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Evaluation of Vaginal Temperature Measurements Versus Walking Activity as Tool for Detection of Estrus in Dairy Cows

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Abstract: In the present study we investigated the effect of measuring the vaginal temperature (VT) on the detection of estrus in Holstein Friesian cows. The effect of hormone treatment of cows with functional corpus luteum on the VT was evaluated by hourly measurement using a temperature data logger. Also walking activity was measured every 15 minutes for estrus detection. A total of 12 non-lactating Holstein Friesian cows were housed in two groups of 6 animals. For estrus synchronization two different methods were utilized. First group of cows was injected with prostaglandin (PG; PG group) and second with PG + Controlled Internal Drug Release (CIDR: PG + CIDR group). From 9 to 39 h the vaginal temperature (VT) in PG group of cows was 0.1 to 0.3°C lower than VT in PG + CIDR group of cows. The cows that received PG + CIDR (exogenous progesterone) did not show a temperature decrease until CIDR was removed. This finding suggest that VT change reflected the progesterone concentration. The effect of VT measurement and the use of walking activity meter system on estrus detection was evaluated in cold and hot seasons. The estrus detection rate of the walking activity meter system was lower in summer than that obtained using the VT. The average of VT during estrus and non-estrus was not affected by season. Estrus detection using VT measurements could be effective throughout the year.

Keywords: Estrus Detection Season, Vaginal Temperature, Walking Activity

1. Introduction

Detecting a high percentage of cows in estrus is important for the success of dairy herds that use artificial insemination (AI) [1]. Failure to detect estrus (heat) is a major factor contributing to low fertility. The most common form of estrus detection is visual observation (VO). It involves a trained observer's recognizing and recording signs of heat. Observable signs of heat include mounting or attempting to mount other cattle, standing to be mounted by other cattle, smelling other females, trailing other females, depressed appetite, vulva swelling or reddening, clear vaginal mucus discharge, and mucus smeared or rump.

The main sing of heat is when a cows allows other cows to mount her while she remains standing (standing heat).

The VO method requires observation of cows at least twice daily (early in the morning and late in the evening). More frequent observation of cows for heat improves detection-accuracy and increase the probability of recognizing the optimal time for AI of cows, especially in herds in which estrus of some cows is less intense or shorter in duration. Nearly 20% more cows will be observed in heat when checked four times per day versus checking twice daily [2].

The Dairy Records Management Systems (DRMS) reported a mean yearly estrus detection rate on US Holstein herds of 44.9% in 2015 [3]. Standing heal and the conception rate have been decreasing due to the increase in milk yield in dairy cows [4]. The silent heat is a serious problem in dairy farms [5].

Environmental factors (greater ambient temperature and humidity) can negatively affect length and intensity of estrus expression [6]. Also, in Holstein cows the duration of estrus decreased from 18 to less than 8 hours in 50 years [7].

Automated estrus detection (AED) technologies are on alternative methods to supplement or replace VO.

Quantifying behavioral and physiological parameters with AED improves estrus detection [8, 9] compared with VO. Parameters with potential for AED include mounting events, activity level, lying time, rumination events, blood or milk progesterone (P4) levels, feeding time or body temperature [10, 11]. Not all these methods are effective for detecting estrus in cows that undergo silent heat because they are based on estrus behavior. Automated systems of monitoring body temperature around estrus are based on radio telemetric transmission of information. The temperature rhythms have been recorded by rectal [12] and vaginal thermometry [13, 14]. Previous studies indicated that elevation of body temperature is related to hormonal secretion [13, 15]. Fisher et al., [13] reported a transient temperature elevation during estrus cycle associated with the expression of luteinizing hormone (LH) surge. In their study, the average temperature increase was 0.48°C, ranging from 0.40°C to 3.22°C in estrus of Holstein Friesian cows. Estrus synchronization methods have been reported to be effective for the expression of estrus because the corpus luteum is forced to regress by administration of hormones [16-18].

Considering this information it is possible that these body temperature changes may still occur in cows that undergo silent heat.

The objectives of this study were to: 1) evaluate the effect of hormone administration to cows on the vaginal temperature; 2) determine the effect of hormone administration on estrus duration and estrus detection rate and 3) determine the effect of heat stress on estrus expression and estrus detection comparing use of vaginal temperature measurement with use of a pedometer to see the efficiency of using vaginal temperature measurement for improvement of summer breeding parameters.

