Biopara-Milk: a whole cow simulation model for the prediction of rumen pH

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Monday 25th August 2014

Annual Meeting of the EAAP Copenhagen - Denmark

Introduction

New technologies .

- Measure physiological, behavioural and production parameters
- Animal health and welfare

Mathematical modelling is a helpful tool:

- Simulate feeding strategies and their impact on performance
- Describe the complexity of the rumen

Photos from:
http://www.ecow.co.uk/wp-content/uploads/2011/07/Brochure-2010.pdf
http://www.hoards.com/IB_Dairymaster_MooMonitor_Best_Heat_Detection_System_Worldwide

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Simulation models in Ruminant Nutrition

Biopara-Milk developed by Bioparametrics Ltd.

- Mechanistic whole cow model
- It includes a simulation of the entire digestive system
- Predicts the impact of feeding strategies on
  - Performance
  - Circadian pH

Jessop and Herrero (1996); Emmans (1997); Friggens et al., (2004); Gordon and Illius (1996); Djikstra et al (2012) Mertens and Ely (1979); Rymer and Givens (1998) Kohn and Dunlap (1998)

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Biopara-Milk principles

Ration formulation programme

- Simulation model
- Rumen function and Microbial growth
- Feed digestion lag and fermentation rates (*in vitro* gas production technique)

- Predictions based on 6min simulation model outputs
  - Milk yield
  - Feed intake
  - Rumen pH

Jessop and Herrero (1996); Emmans (1997); Friggens et al., (2004); Gordon and Illius (1996); Djikstra et al (2012) Mertens and Ely (1979); Rymer and Givens (1998) Kohn and Dunlap (1998)

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How does Biopara-Milk predict pH?

pH is calculated from bicarbonate concentration in the rumen (Kohn and Dunlap, 1998)

- Bicarbonate production
  - Bicarbonate from saliva (rest, eating and ruminating)
  - Dietary input
  - Absorption of VFA = bicarbonate production from CO_2
- Bicarbonate usage
  - Hydrogen production or consumed from diet neutralise bicarbonate
  - VFA and lactic acid production determined by feed consumed
  - Bicarbonate flux with solid and liquid passage

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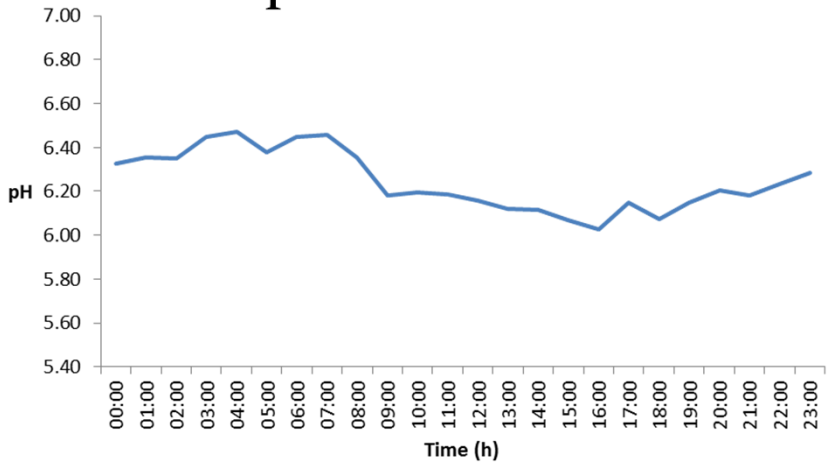
Intra-ruminal boluses

- Detailed and reliable information
  - Record pH dynamics accurately
  - pH every 15min (variable)
  - Size (27mm x 115mm)
  - Data storage/download
- Do not compromise animal performance



Mottram (2008, 2012) Phillips et al. (2010)

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Photo from:
http://www.ecow.co.uk/wp-content/uploads/2011/07/Brochure-2010.pdf

Aim

To compare rumen pH predictions from Biopara-Milk against those obtained with rumen pH boluses in lactating dairy cows.

