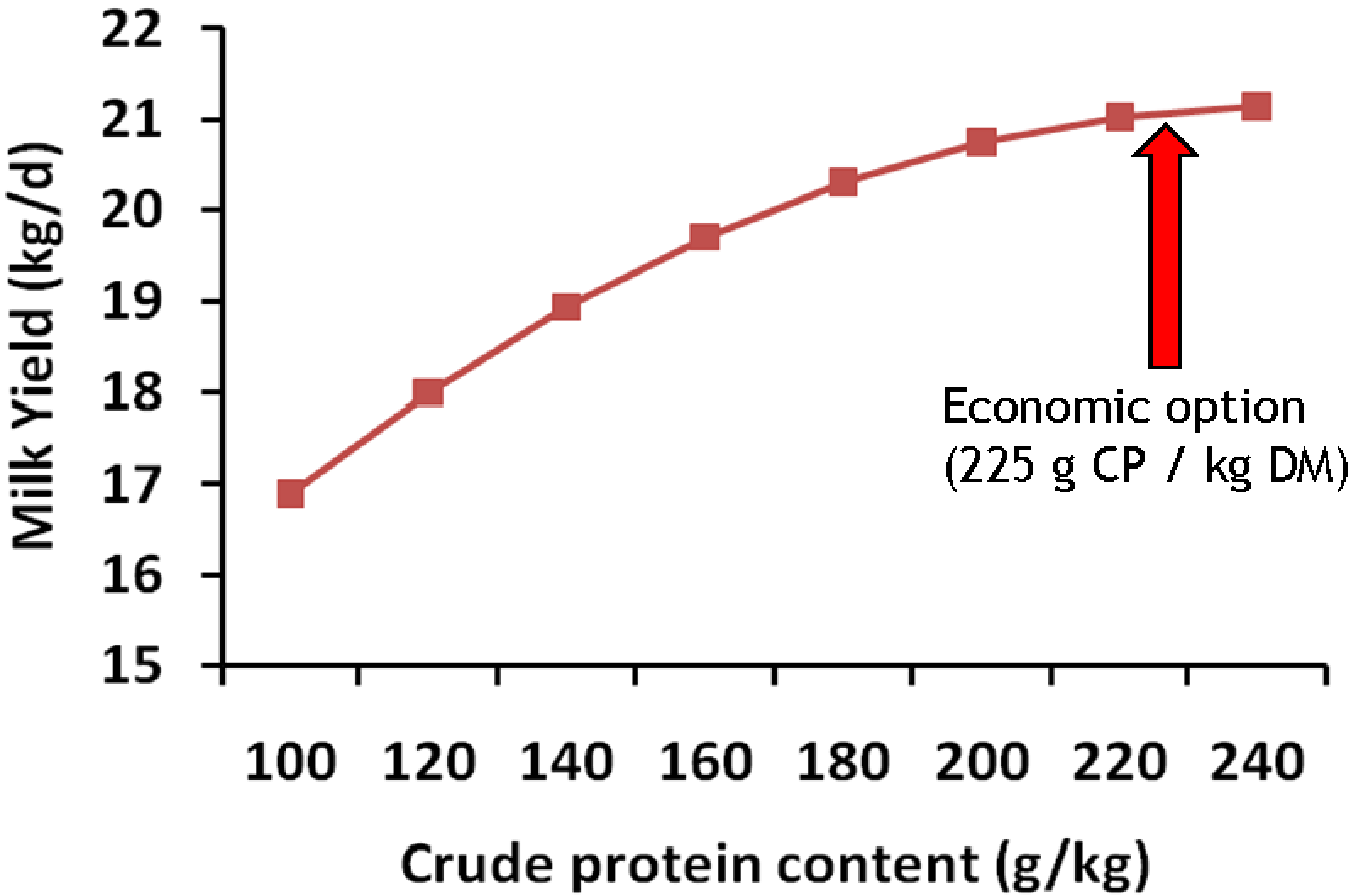
University of Reading

	Milk N efficiency			
	USA (n = 167)		EU (n = 287)	
	Low	High	Low	High
Milk N efficiency	0.22	0.33	0.21	0.32
DM intake (kg/d)	23.2	23.8	17.9	18.9
3.5% FCM (l/d)	31.8	38.2	26.8	31.2
Forage (g/kg DM)	534	526	665	569
Forage CP (g/kg DM)	179	154	200	148

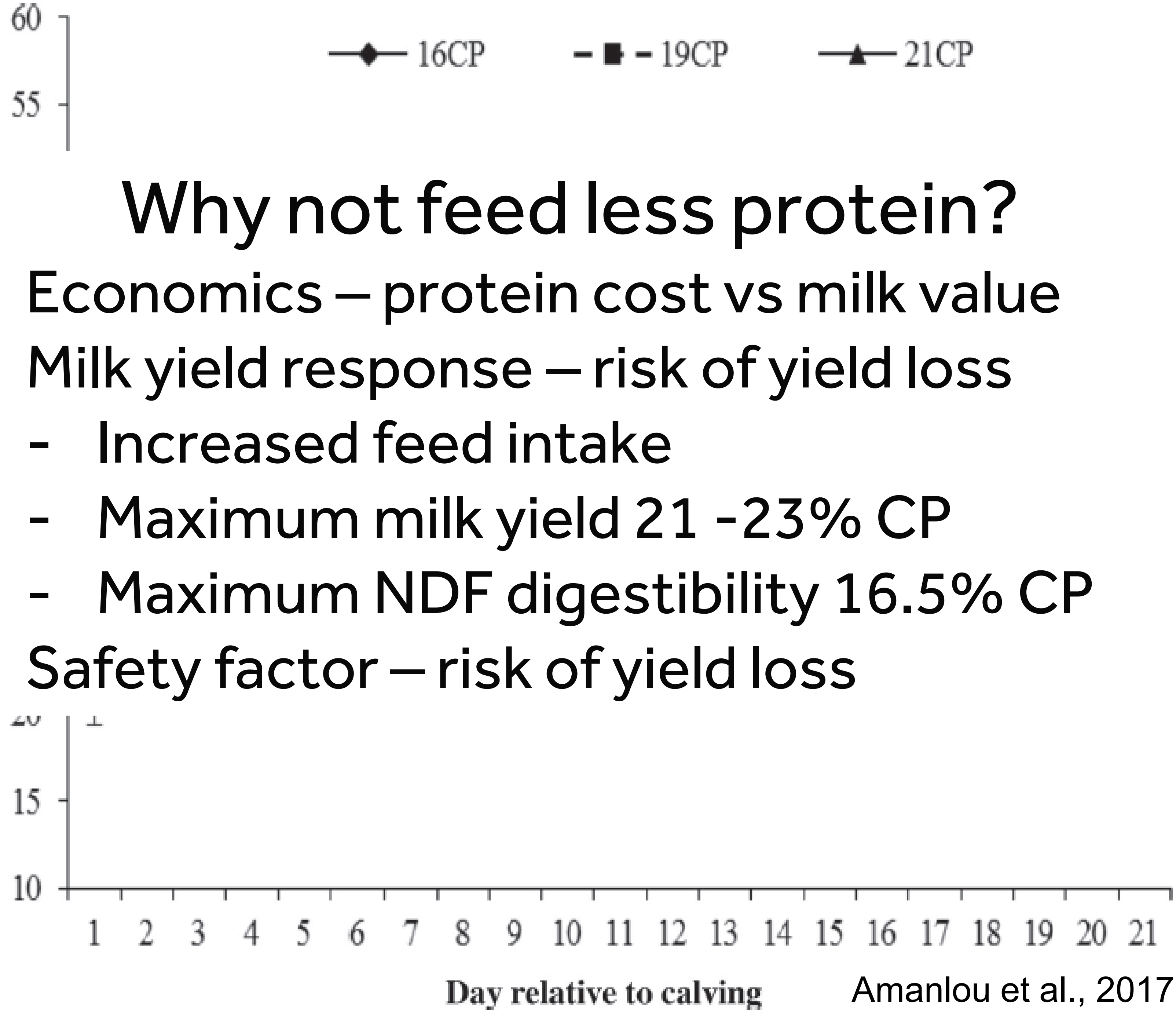
Lower (low) and upper (high) quartile for N efficiency

Calsamiglia et al. (2010)

Milk Yield Response - Lower Yielding Cows



Gordon & McMurray 1979



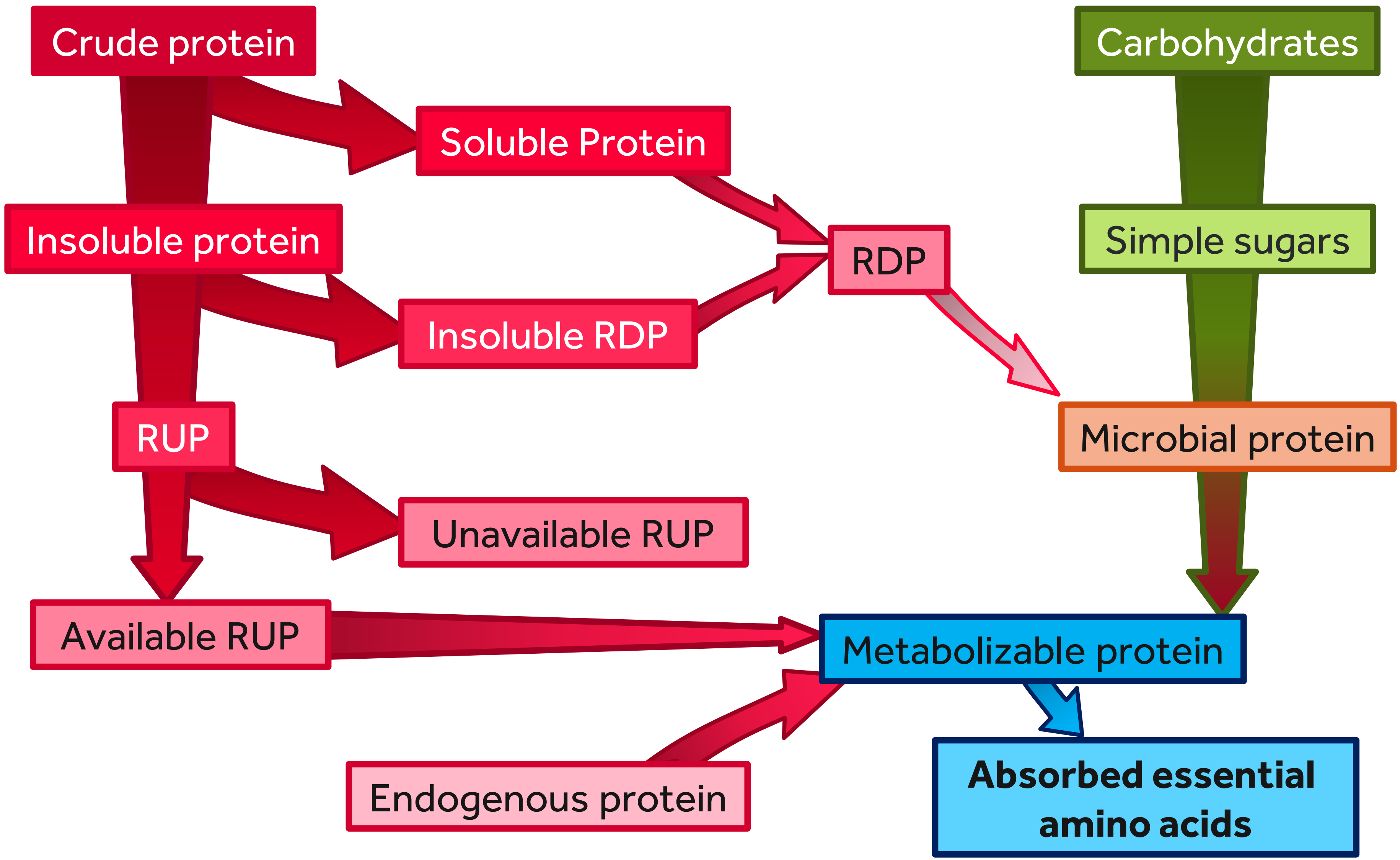
Why not feed less protein?

