Case Study: Improving Heat Abatement Strategies for Lactating Dairy Cows in Southwest Kansas

L. Mendonça and A. Scanavez

Summary

Temperature loggers attached to intravaginal devices can be used to assess severity of heat stress in dairy cows. Vaginal temperature data collected using this method can be used to evaluate effectiveness of heat abatement systems. The goal for this study was to use vaginal temperature information to evaluate the impact of implementing new heat abatement strategies in order to minimize heat stress in lactating dairy cows. Vaginal temperature of cows from 2 dairies located in southwest Kansas were assessed during summers of 2014 and 2017. Dairy A improved the heat abatement systems in 2017, while Dairy B did not. Historical information of herd fertility was evaluated from 2012 to 2017 for both herds. In 2014, cows from Dairy A had greater vaginal temperature compared with Dairy B. The assessment conducted in 2017, after implementation of new heat abatement strategies, revealed that cows from Dairy A had comparable vaginal temperature to their counterparts from Dairy B. This indicates that the new cooling system minimized the effects of heat stress. Moreover, fertility of Dairy A in the summer of 2017 was improved compared with previous years. Herd fertility during the summer was better in Dairy B than Dairy A from 2012 to 2016. In contrast, Dairy B had poorer fertility than Dairy A in 2017. These data suggest that fertility of dairy herds may be positively impacted by reducing heat stress through improved cooling systems.

Introduction

Heat stress in dairy cows impacts production, health, and reproduction. Furthermore, wellbeing of cows may be affected because their behavior is altered during periods of heat stress. Even though heat abatement strategies have been demonstrated to minimize the effects of heat stress, most strategies do not completely eliminate the negative effects of hyperthermia in dairy cattle. In addition, efficacy of heat abatement systems may vary across dairies. Core body temperature assessment can be used to evaluate effectiveness of heat abatement strategies used in dairy farms. Since the core body temperature of heat-stressed lactating cows fluctuates remarkably, it is important to assess the circadian rhythm of body temperature to fully understand how cows are regulating body temperature throughout the day.

Temperature loggers attached to a controlled internal drug release (CIDR) insert can be used to assess vaginal temperature of cows. Therefore, it is a useful tool to evaluate

effectiveness of heat abatement strategies. When using this methodology, vaginal temperature should be assessed frequently (every 5 minutes) for consecutive days because of cows' time budgets. For instance, milking time during summer is a critical period for lactating dairy cows because heat abatement strategies in the holding pen and parlor may drastically impact body temperature of cows. If heat is not dissipated while cows are in the milking barn, core body temperature may increase and the negative effects of heat stress are aggravated. Because heat stress vastly impacts fertility traits of dairy cows, herds that do not have an efficient heat abatement strategy often do not observe good reproductive efficiency during summer.

The purpose of this case study was to evaluate how implementing new heat abatement strategies in a dairy farm impact vaginal temperature of lactating dairy cows and overall herd fertility during summer months.

Experimental Procedures

Vaginal temperature assessments of multiparous lactating dairy cows were conducted in 2 dairies in August 2014 and August 2017. Assessments at the dairies were conducted concomitantly. In 2014 and 2017, 21 cows (Dairy A = 9; Dairy B = 12) and 40 cows (Dairy A = 20; Dairy B = 20) were used in the study, respectively. Calibrated temperature loggers (iButton DS1922L, Embedded Data Systems, Lawrenceburg, KY) were attached to a blank CIDR device to assess vaginal temperature. Temperature data were collected every 5 minutes for 5 and 7 consecutive days in 2014 and 2017, respectively.

Facilities – Dairy A

Cows were housed in a freestall barn and had access to a dirt exercise lot. In 2014, the freestall barn was equipped with 48-inch fans spaced 25 feet apart. In 2017, the new heat abatement system consisted of substituting fans. The barn was equipped with 72-inch fans spaced 50 feet apart. In both years, fans were mounted above the stalls, and feed-line sprinklers were activated intermittently.