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On-farm trial

Trial at Langhill dairy farm R(D)SVS

The University of Edinburgh

- Two weeks to adapt to facilities, measurements recorded in week three
- Each cow was administered an intra ruminal bolus

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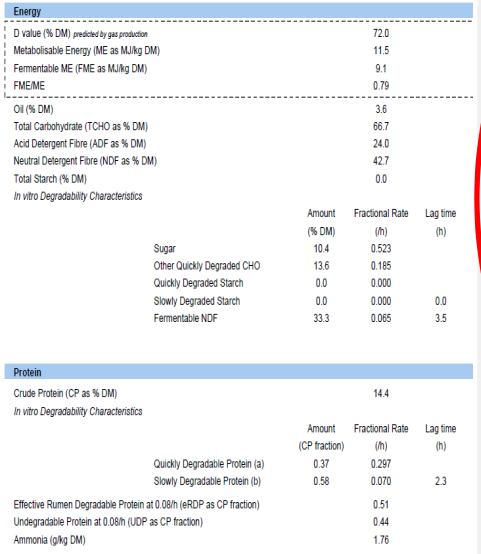
Inputs to run Biopara-Milk: Feed and forages

- Diet composition
- Chemical characteristics
- Degradation parameters
  - *In vitro* gas production



Energy	
D value (% DM) *predicted by gas production*	72.0
Metabolisable Energy (ME as MJ/kg DM)	11.5
Fermentable ME (FME as MJ/kg DM)	9.1
FME/ME	0.79
Oil (% DM)	3.6
Total Carbohydrate (TCHO as % DM)	66.7
Acid Detergent Fibre (ADF as % DM)	24.0
Neutral Detergent Fibre (NDF as % DM)	42.7
Total Starch (% DM)	0.0

In vitro Degradability Characteristics

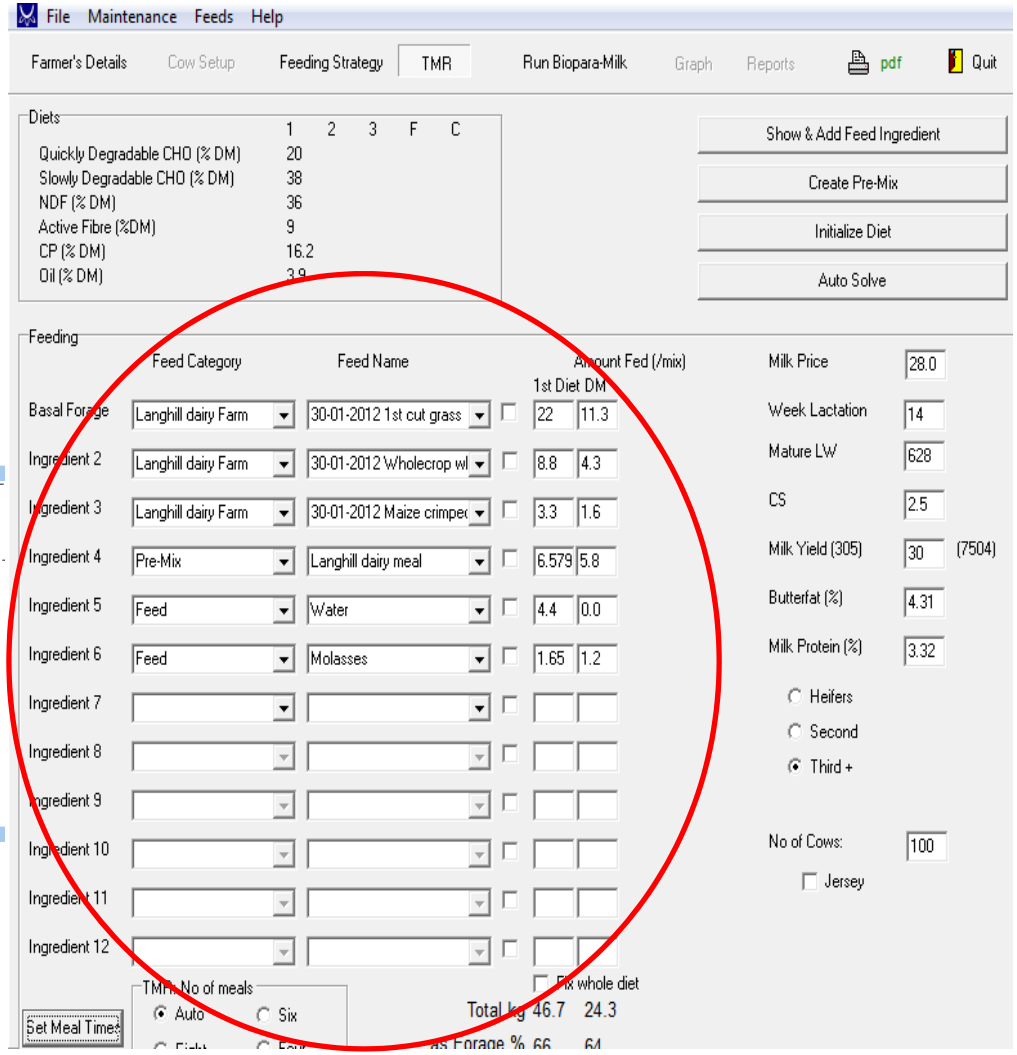
	Amount (% DM)	Fractional Rate (/h)	Lag time (h)
Sugar	10.4	0.523	
Other Quickly Degraded CHO	13.6	0.185	
Quickly Degraded Starch	0.0	0.000	
Slowly Degraded Starch	0.0	0.000	0.0
Fermentable NDF	33.3	0.065	3.5

