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Automated activity monitoring and visual observation of estrus in a herd of loose housed Hereford cattle: Diagnostic accuracy and time to ovulation

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ABSTRACT

A prospective cohort study was performed in the purebred Hereford herd at Götala Beef and Lamb Research Centre, Sweden. The study's first objective was to assess the ability of an automatic activity monitoring system (AAMS) to detect estrus in beef suckler cows, and its second objective was to estimate the time from estrus to ovulation. The study sample (n = 38) consisted of 14 Hereford heifers and 24 Hereford cows. Standardized visual observation of estrus was performed for 20 minutes thrice daily, and animal activity was recorded with an AAMS system, Heatime (SCR Engineers Ltd., Israel). Cows in estrus underwent transrectal ultrasonography every 8 hours, to estimate the time of ovulation. Blood samples for progesterone analysis were collected thrice weekly throughout the study period. A cutoff value of 1-ng progesterone/mL of serum was used to define luteal activity. The AAMS had a 90% (95% confidence interval [CI] 77%–97%) sensitivity and 100% specificity (95% CI 94%–100%), and visual detection of estrus had a 77% sensitivity (95% CI 62%–88%) and a 89% specificity (95% CI 79%–95%) for identifying estrus when compared to the gold standard defined by temporal pattern of serum progesterone concentration. When both methods were used in parallel, the sensitivity increased to 96% (95% CI 86%–99%), and the specificity increased to 90% (95% CI 80%–96%). The time of ovulation after estrus was determined on 50 occasions. The median estrus (AAMS detected) to ovulation interval was 25 hours for heifers and 23 hours for cows (interquartile range 11–29 hours and 19–25 hours, respectively). The median estrus (visually detected) to ovulation interval was 28 hours for heifers and 21 hours for cows (interquartile range 13–29 hours for both categories). In conclusion, the AAMS had both a higher sensitivity and specificity for estrus detection than thrice-daily visual observation. The time from detection of estrus to ovulation observed in this study indicates that reproductive performance might be improved if Hereford cattle are inseminated sooner after detection of estrus than is currently recommended.

1. Introduction

The duration of bovine estrus is between 11 and 21 hours, in an estrous cycle which lasts between 18 and 24 days [1–4]. Typically, ovulation occurs 12 hours after the end of estrus, and it is recommended that artificial insemination (AI) is performed 6 to 24 hours before ovulation [5]. Studies investigating estrus, ovulation, and timing of AI have almost exclusively been performed on dairy cows. There is evidence that patterns of estrus expression, e.g., a decrease in the primary sign of estrus "standing to be mounted," in dairy cows have changed in the past half century [6]. Concurrent with this altered

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expression of estrus, there have been considerable production increases and intense genetic selection for traits such as milk yield [7] which may have altered the relationship between estrus behavior and ovulation in dairy cows. The selection for productivity has been different in beef populations, and it is not known how, and if beef cows estrous behavior and its relationship to the time of ovulation, has changed over time.

Despite the clear benefits of AI, less than 15% of Norwegian beef cows are artificially inseminated [8]. This is low compared to the Norwegian dairy population in which 85% of cattle are bred to AI [9]. Reasons AI is not used include the following: difficulties in the detection of estrus, time constraints, and inconvenience [10]. Various automatic activity monitoring systems (AAMSs) have been developed for the detection of estrus which negates a number of arguments against performing AI in beef cattle [11], but studies evaluating AAMS in beef herds are scarce [12]. Instead, research on the use of AI in beef herds has focused on estrus synchronization and timed AI protocols [13,14]. These protocols have been so successful that these programs are believed to be the main reason for increases in AI use among beef cattle producers in many parts of the world [15]. However, in Europe, there is a resistance to the use of hormones to treat cattle [16], and studies determining the optimal AI time in unsynchronized beef cows are limited [17]. Therefore, knowledge about the optimal time to perform AI in unsynchronized beef cows is important for beef production in Europe and other areas.

There is little reason to assume the duration of estrus and estrous behaviors are identical between beef and dairy cows given the considerably different genetic selection and production demands placed on them [7]. Particularly, when there is evidence from the dairy population that breed affects estrous behavior [18]. A better understanding of temporal relationships of estrus and ovulation in beef cows is important if AI is to be successful in beef herds. The primary objective of this applied study was to evaluate the ability of an AAMS and visual observation to detect estrus in beef suckler cows, both compared to a gold standard for estrus defined by serum progesterone levels. The secondary objective was to determine the time from AAMS or visual detection of estrus to ovulation in beef suckler cows, comparing nulliparous to multiparous females.

2. Materials and methods

The study was authorized by the Gothenburg Research Animal Ethics Committee (Dnr. Etisk: 187-2014).

2.1. Study population

This prospective cohort study was performed in a purebred Hereford herd at Götala Beef and Lamb Research Centre, Sweden, from the 31st of May to the 4th of July 2015. The herd is a research herd but managed following the principals of a commercial herd. The herd consisted of 40 purebred female Hereford beef cattle over 13 months old, 24 of which had suckling calves, and a bull. The cows that were eligible calved 1 to 70 days before the start of the study, except for two cows which last calved in 2014. The study population was kept in two groups. One group consisted of 15 nulliparous heifers aged between 13 and 16 months, and the other group consisted of 25 multiparous cows. There were no primiparous cows present in the herd during the study period. Both objectives of this study were investigated using the same study population, although different inclusion criteria and unit of observation mean that the number of observations used for each analysis differs.

The heifers and cows were loose housed in separate rectangular pens measuring 105 m^2 and 315 m^2, respectively. The pens were adjacent to each other in an uninsulated barn with deep straw bedding and scraped alleys with solid concrete floors in front of the feed bunks. A young bull was located in a pen at a short end of the rectangular cow pen. The herd was fed ad libitum first cut *Festulolium* grass silage supplemented with 100 g of mineral mix per head as recommended [19] once daily at 6:30 AM, and all animals had free access to water and sodium chloride salt licks. The body condition score (BCS) of all females in the study was assessed on a nine-point scale (1 = emaciated, 9 = obese) [20], by the same member of the staff on the first and final day of the study.

2.2. Detection of estrus

No hormonal treatments were administered to heifers or cows. Consequently, all estrous periods were spontaneous.

2.2.1. Standardized visual detection

Standardized visual observation of estrus was performed by one of three experienced veterinarians (S.T.N., C.S.H., and A.D.M.) in each group of cows for 20 minutes thrice daily at 6 AM, 2 PM, and 10 PM. When a behavior associated with estrus was observed, a score was assigned to that female as outlined in Table 1 [21]. After each observation period, the scores for estrus behaviors were summated for each female. Estrus was defined as starting the first time a female scored 100 points or more in a 20-minute observation period.

2.2.2. Automated activity monitoring system

The neck collars of a commercially available AAMS (Heatime HR System, SCR Engineers Ltd., Israel) were fitted to the females 1 month before the study commenced. The

Table 1
Standardized scoring scale for visually observed estrous behavior.

Estrus sign	Scoring scale
Other signs	
Mucous vaginal discharge	5
Bellowing	5
Restlessness	5
Sniffing the vulva of other cow	10
Resting with chin on other cow	15
Mounting signs	
Mounted by other cow, but not standing	10
Mounting (or attempting) other cows	35
Mounting head side of other cow	45
Standing heat	100

Modified version of [21].