DEFRA Project ACO122

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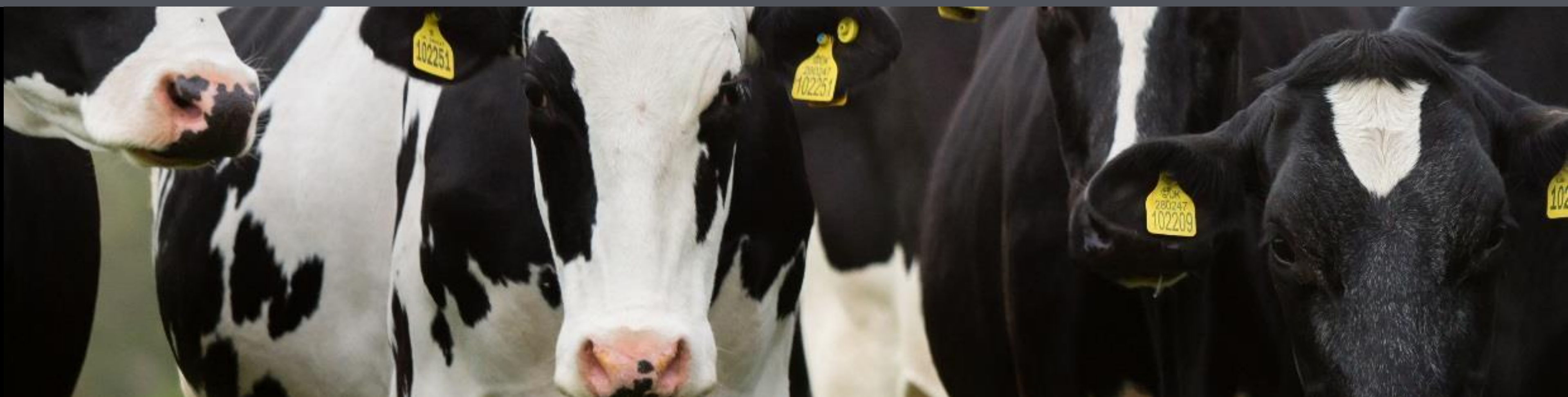
USING FEED PROTEIN MORE EFFICIENTLY AND REDUCING ENVIRONMENTAL IMPACTS OF DAIRY PRODUCTION SYSTEMS - LONG TERM PRODUCTION RESPONSES TO LOWER PROTEIN DIETS



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

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

Inevitable N Losses Determining N Use Efficiency for Milk Protein

Source	Faeces N	Urine N	Milk N
Fermentation		35	
Microbial nucleic acids	13	71	
Undigested protein	39		
Endogenous protein	39	19	
Maintenance		13	
Milk production		13	
Total	89	174	198
Maximum N use efficiency			**43 %**
Reference cow at 40 milk/d with 31.5 g/kg true protein content			

Dijkstra et al., 2013.

VARIATION IN N USE EFFICIENCY IN DAIRY CATTLE

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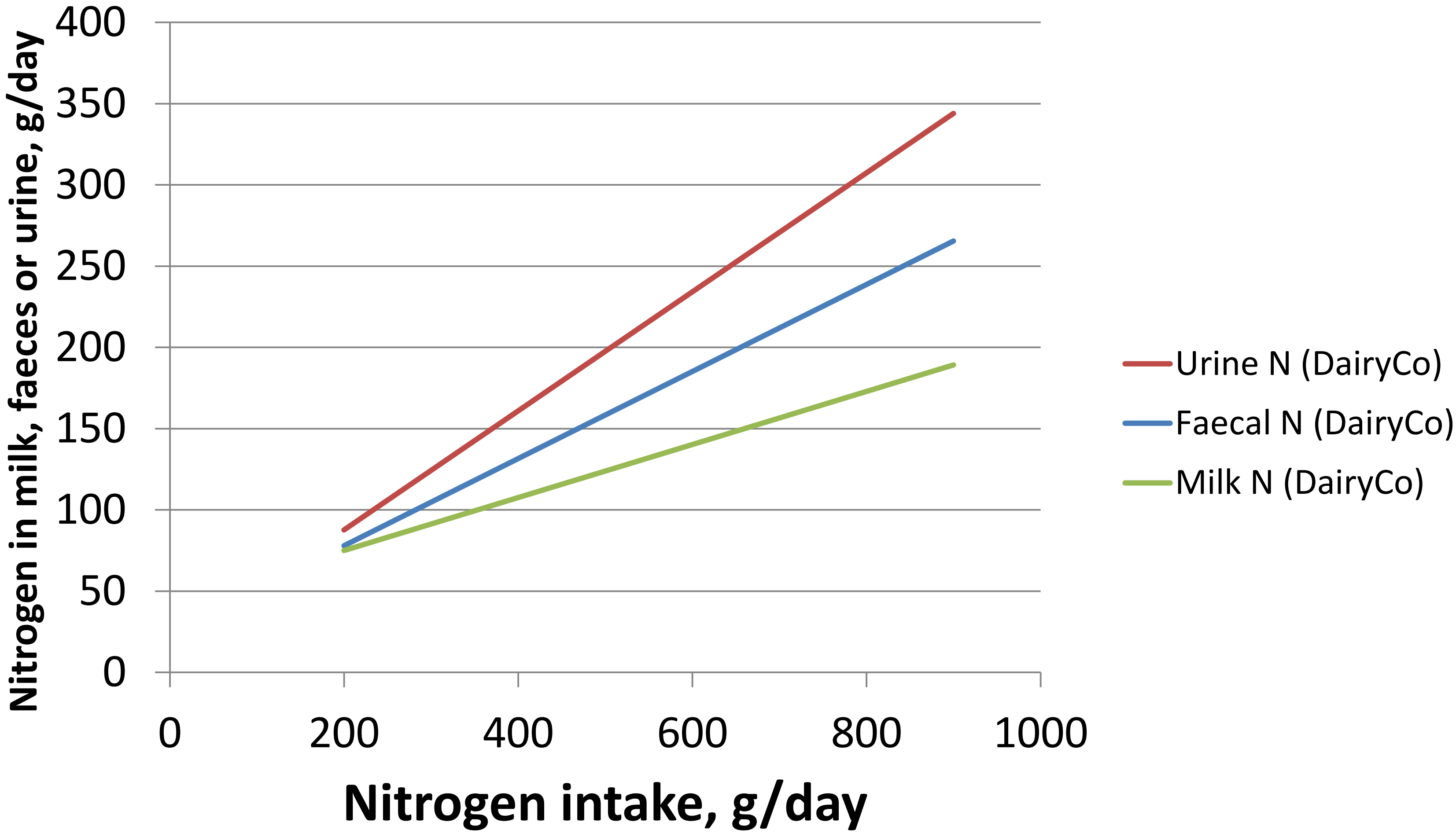
	Milk N efficiency			
	USA (n = 167)		EU (n = 287)	
	Low	High	Low	High
Milk N efficiency	0.22	0.33	0.21	0.32
DM intake (kg/d)	23.2	23.8	17.9	18.9
3.5% FCM (l/d)	31.8	38.2	26.8	31.2
Forage (g/kg DM)	534	526	665	569
Forage CP (g/kg DM)	179	154	200	148

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

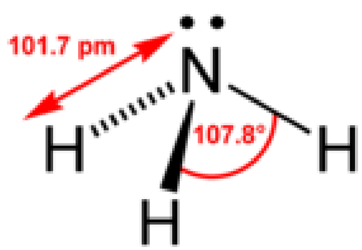
Calsamiglia et al. (2010)

META-ANALYSIS OF N-BALANCE TRIALS



Mills et al. (2009)

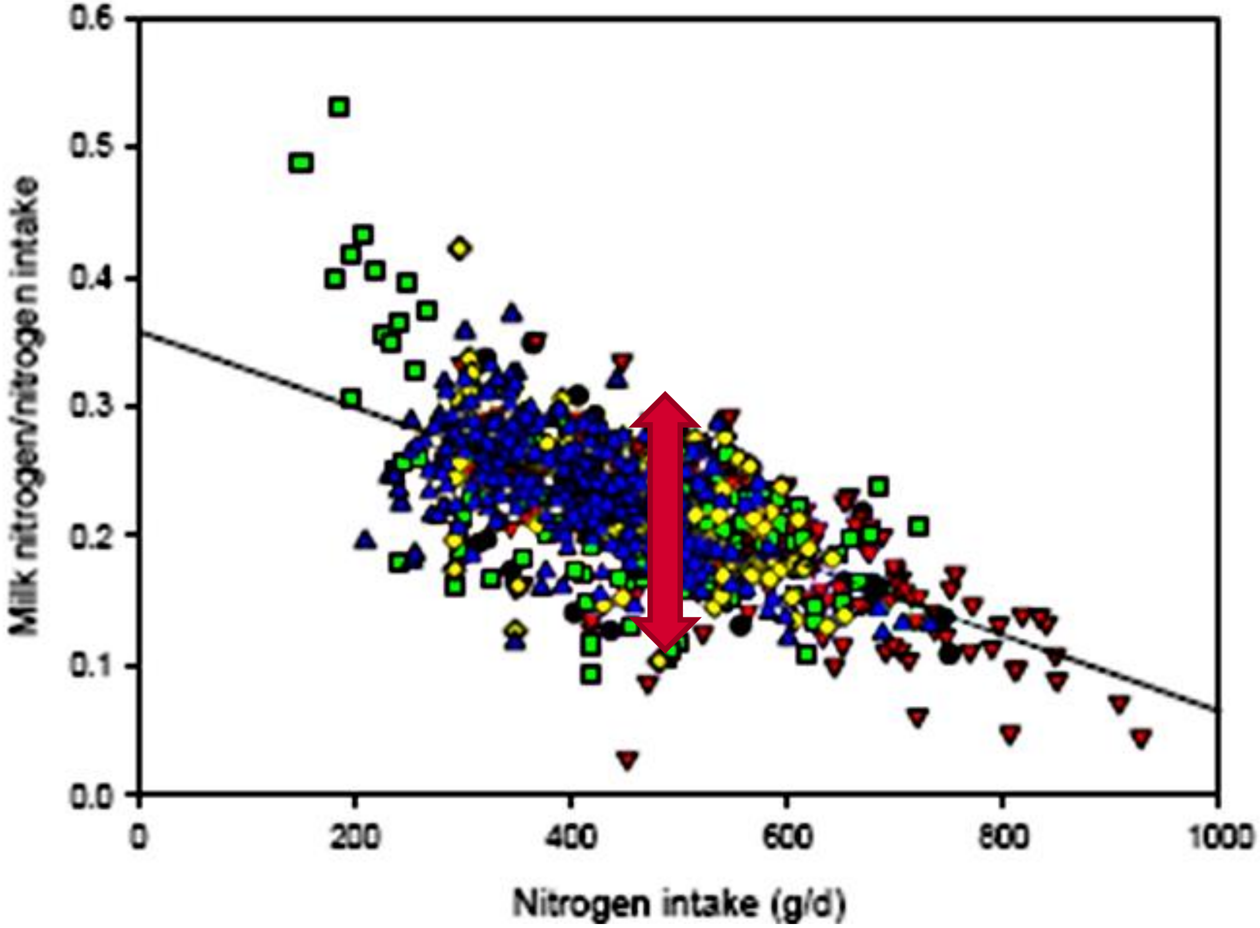
+



Ammonia

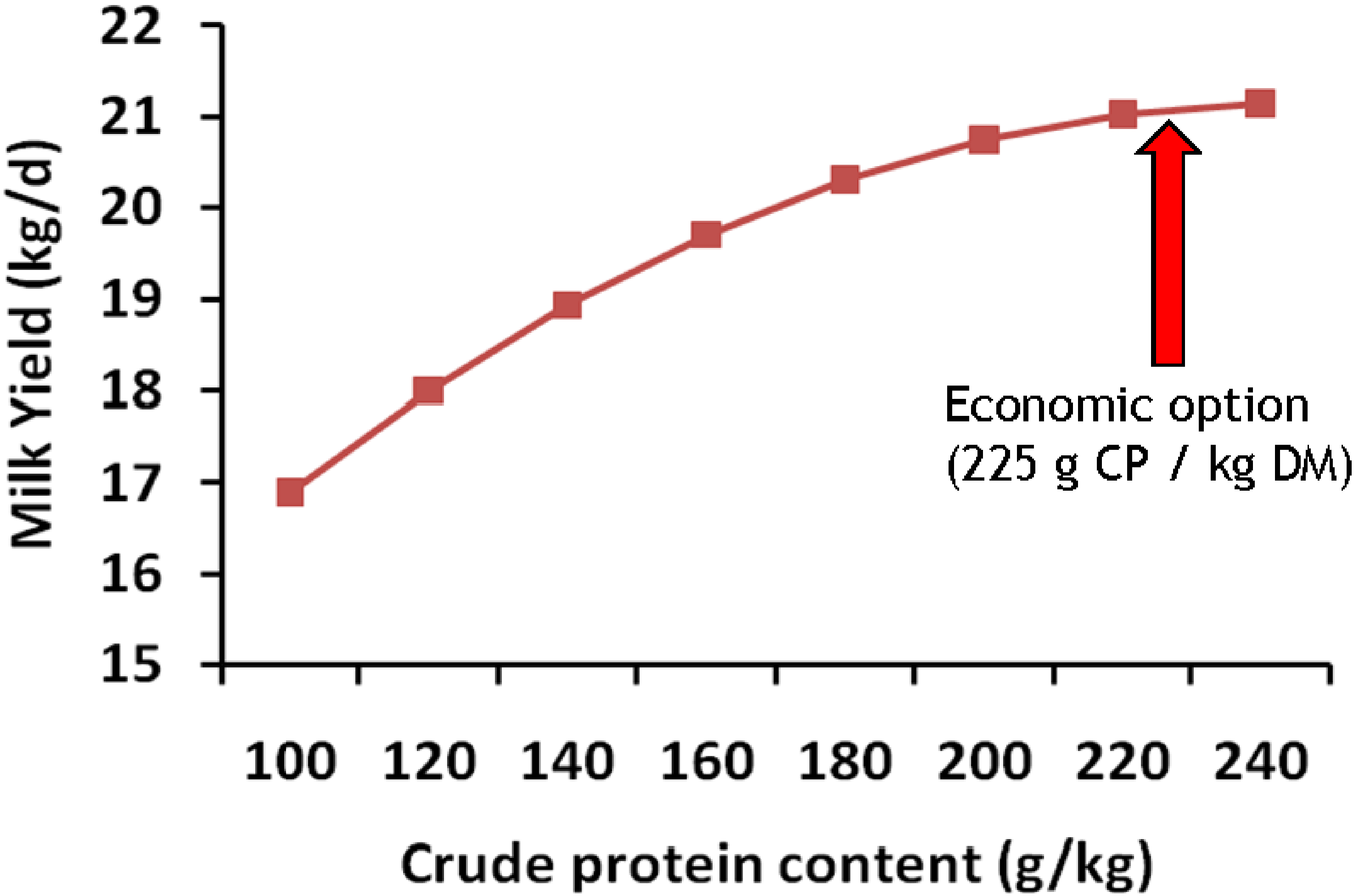
Bill Weiss, OSU

MILK N/INTAKE N VS. N INTAKE



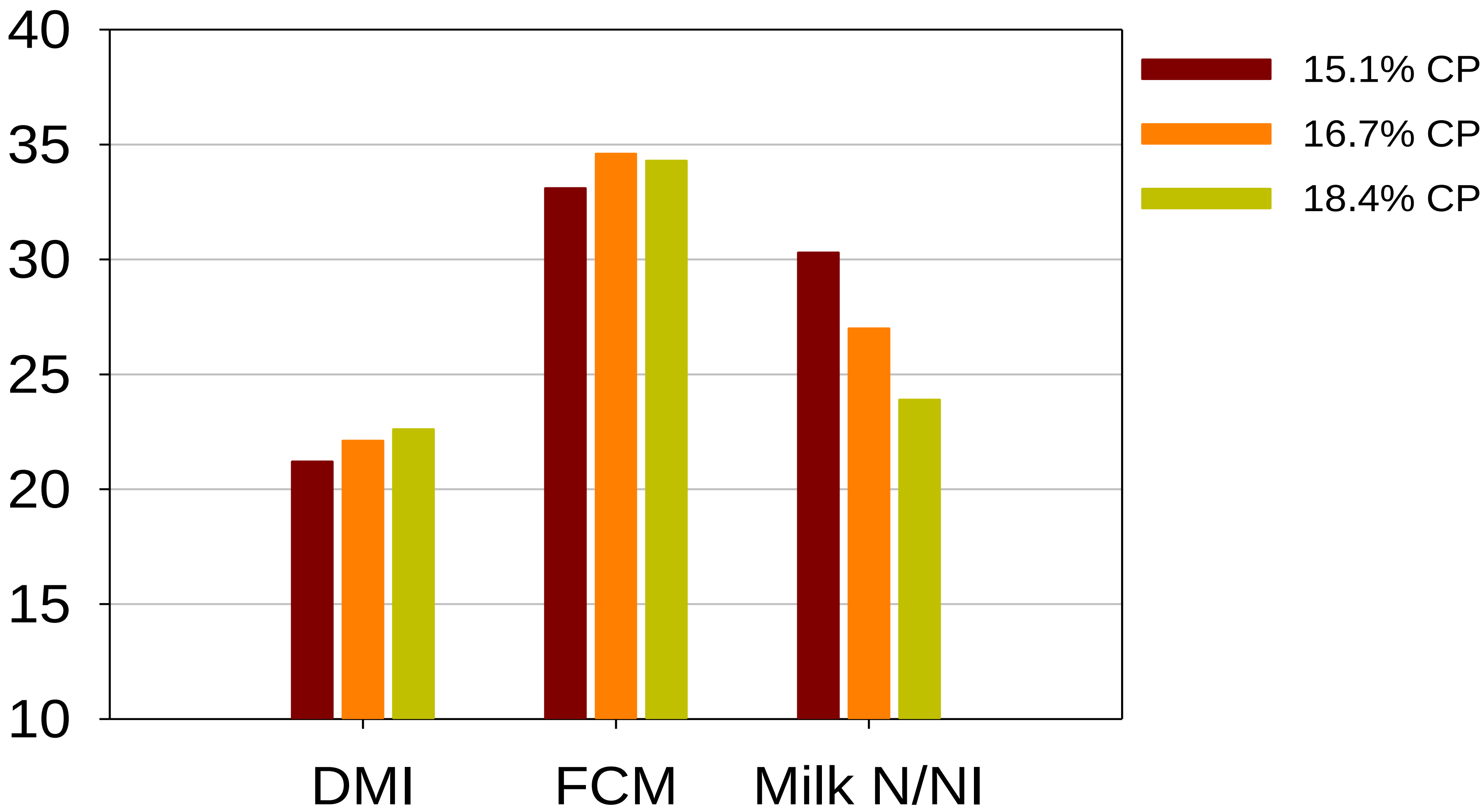
Mills et al. (2009)

Milk Yield Response - Lower Yielding Cows



Gordon & McMurray 1979

EFFECTS OF DIET CRUDE PROTEIN % ON DMI AND FAT CORRECTED MILK YIELD



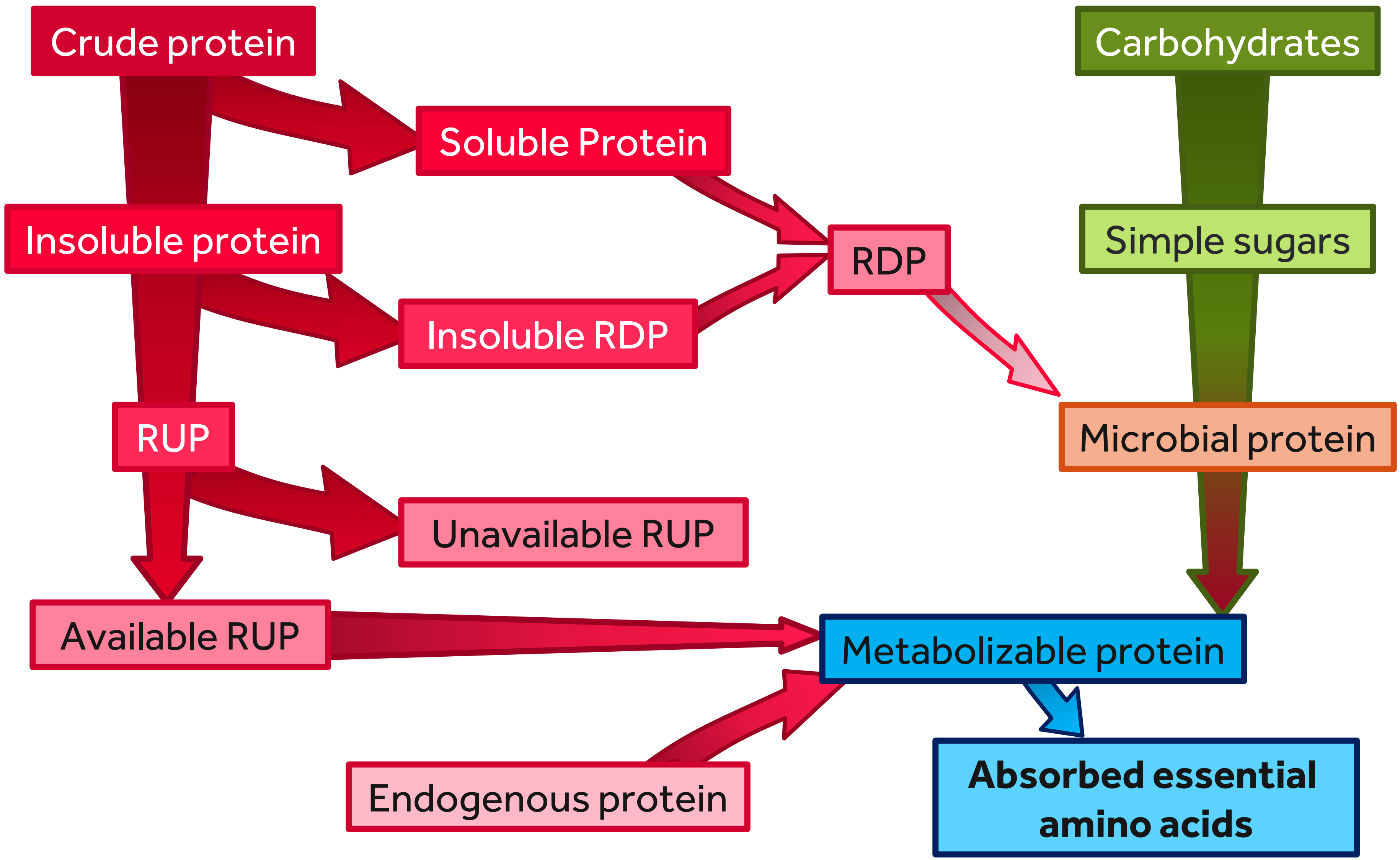
Broderick (2003)