- Economics – protein cost vs milk value
- Milk yield response – risk of yield loss
  - Increased feed intake
  - Maximum milk yield 21 -23% CP
  - Maximum NDF digestibility 16.5% CP
- Safety factor – risk of yield loss

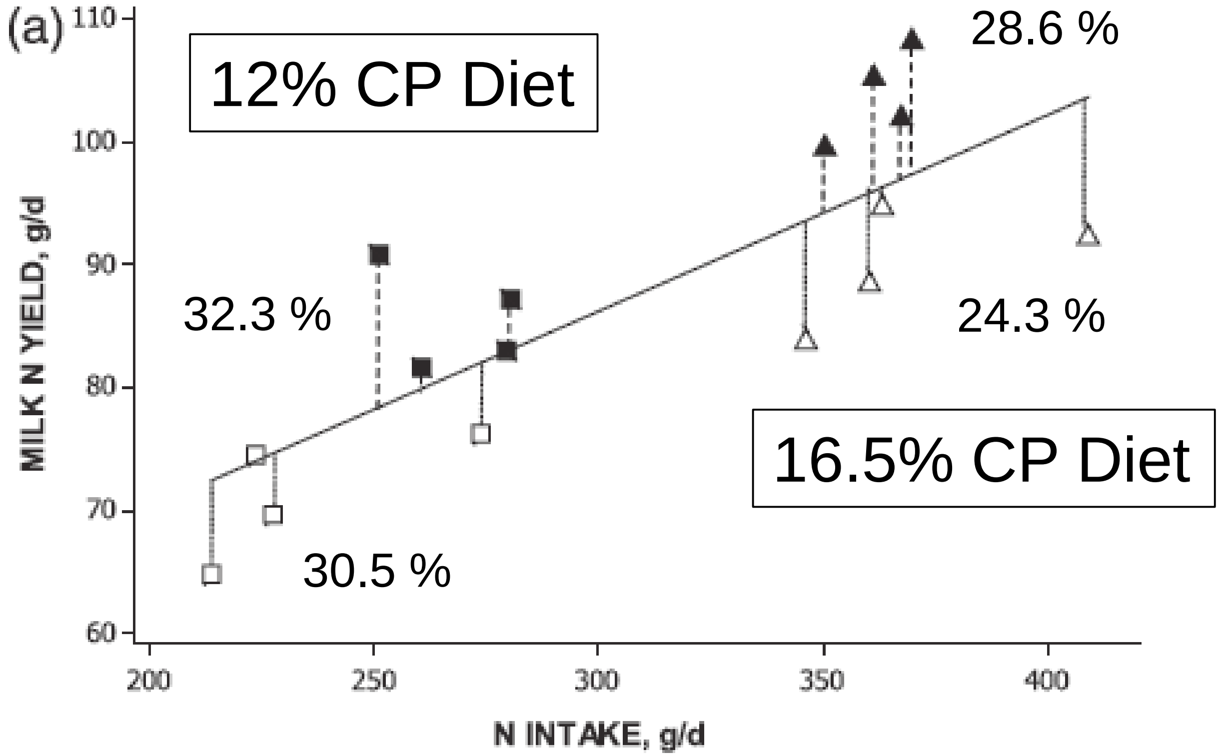
Amanlou et al., 2017.

MAKING METABOLISABLE PROTEIN

University of Reading



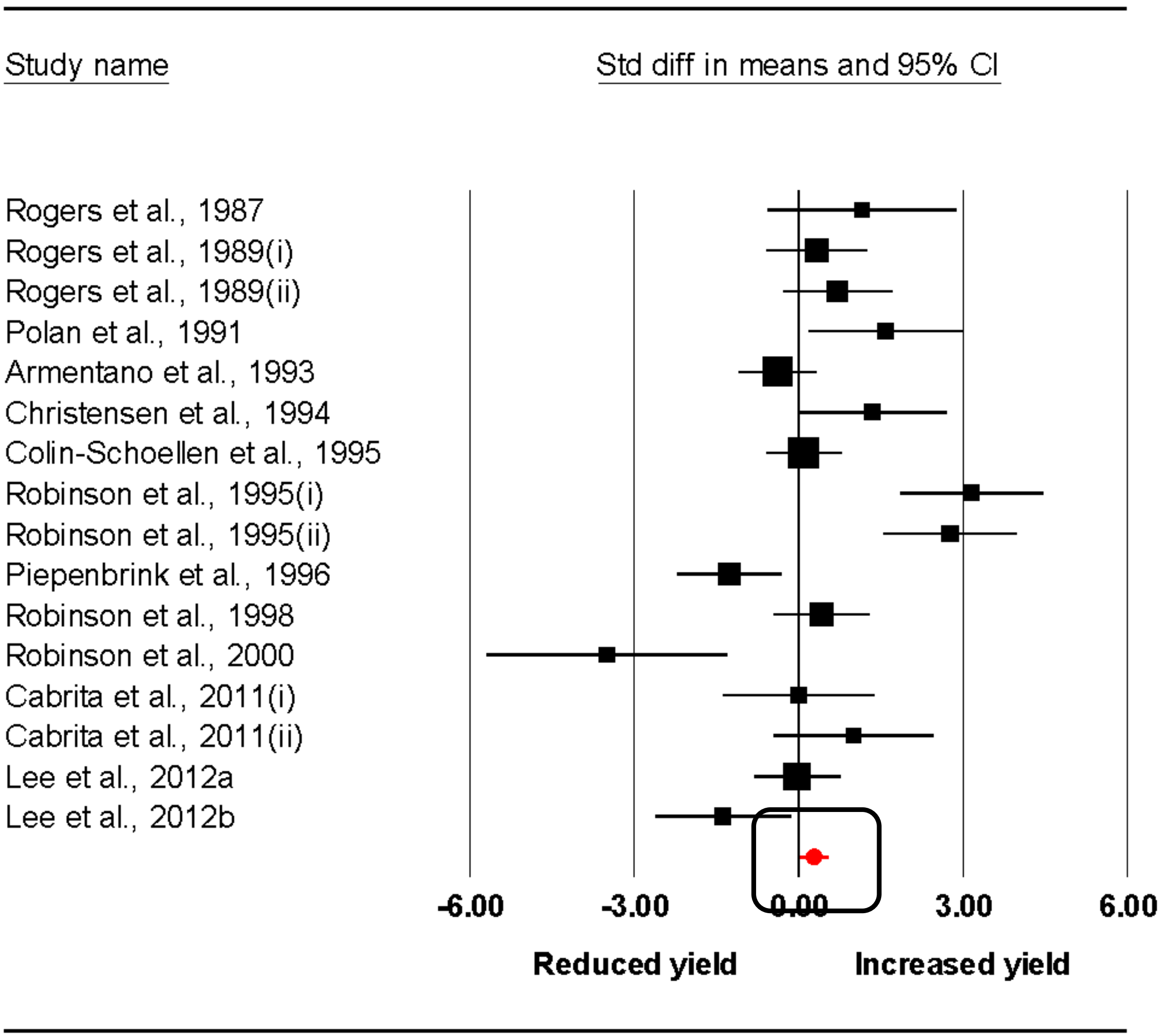
Effects of Higher Starch Diets on N Utilization



11% improvement in N milk / N intake with higher starch diets

Using Jersey cows *Cantalapiedra-Hijar et al., 2013.*

Effect of Rumen Protected Met and Lys on Milk Protein Yield for Diets With Less Than 15% CP



Sinclair et al 2014

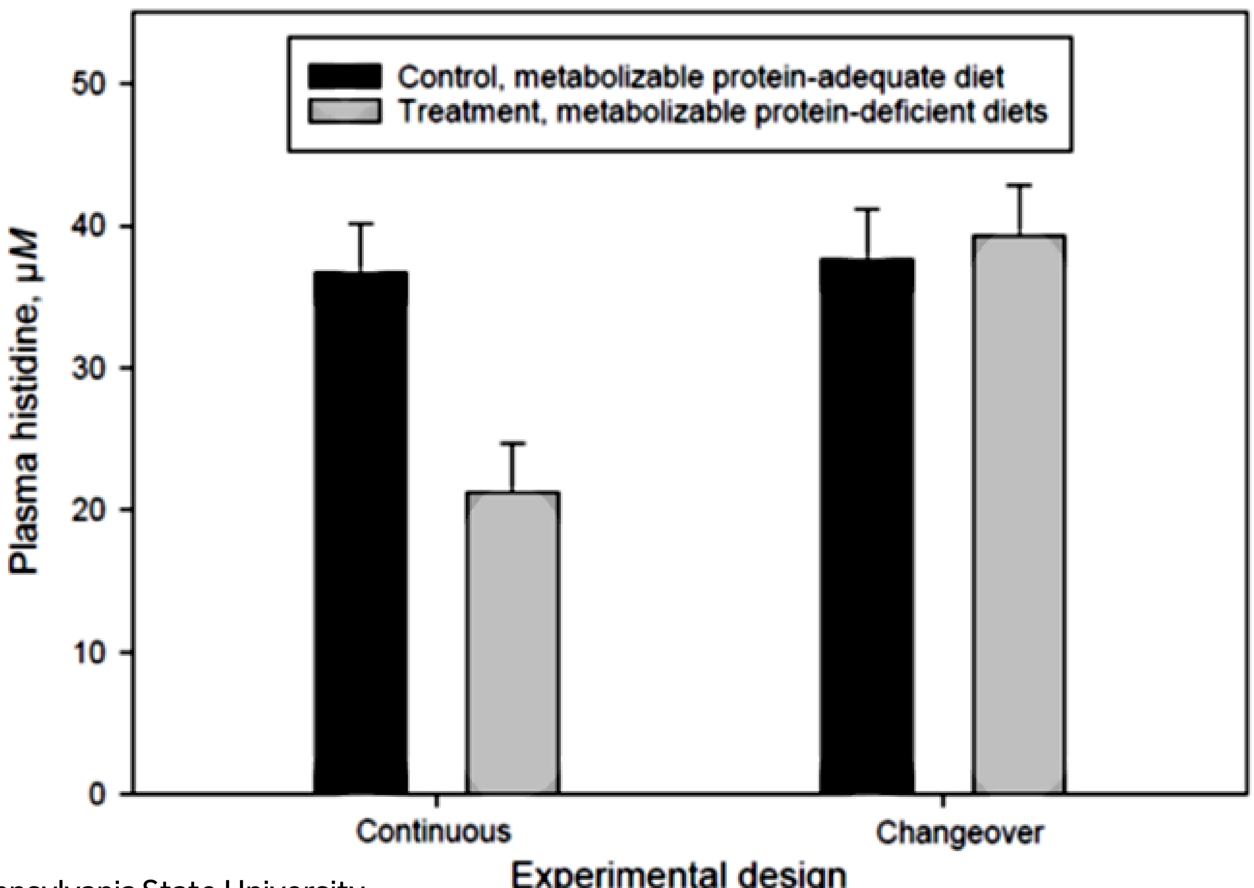
DIETARY PROTEIN AND MILK PRODUCTION

- Numerous (!) studies examining the effect of dietary protein supply on animal performance
  - Concerns over environmental impacts → lower protein diets
  - Accompanied by changes to dietary energy supply
  - Fermentable energy and metabolizable energy both important
- Interest in lower protein diets with rumen-protected protein or essential amino acids
  - Lysine and methionine (also histidine) considered first limiting

- **Short-term, cross over designs, often periods of weeks**
  - Dietary adaptation – changes to labile protein pool
  - Differential response to dietary protein content
    - Low to high different from high to low

- **<u>Long-term studies over an entire lactation(s) lacking</u>**

PLASMA HISTIDINE RESPONSE TO A DEFICIT OF MP
CONTINUOUS VS CHANGEOVER DESIGN



Alex Hristov, Pennsylvania State University
Lee et al., 2012 and 2015. 70 vs 28 day periods.

