Survey of rumen pH in commercial dairy herds

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Abstract

The development of the rumen telemetry bolus now permits precision in determining the risk of acidosis for commercial cattle. At the EAAP 2014 Mottram *et al.* presented case studies of the effects of husbandry on reticulo-rumen pH. In this study we analysed 450 rumen pH records from commercial and research herds through 2013/2014. For ten farms where metadata was available the rumen profiles of 38 cows were categorised by husbandry and feeding type (grazing and concentrate (GC), TMR and concentrate (TC), grass silage and concentrate (GSC), robotic milking (Robot)). The data files were reduced to exclude any risk of sensor errors. The daily mean pHs for over each period ranged from 5.961 to 6.894 with an average of 6.315 pH units. The daily mean pH values were poorly correlated to milk yield (R^2 = 0.248). The metric of percentage hours below 5.8 pH showed a better correlation with milk yield (R^2 = 0.469) but there were bigger between farm differences indicating that statements such as high yielding cows all have SARA are not supported by this evidence. ANOVA shows that variation within groups shows that we have to reject a null hypothesis that there is a husbandry effect on mean rumen pH and percentage time below 5.8pH.

Introduction

The eCow telemetry bolus, used for measuring reticulo-rumen pH and temperature to determine the risk of acidosis and the overall health of the cow, has been available to farm customers since 2013. A large amount of rumen pH data has been collected from a wide variety of locations and systems. At the Mottram *et al.* 2014 presented case studies of the effects of husbandry on reticulo-rumen pH, showcasing how the data from individual cows can lead to insights into the cows health and the suitability of their diet. In this study we provide the first large scale analysis of rumen pH and temperature profiles to give unique insights into the effects of different management systems and seasonal variations on a cows health.

In this paper we filtered 450 rumen pH and temperature records spanning up to 200 days in length from commercial farms to extract continuous data records of rumen pH.

Materials and Methods

The boluses used were the farmBolus from eCow Ltd. The boluses were 125mm long by 27 mm diameter weighing 200g. The sensor end was made of stainless steel which inverts the bolus into a normally sensor down position in cows with a normal shaped reticulum. The electronics were encapsulated with a cold poured resin coat that has proved resilient against rumen liquor in trials and obviates the need for vulnerable seals. The sensor was a combined electrode pH probe routinely used in applications in industry. The temperature probe was embedded in the stainless steel end cap, which has machined holes to allow rumen liquor to flow past the sensor

tangentially without permitting direct impact of stones or grit on the glass sensing bulb.

The density of the bolus (specific gravity greater than 2) allowed it to remain in the reticulum for the life of the cow; data was collected wirelessly. The bolus contained no toxic materials at doses harmful to the cow. The bolus measured pH and temperature every 60 s and took an average value every 15 minutes and stored up to 2700 lines of data in a .csv format date, time, pH, temp, battery V, which was 96 lines of data per day stored over 28 days of data. If data was not collected the file on the bolus was overwritten starting from the beginning.

The boluses were administered to the cow by mouth with a standard bolling gun, the only restriction on operation was that a period of 2 hours should be allowed before reading for it to migrate to the reticulum. The bolus has a temperature switch which causes it only to activate when the temperature was above 31°C, to extend the shelf life. The device was calibrated at the factory before use and the calibration was accurate for four weeks in normal storage.The radio frequency used was in the 433 MHz ISM band.

Data was collected wirelessly using a 433 MHz antenna connected to an adapted mobile phone via micro USB. The customer collected the data with the adapted mobile phone handset by standing near the cow on the left front side. The customer was advised to administer 3 boluses to 3 normal healthy cows for a feeding group of 100 animals. Cows in the ante-partum period were often used to monitor through the transition phase and early lactation. This study had no control of the selection of cows as this was at the discretion of the farmer.

Farm Selection

The farms used in this trial were commercial farms buying and using eCow boluses to better understand the health of their herd and the suitability of their diet. Metadata from the farmswere collected through work with eCow's commercial partners Three Counties Feeds and Mole Valley Farmers. The main objective of this was to determine the type of feeding system other information was collected as well such as breed of cow and annual milk yield. All the farms were situated in the South West of England where the traditional system is summer grazing and winter silage feeding. However, the farms who purchased boluses tended to be those with higher yields with cows housed and fed through most of the year. Robotic milking systems were a subset of the TMR plus concentrate but the difference of profile shown by Mottram *et al.* 2014 was so profound that they were treated as a separate group.

The groups were Grazing, Silage and Concentrate (GSC), Silage and Concentrate with parlour milking (SC), TMR and Concentrate (housed cows) fed in parlour (TC), Robotically milked cows (Robot) with cows receiving a concentrate ration in the robot and a largely silage based bulk feed. The annual milk yields were rounded to the nearest 500 litres during the year in question.

The data were aggregated and the null hypothesis that the difference husbandry systems would affect mean pH was tested by ANOVA.

