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BRIEF COMMUNICATION: Verification of an automated camera-based system for oestrus detection in dairy cows

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Introduction

Accurate oestrus detection is critical in New Zealand dairy farming, where many farms operate a seasonal farming model and, therefore, rely on a compact calving spread and a short mating period to farm efficiently. Automated oestrus detection systems are available that automatically identify and draft cows in oestrus. There are two types of automatic systems available commercially in New Zealand; activity-based systems that involve pedometers/accelerometers and systems that detect mounting behaviour using a sensor attached to the animal's back.

Recently, Hempstalk et al. (2010) investigated the performance of a camera-based system (CS) with respect to its ability to read traditional heat patches accurately. In this system, heat patches such as Kamars ® (Kamar Inc., Steamboat Springs, Colorado, USA) or Bulling Beacons ® (Beacon Marketing Ltd., Muswellbrook, New South Wales, Australia) are applied to the cow, along the spine between the pin bones and hips. These heat patches are a fabric or plastic patch containing a pressure sensitive dye pack that bursts during mounting activity. The CS takes a photograph of the area on the animal where the heat patch should be positioned during milking. The image is immediately processed using a computer algorithm, a status assigned of either Missing, Not-activated, or Activated, and an appropriate drafting action is implemented. This CS is limited by the performance of the heat patches themselves. It can only perform as accurately as the patches it is reading. Hempstalk et al. (2010) reported 99% sensitivity and specificity for the CS reading the heat patches automatically. However, the question of how accurate the CS is in detecting cows in oestrus remained unanswered.

The objective of this study was to investigate the performance of the camera-based detection system in identifying cows in oestrus.

Materials and methods

Data were collected from a 700 cow herd at the Lincoln University Dairy Farm during the 2010-11 milking season. As described by Burke et al. (2012), milk samples from all animals were collected and analysed for progesterone at twice-weekly intervals from the start of mating on 25 October 2010 until the end of December 2010. Progesterone profiles were created retrospectively to determine whether an animal had experienced an ovulation that would likely be associated with an oestrous event.

The heat patches used in this trial were blue plastic Bulling Beacon ® (Beacon Marketing Ltd., Muswellbrook, New South Wales, Australia) patches with a self-adhesive back, a white bubble and red dye. After each morning milking, activated patches were removed and replaced with a new patch. New patches were applied in cases where the patch was missing.

The CS was set to photograph each of the 666 cows in the milking group at every milking session during the 35-day trial between 28 October 2010 and 1 December 2010. The CS assessed the images in real-time and reported the results into the Protrack (LIC, Hamilton, New Zealand) database. Results from the CS were hidden from view to prevent bias in the farmer's selection of cows for mating during the trial.

Farm staff applied tail paint to every animal and maintained it for the duration of the mating period. Tail paint is used as part of their normal mating detection programme, along with records of calving dates and previous mating events. The heat patches used by the camera-based system were visible to the farm staff, but they were instructed to ignore them.

Data collection

The CS was initially aligned incorrectly, causing photographs in the first half of mating to be over-exposed in the afternoon. Some patches in both morning and afternoon milking sessions were also out-of-frame. The alignment of the camera was corrected on 16 November 2010 but the camera was not moved closer to the milking platform. As a consequence, the photographs in the second half of mating were under-exposed in the morning because of insufficient lighting; the afternoon photographs were acceptably exposed.

The problems with the camera alignment would have been discovered earlier if this was a normal commercial installation but, because the trial conditions were established to prevent bias in the farmer's mating management decisions, the camera-based system always reported a 'Not activated' status. Despite this, the photographs from all morning milkings could be assessed visually once contrast and brightness had been manually adjusted. Photographs

Table 1 Categories of alert types when comparing a detection system with a gold standard.

Criteria		Alert from detection system (Farmer/Heat patch/Camera system)	
		Yes	No
Cow on oestrus based on gold standard (Progesterone profiling)	Yes	True positive	False positive
	No	False positive	True negative

Table 2 Results of comparing three heat detection systems with progesterone-derived oestrous events for 797 oestrous events. Sensitivity = Proportion of animals in oestrus as defined by progesterone profiling, that were identified by the detection system; Success rate = proportion of animals identified as being in oestrus by the detection system that were in heat as defined by progesterone profiling; Farmer = Identified as being in oestrus by the farmer; Heat patch = Identified as being in oestrus by use of a heat patch; Camera system = Identified as being in oestrus by use of an automated camera system.