Where To Go With Dietary Protein?

Lower protein diets

Plus

- Reduced manure N per litre milk – less land
- Improved biological efficiency of cow
  - Less loss of body reserves?
  - Higher fertility?
  - Reduced culling and more longevity?

Minus

- Reduced milk yield?
- Profitability?
- Fertility loss?

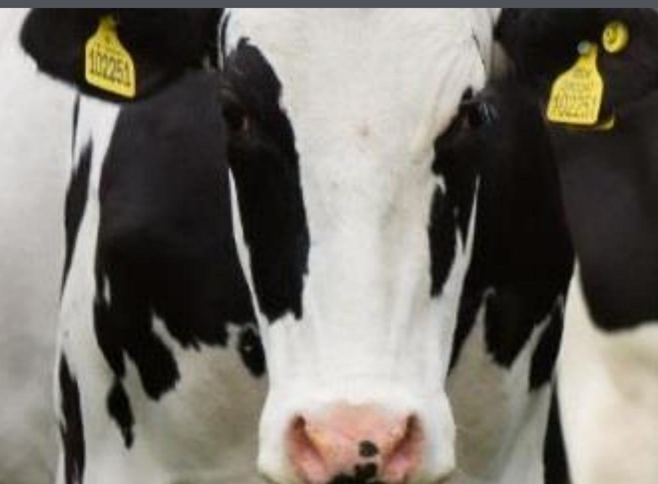
- Maintaining milk yield with lower protein diets by diet formulation?
  - Energy source, essential amino acid balance etc

DEFRA Project ACO122

University of Reading

EFFICIENCY OF PROTEIN UTILISATION IN LACTATING DAIRY COWS:

LONG TERM EFFECTS OF REDUCED PROTEIN SUPPLY



University of Reading, Aberystwyth University, SRUC, Rothamsted Research

2012-2018

Rothamsted Research | 1872 Prifysgol Aberystwyth University | SRUC | AHDB Dairy | Department for Environment Food & Rural Affairs

LIMITLESS **POTENTIAL** | LIMITLESS **OPPORTUNITIES** | LIMITLESS **IMPACT**

AC0122 - WP2 LACTATION TRIAL

University of Reading

- Measure the long-term effects of incremental reductions in protein concentration of maize silage-based diets for high yielding dairy cows
- 215 heifers enrolled at calving
- Fed one of 3 diets – Low 14%, Med 16% and High 18% crude protein
- Treatments maintained for 3 full lactations
- Managed as for CEDAR commercial herd except:
    - No grazing - common dry period management
    - No change in diet protein concentration in late lactation
- Culling as for commercial herd
    - Served from day 50 - 200
    - Failed to conceive cows removed after 305 d lactation

AC0122 – LACTATION TRIAL

TWO CONCENTRATE BLENDS

University of Reading

	Crude protein concentration		
	14%	16%	18%
Grass silage	150	150	150
Maize silage	350	350	350
Barley straw	15	15	15
Cracked wheat	**115**	**100**	**85**
MSBF	40	40	40
Soy hulls	**81**	**73**	**65**
Wheat feed	**139**	**93.3**	**47.6**
Soybean meal	**37.5**	**71.9**	**106.2**
Rapeseed meal	**37.5**	**71.9**	**106.2**
Molasses	15	15	15
Mins & vits	20	20	20

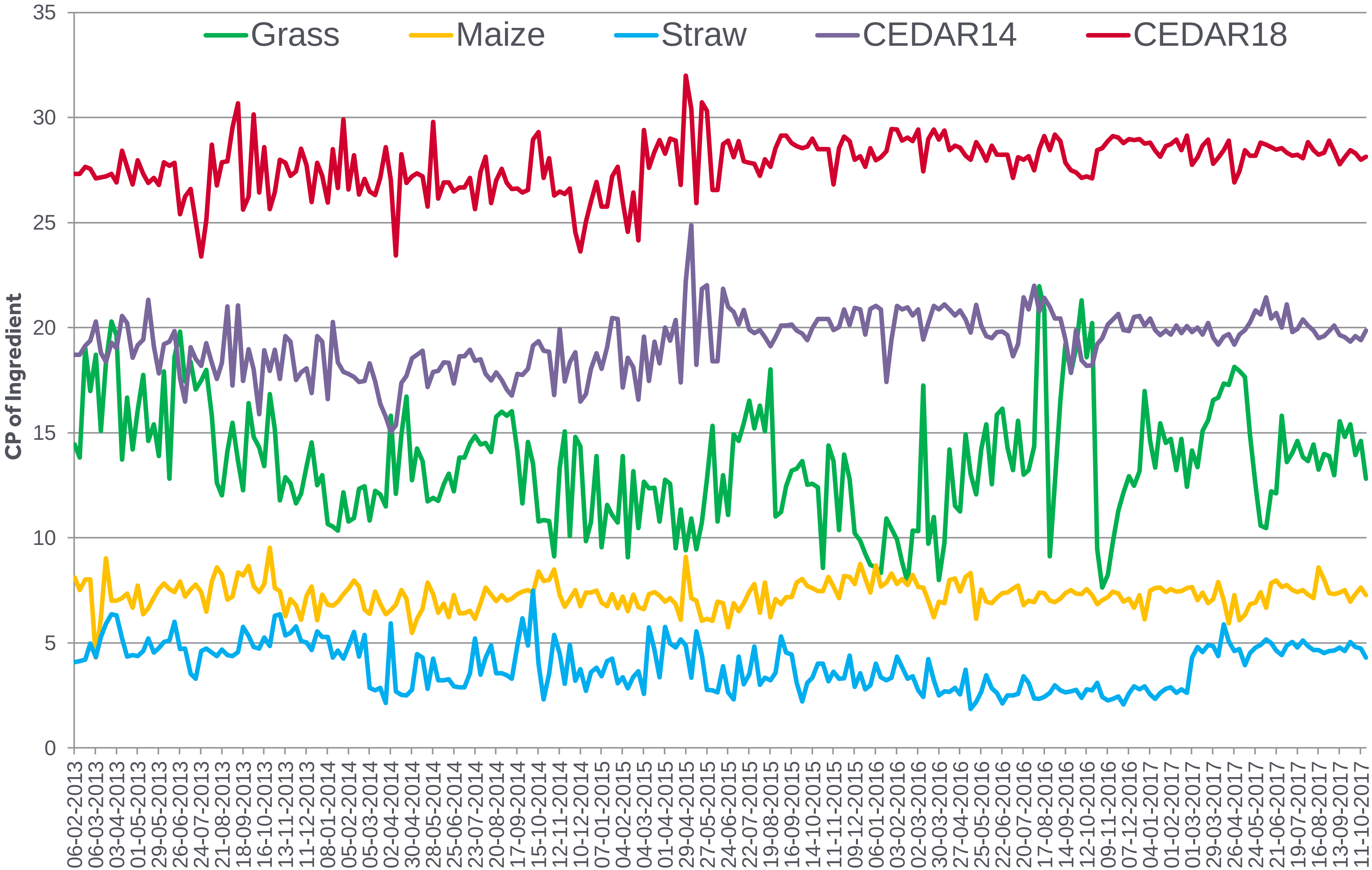
LACTATION RATIONS

University of Reading

	Crude Protein Concentration		
Item	14%	16%	18%
CP	140	160	180
ME – MJ/kg DM	11.27	11.32	11.38
NDF	**352**	**343**	**334**
ADF	238	237	236
Starch	**231**	**213**	**195**
WSC	49	52	54
EE	45	45	45
Starch + WSC	**280**	**265**	**249**
MPn - % of required	**89.9**	103.2	115.9
MPe - % of required	95.2	**99.9**	**103.8**