Data filters

Each bolus had an idividual data file on the eCow server in .csv format. These files were a concatenation of multiple uploads over a period of months. If there were missing data for example, through a gap in visits to the farm or any evidence that the bolus had failed the data were discarded from that point or at 60 days whichever was sooner.
Rumen boluses can fail from a number of reasons, if rumen liquor compromises the body of the sensor then the electronics stops working and no data is transmitted. More difficult is when data arrives but could be compromised by sensor failure. Sensor failures can be a cracked measurement electrode where the pH values are reported as below 4 due to an open circuit being created and this lies outside the physiological range. More difficult to detect is when after many months of operation the pH values tend towards pH7. This is due to the wet junction reference electrode becoming contaminated by rumen liquor and giving approximately the same reading as the measurement electrode. At a voltage potential of 0 the pH is read as 7. However, this contamination usually only occurs after 150 days and is also characterised by a narrowing of the pH range.

Results

In total 1876 days of data from 38 boluses were analysed. The daily mean pH values were poorly correlated to milk yield ($R^2 = 0.248$). The metric of percentage hours below 5.8 pH showed a better correlation with milk yield ($R^2 = 0.469$).

Yield (l/pa)	Mean pH	Percent time below 5.8 pH	n
7000	6.4	1.82	2
9500	6.2	4.79	4
10000	6.4	0	1
11000	6.4	1.12	1
11500	6.3	9.64	1
12000	6.3	5.65	1
R2	0.248	0.46960974	
System	mean pH	% below	n
SC	6.212	2.68	1
GSC	6.526	0.82	1
Robot	6.205	4.79	4
TC	6.348	5.08	4

Table 1: Group values of mean pH and % time below 5.8 against yield

Farms	mean pH	% hours below 5.8 pH	Block
A	6.212	2.68	SC
B	6.526	0.82	GSC
C	6.11	2.4	Robot
D	6.156	0	Robot
E	6.188	9.38	Robot
F	6.311	0.14	Robot
G	6.443	0	TC
H	6.411	1.12	TC
I	6.304	9.64	TC
J	6.268	5.65	TC

Table 2: Mean pH and time below threshold by farm

The F value was greater that the Fcrit value and thus the null hypothesis is rejected the effect of husbandry is not as great as the within system and within farm difference.

Discussion

This study shows that rumen boluses are now a reliable way of routinely capturing reticulo rumen pH values in commercial dairy cows. Some boluses still fail before the data becomes unreliable due to sensor drift but as the technology progresses this is less and less likely. The biggest surprise in this study was how little the mean pH varied between systems. This begs the question how accurate is the damaging rumenocentesis procedure that has hitherto to been used to capture a single time specific data point and use that data to claim high levels of SARA (Atkinson, 2013) are present. There are major differences between farms which reflect the importance of careful management of the balance of fibre and digestible in cows. Mottram *et al.* (2014) presented the various daily pH profiles of different systems and it is clear that the mean pH masks major differences in daily profile.

A better correlation exists between hours below 5.8 pH (Garrett *et al.* 1999, Tajik *et al.* 2011 definition of 5.5 pH in the ventral sac) and farm milk yield but even here the differences between farms is striking, the highest yielding herd clearly manage the diet successfully to maintain

The four robotic milking herds all had the same annual average yields presumably becuase they follow a system laid down by the same nutritionist but even here there

were major differences between farms. One robotic milking farm had a cow with a pH which stayed low for several weeks. At first we were set to exclude these data on the basis that the bolus must have failed in some previously unknown way but we saw the pattern in the all the cows in the herd so we just assume that this cow had a serious SARA problem.

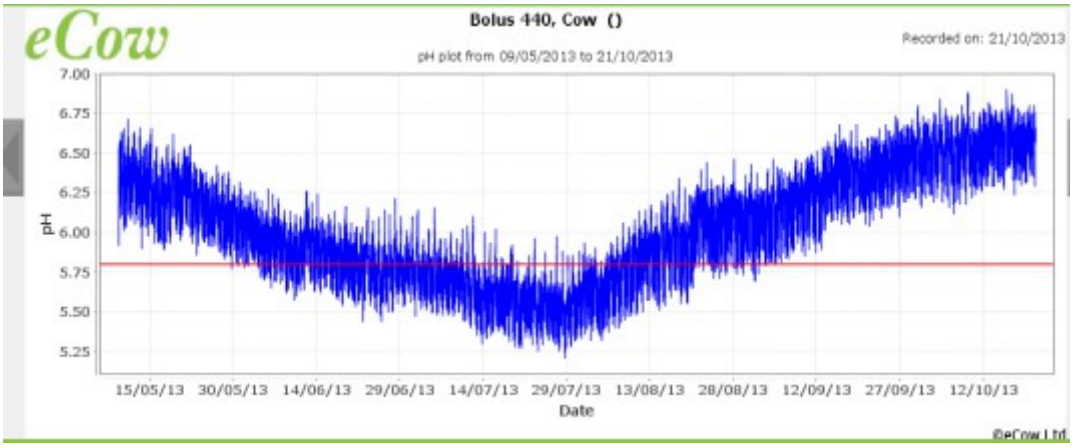

Figure 1 A cow with a serious SARA problem corrected by nutritional change emphasises the need for regular monitoring

ANOVA was applied to determine whether there was an effect of husbandry system on the pH characteristics but the F value was above the Fcrit and so the null hypothesis cannot be accepted.

It is clear that the use of rumen pH telemetry boluses can have a major role in identifying and monitoring the correction of a nutritional problem that has hitherto been difficult to diagnose. These data overturn the lazy suggestion that high yielding cows all have sub-clinical acidosis, skillful management of diets can maintain rumen health in high yielding cows.

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