Dairy Research Summary

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Thermal and Behaviour Biometrics Associated with Induced Estrus in Dairy Cows in a Tie-Stall Barn

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Why is this important?

Tie-stall housing represents one of the most challenging housing types in which to detect estrus because of the lack of space for cows to express obvious estrus behaviours (e.g. mounting). In addition, intensive management and reproductive abnormalities have reduced the rate of visual-based estrus detection to below 40% in tie-stall barns. Other alternatives require hormone synchronization protocols, which are invasive, and can be cause for social concern. Over the last number of decades, rapid technological advances in software and algorithm learning have led to the development of several estrus detection devices, which combine behavioural and physiological parameters to estimate estrus occurrences. Nevertheless, most behaviour-based estrus aids have been designed for free-stall housing and often fail to detect estrus within tie stall housing. As such, the objective of this research was to evaluate the accuracy of estrus detection using thermal and behavioural biometrics during milking in a tie-stall barn.

What did we do?

A total of 36 multiparous Holstein cows were studied at the Dairy Research and Technology Center at the University of Alberta (a tie-stall barn) from January to May 2016. Eighteen open cows were treated with an estrus synchronization protocol (Induced), and eighteen pregnant cows (Control) received a sham protocol on the same schedule as the Induced cow treatment. The appearance of a dominant follicle (> 15 mm) and a decline in blood plasma concentrations of progesterone were used as physiological indicators of estrus, and the disappearance of a dominant follicle was used to confirm ovulation. Cows were monitored for 15 min around milking time (3 AM – 3 PM) and at 11 AM via visual cameras to determine the frequency of stepping, drinking, neighbour interaction, tail movement, laying and shifting behaviours. Infrared thermography (IRT) pictures were recorded at the eye, muzzle, cheek, neck, front right foot, front left foot, rump, flank, vulva area, tail head, and withers.

Radiated temperatures were divided into raw IRT and residual IRT (Res; data accounted for ambient temperature and humidity). Behavioural and IRT parameters were then evaluated as estrus alerts, with a predetermined minimum accuracy score of 0.60, based on the overall estrus detection rate (55%) for visual observation.

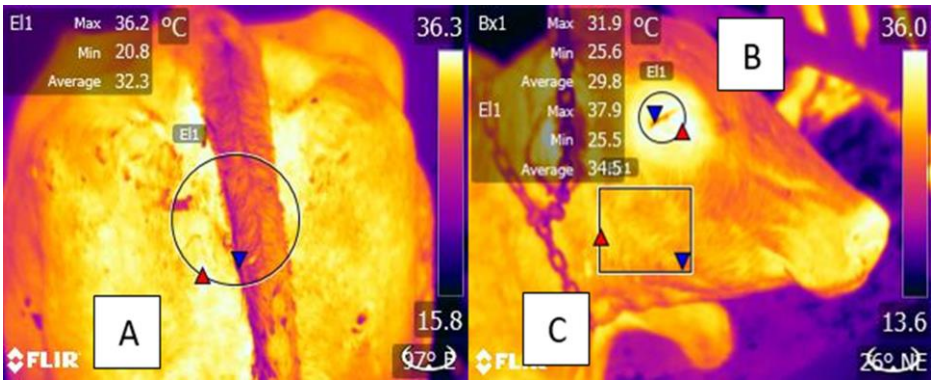

Figure 1. Sample thermal images from the vulva area (A), tail head (2), eye (B), and cheek (C). The squares and circles in the thermal pictures represent the area used to identify the hottest radiated temperature for each anatomical location.

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Table 1. Test of performance results for behavioural and IRT parameters to detect estrus.

Parameter	Threshold	TP	TN	Accuracy
Stepping (events/5min)	≤16.0	76.9	61.0	0.65
Tail movement (events/5min)	≤6.00	76.9	61.0	0.67
IRT °C				
Vulva area	>35.9	53.9	79.2	0.65
Rump	>32.2	100	31.3	0.63
Neck	>33.6	84.6	62.8	0.76
RES Flank	≤0.19	100	40.4	0.60
RES Cheek	>0.01	84.6	60.0	0.75
RES Withers	>0.30	53.9	76.6	0.64

True Positive Estrus (**TP**): proportion of estrus events correctly identified; True Negative Estrus (**TN**): proportion of non-estrus events correctly identified

Residual IRT temperature (**RES**)

What did we find?

Ovulation was confirmed in 14 (77.7%) out of 18 Induced cows and Induced cows had lower concentrations of progesterone compared to Control cows (2.25 vs. 24.7 nmol/L). Significant results such as tail movement frequency were higher in Induced cows compared to Control cows during the two days preceding ovulation (14.8 vs. 10.1 events/5min). Infrared thermography pictures at nine anatomical locations (vulva area, tail head, muzzle, front left foot, front right foot, rump, cheek, neck and withers) exhibited an increase in radiated temperature at 48 h and 24 h (+0.30 to 1.20 °C) prior to ovulation. Parameters that met the minimum acceptable accuracy score, sensitivity, and specificity levels are presented in Table 1.

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What does this mean?

Our results support our hypothesis that IRT and behaviour biometrics differ during the days before ovulation in dairy cows. Induced cows showed increased tail activity at 48h pre-ovulation followed by a decrease during the 24 h pre-ovulation. These patterns are similar to the increase in overall activity followed by reduction in overt movements (e.g. mounting) previously reported during estrus. Infrared temperatures increased 0.50 - 1.20 °C 48 h prior to ovulation at several body locations, while progesterone decreased during the estimated estrus period. Some possible explanations for this include increased activity before ovulation increasing radiated temperatures, heat production from the synthesis of steroid hormones before ovulation, and/or physiological changes in the skin which take place during the estrus period. Additionally, five IRT anatomical locations, stepping and tail movements were identified as diagnostically significant estrus alerts. Thus, our findings encourage further research into using IRT and behavioural biometrics as a combined estrus detection method and to monitor the entire estrous cycle to better understand how these parameters fluctuate during the estrus period.

Summary Points

- Radiated temperature changes from several body landmarks on days leading to ovulation were associated with the estrus period
- Changes in the frequency of stepping and tail movements were also observed on days prior to ovulation and coincide with infrared measurements
- Behaviour biometrics and IRT may be useful for estrus detection in tie-stall dairy systems

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