

EBLEX Oestrus and Parturition Project - Final report

Project title

“Evaluating the prediction of oestrus and parturition from data generated by a remote telemetry activity meter, ruminal temperature bolus and visual observation”

1. Introduction

1.1 Project background, context and need

Reproductive performance drives the success of the beef suckler herd. Minimising barren cows and maximising cows calving in the first few weeks of the calving pattern promotes weaning the maximum possible kg of beef/cow mated. Analysis of EBLEX’s 2011 Business Pointers data for extensive finishing enterprises shows dramatic differences between top and bottom third producers for output prices achieved. The best performing enterprises have produced improved margins despite higher costs. The average price received per animal sold was £521 for top third compared to £337 for bottom third. Caldow et al (2005, 2007) proposed a five point plan to manage beef cow productivity. Point 4 is ‘Avoid difficult calvings’ and point 1 is ‘Heifer management’. All too often heifer replacement management remains an afterthought for the beef suckler herd, with inappropriate genetic selection for future suckler cow production and strategically poor integration to the overall farm business.

Artificial insemination (AI) represents an opportunity for improvement in the beef suckler herd. AI of cows and especially maiden heifers is an underutilised opportunity to critically select appropriate bull genetics for positive calving ease and negative gestation length EBVs. Currently, heifers are frequently naturally mated inappropriately by terminal sire bulls, at best selected for cow mating, with poor outcomes for future herd breeding potential. Bull genetics for AI could be selected on EBVs targeted specifically towards future maternal breeding performance for heifers and towards marketable carcass traits associated with terminal sires for cows.

Oestrus synchronisation protocols exist for fixed time AI (Penny 2005), but results can be disappointing when compared to natural service and over-reliance on hormone inputs can be an issue for consumer confidence in the UK and wider EU market. In addition, many beef enterprises have limited labour resources for monitoring cows in oestrus to determine appropriate timing for AI.

1.2 Activity levels

It has been widely demonstrated that motor activity increases during oestrus in the dairy cow. Moore and Spahr (1991) found mean daily activity to be significantly greater on the day of observed oestrus than during the three days before or after. Redden et al (1993) identified a 2.3 fold increase in activity over 24 hours during oestrus when compared with the dioestrus period. Roelofs et al (2005) suggested that pedometers could accurately detect oestrus and may also present a promising tool for prediction of ovulation and hence improved fertilisation rates. This technology has become widely adopted in the dairy sector. Barriers to uptake in the beef industry have included issues of range in data download systems as beef cattle are not passing through management systems to be milked as in dairy herds. However, new systems are now commercially available which have longer range signalling and within-collar data processing and storage ('Heatime', SCR technologies and 'Silent Herdsman, NMR). With opportunities for siting base station readers near water troughs or feeding areas, this offers a promising solution to these barriers.

1.3 Rumen temperature

Similarly, Cooper-Prado et al (2010) proposed that ruminal temperature (RuT) of beef cows changes before oestrus; showing significant increase around oestrus. RuT may therefore have potential to predict oestrus with sufficient accuracy to facilitate appropriate timing of insemination. Use of ruminal temperature boluses and telemetry may facilitate frequent determination of body temperature. Measurement of ruminal temperature with a bolus is minimally invasive, allows frequent records of real-time data to be obtained, requires minimal labour, and permits cows to be maintained in a natural environment.

Prediction of parturition has also been an industry goal for many years. Targeting limited labour resources at the appropriate time could result in more successful calving outcomes. Cooper-Prado et al (2010) proposed that ruminal temperature (RuT) of beef cows changes before parturition; showing significant decrease the day before parturition. RuT may therefore also have the potential to predict parturition. Additional studies to evaluate the association of RuT with parturition may refine the use of automated technology systems to increase reproductive performance of beef cows.

Use of breeding technologies also represents an important opportunity for beef suckler herds to mitigate greenhouse gas emissions by improving productivity and efficiency (Chadwick et al 2007).

This pilot study investigates the opportunity presented by new remote telemetry devices to deliver automated prediction and signalling of oestrus and parturition in beef cows and heifers to facilitate improved performance outcomes from AI programmes.

2 Method

2.1 Background to the project

A literature review, completed by RAFT Solutions in March 2012, concluded that the use of breeding technologies represented an important opportunity for beef suckler herds to improve profitability and mitigate greenhouse gas emissions by improving productivity and efficiency. Sustainable beef production may be supported through selection of optimal EBV genetics available through artificial insemination (AI). Activity meters and rumen temperature boluses are being successfully exploited in the dairy industry, but

remain largely overlooked in the beef industry which is often compromised by the availability of trained labour and extensive systems. This pilot study aimed to test the hypothesis, in contrasting beef herd profiles, that:

Technologies that record increased activity in beef cows and heifers as detected by distance telemetry activity meter and/or changes in ruminal temperature can be used to:

(a) successfully predict oestrus and facilitate appropriate timing of AI in beef suckler herds, and

(b) successfully predict the timing of parturition and hence facilitate calving management and outcomes

It was proposed that successful oestrus detection would be confirmed by correlating both technologies with farmer observations, service by the bull and blood/milk progesterone testing. In some cases, to determine ovulation timing, ultrasound scanning and follicular mapping of the ovaries would also be carried out.

The sample size of two farms is insufficient for a robust statistical analysis of data relating to prediction of oestrus and parturition. The project aimed to test the feasibility of translating these two currently dairy based technologies into a real beef environment and explore the practical issues associated with their evaluation.

2.2 The study farms

Two farms were recruited to this study; one upland pedigree and one lowland commercial beef suckler enterprise. Farm details are summarised in Appendix 1.

2.2.1 Farm C

This pedigree upland Limousin farm is high health status for BVD and Johnes disease with all 40 breeding animals being synchronised and served during housing by AI. High health and high genetic merit cattle are of high value and so parturition prediction offers a huge benefit to the farm in targeting labour to calving. This upland farm houses cattle indoors for the initial part of the breeding season, so selection of this farm enabled assessment of the use of the technologies in a housed system. The farm has several large modern buildings all closely situated to one another, with some of multi-span construction.

2.2.2 Farm P

This commercial lowland farm runs 150 South Devon cross suckler cows. Spring calving takes place indoors, with optimal use made of available grazing feed supply for the freshly calved cows. Service is performed out in the field by AI so correctly identifying cows in heat is crucial to this system.

