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Assessing heat load in drylot dairy cattle: Refining on-farm sampling methodology

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ABSTRACT

Identifying dairy cattle experiencing heat stress and adopting appropriate mitigation strategies can improve welfare and profitability. However, little is known about how cattle use heat abatement resources (shade, sprayed water) on drylot dairies. It is also unclear how often we need to observe animals to measure high heat load, or the relevance of specific aspects of this response, particularly in terms of panting. Our objectives were to describe and determine sampling intervals to measure cattle use of heat abatement resources, respiration rate (RR) and panting characteristics (drooling, open mouth, protruding tongue), and to evaluate the relationship between the latter 2. High-producing cows were chosen from 4 drylots (8 cows/dairy, n = 32) and observed for at least 5.9 h (1000 to 1800 h, excluding milking) when air temperature, humidity, and the combined index averaged 33°C, 30%, and 79, respectively. Use of heat abatement resources was recorded continuously; RR and the presence and absence of each panting characteristic were recorded every 5 min. From the observed values, estimates using the specified subsampling intervals were calculated for heat abatement resource use (1, 5, 10, 15, 20, 30, 60, 90, and 120 min), and for RR and panting (10, 15, 20, 30, 60, 90, and 120 min). Estimates and observed values were compared using linear regression. Sampling intervals were considered accurate if they met 3 criteria: $R^2 \geq 0.9$, intercept = 0, and slope = 1. The relationship between RR and each panting characteristic was analyzed using mixed models. Cows used shade (at corral or over feed bunk) and feed bunk area (where water was sprayed) for about 90 and 50% of the observed time, respectively, and used areas with no cooling for 2 min at a time, on average. Cows exhibited drooling (34 ± 4% of observations) more often than open mouth and protruding tongue (11 ± 3 and 8 ± 3% of observations, respectively). Respiration rate varied depending on the presence of panting (with vs. without drool present: 97 ± 3 vs. 74 ± 3 breaths/min; open vs. closed mouth: 104 ± 4 vs. 85 ± 4 breaths/min; protruding vs. nonprotruding tongue: 105 ± 5 vs. 91 ± 5 breaths/min). Accurate estimates were obtained when using sampling intervals ≤90 min for RR, ≤60 min for corral shade and sprayed water use, and ≤30 min for drooling. In a hot and dry climate, cows kept in drylots had higher RR when showing panting characteristics than when these were absent, and used shade extensively, avoiding areas with no cooling. In general, 30 min intervals were most efficient for measuring heat load responses.
Key words: heat stress, behavior, cooling, sprinkler

INTRODUCTION

In the arid western United States, about 1.8 million cows are kept in drylots (open, dirt-based pens), comprising 30% of dairy farms (USDA, 2010). Compared with other housing types, this system has several benefits, including lower capital costs (Stokes and Gamroth, 1999), lower disease prevalence (e.g., lameness and mastitis), and better reproductive outcomes (USDA, 2010). However, because drylots are found mainly in hot, dry regions such as California, exposure to heat load during the summer creates economic and ethical concerns relating to reduced milk production, infertility, and mortality (St-Pierre et al., 2003; von Keyserlingk et al., 2013). Identifying dairy cattle experiencing high heat load and adopting appropriate mitigation strategies can lead to improvements in animal welfare and profitability.

To help their cattle cope with heat load, dairy producers commonly provide heat abatement resources such as drinking water, shade, fans, or sprayed water (USDA, 2010). However, little is known about how cattle use such resources on commercial drylot operations. To assess the effectiveness of heat abatement resources, the behavioral and physiological strategies cattle use to reduce heat gain or to promote heat loss can be measured. Relatively short-term responses to hot weather include increased use of shade (Schütz et al., 2008, 2009, 2010), sprayed water (Legrand et al., 2011; Chen et al., 2013), and higher respiration rate, along with panting (Brown-Brandl et al., 2005; Gaughan et al.,

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2008). These responses provide a well-established set of variables to assess heat load, but aspects of their measurement require refinement.