DIETARY PROTEIN CONCENTRATION AND MILK PRODUCTION

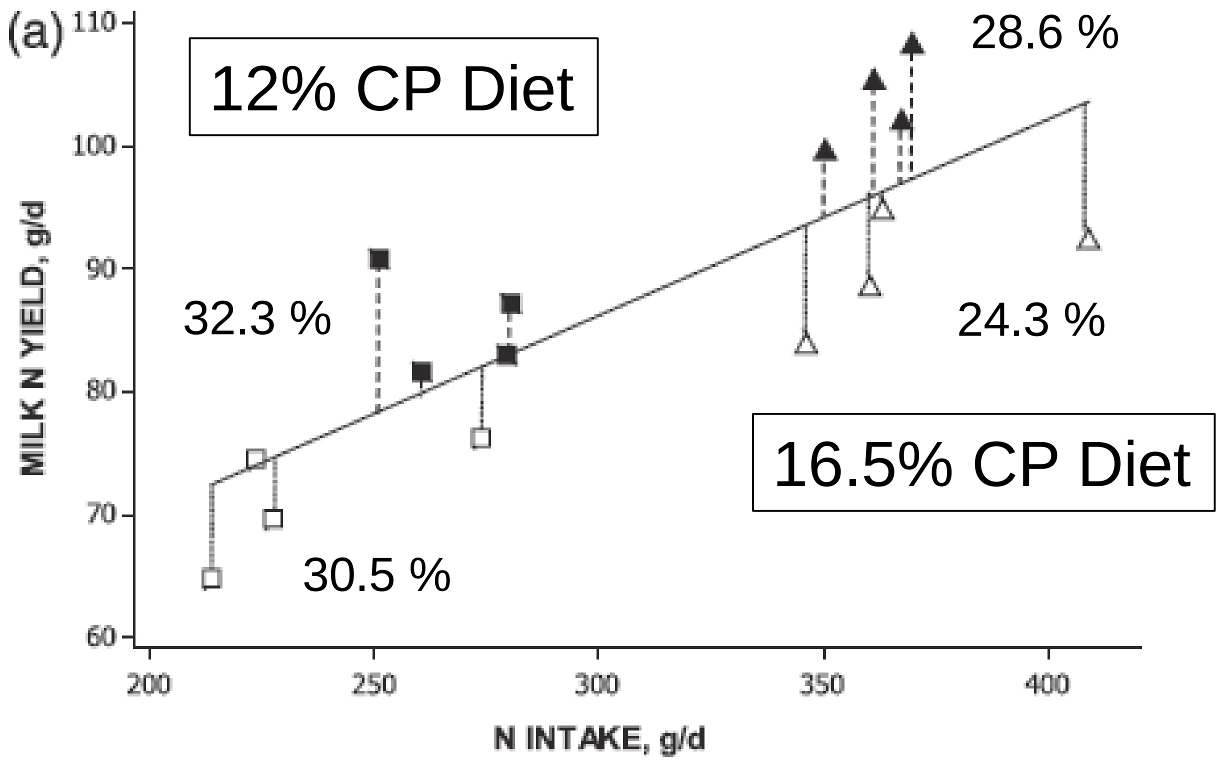
- Olmos Colmenero and Broderick 2006
  - Optimal milk and milk protein yield at 16.5% CP
  - Lucerne/maize silage and high moisture maize grain
  - 48 to 55% NFC!

- Meta-analyses of published data:
  - e.g. NRC, 2001; Huhtanen and Shingfield, 2005; Ipharraguerre and Clark, 2005
  - Maximal milk and milk protein yield at 21-23% CP
  - Maximal digestibility of DM, NDF, etc. at 16.5% CP

MAKING METABOLISABLE PROTEIN



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.*

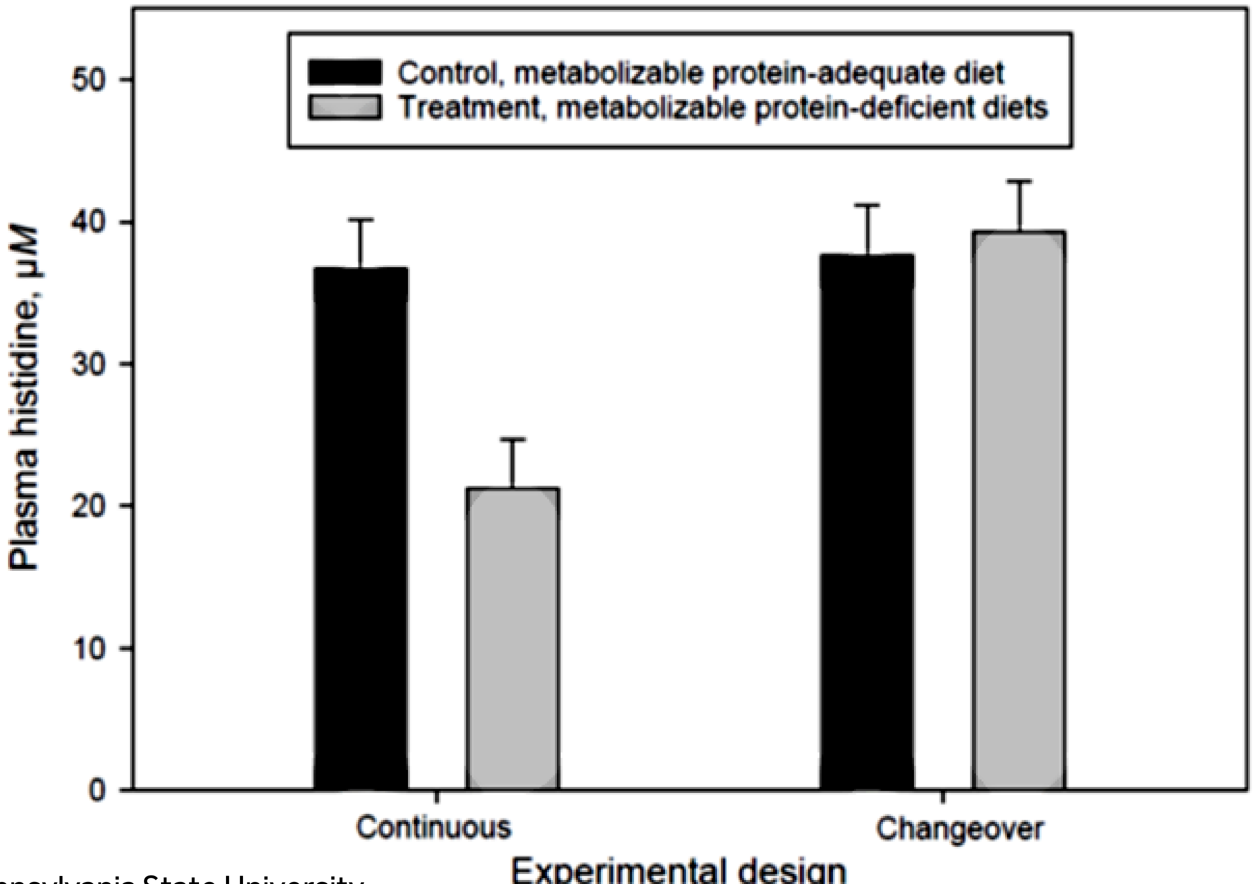
DIETARY PROTEIN AND MILK PRODUCTION

- 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
- Recent 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

- **Long-term studies over an entire lactation(s) lacking**

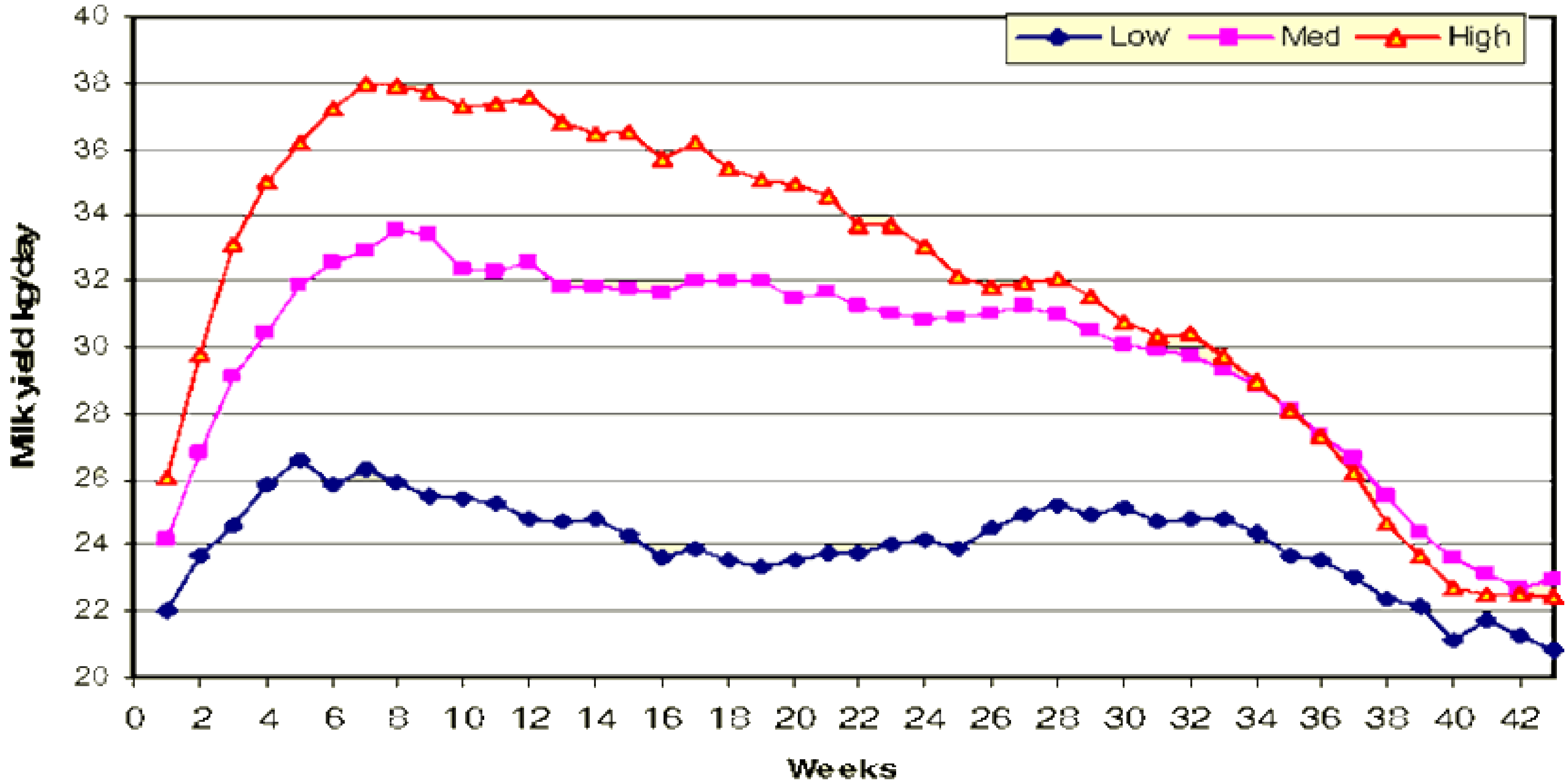
PLASMA HISTIDINE RESPONSE TO A DEFICIT OF MP
CONTINUOUS VS CHANGEOVER DESIGN



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

DIET PROTEIN CONCENTRATION
AFBI STUDY OVER ONE LACTATION

60:40 Grass:maize silage – 12%, 15%, 18% CP diets



305 day yield

High 9653kg **Medium** 9089kg **Low** 7435kg

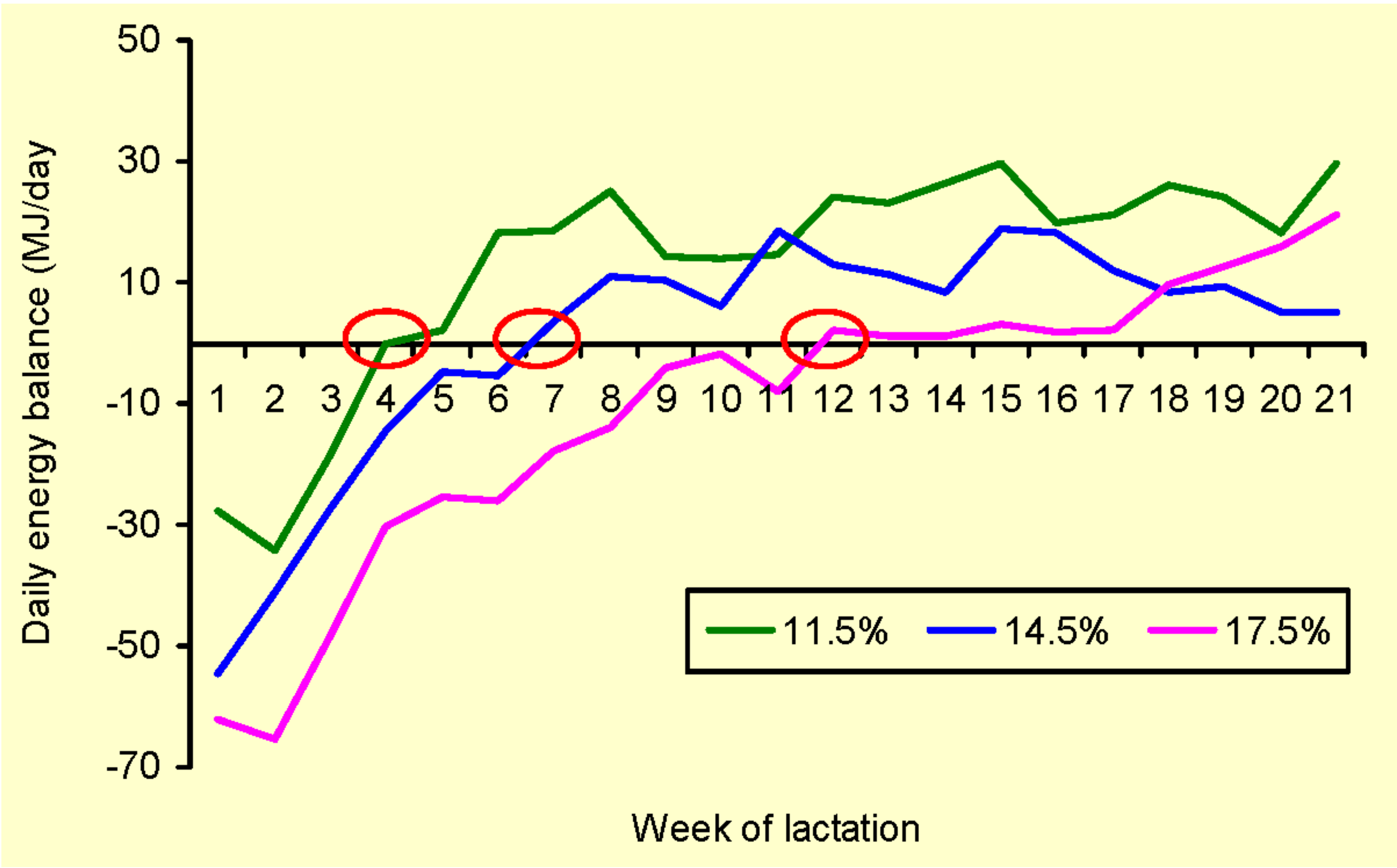
Law et al 2009; 2010

Effects of Diet Protein Concentration - AFBI Study Over One Lactation

	Crude protein content of diet (% DM)			Sig.
	11.5	14.5	17.5	
N intake (g / cow / day)	322	445	562	***
N in milk (g / cow / day)	100	132	144	***
N in manure (g / cow / day)	227	300	380	***
N balance (g / cow / day)	-5	13	38	***
Milk N / N intake (g / g)	0.310	0.297	0.256	***

Law et al 2009; 2010

Effects of Diet Protein Concentration - AFBI Study Over One Lactation



Law et al 2009; 2010

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 altering diet composition?
  - Energy source, essential amino acid balance etc

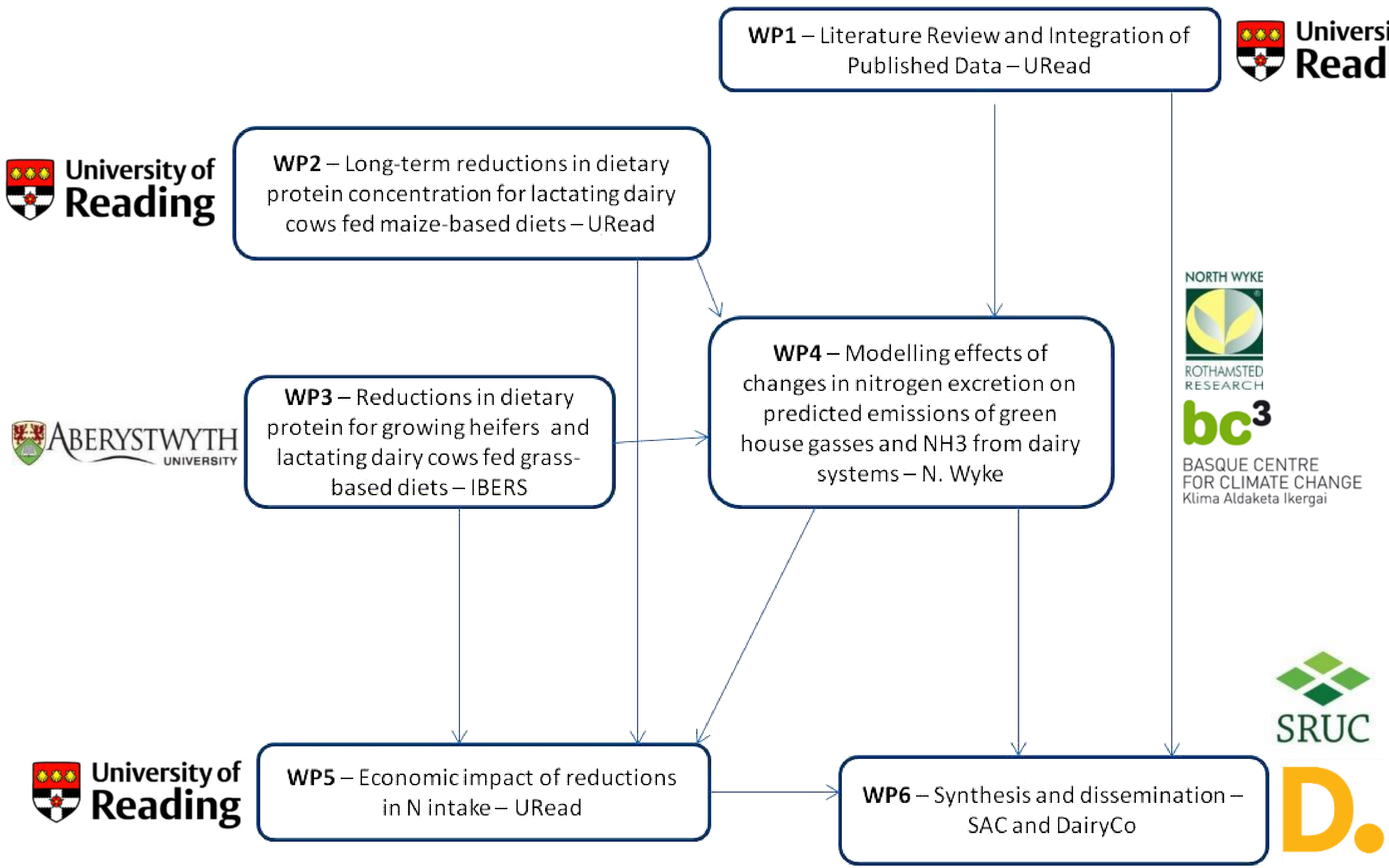
EFFICIENCY OF DIETARY N UTILIZATION FOR MILK PROTEIN PRODUCTION

Long term effects???? Defra AC0122

Reading, IBERS, SRUC, Rothamsted

Similar maize silage based diets
215 heifers – 3 lactations
7 year project

DEFRA PROJECT AC0122
WORK PACKAGES



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 at Cedar enrolled at calving
- Fed one of 3 diets – Low 14%, Med 16% and High 18% crude protein
- Treatments maintained for 3 lactations
- Managed as for commercial herd except:
  - No grazing and 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 - CEDAR LACTATION TRIAL

- First heifer enrolled February 2013
- Enrolment completed 26 September 2014
  - 20 months to enrol 215 heifers
- Last cow lactation completed November 2017
- Cows completing each 305 day lactation:

  Lactation 1 completed (207 of 215)

  Lactation 2 completed (164 of 179)

  Lactation 3 completed (116 of 132)

AC0122 - WP2 LACTATION TRIAL

University of Reading

Measurements:

- Daily milk yield – weekly milk composition
- Daily feed intakes – feed conversion efficiency
  - Feed composition measured monthly
  - Diet nitrogen composition closely monitored
    - Weekly Kjeldahl analysis in house
- Digestion trials weeks 6, 20, 34
    - 4 cows per treatment
    - faecal and urine nitrogen (and urea) excretion

