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Infrared technology for estrus detection and as a predictor of time of ovulation in dairy cows in a pasture-based system

S. Talukder [a,*], K.L. Kerrisk [a], L. Ingenhoff [b], P.C. Thomson [c], S.C. Garcia [a], P. Celi [a,d]

[a] Dairy Science Group, Faculty of Veterinary Science, The University of Sydney, Camden, New South Wales, Australia
[b] Livestock Veterinary Teaching and Research Unit, Faculty of Veterinary Science, The University of Sydney, Camden, New South Wales, Australia
[c] ReproGen-Animal Bioscience Group, Faculty of Veterinary Science, The University of Sydney, Camden, New South Wales, Australia
[d] Melbourne School of Land and Environment, The University of Melbourne, Parkville, Victoria, Australia

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ABSTRACT

The development and application of an algorithm to assess the ability of an infrared thermography (IRT) device to predict cows in estrus and about to ovulate was investigated. Twenty cows were synchronized using a controlled internal drug release and PGF2α. Vulval and muzzle temperatures were measured every 12 hours from controlled internal drug release insertion to 32 hours after PGF2α treatment and then every 4 hours until ovulation occurred or until 128 hours after PGF2α treatment (whichever occurred first). Thermal images obtained with a FLIR T620 series infrared camera were analyzed using ThermaCAM Researcher Professional 2.9 software. Cows were also monitored for behavioral signs of estrus and color changes of an Estrotect applied to the tail head of each cow 36 hours after PGF2α treatment. Algorithms were developed by adjusting body surface temperature of individual animals for ambient temperature and humidity during each observation period, and were expressed as a deviation from the baseline temperature. Of the 20 cows enrolled in this study, 12 (60%) ovulated. An IRT estrus alert was defined using different thresholds (D = 1 °C, 1.25 °C, and 1.5 °C). Sensitivity and specificity to predict estrus depended upon the chosen threshold level. At a threshold D = 1 °C, the highest sensitivity (92%; n = 11) and the lowest specificity (29%) and positive predictive value (64%) were observed. Conversely, D = 1.5 °C resulted in sensitivity of 75%, specificity of 57%, and positive predictive value of 69%. The mean ± standard deviation intervals between onset and the end of IRT estrus alert to ovulation were 30.7 ± 8.2 and 13.3 ± 7.7 hours, respectively. Ovulation occurred 24 to 47 hours after the onset of the IRT estrus alert for eight out of the 11 ovulated cows (73%). Although the sensitivity of the IRT alert was greater than visual observation (67%) and Estrotect activation (67%), the specificity and positive predictive value were lower than these two aids (i.e., the IRT overpredicted the incidence of ovulation). Results presented indicate that IRT shows some potential as an estrus detection aid; however, further studies investigating the potential to improve the specificity and capturing data throughout entire 21-day reproductive cycles would be worthwhile.

1. Introduction

Various methods can be used to detect cows in estrus accurately, e.g., visual observation, changes in body

* Corresponding author. Tel.: +61 2 9351 1709; fax: +61 2 4655 2374.
E-mail address: talukdersaranika@yahoo.com (S. Talukder).

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temperature, changes in vaginal mucus resistance, and recording of mounting activity [1]. Different techniques have been used to measure changes in body temperature during estrus [2–7], and these have shown to be associated with the surge in LH and ovulation. However, restraining animals to measure the rectal and/or vaginal temperatures and using implants within the vaginal cavity to record body temperature may cause discomfort and stress to animals that may alter the actual body temperature. With the development of noninvasive diagnostic tools, such as infrared thermography (IRT), it is now possible to measure body surface temperature precisely and with minimal discomfort to the cow.

Infrared thermography is a noncontact technique of thermal visualization through which temperatures are monitored and recorded. It has been used in veterinary science for lameness [8] and mastitis [9] in dairy cows. It has also been reported that IRT can be used to detect changes in vulval temperatures between estrus and diestrus sows [10,11]. Hellebrand, et al. [12] reported that the vulval temperature changes combined with the body temperature and thermal imaging technology could be used for estrus detection. A small number of cows were recruited in that study, and vulval temperature changes reported during estrus were not evaluated in relation to the hormonal profile [12]. Jones, et al. [13] evaluated thermal imaging technology in dairy cows, and were able to discriminate first estrus from diestrus after estrus synchrony but not in subsequent cycles. However, no information regarding the housing system and methods for differentiating estrus from diestrus groups were reported in that study. To the best of our knowledge, there are no studies that have focused on improving efficiency of estrus detection using IRT in dairy cows.