Protein	
Crude Protein (CP as % DM)	14.4

In vitro Degradability Characteristics

	Amount (CP fraction)	Fractional Rate (/h)	Lag time (h)
Quickly Degradable Protein (a)	0.37	0.297	
Slowly Degradable Protein (b)	0.58	0.070	2.3

Effective Rumen Degradable Protein at 0.08/h (eRDP as CP fraction)	0.51
Undegradable Protein at 0.08/h (UDP as CP fraction)	0.44
Ammonia (g/kg DM)	1.76



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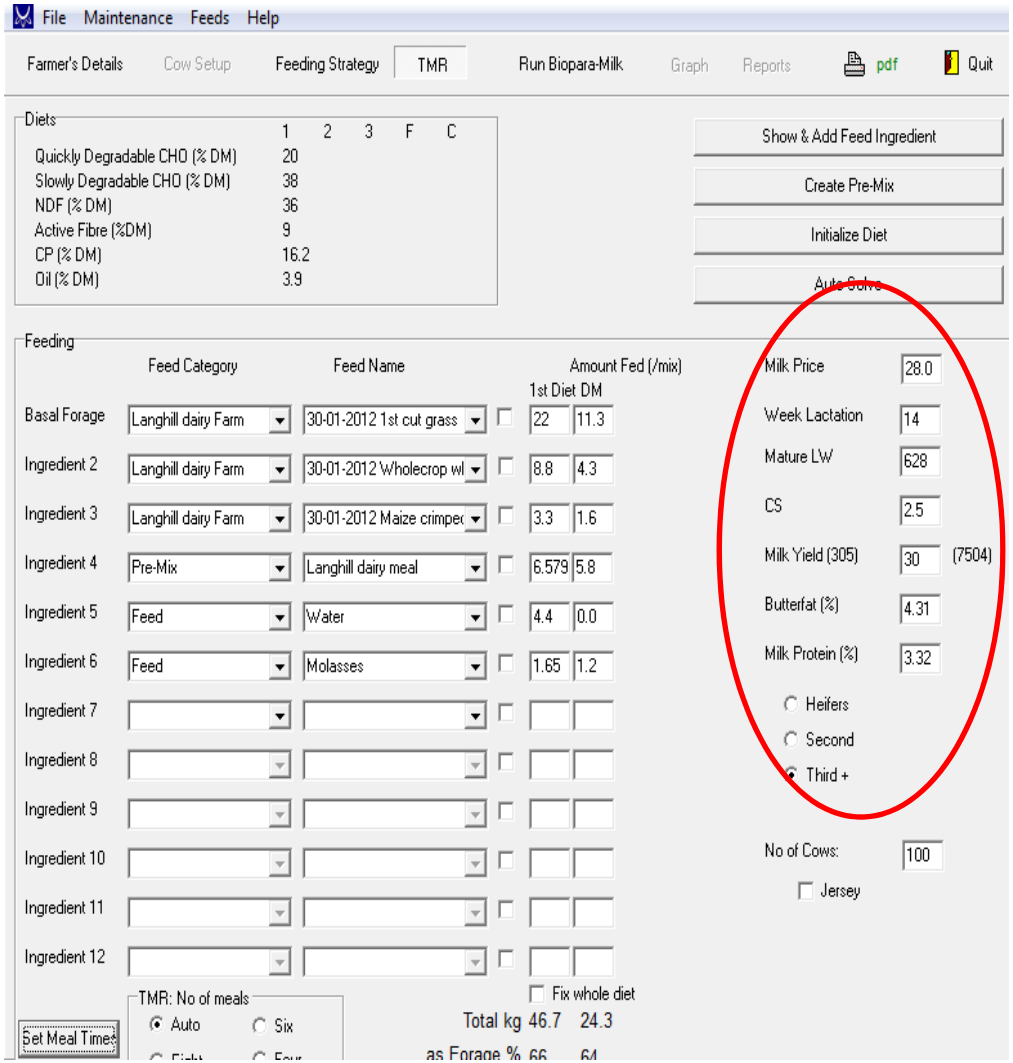
Inputs to run Biopara-Milk: Animal characteristics