AC0122 – LACTATION TRIAL

University of Reading

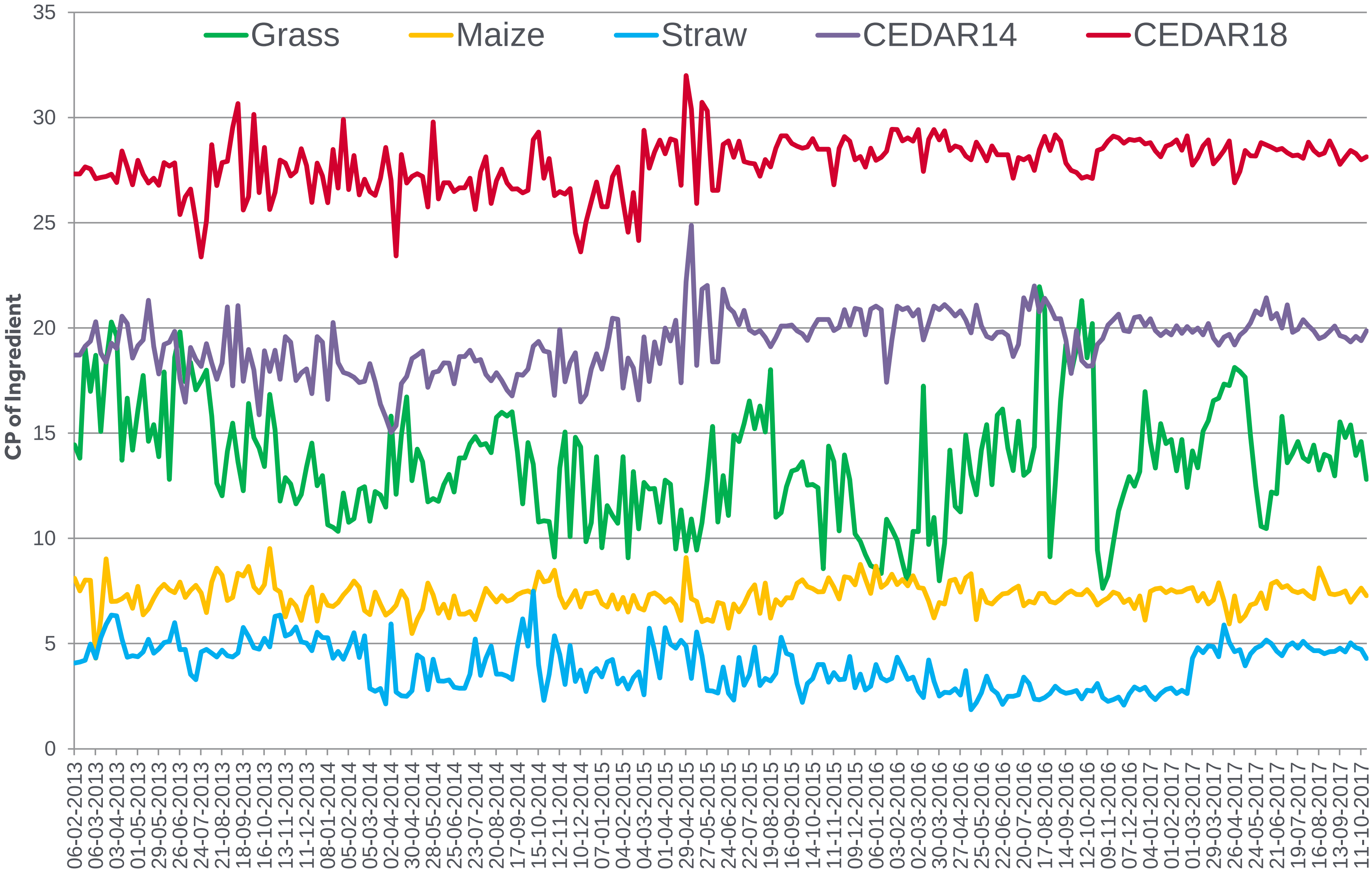
TWO CONCENTRATE BLENDS

	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

	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



TMR CP VARIATION (UNADJUSTED)

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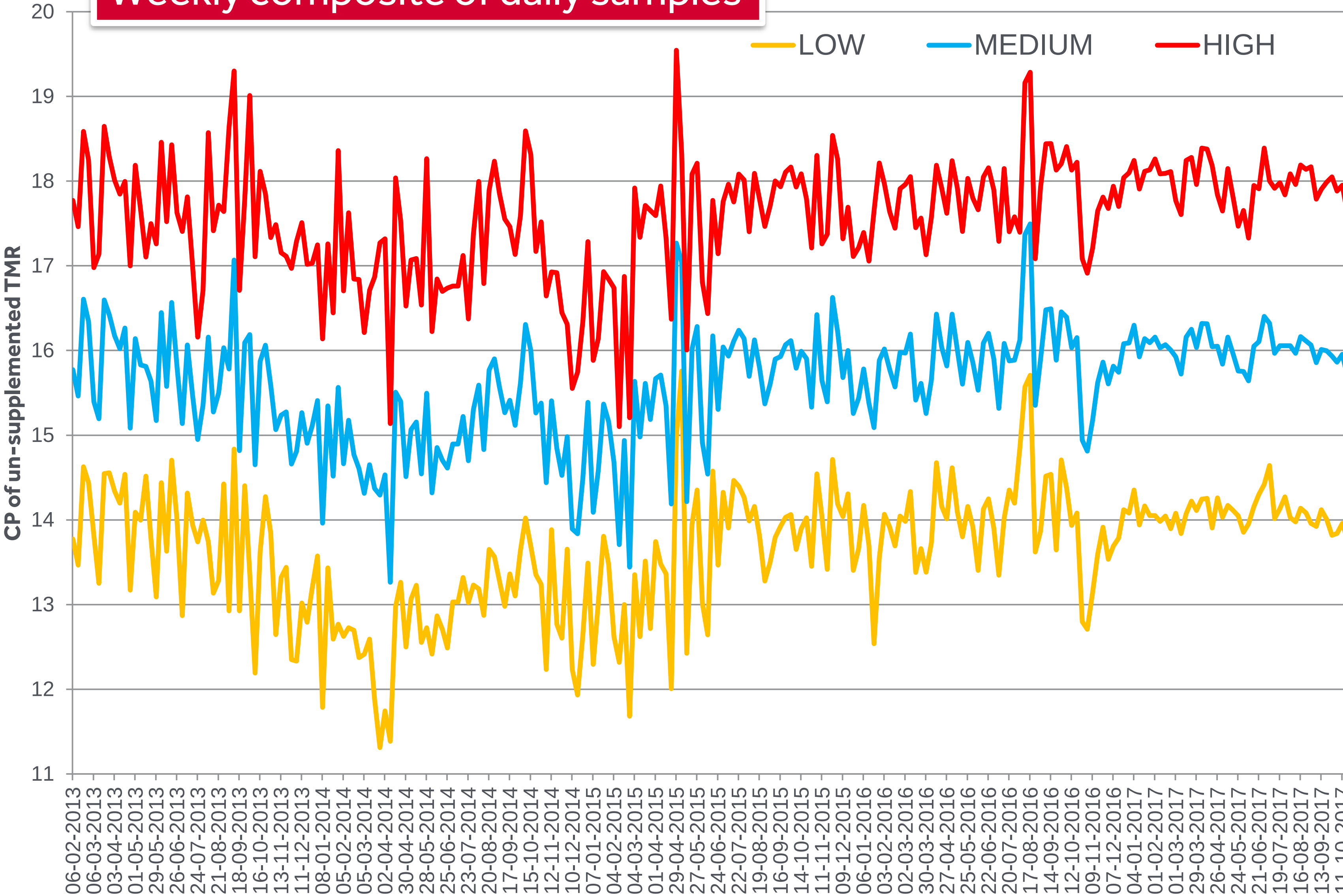
Weekly composite of daily samples



TMR CP VARIATION (ADJUSTED)

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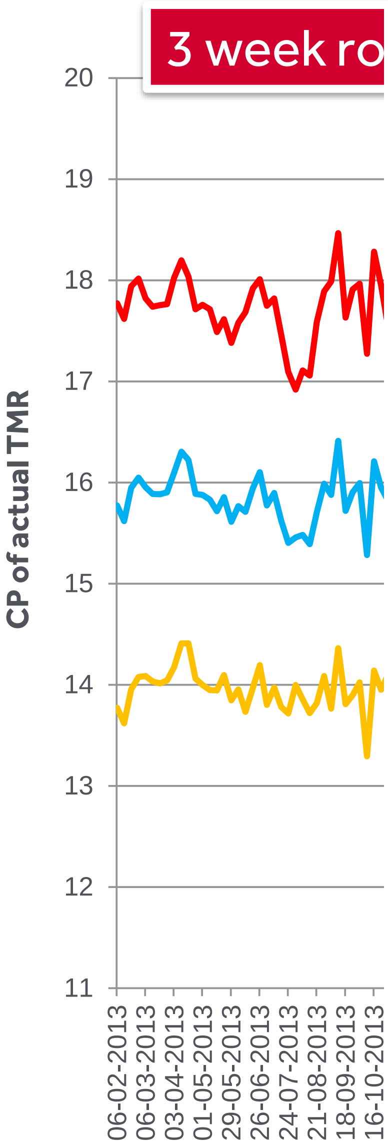
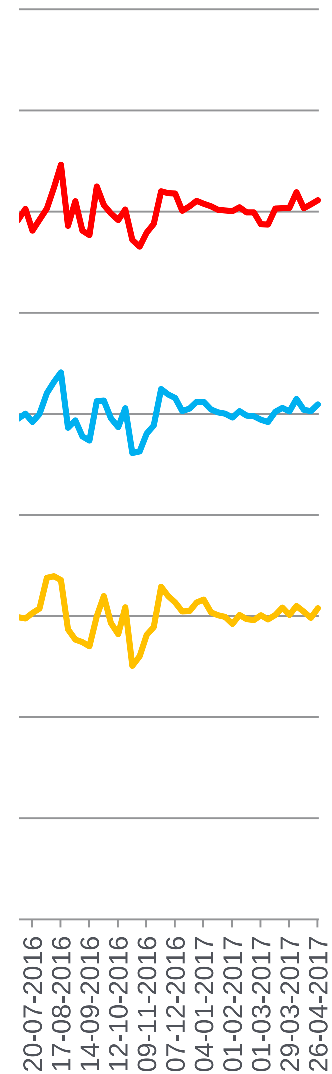


0342 Effects of oscillating the crude protein content in dairy cow rations. A. N. Brown*[1] and W. P. Weiss[2], *[1]The Ohio State University, Wooster, [2]Department of Animal Sciences, The Ohio State University, Wooster.*

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

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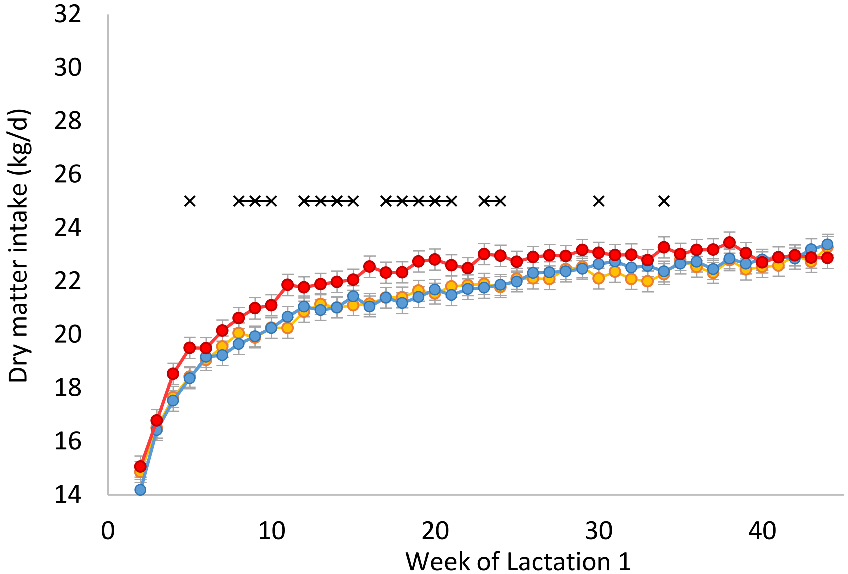
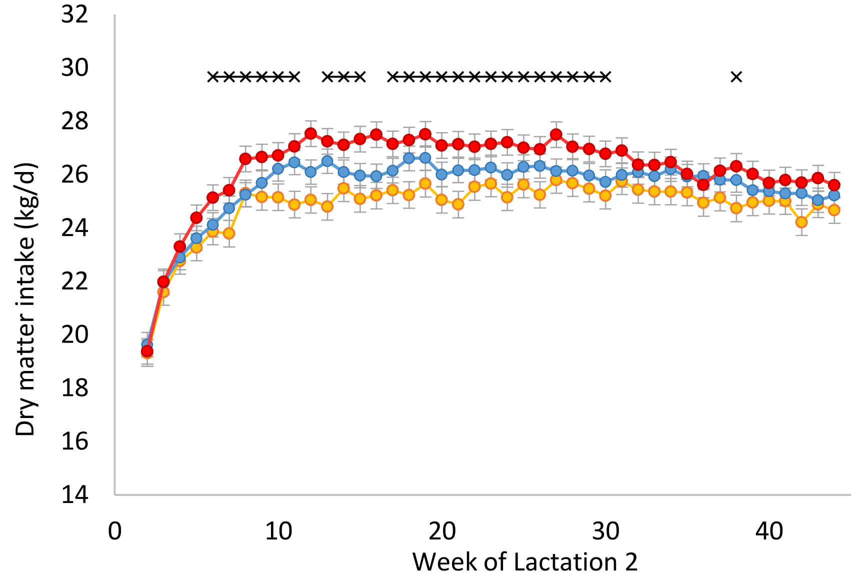
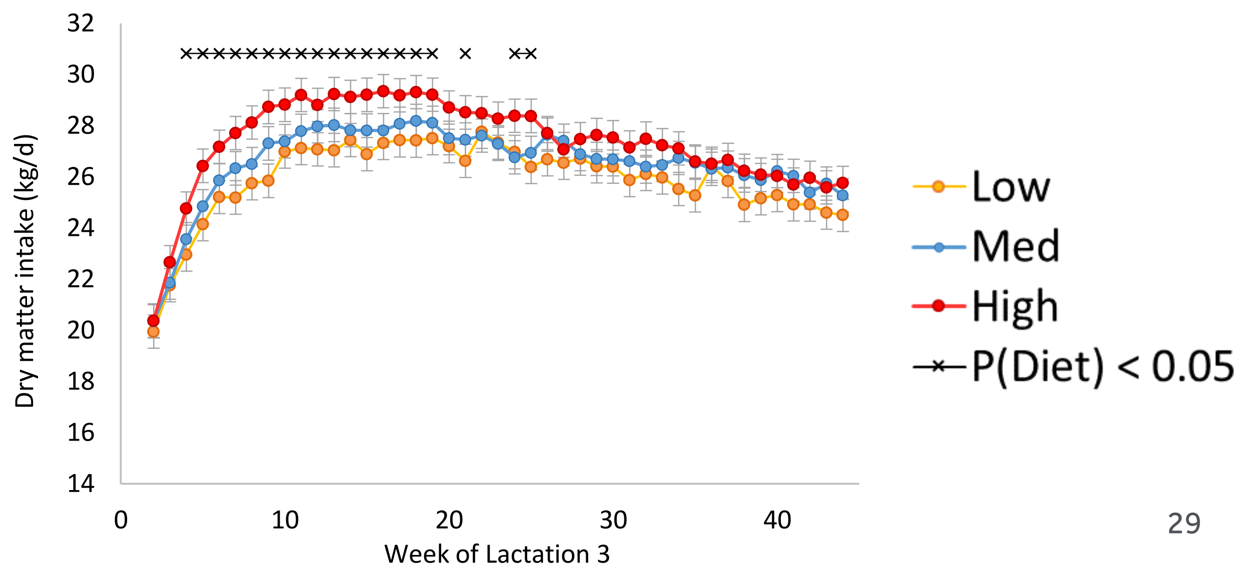




	Low	Med	High
Lac 1	21.3[b]	21.3[b]	22.0[a]
Lac 2	24.8[b]	25.5[ab]	26.2[a]
Lac 3	25.9[c]	26.5[b]	27.3[a]



MILK YIELD

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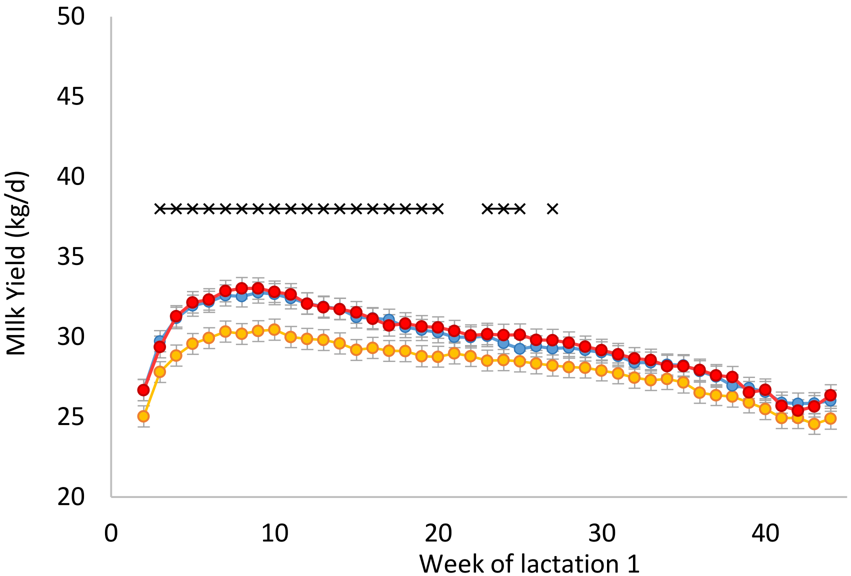
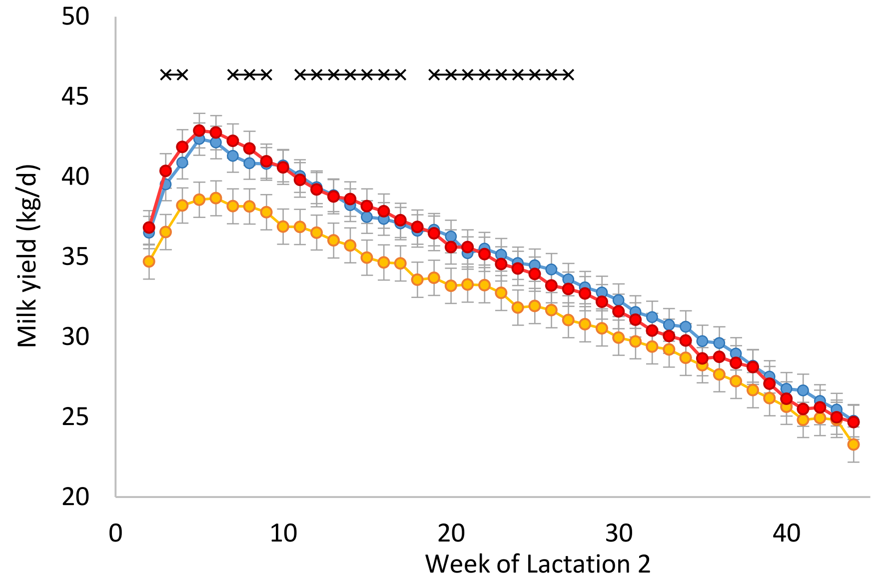
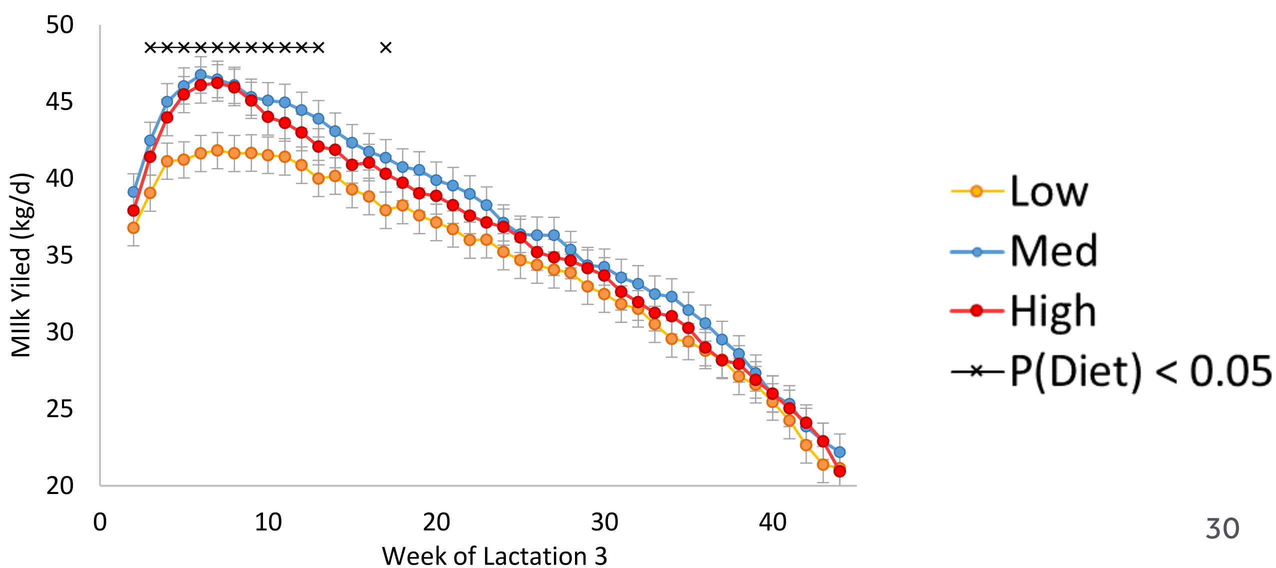