Fertilization rates in dairy cows are influenced by the interval between insemination and ovulation [14]. Identifying the optimal time to inseminate cows relative to the stage of estrus requires practical methods [15]. To achieve optimal herd conception rates and submission rates, estrus detection should have high levels of both sensitivity and specificity to ensure that a high proportion of cows are inseminated before an imminent ovulation [15].

The aim of this study was to evaluate the potential of IRT temperature monitoring for estrus detection and prediction of time of ovulation in dairy cows.

2. Materials and methods

This study was approved by the Animal Ethics Committee (The University of Sydney, NSW, Australia, approval number: N00/9-2012/1/5829).

2.1. Animals, experimental design, and estrus synchronization

Twenty (14 primiparous and six multiparous) healthy, lactating, cycling Holstein Friesian dairy cows averaging 65 ± 5 days in milk, and producing 27 ± 6 kg (mean ± SD [standard deviation]) of milk per day (during the week before study commencement) were enrolled in this study. As estrous behavior can be affected by both body condition score (BCS) and lameness [16], all cows were also assessed on the day before commencing the study for BCS [17] and locomotion score [18] to ensure that all recruited cows had a BCS within the range of 2.5 to 4, and a locomotion score between 1 to 2.

The study was performed during October and November 2012 (spring) at the University of Sydney's Corstorphine dairy farm, Camden, NSW, Australia. To conduct intensive measurement during the experimental period, cows were kept in a paddock separate to the main milking herd and fed *ad libitum* lucerne silage plus concentrate (8 kg per cow per day) at milking.

Estrus was synchronized in all trial cows (on the same date) by inserting a controlled internal drug release (CIDR; Eazi-Breed, Pfizer Animal Health Limited, West Ryde, NSW, Australia) on Day 0 into the vagina for 7 days. On Day 7, the CIDR was removed, and 2 mL (500 μg) of PGF2α, a synthetic prostaglandin analogue, cloprostenol sodium (Estrumate; Schering-Plough Animal Health Limited, Baulkham Hills, NSW, Australia) was administered to each cow (Fig. 1).

2.2. Ultrasound scanning

The day before commencing the study, cows were subjected to ultrasound scanning (Ibex Pro portable ultrasound; E.I. Medical Imaging, Loveland, Colorado, USA) to confirm the presence of follicle(s) and absence of abnormal structures (cysts). Ovarian activity was also monitored via transrectal ultrasound scanning three times daily between 48 and 68 hours after PGF2α treatment and six times daily thereafter until either ovulation or 128 hours after PGF2α treatment (whichever occurred

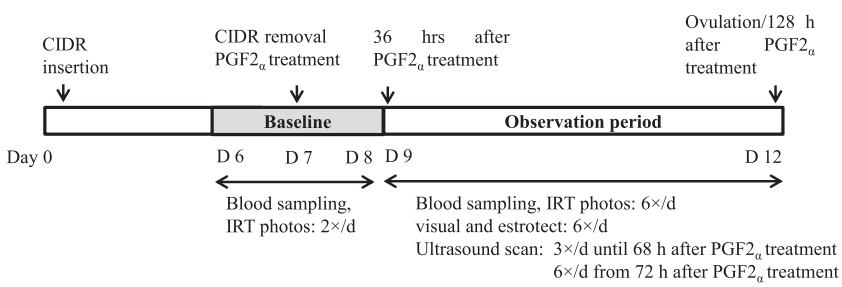

Fig. 1. Schematic diagram of experimental procedure and estrus synchronization protocol. Transrectal ultrasonography was used to assess ovarian structures, and blood samples were collected to assess plasma progesterone concentrations. Infrared thermography (IRT) was performed to measure the surface temperatures of vulva and muzzle. CIDR, controlled internal drug release.