Both farms are run very successfully, yet very differently. One key characteristic is that both the farmers are highly conscientious, dedicated, and committed to progression of the industry.

2.3 Technology set up at each farm

Both farms were equipped with activity meter and rumen temperature bolus technology, utilising products which are commercially available in the UK and abroad:

- (i) 'Heatime' activity meters (SCR technologies; supplied by Semex UK and Fabdec UK)
- (ii) 'Bella Ag' rumen temperature boluses.

A summary description of the technologies is included in Appendix 2.

2.3.1 Farm C

Activity monitoring software 'Heatime Horizon' was initially installed, consisting of 40 collars (Figure 1), an antenna and a control panel. The control panel was removed roughly halfway through the trial and successfully upgraded to 'Heatime Dataflow II', allowing data back up and export to a PC.



Figure 1: Heatime collar at Farm C



Figure 2: Bella Ag reader at Farm C

Fifty rumen temperature boluses (Bella Ag) were supplied (sufficient for the 39 cows in the trial, plus some spares for replacement purposes) along with four 'readers' (Figure 2). The readers all communicated with a single coordinator which then sent data to a PC. Bella Ag supplied an additional reader part way through the trial as it was found that the readers were not covering all the areas required.

2.3.2 Farm P

Heatime (Heatime Horizon) was already in use on the farm as a method of oestrus detection. All 150 cows were collared but for the purpose of this trial only 100 cows were enrolled due to management factors, excluding the heifer group which spend time away from the main farm. The newer release of the system, 'Heatime Dataflow II', requires a computer within range of the cows so would not be suitable on a beef farm such as Farm P where, in contrast to farm C, the cows are inseminated out in the field away from the main farm premises. Whilst out in the field the farm powered the Heatime unit using a solar panel attached to a trailer (Figure 3). The Heatime antenna was also attached to the trailer, in this case with a range of 1000m.



Figure 3: Trailer fitted with reader and solar panel for outdoor use at farm P

One hundred Bella Ag rumen temperature boluses (Figure 4) were supplied with three readers and a co-ordinator. This farm consists of two main buildings; a fold yard style brick building and an open, more modern shed. Cows were moved into these sheds shortly before calving and bolused at the same time. After calving, cows were let out to grass.



Figure 4: Bella Ag bolus

2.4 Trouble-shooting factors

Implementation of the technologies presented a range of issues in the beef suckler environment as discussed in the following paragraphs. There have been several key learning points so far with the study, offering useful points of guidance for farmers and advisors considering future use of this type of technology in beef systems. Parturition and oestrus data have been collected comprehensively from one farm. Technology problems with the bolus system at the second farm have prevented a full data set being gathered. Despite three different versions of the bolus and reader technology, issues with successful transmission of temperature signalling persisted on farm P. These were not satisfactorily resolved and it was concluded that site specific issues, potentially relating to the close proximity of a RAF base, were a significant factor here. Consequently, at the conclusion of the study duration, the reading equipment and a set of mark 3.0 boluses were installed on a third site where temperatures are being successfully transmitted and read in similar fashion to farm C. Farm C continues to use the boluses and collars with increasing success.

2.4.1 Activity meters

At both farms several days to approximately two weeks were required to establish a baseline activity level, meaning that early events may be missed or false alerts generated. Early set up of the system, well in advance of calving and/or oestrus, would therefore be important in a commercial situation.

The standard collars supplied for the trial were 135cm long, which proved too small for large beef animals such as the Limousins in good to fat body condition score i.e. >3.5 on Farm C. Collar fitting has therefore been challenging with a high rate of collar loss. Farmers looking to use this system in a commercial beef situation would need to work with the supplier to ensure adequate collar length for the breed and condition of the animals on their farm. An extra-long collar is available from the manufacturer measuring 155cm which would be suitable in most situations.

Locking head yokes were also thought to be a causal factor in collar losses. Lost collars resulted in interruption to the baseline data for the cow, which then potentially required up to a week to re-establish an activity baseline. Events that took place while the collar was off or shortly after the collar had been refitted could have been missed by the activity monitor.

Pen size and group changes may also affect activity levels. Moving cows to smaller pens may result in decreased activity and conversely activity may increase when moving to larger pens. Cows changing groups also may result in altered activity. This may therefore result in false positive or false negative activity meter alerts. This is more of an issue for calving prediction, where moving cows to smaller calving pens is a common practice.

An additional problem was encountered regarding the power requirement to run 'Heatime' out in the field. Initially Farm P was provided with a very small solar panel with which to run the Heatime unit. This was far from sufficient so the farm purchased a very large 4.2Amp panel. This larger panel was adequate to power the system during the day with the sun out, but it did not provide enough energy to charge a battery to allow the system to run through the night. Therefore the system shut down overnight and readings were disrupted; the farmer turned the system off soon into the breeding season because of this disruption. The power requirement needed was 4.2Amp at 24Volts per 12 hours; to achieve this two large 2.4A panels were required, roughly 20 times larger and more powerful than the initial panel supplied.

2.4.2 Temperature boluses

At Farm C, readings were delayed from some boluses. This may have been due to the bolus descending slowly through the rumen fibre mat to the floor of the rumen/reticulum. Both farms feed ad lib long chopped baled silage which may delay bolus descent when compared with a shorter chopped diet. Modification in feeding management around the time of bolusing, through timing of feeding and chop length of forage may address this issue. However having to change diet to use boluses would be a major disadvantage of that technology.

Building type may also be a factor, with large open metal framed buildings potentially producing more consistent readings than smaller masonry buildings, with very thick walls. This was shown at Farm P where the older brick building has very thick walls and it has been conjectured that this interfered with signal transmission. The bolus-to-reader range must be carefully considered to ensure that cows are in range of a reader for at least the majority of the day. This is particularly significant in large buildings or outdoors. At

Farm C it was necessary to install an additional reader to one of the larger sheds (150 by 130 foot) to increase the number of readings from a group of cows in a far-away pen.

A number of boluses were regurgitated (seven on Farm C and two on Farm P) and had to be replaced. These regurgitations occurred several weeks, even months after application. On Farm C regurgitation seemed to coincide with turnout. It is hypothesised that the change in diet and rumen turnover led to bolus regurgitation.

There have been a number of other issues with this technology at Farm P.