DIET INGREDIENT VARIATION

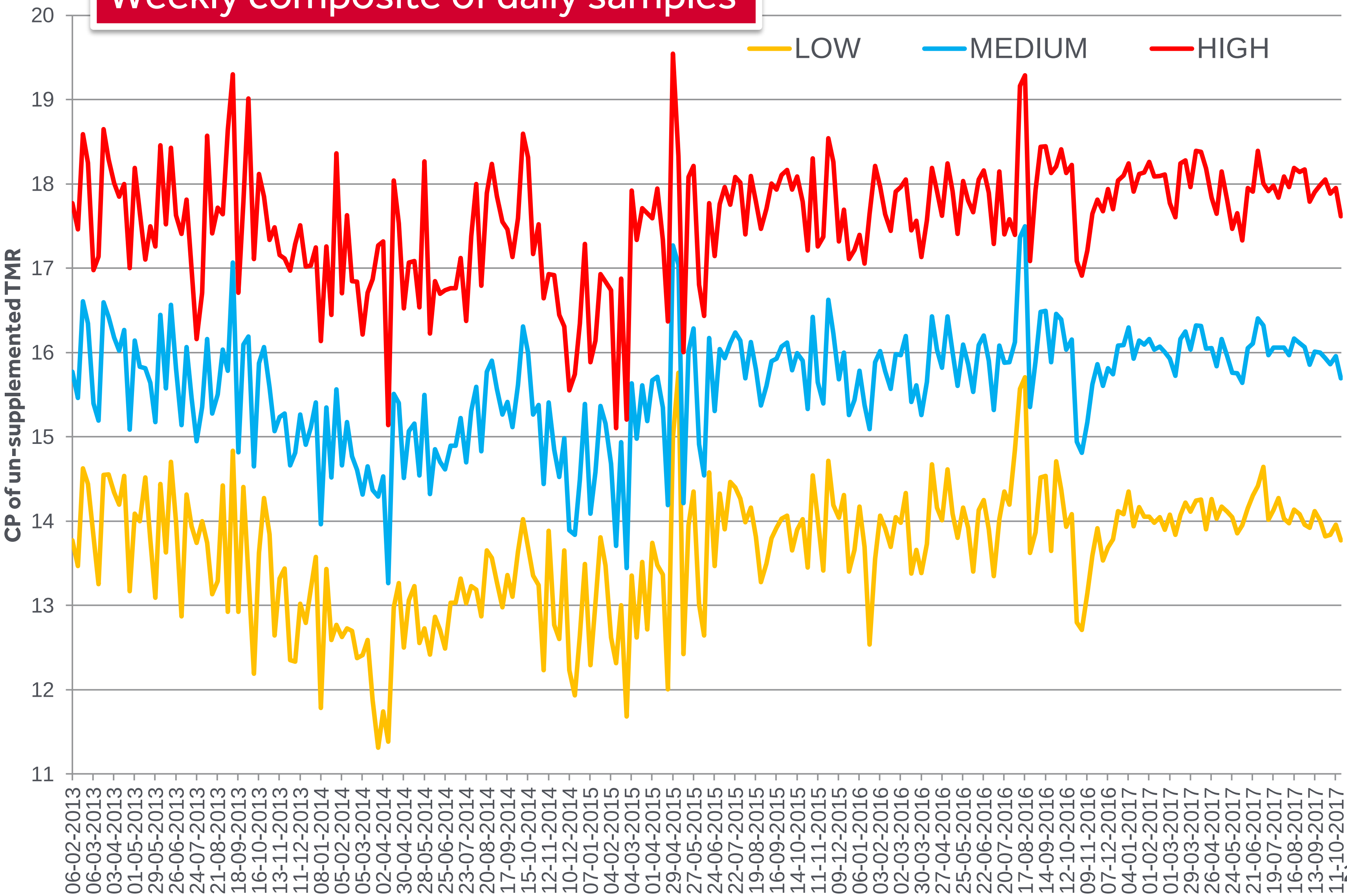
University of Reading



TMR CP VARIATION (UNADJUSTED)

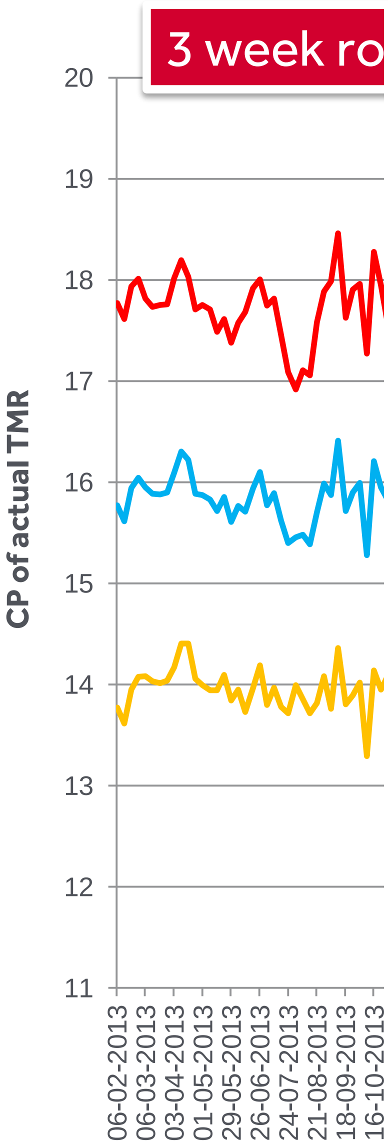
University of Reading

Weekly composite of daily samples



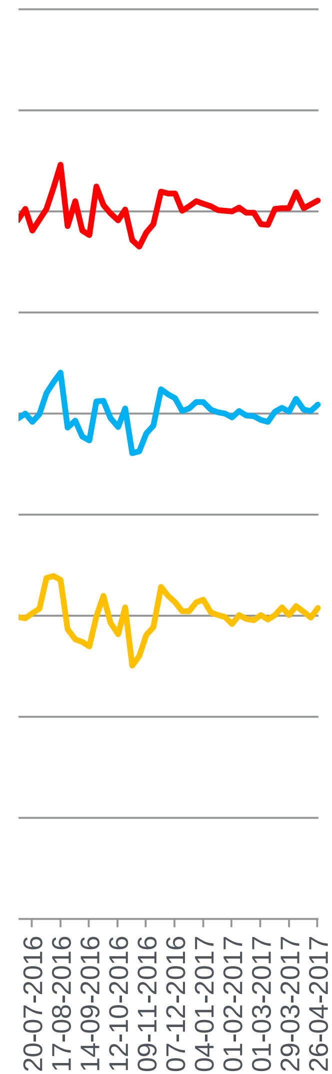
TMR CP VARIATION (ADJUSTED)

University of Reading

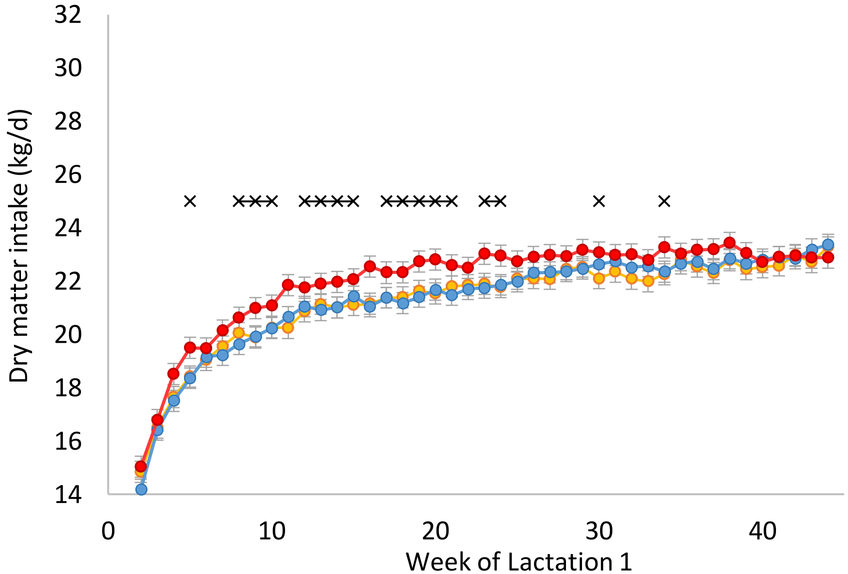


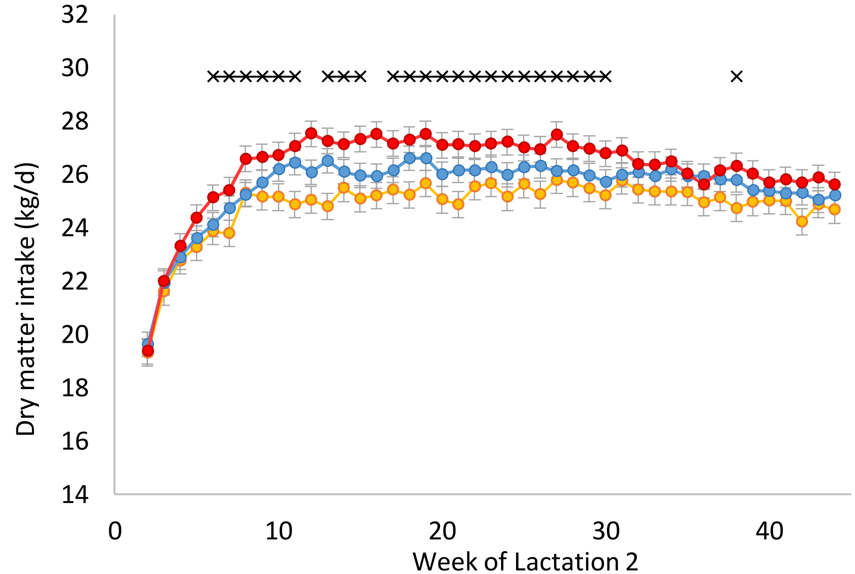
0342 Effects of oscillating the crude protein content in dairy cow rations. A. N. Brown*[1] and W. P. Weiss[2], *[1]The Ohio State University, Wooster, [2]Department of Animal Sciences, The Ohio State University, Wooster.*

Overfeeding crude protein (CP) is a common practice in the dairy industry to reduce the risk of a loss in milk; however, overfeeding CP increases costs and negatively impacts the environment. We hypothesized that oscillating dietary CP concentrations to equal the average concentration of a diet limited in metabolizable protein (MP) for lactating dairy cows will improve milk protein yield and milk N efficiency because oscillating CP should stimulate nitrogen recycling to the rumen. Twenty-one Holstein dairy cows averaging 123 DIM were randomly assigned to a treatment sequence in seven 3 × 3 Latin Squares with 28-d periods. The control diet contained 16.4% CP (MP allowable milk = 47 kg/d), the low protein diet contained 13.4% CP (MP allowable milk = 31 kg/d), and the oscillating treatment consisted of a diet with 10.3% CP fed for 2 d followed by a diet with 16.4% CP fed for 2 d repeated over the 28 d period to average 13.4% CP. The cows were fed once daily and milked twice daily. Cows on the low protein diet had greater DMI than cows on the oscillating treatment (24. 8 kg/d vs. 24.3 kg/d; $P = 0.04$) but were similar in DMI compared to

