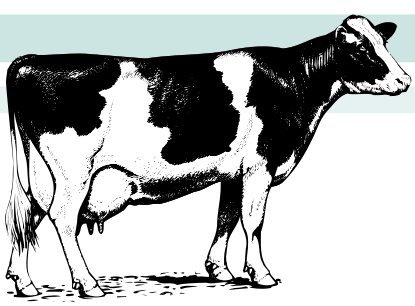
Coping With Summer Weather

Dairy Management Strategies to Control Heat Stress

John Smith, Extension Specialist;
Joe Harner, Extension Specialist;
Dick Dunham, Extension Specialist;
Jeff Stevenson, Professor; John Shirley, Associate Professor; Gerald Stokka, Extension Beef Veterinarian; Matt Meyer, Senior, Animal Sciences and Industry



Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service

Heat stress occurs when a dairy cow's heat load is greater than her capacity to dissipate the heat. Effects of heat stress include: increased respiration rate, increased water intake, increased sweating, decreased dry matter intake, slower rate of feed passage, decreased blood flow to internal organs, decreased milk production and poor reproductive performance. Reductions in milk production and reproductive performance are an economic loss to dairy producers. This publication discusses strategies that can be used on commercial dairies to reduce the effects of heat stress on dairy cattle.

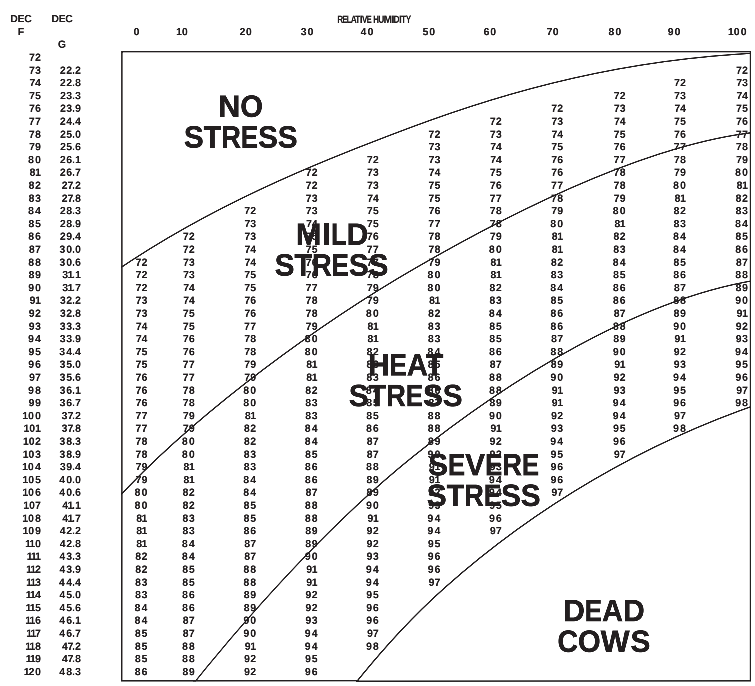
Measuring Heat Stress

Severity of heat stress is quantified using a temperature humidity index (THI). Both ambient temperature and relative humidity are used to calculate a THI. Signs of heat stress become evident in dairy cows when the THI exceeds 72. The same THI can be produced by various combinations of temperature and humidity (Figure 1). Dairy producers can purchase a thermometer / hygrometer and use Figure 1 to determine the level of heat stress at different locations on the dairy. Measurements should be taken at the level of the cows' back, along the feeding area, in the freestalls and in the holding pen.

Heat Loss in Dairy Cows

Dairy cows dissipate heat through conduction, convection, radiation and evaporative cooling. Conduction is based upon the principal that heat flows from warm to cold. This method of heat loss requires that a cow have physical contact with surrounding objects. When a cow wades into a pool, she is cooled by conduction. Cooling by convection occurs when the layer of air next to the skin is replaced with cooler air. Radiation of body heat can occur

Figure 1. Temperature Humidity Indexes (THI)



when the ambient temperature is significantly cooler than the cow. At cool temperatures, dairy cattle are efficient at radiating heat. Evaporative cooling occurs when sweat or moisture is evaporated from the skin or respiratory tract. This explains why dairy cattle sweat and have increased respiration rates during heat stress. High humidity limits the ability of the cow to take advantage of evaporative cooling. When the ambient temperature is under 50°F, nonevaporative methods account for 75 percent of the heat loss. Above 70°F, evaporative cooling is the cows' primary mechanism for dissipating heat. This mechanism can be applied to cool dairy cows on the farm.