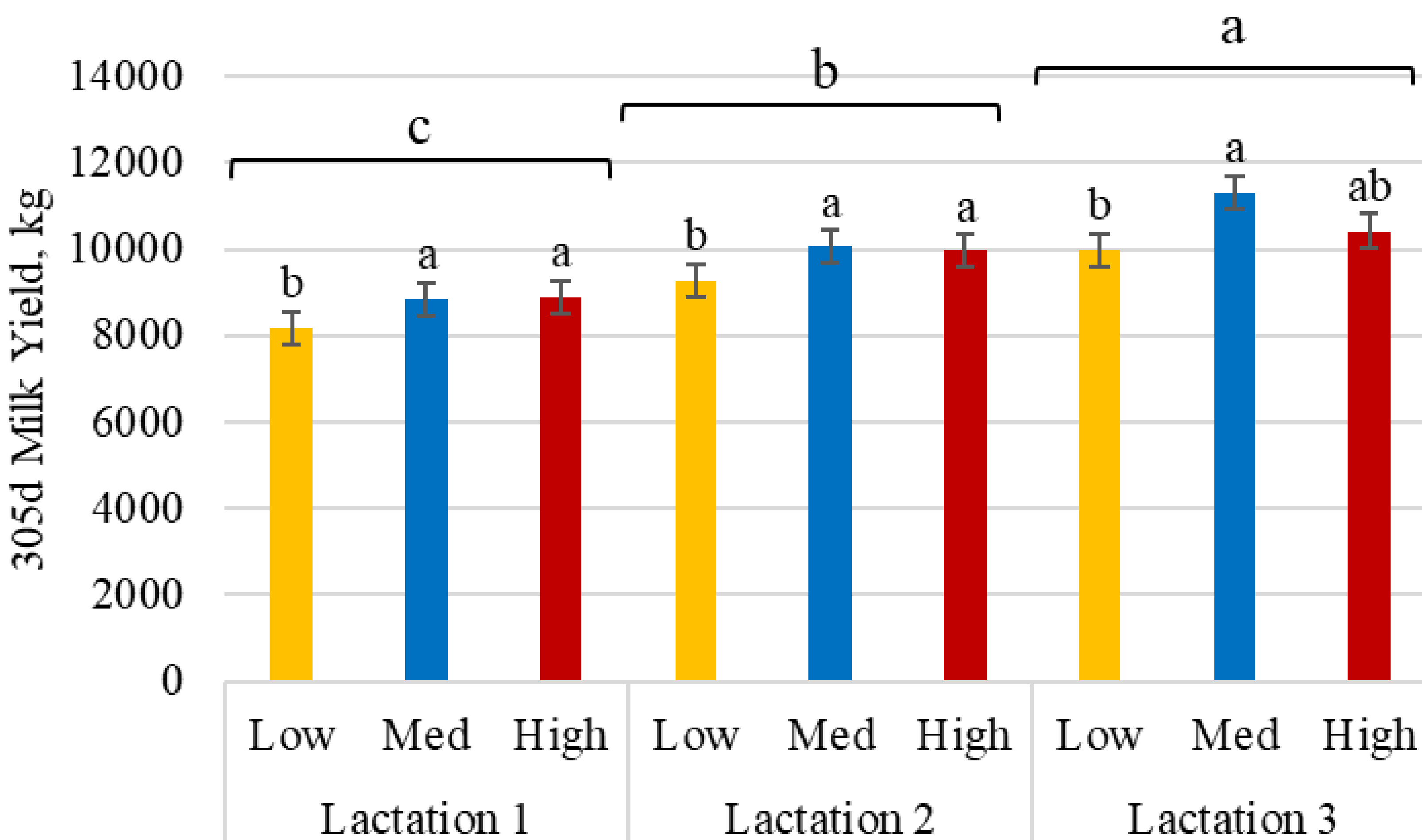


	Low	Med	High
Lac 1	28.1[b]	29.6[a]	29.7[a]
Lac 2	32.1[b]	34.5[a]	34.3[a]
Lac 3	34.5[b]	37.0[a]	36.1[ab]



305 DAY MILK YIELD

University of Reading



MILK PROTEIN YIELD

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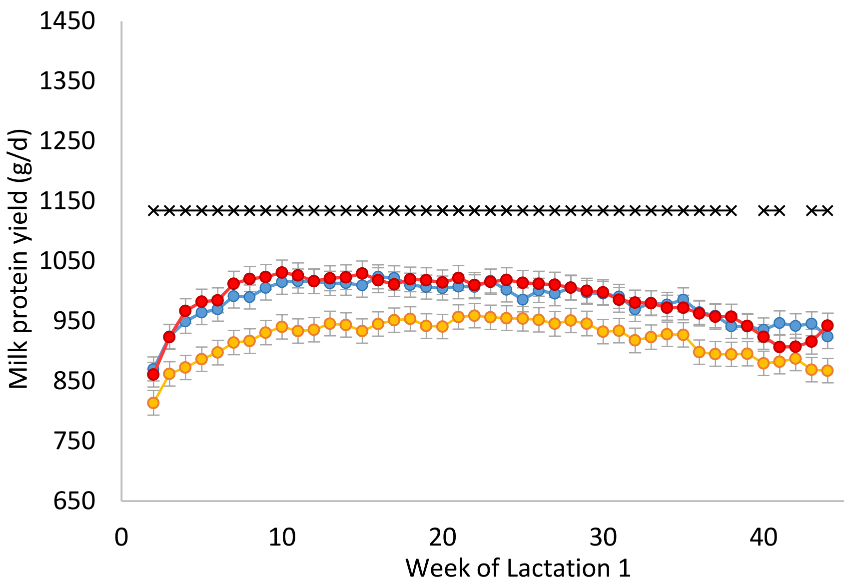
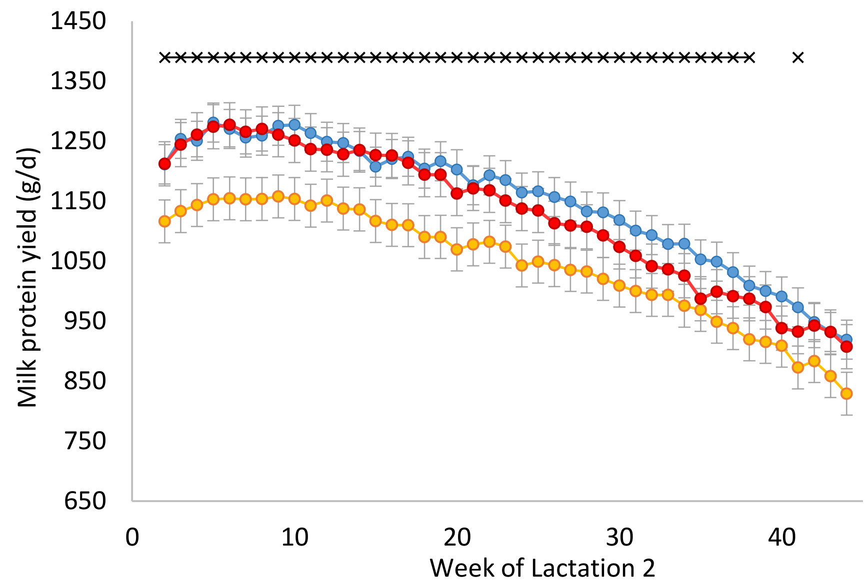
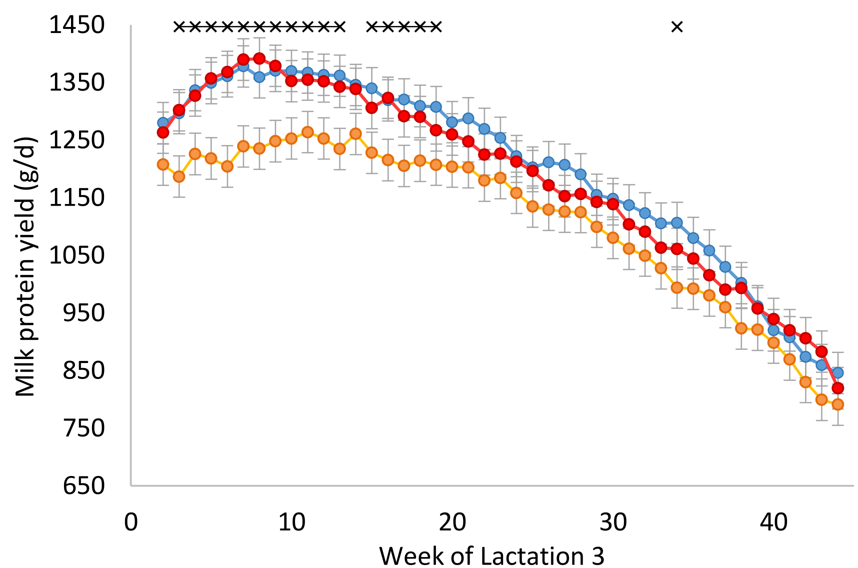
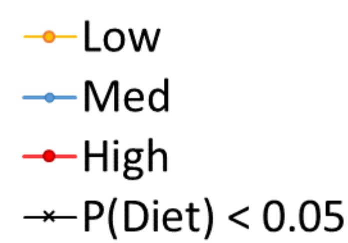


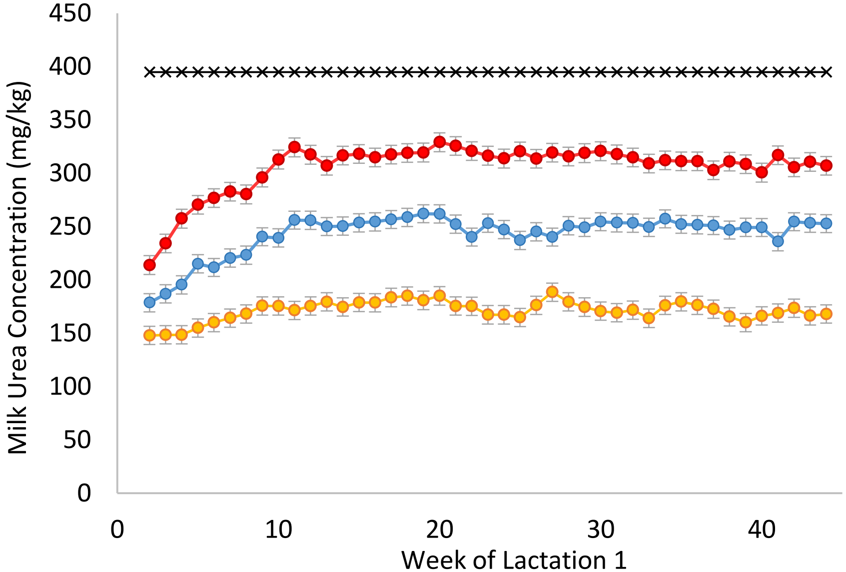


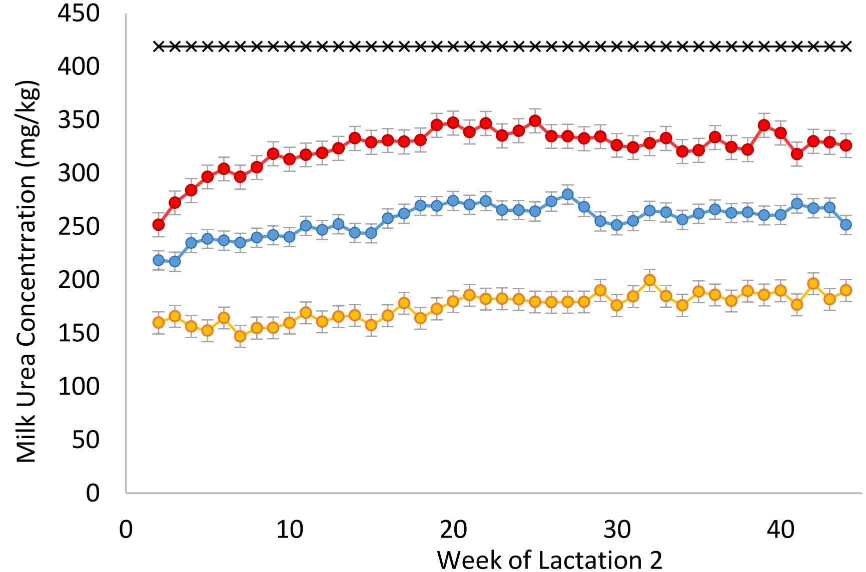
	Low	Med	High
Lac 1	920[b]	982[a]	986[a]
Lac 2	1045[b]	1150[a]	1127[a]
Lac 3	1112[b]	1199[a]	1184[a]



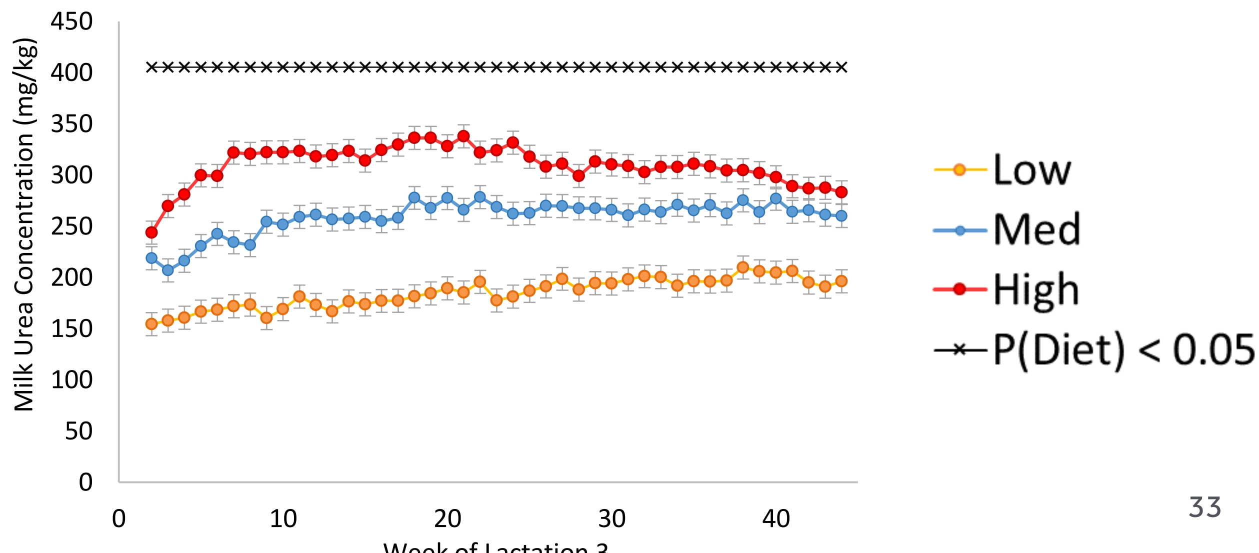


MILK UREA CONCENTRATION





	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}



NITROGEN USE EFFICIENCY

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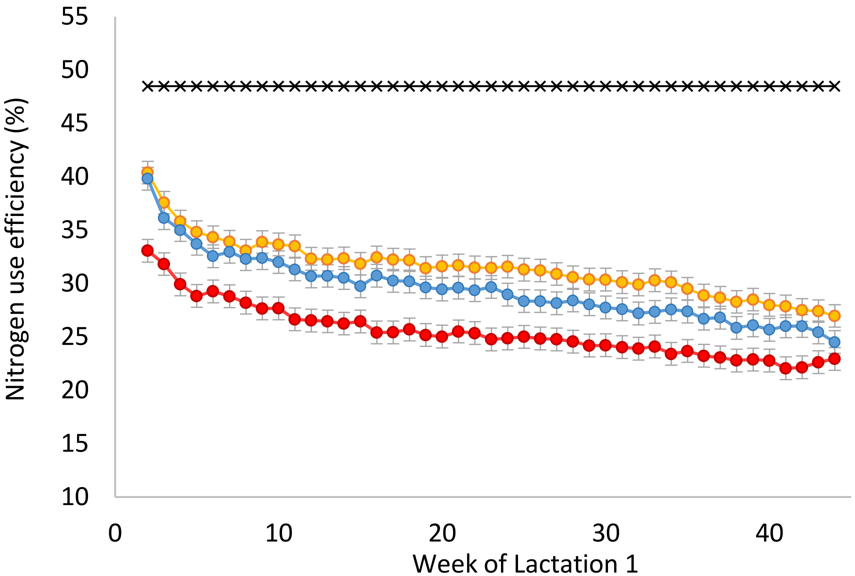
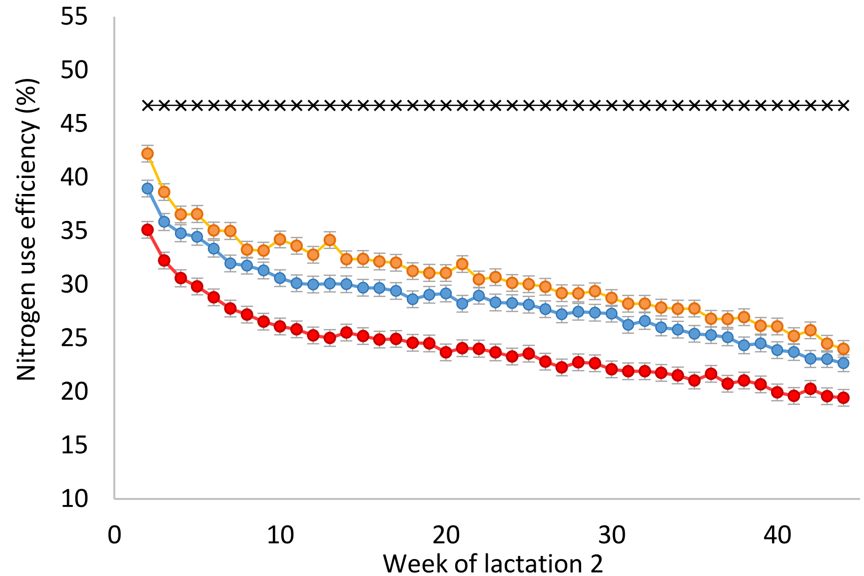
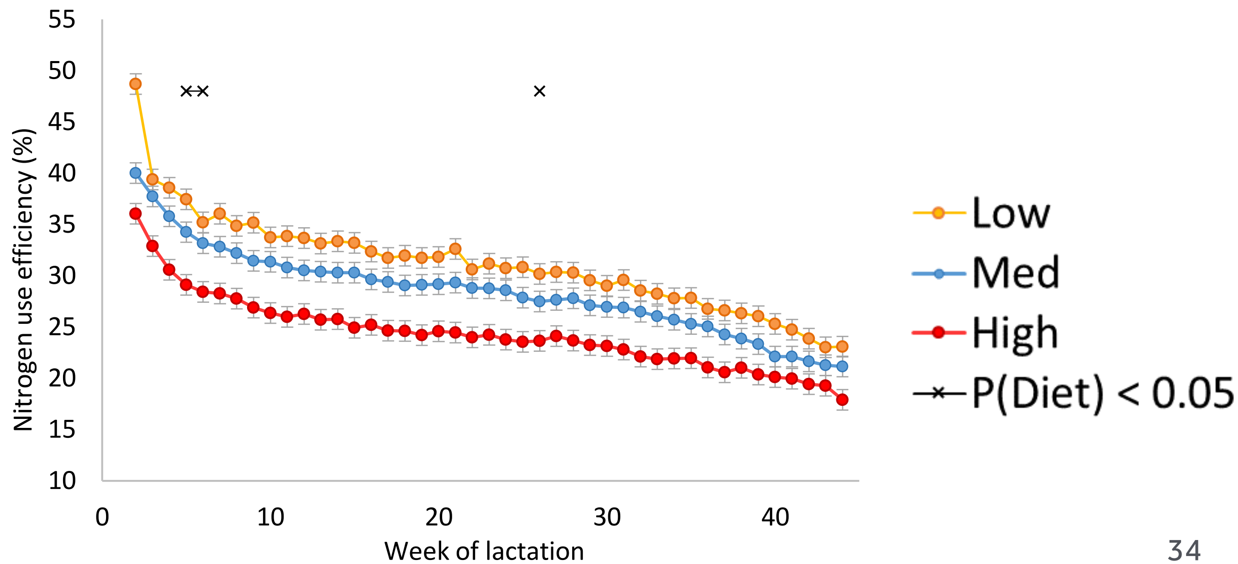




	Low	Med	High
Lac 1	31.5[a]	29.5[b]	25.5[c]
Lac 2	30.7[a]	28.4[b]	24.1[c]
Lac 3	31.1[a]	28.4[b]	24.3[c]



FEED EFFICIENCY

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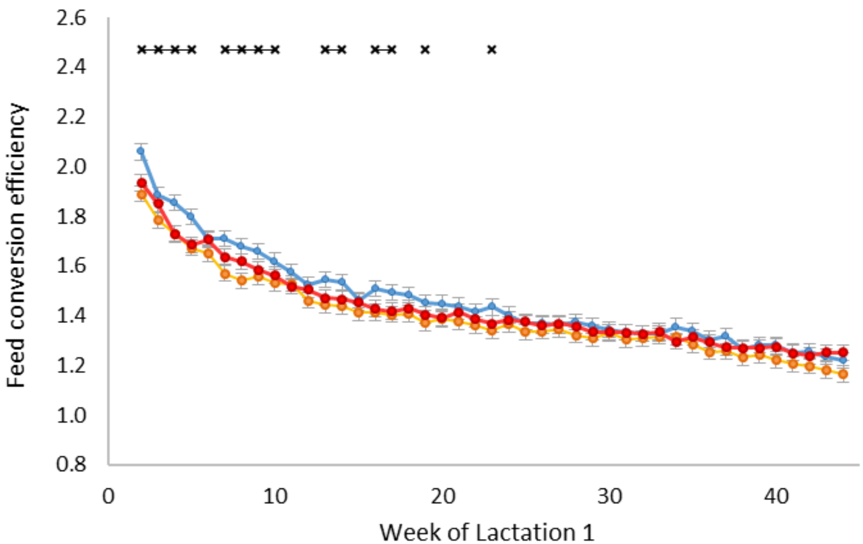
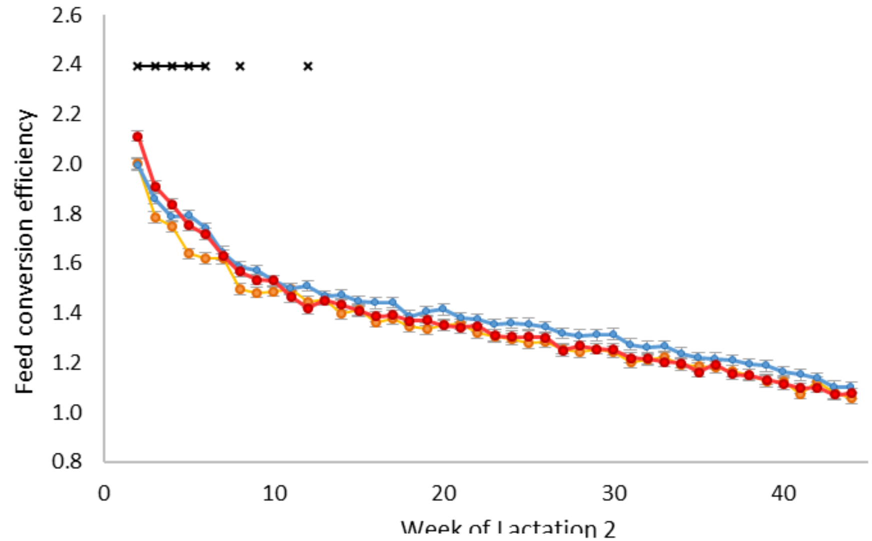
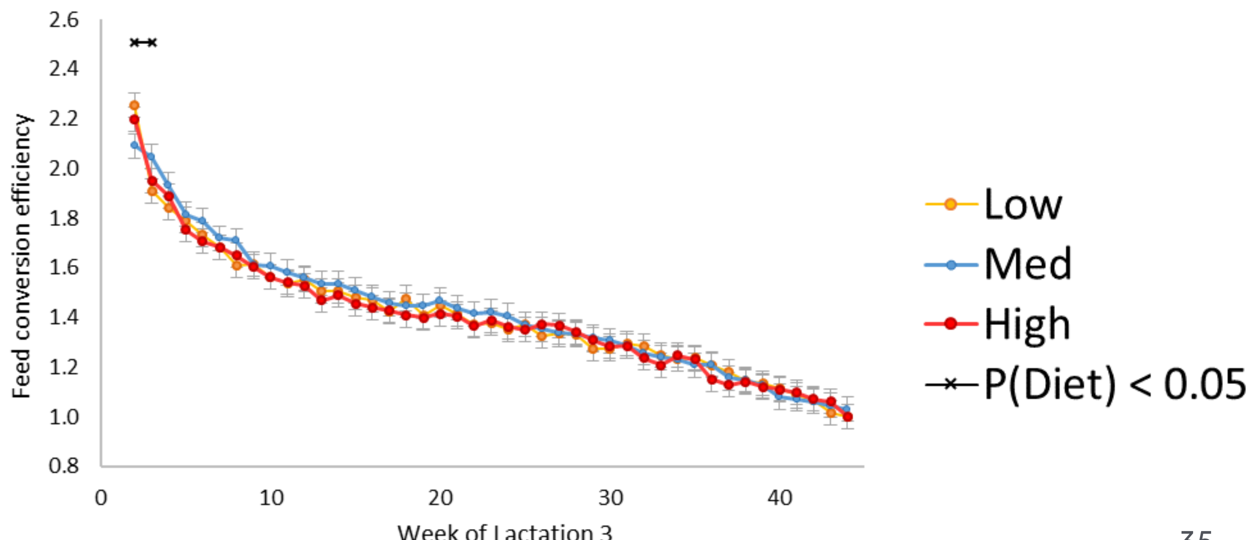