- The farmer's PC was unable to process the software and thus a new PC had to be purchased.
- The system was subject to a number of system failures and required rebooting.
- Inconsistent temperature readings were initially associated with a faulty batch of boluses which were incompletely filled with polymer resin. This allowed rumen fluid to enter the bolus chamber resulting in bolus failure. This problem was traced to a single box (25 boluses) and Bella Ag provided replacements.
- Despite the above fixes, a significant percentage of the remaining boluses were still not fully functional at Farm P with only 20 out of 70 cows bolused associated with sufficient frequency of reads. Bella Ag have proposed a number of theories for this including interference from a nearby RAF base, but ultimately they were unable to resolve the problem satisfactorily, despite very significant input of time by the company, study team and the site farmer.

2.4.3 Bolus 3.0

New boluses (system version 3.0) were supplied by Bella Ag at no additional cost to the project. The frequency at which this system transmits signals can be adjusted in the new bolus, enabling any interference issues (e.g. from nearby radio masts or airbases) to be overcome. This new bolus also has a memory chip so reads should not be missed, as all reads throughout the day are stored at a sampling rate that can be determined by the operator (rates of 10 to 30 minutes). Reads are then downloaded once the reader is within range. Reads should therefore not be lost when the cow happens to be out of reader range. This technology is less important in a dairy situation where regular milking parlour visits allow regular data download. However, the company had not appreciated the value of this memory feature in a beef system where heat detection or even calving is occurring outside. This bolus is therefore targeted to the beef management situation, but was not available at the start of the study.

An additional feature of the new bolus is that the antenna is non-directional, meaning positioning and orientation of the antenna is less important and 'cleaner' reads should be achieved with less signal interference. A further development is a 30% increase in weight to help retain the bolus down in the reticulum with the intention of preventing regurgitation.

At the point the trial completed, bolus 3.0 had been trialled at farm P using 13 boluses within a hot water bath for five days. Readings could be registered from the boluses, consistent with overcoming potential

interference with transmission on this farm, prior to bolus administration to the cows. All boluses read with an average of 86 readings per day. Additionally the temperature of the water bath was changed over the five days to monitor how the boluses read this change. Closure of the project meant no further work was possible with bolus 3.0 technology on Farm P, although it has since been successfully installed at Farm C and an additional study site.

3. Results

Detail of how the ‘alert’ process is created for Heatime activity monitors and Bella Ag temperature boluses is included in Appendix 3.

3.1 Oestrus

3.1.1. Farm C

Cows were batched in three groups and enrolled onto a double CIDR synchronisation program as per the farms usual protocol (see Appendix 1). Cows were served by AI following synchronisation. A ‘sweeper’ bull was run with each group to allow service of any returns. Target Progesterone Kits were used on all synchronised cows to confirm oestrus. These test kits used blood samples to establish whether cows and heifers were at low progesterone at insemination and therefore were the ‘Gold Standard’ for oestrus detection, although ultrasound was additionally used to image ovarian and uterine characteristics. (Milk samples were used on farm P with very quiet well-handled cows; this would not be the norm in beef herds).

Batch	AI date	Number of cows in batch	Oestrus detection							
			Cows confirmed in oestrus by Target progesterone kits	Cows identified in oestrus by all three methods combined	Cows identified in oestrus by visual observation	Cows identified in oestrus with activity alerts	Cows identified in oestrus with temperature alerts	Agreement of Activity and temperature alerts.	Agreement of observation and Activity alerts	Agreement of observation and temp alerts
1	25 th and 26 th Jan	13	13	9/13	6/13	9/13	Technology not installed	NA	6 cows	NA
2	22 nd and 23 rd March	10	10	6/10	3/10	3/10	3/10 (7/10 showed obvious spike just below threshold)	2 cows	1 cow	1 cow
3	26 th and 27 th April	9	9	9/9	5/9	8/9	5/9 (7/9 showed an obvious spike just below threshold)	3 cows	5 cows	3 cows
Ave. accuracy				75%	44%	63%	42% (74%)			

Table 1: Identification of oestrus by each detection method for service by AI following synchronisation, Farm C

The above table shows the proportion of cows that were detected in oestrus by visual observation, activity alerts and temperature alerts. The cows identified in oestrus were not always the same cows between each method. Temperature alerts were generated for 42% of the cows. Clear temperature spikes were visible for 74% of the cows but not all temperature elevations made it over the alert threshold. This threshold could be lowered to increase alerts; however this may result in an increase in false positive alerts. For cows that were not synchronised it was not possible to progesterone test them as it would have meant frequently getting individual cows into the crush to blood test. It was therefore not possible to quantify the increase in false positives for cows returning to oestrus.

Number of return services during period where both technologies were active (across all batches)	Number of cows in oestrus by visual observation	Number of cows in oestrus detected by activity alerts	Number of cows in oestrus detected by temperature alerts	Number of cows in oestrus detected by both technologies	Number of cows identified in oestrus by the combined use of both technologies that were not identified by visual observation.
24	18	10	8	3	3

Table 2: Identification of oestrus by each detection method for cows returning to oestrus, Farm C

These results show a variation in detection of oestrus across the two technologies and visual observation for cows that returned to oestrus. As a bull was running with the cows at this point visual detection was improved, however due to general increased group activity some pregnant cows also expressed signs of oestrus meaning false positives occurred. In some cases it was noted that the temperature spike was very transient; if the read frequency was poor then the chance of missing an elevated temperature would be high.

Only a small proportion of cows were identified in oestrus by both technologies. Three cows were identified in oestrus using both technologies but were not observed visually; this could be significant if the farm were only serving cows by AI when they observed oestrus. The wide variation in oestrus detection may suggest differences in how individual cows express oestrus; this is something which would be best studied across a large data set.

3.1.2 Study extension Farm C

10 out of the 13 cows in batch 1 returned to oestrus three weeks later, consistent with a poor conception rate. Therefore ultrasound imaging of ovaries was performed on the next batch of cows at first and second insemination to monitor ovarian activity. This allowed timing of ovulation to be correlated more closely with time of service and with activity levels and temperature changes.