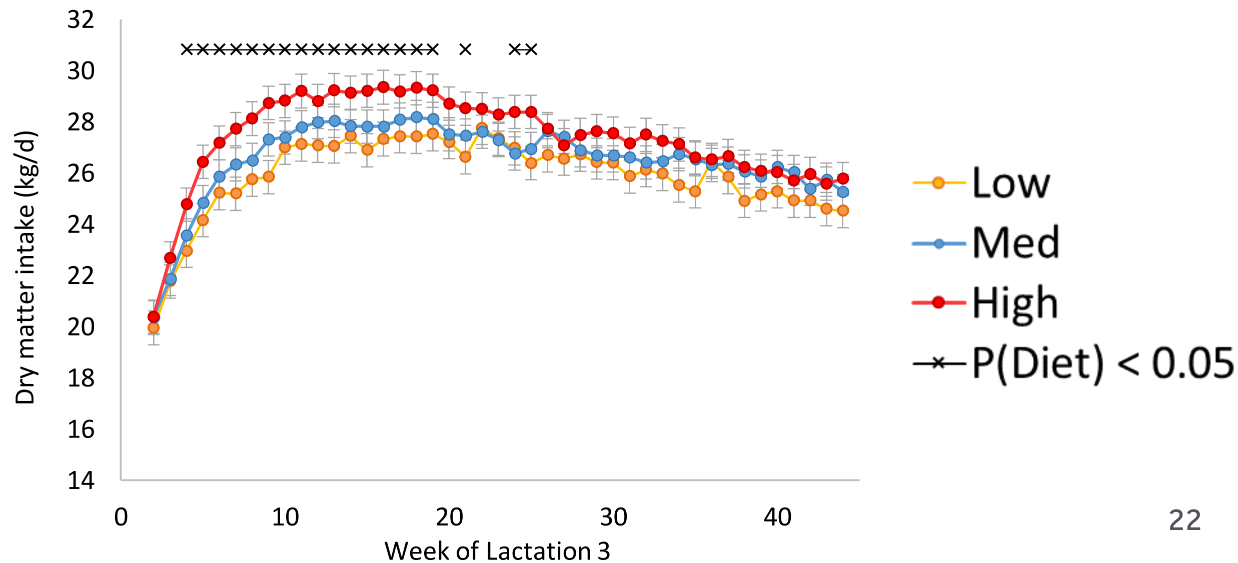


DRY MATTER INTAKE



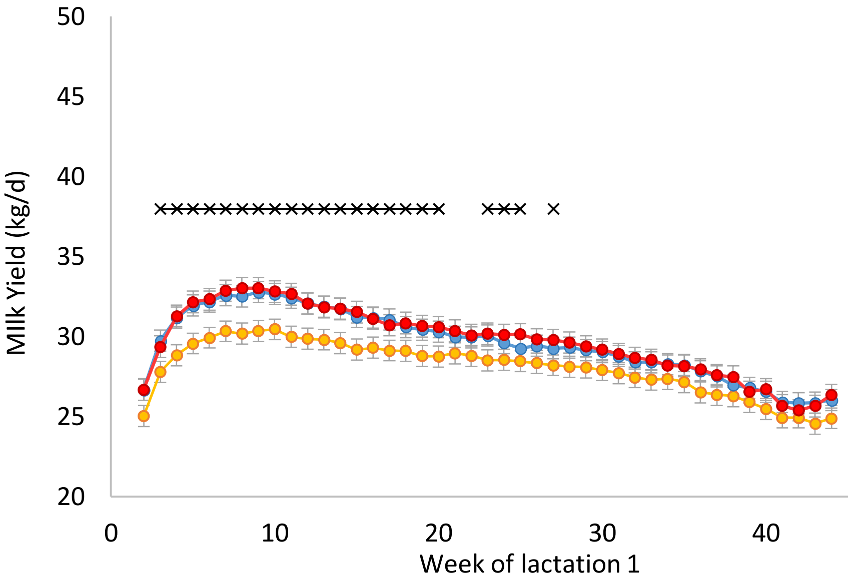


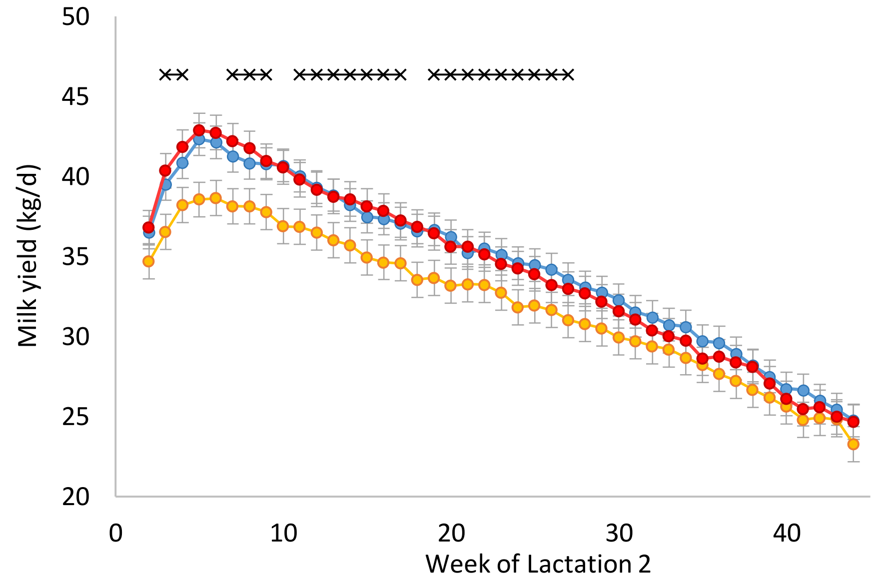
	Low	Med	High
Lac 1	21.3[b]	21.3[b]	22.0[a]
Lac 2	24.8[b]	25.5[ab]	26.2[a]
Lac 3	25.9[c]	26.5[b]	27.3[a]



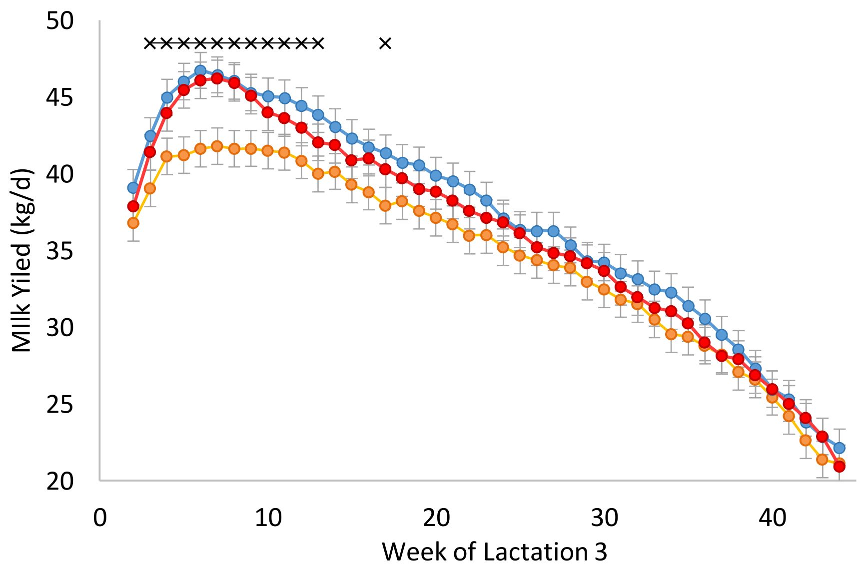
MILK YIELD

University of Reading





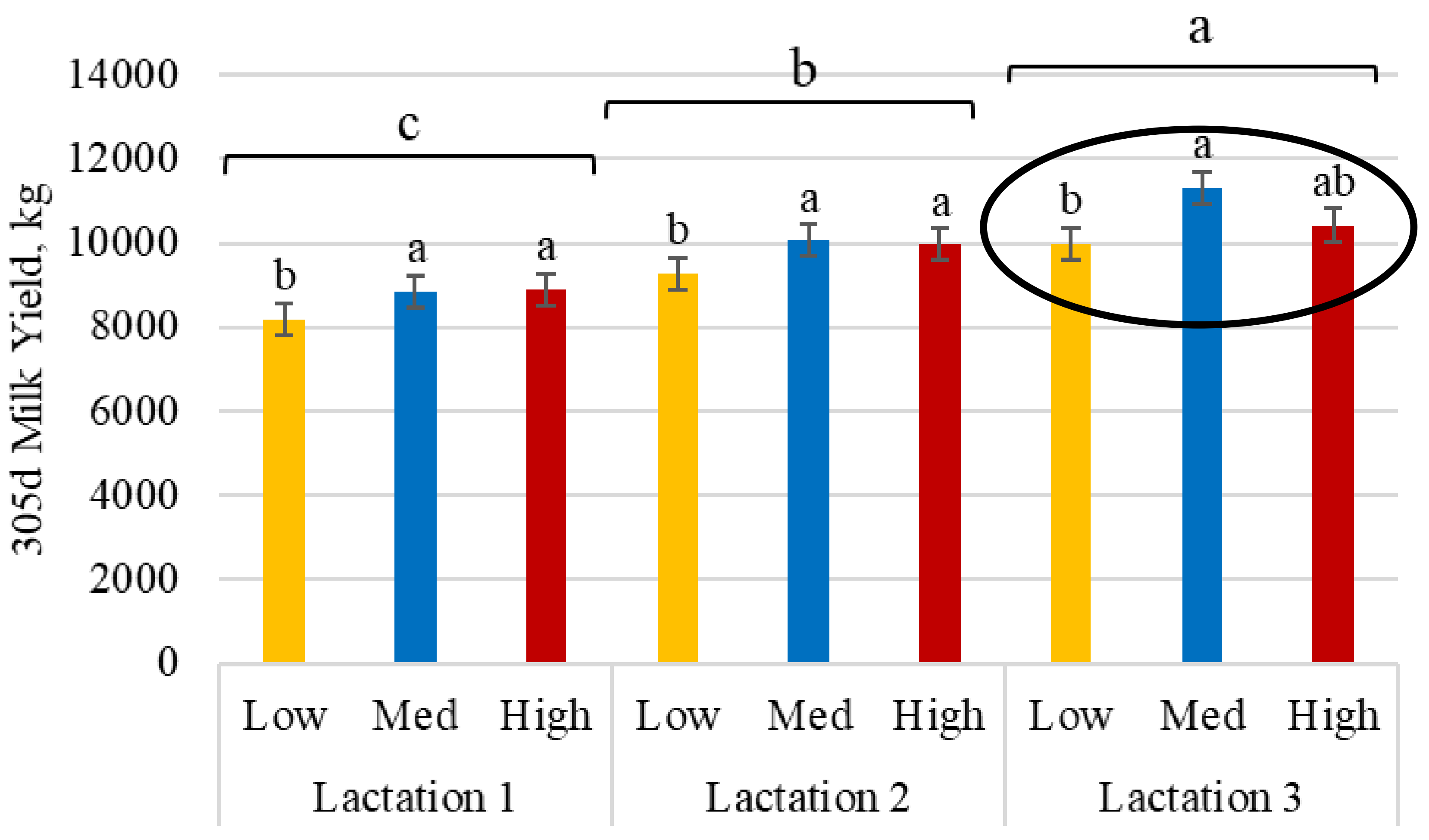
	Low	Med	High
Lac 1	28.1[b]	29.6[a]	29.7[a]
Lac 2	32.1[b]	34.5[a]	34.3[a]
Lac 3	34.5[b]	37.0[a]	36.1[ab]



