New insights into feeding dairy cows at pasture

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TEAGASC RESEARCH INSIGHTS

LEADING RESEARCH FOR TOMORROW'S AGRI-FOOD SYSTEMS

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Pasture-based systems

- Human inedible feed ➡ Highly nutritious food
- Low environmental footprint
- Resilient business model

Climate Change

Biodiversity

Water Quality

Perennial ryegrass (*Lolium perenne* L.)

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Potential Solutions

- ❑ White clover and multi-species swards
- ❑ Genetically improved pastures
- ❑ Strategic supplementation

Climate Change

Biodiversity

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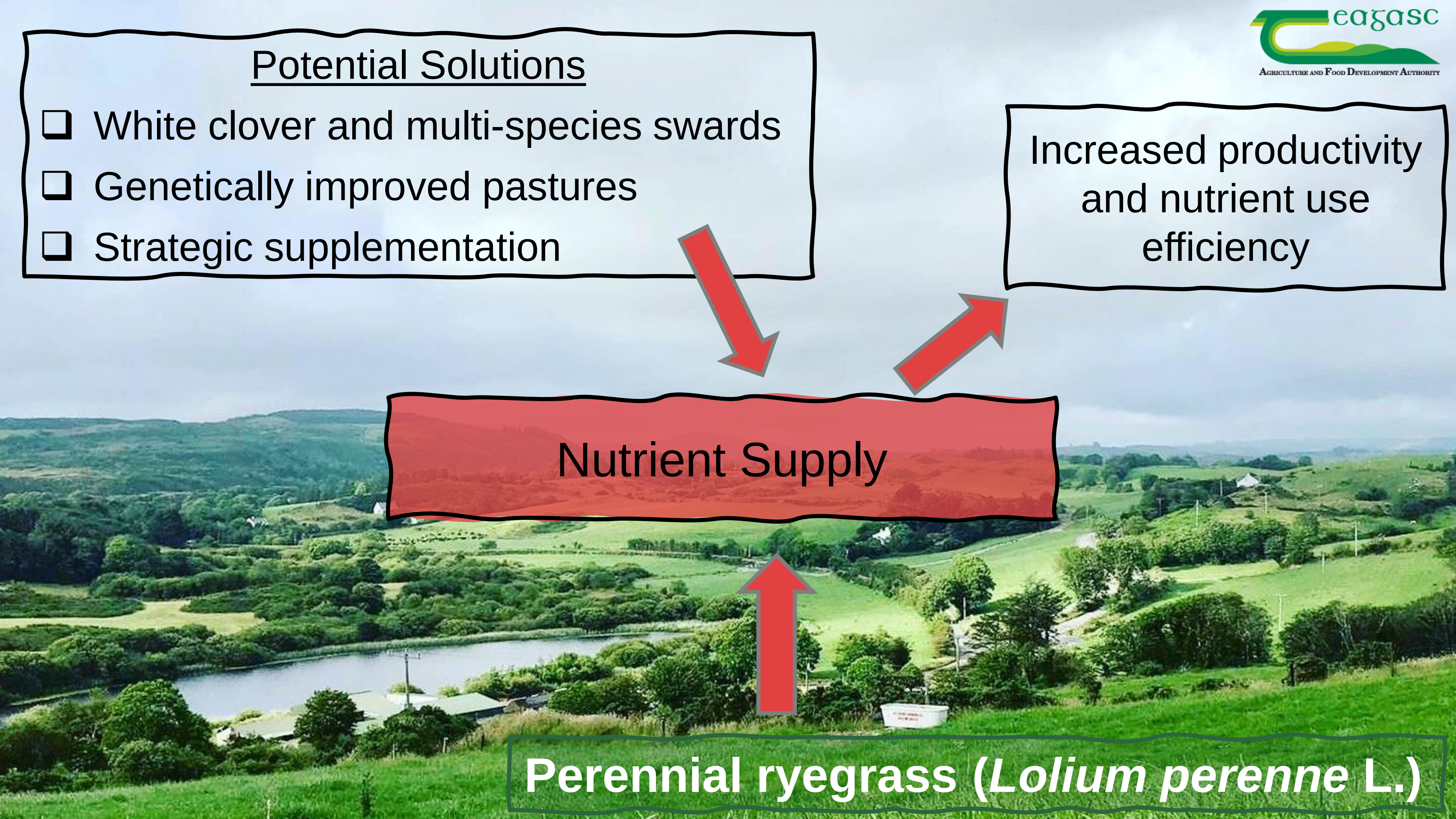
Perennial ryegrass (*Lolium perenne* L.)


Potential Solutions
White clover and multi-species swards
Genetically improved pastures
Strategic supplementation
Increased productivity and nutrient use efficiency
Nutrient Supply
Perennial ryegrass (Lolium perenne L.)
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Programme Background

- Collaboration with Prof. Mike Van Amburgh, Department of Animal Science, Cornell University, USA
  – Cornell Net Carbohydrate and Protein System (CNCPS)
  – Feed chemistry analysis
- Goals:
  1. Develop new approaches to grass feed analysis
  2. Develop a greater understanding of the feeding value of grazed grass
  3. Identify supplementation strategies to complement grazed grass

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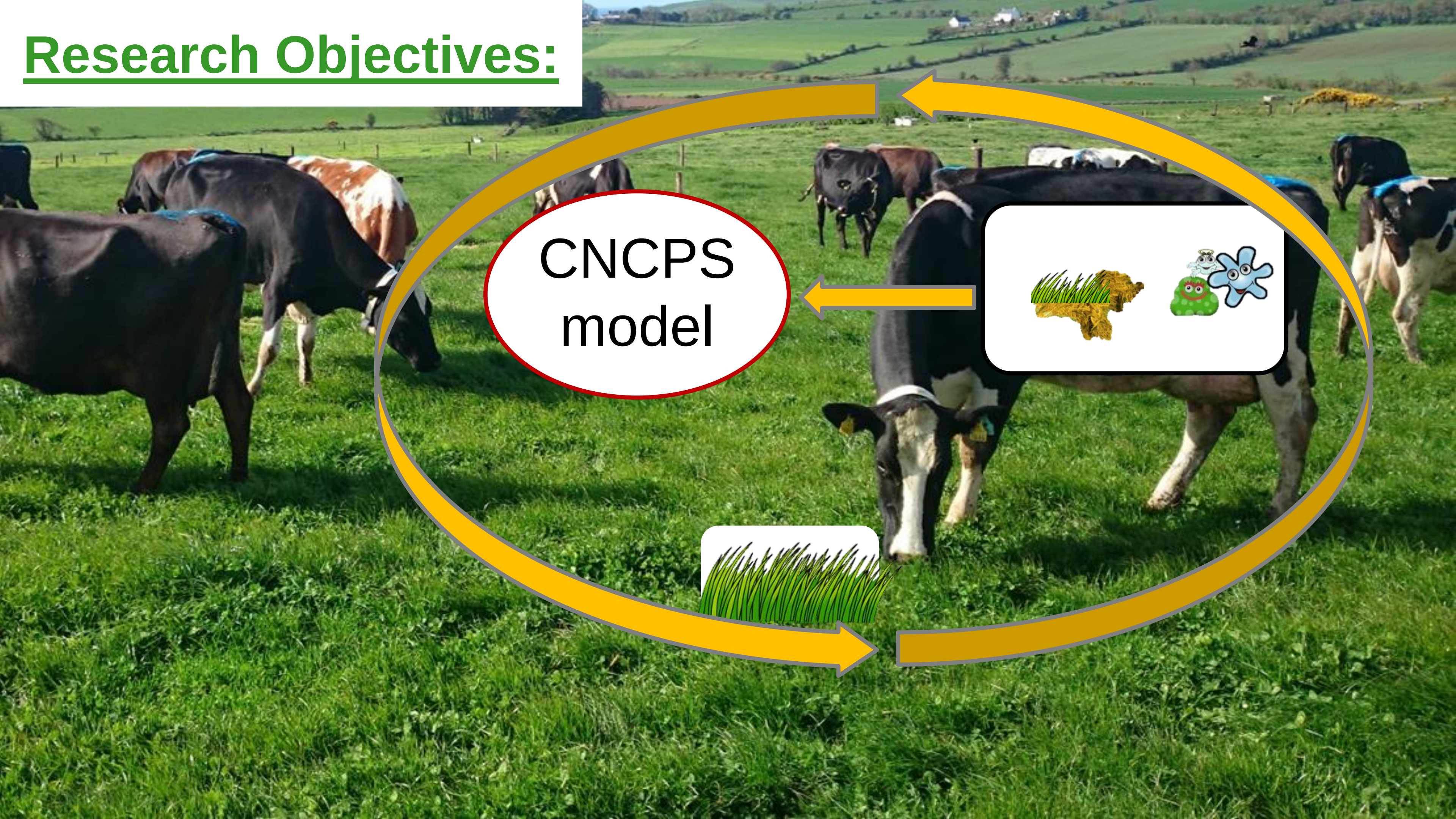
Research Objectives:



Research Objective 1:

Use new and updated feed chemistry methods to estimate the feeding value of PRG

CNCPS Framework

Irish Standard Analysis
CP
Sugar
Starch
NDF
ADF
Lignin
Fat
Ash

OMD

CNCPS Analysis	
PA1	Ammonia
PA2	Soluble True Protein
PA3	Insoluble True Protein
PA4	Fiber Bound Protein
PA5	Indigestible Protein
CA1	Volatile Fatty Acids
CA2	Lactic acid
CA3	Other Organic Acids
CA4	Sugar
CB1	Starch
CB2	Soluble Fiber
CB3	Digestible NDF
	Fast pool dNDF
	Slow pool dNDF
CC	Indigestible NDF
Fat	
Ash	

- kd/(kd + kp)
- Feed → Ruminal fermentation
- Feed → Ruminal escape
- Microbial protein synthesis
- **First limiting?**
  - Metabolisable Energy (ME)
  - Metabolisable Protein (MP)

In vitro NDF Digestibility Method

Development of an in vitro method to determine rumen undigested aNDFom for use in feed evaluation

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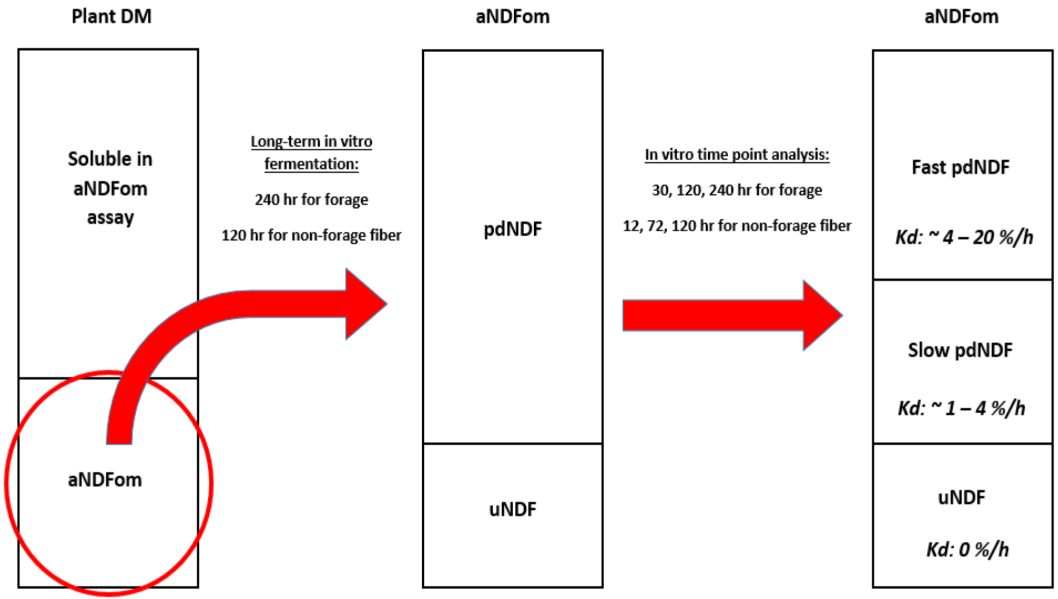
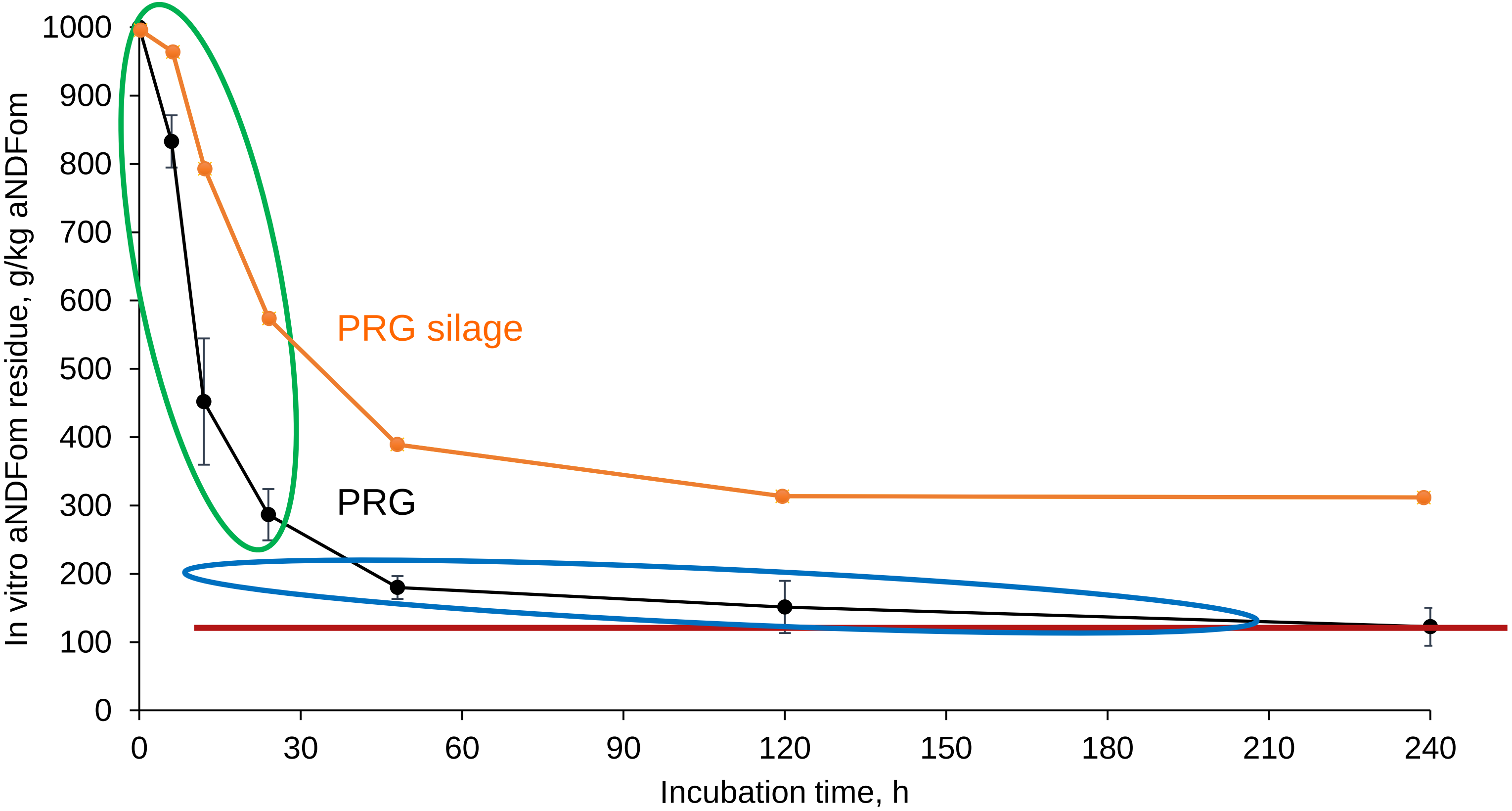