Cow	Activity alert	Activity alert ideal time to serve	Temp alert	Temp alert ideal time to serve	Actual service times based on sync protocol	Estimated ovulation time by ovarian ultrasound scanning
92	-	-	23/3/13 13.00	23 rd PM	22 nd Morning and evening 23 rd Morning	22 nd PM
158	-	-	23/3/13 11.00	23 rd PM	22 nd Morning and Evening 23 rd Morning	22 nd PM
111	-	-	-	-	22 nd Morning and evening 23 rd Morning	22 nd PM
151	22/3/13 14.02	23 rd AM	22/3/13 15.00	23 rd AM	22 nd Morning and evening 23 rd Morning	23 rd PM
119	-	-	-	-	22 nd Morning and evening 23 rd Morning	22 nd PM
157	-	-	-	-	22 nd Morning and evening 23 rd Morning	22 nd PM
52	-	-	-	-	22 nd Morning and evening 23 rd Morning	21 st AM
44	-	-	22/3/13 11.00	22 nd PM	22 nd Morning and evening 23 rd Morning	22 nd PM
164	22/3/13 16.07	23 rd AM	22/3/13 16.00	23 AM	22 nd Morning and evening 23 rd Morning	22 nd PM
118	24/3/13 22.55	25 th AM	24/3/13 15.00	25 th AM	22 nd Morning and evening 23 rd Morning	22 nd PM

Table 3: Relationship between Heatime activity and Bella Ag temperature alerts and ovulation for 10 synchronised cows in batch 2, Farm C

Ultrasound examination of ovaries was consistent with ovulation occurring at the predicted time according to the synchronisation protocol in most cases, and therefore timing of AI was assumed to be correct in these cows. Heatime and Bella Ag alert accuracy was very varied. For both technologies only one alert was correctly timed, however in this case the follicle failed to naturally ovulate. The technologies agreed with each other for all three of the Heatime alerts. Bella Ag had three additional alerts; however these were timed late in relation to ovulation. Ovulation usually occurs around 30 hours after the start of standing oestrus.

AI timing was assumed to be appropriate for this given synchronisation protocol and batch 3 was not examined by ultrasound.

3.1.3 Farm P

100 cows were kept in one group out at grass to be served. Service by AI commenced on 1st August. All cows identified in oestrus were subjected to cow side milk progesterone tests (P4 Rapid, Ridgeway Science). These tests confirmed that all but one cow were correctly identified as in oestrus. Only one was shown to have high progesterone, so was not served. This cow was later diagnosed as pregnant.

Activity monitoring

Technical problems with the solar panels of the Heatime system as previously described resulted in reduced data collection in the early stages of the project. Approximately 72 out of a total 103 serves were monitored by Heatime before the farmer elected to turn the system off due to issues with power supply and missed heats.

Ovarian ultrasound examination was not carried out on Farm P. This was an additional step at Farm C only which aimed to address the synchronisation program and actual ovulation timing following prior poor conception rates.

Total number of serves during period when activity monitoring software was active	Cows identified in oestrus by visual observation	Cows identified in oestrus by Heatime*	Cows identified in oestrus by both methods combined	Visual observation accuracy	Heatime accuracy
72	71	62	72	98.7%	86.1%

Table 4: Identification of oestrus detection by visual observation and Heatime monitoring, Farm P.

The above results show high accuracy of both methods of oestrus detection. *During this time one cow was shown to be in oestrus by Heatime monitoring that was not observed visually, therefore combining the two methods positively identified every cow as in heat. It is speculated that should the solar panel have been sufficient to power the Heatime system throughout the night, accuracy could have been further increased, as cows could not be detected unless sufficient light was available to power the system.

As AI is carried out in the field on Farm P, correctly identifying cows in oestrus is very important and therefore a substantial amount of time and effort is devoted to this.

Rumen temperature

As previously detailed a number of technical problems with the temperature bolus system on Farm P resulted in a small dataset whilst housed and even less data recorded out in the field.

3.2 Calving (Parturition)

3.2.1 Farm C

The Bella Ag system commenced reading on 20th February, meaning a number of calvings were not recorded. This gave a possible 15 calvings to analyse. Daily bolus read frequency increased with time and an extra reader was added which acted to further improve read frequency.

Cow ID	Date calving	Activity Change	Activity alert	Temperature	Temperature alert
152	22.2.13	No	No	38.46	No
141	22.2.13	No	No	38.50	No
186	22.2.13	No	No	Reads missed	No
116	28.2.13	No	No	38.21	No
170	6.3.13	No	No	39.21	No
61	7.3.13	+48% change	Yes	38.46	No
127	10.3.13	No	No	Reads missed	No
83	10.3.13	+46% change	Yes	Reads missed	No
135	13.3.13	No	No	Reads missed	No
138	8.4.13	No	No	37.81	No
99	12.4.13	No	No	38.21	No
97	5.5.13	No	No	38.71	No
88	8.5.13	No	No	38.71	No
108	11.5.13	No	No	38.71	No
81	23.5.13	No	No	39.40	No

Table 5: Activity and temperature alerts at the time of calving, Farm C.

Activity monitoring

The above results show that two cows registered an activity alert in the time up to calving. These alerts were generated at 36 hours and 9 hours prior to calving, both in very restless cows that showed very clear visual signs of calving up to a couple of days in advance. All other cows showed no or very minimal changes in activity.

Temperature monitoring

No temperature alerts were generated during or leading up to calving. Temperature changes were either very minor or not observed. However, a subtle pattern was noted on a number of temperature traces. This pattern was characterised by a moderate frequency of reads, then a decrease in read frequency and temperature, followed by a significant increase in reads post calving (figure 6). Data will be further analysed following the end of the trial to further investigate this pattern.