Low
Med
High
P(Diet) < 0.05

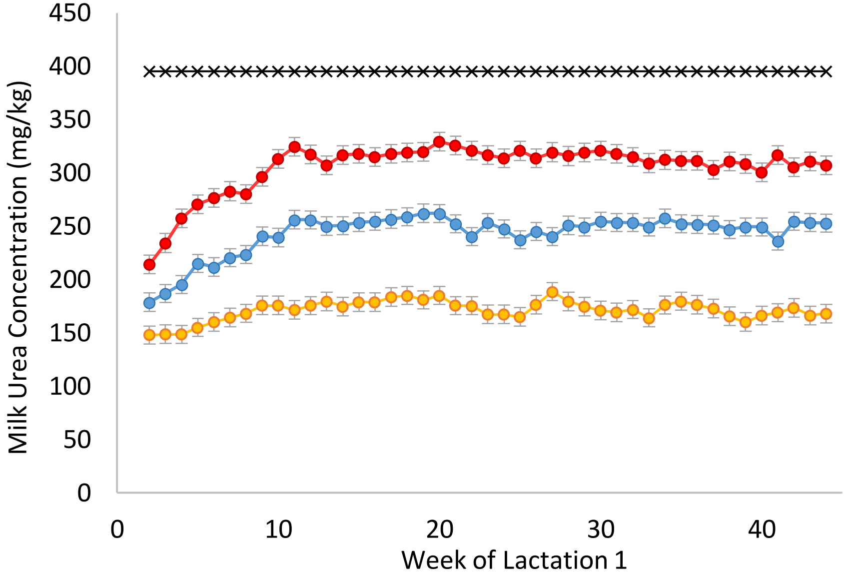
305 DAY MILK YIELD

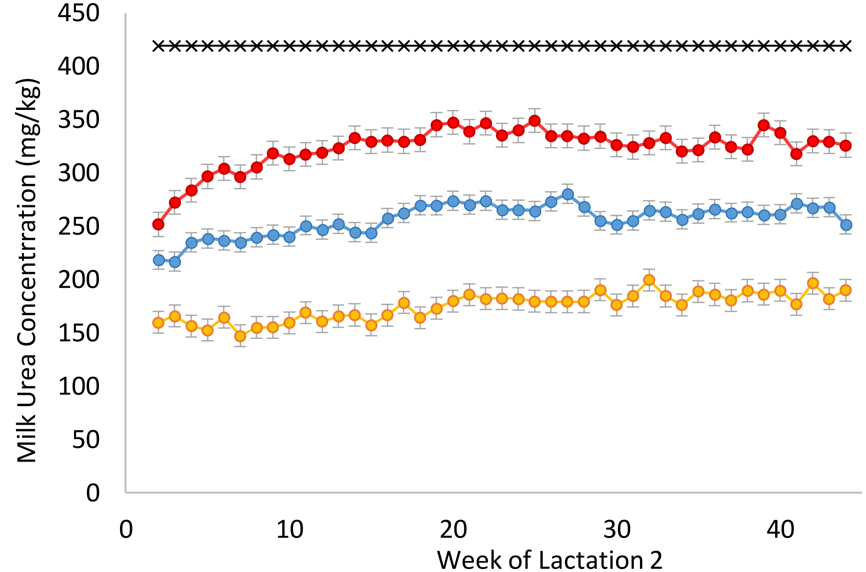
University of Reading



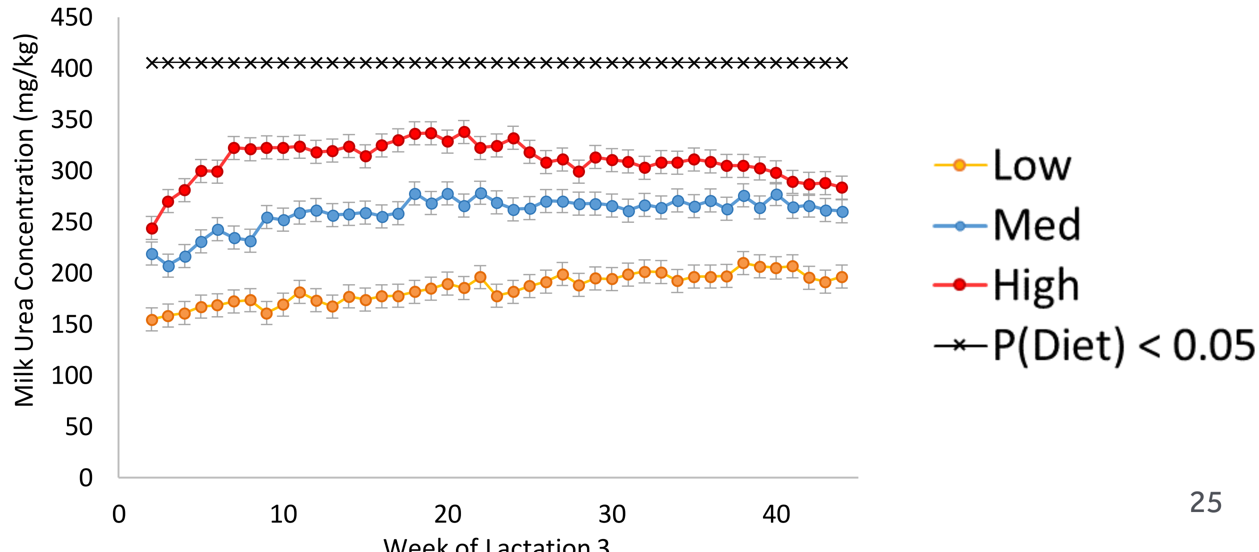
MILK UREA CONCENTRATION

University of Reading



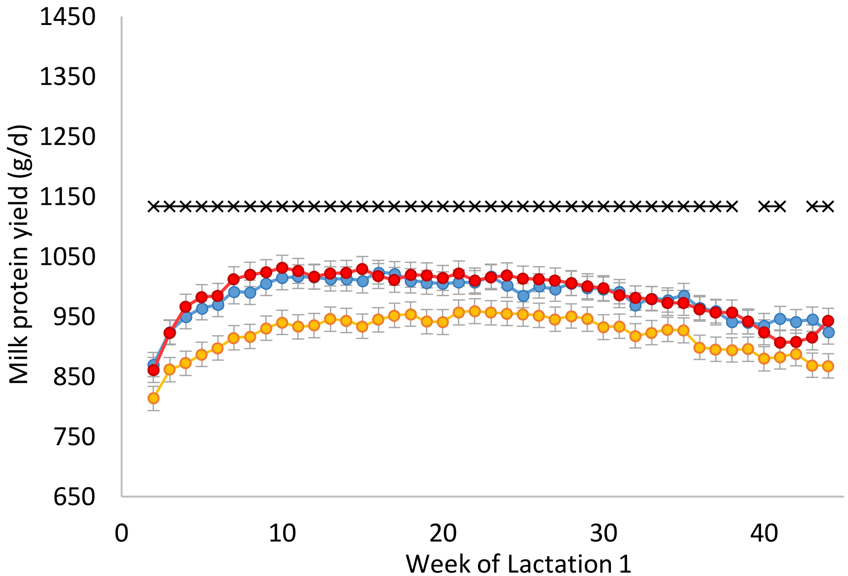


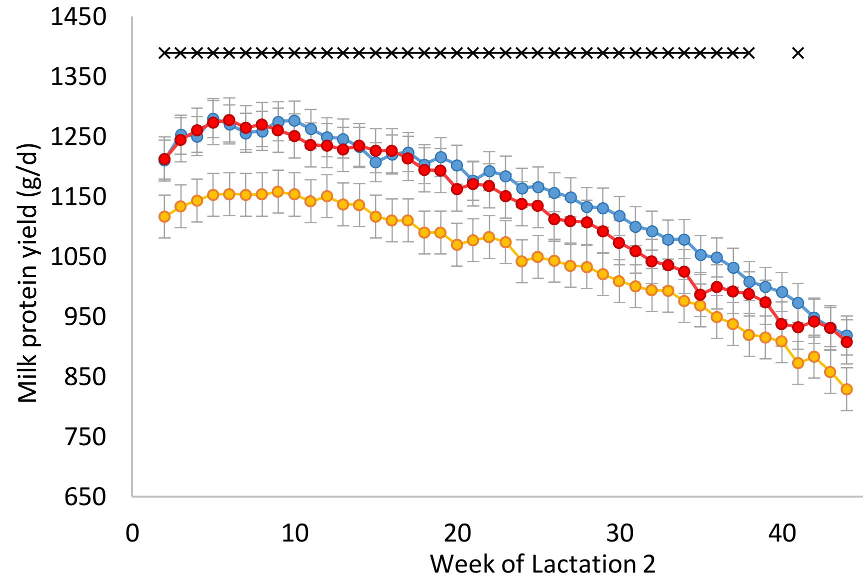
	Low	Med	High
Lac 1	171[c]	243[b]	305[a]
Lac 2	174[c]	256[b]	324[a]
Lac 3	185[c]	259[b]	310[a]



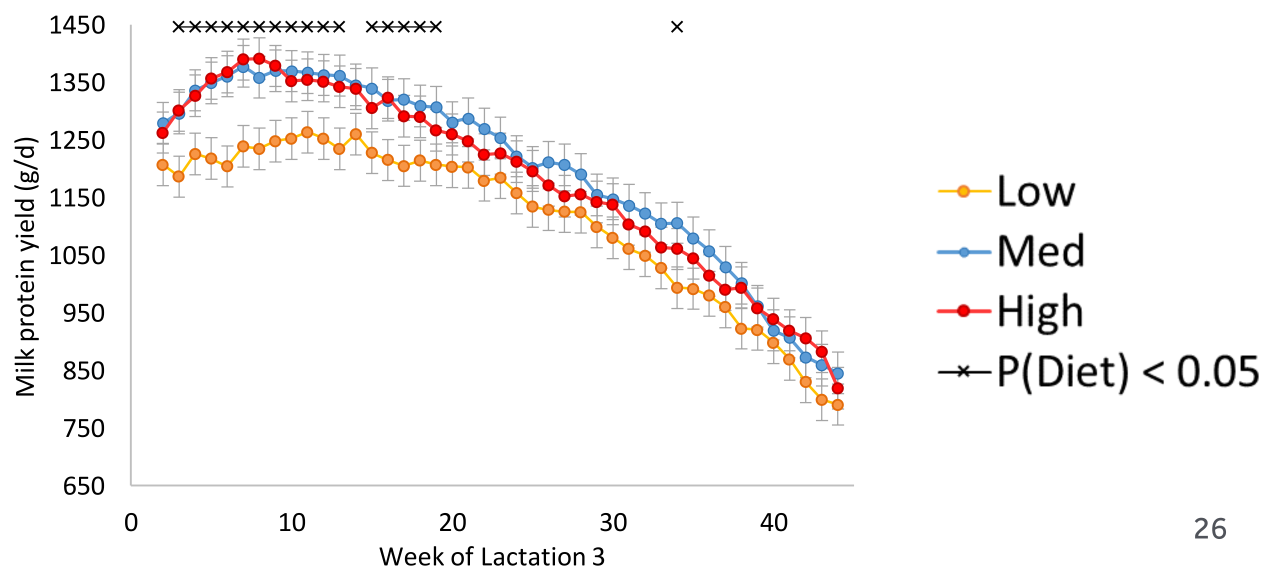
MILK PROTEIN YIELD

University of Reading



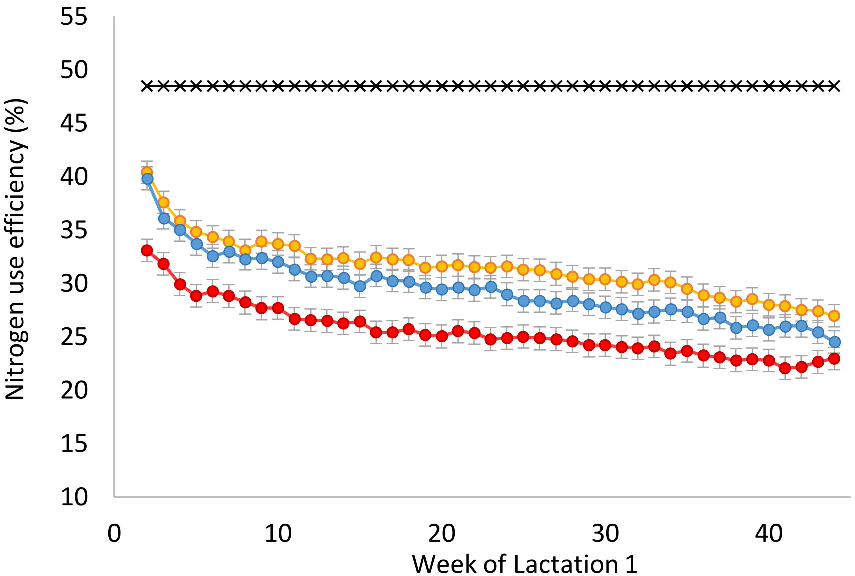


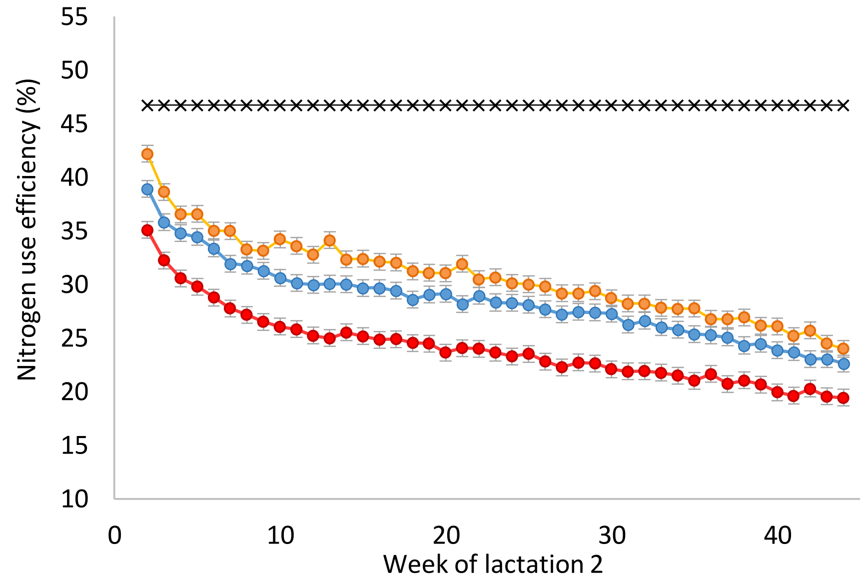
	Low	Med	High
Lac 1	920[b]	982[a]	986[a]
Lac 2	1045[b]	1150[a]	1127[a]
Lac 3	1112[b]	1199[a]	1184[a]



