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Predicting next oestrous date and drafting automatically milked cows for focused attention on oestrous detection

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ABSTRACT

The autumn-calving herd at the Dexcel Automatic milking farm was used to test a system of predicting next oestrous date for individual cows and automatically drafting them for focused observation of behavioural oestrus. During the first 21 days of artificial inseminations (AI), the automatic milking system was programmed to draft cows into a holding paddock on each of three days either side of the due date for next oestrus, which was predicted from oestrous dates and milk progesterone concentrations collected prior to the planned start of mating. Cows drafted into the holding paddock were visually checked in the morning, released if not in oestrus or retained if in oestrus for AI later in the morning. The remainder of the herd was also visually checked for oestrus in the morning and afternoon. During the first 21 days of mating, 29 of the 37 cows (78%) were inseminated, and 22 (76%) of these were inseminated within the predicted 'six-day separation window'. Of these 22 cows, 15 (68%) were detected as being in oestrus after being drafted into the holding paddock. A system for drafting cows due to be in oestrus for focused observation is achievable in practice, although improved performance will be necessary to reach the desired level of reliability.

Keywords: oestrous detection; automation; dairy cattle.

INTRODUCTION

Detecting cows in oestrus and drafting them out for artificial insemination (AI) is a skilled yet laborious job on dairy farms, especially when the goal is to achieve greater than 90% efficiency in detecting cows in oestrus. Furthermore, the trend for reduced availability of skilled labour continues to challenge productivity of dairy farming in New Zealand. Oestrous detection and drafting of cows in oestrus for AI is one routine on-farm task that could be automated. The automated oestrous detection concept has been around for decades and a number of strategies have been investigated (Senger, 1990). Some have been commercialised (e.g. HeatWatch™, pedometers and CowTrakker™) and tested under New Zealand conditions (Woolford *et al*., 1993; Xu *et al*., 1998; Verkerk *et al*., 2001). However, none of these technologies have delivered the expected level of performance or cost-effectiveness required for widespread adoption by New Zealand dairy farmers.

The Automatic Farm at Dexcel (Greenfield Project) is a prototype farm with a focus on automating the dairy farm operation. The emphasis has been on successful integration of automatic milking systems to a rotationally grazed pastoral management system. Cows are milked 24 hours of the day with a combination of fresh pasture, water and palatable dry feed to entice cows from the paddock to the dairy (Jago *et al*., 2002, 2004). At any point in time, cows can be located in one of two automatic milking crates, the dairy waiting yard and races, or one of two paddocks. This situation creates a challenge for some routine 'herd tasks' that are performed at set times of the day. A case in point is oestrous detection and AI, which are normally performed on a twice and once daily basis, respectively. Under current AI practices, both of these tasks are best performed when cows are herded into a single location, such as the dairy holding yard. This study reports on a practical attempt to draft automatically cows due to be in oestrus to overcome the unique challenges of detecting and fetching cows in oestrus for AI on a farm incorporating an automatic milking system.

MATERIALS AND METHODS

The study was conducted with the autumn-calving group (n = 37) at the Dexcel Automatic Farm. The herd had a mixture of spring and autumn calving cows and reached a maximum of 151 lactating cows during the study. The farm layout and herd management are described in detail in Jago *et al*. (2002, 2004). Cows were observed morning and night for signs of behavioural oestrus with the aid of tail paint (Macmillan *et al*., 1988) from 4 weeks before the planned start of mating (25th June 2004) until the end of an 8-week AI mating period. Concentrations of progesterone were measured in milk samples collected automatically using a Lely Shuttle sampler twice weekly for this entire 12-week period. Progesterone was measured using an ELISA kit (Ridgeway Sciences, Gloucestershire, UK) validated for use in cattle (Sauer *et al*., 1986). A veterinarian examined cows not seen in oestrus by the planned start of mating. Seven of the 18 examined were treated for anoestrus using an '8-day CIDR' programme (McDougall, 2001) beginning the day after the planned start of mating.

