J. Dairy Sci. 90:1674–1682
doi:10.3168/jds.2006-634

The Effect of Heat Stress and Lameness on Time Budgets of Lactating Dairy Cows

N. B. Cook,*[1] R. L. Mentink,* T. B. Bennett,* and K. Burgi†
*School of Veterinary Medicine, University of Wisconsin–Madison, Madison 53706-1102
†Comfort Hoof-Care Inc., Baraboo, WI 53913

ABSTRACT

Time budgets for 14 cows housed in a 3-row freestall pen were obtained for 4 filming sessions timed to capture different climatic conditions, with a range in mean pen temperature-humidity index from 56.2 to 73.8. Mean lying time decreased from 10.9 to 7.9 h/d from the coolest to the hottest session filmed. This change in behavior occurred predominantly between 0600 h and 1800 h. Time spent standing in the alley increased from 2.6 to 4.5 h/d from the coolest to the hottest session filmed, with changes occurring between 1200 h and 1800 h. There was a negative effect of increasing locomotion score over the summer with higher locomotion scores associated with less time spent standing up in the alley. Time spent drinking increased from 0.3 to 0.5 h/d across the range in temperature-humidity index. Filming session alone did not affect time spent standing in the stall, but the effect of locomotion score was significant, with score 2 and score 3 cows standing in the stall longer than score 1 cows (4.0 and 4.4 compared with 2.9 h/d respectively). Behavioral changes observed and traditionally associated with heat stress were confounded by changes in locomotion score. Increases in claw horn lesion development reported in the late summer may be associated with an increase in total standing time per day. The changes in behavior described were because of mild to moderate heat stress. The finding that activity shifts occur around a temperature-humidity index of 68 supports the use of more aggressive heat-abatement strategies implemented at an activation temperature of around 21°C.
Key words: heat stress, lameness, time budget

INTRODUCTION

The dramatic impact of heat stress on dairy cow milk production has been the primary focus of climate research in recent years (West, 2003). Under conditions of heat stress, dairy cattle develop respiratory alkalosis as a consequence of thermal panting and attempts to use evaporative heat loss (Benjamin, 1981). Dry matter intake is reduced; thus, blood flow to the mammary gland and the portal plasma flow are lowered, which in turn reduce milk yield (McGuire et al., 1989; Lough et al., 1990). In addition, heat stress affects reproductive performance through reduced viability of the spermatozoa and ova, via a negative effect on the intensity and duration of estrus, and through delayed or inhibited ovulation (Ravagnolo and Misztal, 2002).

The temperature-humidity index (**THI**) has been commonly used to estimate the effect of heat stress on production and reproduction (Ravagnolo et al., 2000; West et al., 2003). There is general agreement that significant effects are observed at a mean daily THI of around 72 (Johnson, 1987; Igono et al., 1992; Armstrong, 1994). Such combinations of temperature and humidity are seen during the summer across North America and in many other parts of the world. Most heat stress research has focused on conditions of sustained moderate to severe heat stress in locations such as the southeastern and southwestern United States, whereas information on the effects of episodic mild to moderate heat stress typical of the upper Midwest has not been readily available (Ominski et al., 2002). Episodic periods of heat stress may present the cow with greater challenges in the short-term because physiological homeorhetic adaptations take weeks rather than days to occur (Beede and Collier, 1986; Collier et al., 2006).

There has been little work on behavioral adaptations to sustained or episodic heat stress. Shultz (1984) studied cow responses to weather types in corrals in the southwestern United States. An almost linear relationship between ambient temperature and the proportion of cows standing was demonstrated. More recently, Overton et al. (2002) documented temporal cyclicity in lying behavior in a freestall pen and noted an inverse relationship between the proportion of cows lying down and ambient temperature. This association, however, was confounded by time after milking. In a study con-

Received October 5, 2006.
Accepted December 13, 2006.
[1]Corresponding author: nbcook@wisc.edu

ducted in 4 Swiss dairy herds, lying behavior of sentinel animals was tracked under different climatic conditions (Zahner et al., 2004). The authors noted that the duration of lying behavior decreased during the day with increasing THI, but lying duration during the night was unaffected. Although it is generally accepted that cows stand more in alleys and stalls during periods of heat stress, no previous study has followed a group of cows through different climatic conditions and reported changes in daily time budgets for lying, standing, drinking, milking, and feeding activity.