NDF Digestion Behavior



Dineen et al., 2021. Anim. Feed Sci. Technol. 272;114752

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N Fractionation

Irish Standard Analysis
CP
Sugar
Starch
NDF
ADF
Lignin
Fat
Ash

OMD

CNCPS Analysis	
PA1	Ammonia
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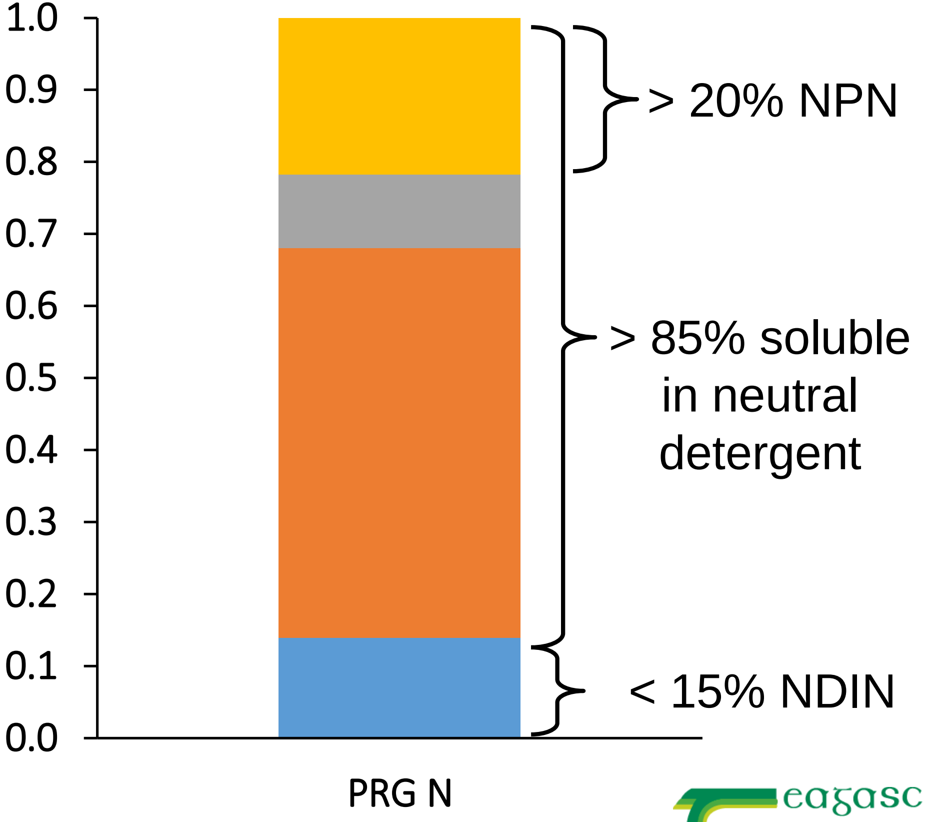

Dineen et al., 2021. Anim. Feed Sci. Technol. 272;114752

Research Objective 2:

Develop a greater understanding of the feeding value of grazed grass

Omasal Sampling Technique (Huhtanen et al., 1997)

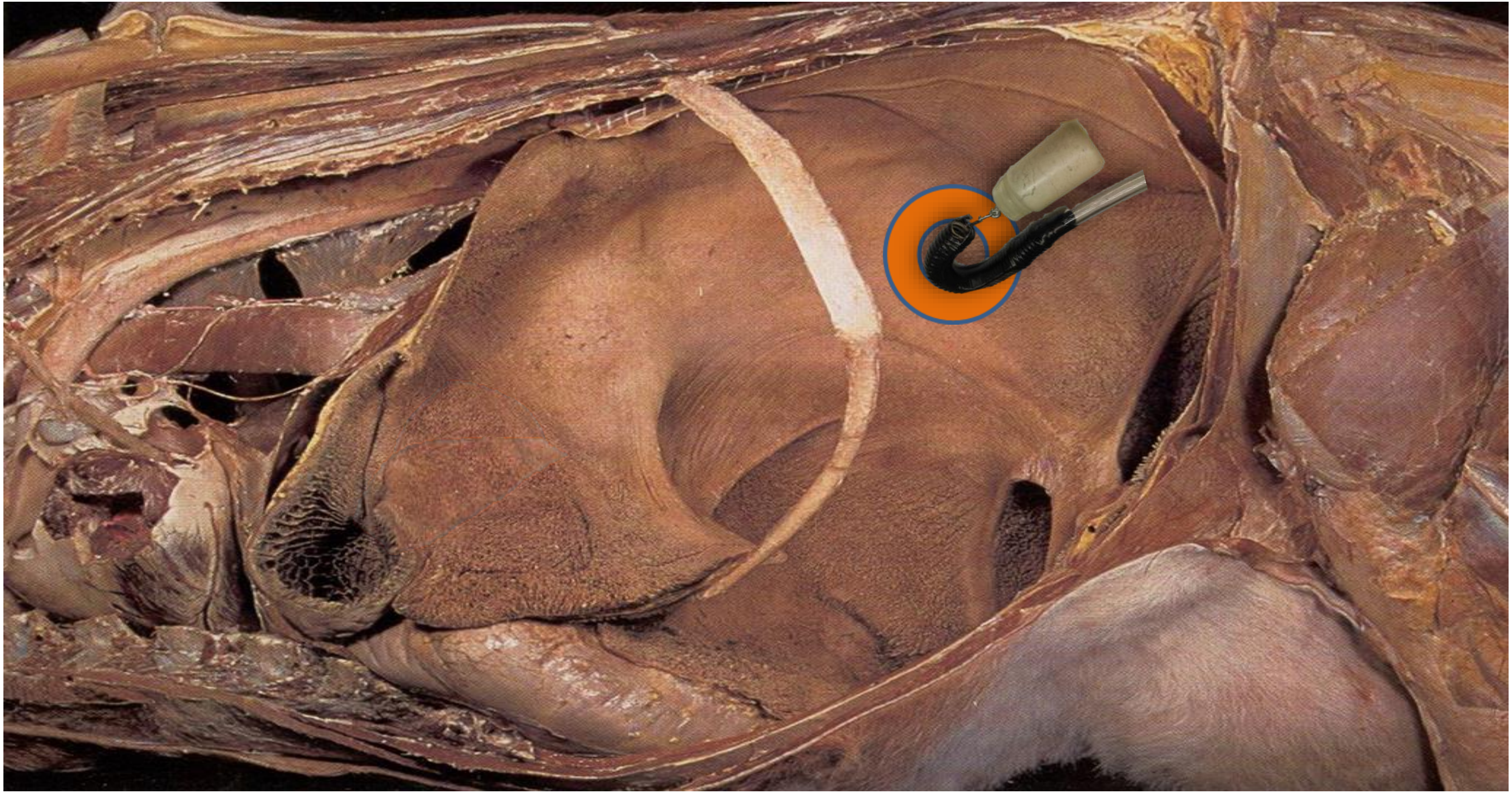

Photo credit A. Foskolos

Additional Experimental Techniques

- Double marker to determine true digesta flow:
  - CoEDTA
  - uNDF

- Microbial isolation procedures (bacteria and protozoa) utilizing ^{15}N enrichment analysis

- Rumen evacuations

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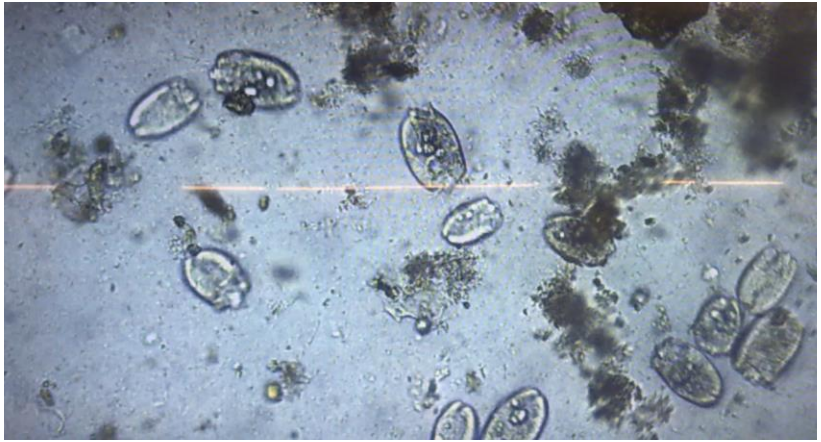
Experimental Design

- Two treatments:
  - Grass only
  - Grass + Rolled Barley (3.5 kg DM, ~ 20% DMI)
- 10 lactating rumen cannulated cows
- 513 kg BW and 70 DIM
- Switchback design
- April – July, 2017

Dineen et al., 2020. J. Dairy Sci. 103:11332–11348 *Dineen et al., 2021. J. Dairy Sci. 104:4192–4205*

Protozoal Dynamics

- Two main sub-categories
- Impact ruminal metabolism
- Contribute substantially to AA and unsaturated fatty acid supply