Principles of Spray and Fan Cooling

Spray and fan systems should be used in the holding pen, over feeding areas, over the feeding areas in some freestall barns, and under shades on drylot dairies in arid climates. In climates with a low relative humidity, fog or mist systems (fine spray) usage provides evaporative cooling. These systems cool the air around the cow. This works well in many areas of the western United States. To cool cows in a more humid climate similar to the Midwest, a larger water droplet is required to wet the skin of the cow. Applying the water intermittently allows for evaporative cooling. Natural air movement, or the use of fans, will also increase the evaporation rate.

When selecting a spray and fan system, consider nozzle size, whether the nozzle spins or is stationary, spray pattern, radius of spray, timing of spray and operating pressure. Experiment with different types and sizes of nozzles to determine the best combination.

Water Availability

Providing access to water during heat stress is critical. Lactating cattle require between 35 and 45 gallons of water per day. Studies completed in climatic chambers indicate that water needs increase 1.2 to 2.0 times when cows are under heat stress. A water system should be designed to meet both peak demand and daily needs of the dairy. Availability of clean, cool water to cows leaving the milking parlor is beneficial for increasing water intake during times of heat stress. Access to an 8-foot water trough when cows are leaving the milking center is adequate for milking parlors with 25 stalls or less per side. When using drylot housing, water troughs are needed at two locations, in addition to 30 feet of trough perimeter per 100 cows or 80 feet of trough perimeter per 200 cows. In freestall housing, it is recommended to provide one waterer or 2 feet of tank perimeter for every 15 to 20 cows. Ideally, water should be available at every crossover between feeding and resting areas.

Shades

Cows housed in drylot or pasture situations should be provided with solid shade. Results from studies in Florida and Arizona indicate that when compared to high-producing cows exposed to direct sunlight and a THI above 80 during daylight hours, shaded cows will produce approximately 4 to 5 pounds more milk per day. Natural shading (trees) is effective, but most often shades are constructed from solid steel or aluminum. Providing 38 to 45 square feet of solid shade per mature dairy cow is adequate to reduce solar radiation. Height of shades should be at least 12 feet, with a north to south orientation to prevent wet areas from developing under the shade. Work done with more porous materials, such as shade cloth and snow fence, has shown that these materials are not as effective as solid shades. Shade cloth is available in patterns that provide 30 to 90 percent shade. Shade cloth, although less expensive, is less effective in blocking solar radiation and has a shorter life than solid shade.

Holding Pen

The holding pen is also another place where cows experience heat stress. Crowding cows into a holding pen is similar to putting several large furnaces into a small area with their thermostats set at 101°F. Provide shade over the holding pen and open the sides of the holding pen to increase ventilation. Fans can also be installed to aid in the ventilation of the holding pen. The level of heat stress in the holding pen can be assessed by holding a thermometer / hygrometer on a long rod over the top of the cows to determine the temperature and relative humidity. These values can then be used to determine a THI from Figure 1.

Cows may be cooled in the holding pen prior to milking. This method uses low volume sprinklers to wet the cows, and large fans to hasten evaporation of the water. Using this technique, cows are cooled at least two to three times per day depending on how often they are milked. Both spray and fans are operated continuously using approximately 1,000 cubic feet per minute (CFM) of air per cow per hour. Fans should be mounted overhead at a 30° angle from vertical, so that the air will blow down and around the cows. Water lines in front of the fans spray 7 to 10 gallons per hour at 125 to 150 psi. Fans with a diameter of 36 to 48 inches are commonly used for holding pens. In an Arizona trial, body temperature was lowered 3.5°F, resulting in 1.76 pounds more milk per cow per day, when cooled in the holding pen. The fans and spray should be used during the summer months when ambient temperatures are above 80°F (day and night). The time that cows spend in the holding pen should not exceed 60 to 90 minutes per milking. Field observations indicate that new dairies should be constructed so that cows spend 30 to 60 per milking minutes in the holding pen, depending on the frequency of milking (2×=60, 3×=45, 4×=30).

Exit Lane Cooling

Cows can be cooled as they exit the parlor. Typically, three to four nozzles are installed in the exit lane, with a delivery of approximately 8 gallons of water per minute at 35 to 40 psi. The nozzles are turned on and off with an electric eye or a wand switch as the cow passes under the nozzles. If properly installed, the top and sides of the cow will be wet, but the head and udder will remain dry so water will not remove post milking teat dip.