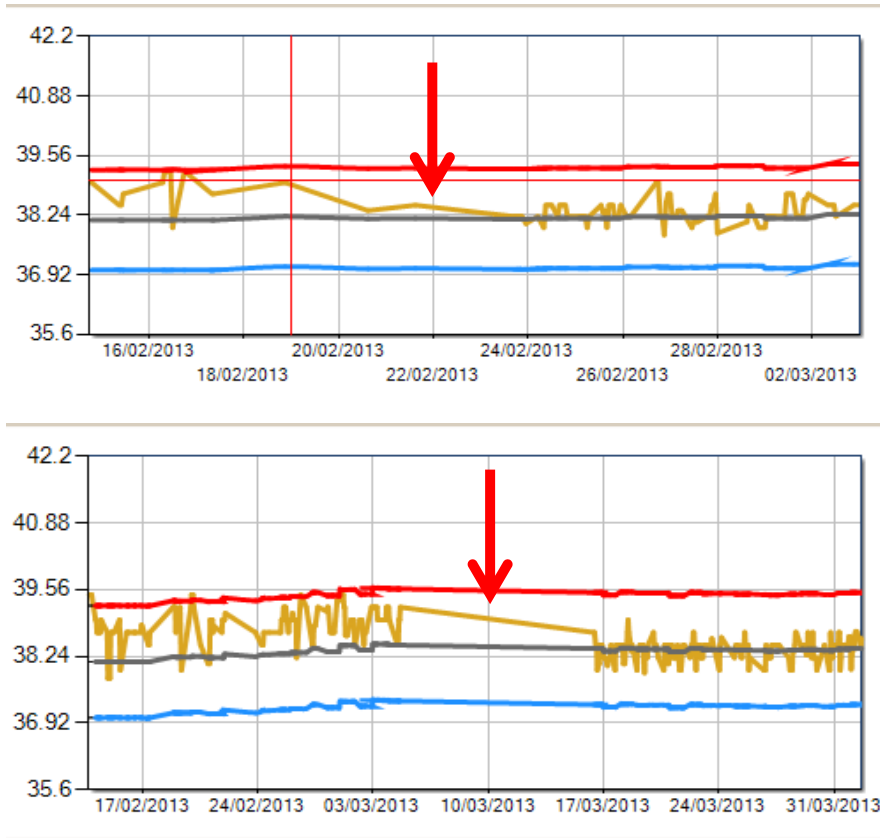


Fig 6: Rumen temperature chart cow 152 and 83 (red arrow indicates calving), Farm C

3.2.2. Farm P

Activity monitoring

Heatime was previously installed on this farm, but only for use in the field. Once set up indoors the system took a long period of time to calculate baseline activity as the previous baseline was for the cows outdoors with very high activity levels. Readings with clarity were first achieved on 14.04.13; cows that calved prior to this date were missed by Heatime monitoring. After 26.04.13 Heatime was removed from the buildings and taken to the field to allow setup ready for breeding.

Cow ID	Date calving	Raw activity at time of calving	Activity change up to calving	Activity alert
225	15.4.13	60	20% decrease	No
62	15.4.13	65	No change	No
513	16.4.13	55	10% increase	No
340	19.4.13	50	10% decrease	No
451	20.4.13	85	Dropped 24 hr before then 100% increase	No
486	21.4.13	120	20% increase	No
474	21.4.13	50	Activity peak 24 hr before then 40% decrease	No
819	22.4.13	Read missed	-	No
429	25.4.13	40	20% decrease	No
16	26.4.13	60	No change	No
315	26.4.13	40	30% decrease	No

Table 6: Activity changes up to the time of calving, Farm P.

The above table shows significant variation in activity at the time of calving. Activity changes were not obviously able to predict parturition across the 11 cows followed. No cows showed alerts in the 12 hours up to calving. Changes in activity around the time of parturition appeared to be gradual and smooth compared with the sharp peaks in activity noted at oestrus.

Rumen temperature

As discussed temperature reads were very intermittent. Out of 70 cows bolused, 59 read at some point over the two month calving period. 42 boluses read less than 20 times, 11 read between 20-60 times and 6 read more than 60 times. Out of all the boluses one read to a frequent level, reading 360 times. This equates to one read every four hours. No low temperature alerts consistent with calving were noted.

4. Discussion

4.1 Oestrus prediction

On Farm C it was not feasible to test progesterone levels in any cows returning to oestrus, in order to confirm oestrus. Any cow that showed an activity alert and/or additional visual signs of oestrus at 21 day intervals +/- 5 days was deemed in oestrus for the purpose of this trial. Therefore some of the return oestrus events may represent false positives in all three methods of oestrus detection. Once all cows have calved next year, and accurate service dates can be established, a more detailed analysis can take place.

A wide variation in both activity and temperature alerts seemed to be generated between cows. For example, some cows appeared to have alerts for every oestrus event, other cows did not show alerts for any oestrus events. This could be due to individual cow factors or due to how successfully the technologies were implemented in different individuals. A larger data set would be required to fully analyse this observation.

4.1.1 Activity monitoring

Activity monitoring for oestrus prediction is very well established in dairy cows. On both Farm C and Farm P activity monitoring also successfully predicted oestrus and in some cases predicted oestrus where visual observation or temperature monitoring did not.

Read frequencies were generally consistent at both farms with minimal technical problems apart from power interruptions at Farm P. Across all cows over both farms activity monitoring successfully predicted 70% of cows in oestrus (128 cows identified in oestrus with both technologies running).

Activity monitoring out in the field at Farm P correctly identified 86% of cows in oestrus compared with 50% of cows indoors at Farm C. It is hypothesised that reduced space allowance and movement between groups and pens indoors potentially resulted in the system taking too long to adjust in order to calculate a baseline activity level. It is also possible that indoors there may have been reduced ability or inclination to express increased activity levels around oestrus.

Overall, activity monitoring proved successful at predicting oestrus and aided the timing of AI using the 'time to AI' feature of Heatime. Further analysis of data may be carried out to investigate a relationship between activity level at time of alert and conception level to the corresponding service.

4.1.2 Temperature monitoring

Temperature read frequency varied significantly between cows, with some boluses reading with a high frequency and consistently, some reading with a high frequency but intermittently and others reading with a very poor frequency or not reading at all. Many of the boluses took several days, and some took weeks for reads to commence. Generally, the greater the frequency of reads the more oestrus alerts from the bolus.

Overall temperature alerts were generated in 37% of cows in oestrus across all synchronised and non-synchronised cows. If the alert threshold was lowered (a feature of the software) then the number of alerts would increase. Where lower temperature spikes (obvious spikes just below threshold) were considered then the accuracy of the technology rose to 74% across two batches of synchronised cows.

Temperature monitoring appeared to be the most successful predictor of oestrus for the batches of synchronised cows when compared with activity monitoring and observed oestrus. However for the cows exhibiting natural heats when returning to oestrus temperature monitoring was the least successful predictor.

4.2 Calving prediction

4.2.1 Activity monitoring

There did not appear to be any trend in activity changes around the time of calving. Activity levels increased in some cows, sometimes by up to 100% but decreased in others. The timing of changes also seemed to differ between cows, occurring from 48 hours before calving up to calving. Activity may be affected by other management factors and individual cow behaviour. This work suggests that change in activity may not be a reliable predictor of calving.