- Production parameters
  - Body weight
  - Body condition score
  - Lactation number
  - Week of lactation
  - Milk potential
  - Milk yield
  - Milk composition
  - Feeding behaviour



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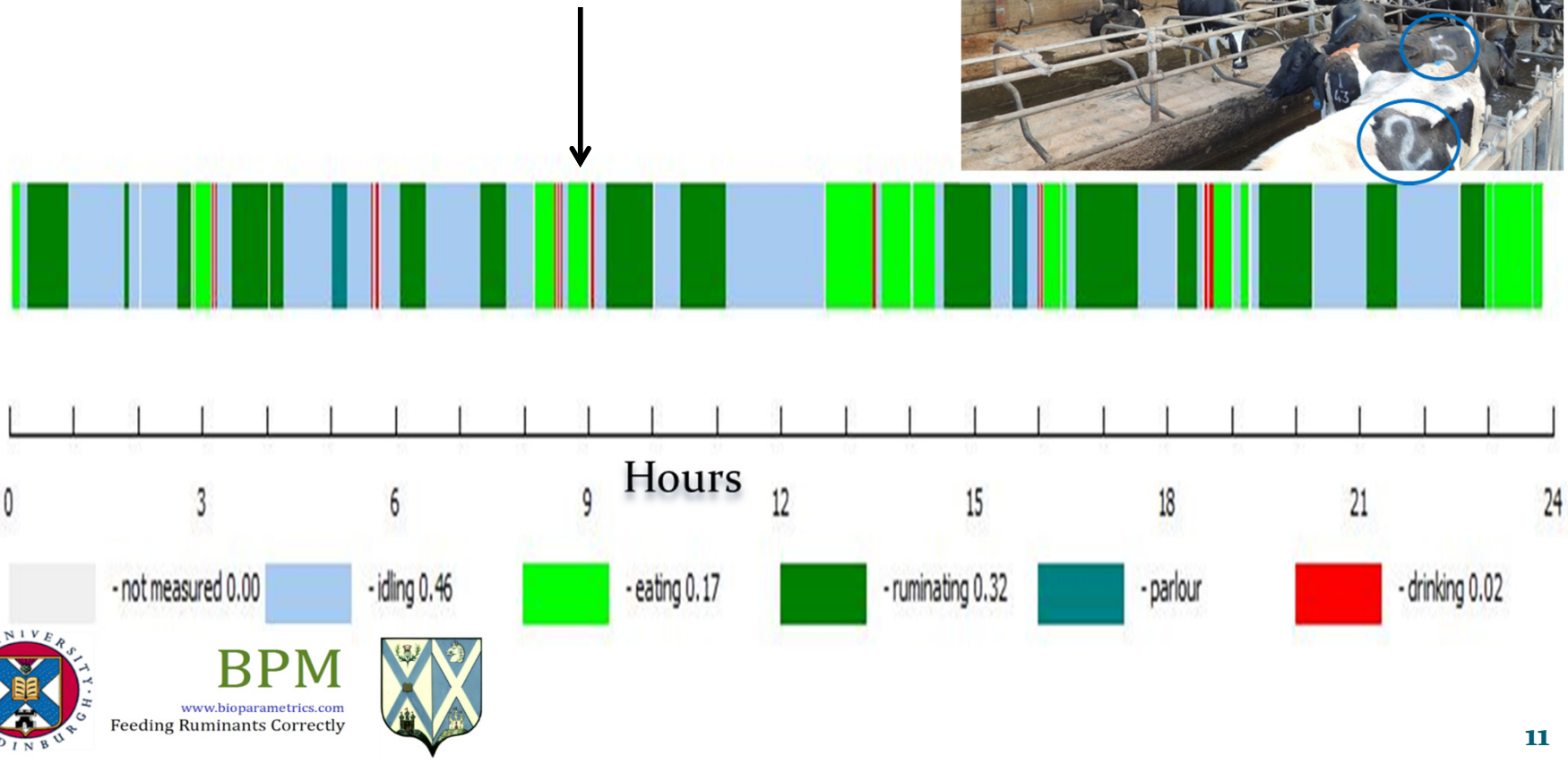
Inputs to run Biopara-Milk

