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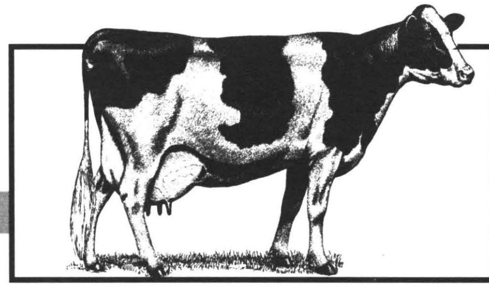

Dairy

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Reducing Heat Stress for Dairy Cattle

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The ideal ambient temperature for a dairy cow is between 41 and 77° F. At temperatures above 77° F, cows have to use energy to cool themselves through heat loss via surface skin and the respiratory tract. As ambient temperature increases, it becomes more difficult for a cow to cool herself adequately. High producing cows are the animals most sensitive to heat stress because of their high feed intake. Dry matter intake starts to drop (8-12%) and milk production losses of 20-30%, which may exceed 10-25 lb./day, occur when temperatures exceed 90° F. It has been found that milk yield peaked at 9 lb. more milk per day by cooled than non-cooled cows. Since each 1 lb. peak daily yield equals 225-240 lb. per lactation, 9 lb. is equivalent to more than 2,000 lb per lactation. Dry cows whose last 3 months of gestation occurred during hot weather had calves with smaller birth weights and more metabolic problems after calving. Also, they produced 12% less milk in the next lactation. Conception rate was lower due to less activity during estrus, reduced folliclar activity, and early embryonic death.

Heat stress can result in sick cows which require prolonged care. It is associated with difficult births, heat exhaustion, fatty liver in fresh cows, and mastitis, as well as adverse reactions to vaccinations leading to abortions and death. Heat stress can contribute to lameness, perhaps due to acidosis or increased output of bicarbonate. Heat stressed cattle eat less frequently and feed during cooler times of the day, but they eat more at each feeding (Shearer, 1999). Reduced feed intake, followed by slug feeding when the temperature cools down, can cause acidosis which is considered a major cause of laminitis. As ambient temperatures rise, the respiratory rate increases with panting progressing to open-mouth breathing. A consequence is respiratory alkalosis resulting from a rapid loss of carbon dioxide. The cow compensates by increasing urinary output of bicarbonate, and rumen buffering is affected by decreased salivary bicarbonate pool. Lameness, with sole ulcers and white line disease, will appear in a few weeks to a few months after the heat stress occurs.

The most common index of heat stress (temperature-humidity index or THI) is calculated from the temperature and relative humidity (RH). Dairy cows begin to suffer whenever the THI exceeds 72. Examples of high THI include 75° F and 80% RH, 80° F and 65% RH, and 85° F and 40% RH (Combs, 1996). Moderate stress can occur with temperatures ranging from 80° F and 100% RH to 90° F and 50% RH, causing rapid shallow breathing, profuse sweating, and reduction in milk yield that can exceed 10%. Severe heat stress, which occurs with temperatures exceeding 90° F and 100% RH to 100° F and 60% RH, causes open mouth panting, elevated body temperature, and a 25% decrease in milk yield. According to Combs (1966), heat stressed cows will:

1) Seek out shade, which they often will not leave to drink or eat,

2) Increase water intake,

3) Reduce feed intake,

4) Stand rather than lie down,

5) Increase respiration rate,

6) Increase body temperature,

7) Increase saliva production.

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The most practical methods to reduce heat stress can be grouped into shade, ventilation, and cooling. Common areas where cows congregate that will benefit from a reduction in heat exposure are holding areas, feed bunks, and loafing areas. But first we must also recognize the importance of cows having access to adequate water.