In 2014, six 50-inch fans were mounted in the front part of the holding pen and sprinklers were activated intermittently. No fans were above the cows in the parlor. In 2017, five 50-inch fans and one 72-inch fan were mounted in the front part of the holding pen and sprinklers were activated intermittently. Six fans were mounted above the cows in the parlor. In addition, four fans were mounted in the side of the parlor with a high pressure fogging system. Cows were milked thrice daily at approximately 01:45, 09:45, and 18:15 h.

Facilities – Dairy B

Cows were housed in dry-lot corrals with shade. Heat abatement in the holding pen and parlor were similar for 2014 and 2017. Four 48-inch fans were mounted in the front part of the holding pen and sprinklers were activated intermittently. In the parlor, six 48-inch fans were mounted above the cows. Cows were milked twice daily at approximately 07:00 and 19:00 h.

Fertility

Reproductive efficiency from 2012 to 2017 was assessed from Dairy A and Dairy B. Number of cows that were eligible to become pregnant and cows that became pregnant were extracted in cycles of 21 days for calculation of 21-day pregnancy risk. Each cycle was assigned to the month in which at least 50% of the days of the cycle were within the month. For calculation of 21-day pregnancy risk according to season, warm and cool months were considered to be June to August and September to May, respectively. To calculate 21-day pregnancy risk per season, total number of pregnancies was divided by total number of cows eligible to become pregnant from June to August and from September to May. Warm to cool ratio was calculated by dividing 21-d pregnancy risk in warm months by the same metric in cool months.

Number of cows inseminated per month and pregnancy outcomes of these inseminations were extracted for calculation of pregnancy per artificial insemination (P/AI). Warm to cool ratio was calculated as described for pregnancy risk.

Results and Discussion

Vaginal temperature of cows from Dairy A and Dairy B from assessments conducted in 2014 and 2017 are outlined in Figure 1 and Figure 2, respectively. In 2014, cows from Dairy A tended ($P = 0.06$) to have greater average temperature than cows from Dairy B (Table 1). Percentage of time with temperature $\geq$ 103.1°F was greater for cows from Dairy A than for cows from Dairy B (42.2 vs. 26.6%). In addition, average of minimum temperatures was greater ($P < 0.01$) for cows from Dairy A than for cows from Dairy B (Table 1). These findings suggest that heat abatement strategies used in 2014 for Dairy A were not sufficient to minimize the effects of heat stress, which resulted in cows having greater peak temperature in the afternoon and a dampened decrease in temperature in the morning. In 2017, however, average temperature did not ($P = 0.95$) differ between cows from Dairy A and Dairy B (Table 2), which indicates that the new heat abatement strategies implemented in Dairy A minimized the effects of heat stress. Indeed, cows from Dairy A had reduced ($P = 0.03$) maximum temperature compared with cows from Dairy B (103.0 $\pm$ 0.10 vs. 103.3 $\pm$ 0.10°F). Nonetheless, cows from Dairy B had lower minimum temperature than cows from Dairy A. It is possible that the additional heat abatement strategies in Dairy A were efficient in reducing the peak temperature of cows in the afternoon, but Dairy B had a better cooling system in the parlor. The decrease in temperature at milking time for cows in Dairy B indicates that cows dissipated heat in a significant manner in the milking barn. On the other hand, the same pattern is not observed in Dairy A. Although it seems the additional heat abatement system installed in the parlor in Dairy A did not play a significant role in reducing heat stress during milking time, it is likely that the 72-inch fans installed in the freestall barns had a major impact in cooling cows.

Historical fertility data were compiled per season (e.g., warm and cool months) to demonstrate fertility of the herds during periods with and without heat stress (Table 3 and 4). From 2012 to 2017, 21-d pregnancy risk was greater than 21% during the cool season for both herds. From 2012 to 2016, 21-d pregnancy risk was decreased during the warm season, indicating that fertility was compromised during periods of summer heat stress. In 2017, after implementation of the new abatement system, Dairy A had

an exceptional 21-d pregnancy risk during the warm season. Improved reproduction for 2017 could be partially attributed to the improved heat abatement systems.