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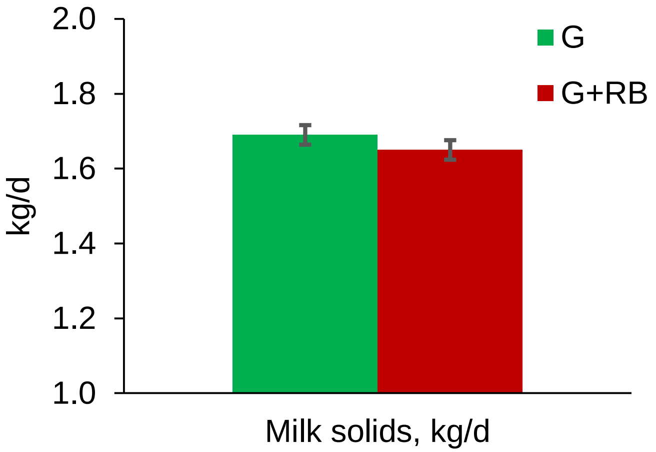
Diet Nutrient Composition

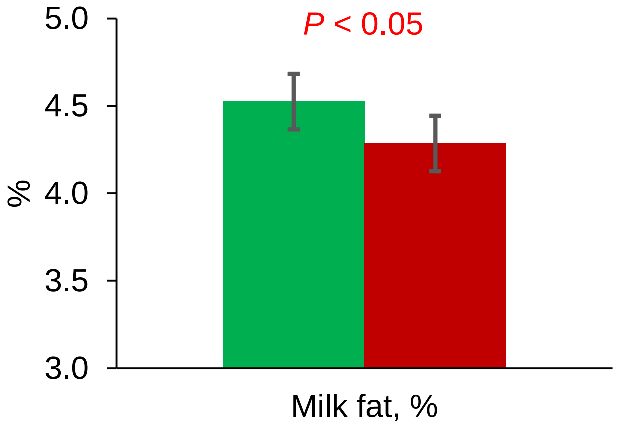
- G: Grass only
- G+RB: Grass + Rolled Barley

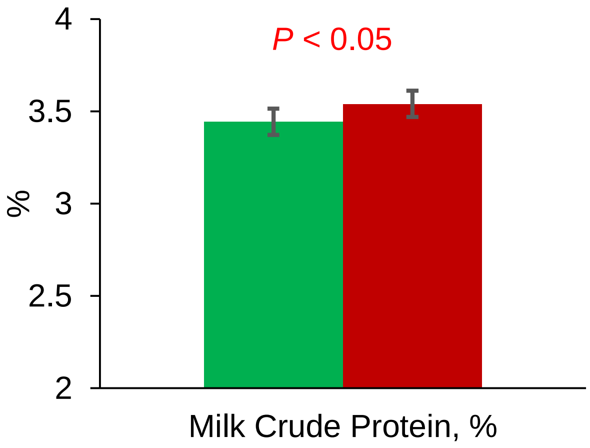
	Diet		
Nutrient composition	G	G+RB	RB
CP, % of DM	16.3	15.4	11.6
Starch, % of DM	2.2	14.4	60.7
NDF, % of DM	36.3	32.7	19.2
WSC, % of DM	23.9	19.3	1.9

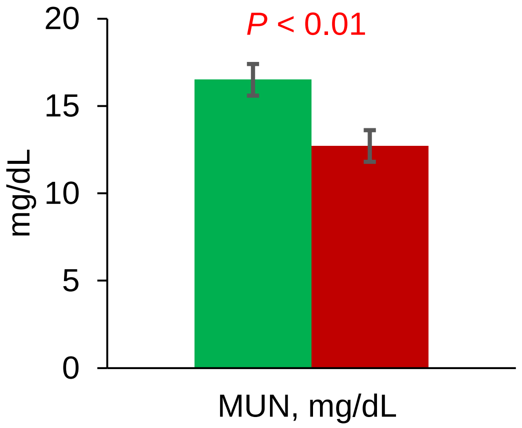
Milk Production and Composition



Item	G	G+RB
Milk solids, kg/d	1.69	1.65
Milk fat, %	4.52	4.28
Milk protein, %	3.44	3.54
MUN, mg/dL	16.5	12.7