However, due to technical difficulties it was only possible to record the activity around 26 calvings over the two farms. With a much larger sample size and with equipment installed and running correctly it may be possible to identify a trend in activity change around calving.

4.2.2 Temperature monitoring

Temperature was only monitored at Farm C due to technical issues at Farm P. As previously mentioned read frequency appeared to drop around the time of calving; the reason for this is unknown. The effect of this may be detrimental to correctly identifying transient subtle temperature changes as small as 0.3°C to successfully predict parturition, such as those found in one previous study (Burfeind *et al.* 2011).

A characteristic pattern in the temperature data around the time of calving was not apparent. The bolus does not have a built in algorithm for prediction of calving, and reads raw temperature alone. The pattern produced may provide the opportunity to develop algorithms and software to predict calving. Further studies with a larger data set would offer the opportunity to investigate an algorithm for prediction of calving from the raw data.

5. Conclusion

This pilot study aimed to investigate whether activity and temperature monitoring technologies could provide a valuable aid to management of the suckler herd. These technologies were initially developed and trialled in the dairy sector, and use in a suckler herd requires some alterations in the set up and running of the system. For example, dairy cows can regularly and reliably pass 'readers' when brought into the milking parlour, in contrast to beef cows which may be sited in fields away from the farm. There have been several key learning points with the study, offering useful points of guidance for farmers and advisors considering future use of this type of technology in beef systems and these are detailed in the appendix 4 below.

Activity meters are an established oestrus detection tool in the dairy industry and offer similar promise in the beef industry. Temperature monitoring is less established in oestrus detection but shows promise and unlike activity monitoring offers real promise in prediction of calving in the beef industry.

Appendix 1: Farm Details

Detail	Farm C	Farm P
Farm type	Upland pedigree farm	Lowland commercial suckler farm
Cows in trial	39	100 (70 bolused to date)
Calving period	Jan-June indoors	March-July indoors
Service period	4 batches Jan-June.	June-Aug
Breeding details	All cows synchronised and served in batches of roughly 10. All returns served by the bull. All cows housed when served.	All cows served by AI to observed heats. All returns are observed and are AI'd. All cows out at grass when served.
Management	All cows housed in groups in large shed. Cows moved to individual calving pens roughly 1 week prior to calving. Cows then moved back into large shed in batches with calves at foot, roughly 1-2 weeks after calving.	All cows housed at another farm. Cows brought onto site in batches roughly a couple of weeks prior to calving. Cows moved out to grass with calves at foot roughly a week after calving.
Activity monitor technology	39 collars Heatime Horizon supplied. All collars fitted in one batch. System updated to Heatime Dataflow midway through trial.	Farm uses Heatime Horizon. Cows collars fitted as they move into the calving shed.
Rumen temperature technology	39 Bella Ag rumen temperature boluses supplied. All cows bolused in one batch.	100 Bella Ag rumen temperature boluses supplied. Cows bolused as they move into the calving shed. System updated to version 2.0 midway through trial (and subsequently to version 3.0).

Appendix 2 : Summary description of technologies used in the study

The following is a summary description of the two technologies fitted at each farm. The summary is based on the manufacturer's claims rather than any endorsement by RAFT Solutions Ltd or EBLEX. For an assessment of these claims in practice please see the later sections of this report.

(i) 'Heatime DataFlow' activity meters (manufactured by SCR technologies; supplied by Semex UK and Fabdec UK)

- Each cow is fitted with an adjustable webbing collar, worn around the neck.
- From the bottom of the collar 'necklace style' hangs a motion sensing LD-tag™
- The motion sensing tag transmits a signal to a control box, which is mounted on a building or other structure near the herd (the manufacturer claims transmission over an area of 200 X 500m)
- The system uses algorithms (complex mathematical calculations) to separate the cow's day to day normal activity from oestrus related activity.
- The data can be viewed real time on a farm PC using the software supplied as part of the product. Training is provided as part of the package.
- The user is provided with graphs and data for each collared cow/heifer. Alerts are given for those animals requiring attention (see fig 7). These can also be transmitted to a mobile device (e.g. phone or tablet)
- The main claim is that the product can assist early detection of oestrus by detecting an increase in activity levels, but there is also reference to detection of illness in cattle
- For more details see www.heatime.co.uk

(ii) Rumen temperature boluses (manufactured and supplied by Bella Ag) based in the USA.

- The Bella Ag Cattle Temperature Bolus™ is administered orally using a standard balling gun.
 - The bolus is 25mm in diameter, and 70mm in length, and is claimed to have a 5 year battery life
5. Once ingested the bolus permanently settles to the bottom of the rumen/reticulum.
 6. The bolus transmits a signal to a reader (or readers depending on the size of the farm), which is a small metal box mounted on a building or other structure near the herd (the manufacturer claims transmission of up to 150ft, 24 hours a day)
 7. The data can be viewed real time on a farm PC using the software supplied as part of the product. Training is provided as part of the package.
 - The user is provided with graphs and data for each bolused cow/heifer. Alerts are given for those animals requiring attention (see fig 8. These can also be transmitted to a mobile device (eg phone or tablet)
 - The manufacturer claims the alerts can assist early detection of oestrus and temperature related illness in cattle
- For more details see www.bellaag.com

Appendix 3: Calculation of ‘alerts’ for Heatime activity meters and Bella Ag temperature boluses, and examples of traces generated from individual cows

Activity monitoring

Research has shown that ovulation will usually take place approximately 18 hours after peak activity (Roelofs 2005). The optimum time for service is therefore around 12 hours after peak activity, allowing time for sperm transport and capacitation before fertilisation. This forms the basis of the widely accepted AM-PM rule, i.e. observe a cow at peak activity and serve 12 hours later.

The Heatime system algorithm is set up to record an alert at the time of peak activity, and give a ‘window of time for service’ following this alert. The window is a period of 26 hours and is displayed as a countdown from 26 hours to 0 hours (too late for service). This may be confusing as the system appears to be counting down to the ideal time to serve, but in actual fact it is counting down the time left to serve. Ideally the cow should be served at ‘time to AI’, i.e. 14 hours.