Freestalls

Freestall housing should be constructed to provide good, natural ventilation. Sidewalls should be 12 to 14 feet high to increase the volume of air in the housing area, and they should be open 75 to 100 percent. Fresh air should be introduced at the cow level. Curtains on the sides of freestall barns allow management greater flexibility in controlling the environment around the cow. Since warm air rises, roofs which are steeper and sloped will provide upward flow of warm air. Roof slopes for freestall housing should range from 4⁄12 to 6⁄12. Roofs with slopes less than 4⁄12 may have condensation and higher internal temperatures in the summer. Providing openings in addition to alley doors on the end walls will improve summer ventilation. Gable buildings should have a continuous ridge opening to allow warm air to escape. The ridge opening should be 2 inches for each 10 feet of building width. Naturally ventilated buildings should have a minimum of 1.5 to 2 times building width between structures.

Additional cooling can be added to freestalls by adding fans and a sprinkler system. However, the bedding in the stalls should not become wet. Typically, a sprinkler system can be located over the lockups, and fans can be used over the feed line freestalls, lockups or both. A sprinkler system may be controlled by a timer to reduce water usage. Producers can use either 180° (half-circle) or 360° (full-circle) nozzles. To prevent feed wetness, the 180° nozzles work well next to feed lines or bunks. Nozzle sizes ranging from 7 to 30 gallons per hour per nozzle are generally used to conserve water. Experiment with nozzle type, nozzle size, nozzle spacing and operating pressure to determine which nozzles

Table 1. Relative changes in maintenance requirements and dry matter intake (DMI) to maintain 60 pounds of milk production with increasing environmental temperature

Temperature	Maintenance requirements	DMI requirements for maintenance	DMI required for 60 lb of milk
(°F)	% of requirements (68°F)	(lb)	(lb)
68	100	12.8	40.1
77	104	13.3	40.6
86	111	14.2	41.7
95	120	15.4	42.8
104	132	16.9	44.5

Sources: National Research Council. 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. National Academy Press, Washington, D.C. Dr. Joe West, Extension Dairy Specialist, University of Georgia.

work best. Sprinklers can be operated intermittently, using automatic timers to regulate cycle length, such as every 2 to 3 minutes per 15 minutes. The cycle can be adjusted depending on the level of heat stress. Freestalls orientated north to south need sunscreen material along the west side to reduce heat load in the building. In the Midwest, it is generally recommended to orient freestall housing east to west.

Feed Lines and Feed Bunks

Dairy cattle can be cooled with a spray and fan system at the feed lines and feed bunks. If the feed line is inside a freestall barn, ensure the barn is properly ventilated and the bedding area is protected from becoming wet. Feed bunks that are outside freestall housing can be shaded, and a spray system or a spray and fan system can be installed. When a spray system is used over the feed bunk, concrete flooring prevents mud holes from developing. The area near the feed bunk needs to be cleaned regularly to prevent cows from lying in the area next to the bunks. If this area is not kept clean, a potential udder health problem is created.

Nutrition

Changes in diet formulation and feeding procedures can help reduce the effects of heat stress on the dairy cow. Changes in the ration should be made slowly and prior to the onset of hot weather to reduce throwing the cows off feed.

As daytime temperatures rise, increased breathing, panting and perspiration is observed as the cow attempts to lower her body temperature. These physiological responses increase the maintenance requirement of the cow by as much as 32 percent, using dietary nutrients fed for milk production. Heat stress also reduces feed intake, again leaving fewer dietary nutrients available for milk production. Table 1 displays the effects of increasing environmental temperature on maintenance requirements and dry matter intake.

Increasing dry matter intake (DMI) can be accomplished by several changes in the feeding program. Increasing both the number of feedings and the number of times feed is pushed up to the cows per day will increase DMI. Dairy cows are “conditioned” to move toward the feed bunk when they hear feeding equipment. Feeding during cooler parts of the day also stimulates feed intake. Cows under heat stress consume two-thirds of their total daily intake during the evening hours after the ambient temperature has dropped. Finally, dry matter intake also is improved by increasing the total mixed ration (TMR) moisture to 45 to 50 percent, making the TMR cooler and more palatable. The average moisture content of a TMR is typically 35 to 40 percent.