Milk progesterone concentration was monitored in individuals with the results becoming available two to five days after samples were actually collected. These data and date of previous oestrus were used to set the due date for next oestrus for individual cows with the assumption of inter-oestrous intervals averaging 21 days in cattle. To allow for normal variation in cycle lengths (i.e. 18 to 24 days), a period three days either side of this due date was established and referred to as the ‘6-day separation window’. During the 8-week AI mating period, 6-day separation windows were sequentially established as cows were inseminated or progesterone profiles clearly indicated that the animal had re-ovulated. During the first three weeks of mating, the automatic milking system support software was programmed so that cows in their 6-day separation window were automatically drafted after milking into a holding paddock with *ad libitum* access to grass silage and water. Drafting applied at all times of the day and night, although cows drafted out during the daylight hours were periodically checked and released back to the paddock until 5 p.m. if not in oestrus. This decision was made to minimise the amount of time cows spent off pasture. Cows were not physically drafted during weeks 4 to 8 of mating, but the practice of predicting the next 6-day separation window continued throughout mating.

Since expression of oestrous behaviour is interactive (Helmer and Britt, 1985; Vailes *et al.,* 1992), a contingency was made to ensure that at least three cows were automatically drafted to the holding paddock each night during the first three weeks of mating. Additional cows from within the spring-calving herd were used to make up numbers if only one or two cows of the autumn-calving herd were due for separation. Farm staff checked any cows that had been drafted into the holding paddock for signs of oestrus (e.g. worn tailpaint and/or behaviour) when they first arrived at work at 7 a.m. Cows in oestrus were retained and submitted for AI when the inseminator arrived later the same morning between 9 and 11 a.m. Cows not in oestrus were released back into the herd. In addition, all cows in the herd were observed for signs of oestrus daily at about 7:30 a.m. and again at about 4:00 p.m. by trained staff walking through the herd.

Confidence limits were generated (Owen, 1962) for the proportion of cows inseminated during the first 3 weeks of mating; and of these, the proportion inseminated within the predicted 6-day separation window; and of these, the proportion located in the holding paddock after drafting.

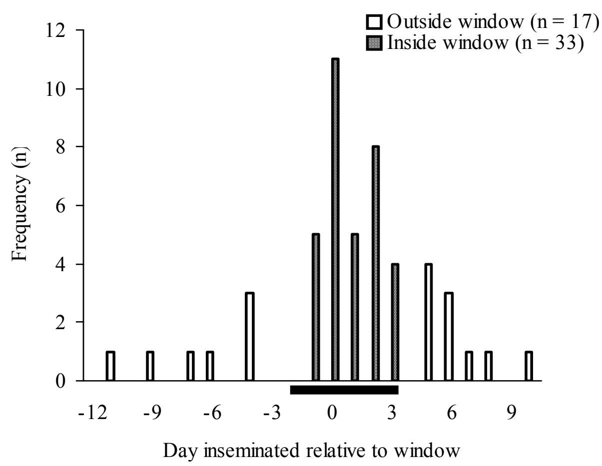
RESULTS

A total of 29 cows (78%) were inseminated for the first time on the basis of detected oestrus during the first three weeks of mating. The majority (76%) of these 29 cows were within their 6-day separation window when inseminated (Table 1). Fifteen of the 22 cows inseminated within their 6-day separation window were found in the holding paddock having visited the milking robot and been drafted out overnight. The remaining seven cows were located within the herd at either of morning and afternoon observations. Cows detected in oestrus at the 7:30 a.m. check were fetched immediately from pasture and inseminated later that morning. Cows in oestrus at the 4 p.m. check were left at pasture but were fetched to the dairy at 7:30 a.m. the next day if they had not already been drafted into the holding paddock overnight. A total of 50 inseminations were made throughout the entire 8-week mating period, including repeat inseminations. The distribution in timing of inseminations relative to the predicted 6-day separation window for the entire 8 weeks of mating is depicted in Figure 1.