Temperature monitoring

Bella Ag do not use an algorithm for monitoring temperature. Alerts are generated using raw temperature data. Each cow establishes a baseline ‘mean’ temperature and a hot and cold alert line relative to this at 1.3°C in either direction. Vaginal temperature has been shown to increase during oestrus for 11 h in dairy heifers (Mosher *et al.*, 1990), and the duration of the increase in vaginal temperature at oestrus has been reported to be between 4 and 8 h in beef cows (Kyle *et al.* 1998). BellaAg recommend the use of a heat alert as an indication of oestrus and that the cow is inseminated using the AM-PM rule (12 hours after an alert) as described above. This method relies up on read frequency being high in order to observe the transient increase in body temperature.

For each cow/heifer in the trial, data were recorded as shown below.

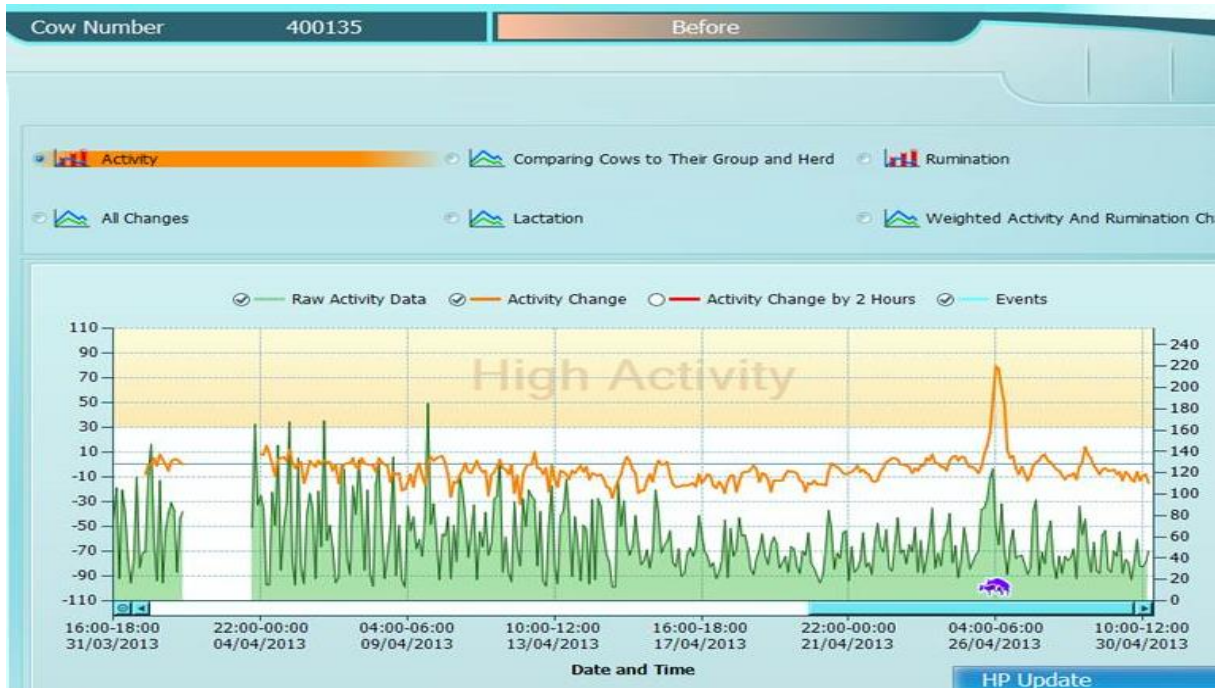


Fig 7: Example of an individual cow activity chart – Farm C tag number 40013

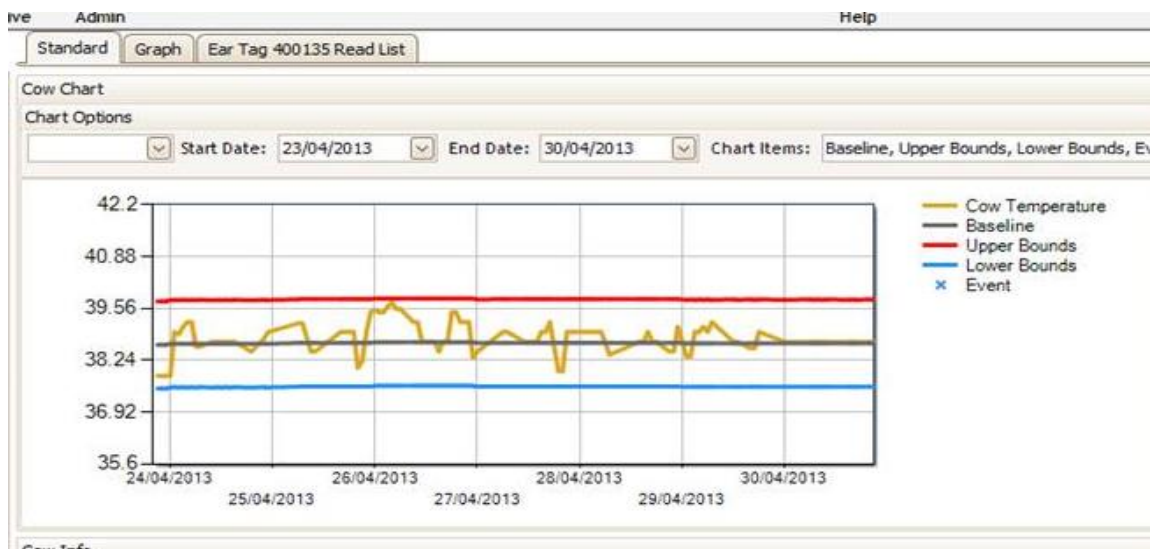


Fig 8: Example of a rumen temperature chart – Farm C tag number 400135

Appendix 4: Farmer Messages

The potential for use of activity measurement and rumen temperature for oestrus and calving prediction in beef herds

Reproductive performance drives the success of the beef suckler herd. Minimising empty cows and maximising cows calving in the first few weeks of the calving pattern all help to maximise weaned calf weight produced per cow mated. Artificial insemination (AI) is an under-utilised opportunity to critically select appropriate bull genetics for maximal growth rates balanced by positive calving ease and negative gestation length EBVs. Currently, heifers are frequently naturally mated inappropriately by terminal sire bulls, at best selected for cow mating, with poor outcomes for future herd breeding potential. Calving represents a time of critical risk in delivering viable calves that will grow optimally to maximal weaning weight, not to mention cows or heifers that get back in calf quickly. Furthermore, calving often imposes very high labour demands to provide adequate supervision.