	Low	Med	High
Lac 1	1.40[a]	1.46[b]	1.43[ab]
Lac 2	1.34[a]	1.40[b]	1.36[ab]
Lac 3	1.41	1.42	1.40



URINARY N

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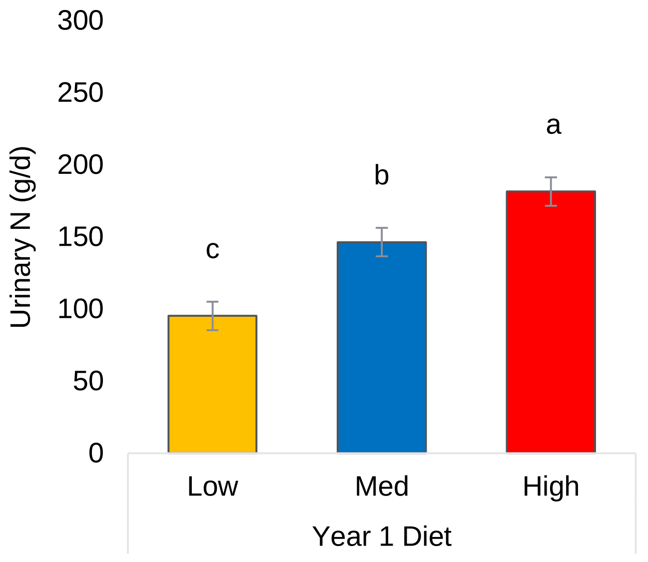

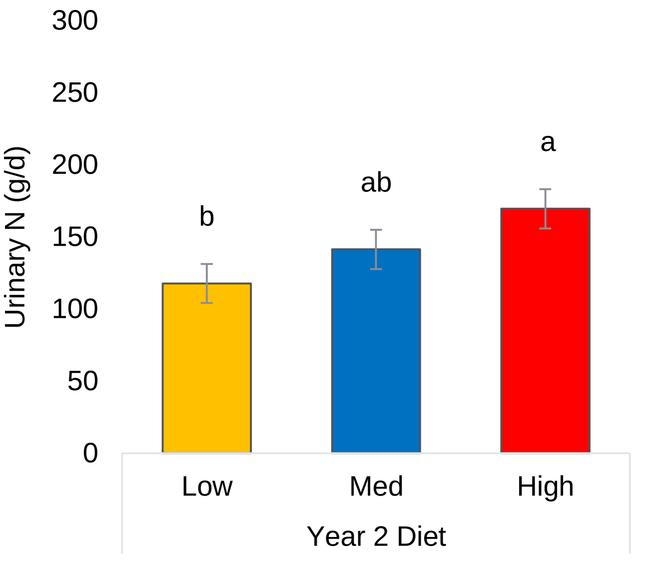

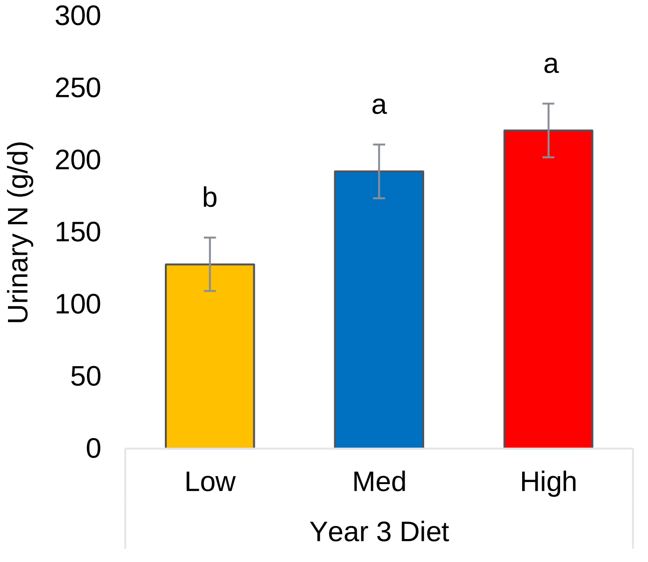

SLURRY AMMONIA EMISSION

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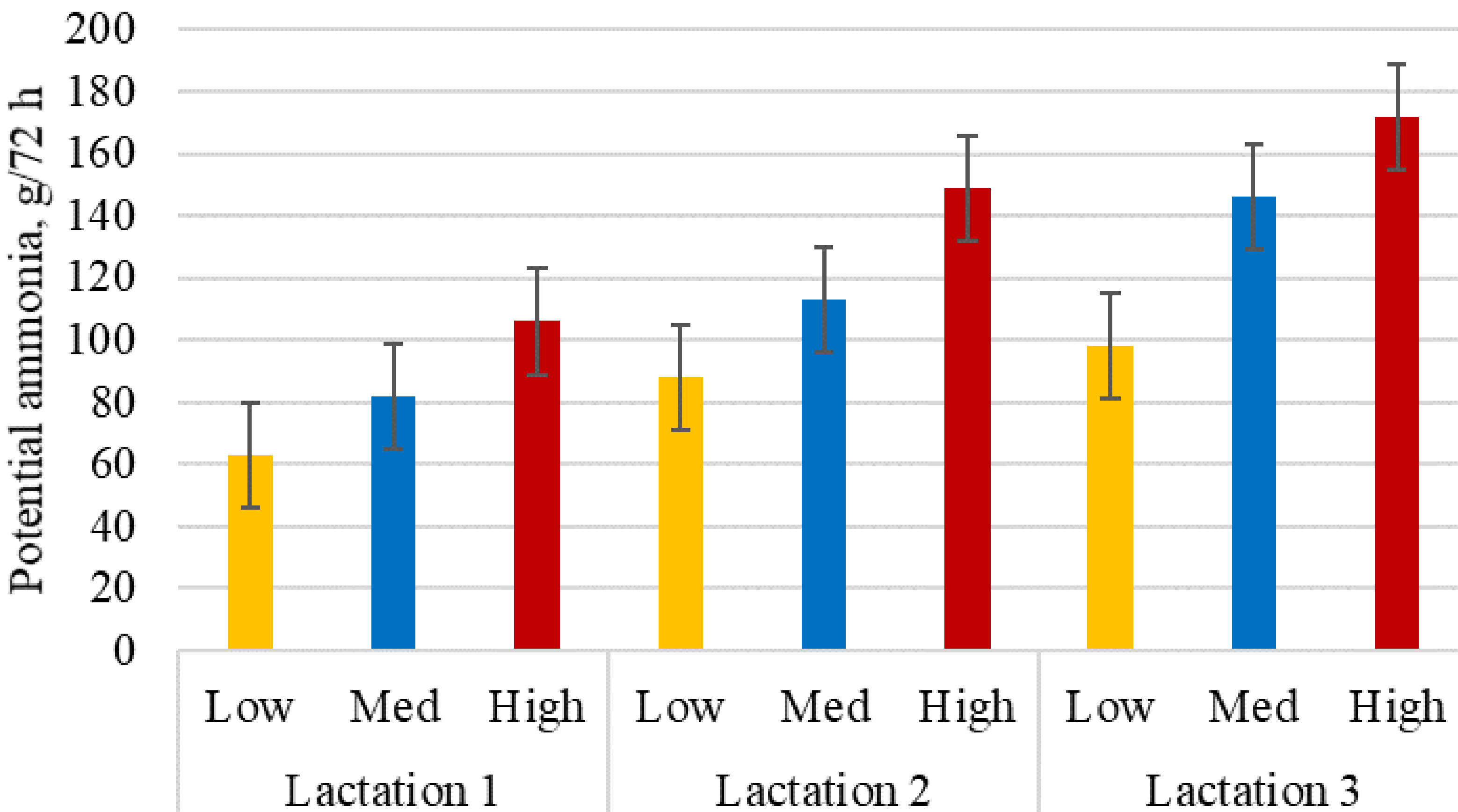

Potential 3 day emission from daily manure excretion

CONCLUSIONS – CEDAR TRIAL

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- Lower protein diets more 'N efficient' but need to consider longer term effects at systems level
  - Economic and environmental implications
- Large variation in diet protein concentrations
  - Implications for precision feeding lower protein diets
- For this study, the 16% crude protein diet was 'optimal' for production - this was by design
- Long-term effects of 'sub-optimal' or excess protein supply need to be assessed (next talk!)

SOME TAKE HOME MESSAGES

University of Reading

- Economic and environmental pressure to reduce dietary protein inputs (especially imported feed proteins)
  - Less environmental impact
  - Risk of reduced milk yield
- Lower protein diets more 'N efficient' ….

  but need to consider longer term effects at systems level
  - Energy supply key to maximum N use efficiency
- Precision feeding lower protein diets – challenges of variations in feed composition – cows very resilient – long term average important
- The longer term effects of 'sub-optimal' metabolizable protein supply must be assessed relative to the benefits

Department for Environment Food & Rural Affairs

University of Reading

THANK YOU!

@UniRdg_SAPD

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www.reading.ac.uk/protein-efficiency

DEFRA Project ACO122

USING FEED PROTEIN MORE EFFICIENTLY AND REDUCING ENVIRONMENTAL IMPACTS OF DAIRY PRODUCTION SYSTEMS - LONG TERM RESPONSES TO LOWER PROTEIN DIETS

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DIET PROTEIN CONCENTRATION
AFBI STUDY OVER ONE LACTATION

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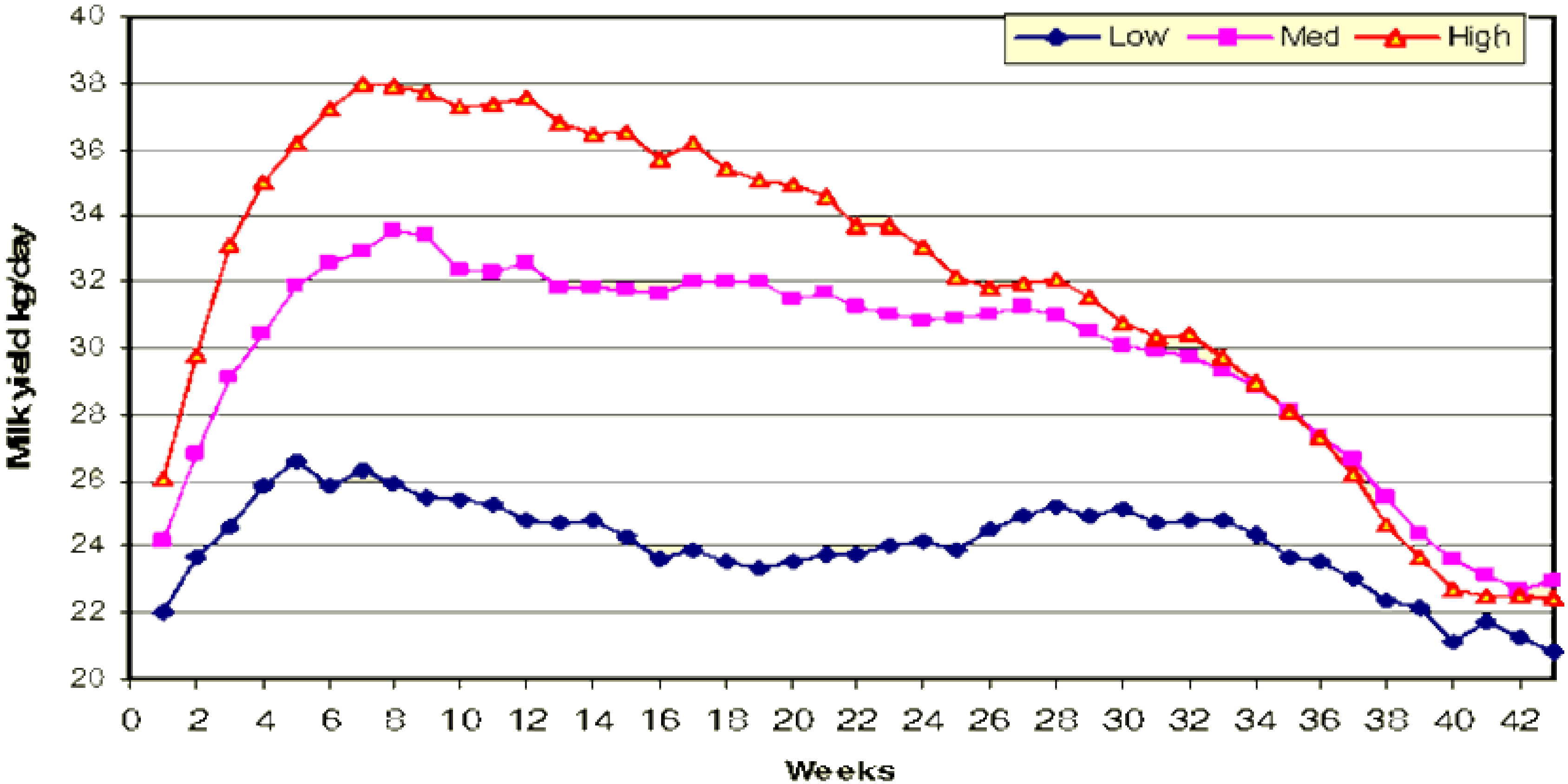
60:40 Grass:maize silage – 12%, 15%, 18% CP diets

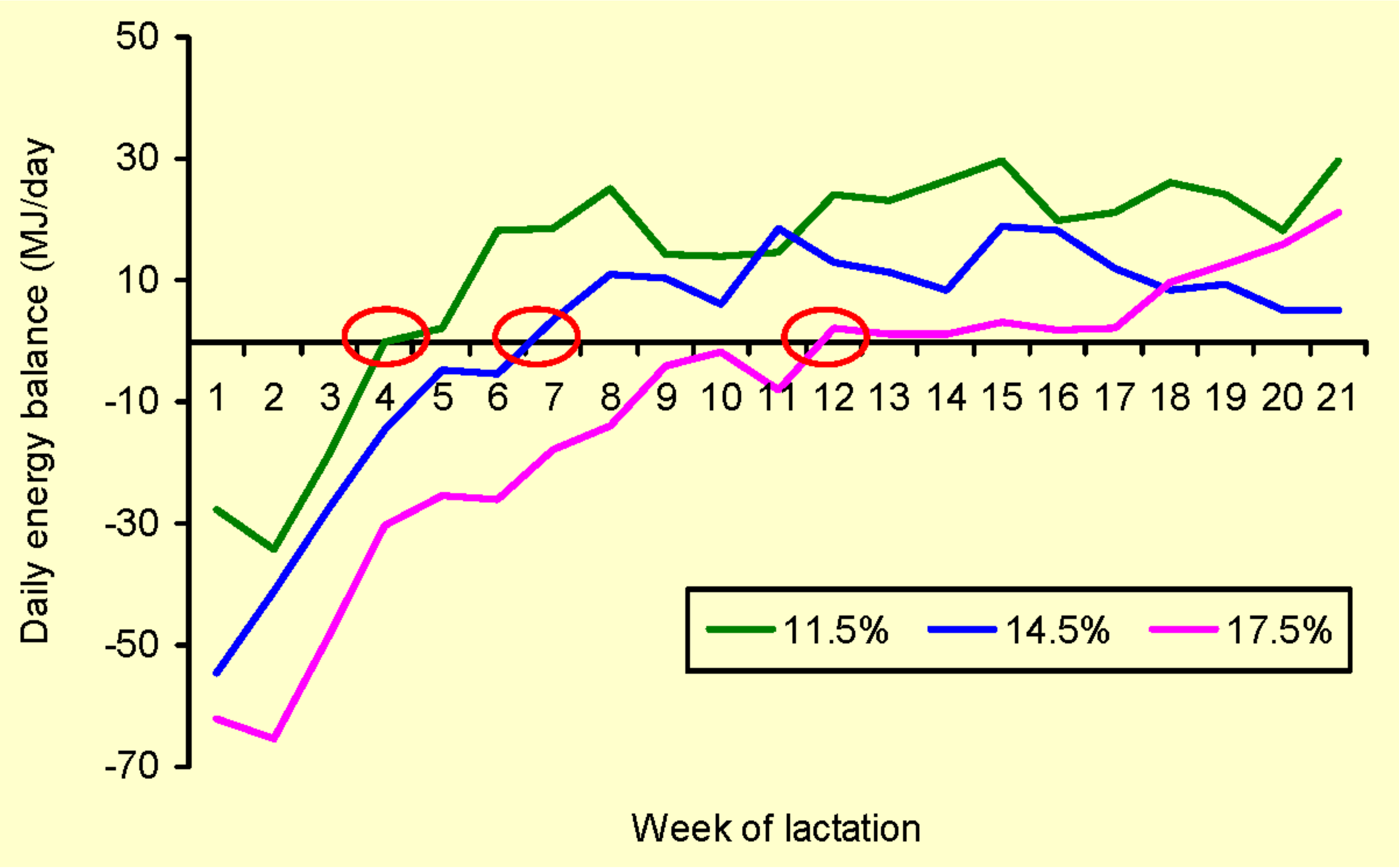


305 day yield

High 9653kg **Medium** 9089kg **Low** 7435kg

Law et al 2009; 2010

Effects of Diet Protein Concentration - AFBI Study Over One Lactation



Law et al 2009; 2010

Effects of Diet Protein Concentration - AFBI Study Over One Lactation

	Crude protein content of the diet (DM basis)			
	Low (11.5%)	Medium (14.5%)	High (17.5%)	P value
Pregnancy to 1st service (%)	34.5	29.7	27.6	ns
Pregnancy to 1st and 2nd service (%)	55.4	62.9	52.1	ns
100 day in-calf rate (%)	82.7	66.7	62.1	ns
Conception rate (%)	100	92.9	86.7	ns
Calving interval (days)	398	399	398	ns

Law et al 2009; 2010

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?

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 at Cedar enrolled at calving
- Fed one of 3 diets – Low 14%, Med 16% and High 18% crude protein
- Treatments maintained for 3 lactations
- Managed as for commercial herd except:
  - No grazing and 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

	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

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	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**

AC0122 - WP2 LACTATION TRIAL

Measurements:

- Weekly body weight and BCS
- Milk progesterone through early lactation (90 days)
- Weeks 1, 6, 20, 34 – blood metabolic profiles
- Fertility, health and veterinary records
- Culling as for commercial herd
  - Fail to conceive cows removed after 305 d lactation
  - Serve from 50 to 200 d
    - Sire use monitored to insure no treatment bias

AC0122 - CEDAR LACTATION TRIAL

- First heifer enrolled February 2013
- Enrolment completed 26 September 2014
  - 20 months to enrol 215 heifers
- Last cow lactation completed November 2017
- Cows completing each 305 day lactation:

Lactation 1 completed (207 of 215)

Lactation 2 completed (164 of 179)

Lactation 3 completed (116 of 132)

PLASMA METABOLITES: UREA

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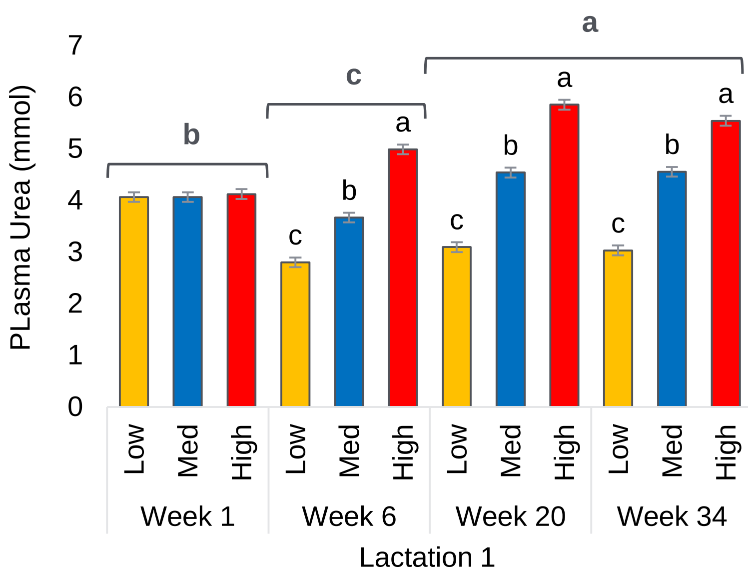