Water

Cows need to increase water intake during times of heat stress to dissipate heat through the lungs (respiration) and by sweating. Water consumption will increase by as much as 50%. If water supplies are not adequate or heat stress becomes severe, cows divert water normally used in milk synthesis to the metabolic processes of heat dissipation. Water intake will rise by 5-6 gal on summer days due to temperature effects alone. Beede (1992) showed that cows consumed about 3 lb. water/lb. dry matter intake (DMI) with temperatures between 0-41° F but reached 7 lb./lb. DMI at high temperatures with high producing cows capable of consuming 50 gal. water/day. In order to encourage water consumption:

1) Put waterers in the shade,
2) Provide access to water right after milking (large intakes of water shortly before milking may elevate freezing point of milk),
3) Ensure enough waterer space by:
   - Providing at least 2 waterer locations per group (at least 1 watering station per 20 cows and this may not be enough),
   - Having a water supply of at least 3-5 gal/minute (cows can consume 6 gal./hr.),
   - Maintaining a minimum of 3 in. water depth, and
   - Providing a minimum of 0.65 sq. ft. of surface area per cow at single- or double-position waterers,
4) Keep water tanks clean (a large Florida dairy empties tanks each week and brushes them with a chlorine solution to disinfect surfaces and cut down on algae growth),
5) Monitor temperature of water because cows prefer water at 70-86° F.

Shade

Although shade trees are the best method for relieving heat stress, most trees don't survive intensive use. When not enough natural shade is available, artificial shades can provide needed shelter from the effects of solar radiation. If cows are to be confined under a shade structure, it should be oriented with a southeastern exposure of an open sidewall. Walls of freestall barns should be opened up to maximize air movement. Eliminate any wind block within 50 ft. of the windward side of the building. Each cow should be provided with 60 sq. ft. of shade. The floor should have 4-inch concrete and should be grooved to provide firm footing. It should be sloped about 1.5 to 2% for proper operation of flush systems. Earthen floors under shades quickly can become mud holes and thus are not generally recommended. The concrete slab needs to be larger than the area of the shade roof. The slab should extend 8 ft. on the north side, and 20 ft. on the east and west sides if the eave height is 12 ft. Higher eaves will require that the slab be extended out farther. The recommended eave height is 12 ft. for structures up to 40 ft. wide and 16 ft. for structures wider than 40 ft. Gable roofs should have a 4:12 slope and a continuous open ridge, overshot ridge, or raised ridge cap to promote natural ventilation. All eave blocking should be eliminated. The holding area should have open sidewalls and ridge ventilation. Cows should be in the holding area for no more than one hour per milking.

Shade cloth is available in patterns providing 30 to 90% shade and fabricated from a variety of yarn materials. The most common material used for animal shades is woven polypropylene fabric, providing 80% shade. Shade cloth is considerably less expensive than solid roofing material but does not provide as much protection from solar radiation as a solid roof. It should last five years or longer if kept tight. To achieve the most benefit from the shade structure, feed and water must be available to the cows under the shade. A waste management system must be planned as an integral part of any shade structure.

Cooling

Cooling cows pays big dividends. Each area of the dairy facility must be considered when looking at cow cooling options. First, cool the holding pen near the milking parlor. Crowding cows into a small area restricts air flow and aggravates heat stress. Fans and sprinklers can reduce ambient temperature by 15° F, and cooled cows produce more milk than non-cooled cows. Also, it is important to minimize the time cows spend in the holding area.

To keep cows cool in holding pens:

- Raise the roof and sidewalls to allow natural air flow and have an open ridge row in the roof to let hot air out;
- Place banks of 36- or 48- inch fans 8 feet off the ground and 8 feet apart depending on the width of the holding pen) pointed down at 30 degrees from vertical.
- Place water sprinklers under the fans to wet the cows every 15 minutes; and/or place high pressure fogger kits (200-225 psi) on the fans to continually emit water.

Low-cost and quick suggestions to cool exit lanes include:

- Putting shower head nozzles on an electric eye to wet cows and encourage them to eat feed after exiting the parlor; and
- Placing water troughs in the barn or travel lanes, making sure adequate space is available, as cows want to drink immediately after exiting the parlor.

