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Cooling cows efficiently with water spray: Behavioral, physiological, and production responses to sprinklers at the feed bunk

Jennifer M. Chen,* Karin E. Schütz,† and Cassandra B. Tucker*[1]
*Department of Animal Science, University of California, Davis 95616
†AgResearch Ltd., Hamilton 3240, New Zealand

ABSTRACT

Dairies commonly mount nozzles above the feed bunk that intermittently spray cows to dissipate heat. These sprinklers use potable water—an increasingly scarce resource—but there is little experimental evidence for how much is needed to cool cows in loose housing. Sprinkler flow rate may affect the efficacy of heat abatement, cattle avoidance of spray (particularly on the head), and water waste. Our objectives were to determine how sprinkler flow rate affects cattle behavioral, physiological, and production responses when cows are given 24-h access to spray in freestall housing, and to evaluate heat abatement in relation to water use. We compared 3 treatments: sprinklers that delivered 1.3 or 4.9 L/min (both 3 min on and 9 min off, 24 h/d) and an unsprayed control. Nine pairs of high-producing lactating Holstein cows received each treatment at a shaded feed bunk for 2 d in a replicated 3 × 3 Latin square design [air temperature (T): 24-h maximum = 33 ± 3°C, mean ± SD]. Cows spent 5.8 ± 0.9 h/24 h (mean ± SD) at the feed bunk overall, regardless of treatment. With few exceptions, cows responded similarly to the 1.3 and 4.9 L/min flow rates. Sprinklers resulted in visits to the feed bunk that were on average 23 to 27% longer and 13 to 16% less frequent compared with the control, perhaps because cows avoided walking through spray. Indeed, when the sprinklers were on, cows left the feed bunk half as often as expected by chance, and when cows chose to walk through spray, they lowered their heads on average 1.7- to 3-fold more often than in the control. Despite possible reluctance to expose their heads to spray, cows did not avoid sprinklers overall. In warmer weather, cows spent more time at the feed bunk when it had sprinklers (on average 19 to 21 min/24 h for each 1°C increase in T), likely for heat abatement benefits. Compared with the control, sprinklers resulted in 0.3 to 0.7°C lower body temperature from 1300 to 1500 h and 1700 to 2000 h overall and attenuated the rise in this measure on warmer days (for each 10°C increase in T, body temperature increased by on average 0.5 to 0.7°C with sprinklers vs. 1.6°C without). Sprinkler access also resulted in milk yield that was, on average, 3.3 to 3.7 kg/24 h higher than in the control treatment. In this hot and dry climate, 1.3 L/min cooled cows more efficiently than 4.9 L/min, as the lower flow rate achieved equivalent reduction in body temperature and increase in milk yield relative to no spray, despite using 73% less water.

Key words: heat load, sprinkler, soaker, behavior

INTRODUCTION

The accumulation of heat load in cattle results in increased body temperature, decreased milk yield (West, 2003) and fertility (De Rensis and Scaramuzzi, 2003), and in extreme cases, mortality (Stull et al., 2008; Morignat et al., 2014). For heat abatement, US dairy producers commonly provide water spray (62% of milking herds ≥500 head; USDA, 2010). Relative to shade alone, spray reduces body temperature (Valtorta and Gallardo, 2004; Kendall et al., 2007; Chen et al., 2013), respiration rate (Mitlöhner et al., 2001), and localized air temperature (Frazzi et al., 2002; Kendall et al., 2007; Chen et al., 2013). This resource has also been shown to increase feed intake (Strickland et al., 1989) and milk yield (Her et al., 1988).

Along with reducing heat load in cows, minimizing the water footprint is a sustainability concern for US dairy production (von Keyserlingk et al., 2013). Spraying cattle uses potable water, which is predicted to become more limited due to decreasing rainfall, changes in precipitation patterns, and rising temperatures (Rosenstock et al., 2006). Spray is often provided at the feed bunk using soaker nozzles that deliver coarse droplets to wet through the hair coat to the skin. In addition to cooling the microclimate, spray dissipates heat from cows via evaporation when the water is turned off (similar to sweating). To allow for this, sprinklers for the entire pen of cattle are typically activated intermittently with a controller when air temperature (**T**) reaches a threshold set by the dairy producer.

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[1]Corresponding author: cbtucker@ucdavis.edu

Dairies vary widely in the amount of water used to cool cows (e.g., 23 to 256 L/24 h per cow; G. Tresoldi, UC Davis, Davis, CA, personal communication). Applying more water (by increasing nozzle flow rate or application duration) results in diminishing returns. In a hot, humid climate, higher flow rates (8.2 and 11.7 L/min) did not reduce body temperature or respiration rate relative to the lowest (5.2 L/min, applied intermittently above the freestalls; Means et al., 1992), although no unsprayed controls were tested. In California's hot, dry Mediterranean climate, we found 1.3 L/min reduced body temperature and respiration rate relative to 0.4 L/min and no spray, but ≥4.5 L/min provided little additional cooling when cows were required to use spray (applied intermittently for 1 h at the feed bunk; Chen et al., 2015).