TABLE 1: Overall number of cows inseminated, number inseminated within the predicted 6-day window and number located in the holding paddock after being drafted out during milking when in the 6-day separation window during the first 3 weeks of mating.

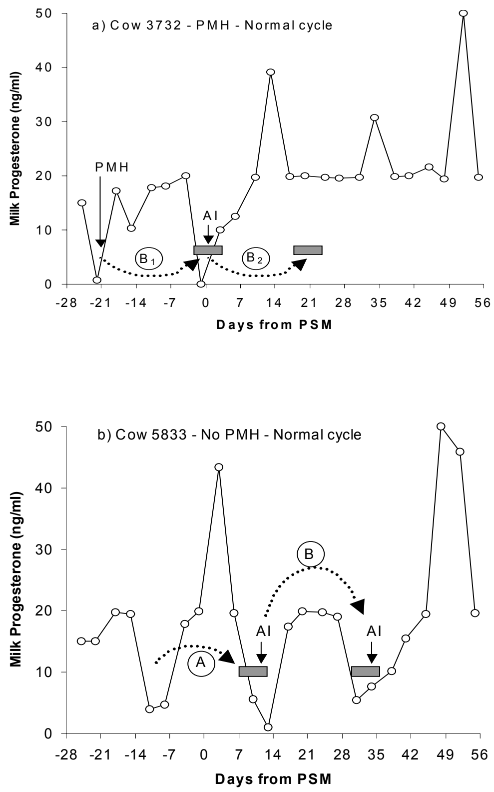
	Number (%)	95% Confidence Limits (%)
First 3 weeks mating for 37 cows		
Cows AI	29 (78)	62 - 90
Cows inseminated in 6-day window	22 (76)	56 - 88
Oestrous cows drafted out in 6-day window	15 (68)	45 – 86

FIGURE 1: Frequency distribution of cows inseminated on basis of detected oestrus relative to due date of next oestrus (Day 0) predicted from previous oestrous date and/or milk progesterone profiles. Solid bar on the horizontal axis depicts the 6-day window for focused observation of oestrus.



Three reproductive states were identified during the premating period when attempting to predict next oestrous date: A) cows having oestrous cycles as evidenced by elevated concentrations of progesterone in milk but having no previous oestrous date; B) as for Type-A but cow also had a previous oestrous date; and C) anoestrous cows with no previous oestrous date and no elevated concentrations of progesterone. For any of these states, next oestrous date could be correctly predicted (Figure 2a-c) or incorrectly predicted (Figure 3a-c). Incorrect predictions occurred when the inter-oestrous interval was atypically long (Figure 3a) or short (Figure 3b) as compared with the 'normal' range of 18 to 24 days. Incorrect predictions for anoestrous-treated cows occurred when the animal failed to resume having normal oestrous cycles following treatment (Figure 3c).

FIGURE 2: Progesterone profiles, premating heats (PMH) or AI, and separation windows (shaded rectangles) predicted by progesterone data alone (circle with 'A') or progesterone plus previous oestrus (circle with 'B') in representative animals having <u>normal</u> length cycles and having a reproductive status of: a) premating heat supported by progesterone data; b) progesterone data only; or c) anoestrus. Events are relative to the planned start of mating (PSM).