Claw horn lesions, such as sole ulcer, are believed to develop from increased pedal bone mobility induced by changes in the corium at calving (Lischer et al., 2002) and potentially from nutritional insults such as subacute ruminal acidosis (Cook et al., 2004a; Stone, 2004). Factors that contribute to an increase in time spent standing may exacerbate these changes by further compromising the structure of the claw. Reductions in lying activity per day have been associated with lameness in dairy cows (Leonard et al., 1996; Cook et al., 2004a). Poor stall design and excessively long milking times also have a negative effect on hoof health (Cook et al., 2004b; Espejo and Endres, 2007). Behavioral adaptations to heat stress may be another potential risk factor for reduced lying times and associated lameness. An increase in the rate of claw horn lesion associated lameness in the late summer has been reported and associated with periods of heat stress in Wisconsin dairy herds (Cook, 2004). This may be because of increased susceptibility to subacute ruminal acidosis or because of an increase in standing activity or a combination of the two.

This study documented the degree of change in daily activity time budgets in a group of lactating dairy cows between filming sessions that targeted different THI on a commercial free-stall dairy farm. In addition, changes in activity during 4 specified periods of the day between filming sessions were recorded.

MATERIALS AND METHODS

Cow Selection

Twenty multiparous Holstein cows were randomly selected from a subset of cows less than 150 DIM, within a single pen of a commercial freestall-housed dairy herd. Each cow was given a unique identification number using black hair dye, visible from both flanks and the head. Three weeks before the start of filming, the feet of each cow were trimmed and balanced. Cows identified as clinically lame by the herdsman during the filming period were treated within 7 d.

The pen was monitored for a total of 4 filming sessions under different weather conditions. At a single milking during each filming session, the cows were scored for locomotion on a flat and level surface when returning from milking using a 4-point scoring system where 1 = nonlame, 2 = slightly lame, 3 = moderately lame, and 4 = severely lame (Nordlund et al., 2004). Parity, locomotion score, current DIM, and most recent DHIA-recorded daily milk weight at each filming session were used as covariates in the statistical modeling.

Animal Housing

Study animals were housed with a group of multiparous cows in an east–west oriented pen with curtain sidewalls and 3 rows of freestalls bedded with sawdust on top of a rubber crumb-filled geotextile mattress. Group size was maintained between 100 and 105 cows with access to 92 stalls that measured 1.19 m wide and 2.49 m long against the side wall (2.21 m long for the head-to-head stalls), 1.68 m from curb to brisket locator, with a neck rail 1.14 m above the stall surface and 1.68 m from the rear curb. Pen flooring was grooved concrete, with a 1.8-m wide rubber surface in the feed alley, adjacent to the feed bunk that consisted of 65- × 0.61-m wide headlocks. Water troughs were located at the ends of the pen and at the single cross alley in the middle of the pen.

Heat abatement was provided by 3 recirculation fans (1.22 m diameter) spaced at 12-m intervals and located over the feed bunk. No fans were located over the stalls. The fans were activated above a temperature of 21.1°C. In addition, water soakers were located along the feed bunk at 1.98-m intervals. The soaker cycle was activated above a temperature of 25.6°C and cycled through 1.5-min periods on and 11-min periods off.

Cows were milked 3 times daily. Fans and water soakers were present in the holding area. A TMR was fed once a day at approximately 0900 h and pushed up 6 times per day. Cows were added to and removed from the pen at weekly intervals. Filming was timed to avoid periods within 48 h of new pen additions.

Choice of Filming Times

Weather forecasts were used to predict local weather conditions for 4 filming sessions between early June and the beginning of September 2004. The aim was to film 2 sessions with a predicted maximum outside ambient temperature less than 23.9°C and 2 sessions with a predicted minimum outside ambient temperature greater than 18.3°C. The pen was filmed over a 3-d period when weather predictions were favorable. The dates of filming for each of 4 sessions (S1 to S4) were June 22 to 24, July 12 to 14, August 10 to 12, and August 25 to 27, 2004.