Feeding behaviour

- Analysis of cow behaviour from video recordings



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Results

- Data from 9 cows
  - pH data
  - Feeding behaviour
  - Cow details
  - Feed/forage composition
- pH data from Biopara-Milk predictions

- Statistical Analysis
  - Limits of Agreement method
  - Concordance Correlation Coefficient

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Comparison by cow

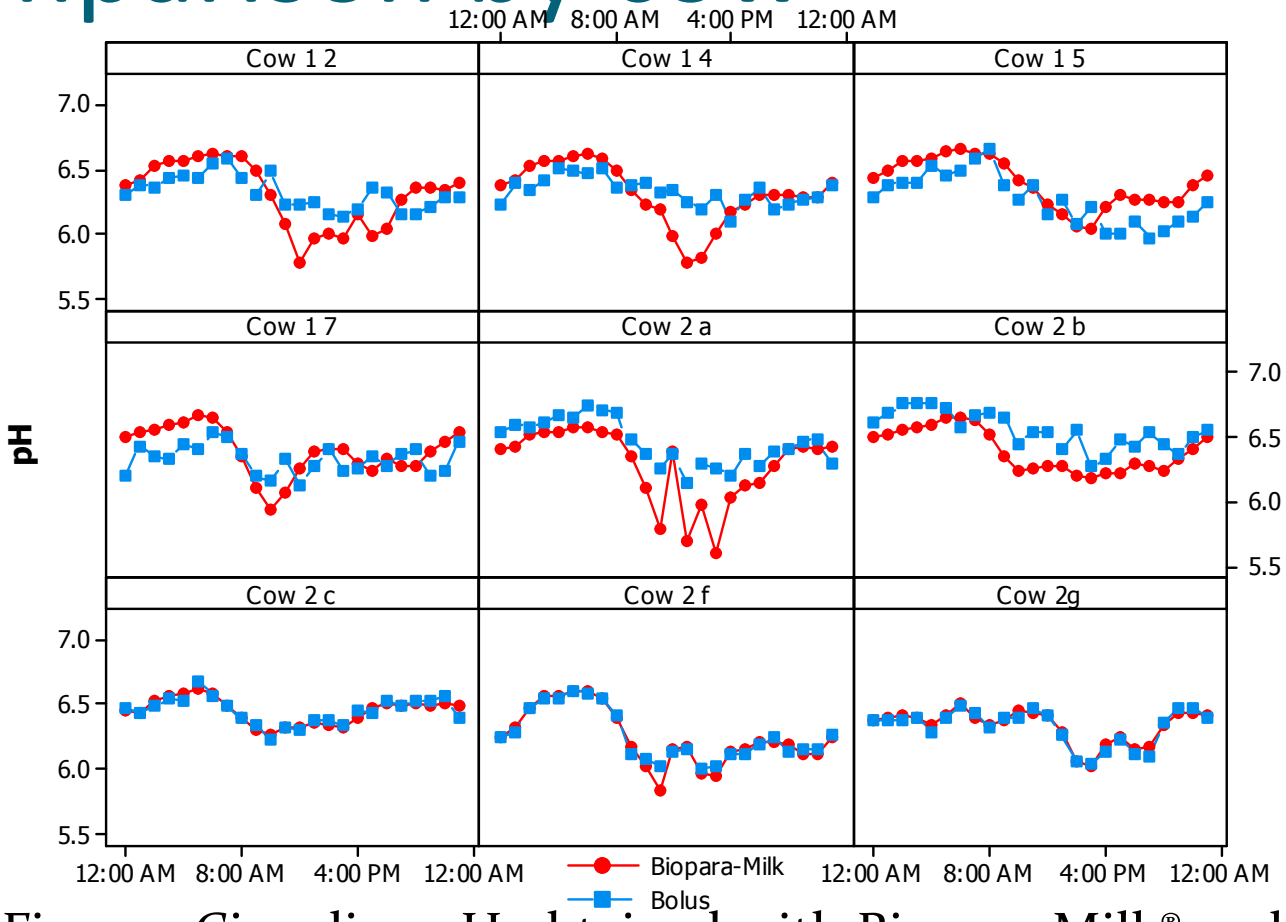

Figure 1 Circadian pH obtained with Biopara-Milk® and by intra ruminal boluses for each cow.

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Differences between predicted and observed rumen pH

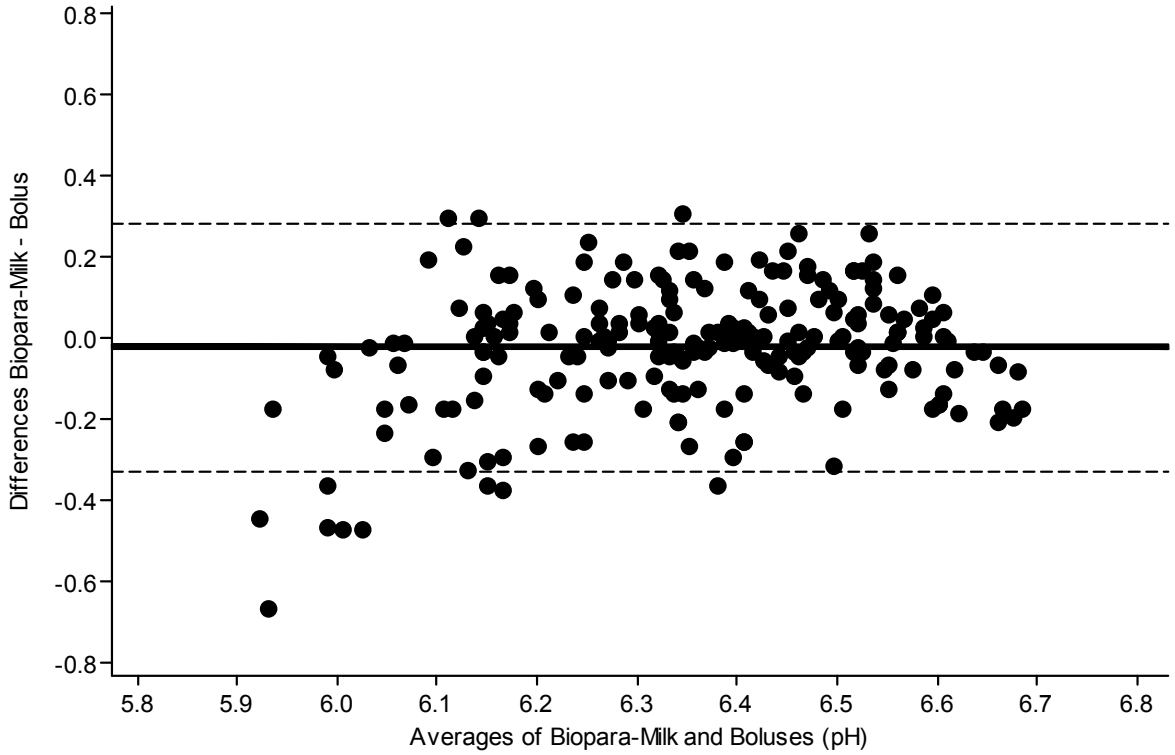

Figure 2 The limits of Agreement method with multiple observations per individual.

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Hourly average of predicted and observed rumen pH??

