Electronic Heat Detection

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Introduction

Herd reproductive performance depends on cows being accurately detected in heat and achieving adequate conception rates when they are presented for artificial breeding to superior progeny tested bulls. Since our New Zealand cows are intended to calve in a restricted breeding season of 8 to 12 weeks, breeding must also occur in a restricted breeding period of 6 to 12 weeks. Heat detection efficiency and accuracy is critical to ensure that the maximum number of cows is artificially bred and becomes pregnant within the first 4 to 8 weeks of the breeding season, before genetically inferior bulls for natural service are turned in with the cows.

Heat detection techniques have been developed in New Zealand and some from elsewhere have also been used here to improve herd performance. However these all take some extra effort.

The Importance of Heat Detection

Inadequate heat detection has been identified as a major limit to herd reproductive performance over many years. Each missed heat represents the loss of a complete oestrus cycle of approximately 21 days that in a seasonally calving herd represents 21 days of lost potential production, so each missed heat has a significant financial consequence. Esslemont (1974) estimated the costs of inadequate heat detection to farms in the UK in 1972-3 and found that a missed heat cost 4 pounds if missed early after calving to over 12 pounds near the desirable breeding time. In the USA, losses from inadequate heat detection were estimated to cost the dairy industry $300,000,000 annually (Senger, 1994a).

A study conducted by Chris Burke and Mark Blackwell of Dexcel found that adequate heat detection on farms faced challenges from the performance of staff that depended on their skill, attitudes and motivation. Heat detection was seen as a laborious and inefficient due to the time taken finding cows on heat, identifying them, then drafting them out for insemination. It was concluded that the tasks involved in heat detection “disrupt the flow of cows, people and machinery during milking.”

Electronic Heat Detection

Electronic Heat Mount Detectors

The Heat Watch® system (DDX Inc. Denver CO, USA) is a radio-telemetric automated heat detection system that allows mounting activity such as the time and date of occurrence, sensor identification and the length of a mount to be accurately sensed and then transmitted to a receiver to be recorded by computer for retrieval by farm workers. A cow is confirmed heat if she is mounted 3 times within 4 hours. Automated heat detection has been studied previously in New Zealand using the Heat Watch® system that relies on a pressure sensitive device and receiver stations linked to a computer. This system was found to have an efficiency of detection (i.e. percentage of the total number of heats detected) of 91.7% compared to a farmer and tail paint efficiency of 98.4% and a high accuracy of detection that was not different between groups Xu et al. (1998). The accuracy of detection in cows fitted with Heat Watch™ was 100% compared with 97.6% in a group where detection was by tail paint and observation. However 91.7% of the heats were detected in the Heat Watch group while 98.4% of heats were detected in the tail paint group. Conception rates were comparable at 65% and 65.8% respectively.

A cheaper alternative device, the Mount Count® that also is a pressure activated, self contained oestrus detector glued to the sacral area of the cow is a stand alone monitor that operates in a similar way, being activated by mounting pressure. Mounting activates a series of LED lamps to signal the time since mounting.

Vaginal Conductivity

The changes in electrical resistance or conductivity of the vaginal tissues and discharges were very actively investigated in the 1970s and were reviewed by Senger (1994b). A study was conducted in Australia by Carter and Dufty (1980) but their device did not produce results that were suitable for detecting peak oestrus. This technique has a reasonable basis in the physiological changes that occur during heat but it is generally impractical under New Zealand conditions, because the accurate us of such devices requires the plotting of readings over time, requiring repeated measurements. A further limit of this type of device is that repeated measurements can produce an inflammation that in itself alters readings and leads to spurious results.

Pedometers and Activity Meters

These detect heats by determining increased activity since cows in heat are more mobile and walk 2 to 4 times as far as non-oestrous cows. Activity meters can be attached to the neck or a leg of cows and they may be read by a receiver and processed by computer in a milking parlour (Phatak, 1980). Some pedometers emitted a light signal when cows showed increased activity. Studies with pedometers and activity meters have shown them to be effective in New Zealand but they are relatively costly and rely on acceptance that they are correct, since they are in effect a black box and cannot be confirmed by manual means. Verkerk et al (2001) reported that activity meters should be used in conjunction with careful observation due to a high number of false positive readings.

Video Cameras and Recording

These have been used in research and in commercial herds with their use being most convenient for housed cattle (Pollock and Hurnick, 1979). Where cows are grazed on pasture, the scope and range of most cameras either miss cows because they are not within view of the camera when they display the behaviour of heat or they are unable to be identified.

Heat Expectancy Charts

These simple management aids allow heat to be recorded and the time of the next heat to be predicted so that cows can be watched more closely at the time of the next expected heat. Manual systems and computer based ones are used and they can assist in improving heat detection. Burke et al (2005) reported on an automatic drafting system for such a purpose and concluded that although possible, such a system would require refinement to be accurate.