Technologies which predict oestrus and calving have the potential to improve reproductive outcomes and significantly improve the ease of beef herd management.

It has been widely demonstrated that motor activity increases during oestrus in the dairy cow. It has therefore been suggested that devices measuring activity such as pedometers or collars could accurately detect oestrus. This technology has become widely adopted in the dairy sector, but there has been less uptake in the beef industry due to various barriers to use of the technology. However, new systems are now commercially available which have longer range signalling and within-collar data processing and storage. With opportunities for siting base station readers near water troughs or feeding areas, this offers a promising solution to these barriers.

Research has also shown that rumen temperature (RuT) of beef cows increases around oestrus and decreases around calving. RuT may therefore have potential to predict oestrus with sufficient accuracy to facilitate appropriate timing of insemination and to predict calving with sufficient accuracy to optimise labour inputs to supervising calvings. Measurement of rumen temperature with a bolus is minimally invasive, allows frequent records of real-time data to be obtained, requires minimal labour, and permits cows to be maintained in a natural environment.

How the technology works

EBLEX have funded a project on two farms to explore the use of activity meters and rumen temperature boluses in beef herds. Findings from these projects have identified a number of points which any beef farmer looking to use these technologies should be aware of, and these are outlined below.

This section describes the specific make and model of technology used in this project. Other similar technologies exist but may vary from the description below.

Activity meters

- Each cow is fitted with an adjustable collar, worn around the neck
- From the bottom of the collar 'necklace style' hangs a motion sensing tag
- The motion sensing tag transmits a signal to a control box, which is mounted on a building or other structure near the herd
- The system uses algorithms (complex mathematical calculations) to separate the cow's day to day normal activity baseline from oestrus related changes in activity.
- The data can be viewed real time on a farm computer using the software supplied with the product.
- The user is provided with graphs and data for each collared cow/heifer. Alerts are sent for those animals requiring attention. These can also be transmitted to a mobile device (e.g. phone or tablet).
- The main claim is that the product can assist early detection of oestrus by detecting an increase in activity levels, but there is also growing reference to detection of illness in cattle, especially when a refinement of the collar which includes a method of measuring rumination is included.

Rumen temperature boluses

- The bolus is administered orally using a dedicated dosing gun.
- Boluses vary in materials, weight, length and diameter and importantly battery life
- Once ingested the bolus permanently settles to the bottom of the rumen/reticulum.
- The bolus transmits a signal to a reader (or readers depending on the size of the farm), which is a small metal box mounted on a building or other structure near the herd
- The data can be viewed real time on a farm PC using the software supplied as part of the product.
- The user is provided with graphs and data for each bolused cow/heifer. Alerts are sent for those animals requiring attention (these can also be transmitted to a mobile device, e.g. phone or tablet).

Activity meters – things to look out for

Collars:

- For larger breed beef animals the standard collars provided by the manufacturer may be too short in some cases. There is a larger collar size which is 20cm longer than the standard size (155cm). It is important to assess what collar size would be needed for your particular herd.

- Collars must be fitted correctly according to the manufacturer recommendations. If the collars are too tight or too loose then reading quality may be affected.

Readers and PCs:

- A few days, and in some cases a few weeks, is required after fitting collars before accurate readings can be expected. This is because a baseline of average activity must be generated over several days to a week in order to determine future changes in activity.
- In systems where cows are moved frequently to pens of differing sizes or mixed with new herd mates there may be a disruption in activity leading to false positive and false negative results.
- If the computer is running other software it may not be possible to also run the activity software on the same computer. This requires prior checks to be made with the manufacturer.
- Where the system is used out in the field at grazing, sufficient power must be available from either batteries or solar panels. The manufacturer should be consulted on the power requirements of the particular system in question.

Results

- Current activity monitoring systems appear to be unable to predict calving, although this is a potential development for the future.
- When an alert is generated a 'Time to AI' is given, which counts down the time still left to inseminate the cow starting from 26 hours down to 0. Peak fertility is predicted to occur between 18 to 10 hours from the alert (with 14 hours being the ideal) and this is when insemination is recommended to take place.

Rumen temperature boluses – things to look out for

Boluses

- Regurgitation of the boluses may occur shortly after dosing and at times of diet change- such as when cows go out to grass in spring. Ways to help combat this include dosing with a magnet bolus at the time as bolus administration. Withholding of forage for a period of time before bolus administration then feeding forage immediately after may also help to reduce regurgitation.

Readers and PCs

- The bolus-to-reader range should be carefully considered to ensure that cows are in range of a reader for at least the majority of the day. This is particularly significant in large buildings or outdoors. If readings are poor then it may be necessary to install additional readers.

- A suitable computer is required to run the software. Windows 7 or newer is required with 4GB of RAM and at least 250GB hard drive.
- A sufficient period of time is required after bolusing before accurate readings can be expected; this is because a baseline of average temperature must be generated in order to determine changes in temperature. It can take up to three weeks for boluses to start reading following bolusing, which is thought to be due to the bolus becoming trapped within the fibre mat in the rumen and taking time to descend down into the reticulum.
- Building type may also be a factor determining read frequency, with large open metal framed buildings potentially producing more consistent readings than smaller masonry buildings, with thick walls. Older brick buildings can have very thick walls and it has been suggested that this may interfere with signal transmission.
- It is recommended to trial the boluses in a warm water bath on site before administering to all cows, to ensure all boluses read reliably and that there are not issues with local radio signal interference.

Results

- The temperature threshold at which alerts are generated can be altered. It is recommended to work with the supplier to find a threshold that correctly identifies as many cows in oestrus as possible whilst minimising false positives.
- A cow should be inseminated 12-15 hours after an oestrus alert using the commonly accepted AM-PM rule.
- Temperature monitoring is currently still in the development phase in terms of the reliable prediction of calving.

Overall

These technologies represent an exciting opportunity in beef herds to unlock the genetic and technological advances that have made such an enormous impact on the dairy industry. However, whilst both activity collars and rumen boluses are becoming well established in dairy herds, there are still some challenges facing the use of these new technologies in the beef herd. A thorough exploration with the manufacturers and herd advisors addressing the practicalities of using a system on any particular farm is advisable. This might include a demonstration on a small number of animals and a site specific pilot phase before purchasing the full system.