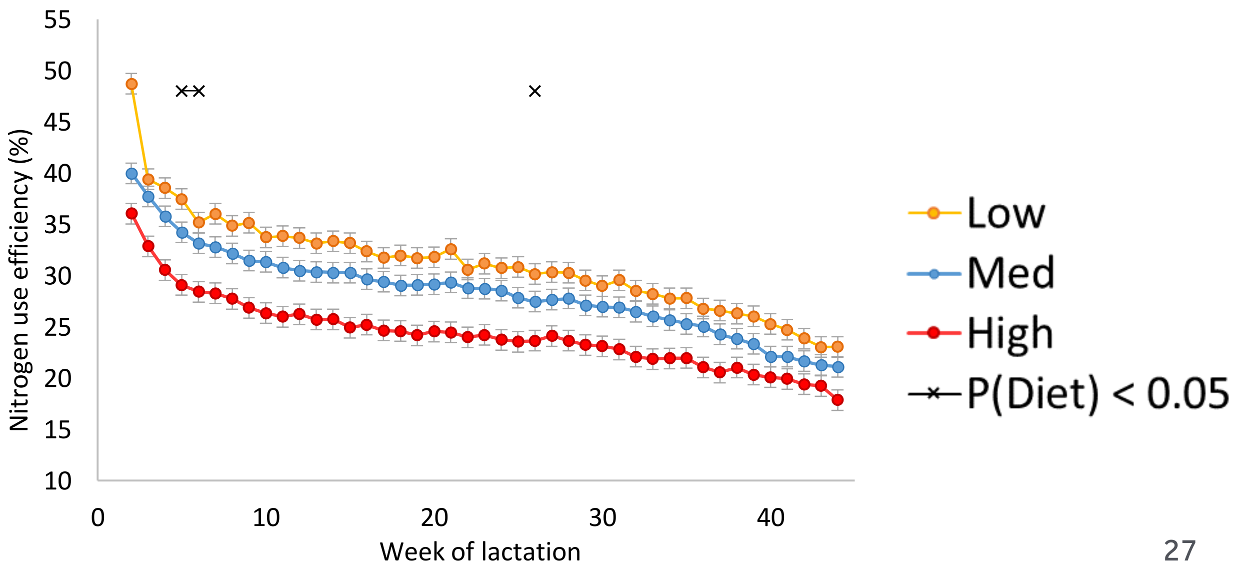
NITROGEN USE EFFICIENCY

University of Reading

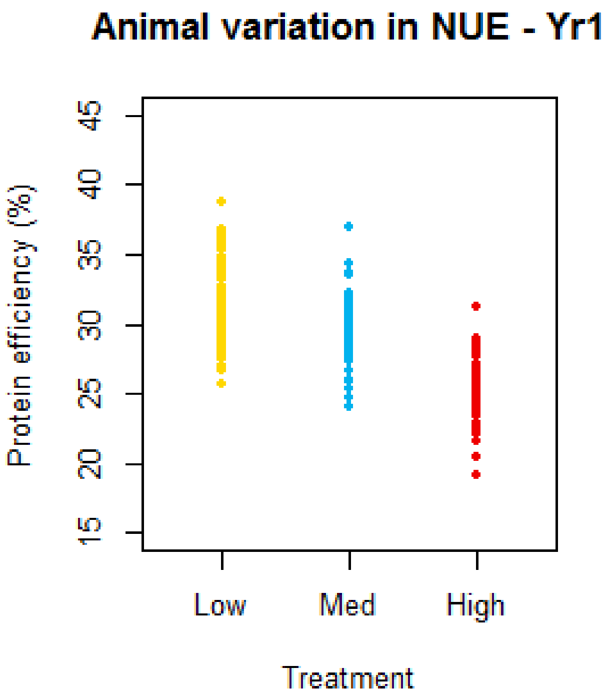


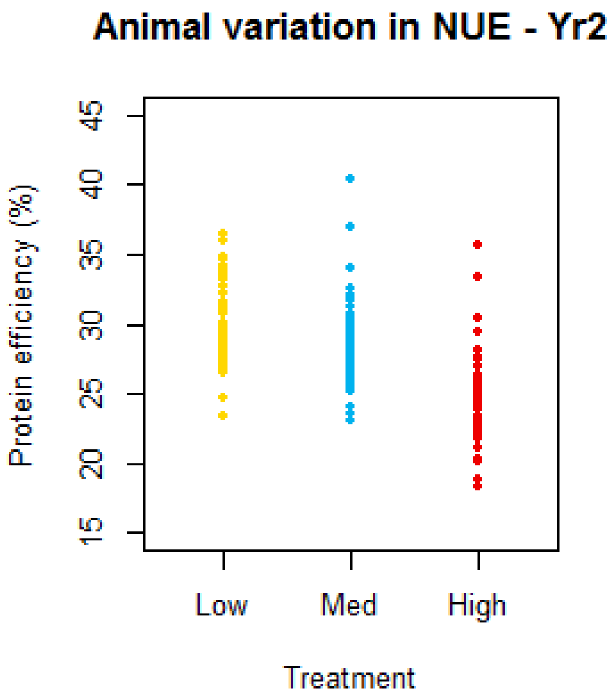


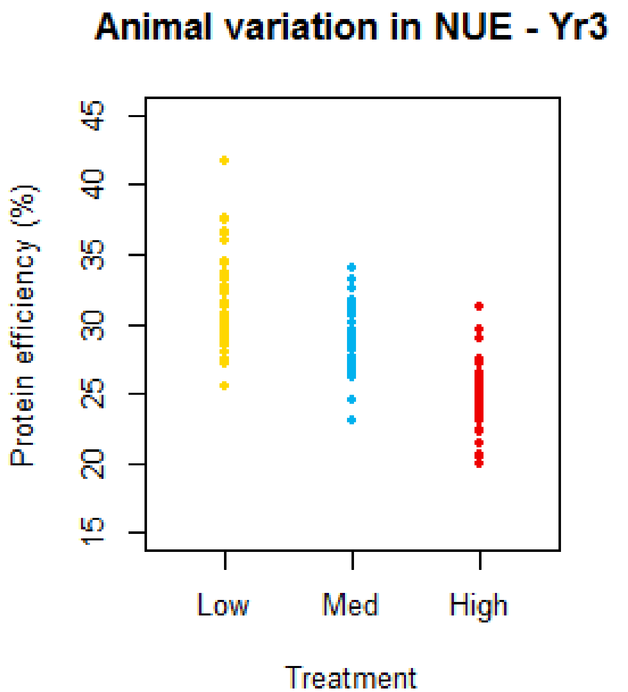
	Low	Med	High
Lac 1	31.5[a]	29.5[b]	25.5[c]
Lac 2	30.7[a]	28.4[b]	24.1[c]
Lac 3	31.1[a]	28.4[b]	24.3[c]



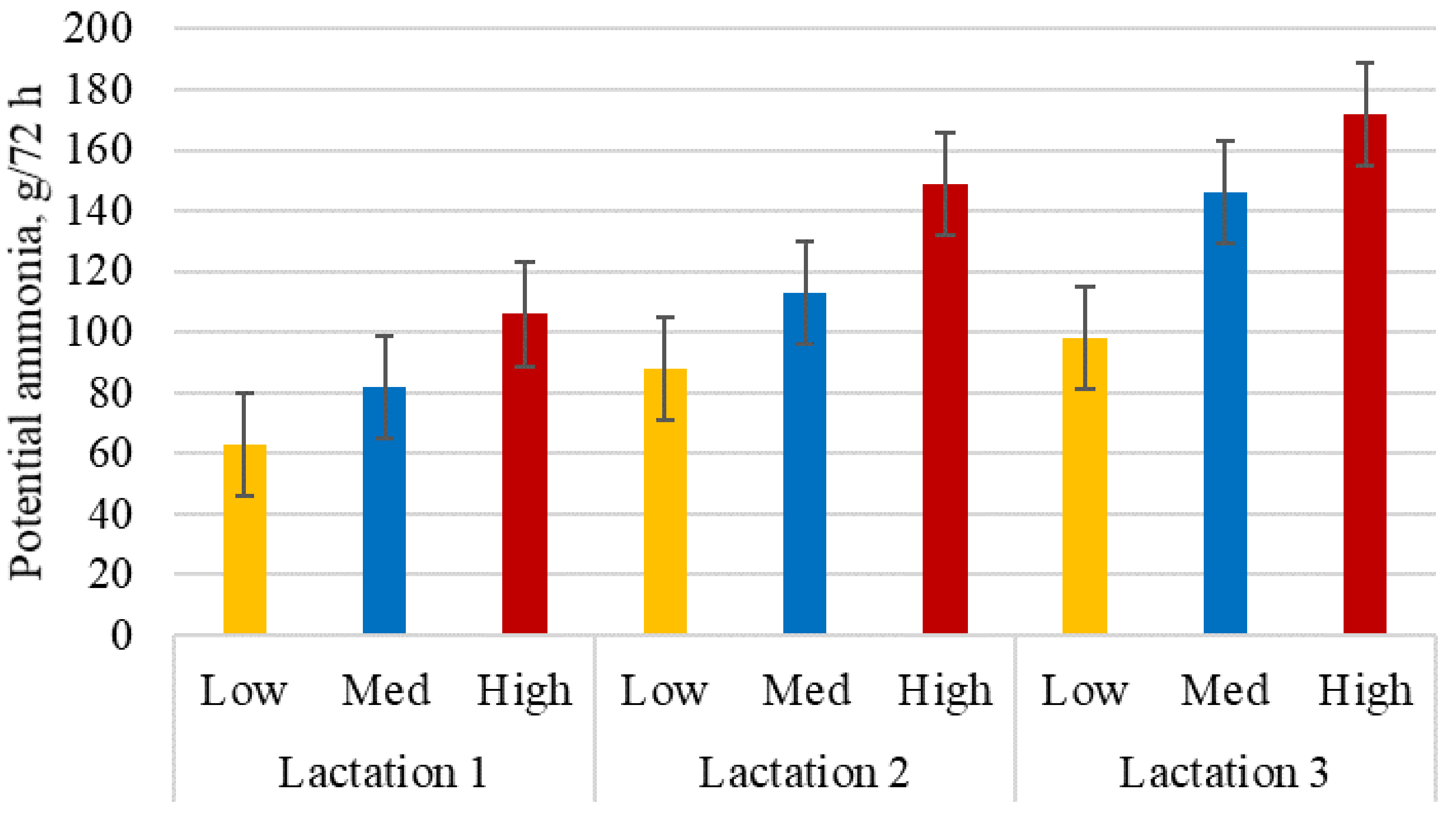
NITROGEN USE EFFICIENCY: ANIMAL VARIATION