Increasing the energy density of the TMR is an effective way to increase energy intake when dry matter intake is reduced. Feeding supplemental fat is a highly effective method of increasing the energy density of a ration. Recommendations for total dietary fat in the ration range from 4 to 8 percent, depending on the fat source(s) utilized. Due to the potentially negative impact of unsaturated fats (i.e. vegetable oils) on rumen microorganisms, no more than 30 to 40 percent of the total dietary fat should come from sources such as whole cottonseed, roasted soybeans, etc. A second fat source is tallow, which is a highly efficient energy source. One benefit of feeding tallow instead of unsaturated vegetable fat sources is its minimal requirement for ruminal digestion. A third supplemental dietary fat source is manufactured rumen-protected fats. These bypass fats are expensive and often lack palatability. Feeding this type of fat may be cost effective only in herds with a daily average milk production in excess of 60 pounds per cow.

Reducing the heat of fermentation or heat increment of a ration reduces the overall amount of heat the cow must dissipate. Metabolism of poor quality, high fiber feedstuffs yield significantly greater amounts of metabolic heat when compared to high quality fiber sources. Thus, feeding high quality forages, effectively reducing the ration acid detergent fiber (ADF) (minimum of 19 percent) and neutral detergent fiber (NDF) (minimum of 28 percent), reduces the overall amount of heat the cow must dissipate. Carefully reduce the fiber portion of a diet to avoid problems such as rumen acidosis. Rumen acidosis can cause laminitis.

Feeding excessive amounts of highly soluble protein can lead to reduced feed intake, reduced milk production and increased production of metabolic heat. The goal is to establish an effective relationship between total dietary protein and the rumen degradability of the protein. Common recommended values are 18 percent protein, with 37 to 39 percent of that protein to be rumen undegradable.

Maintaining the normal electrolytes in the cow is a concern during heat stress. The following increases in dietary minerals should be considered when balancing a ration for heat-stressed lactating cows: potassium to 1.5 to 1.6 percent, sodium to 0.45 to 0.60 percent, and magnesium to 0.35 to 0.40 percent. It also may be beneficial to increase dietary vitamins A, D and E during hot weather. This will help offset the negative effect of heat stress on the immune system.

Reproduction

Heat stress negatively impacts all aspects of dairy cow reproduction. Any changes in the feeding program and improved physical facilities that alleviate heat stress lead to improved reproductive rates. Nutrient priorities of the cow first satisfy her requirements for maintenance, growth (2- and 3-year-old cows) and milk production. After these nutritional requirements have been met, excess nutrients can contribute to the reestablishment of estrus cycles and pregnancy after calving.

For example, reduced nutrient intake will delay first ovulation and observed estrus and, thus, delay first inseminations. Heat stress shortens the duration of heat and reduces the number of standing heats during each heat period. Once cows reestablish their normal estrous cycles, the duration of heat is shortened by as much as 50 percent, thus leading to difficulties in heat detection. A decline in pregnancy rates occurs as the THI rises. Reduced pregnancy rates are manifested by decreased embryo survival. As the temperature of the uterus rises to about 104°F (above normal body temperature of 101.5°F), conception occurs but embryos fail to develop.

Based on breeding records from various countries, we know that pregnancy rates of lactating dairy cows decrease sharply when the maximum air temperature exceeds 85°F. In contrast, conception rates for replacement heifers usually does not decline except at extremely high THI. Based on breeding records in Florida, heifers have higher conception rates (50 percent) for all services than lactating cows (34 percent), and suffer only slight depression of fertility during summer months. Pregnancy rates of lactating cows and heifers in Kansas are consistently lower during July, August and September.

Research has demonstrated that the day of heat is extremely critical to the outcome of the artificial insemination (A.I.) breeding. Cows must be kept as cool as possible, or subsequent embryo development after fertilization will be inhibited, and many embryos will die. Embryos are sensitive to heat stress, but appear to become more tolerant as they age. Nevertheless, cattle should be protected from heat stress during the first one to two weeks after insemination in order to maintain somewhat normal fertility. One of the probable detrimental effects of heat stress is the decrease in uterine blood flow. This decrease usually occurs when it is essential that developing embryos receive maximum blood flow to establish and maintain early pregnancy.

Other factors affected by heat stress occur during the last trimester of pregnancy when little or no shade is provided for pregnant cows and heifers. Florida research demonstrated that heat stress during the latter 60 to 90 days of gestation resulted in reduced birth weight of calves, and even less milk yield for those cows that had no shade protection. Uterine involution, the process by which the uterus returns to its nonpregnant size and function after calving, occurred sooner in cows that had shade during late pregnancy. Although days to first ovulation and estrus, days open, and services per conception were unaltered by pre-calving heat stress, the incidence of ovarian follicular maturation and first ovulation occurring on the ovary opposite to the previous pregnant uterine horn increased from an expected 50 percent to 92 percent. This suggests that due to heat stress during pregnancy, the uterus exerted a local negative effect on the ovary after calving. Because of potential carry-over effects of high temperature and humidity during pregnancy, it is not surprising that we see poor pregnancy rates as a result of summer inseminations. This lower fertility may persist sometimes well after temperatures have moderated in the fall.