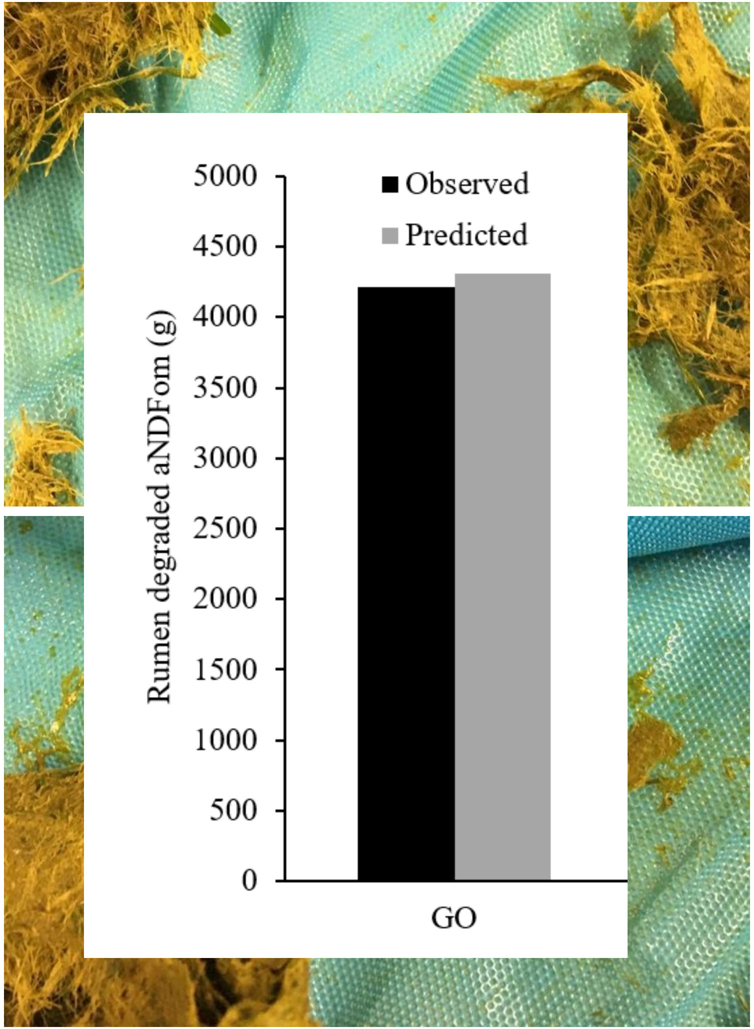




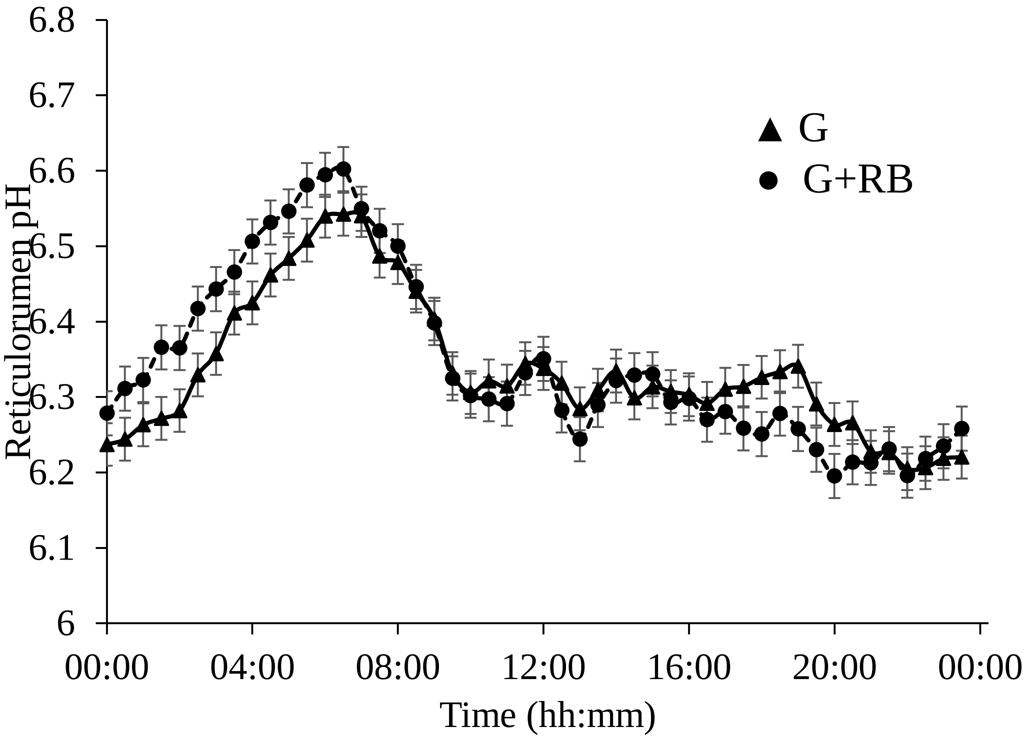


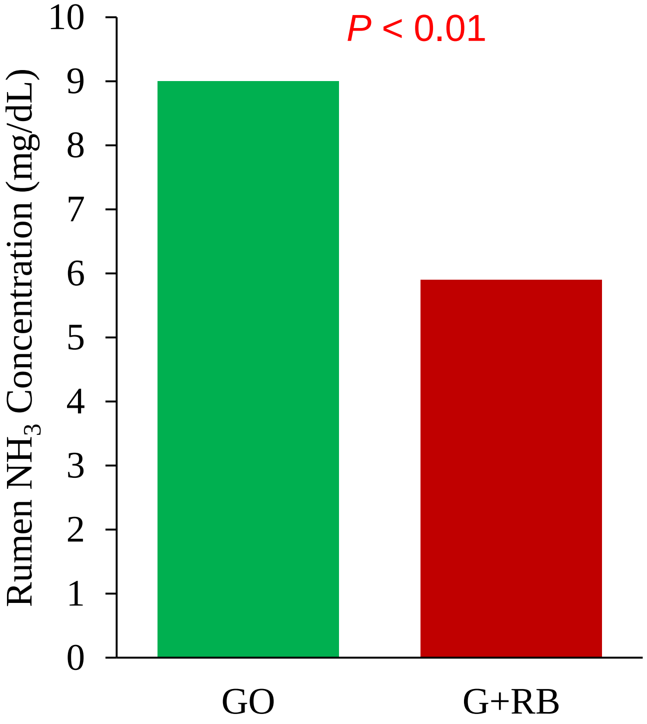
NDF Digestion

Item	G
DMI, kg/d	16.1
NDF intake, kg/d	5.8
Flow at omasal canal, kg/d	1.6
Digested in the rumen, kg/d	4.2
% of NDF intake	72.3
Total-tract digestibility	
% of NDF intake	83.2

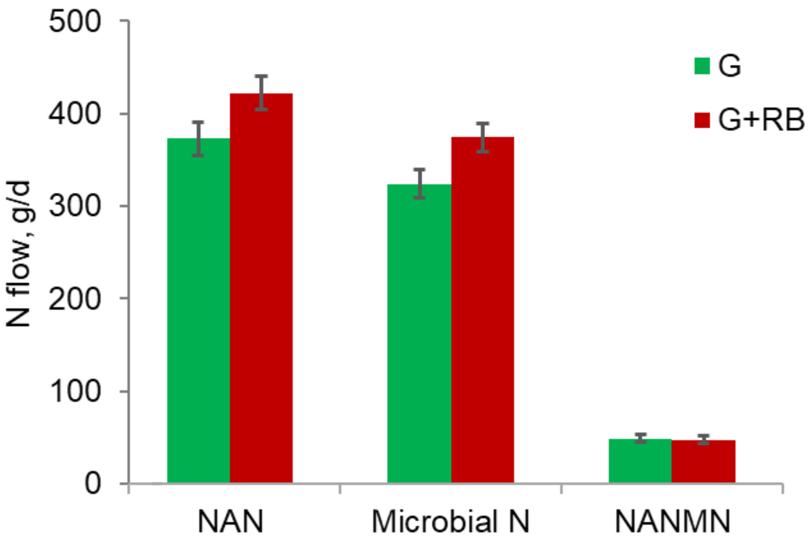


Ruminal NDF Digestion





Protein Nutrition



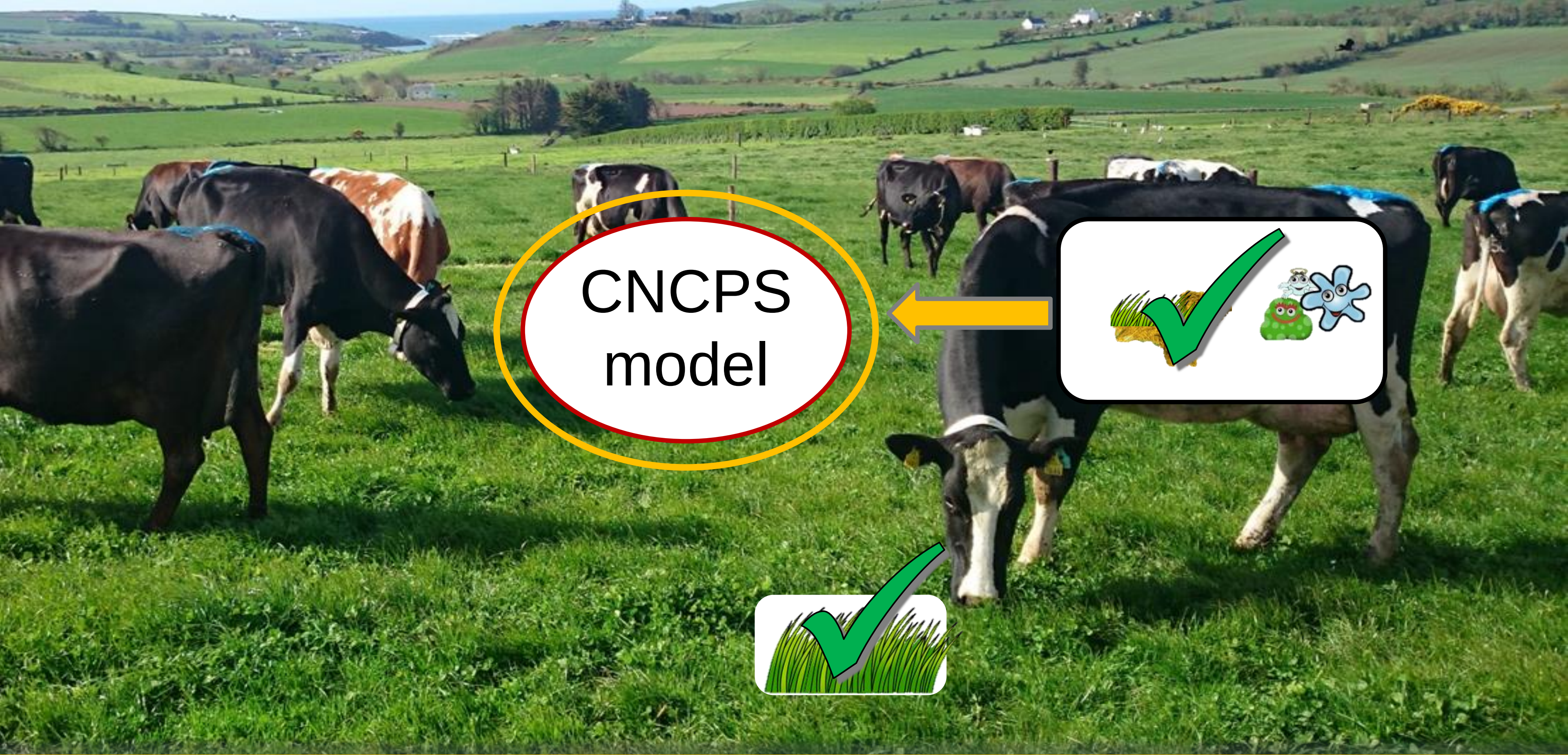
Item	Microbial AA flow, g/d				Non-microbial AA flow, g/d			
	Treatment				Treatment			
	G	G+RB	SEM	P	G	G+RB	SEM	P
EAA								
Arg	80	93	4	<0.01	6	5	1	0.82
His	28	32	1	<0.01	5	5	1	0.87
Ile	97	110	5	<0.01	10	10	1	0.81
Leu	123	141	6	<0.01	32	33	2	0.82
Lys	136	147	7	<0.05	21	19	2	0.56
Met	48	56	2	<0.01	4	3	1	0.27
Phe	72	83	4	<0.01	20	21	1	0.83
Thr	88	100	4	<0.01	18	17	1	0.52
Trp	31	35	2	<0.01	6	5	0	0.13
Val	90	103	4	<0.01	19	19	1	0.80
Total EAA	790	903	38	<0.01	141	135	10	0.67
Total AA	1,639	1,873	78	<0.01	324	321	22	0.93

Implications

- When cows were offered high quality PRG (moderate CP, low NDF) energy supplementation resulted in:
  - High substitution rate
  - Low milk production response
  - Negative associative effect on NDF digestion, independent of pH
  - Increased microbial protein synthesis

