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Short communication: Effect of cross ventilation with or without evaporative pads on core body temperature and resting time of lactating cows

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ABSTRACT

A trial was performed to assess the effect of evaporative pads on core body temperature (CBT) and lying behavior of lactating Holstein cows housed in cross-ventilated freestall facilities in a humid environment. This trial was undertaken in 2 barns equipped with (EP) or without (NP) evaporative pads. Each facility had 4 pens, 1 baffle/pen, and a nominal width of 122 m. Stocking density was higher (123.4 vs. 113.1%) and freestalls were slightly shorter (2.3 vs. 2.4 m) and narrower (1.16 vs. 1.21 m) in EP compared with NP barns. In each pen, lying behavior of 20 cows was monitored using electronic data loggers that recorded at 1-min intervals. A subset (n = 14) of these cows within each pen were also fitted with temperature loggers attached to blank controlled intravaginal drug release devices to determine CBT every 5 min. Ambient conditions were collected every 15 min. Individual cow lying duration and lying bouts were assessed for each cow, as well as time spent standing and CBT within the following categories: CBT <38.6°C, and CBT >38.6, >38.9, >39.2, >39.4, and >39.7°C. These variables were analyzed using pen as the experimental unit, with cow and day as additional random effects. The average maximum ambient conditions over the 9 d were 25°C and 78.74% relative humidity. No differences were observed in lying duration and number of lying bouts over the 9-d period, with overall means of 696 ± 31 min/d and 12.6 ± 0.5 bouts/d. The EP cows spent 170 min/d longer with a CBT <38.6°C and 107 min/d less with CBT >39.2°C than did NP cows. Cooling with evaporative pads tended to increase time spent lying with a CBT >8.6°C and lying bouts/d for EP cows versus NP cows. Results from this trial show that even under mild heat stress, evaporative cooling in cross-ventilated facilities can decrease CBT and tended to increase lying time.
Key words: evaporative cooling, heat stress, lying behavior

Short Communication

Heat stress has very broad effects on animal behavior and physiology (Collier et al., 2006) and, in turn, dramatically affects growth, reproduction, and lactation. Heat stress is estimated to have a cost of $89.01 per cow per year (Scharf et al., 2014) and a total annual cost to the US dairy industry of nearly $897 million (St-Pierre et al., 2003). Although great advances have been made in understanding the effects of heat stress, many of the underlying mechanisms linking heat stress to decreased health and performance remain unclear.

Lying behavior and core body temperature (**CBT**) play critical roles in the production potential and profitability of dairy cattle. Milk yield typically decreases by 1.8 kg and DMI by 1.4 kg for each 0.55°C increase in CBT (Johnson et al., 1963; Umphrey et al., 2001). Fregonesi and Leaver (2001) reported that cows deprived of adequate lying time may have reduced welfare, whereas Munksgaard and Lovendahl (1993) reported decreased growth hormone release with lying deprivation, indicating a possible role in decreased milk production. Furthermore, cows will exhibit physiological and behavioral signs of stress, including lameness, when deprived of ample lying time (Singh et al., 1993; Munksgaard and Simonsen, 1996; Cooper et al., 2008). In congruence with stress, an inverse relationship between the proportion of cows lying and ambient temperature and a positive relationship between lying time and heat stress have been reported (Overton et al., 2002; Cook et al., 2007).

Evaporative cooling systems are more effective in hot and dry regions due to the capacity of the system to

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increase the water content of the air by changing the state of water from liquid to gas through the latent heat of vaporization. However, limited information is available when using evaporative cooling systems in humid environments. Evaporative pad cooling systems have been used in humid environments to decrease the air temperature in tunnel-ventilated facilities (Liao and Chiu, 2002). On the other hand, limited information is available on the use of evaporative pads in cross-ventilated freestall facilities in humid environments. Therefore, our objective was to evaluate the effect of an evaporative pad cooling system on CBT and behavior of Holstein cows housed in cross-ventilated facilities in a humid environment.