Electronic Odour Detectors

Attempts at automatic electronic detection of pheromones associated with heat have begun with some promise being shown in the preliminary results (Lane and Wathes, 1998). This technology is based on the experiments where trained dogs were reported as having the ability to detect oestrous odours correctly in approximately 80% of oestrous cows (Kiddy et al 1978). Chris Burke of Dexcel has received a grant of $215,000 this year to identify chemicals emitted by cows on heat, as part of a 4 year project.

Temperature Measurement

Measurements of skin (Hurnick et al, 1985), deep body (Zartman and De Alba, 1982) intravaginal (Zartman et al, 1983) and milk temperatures (Fordham et al, 1987) have been investigated as means of detecting heat in cattle with some of these means reviewed by Lehrer et al. (1992).

Milk Progesterone Detection

Under experimental conditions, milk progesterone test kits can be used to monitor oestrus cycling. Cows can be bred on the third day of low progesterone and achieve adequate fertility. Although currently not a practical procedure for large numbers of cows if it is conducted manually, this method offers a potential future method of oestrus detection if the procedure can successfully be automated and applied in-line Claycomb and Delwiche (1998).

Other Techniques

Milk yield fluctuation has been observed to occur around oestrus with a decline occurring at the onset of oestrus and a rebound increase occurring at the next milking (Horrell et al 1984). Many other techniques and technologies have been applied to the challenge of accurately detecting oestrus in cattle including near infrared spectroscopy of the vulva and vestibule (Kunzler et al, 1992) and nuclear magnetic resonance spectra of vaginal mucus.

To make the job of heat detection easier for New Zealand dairy farmers, the authors have developed an automated system of heat detection for the milking shed that is based on the same principles as tail painting. It allows the automated and accurate recognition that cows have been mounted, using a specially designed heat detection strip and a system for recognising changes in heat detection strips through digital photography and computer processing (which have been patented by Massey University).

A New Automated System of Heat Detection

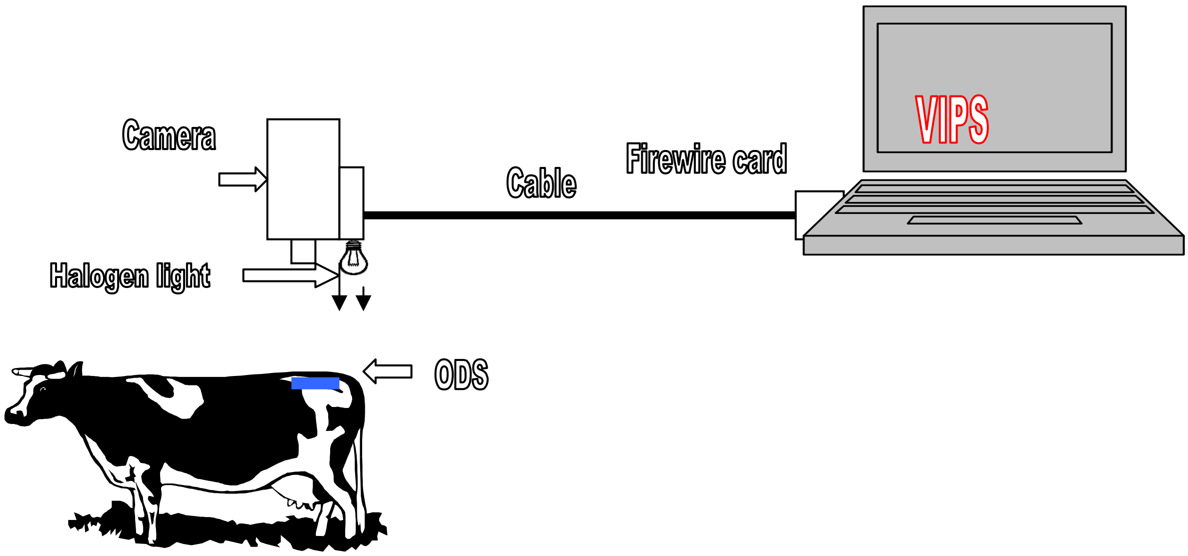
A dairy farmers' idea that the reading of tail paint should be automated was developed in a field trial in the summer of 2000-2001. The system had attraction because it built on the senior author's development of the use of tail painting as an aid to heat detection (Williamson, 1980) that had proven to be successful in New Zealand (Macmillan and Curnow, 1977). The preliminary study showed that a camera-software device could automatically identify and read the amount of paint removed from specially designed heat detection strip. When the proportion of paint removed from the heat detection strips was over 20%, cows were in heat as confirmed by their cycling histories and low milk progesterone levels. This positive result encouraged the further development and evaluation of this technology.

After laboratory and small field trials confirmed some and improved other aspects of the automated heat detection system, a study was designed to be conducted in the Massey University Number 4 dairy herd in the spring 2003 breeding season. A camera and linked computer were installed into the rotary milking shed of the dairy as shown in Figure 1. All 480 cows in the herd that had calved were randomly allocated to groups with half in the treated group that had heat detection strips and half in the group detected by conventional means using observation by the farm manager and staff with the assistance of tail paint.

