

Heat Stress in Dairy Calves

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INTRODUCTION

Calves attempt to maintain a constant body temperature regardless of the outside temperature, and within a certain temperature range—called the thermoneutral zone—calves can accomplish this without expending extra energy. The boundaries of the thermoneutral zone are not constant and are not determined by the outside temperature alone. They are affected greatly by the effective ambient temperature experienced by the calf, which depends on air movement, moisture, hair coat, sunlight, bedding, and rumination. Many of these factors can be influenced by the housing and environment in which the calf is placed. Each of these factors affects temperature regulation, and the impact may differ in summer and winter.

When we think of effects of the environment on calves, cold stress is often the more common concern, especially in more temperate climates. However, soaring summer temperatures, hot sun, and high humidity can cause heat stress in calves and heifers just as in the milking herd. These factors may affect calves many months of the year if they are in areas closer to the equator. Reduced feed intake and increased maintenance energy needs coupled with lowered immunity can lead to poor growth, higher susceptibility to disease, and in extreme cases death.

HOW HOT IS TOO HOT?

In comparison to adult animals, calves may be better able to cope with warmer temperatures due to their large surface area relative to their body weight and also due to the much smaller amount of heat generated by calves compared to cows. Obviously, cows produce an increased amount of heat due to the digestion of fibrous feedstuffs and the metabolic activity required to support high levels of milk production.

In one study of young Holstein calves subjected to various temperatures for a 10- to 11-hour experimental period, heat production was minimal and fairly constant at temperatures between 59 and 84°F with relative humidity of 50%. Heat production increased as temperatures approached 75°F (Gebremedhin et al., 1981). Water lost through respiration increased as the temperature rose above 68°F, and water lost through evaporative cooling started to increase when temperatures reached 75°F (Gebremedhin et al., 1981). In another study where

calves were exposed to a treatment temperature for 7 hours, signs of heat stress were not observed until temperatures approached 90°F with 60% relative humidity (Neuwirth et al., 1979).

More recent data on calf responses to heat stress in a controlled environment are not available. However, observations of calf performance in summer months show average daily gain declined as average nursery temperature over the calf's first 2 months of life increased from 20 to 80°F and suggest calves may not be able to dissipate accumulated heat when daily low temperatures in calf housing exceed 77°F (Bateman et al., 2012). In a Utah study (Wiedmeier et al., 2006) that considered effects of season, pre-weaning average daily gain of calves started in June was lowest (1.39 pounds/day), December calves were intermediate (1.46 pounds/day), and September and March calves had the highest gains (1.55 and 1.53 pounds/day, respectively). Calves in this study were fed a 20% protein, 20% fat milk replacer at 1 pound of powder per day. In a Pennsylvania field study, Place et al. (1998) also found calves born in summer and fall had significantly lower average daily gains than calves born other times of the year, with a variety of housing types.

It seems that calves, like cows, experience less stress when temperatures drop overnight; periods with no night cooling provide no opportunity for accumulated body heat to dissipate. Grain intake is reduced and the energy required to regulate body temperature increases (a maintenance cost), so feed efficiency decreases and weight gain may suffer during heat stress. Rumen development may be slowed by reduced grain intake, leading to a more difficult transition and a growth slump after weaning. In addition immunity can be compromised if energy is redirected to cooling functions. Body temperature rises as calves experience heat stress, and if it reaches approximately 108°F calves are very likely to die from heat stroke.

STRATEGIES TO HELP CALVES BEAT THE HEAT

Provide Shade

Studies have shown providing shade reduces the temperature inside hutches and lowers calf body temperature and respiration rate. In an Alabama study (Coleman et al., 1996), 80% shade cloth positioned about 4 feet above plastic hutches reduced

the temperature inside the hutch by 3°F (92 and 89°F measured at 3 p.m.) and reduced calf body temperature by about 0.5°F compared to hutches with no shade. The study was repeated the following year to observe calf growth. Temperatures were more moderate (81 and 77°F inside hutches at 3 p.m.), but shade reduced the temperature inside the hutch by 4°F. These temperatures are at the low end of those that would be expected to cause heat stress, and the study did not provide any information about the duration of hot weather. Calves in shaded hutches ate less starter and tended to have lower average daily gains than calves in hutches that were not shaded, but feed efficiency was greater for calves in shaded hutches.

In a Missouri study (Spain and Spiers, 1996), 80% shade cloth positioned about 3 feet above plastic hutches reduced the temperature inside the hutch by 4°F (temperatures measured at 3 p.m. were 89 and 85°F). Rectal temperature of calves in shaded hutches was not significantly lower, but did increase at a slower rate than in calves not shaded. Skin temperature of calves under shade was 4°F lower than that of calves with no shade. Respiratory rates of all calves increased when the temperature exceeded 79°F, but calves housed in hutches with shade had respiratory rates 10 breaths/minute lower than calves in hutches with no shade when measured at 3 p.m.