A trial was conducted over 9 d during the summer of 2009 on a commercial dairy farm near Morris, Minnesota. The Institutional Animal Care and Use Committee at Kansas State University approved experimental procedures. Eight pens from 2 cross-ventilated facilities (4 pens/facility) were selected for the trial. One facility was equipped with evaporative pads (**EP**; CELdek; Munters, Mason, MI), whereas the other had no evaporative pads (**NP**). The evaporative pads had a depth of 150 mm and a width of 600 mm. Each facility had a nominal width of 122 m and 1 baffle per pen. Stocking density of the freestalls was higher in the EP facility than in the NP facility (123.4 vs. 113.1%). Freestalls were slightly shorter (2.3 vs2.4 m) and narrower (1.16 vs. 1.21 m) in EP compared with NP.

One-hundred sixty (20/pen) multiparous Holstein cows (average 161 DIM, 2.91 lactations for both treatments) with mean milk production of approximately 36 kg/d were randomly selected for the trial. Cows were allowed at least 1 d of acclimation before data were gathered. Because of the short duration of these experiments, milk yield of cows was not analyzed. Milking times per day were evenly distributed between treatments. Two pens in each treatment were milked twice and the other 2 pens were milked 3 times. The EP facility had exhaust fans located on either side of the holding pen that pulled cooled air from the main building; in addition, overhead sprinklers were used to soak cows while they were in the holding pen. The NP facility had a cross-ventilated holding pen with high-pressure misters on one sidewall and exhaust fans on the other sidewall.

Lying behavior of selected cows was recorded using electronic data loggers (Hobo Pendant G Acceleration Data Loggers, Onset Computer Corp., Pocasset, MA) at 1-min intervals for 9 d to determine time spent lying and the number of lying bouts/day. The electronic data loggers were attached to the medial side of the left cannon portion of the hind leg of each cow with the y-axis perpendicular to the ground. Data of vertical tilt from the y-axis was used to determine the animal's lying position, such that readings $<60^\circ$ indicated the cow standing, and readings $\geq 60^\circ$ indicated the cow was lying down (Ito et al., 2009).

A subset of 14 cows in each pen was also fitted with intravaginal temperature loggers (Hobo U12, Onset Computer Corp.) attached to blank controlled intravaginal drug release devices (CIDR; Pfizer Animal Health, New York, NY) to monitor CBT. Measurements were obtained at 5-min intervals for 9 d.

Outside ambient conditions were collected every 15 min on both sites using 2 data loggers (Hobo Pro H8) per site contained within separate solar radiation shields (M-RSA; Onset Computer Corp.). Loggers recorded temperature and percentage relative humidity (**RH**). In addition, 8 data loggers (Hobo Pro H8; Onset Computer Corp.) were placed inside the facilities (4 on the air intake side and 4 on the air exhaust side) to determine temperature and RH at 15-min intervals. All data loggers were programmed and managed by a single computer, allowing for synchronization of time.

Temperature-humidity index (**THI**) values were calculated based on the average temperature and humidity data obtained from the weather stations and defined by the equation (Ravagnolo and Misztal, 2000)

$$\text{THI} = [(1.8 \times \text{Tdb}) + 32] - (0.55 - 0.0055 \times \text{RH}) \times (1.8 \times \text{Tdb} - 26),$$

where Tdb = dry bulb temperature (°C), and RH = relative humidity (%).

Daily lying time (h/d) and frequency of lying bouts (no./d) were calculated for each cow (Ito et al., 2010). Individual cow CBT and activity data (9 d/cow) were analyzed to determine the amount of time per when CBT was <38.6°C and >38.6°C, >38.9°C, >39.2°C, >39.4°C, and >39.7°C, as well as time spent per day standing within these CBT categories. Threshold temperatures were chosen based on evidence that even mild elevation of CBT over extended periods can negatively affect animal performance (Umphrey et al., 2001).

Variables were analyzed using SAS software (SAS 9.3, SAS Institute Inc., Cary, NC) with mixed models and pen as the experimental unit, with cow and day included as additional random effects. Parity, reproductive status, and DIM were tested as covariates in each model but were determined not to contribute significantly to the prediction equation. The effect of the cooling system was declared significant at $P < 0.05$, and tendencies were declared at $P < 0.10$.

Average ambient conditions were mild during the trial with average maximum temperature of 25°C, relative humidity of 78.74%, and average maximum THI