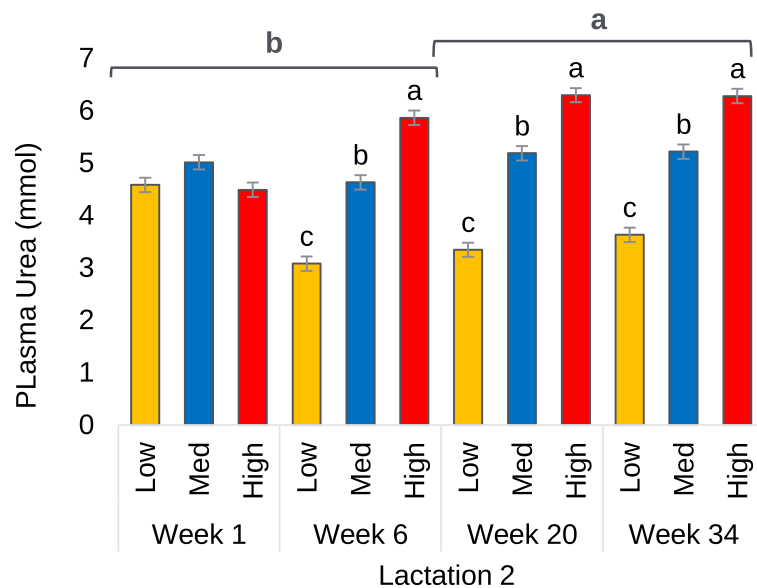

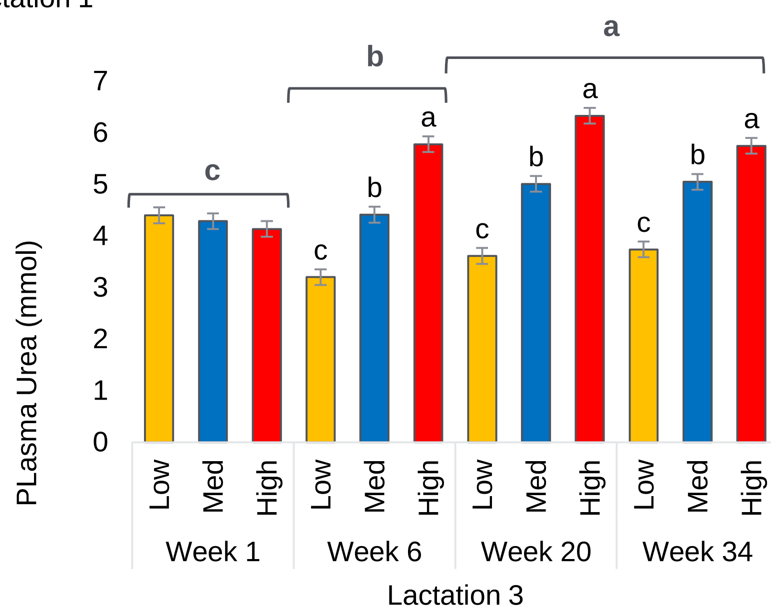

PLASMA METABOLITES: NEFA

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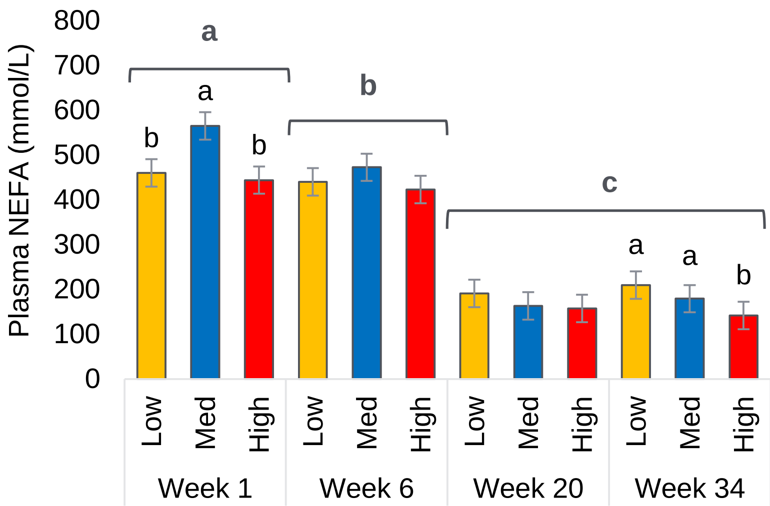
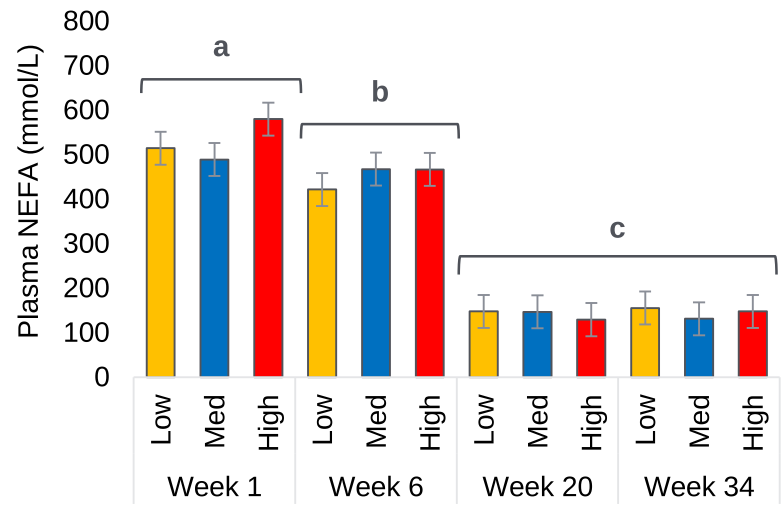
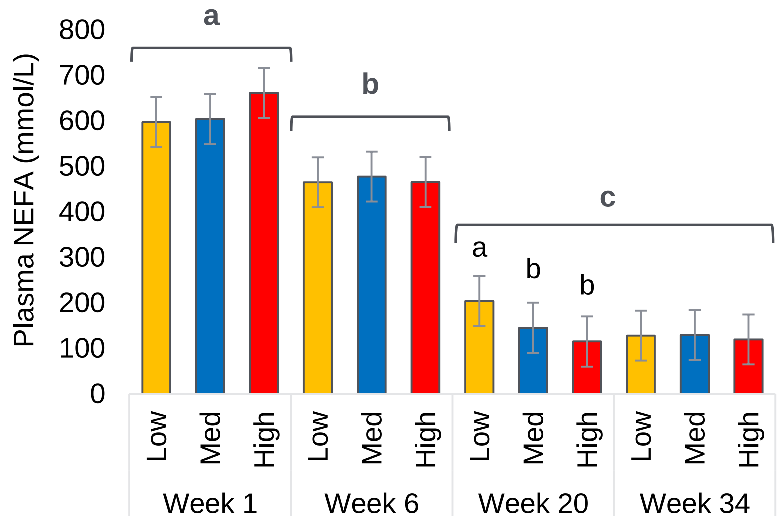


Lactation 1



Lactation 2



Lactation 3

PLASMA METABOLITES: ALBUMIN

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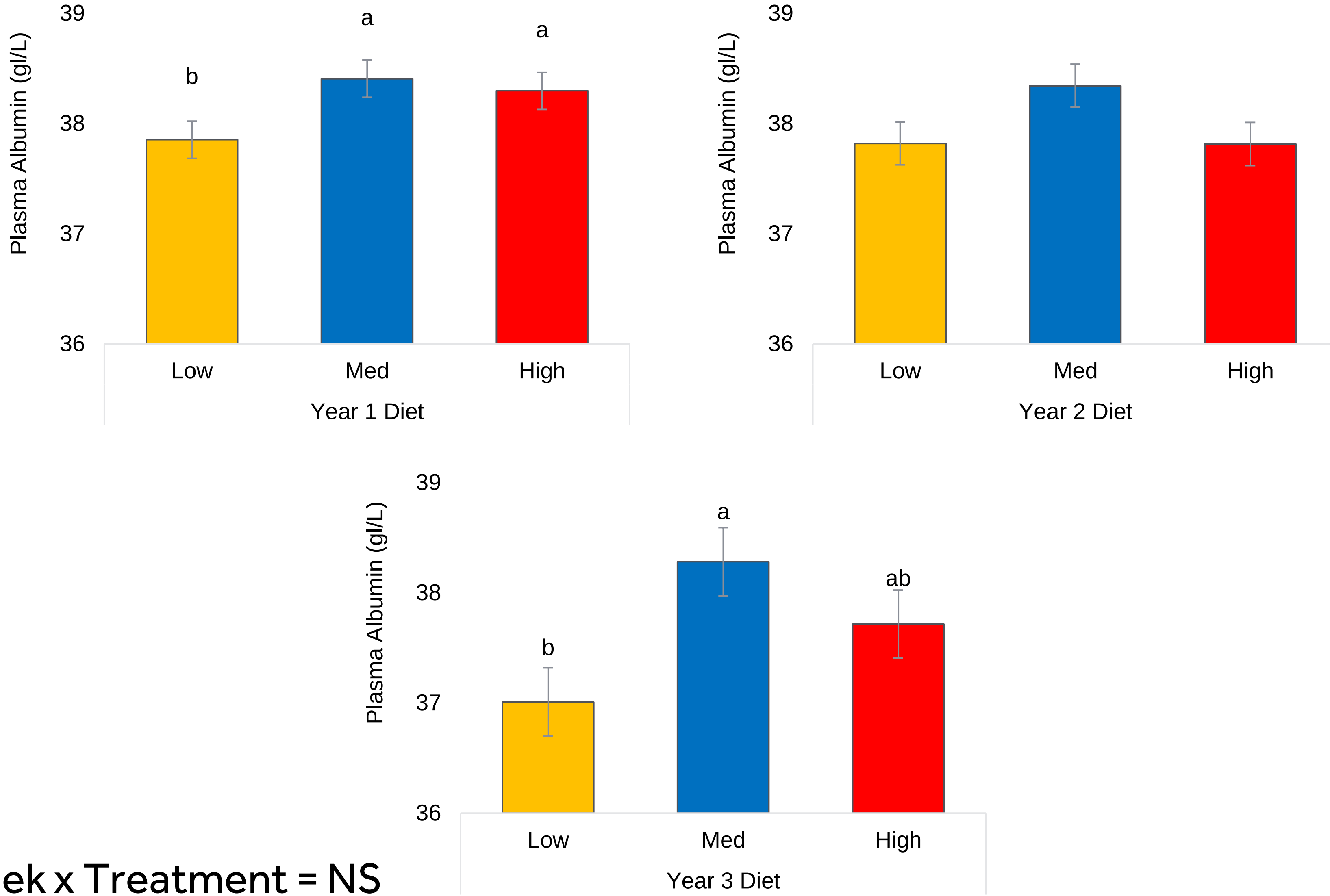

Week x Treatment = NS

NITROGEN USE EFFICIENCY:
ANIMAL VARIATION

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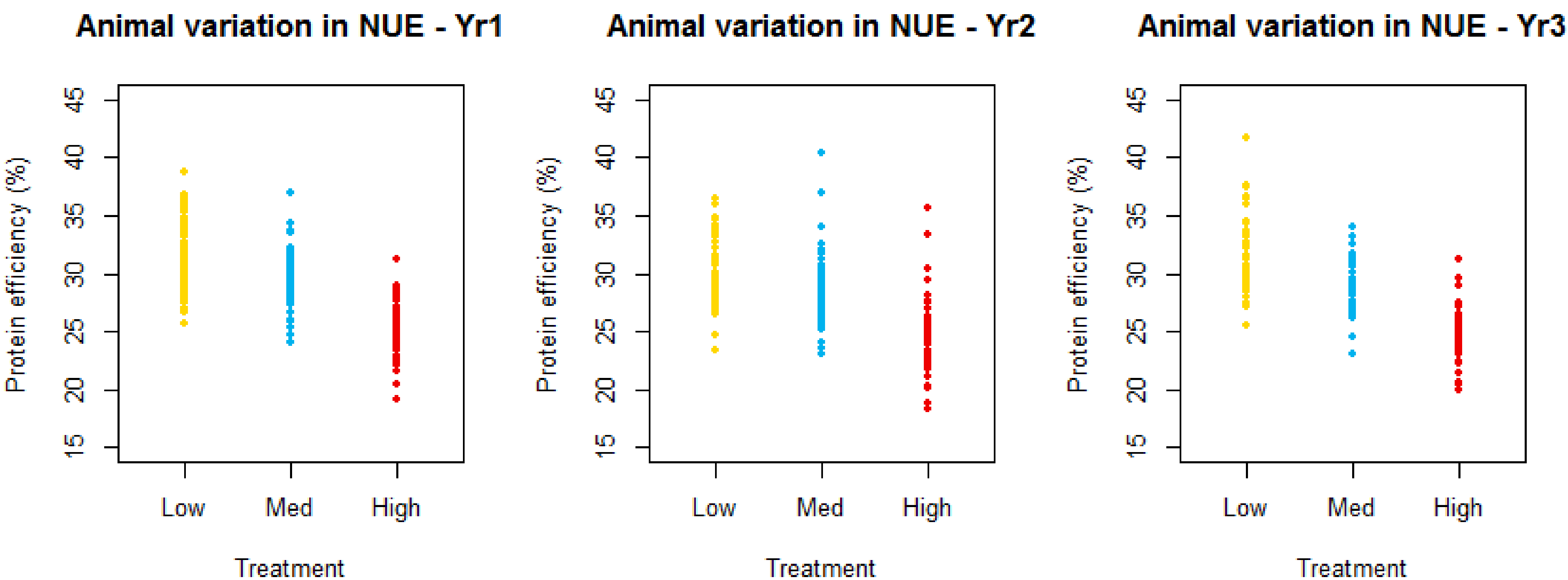

SHORT TERM FOLLOW ON TRIAL

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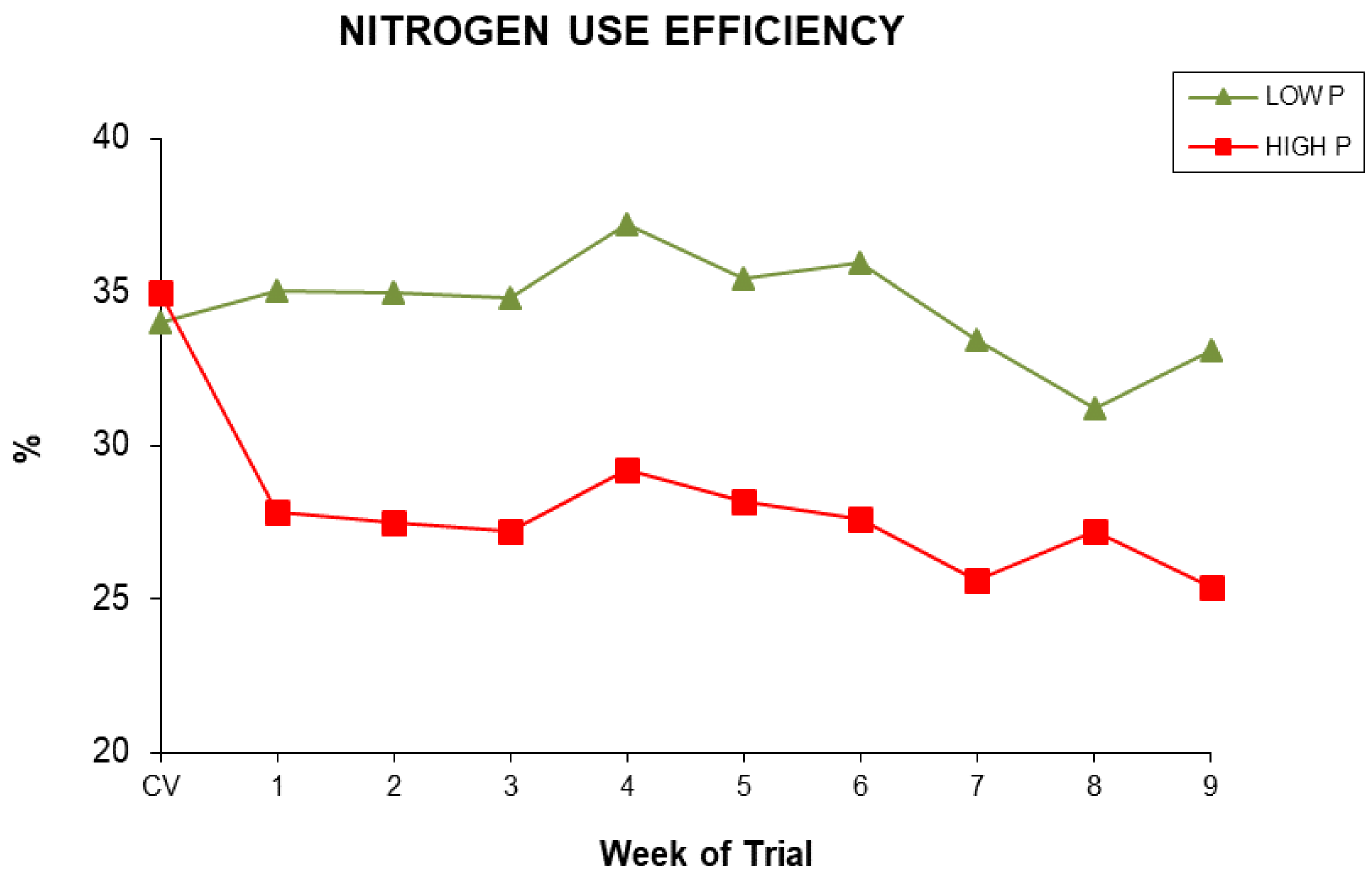
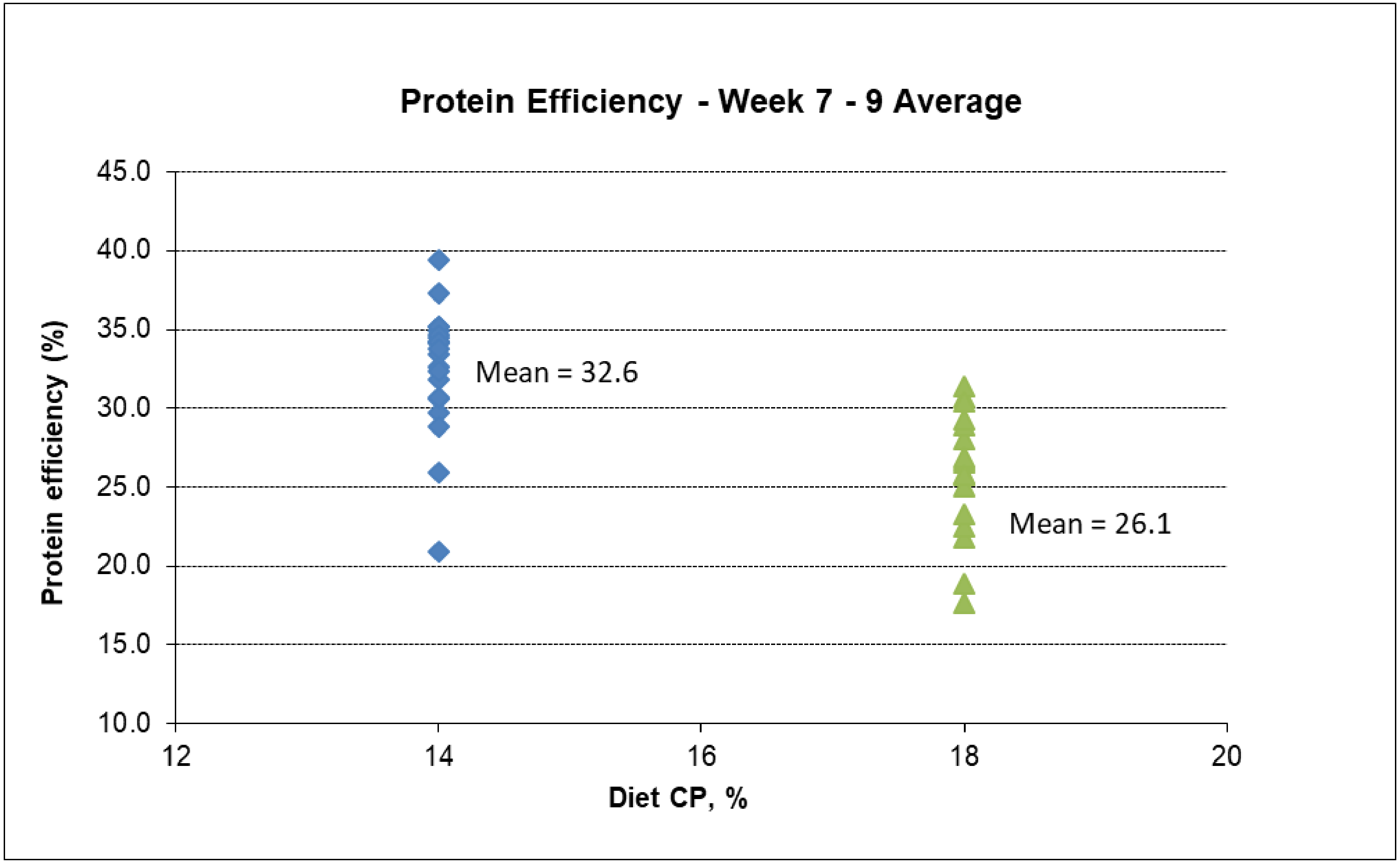