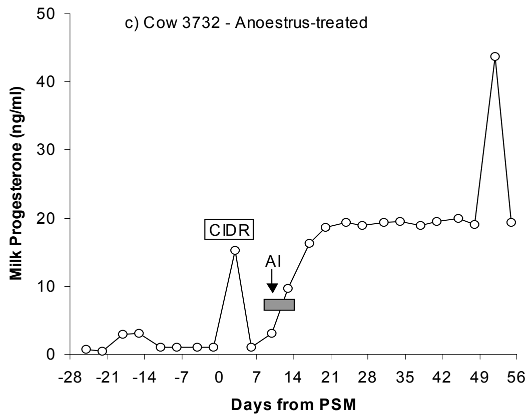
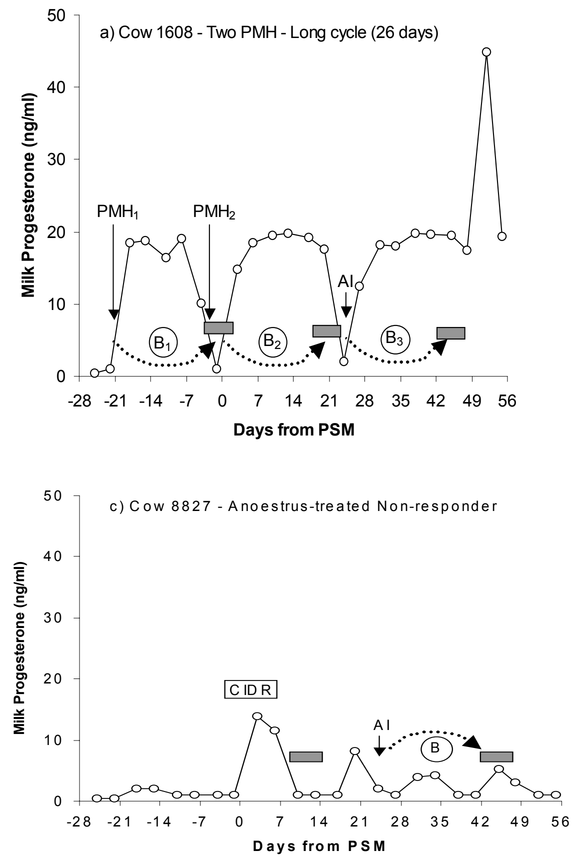
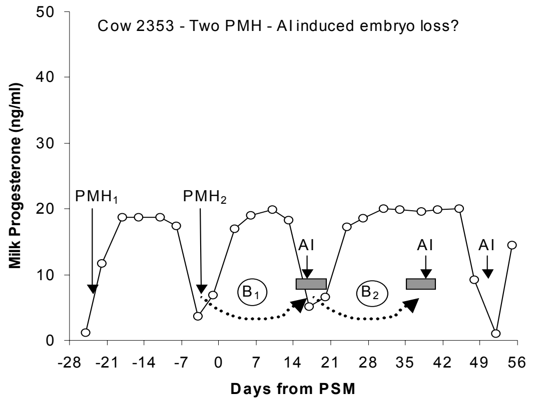


FIGURE 3: Progesterone profiles, premating heats (PMH) or AI, and separation windows (shaded rectangles) predicted by progesterone data alone (circle with 'A') or progesterone plus previous oestrus (circle with 'B') in representative animals having <u>abnormal</u> length cycles and having a reproductive status of: a) premating heat supported by progesterone data; b) progesterone data only; or c) anoestrus. Events are relative to planned start of mating (PSM).



There were two instances where a cow was incorrectly inseminated within a 6-day separation window established on the basis of a previous AI, with the assumption that maintained elevation of milk progesterone concentrations would prevent oestrus occurring (Figure 4 depicts a representative cow incorrectly inseminated on about Day 40 of mating). A prolonged elevation in milk progesterone is likely to indicate that the cow was pregnant, but a precipitous decline occurred subsequent to the incorrect AI for both cows (as depicted in Figure 4).

FIGURE 4: Progesterone profile, premating heats (PMH) or AI, and predicted separation windows (shaded rectangles) in an individual re-inseminated when likely to have been pregnant to first AI. Events are relative to planned start of mating (PSM).



DISCUSSION

Next oestrous date was predicted to within a 6-day period for three-quarters of cows inseminated and approximately two-thirds of these cows were drafted out by the milking robot for focused observation of oestrus. The combined inefficiencies resulted in an overall success rate of 52% (i.e. 15 of 29 cows inseminated were found in the holding paddock when on separation). This would not be a satisfactory outcome in achieving the industry target 3-week submission rate of 90%, without having also to check the entire herd at least twice daily for oestrus. However, this study has demonstrated that predicting timing of next oestrus and drafting cows on that basis using an automated drafting system for AI is technically feasible.