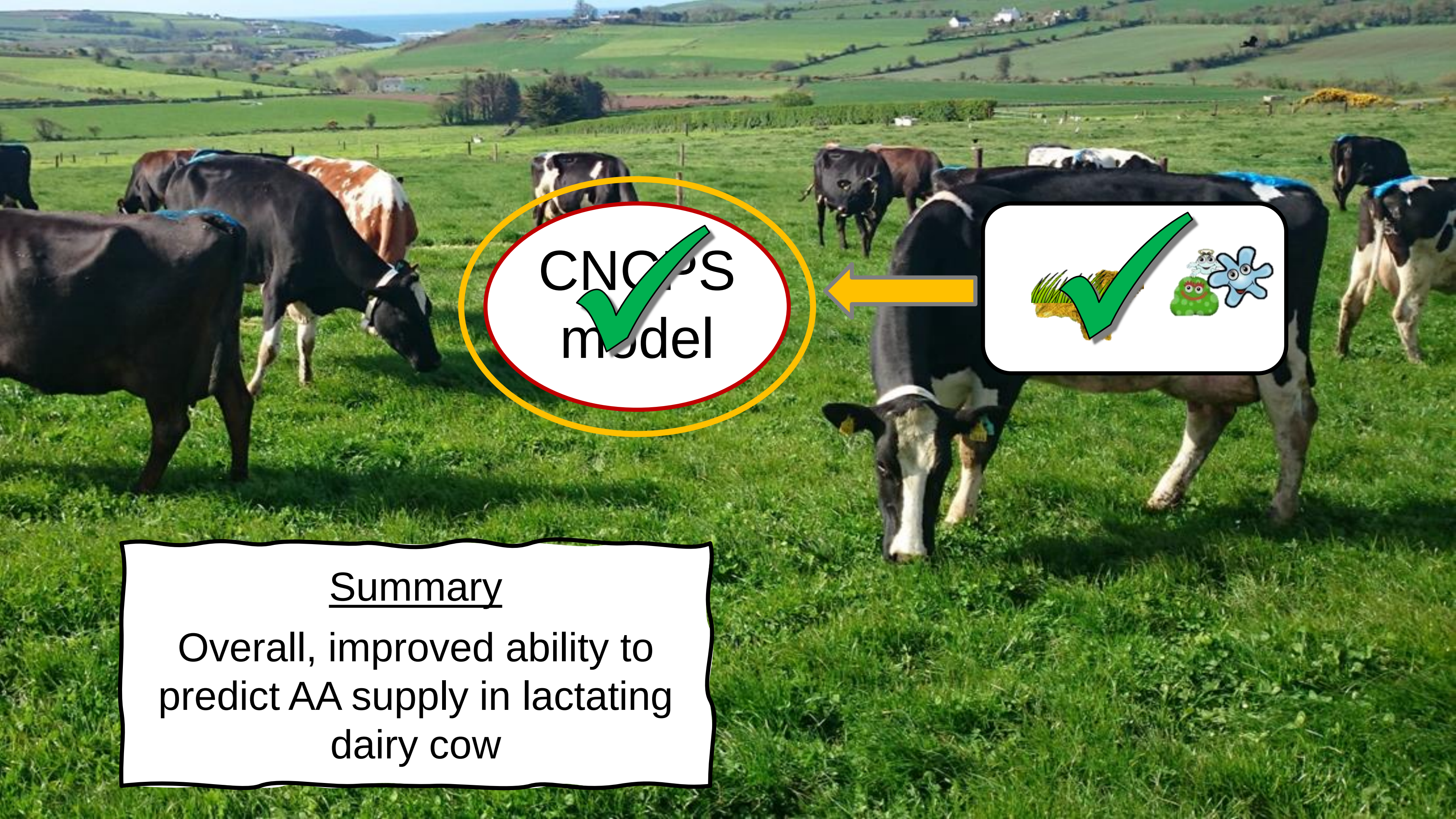
- PRG pasture can be extremely degradable allowing high DMI to be achieved

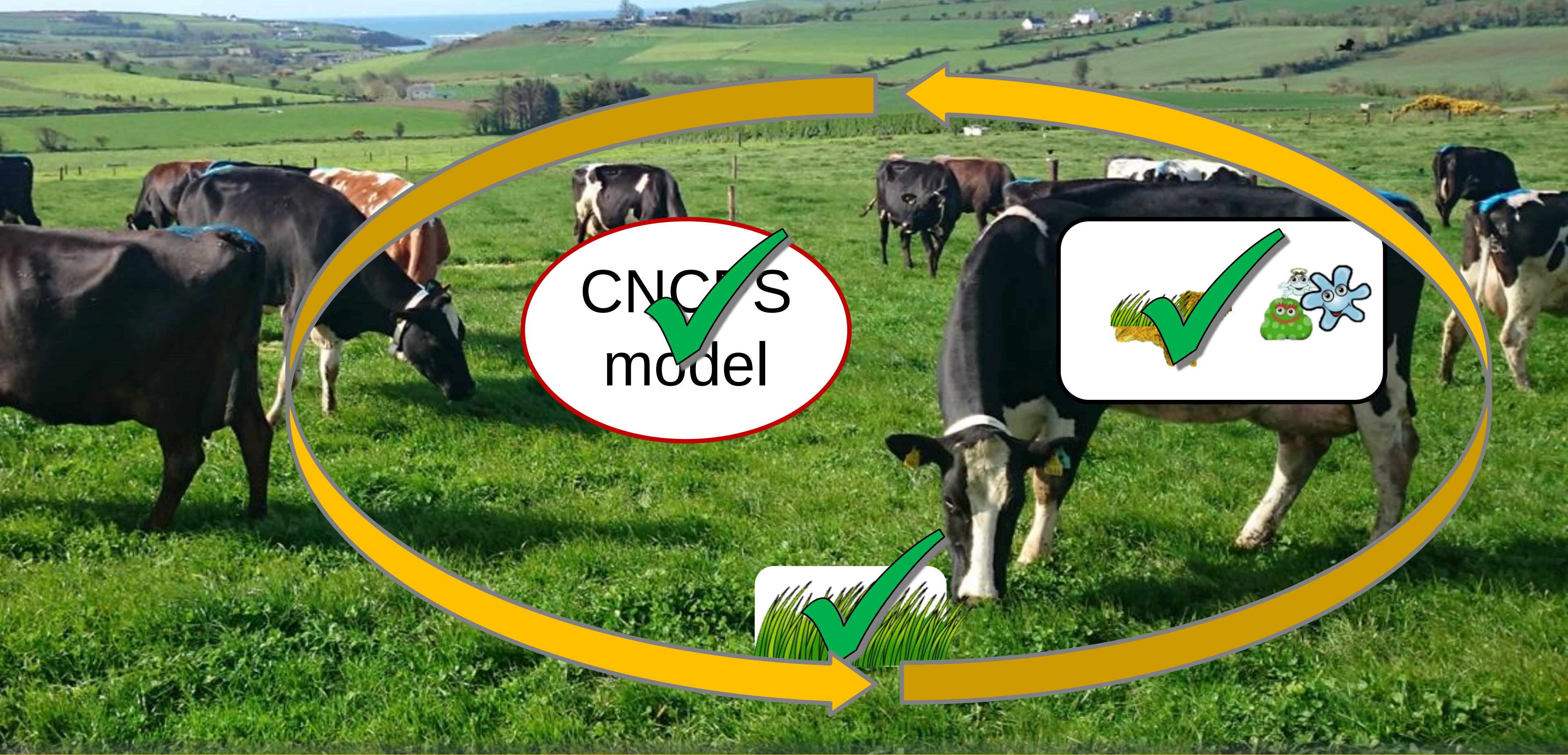
- PRG protein can be extensively degraded in the rumen:
  - Cows extremely dependent on microbial AA supply
  - Large contributions from protozoa, which were demonstrated to grow rapidly