Diets changed from 16% CP to 14% (Low) or 18% (High) week 0

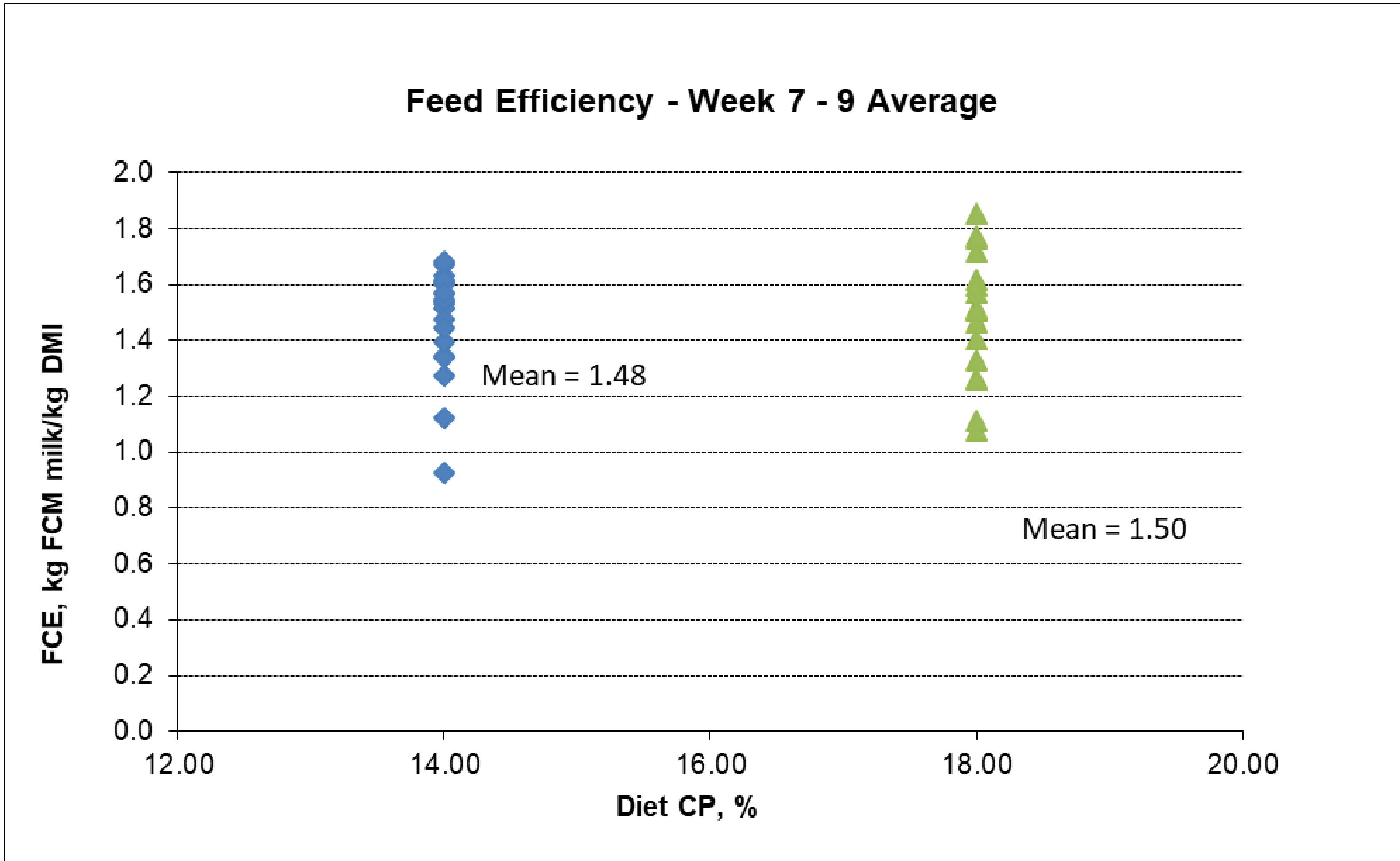
SHORT TERM FOLLOW ON TRIAL

University of Reading



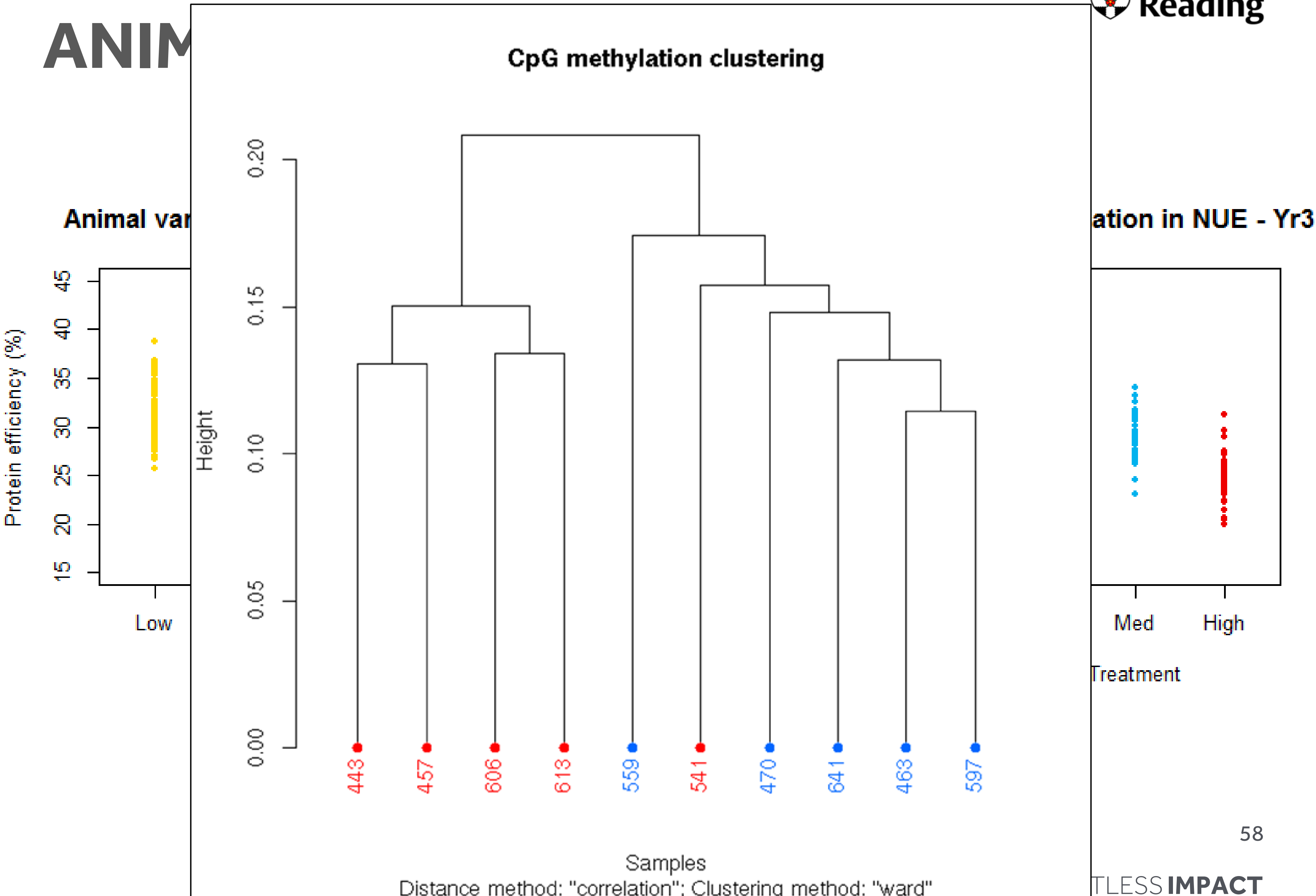
Diets changed from 16% CP to 14% (Low) or 18% (High) week 0

SHORT TERM FOLLOW ON TRIAL

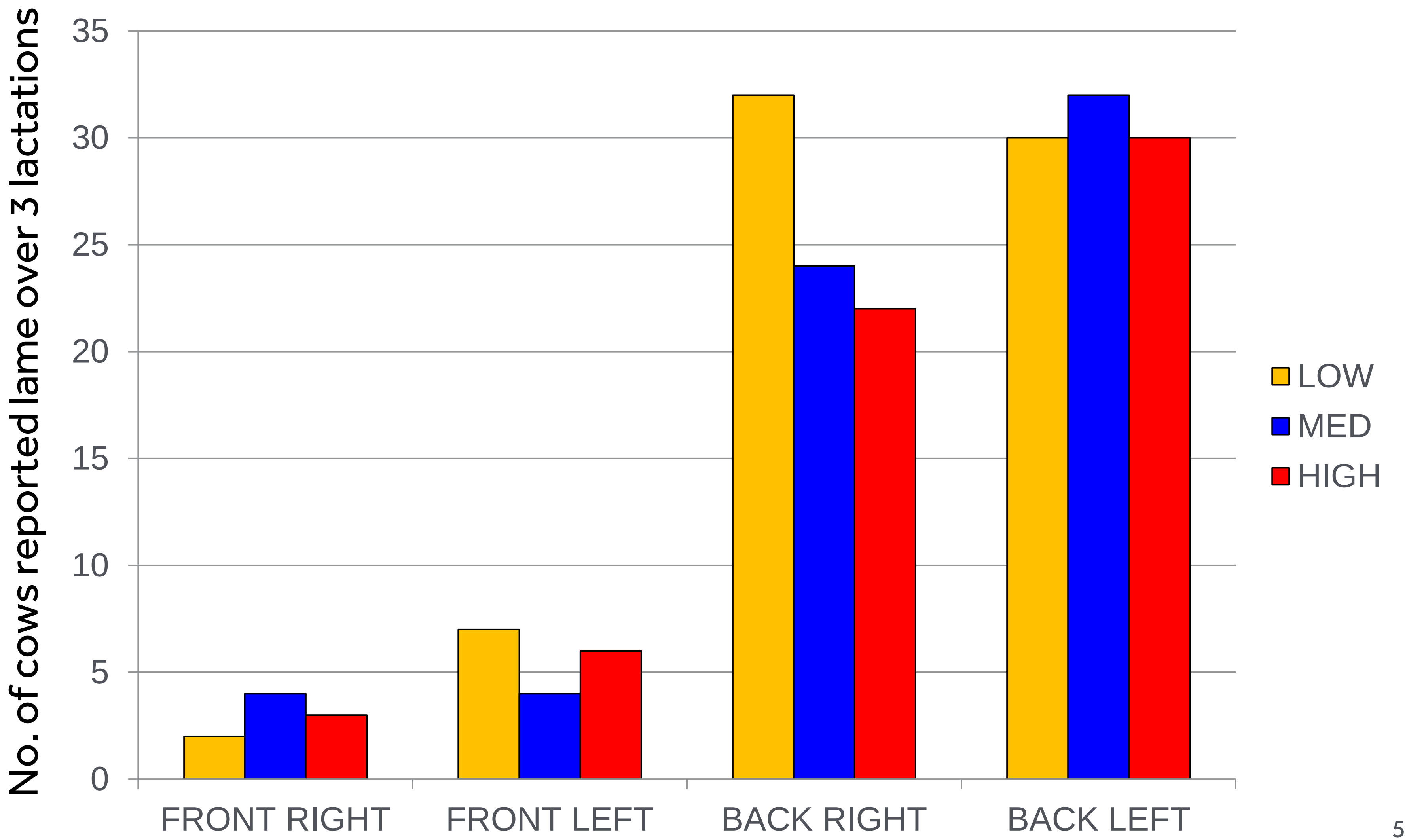


Diets changed from 16% CP to 14% (Low) or 18% (High) week 0

NITROGEN USE EFFICIENCY:
ANIM

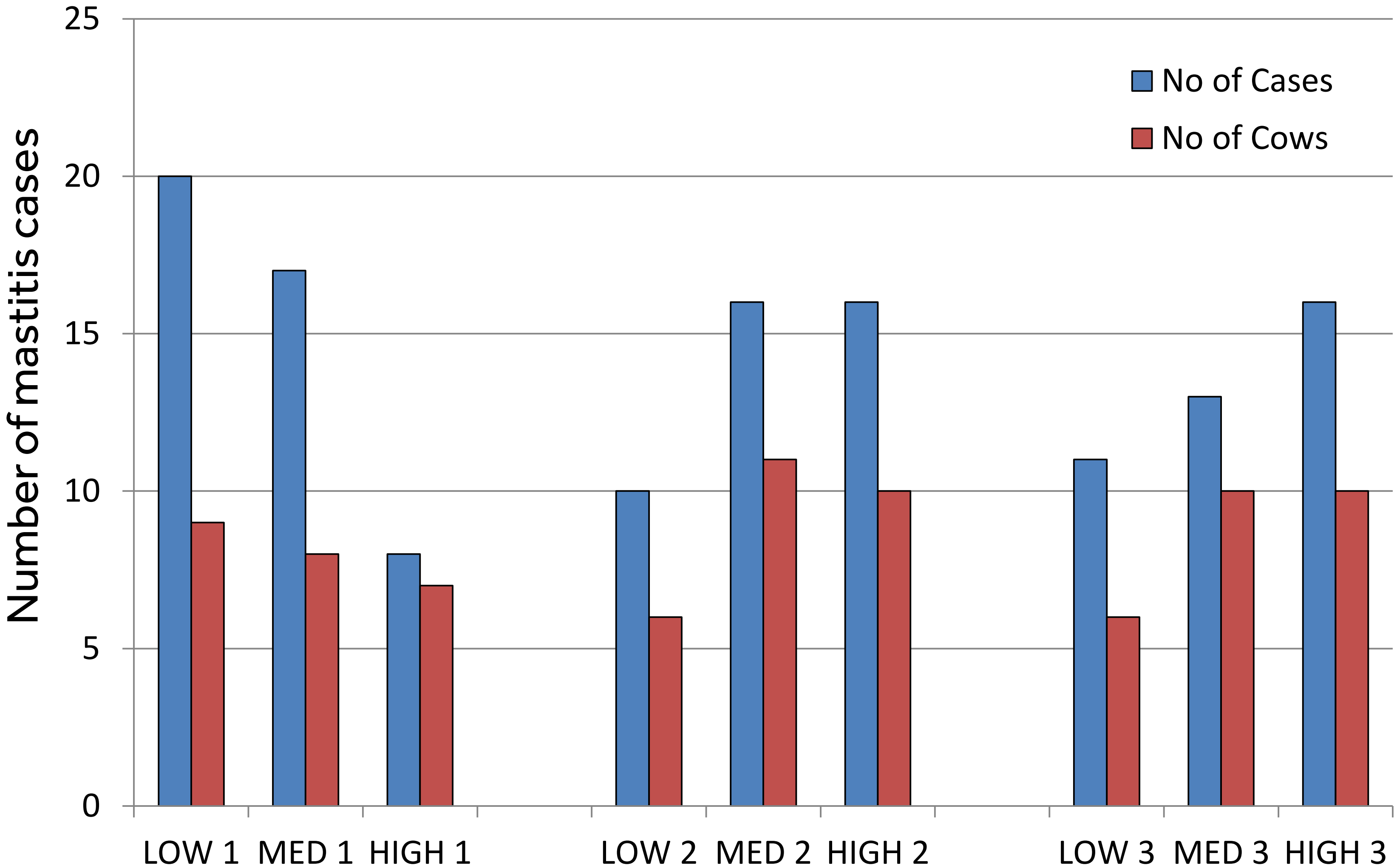


LAMENESS



No. of cows reported lame over 3 lactations
35
30
25
20
15
10
5
0
FRONT RIGHT
FRONT LEFT
BACK RIGHT
BACK LEFT
LOW
MED
HIGH

MASTITIS



Number of mastitis cases
25
20
15
10
5
0
No of Cases
No of Cows
LOW 1
MED 1
HIGH 1
LOW 2
MED 2
HIGH 2
LOW 3
MED 3
HIGH 3

BODYWEIGHT

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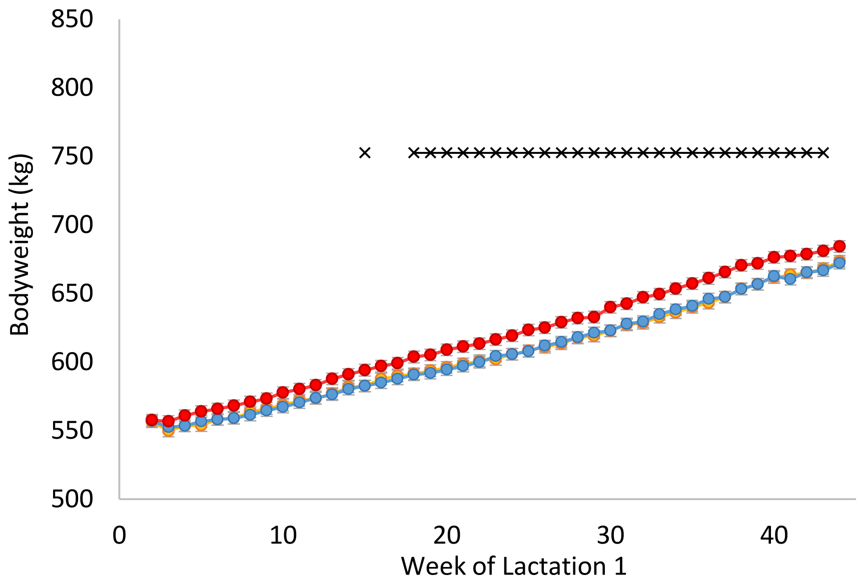
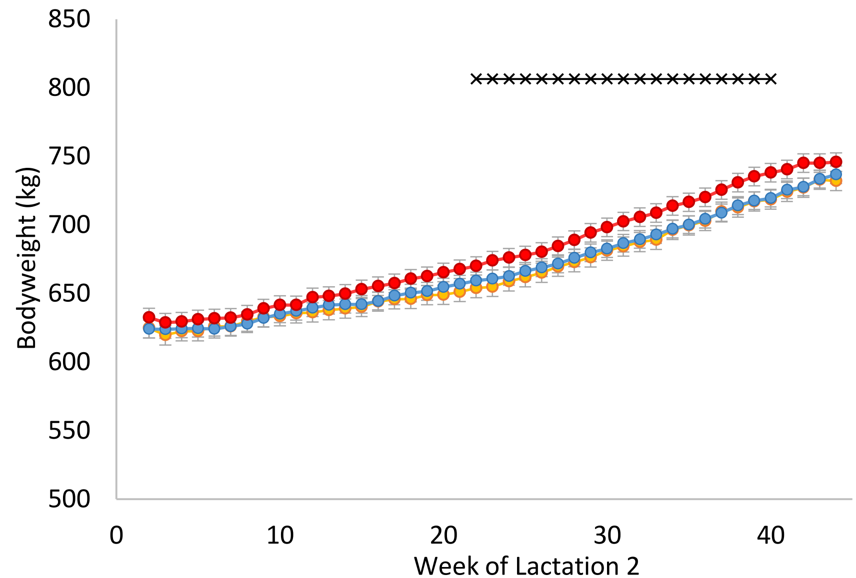
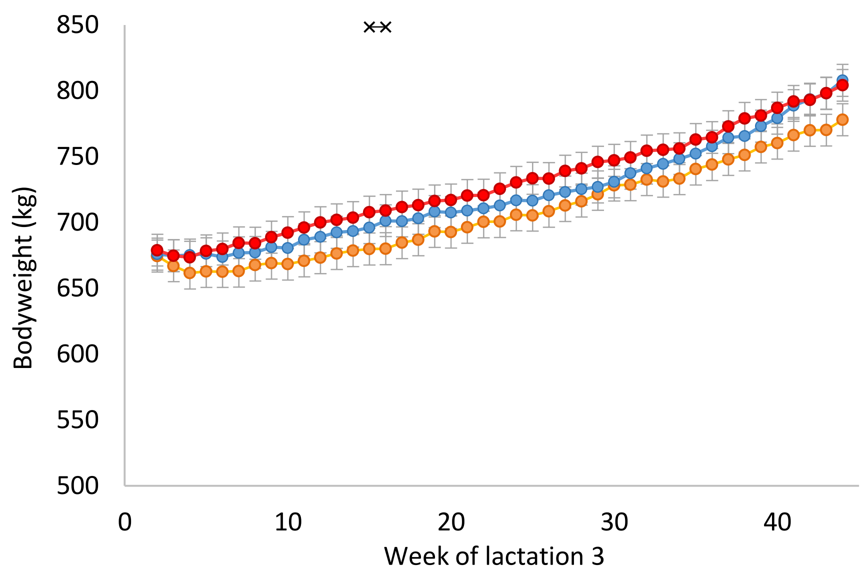
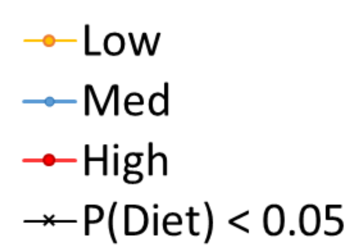




	Low	Med	High
Lac 1	606^{b}	606^{b}	619^{a}
Lac 2	666^{b}	668^{b}	680^{a}
Lac 3	707^{b}	721^{ab}	730^{a}





BODY CONDITION SCORE

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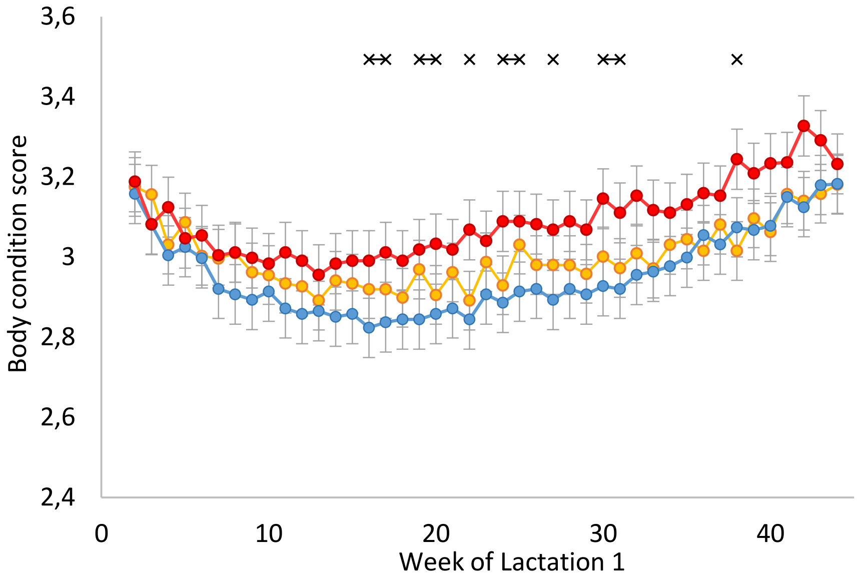
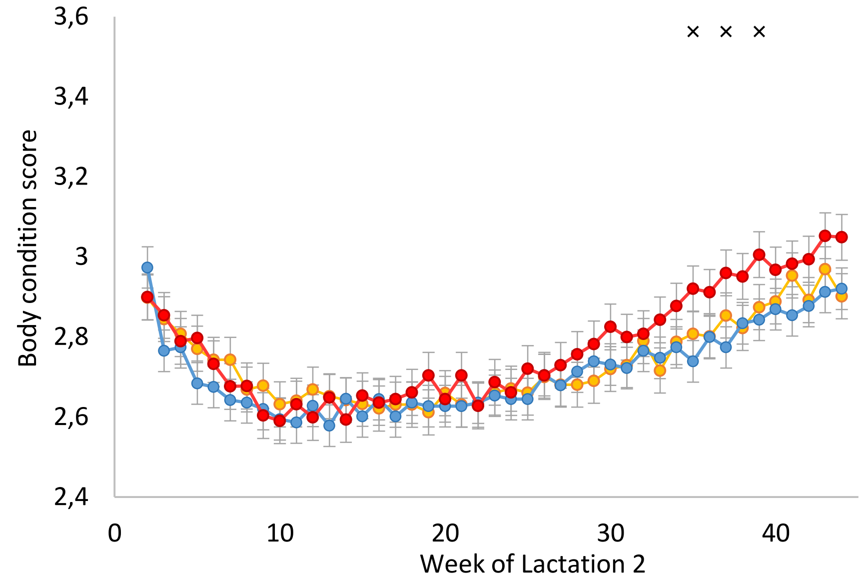
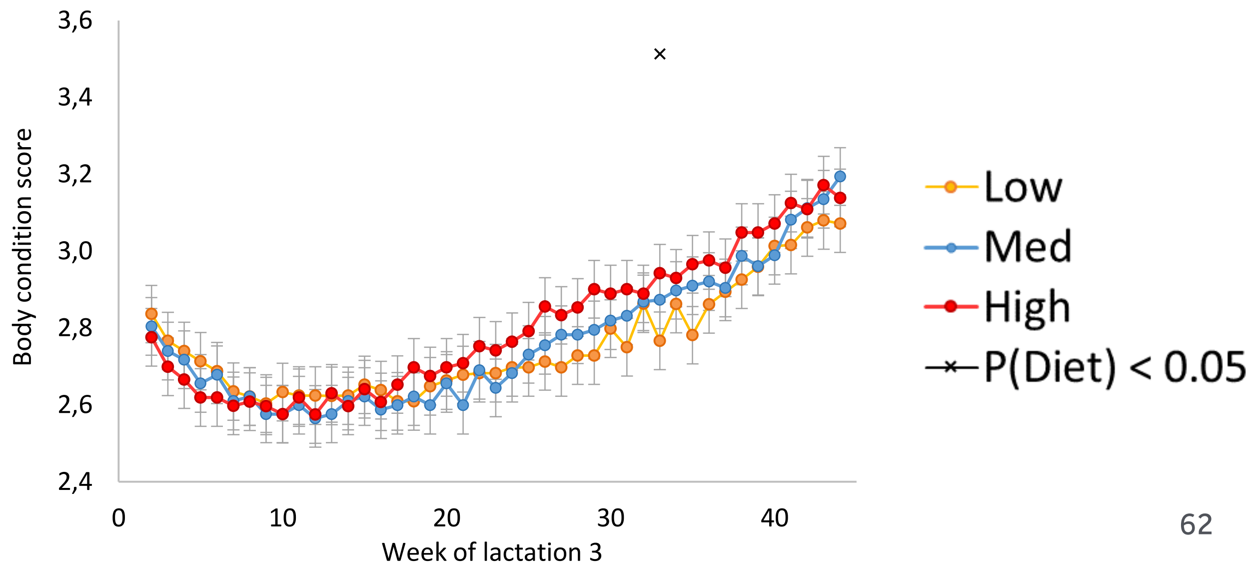