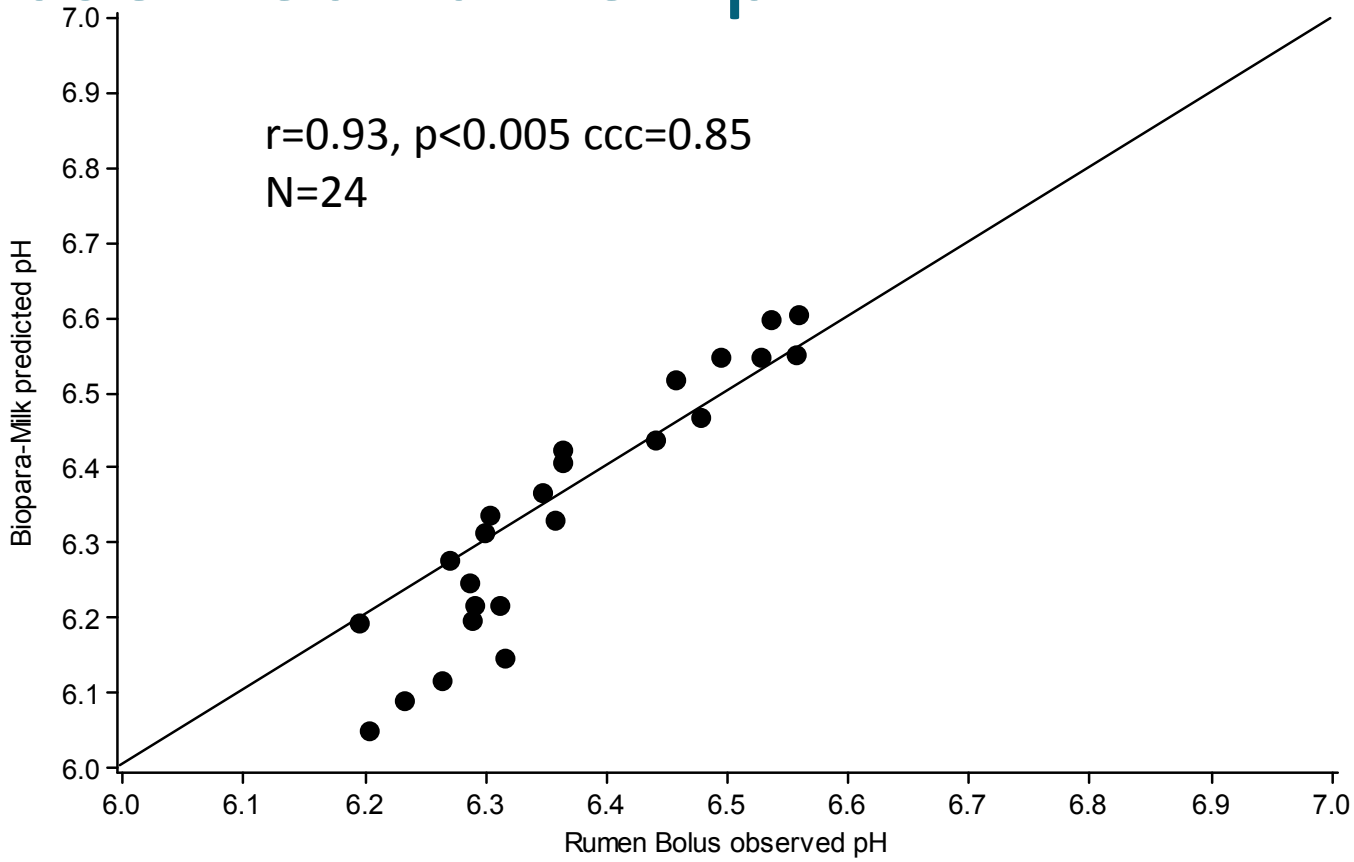

Figure 3 Pooled data of rumen pH per hour for all cows obtained with Biopara-Milk and the rumen pH boluses.