Heat detection in the treatment group was aided using the strips and computer-software device (CSD) in addition to the normal farm practice. Herdsmen marked cows that were observed or suspected to be in heat at the morning milking of each day and drafted them for breeding with the cows observed at the previous evening milking. A decision was then made by the farm manager on which cows to inseminate from the drafted cows.

The pregnancy diagnosis (PD) results were used as a standard to allow comparison of the different heat detection methods used. When a cow was confirmed to be pregnant by palpation and/or ultrasound examination to a service on a specific date as recorded in the herd's AI records, that heat was regarded as a true one. A reverse count of 21 days (± 3 days) from the AI producing a confirmed pregnancy was also made and if a heat was detected by any of the methods, that was considered to be a true heat. The heat detection method that detected heat on these days was credited with having correctly recognised a heat. If there was no heat detected at that date or by a further reverse count for another 21±3 days then the insemination was considered to have occurred at first heat.

Figure 1: Automated heat detection setup.



Reproductive performance including cows calved within 40 days of PSM, submission rates to AI, conception rates to dates since calving, and non-return rates were calculated using standard DairyWIN reports. The results of the DairyWIN analyses for the treatment group and the control group are shown in Table 1. The study was repeated in this herd in the current 2005-6 season and again the results obtained are very encouraging as can be seen in Table 1.

The equipment used in this pilot trial is not yet developed as a finished commercial system, however the costs for a system have been closely investigated and appear to be well within the reach of farmers desiring automation. If heat detection is suboptimal and performance is improved as much as in the study herd, it appears that an investment in this technology would be repaid within a year. However, even if current heat detection performance is exceptionally good, the technology offers the opportunity to automate this task.

Table 1: Reproductive indices for Dairy Number 4 from the DairyWIN Monitor Reports

	Reproductive Monitor	Group and Year				
		Control 2003	CSD 2003	Control 2005	CSD 2005	Target
Submission Rates	% calved<40 days @PSM	26%	19%	2%	5%	<10%
	21 day submission rate	76%	75%	87%	86%	90%
	28 day submission rate	81%	81%	92%	95%	92%
Return Intervals	Return Intervals: % 2-17 days	21%	32%	36%	61%	13%
	Return Intervals: %18-24 days	64%	56%	56%	29%	69%
	Return Intervals: %39-45 days	3%	1%	0%	0%	7%
	Ratio (18-24 d) : (39-45 d) cyc	22:1	42:1	-	-	9:1
Conception Rates	1st service 49 day non-return	47%	71%	49%	50%	61%
	Total services 49 day NR	57%	74%	65%	58%	61%
	1st service pregnancy rate	39%	72%	39%	56%	60%
	Total services pregnancy rate	46%	70%	44%	50%	60%
	Services per conception	2.2	1.4	2.3	2.0	1.7
In-Calf Rates	4 week in calf rate	44%	70%	46%	65%	57%
	8 week in calf rate	70%	90%	73%	87%	86%
	% not in calf by PSM+165 days	27%	10%	27%	12%	7%
	Calving to conception (days)	84	77	102	89	83

In the 2003 year the first service pregnancy rates achieved in the treated group of the herd are as high as the author has ever observed and interestingly are comparable to those reported on much smaller numbers of cows using other electronic oestrus detection devices such as the Heat Watch (72.4%), Mount Count (71.4%) and Show Heat (70.0%) as reported by Rorie et al (2002).

Two other groups have worked on automated tail paint reading in the absence of strips, to aid detection. One of these is in the Canterbury region of New Zealand and a report has been submitted from an Argentinean research group working on the same approach (Macchi et al. 2005, personal communication).

Conclusion

Inadequate heat detection is one of the major factors limiting reproductive performance in herds, so it is an area of farm activity where increased effort or investment is likely to be profitable. Remembering that 67% of apparent failure to show heat in New Zealand is due to inadequate heat detection, a system that automates heat detection is likely to improve performance where this occurs as well as make the task of heat detection much easier. There are a number of technologies available to conduct or assist with heat detection and many show promise as a means to automate heat detection. Most of these technologies require a "leap of faith" in the system since they operate essentially as a "black box" that provides an outcome.

The system developed and tested at Massey University has the advantage that it replicates familiar visual based systems and in the event of malfunction of the sensing mechanism, can be visually read in a similar way to interpreting tail paint. It has performed extremely well at oestrus detection and allowed a level of heat detection performance that caused the reproductive performance of the cows utilising the technology to achieve levels of performance that reached or exceeded levels of performance achieved by farmers for the economically important indices of reproductive performance. The proportions of cows that had not conceived by 165 days after calving (i.e. the likely cull cows) at 10% and 12%, although above a target of 7%, are still at levels that can be sustained in a productive herd.

The computer software device and heat detection strips developed at Massey University have shown that they are capable of performing at a high level in heat detection in a setup that allows automatic heat detection, thus removing an unwanted and unpopular task from farm workers and showing the ability to improve performance in the test herd where the potential to improve heat detection was considerable.

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