	Low	Med	High
Lac 1	3.01[ab]	2.96[b]	3.09[a]
Lac 2	2.74	2.71	2.78
Lac 3	2.76	2.77	2.80



ENERGY BALANCE

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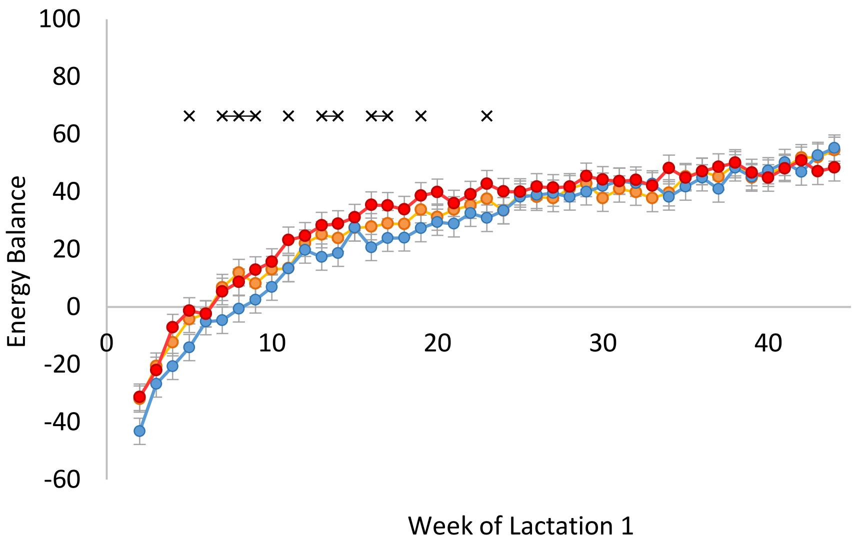
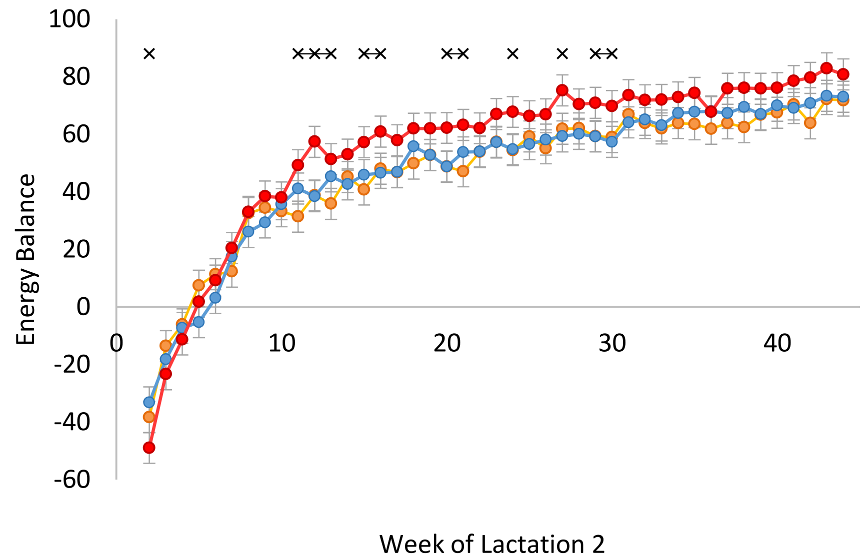
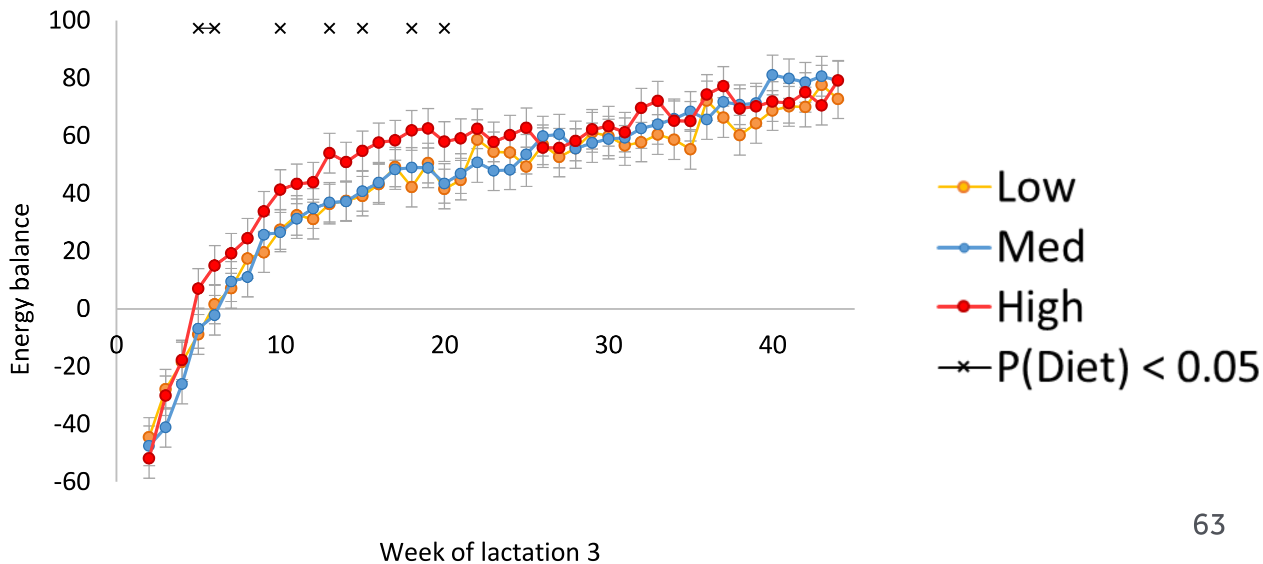
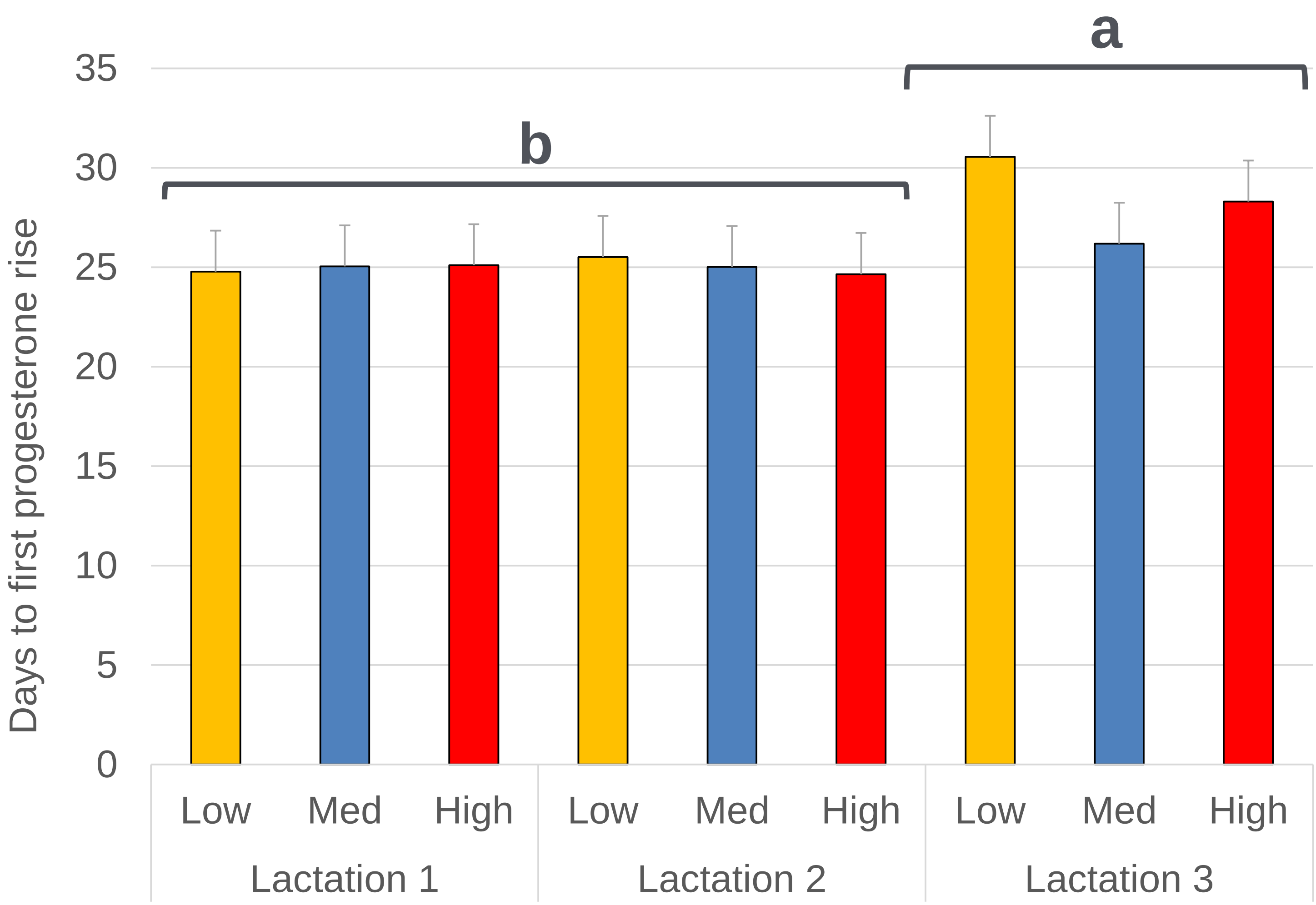




	Low	Med	High
Lac 1	29.1[ab]	26.0[b]	31.7[a]
Lac 2	46.6[b]	47.4[b]	55.1[a]
Lac 3	42.7[b]	44.2[ab]	50.6[a]



DAYS TO 1ST PROGESTERONE RISE



CALVING TO CONCEPTION

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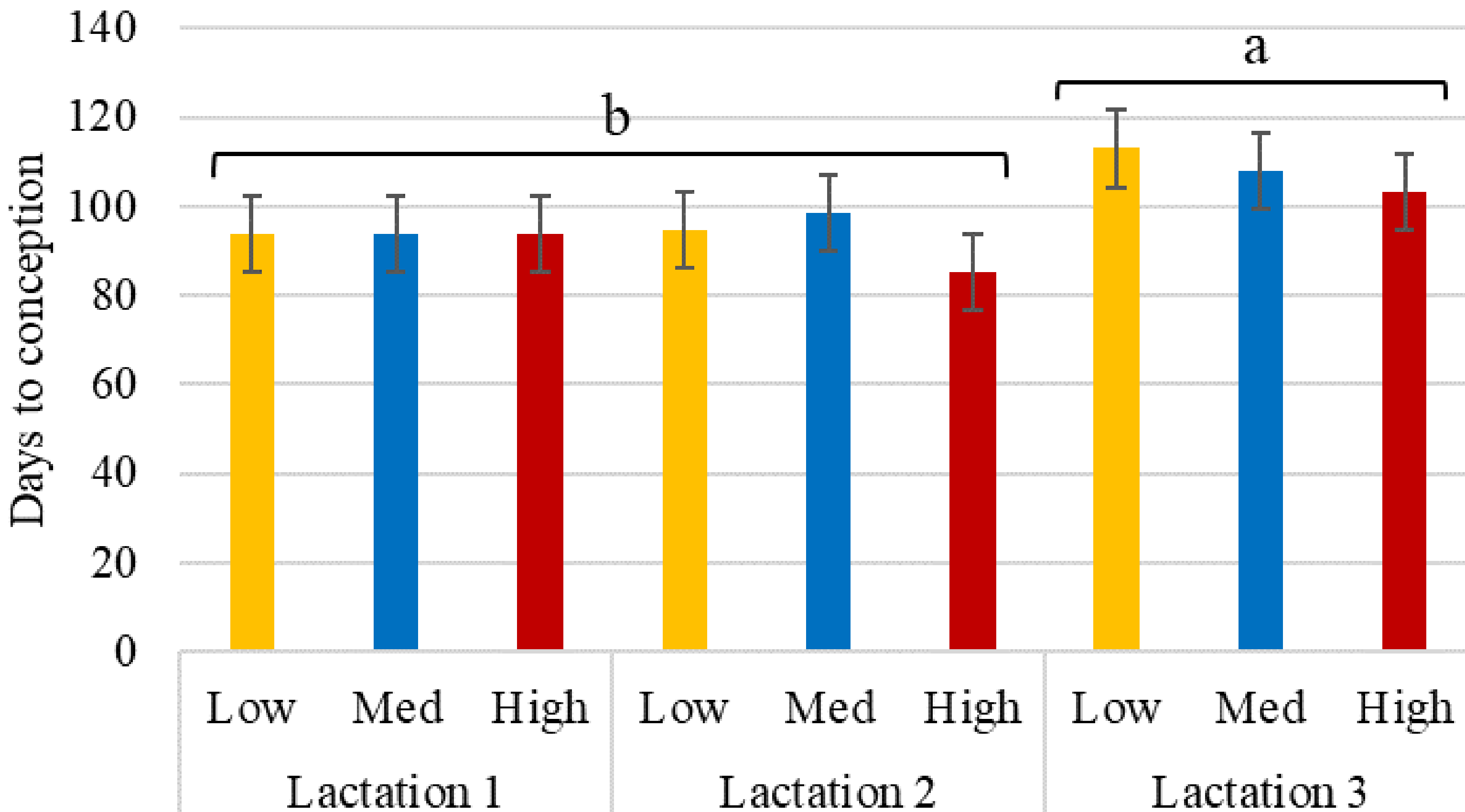
Treatment = NS
Year x Treatment = NS



ATTRITION – WHOLE STUDY

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	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 4th 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.

EMBRYO LOSS

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	Low	Med	High
Lactation 1	4	0	1
Lactation 2	0	0	3
Lactation 3	4	2	0
Total	8	2	4

Not included in attrition as cows were given the chance to continue the study following embryo loss

RPM and Fertility in Dairy Cows

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Table 6. Overall effect of rumen-protected methionine (RPM) treatment on fertility responses and pregnancy loss in lactating dairy cows.

	Treatment[1]		
Item [% (n/total n)]	CON	RPM	P-value
Multiparous			
P/AI at 28 days	67.1 (51/76)	66.7 (54/81)	0.48
P/AI at 32 days	58.4 (45/77)	62.2 (51/82)	0.31
P/AI at 47 days	55.8 (43/77)	61.7 (50/81)	0.23
P/AI at 61 days	54.0 (41/76)	59.7 (46/77)	0.23
Pregnancy loss			
28 and 61 days	19.6 (10/51)	6.1 (3/49)	0.03
32 and 61 days	8.9 (4/45)	0.0 (0/46)	0.03

Toledo et al., 2017.

RPM and Fertility in Dairy Cows

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Table 7. Effect of rumen-protected methionine (RPM) feeding on ultrasonographic morphometry of amniotic vesicle and embryo on gestation Day 33.

		Amniotic Vesicle	Embryo			
Treatment[1,2]	n	Volume (mm^3)	n	Crown-rump Length (mm)	Abdominal Diameter (mm)	Volume (mm^3)
Overall						
CON	63	542.6 ± 25.7	69	10.5 ± 0.2	5.5 ± 0.1	167.1 ± 6.0
RPM	80	594.9 ± 30.6	82	11.0 ± 0.2	5.8 ± 0.1	201.2 ± 10.6
P-value		0.27		0.08	0.04	0.01
Primiparous						
CON	30	617.1 ± 39.3	34	10.5 ± 0.2	5.6 ± 0.2	171.6 ± 7.6
RPM	36	596.0 ± 37.0	38	10.9 ± 0.2	5.7 ± 0.2	191.9 ± 14.3
P-value		0.67		0.21	0.61	0.38
Multiparous						
CON	33	479.4 ± 29.4	36	10.6 ± 0.2	5.3 ± 0.1	162.7 ± 9.2
RPM	44	593.9 ± 46.0	44	11.0 ± 0.2	5.9 ± 0.2	209.3 ±15.6
P-value		0.04		0.22	0.02	0.009

Toledo et al., 2017.

ATTRITION – WHOLE STUDY

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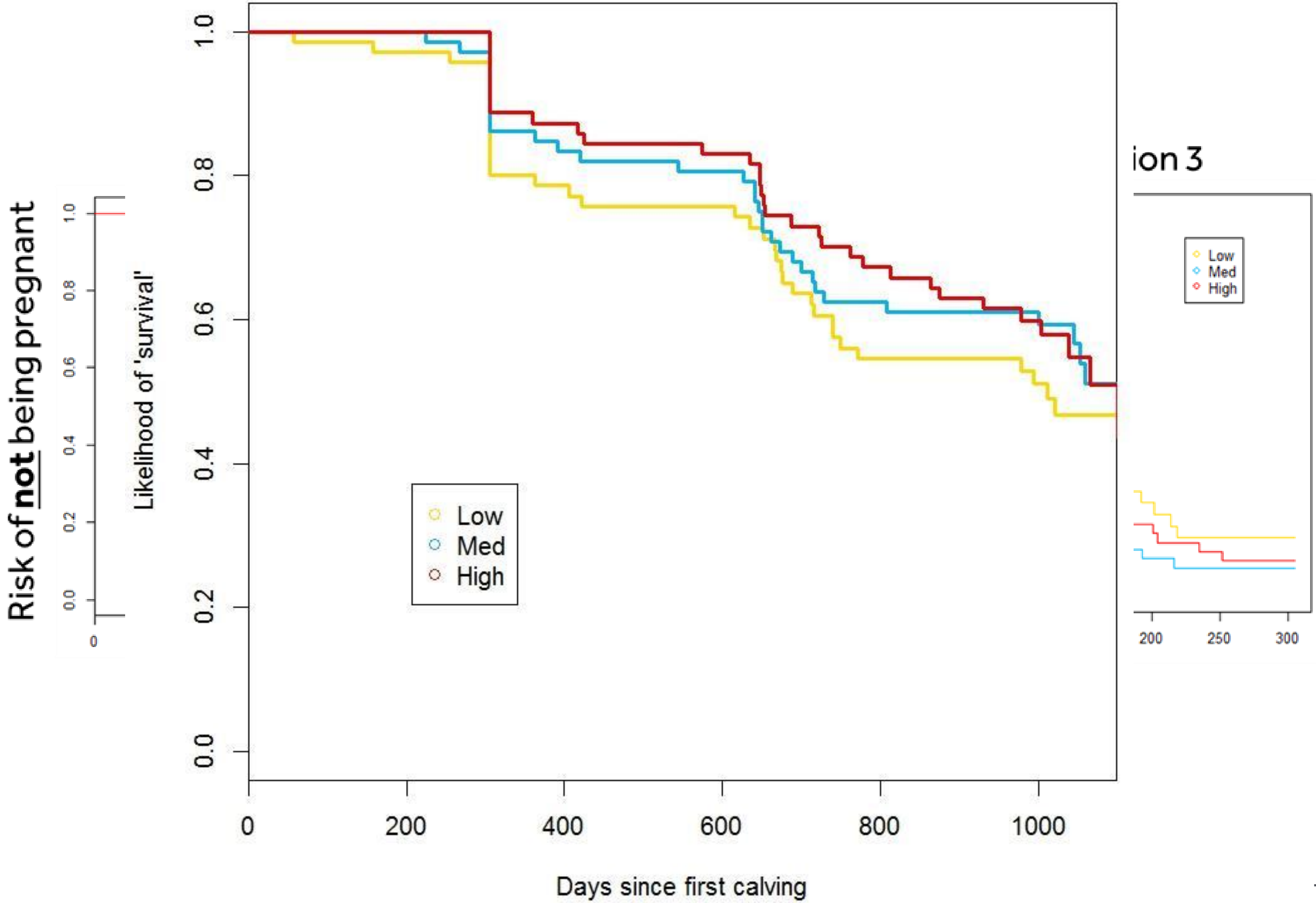

ECONOMIC IMPACT

- 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

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- 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 within treatments
  - Reasons for animal variation of considerable interest
  - No benefit of low protein diets for fertility
- Large variation in diet protein concentrations
  - Implications for precision feeding lower protein diets?
- For this study, the 16% crude protein diet was 'optimal' in many respects - this was by design
- Long-term negative effects of 'sub-optimal' protein supply evident (numerically) – survival reduced

SOME TAKE HOME MESSAGES

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- Economic and environmental pressure to reduce dietary protein inputs (especially imported feed proteins)
  - Less environmental impact
  - Risk of reduced milk yield
  - Risk of reduced survival for diets providing EAA below requirements
- Lower protein diets more 'N efficient' ….

  but need to consider longer term effects at systems level
- Precision feeding lower protein diets – challenges of variations in feed composition – cows very resilient – long term average important
- The longer term effects of 'sub-optimal' metabolizable protein supply must be assessed relative to the benefits
  - Including effects during the rearing period – often 'over' fed protein
  - Animal and system level
  - Economic and environmental impacts
    - Benefits vs risks and costs

Department for Environment Food & Rural Affairs

University of Reading

THANK YOU!

@UniRdg_SAPD

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www.reading.ac.uk/protein-efficiency

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