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Feeding behaviour

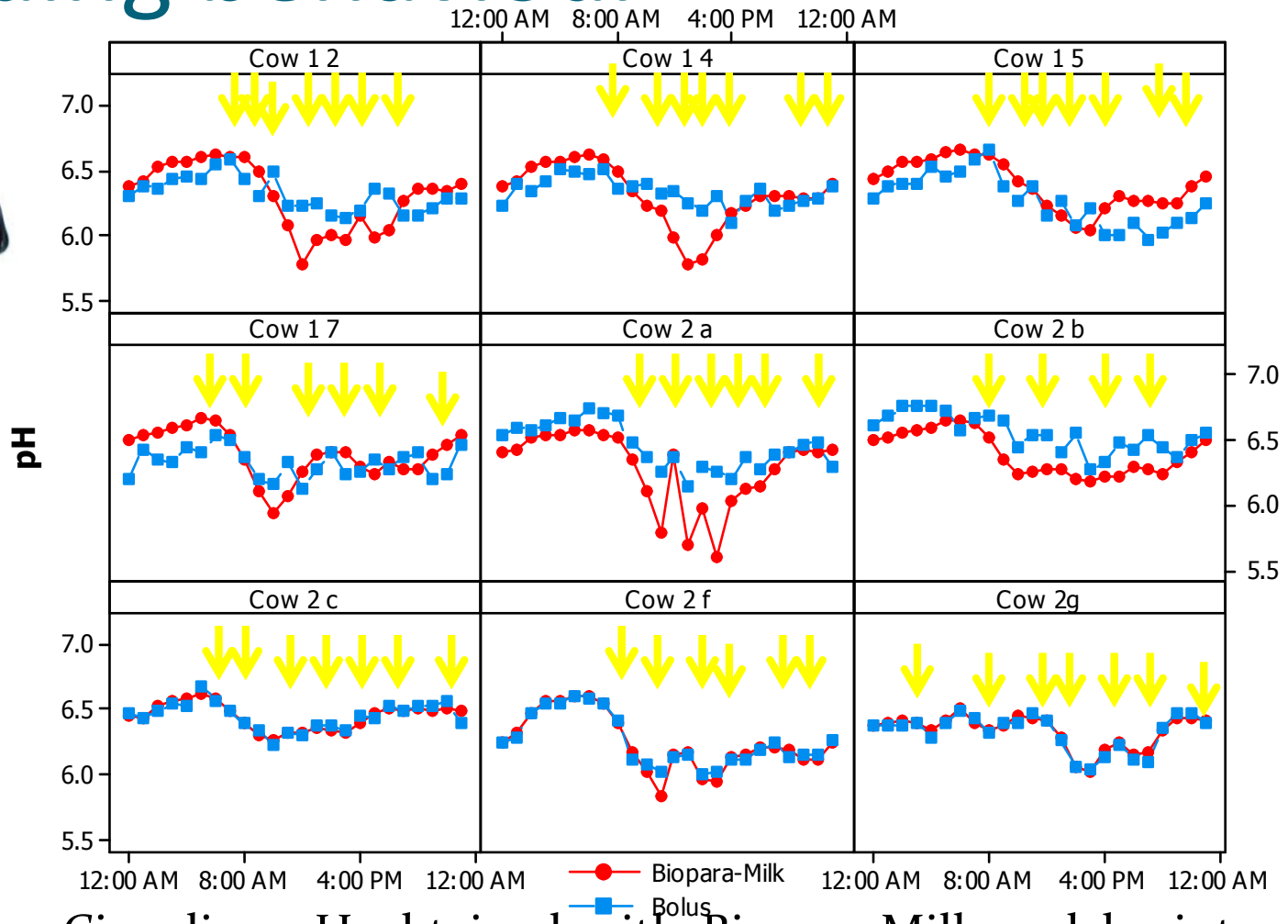

Figure 4 Circadian pH obtained with Biopara-Milk and by intra ruminal boluses for each cow the yellow arrows represent meal patterns

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Conclusions

- Given an accurate description of the animals and the feed consumed, Biopara-Milk is capable of accurately predicting pH dynamics in dairy cows
  - The limits of Agreement (0.02 pH) and the concordance correlation coefficient (CCC=0.85) showed minimal differences between predicted and actual rumen pH

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Implications

- Testing Biopara-Milk on different feeding regimes and feedstuffs
- Using different feeding patterns
- Improving accuracy of rumen pH predictions will benefit ration formulation for dairy cows
- Biopara-Milk can be used to test different feeding regimes and the effects they have on rumen pH before they are applied on-farm

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Thank you for your attention

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