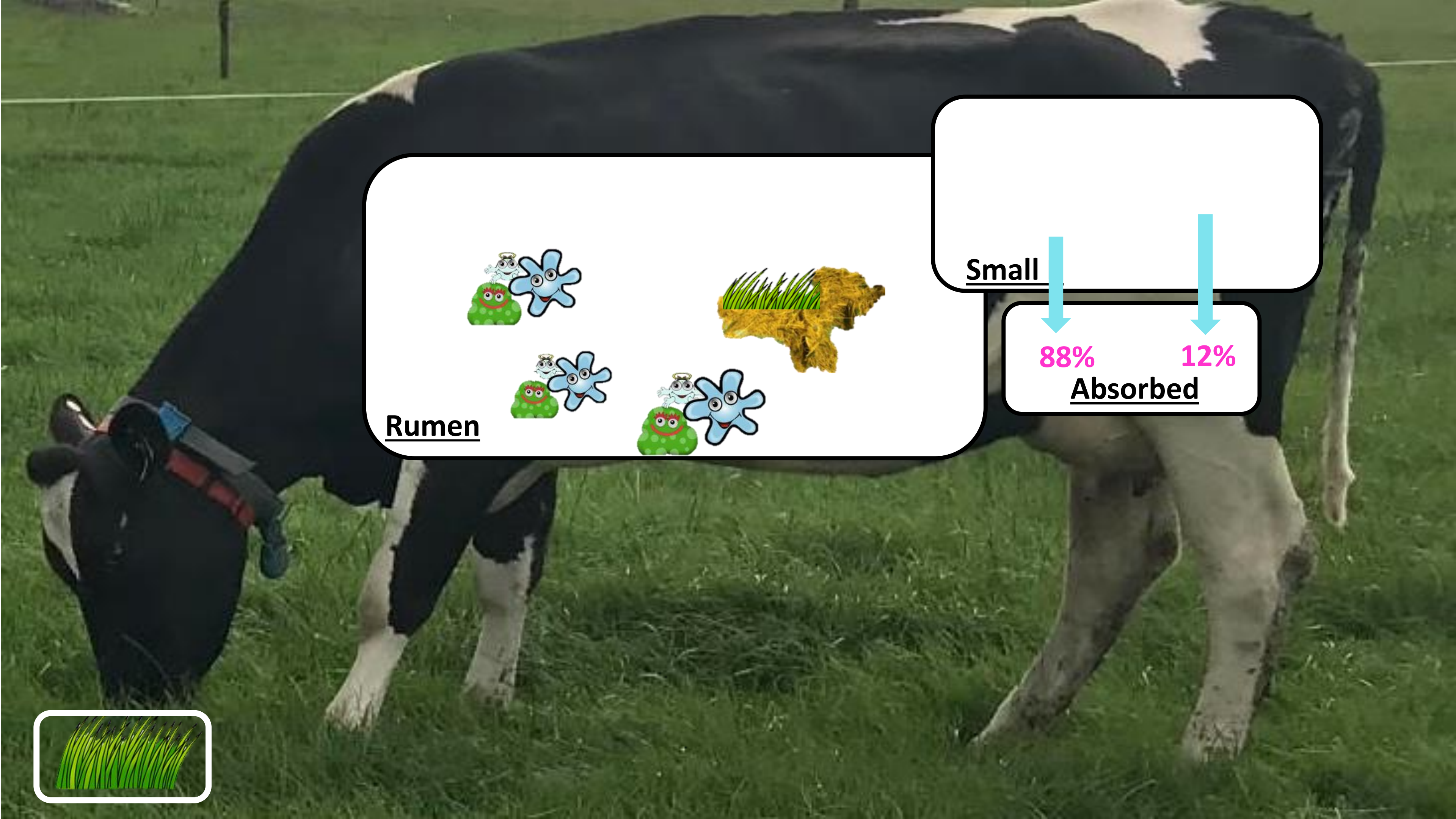
Research Objective 3:

Integrate new understanding into the CNCPS


CNCPS
model
Summary
Overall, improved ability to predict AA supply in lactating dairy cow



Research Objective 4:
Identify supplementation strategies to complement grazed pasture


Small
88%
12%
Absorbed
Rumen

Grazing Supplementation Experiment

- 80 dairy cows (98 ± 25 DIM and 518 ± 64 kg of BW) – June - August, 2018
- 2 wk co-variate and 10 wk data collection
- Treatments:
  - ➢ Perennial ryegrass only (GO)
  - ➢ PRG + Citrus pulp (4.8 kg DM) + Urea (0.07 kg; CITRUS)
  - ➢ PRG + heat-treated soybean meal (0.8 kg DM; RP-SBM)
  - ➢ PRG + Citrus pulp + HT-SBM (3.1 kg DM; 3:1 MIX)

Dineen et al., in review. J. Dairy Sci.

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Formulated Diets

Item	GO	CITRUS
Supplement fed (kg DM)	-	4.8
CP (% DM)	18.3	16.4
NDF (% DM)	35.0	31.9
pdNDF (% NDF)	91	89
ME supply v. 7* (Mcals day^{-1})	48	52
MP supply v. 7* (g day^{-1})	1,781	2,036

*Calculated using CNCPS v.7.0

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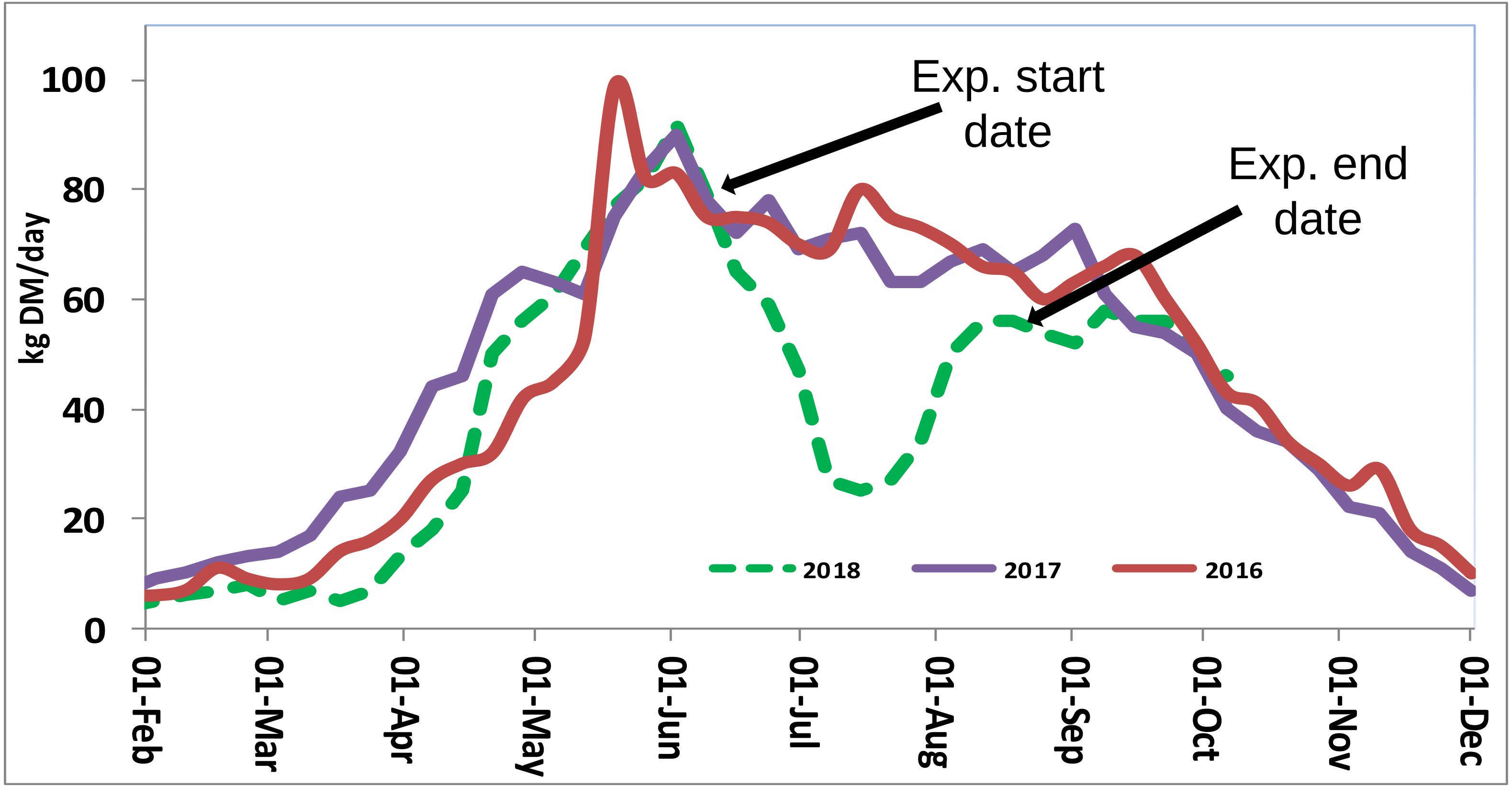


kg DM/day
100
80
60
40
20
0
Exp. start date
Exp. end date
2018
2017
2016
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec

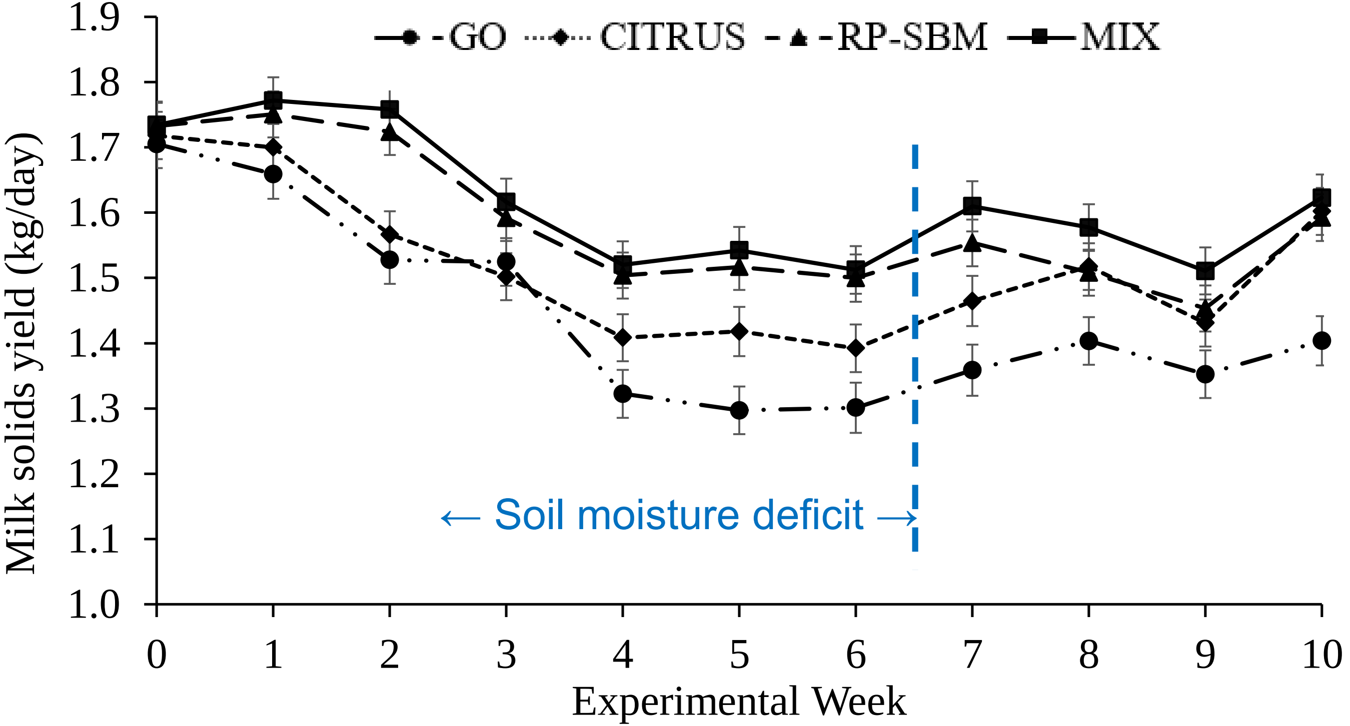
Pasture CP, NDF and uNDF Concentrations

Intake and Digestibility

	Diet					
Item	GO	CITRUS	RP-SBM	MIX	SEM	*P*
Intake, kg/d						
Pasture DM	15.6[a]	12.8[b]	15.3[ac]	13.8[bc]	0.47	<0.01
Supplement DM	0.0	4.8	0.8	3.1	-	-
Total DM	15.6[a]	17.6[b]	16.1[ab]	16.9[ab]	0.48	<0.05
Apparent total-tract digestion, g/g						
NDF	0.70[a]	0.67[b]	0.70[a]	0.68[ab]	0.006	<0.01
ME supply*, Mcals/d	38	43	39	41	-	-

*Calculated using CNCPS v.7.0

Milk Solids Production

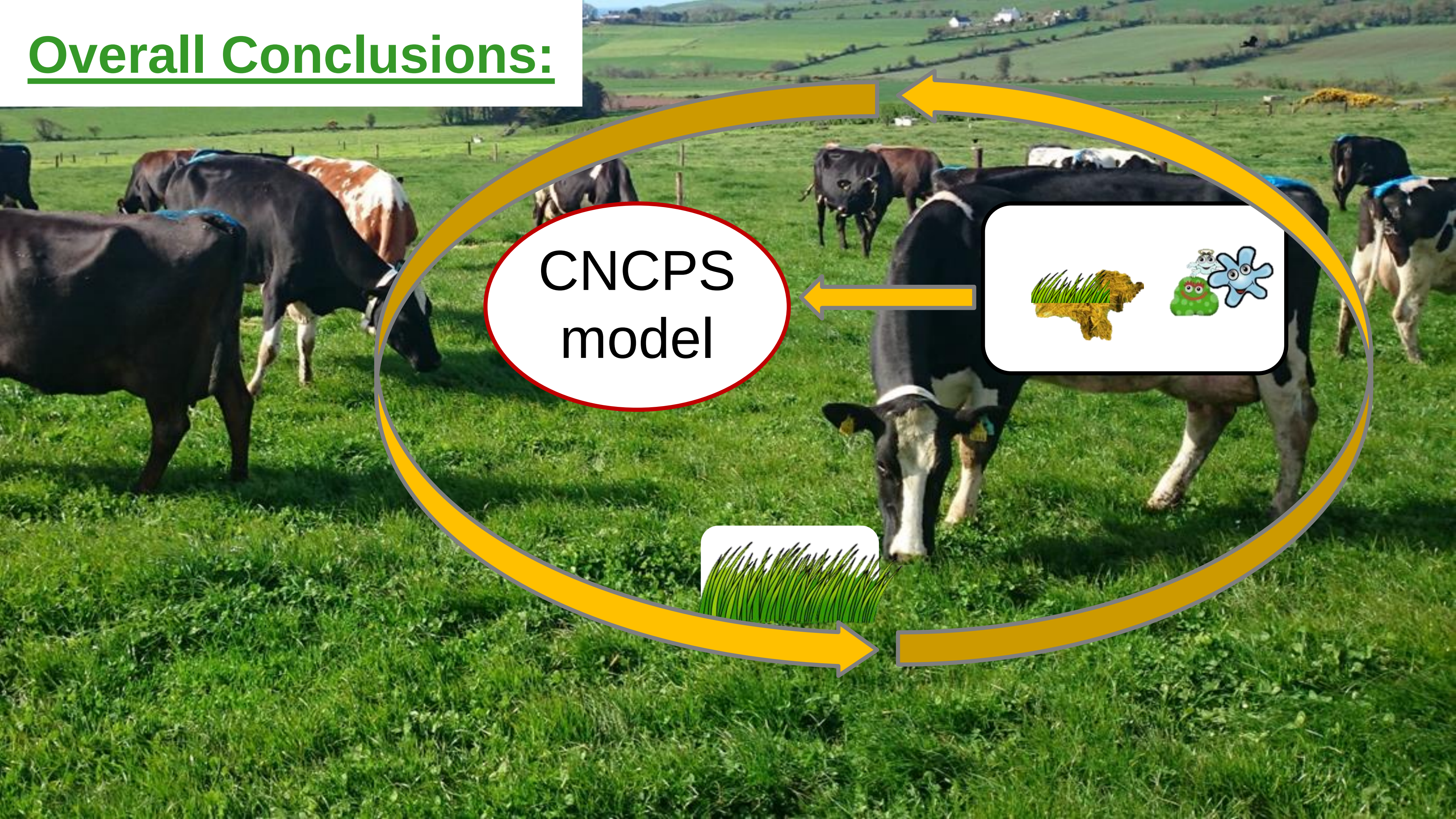


Item	GO
Milk solids, kg/d	1.41[a]
Milk response, kg MS/kg supplement	-

Implications

- When cows were offered low quality PRG (low CP, high NDF):
  - Supplementation with a fermentable CHO source (citrus pulp) increased DMI but did not affect MS yield
  - Supplementation with a RP-P source (HT soybean) did not affect DMI and increased MS yield indicating that cows were more limited by MP supply rather than ME supply
- Supplementation type needs to be considered in conjugation with pasture nutrient composition

Overall Conclusions:



Future Work

- Develop new feed chemistry methods
- Perform further omasal flow experiments
- Repeat the final experiment
- Early lactation supplementation experiments
- On-farm sample collection
- Continue development and refinement of the CNCPS

Acknowledgments

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Thank you!

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