Cattle Handling

Physiological mechanisms exist in the body to set and control internal body temperatures. Environmental factors and humidity stress disrupt this heat regulatory mechanism. Cattle seem to have a normal rhythmic pattern in body temperature that is independent of environmental temperatures.

Cattle body temperatures can range several degrees during the day. The most cool body temperatures occur in the early morning and morning hours. The warmest body temperatures tend to occur around 6 p.m. With this knowledge, additional activities (such as sorting or adding cattle to the herd) should be done during the early morning hours or delayed until environmental temperatures moderate. Heat stress will suppress the immune response of cattle and, thus, diligence in observing cattle for symptoms of illness must be increased. In addition, to maximize response to vaccines and minimize heat stress from handling, preventive vaccinations should only be given during the cooler hours of the day.

Summary

Reduced milk yield and reproductive rate are an economic loss to dairy producers. A number of steps can be taken to minimize the effects of heat stress. However, the methods of minimizing heat stress should be appropriate to the climate of the dairy. When done in unison with improvements to physical facilities, changes to the summertime ration and feeding program can improve the cow's ability to cope with heat stress and ultimately minimize losses in milk production. Cow comfort should be a priority. Access to cool, clean drinking water and providing shade in the holding pen and housing area, should be the first priorities. The second priority should be to provide proper ventilation in the freestall housing and milking center. Spray and fan cooling systems can be installed in the holding pens, feed area and some freestall facilities as a third priority.

References

Armstrong, D.V. 1993. Environmental Modifications to Reduce Heat Stress. *Proceedings:* Western Large Herd Dairy Management Conference, Las Vegas, NV, pp. 2–7.

Beede, D.K. 1993. Water Nutrition and Quality for Dairy Cattle. *Proceedings:* Western Large Herd Dairy Management Conference, Las Vegas, NV, pp. 194–204.

Beede, D.K. and J.K. Shearer. 1991. Nutritional Management of Dairy Cattle During Hot Weather. Agri-Practice, Volume 12, No. 5.

Beede, D.K. and J.K Shearer. 1991. Thermoregulation and Physiological Responses of Dairy Cattle in Hot Weather. Agri-Practice, Vol. 11, No. 4. July / August.

Bickert, W.G. 1990. Feed manger and barrier design. Dairy Feeding Systems. *Proceedings:* Dairy Feeding Systems Symposium, Northeast Regional Agriculture Engineering Service, NIRAES-38, pp. 199–206.

Dunham, J.R. 1997. Hot Weather and Feed Intake. K-State Research and Extension and Oklahoma State University. Dairy Lines, Volume 3 No. 2.

Hutjens, M.F. 1994. Feeding Strategies Under Heat Stress, Illini Dairy Guide. Extension Bulletin Dairy Guide 25, University of Illinois at Urbana–Champaign.

Mallonee P.G., et al. 1985. Production and Physiological Responses of Dairy Cows to Varying Dietary Potassium During Heat Stress. J. Dairy Sci. 68: 1479–1487.

McFarland, D.F. 1995. Proceedings: Freestall Housing Guidelines: Design Details to Enhance Management. Las Vegas, NV, pp. 89–102.

MidWest Plan Service. 1995. Dairy Freestall Housing and Equipment, MWPS-7, Fifth Edition. Agricultural and Biosystems Engineering Department, Iowa State University, Ames, IA 50011–3080.

Roman–Ponce, H., W.W. Thatcher, D.E. Buffington, C.J. Wilcox and H.H. VanHorn. 1977. Physiological and Production Responses of Dairy Cattle to a Shade Structure in a Subtropical Environment. J. Dairy Sci. 60:424.

Smith, J.F. 1996. Why is Milk Production Depressed in the Summer? K-State Research and Extension and Oklahoma State University. Dairy Lines. Volume 2 Number 7.

Turner, L.W., R.C. Warner, and J.P. Chastain. 1992. Micro-Sprinkler and Fan Cooling for Dairy Cows: Practical Design Considerations. University of Kentucky Cooperative Extension Service, AEN-75.

Notes:

Publications from Kansas State University are available on the World Wide Web at: http://www.oznet.ksu.edu

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2319 March 1998

File code: Dairy Science—4 3-98—1M