Each of the prediction and drafting processes can be considered as independent challenges. Predictive failures in this study were largely a consequence of animals having unusually short or long oestrous cycles, or with cows not responding to anoestrous treatment. These are distinctly physiological issues that deal with the animal itself. The assumption that all cows have normal length cycles and that all respond to anoestrous treatment is in itself the underlying cause for predictive failure for the majority of these cases. This outcome strengthens any argument that technological developments in automating submission of cows to AI need to focus on detecting, rather than predicting, timing of oestrus. Drafting failures occurred when the cow did not visit the milking robot for drafting prior to arrival of the AI technician. This problem could be more easily overcome by devising a means to increase attendance at the pre-selection points and dairy, and by resolving the issue of where best to hold cows for extended periods. It is possible that the cows in oestrus were more likely to remain in the paddock with sexually active herd mates than visit the selection unit. They would need to visit the selection unit before being sent to the milking machines for drafting into the holding paddock. The effectiveness of locating a 'teaser' bull near the milking machines or selection units as an attractant for the cow to depart the paddock when in oestrus could be investigated in future studies.

The process of predicting and drafting cows due to be in oestrus generated additional tasks and concerns that reduced the overall appeal of this strategy. The most prominent additional investment was in establishing a base to initiate the process for predicting time of next oestrus, which involved twice weekly progesterone measurements and premating oestrous observations in this study. Development of a cheap, labour-free and effective method for measuring progesterone on a frequent basis with rapid reporting of results would greatly enhance the feasibility of predicting oestrus. Twice-weekly milk sampling with a lag of several days before progesterone results were known provided a useful retrospective characterisation of oestrous cycle patterns (as depicted in Figures 2 to 4), but was insufficient for responding quickly enough to abnormal length cycles. Alternative methods of monitoring progesterone in milk at each milking with immediate availability of results are being investigated with the wider Greenfield Project. Other concerns included the amount of time cows spent in the holding paddock with pugging of the ground and feeding of poorer quality feed as compared with high quality pasture. These concerns were mitigated to a large extent by releasing drafted cows during the day and limiting the drafting procedure to the first three weeks of mating. Additionally, beyond the third week of mating, many pregnant cows would be placed on separation unnecessarily.

There were two instances of a cow being inseminated during a 6-day separation window when milk progesterone concentrations were subsequently found to be elevated at AI. From this, the concern could be raised that knowing a cow is due for oestrus influences the decision-making process involved with oestrous detection. However, similar cases have been observed in other studies monitoring progesterone (C.R. Burke; *unpublished data*) where oestrous predictions were not made, suggesting a more widespread phenomenon. It could be inferred from the progesterone data that these incorrect inseminations caused pregnancy loss. This inference would be supported by findings from a controlled study showing that inseminating already pregnant cows causes embryonic loss in half the cases (Macmillan *et al*., 1977) and more recent estimations on AI-induced embryonic loss (Sturman *et al*., 2000). Such occurrences would be prevented if progesterone data were immediately available using biosensing technology (Gillis *et al*., 2002), rather than lagging by several days under current technological constraints, as in the case of the present study.

In conclusion, a procedure is described for predicting timing of next oestrus and drafting cows on this basis for focused observation in an automatic milking system managed on pasture. Establishing the basis for initiating a predictive process required substantial investment with current technologies. The combined inefficiencies of prediction and drafting observed in this study would not allow for an oestrous detection programme to be conducted without checking the entire herd twice daily. Predictive failures eventuated when cows had abnormal length cycles or did not respond to anoestrous treatment therapy. Drafting failures were a consequence of systems decisions that could be corrected. Positive outcomes from this study will be incorporated in ongoing developments with the overall goal of streamlining the task of submitting cows detected in oestrus for AI within an automatic milking system.

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