Caution should be taken in making direct comparisons across years, because other factors may have influenced herd reproductive efficiency. Nonetheless, decreased vaginal temperature observed in the 2017 assessment supports the idea that improving the environment of cows impacted reproductive traits. In addition, the warm to cool ratio of 21-d pregnancy risk in Dairy A was consistently less than 80% across the years, except for 2017. In Dairy B, warm to cool ratio ranged from 74.3 to 87.1% from 2012 and 2016, indicating a greater reproductive efficiency during the summer when compared with Dairy A. In 2017, however, Dairy A had greater warm to cool ratio than Dairy B (105.1 vs. 94%). Furthermore, P/AI during the warm season in 2017 was greater for Dairy A than Dairy B (Table 3 and 4). In previous years (2012 to 2016), Dairy A consistently had decreased P/AI compared with Dairy B.

In conclusion, this case study presents evidence that using effective heat abatement strategies to decrease body core temperature of lactating dairy cows impacts herd reproductive efficiency.

Table 1. Vaginal temperature and percentage of time with vaginal temperature greater than specific cut-offs of multiparous cows from two dairies in August 2014

	Dairy A	Dairy B	*P* value
Average of maximum temperature, °F	104.5 ± 0.23	104.1 ± 0.20	0.29
Average temperature, °F	102.9 ± 0.18	102.5 ± 0.16	0.06
Average of minimum temperature, °F	101.5 ± 0.17	100.8 ± 0.15	< 0.01
Percentage of time with temperature ≥ 101.3°F	96.1 ± 3.05	84.9 ± 2.64	0.01
Percentage of time with temperature ≥ 102.2°F	75.9 ± 6.11	56.4 ± 5.29	0.03
Percentage of time with temperature ≥ 103.1°F	42.2 ± 6.65	26.6 ± 5.76	0.09
Percentage of time with temperature ≥ 104.0°F	14.4 ± 3.83	9.8 ± 3.32	0.38

Table 2. Vaginal temperature and percentage of time with vaginal temperature greater than specific cut-offs of multiparous cows from two dairies in August 2017

	Dairy A	Dairy B	*P* value
Average of maximum temperature, °F	103.0 ± 0.10	103.3 ± 0.10	0.03
Average temperature, °F	101.9 ± 0.09	101.9 ± 0.08	0.95
Average of minimum temperature, °F	100.8 ± 0.06	100.6 ± 0.06	0.02
Percentage of time with temperature ≥ 101.3°F	80.5 ± 2.60	70.8 ± 2.57	0.01
Percentage of time with temperature ≥ 102.2°F	27.0 ± 3.77	27.2 ± 3.72	0.97
Percentage of time with temperature ≥ 103.1°F	3.2 ± 2.00	7.4 ± 1.97	0.14
Percentage of time with temperature ≥ 104.0°F	0.07 ± 1.11	1.9 ± 1.09	0.25

Table 3. Herd fertility of Dairy A from 2012 to 2017 during cool and warm seasons

	Years					
	2012	2013	2014	2015	2016	2017
21-d pregnancy risk in the warm season, %	16.8	15.9	16.4	17.4	16.1	26.1
21-d pregnancy risk in the cool season, %	23.0	22.5	21.7	21.8	22.4	24.8
Warm to cool ratio of 21-d pregnancy risk, %	72.9	70.8	75.4	79.8	71.8	105.1
Pregnancy per AI in the warm season, %	26.9	27.4	28.0	27.9	27.4	35.7
Pregnancy per AI in the cool season, %	35.6	36.1	37.1	34.9	36.2	35.9
Warm to cool ratio of pregnancy per AI, %	75.7	75.8	75.4	80.1	75.8	99.4

In Dairy A, a modified heat abatement strategy was implemented in 2017 immediately before the beginning of summer.
Cool season = September to May.
Warm season = June to August.