SLURRY AMMONIA EMISSION

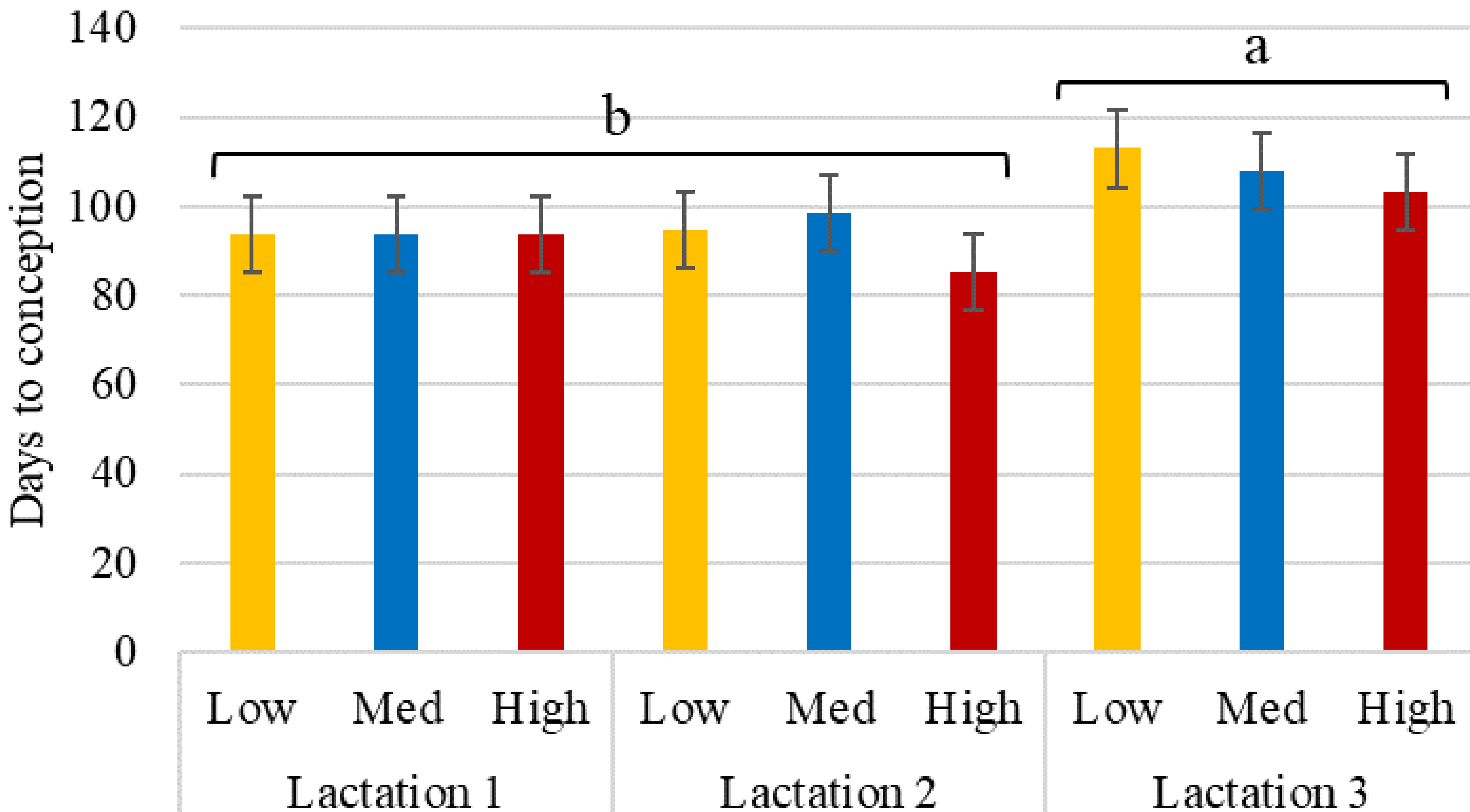


Potential 3 day emission from daily manure excretion

CALVING TO CONCEPTION

University of Reading

Treatment = NS
Year x Treatment = NS



ATTRITION – WHOLE STUDY

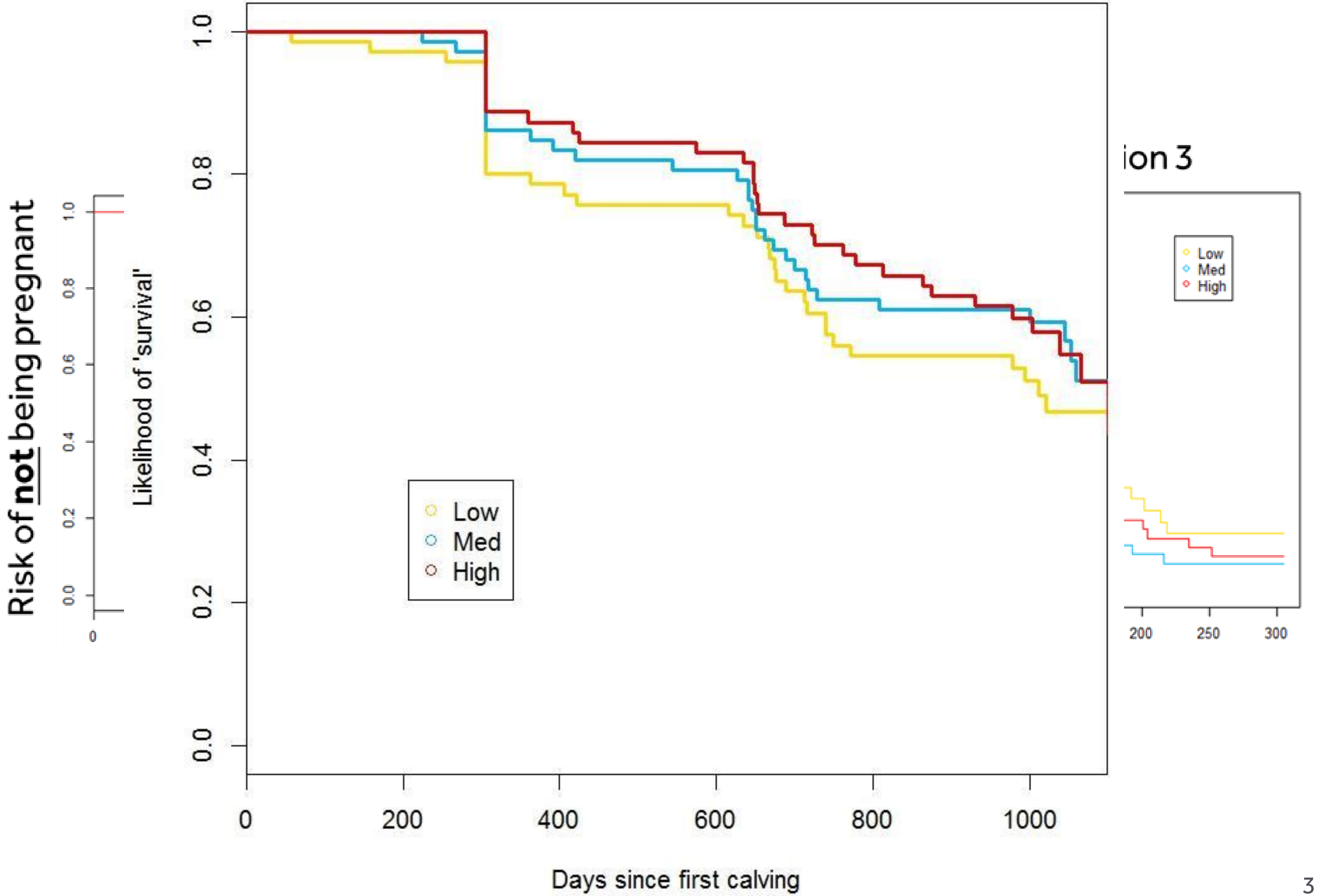
University of Reading

	Low	Med	High
Started	72	72	71
Stealers	7	2	3
Start minus stealers	65	70	68
Cull or died	10	8	10
Reproductive failures			
Abortion	9	4	3
Not in calf	19	22	21
Culled after study	4	3	2
Would continue to 4^{th} lactation[1]	23 (35%)	33 (47%)	32 (47%)

[1]Final percentages = [would continue] / [start minus stealers] *100

Embryo loss not included (some rebred): **8, 2, and 4** for low, medium and high, respectively.

ATTRITION – WHOLE STUDY



ECONOMIC IMPACT

- Financial model of dairy enterprise to examine effect of varying dietary nitrogen
  - Variable inputs, fixed costs, output/revenue, gross and net margin

- Medium protein ration generates highest net margin

- Variable costs increase with both high and low protein diets
  - Feed costs highest in the HIGH group
  - Vet & med costs highest for LOW group
  - Replacement costs highest in the LOW group
  - Milk dumping highest for the LOW group

CONCLUSIONS – CEDAR TRIAL

University of Reading

- Lower protein diets more 'N efficient' but need to consider longer term effects at systems level
  - Economic and environmental implications
  - Similar degree of animal variation across treatments
  - Reasons for animal variation of interest – genetics
- Large variation in diet protein concentrations
  - Implications for precision feeding lower protein diets
- Long-term negative effects of 'sub-optimal' protein supply evident (numerically) – survival reduced
- For this study, the 16% crude protein diet was 'optimal' in many respects - this was by design

SOME TAKE HOME MESSAGES

University of Reading

- Economic and environmental pressure to reduce nitrogen inputs – including fertilizer and imported feed proteins
  - Less environmental impact
  - Risk of reduced milk yield
  - Risk of long-term undernutrition and reduced fertility
- Balance of benefits vs risks and their costs
- Need to consider on a system basis – not just what goes into and comes out of a cow

SOME TAKE HOME MESSAGES

University of Reading

- Diets can be formulated to meet requirements with lower crude protein concentrations
  - Energy supply key to maximum dietary N efficiency
    - Dietary N efficiency linked to milk protein yield and feed efficiency
  - Precision feeding lower protein diets – challenges of variations in feed composition – cows very resilient – long term average important
  - *Heifer rearing diets also important*

Department for Environment Food & Rural Affairs

University of Reading

THANK YOU!

@UniRdg_SAPD

UniRdgAPD

www.reading.ac.uk/protein-efficiency

LESS **OPPORTUNITIES** | LIMITLESS **IMPACT**