2. Material and Methods

2.1. Animals

Dairy cows enrolled in this study were located at Agriculture Research and Development Station (ARDS) Simnic-Craiova, Romania. The experiments were performed in compliance with European Union Directive 86/609/Ec. on Holstein Friesian dairy cattle that belong to a large and long genetic improvement program. The research dairy farm has a 140 – cow milking herd. Experiments were conducted from January to May 2019 (cool season) and from June to September 2019 (hot season).

A total of 12 non-lactating Holstein Friesian cows were enrolled (28 to 36 months old and 380 to 450 kg). No reproductive problems were observed prior to the experiments. The cows were housed (loose housing) in two groups of 6 animals in pens that share identical characteristics: area of feed and water troughs, rest area with straw (5 m^2/cow). Cows were fed with grass hay and green fodder to meet nutritional requirements. Water was supplied at libitum.

2.2. Meteorological Data

The meteorological data (average ambient temperature and humidity) were obtained from our institutional weather data collection system. The temperature-humidity index (THI) was calculated using the following formula [19]:

$$THI = [0.8 \text{ x } AT + (RH/100) \text{ x } AT - 14.4] + 46.4,$$

Where AT is ambient temperature (°C) and RH is the relative humidity (%).

2.3. Measurement of Vaginal Temperature

Vaginal temperature was recorded with a temperature logger (DST centi–T logger; star-Oddi; temperature accuracy +/- 0.1°C). The temperature data logger was fitted in a blank Controlled Internal Drug Release (CIDR) device, allowing the sensor to be in direct contact with the vaginal wall.

Measurement of walking activity

Walking activity was measured with a DeLaval activity meter system (95% accuracy) every 15 minutes and the data is logged into ALPRO Farm manager. If the number of steps was 1.5-hold higher that the two-week average, and the increased level continued for at least 3 hours, the cow was considered to be in estrus [14].

2.4. Estrus Synchronization

For estrus synchronization two different methods were utilized. The presence of a functional corpus luteum was confirmed by rectal palpation on day 7 to 14 after estrus (the day of estrus = day 0). Then 1 ml of prostaglandin (PG) Prosolvin (Intervet, Romania) was injected (i.m.) into first group of cows, which was labeled the PG group. In a second group 1 ml of Prosolvin was injected (i.m.) and a CIDR device (including progesterone, P4) was inserted. The CIDR device was removed after 144 hours after the PG treatment. In both groups a temperature data loggers attached to the CIDR (blunk) devices were inserted into vaginal at the time of PG treatment. Vaginal temperature data were recorded hourly until the second or third estrus [14].

2.5. Estrus Detection

Estrus expression was determined by VO, the presence of standing heat. On Day 7 the presence of a corpus luteum was confirmed by rectal palpation.

The beginning of estrus was determined using DeLaval activity meter system as the, time at which the number of steps per 1 hour became 1.5 hold higher than the two-week average (steps/hour) and remained at this value for more than 3 hours [14]. The end of estrus was defined as the time when the steps/hour (4) returned to the less than 1.5 times the two-week average level. The vaginal temperature was analyzed as described in a previous report [20]. The beginning of estrus was determined when the vaginal temperature was 0.3°C higher than it had been at the same time the previous day and the higher temperature continued for more than 3 hours. The end of estrus was determined when the VT was less than 0.3°C [14].

2.6. Statistical Analysis

The VT changes caused by the PG treatment were analyzed by student's t-test. The vaginal temperature under the PG + CDIR treatment was compared between days using ANOVA and Tukey-Kramer test.

The estrus detection rate was analyzed by the chi-square test and by Fisher test. The estrus duration, was compared between seasons, detection methods and synchronization methods by student's t test. Average walking activity, average V. Tamd temperature differences between estrus and non-estrus were compared between seasons.

3. Results

3.1. The Effect of Hormone Administration on Vaginal Temperature

Eleven estrus cycle of 6 cows were treated with PG (PG group). Twelve estrus cycles of 6 cows were treated with PG + CIDR (PG + CIDR + P4 group). The vaginal temperature changes induced by PG treatment were recorded in PG group of cows. The vaginal temperature changes after CIDR + P4 was removed, were recorded beginning on day 7 in PG + CIDR + p4 group of cows. Vaginal temperature in both group of cows were compared (figure 1).