Determining appropriate measurement strategies is essential for generating accurate estimates when assessing heat load. Although continuous observation quantifies a response accurately (Martin and Bateson, 2007), many practical issues are associated with this sampling method. It can be time-consuming, labor-intensive, and highly reliant on technology (e.g., video cameras, data loggers), which is not always available for on-farm assessments. Alternatively, some measures can be sampled at fixed intervals over time without compromising the results obtained (Mitlöhner et al., 2001; Ledgerwood et al., 2010), but it remains unclear how often we need to observe cattle to capture responses to heat load. Measurement of respiration rate, for example, varies in the literature from every 15 min over a 24-h period (Brown-Brandl et al., 2005) to once a week (Keister et al., 2002). Variation across studies suggests an opportunity to identify appropriate sampling methods for such measures to improve the reliability and accuracy of the results.

Another methodological concern related to measures of heat load is the way they are described and recorded. Panting, for example, has been thought to be a more accessible tool (i.e., easier to measure than respiration rate, for example) for identifying cows that experience high heat load. This response has been recorded using a scoring system (Mader et al., 2006; Gaughan et al., 2008), with characteristics to define panting intensity including drooling, whether the mouth is open or closed, whether the tongue is protruding or not, breathing rhythm, and posture. However, the biological meaning of these different characteristics and their relationship with respiration rate are not clearly understood. In addition, the subjectivity of description of some of these characteristics can contribute to poor reliability, and, possibly, low accuracy. Thus, our objectives were (1) to describe the use of heat abatement resources on commercial drylot operations, and (2) to refine the methodology used to assess heat load in dairy cows by determining accurate sampling intervals to measure respiration rate, panting, and use of heat abatement resources, and by evaluating the relationship between respiration rate and specific panting characteristics such as drooling, open mouth, and protruding tongue.

MATERIALS AND METHODS

Farms and Animals

All procedures involving animals were approved by the University of California, Davis, Institutional Animal Care and Use Committee. This study was carried out from July to August 2014 in 4 drylot dairies in the Central Valley of California (Tulare and Kings Counties). The 4 operations varied in terms of heat abatement strategies provided, milk production, and herd size (Table 1). On each farm, 8 Holstein-Friesian cows were randomly selected from the high-producing group of cows (total n = 32). The selected cows were identified with numbered collars and tail spray paint. Individual and whole-group data for DIM, lactation number, and milk yield were obtained from computer records (Dairy Comp 305, Valley Agricultural Software, Tulare, CA) and are summarized in Table 1.

Data Collection

Data were recorded from 1000 to 1800 h, excluding when cows were away from the home pen for milking, averaging 6.6 h of observation/cow (range = 5.9 to 7.7 h). This window was chosen to capture the warmest daily weather in this region. Each day, 2 cows were tracked individually by 2 observers from outside the pen (1 observer/cow). Observations lasted 4 d/dairy, for a total of 8 cows/operation, 32 in total. Binoculars (Powerview 7-15 × 25, Bushnell, Overland Park, KS) were used when necessary. Two observers recorded all the measurements taken.

Use of Heat Abatement Resources. The use of heat abatement resources was recorded continuously based on the location of each cow in the pen. The home pen was divided into 4 different locations: feed bunk (concrete-floored surface behind the area where feed was provided), water trough (2 cow body-lengths area around the water source), corral shelter (dirt-floored surface underneath the roof of the shelter or within the shadow it projected, when visible), and open area (any other dirt-floored area that did not correspond to any location described above). At the start of observation, a cow was recorded as using a location where she had the majority of her hooves (if hooves were evenly split across areas, then we recorded the location where she had her front hooves). When the cow changed her location, the starting time was recorded as the second when she placed the first (front) hoof in the next location. The use of heat abatement was defined based on the resources provided on each farm: shade overall (corral shelter or shaded feed bunk), corral shade (corral shelter), shade + sprayed water (shaded feed bunk), sprayed water (unshaded feed bunk), and water trough. Except for dairy 3, where shade was not provided at the feed bunk (thus, unshaded feed bunk), all other forms of heat abatement resources were found in all farms. None of the farms provided fans. For each loca-