Table 4. Herd fertility of Dairy B from 2012 to 2017 during cool and warm seasons

	Years					
	2012	2013	2014	2015	2016	2017
21-d pregnancy risk in the warm season, %	21.3	19.6	19.1	20.0	19.3	23.8
21-d pregnancy risk in the cool season, %	25.7	23.8	25.7	22.9	23.6	25.3
Warm to cool ratio of 21-d pregnancy risk, %	82.7	82.3	74.3	87.1	81.8	94.0
Pregnancy per AI in the warm season, %	30.7	29.1	28.9	29.3	28.6	33.5
Pregnancy per AI in the cool season, %	35.7	34.0	36.9	33.6	33.8	36.0
Warm to cool ratio of pregnancy per AI, %	85.9	85.7	78.5	87.2	84.7	93.1

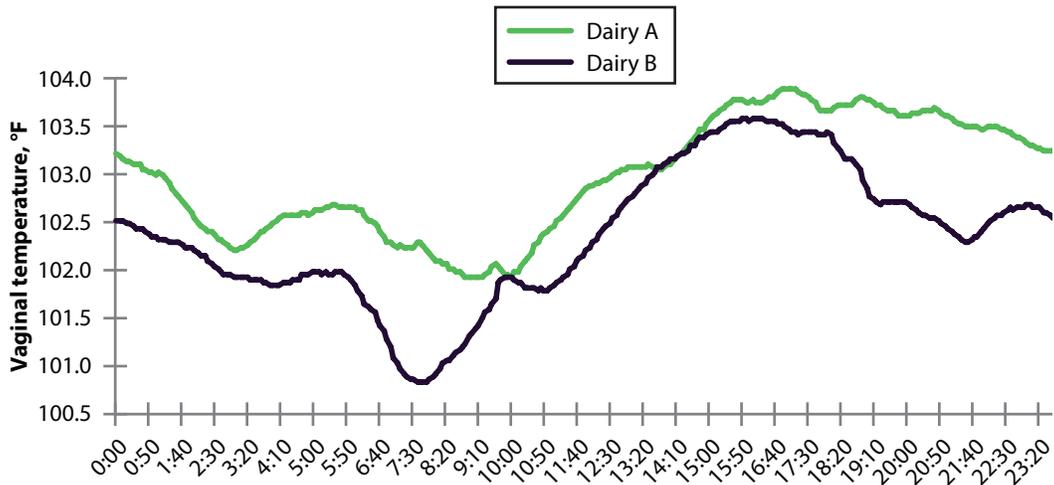Cool season = September to May.
Warm season = June to August.

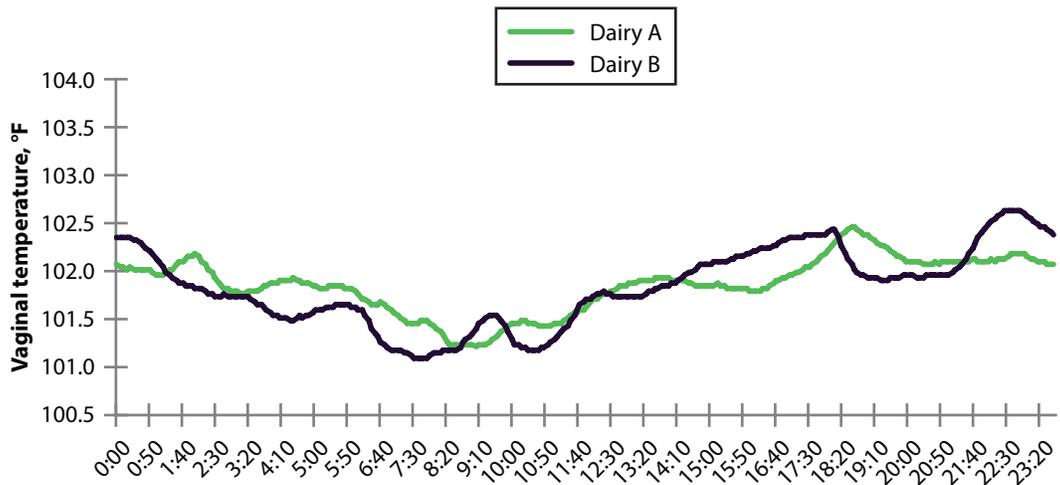Figure 1. Vaginal temperature of multiparous cows from Dairy A and Dairy B in 2014.

Figure 2. Vaginal temperature of multiparous cows from Dairy A and Dairy B in 2017.