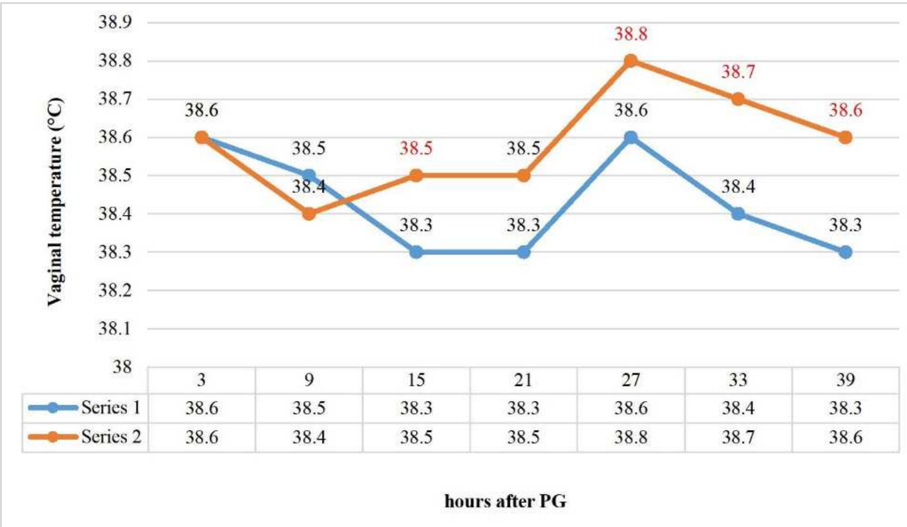

Figure 1. *Changes in the vaginal temperature in PG group of cows (blue line; n=11) and in PG + CIDR group of cows (orange line; n=12). Results are shown in averages. Red color values - Significant differences between groups of cows.*

From 9 to 39 hours the vaginal temperature in PG group of cows was 0.1 to 0.3°C lower than the vaginal temperature in PG + CIDR group of cows. Cows in PG group started estrus from 46 to 96 hours after PG treatment and their vaginal temperature increased during estrus. Cows in PG + CIDR group started estrus from 40 to 98 hours after CIDR removal, and their VT increased during estrus.

3.2. The Effect of Estrus Synchronization Methods on Estrus Expression and Detection Rate

The VT differences in the beginning of estrus or end of estrus in both groups of cows are presented in figure 2 and figure 3.

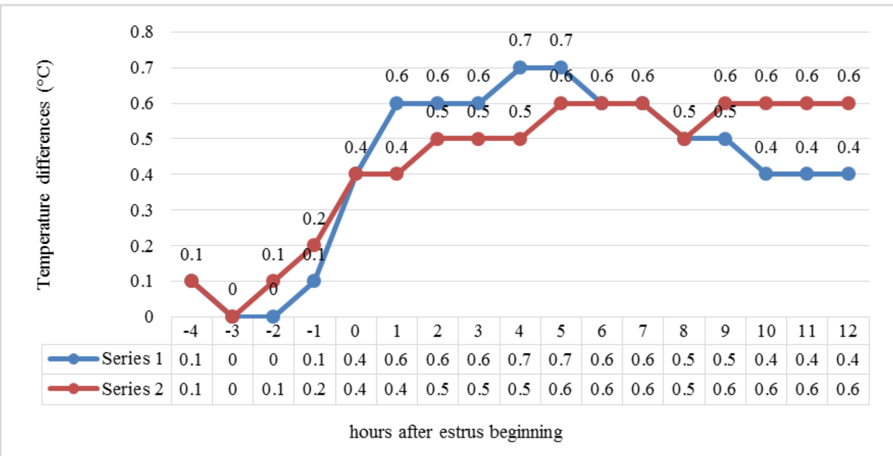

Figure 2. *Vaginal temperature differences at the beginning of estrus in PG group of cows (blue line) and in PG + CIDR group of cows between day 0 (day of estrus) and day -1 from -4 to 12 hours after estrus beginning. Results are shown in averages.*