Plywood hutches have been shown to have lower inside air temperatures than polyethylene plastic hutches in the summer. Providing shade over polyethylene hutches (blue plastic tarp placed 6.6 feet above the hutch) did reduce the inside air temperature compared to no shade, but shaded plastic hutches were not as cool as wooden hutches in a Pennsylvania study. In this study temperatures in the middle of the hutch were 78°F for wood hutches, 80°F for plastic hutches with shade, and 82°F for plastic hutches with no shade (Lammers et al., 1996).

Shade may be provided by solid roofing, 80% shade cloth, or by moving hutches to an area shaded by trees. Calves that are confined to hutches may be at greater risk of heat stress than calves that are able to choose where they lie. Providing a pen in front of the hutch or using a tether allows calves more freedom to select a comfortable spot.

Calves housed in barns with solid roofs have built-in shade, but depending on the layout, some pens may experience more direct sunlight than others. If calves

do not have the ability to move out of direct sunlight, shade curtains may provide some relief. In greenhouse-style barns, clear plastic covered with shade cloth or white plastic have been found to be equally effective in blocking solar radiation (Gooch and Inglis, 2001).

Move More Air

Calf housing should be positioned to utilize prevailing winds and should incorporate as many openings as possible to take advantage of natural air movement. Typically, open-faced buildings should face southeast. Hutches may be turned to face east in summer to maximize air movement and minimize solar heating. Placing hutches 4 feet apart with 10 feet between rows allows air to circulate freely, eliminates calf-to-calf contact, and provides easy access for feeding and cleaning (Tyson et al., 2007).

Air movement can be enhanced by opening vents on hutches and placing a block under the back wall (be sure to maintain this opening as bedding builds up inside the hutch). Moore et al. (2012) from Washington State University demonstrated that placing a concrete block under the back wall of hutches (blocks were 7.9 inches in height) reduced the temperature and carbon dioxide levels inside the hutch and reduced calf respiratory rates. Temperatures inside hutches were slightly lower than outside temperatures for hutches that had been propped up, while the opposite was true for hutches that were not elevated. Other research found that airborne bacteria counts were lower in hutches elevated about 1.5 inches compared to hutches that were not elevated; this was presumably due to increased airflow (Hill et al., 2011).

Hill et al. (2011) evaluated the effectiveness of fans for cooling calves housed in a naturally ventilated barn with curtain sidewalls, a covered ridge vent, and wire panel pens. Running fans between 8 a.m. and 5 p.m. each day improved average daily gains by 23% and feed efficiency by 20% for calves otherwise treated identically and who ate similar amounts of milk and grain (average daily gains of 0.9 and 1.1 pounds/day and gain to feed ratios of 0.385 and 0.466 for calves that were not cooled and those cooled by fans, respectively). Respiration rates were also lower in calves cooled by fans. Temperatures averaged about 72°F (range of 48 to 99°F) in the barn during the trial.

Depending on the facility, continual adjustments may be needed to keep ventilation adequate as weather

changes occur, and automated controls can be very helpful (Gooch and Inglis, 2001). Greenhouse-type barns with transparent or translucent coverings will require more frequent adjustment than buildings with wooden or opaque roofs. Once temperatures reach 75°F, curtain sidewalls on calf barns should be completely open (Brotzman and Nordlund, 2012).

Offer Plenty of Water

As calves attempt to maintain their body temperature, water is lost through increased respiration and evaporative cooling (sweating). While we know that calves need to increase their water consumption to replenish the water lost to cooling functions, there is little data available to estimate exactly how much water is needed as temperatures rise.

Over 33,000 observations of water intake by calves in Iowa were used to develop equations to predict water intake (Quigley, 2001). Starter intake, environmental temperature, and amount of milk replacer fed were the three most important factors in predicting water intake. While starter intake accounted for 60% of the variation in water intake, this study found that calves increased water intake exponentially as the daily high temperature increased (Quigley, 2001). In addition, when the temperature exceeded 77°F calves increased water consumption independent of their grain intake (Quigley, 2011). Whether calves are eating grain or not, they need to have access to water in hot weather. In addition, it may be critical to introduce each calf to water to insure they understand water is available.

Although it is recommended water be provided to calves beginning in the first day or two of life, the USDA Dairy 2007 survey reported the average age calves were first offered water was 15.3 days. Calves less than 2 weeks of age are the most vulnerable to diarrhea, which can lead to rapid dehydration. If calves are scouring and no water is available, they are extremely vulnerable to heat stress. Again, this underscores the importance of providing fresh water to calves in the first week of life. For scouring calves, early and aggressive use of fluid therapy is especially critical during hot weather; feed electrolytes at the first sign of scouring to help calves avoid dehydration. Water buckets also may need to be filled more frequently (or switched to a larger size) in the summer, particularly for calves nearing weaning and those who have recently been weaned.

There is also evidence that keeping fresh water in front of calves can improve performance. In a Utah study, calves were fed and managed identically except for the frequency of rinsing water buckets, which was done daily, weekly, or every two weeks (Wiedmeier et al., 2006). All water buckets were kept full and cleaned if contaminated by manure. Calves whose buckets were rinsed daily gained 1.55 pounds/day prior to weaning, compared to 1.48 pounds/day for calves with buckets rinsed weekly and 1.40 pounds/day for buckets rinsed every 14 days. In addition, calves whose water buckets were rinsed every two weeks required more treatments for illnesses than calves with buckets rinsed daily or weekly. The impact of rinsing buckets was the same across seasons (calves started in June, September, December, or March).