Although flow rate affects cooling when cows are required to use sprinklers, little is known about the effect of this spray attribute on behavior in loose housing. In freestalls and drylots, which house three-quarters of US dairy cows (USDA, 2010), cattle can choose whether to stand under spray. Sprinklers activate intermittently regardless of cattle presence at the feed bunk and water is wasted when they avoid spray. Loose-housed cattle use sprinklers for at least part of the day (Legrand et al., 2011; Parola et al., 2012; Chen et al., 2013), but they avoid spray to the head by lowering (Kendall et al., 2007; Schütz et al., 2011) or keeping this body part out of the spray radius (Schütz et al., 2011; Chen et al., 2013). Cows lowered their heads 5 times as often in response to 4.5 L/min compared with 0.4 L/min (Chen et al., 2016), likely because higher flow rates generate greater spray impact (i.e., 8-fold difference in this study). Nonetheless, cows did not avoid the higher flow rate altogether in brief tests: they did not require additional pressure from a handler to approach 4.5 L/min spray compared with 0.4 L/min (delivered for 1 min in an aversion race; Chen et al., 2016) and showed no preference between these flow rates (delivered for 12 min in a choice maze; J. M. Chen, unpublished data). In a commercial setting, however, if reluctance to wet the head translates into overall avoidance of spray, this could result in reduced efficacy of heat abatement and in water waste.

Our objectives were to evaluate the effects of flow rate on behavioral, physiological, and production responses to sprinklers in freestall housing, and to evaluate heat abatement compared with water use. We predicted cows would show greater reluctance to wet their heads when encountering a higher flow rate, which could result in reduced overall use. If cows use different flow rates equally, we predicted that flow rates ≥1.3 L/min would have similar effects on body temperature (based on previous work), and thus on feed intake and milk yield. Therefore, we predicted 1.3 L/min would use water more efficiently to cool cows relative to a higher flow rate.

MATERIALS AND METHODS

Animals and Housing

The study was conducted during the summer (July to August 2013) at the University of California-Davis (UC Davis) dairy facility, with all procedures approved by the Institutional Animal Care and Use Committee. Eighteen lactating Holstein-Friesian dairy cows were used, with average parity 2.3 ± 1.0, DIM 199 ± 69, daily milk yield 45 ± 4 kg, and BW 721 ± 98 kg (mean ± SD); 15 of the cows were pregnant.

Cows were housed in pairs (n = 9 pairs), in 3 cohorts comprising 3 pairs each, balanced for average milk yield. Each pair of cows had an unshaded water trough and a fan (model 36-DMCH, 91.4-cm blade diameter; Future Products Corp., Mosinee, WI) mounted above each row of 4 shaded, sand-bedded freestalls (2 to 4 freestalls/cow). They had ad libitum access to a TMR [89.3 ± 0.6% DM, mean ± SD; 41% alfalfa hay, 41% grain mix, 8% whole cottonseed, 8% almond hulls, 1% EnerGII (Vitus Nutrition, Corcoran, CA), and 1% mineral mix, as-fed], which was replenished during each milking. Cows were milked twice daily at 0400 and 1600 h in a parlor approximately 60 m from the home pen, for a total of 1.8 ± 0.6 h/24 h (mean ± SD). Milk yield was recorded using DairyComp 305 (Valley Agricultural Software, Tulare, CA).

Treatments

For each pair of cows, the shaded feed bunk was fitted with 2 soaker nozzles (Turbo FloodJet wide-angle flat spray tips; Spraying Systems Co., Wheaton, IL) spaced 1.9 m apart on a water line 1.8 m from the feed bunk at 2.3 m high. The nozzles were aimed toward the bunk and angled downward to avoid wetting the feed. The operating water pressure was 207 kPa (30 psi, 2.1 kg/cm^2) and the spray radius extended to 1.85 m from the feed bunk, where a black-and-white dashed line was painted on the ground. To minimize spray drift between pens, 2.4-m-high × 3.7-m-long plywood partitions were placed perpendicular to the feed bunk. Spray was delivered for 3 min followed by 9 min off for 24 h/d, controlled by a cycle timer (custom; Chipponeri Electric Inc., Hilmar, CA) that triggered a solenoid (Meter-Man; Komelon USA Corp., Waukesha, WI).

There were 3 treatments: a control in which no water was applied and 2 sprinkler treatments that differed in flow rate (1.3 L/min, model TF-VP2, 450 μm average