Oestrus detection system	Accuracy	
	Sensitivity (%)	Success rate (%)
Farmer	89.2	95.4
Heat patch	89.0	86.4
Camera system	87.9	78.5

from afternoon milkings have been excluded due to overexposure. Even after image adjustment they could not be reliably assessed manually. This exclusion should not affect oestrus detection results because heat patch maintenance was only performed directly after the morning milking. Patches Activated or Missing in the afternoon would have remained so until the following morning's milking.

During the first three weeks of mating, patches were well maintained. During the second half of the 35-day trial patches were often not replaced after being lost or activated. This resulted in continuous repeated alerts by the CS for some animals. To correct this problem, the time of the first alert was retained, and the subsequent alerts removed from the data set. This has led to some residual error with missed oestrous events where milk progesterone profiles and tail paint supported an oestrus occurrence.

Lastly, when the Protrack system fails to get an electronic identification (EID) but records that the bail was occupied, it returns an 'Unknown' ID for that cow. There were 23 alerts for Unknown cows. In six of these cases, the cow was identified from other milking time data and using previous photographs.

Assessment criteria

In commercial installations, the CS is tuned to provide an alert for oestrus when a patch bubble is ≥50% activated, that is 'half red', or when the patch is completely missing. For the trial, the morning photographs were assessed manually and annotated according to the activation level as 0%, 25%, 50%, 75%, 100% or Missing. Only patches that were ≥50% Activated or Missing were flagged as alerts for oestrus. The results for this manual assessment of the altered morning photographs are further referred to as 'Heat patch' results. Results for the CS on the unaltered morning photographs are further referred to as 'Camera system'. Finally, insemination records were used as alerts to evaluate the performance of the farmer. These results are referred to as 'Farmer'.

An alert by any of the three detection systems of 'Farmer', 'Heat patch' or 'Camera system', was considered a true positive (TP) (Table 1) if it occurred within 48 hours before an oestrous event as identified using the method described by Burke et al, 2012. For example, an alert on 1 November 2010 was deemed correct if there was also a period of low milk progesterone concentration between 1 November 2010 and 3 November 2010. Alerts that occurred outside this time-window were considered a false positive (FP). Oestrous events that did not receive an alert were considered false negative (FN) (Table 1).

For each detection system, the TP, FP and FN alerts were used to calculate the sensitivity of a system as the proportion of oestrous events correctly identified by that system. This was calculated as TP / (TP + FN) (Table 1) and the success rate of proportion of all alerts generated by a system that were correct, were calculated as TP / (TP + FP) (Table 1).

Results and discussion

A total of 797 oestrous events were identified during the 35-day trial.

The sensitivity was similar for all three systems (Table 2), suggesting that the CS could detect oestrous events to a level comparable to the farmer. The success rates of both the heat patches and CS were lower than that of the farmer because both the heat patches and the CS produced more false positive alerts. One explanation for this difference is that the farmer had multiple information sources to detect cows in oestrus, including tail paint, previous health and mating records, and visual observation of the cow. While instructed to disregard information from the heat patches, this would have been difficult in practice, especially if there were other signs of oestrus. However, the farmer did select some animals in oestrus that the heat patches and camera did not, and vice versa.

There was a substantial difference in performance between the CS and heat patches. This may be explained by the technical issues around the CS's initial configuration. The CS does not adjust for brightness, so the patch was often not visible in the photograph when it was assessed automatically. Previous work has indicated the CS is able to assess heat patches at a high level of accuracy when it is configured correctly (Hempstalk et al., 2010).

Conclusion

Automated heat detection systems that utilise heat patches are a new commercial development in dairy farming. The initial results show potential. This study compares the performance of a CS with an expert farmer's ability to detect heat, using an accurate measure of ovulation events during a 35-day period of artificial breeding at Lincoln University Dairy Farm. The heat patches and CS were able to identify ~89% of cows in oestrus at a level comparable to the farmer. Cows that were not on heat were also identified as in oestrus, or false positives, in all methods. Substantially more false positives were produced by the CS. Overall, the results were encouraging in that an automated CS has the potential to be able to be used for effective automatic heat detection.

References

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