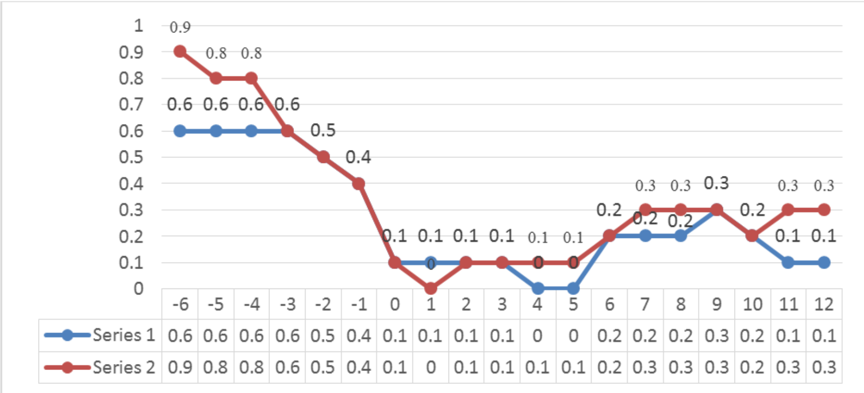

Figure 3. *Temperature differences in the end of estrus between Day 0 and day 1 from –6 to 12 hours after the estrus ending. Results are shown in averages for PG group of cows (blue line) and for PG + CIDR group of cows (orange line).*

The temperature differences between Day 0 (day of estrus) and Day - 1 from – 4 to 12 h after the estrus beginning (figure 2) and between Day 0 (day of estrus) and Day 1 from -6 to 12 h after estrus ending (figure 3) are shown in averages (blue line For PG group of cows; orange line for PG + CIDR group of cows).

The effect of estrus synchronization on estrus duration and estrus detection rate is presented in table 1.

Table 1. *Estrus duration and estrus detection rate by different methods.*

Treatment group of cows	Estrus duration (hours)		Estrus detection rate (%)	
	Vaginal temperature	Activity meter system	Vaginal temperature	Activity meter system
PG only	14.8 ± 0.9	14.6 ± 0.9	96.9	82.7
PG + CIDR	18 ± 2.8	17.8 ± 1.4	98.8	98.4

Estrus duration was not affected by synchronization methods or by the estrus detection methods (table 1).

Estrus detection rates using vaginal temperature were higher and affected by synchronization methods.

The ambient temperature and THI in the cool and hot season were 13.3°C and 29.2°C and 59.2 and 79.8 respectively. The estrus duration in the cool and hot seasons were 16.8 ± 0.9 hours and 15 ± 0.5 hours as measured by the activity meter system and 16.2 ± 0.08 hours and 15.2 ± 1.4 hours as measured by the vaginal temperature respectively.

Table 2 shows the average walking activity (steps/hour) activity increase rations, average vaginal temperature during estrus and during non-estrus periods and vaginal temperature differences between and during non-estrus periods in each season.

Table 2. *Vaginal temperature and steps during estrus or non-estrus periods in the cool and hot seasons.*

Seasons	Activity meter system			Vaginal temperature (°C)		
	Estrus steps/h	non-estrus steps/h	Estrus/non-estrus	Estrus	Non-estrus	Differences
Cool	358.2	93	3.85	38.76	38.44	0.32
Hot	383.6	139.5	2.75	38.72	38.42	0.3

The average walking activities during estrus were not different between seasons. The level of walking activity during non-estrus in hot season were higher than those in the cool season (table 2). None of the average vaginal temperature during estrus and non-estrus on the temperature differences were different between seasons (table 2).

3.3. Discussion

It has been suggested that there is a correlation between the progesterone concentration secreted by the corpus luteum and body temperature in cattle [21, 22]. In the present study PG treatment in the presence of a functional corpus luteum revealed that vaginal temperature were significantly lower from 15 to the beginning of estrus compared with PG + CIDR treatment. Ginther and Beg [23] reported a length of luteolysis of 24 h in heifers. Our results indicated that the vaginal temperature (VT) decrease after the PG treatment would be linked to functional regression of the corpus luteum as the progesterone concentrations decreases.

Administration of exogenous progesterone (CIDR + P4) was reported to be effective for preventing the LH surge and ovulation [16]. Synchronized cows showed high estrus detection rate more than 82% using walking activity or vaginal temperature. Vaginal temperature measurement showed a high detection rate in all seasons >96.9 compared with walking activity method >82.7.

4. Conclusion

The results of this study indicated that the vaginal temperature changes observed during estrus cycles reflect changes in progesterone concentration.

Estrus detection using vaginal temperature has the potential to be a good method for detection of estrus in dairy cows.

Estrus detection using vaginal temperature measurements could be effective throughout the year.

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