Keep Grain Fresh

Calves will naturally tend to eat less grain during periods of heat stress. This means efforts to encourage starter intake take on added importance. Offer only small handfuls at each feeding until calves begin to eat starter. Remove uneaten starter and clean out wet or moldy feed daily to maintain freshness. A divider between the grain bucket and water bucket can help keep starter fresh longer by limiting the amount of transfer between the two buckets.

Consider Inorganic Bedding

Inorganic bedding is preferred by some calf raisers as it helps keep calves cooler by absorbing body heat and dissipating it, rather than retaining it. However, in the study by Hill et al. (2011) described above, calves housed in the naturally ventilated barn and bedded on straw had greater average daily gain (0.13 lbs/d) than those bedded with sand and housed either in the barn or in hutches. Regardless of the material used for bedding, the priority should be to provide a clean, dry area for calves to rest.

Work Calves in the Morning

As with other classes of cattle, it is wise to handle calves in the morning so that stressful activities, such as dehorning, vaccinations, pen moves, or transportation, can be completed when both calf body temperatures and environmental temperatures are at their lowest point for the day.

Consider Feeding More Milk Replacer

There is a considerable body of evidence that most Holstein calves should be fed more than the conventional 1 pound of powder per day, simply based on the maintenance requirements of calves with typical body weights. Cold stress gets more attention than heat stress, but as temperatures drop calves often increase their starter intake to help meet their increased energy needs (this is especially true for calves older than 3 weeks of age). Thus, in a period of cold weather, calves that have started eating grain can often meet their increased energy needs by eating more grain. During heat stress, however, starter intake often stalls or goes down, leaving calves with less energy available to support their increased maintenance requirements. Generally speaking, healthy calves are unlikely to refuse to drink milk, so there is opportunity to increase the amount of energy provided to calves by increasing the amount of liquid feed offered.

At this point, there is little data to suggest how much milk replacer to add to help calves combat heat stress. For beef cattle maintenance energy needs are adjusted based on acclimatization to the environment using an average daily temperature over the previous 30 days, and additional adjustments are made to reflect increased maintenance energy needs due to short-term heat stress (NRC, 1981; 2000). Severity of panting is used to indicate short-term heat stress, and maintenance energy requirements are suggested to increase 7% when cattle exhibit rapid, shallow panting or 11 to 25% for open-mouth panting (NRC, 1981). More sophisticated models have been developed (Fox and Tylutki, 1998, for example), but they have not been validated for dairy calves.

Comparing results of trials in the same research facility with calves fed the same milk replacer during summer and winter conditions provides some interesting food for thought (Hill et al., 2007; 2012). During the first trial daily temperatures in calf pens averaged 27°F; for the second trial the temperature averaged 75°F. Calves in the winter trial were fed 1.0, 1.25, or 1.5 pounds per day of milk replacer containing 20% protein and 20% fat, weaned at 42 days, and bedded with shavings or straw (Hill et al., 2007). Calves in the summer trial were fed the same milk replacer at approximately 1.0 or 1.5 pounds per day, weaned at 42 days, and bedded with straw (Hill et al., 2012). In the winter trial average daily gain through day 56 was not different between the

three feeding rates and averaged 1.4 pounds per day. Starter intakes decreased linearly as milk replacer feeding rate increased. In addition, calves bedded with straw ate more starter and gained more than those bedded with shavings (1.5 vs. 1.3 pounds per day). By contrast, in the summer experiment calves fed the higher rate of milk replacer gained more than those fed 1 pound per day (average daily gains were 1.1 and 1.0 pounds per day through 56 days of age), and starter intake was similar for the two treatments.

This comparison does not take into account effects of heat stress on the dam before calving, which has been shown to negatively affect calves. In a University of Florida study (Tao et al., 2012), calves born to heat-stressed dams weighed 13 pounds less at birth and 28 pounds less at weaning than calves born to dams with access to cooling. Average daily gain from birth to weaning was not different for the two groups of calves. Although other studies have found heat stress can reduce colostrum IgG content, in this Florida study colostrum IgG content was not affected by heat stress. However, calves born to heat-stressed dams had reduced passive transfer of immunity and compromised cell-mediated immunity compared to calves born to cooled cows. The link between successful passive transfer and improved calf performance is well-established, so the potential influence of impaired immune status on calf performance in hot weather (regardless of feeding level) should not be forgotten.

Combining the results of research related to calf environmental temperature stresses, it appears insulation from bedding and increased starter intake allow calves to compensate for cold temperatures, but in warm weather starter intake is lower and additional milk replacer is needed to support desired growth. Therefore, it seems logical to conclude programs that routinely feed more than 1 pound per day of powder or 1 gallon of milk are more likely to provide energy in excess of maintenance requirements over a broader range of environmental conditions (Hill et al., 2013). In addition, it appears heat stress may indeed be greater than cold stress in terms of limiting desired average daily gain in dairy calves.

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