1) **Evaporative cooling pads and fan systems** appear to be effective in areas of low or high humidity and cool the air while raising the relative humidity. Arizona studies found that fans and pads reduced the temperature by 20-24° F, which resulted in 7-13 lb. more milk per cow. This system requires fans, evaporative cooling pads, and pumps to circulate water to the pads. A fine mist injection apparatus injects water under high pressure into a stream of air blown downward from above (Shearer et al., 1999). Coolers are positioned every 20 ft. in the roof and air is pulled through the cooler at very high rates. Although there is a substantial initial investment and operating expense, the cost is probably offset by increased milk yield, improved reproduction, and decreased culling.

2) Other evaporative cooling methods include mist, fog, and sprinkling systems. A mist or fog system sprays small water droplets into the air and cools the air as the droplets evaporate. When an animal inhales the cooled air it can exchange heat with the air and remove heat from its body.

   a) High pressure **foggers** disperse a very fine water droplet which quickly evaporates and cools air while raising the RH. As fog droplets are emitted they are immediately dispersed into the fan's air stream where they soon evaporate. A ring of fog nozzles is attached to exhaust side of fan. Cooled air is blown over animal's body. Foggers should operate during daylight hours only; humidity is too high at night but fans should operate continuously. They use about 3-5 gals water /cow/day but require maintenance because water filters must be checked daily and cleaned. They should not be used in low barns with side walls that restrict air flow, droplet evaporation, and reduce cooling, while making excessively wet conditions. Fog systems are very efficient methods of cooling air but also are more expensive than mist systems and require more maintenance.

   b) A **mist** droplet is larger than a fog droplet and animals are cooled primarily by inspiration of cooled air. Mist systems are difficult to use under windy conditions or in combination with fans. In warm humid environments, mist droplets are too large to fully evaporate before settling to the ground, and bedding or feed become wet. If a misting system does not wet the hair coat through to the skin, an insulating layer of air can be trapped between the skin and the layer of water. This will impede evaporative heat loss and can cause a harmful heat buildup. Cooling studies involving mist systems also reported respiratory and pneumonia problems when cows were exposed to mist particles in enclosed areas. A mist system probably is not advisable for most dairy operations, especially for free stalls bedded with sawdust or shavings.

   c) An alternative to mist and fog systems is the **sprinkling** system. This method does not attempt to cool the air, but instead uses a large droplet size to wet the hair coat to the skin of the cow, and then water evaporates and cools the hair and skin. Sprinkling is most effective when combined with air movement. Fans should provide an airflow of about 11,000 cfm and should be tilted downward at 20-30° angles. At least one 36-inch fan is needed for each 40 animals which will move air effectively for about 30 ft. Other fan sizes can be used (a 48-inch fan at 40 ft. intervals). Nozzles (10 psi, 180° spray) are spaced above cows approximately every 8 ft. Sprinklers should be located immediately below the fans so that water is thrown just under the bottom of the fans which run continuously. Cows are sprinkled for 1-2 minutes at 15-minute intervals. Concrete floors must be sloped to handle water runoff rates of 50-100 gal./cow/day. The sprinkling system can be used in holding areas, shade structures, and feed barns. Avoid wetting feed and freestalls.

Studies conducted at the University of Arizona found that most effective cooling occurred with a "Spray and Fan System" which utilized 36- to 48-inch fans placed on roof support posts 20-24 ft. apart, mounted at an angle of 40-50° toward freestalls and 15-25° downward, and with a height of 7-9 ft. from fan bottom to ground (Mullinax, 1999). Feed lane soakers positioned 6 to 9 ft. above the feed line are found on many dairies. The second most effective system was a "Spray and Orchard Fan System" using fans with two 6-ft. blades mounted every 75-125 ft. over the feed alley and rotated about 150° every 40 seconds combined with a spray nozzle to displace water as the fan rotates.

3) **Cooling ponds** are used in Florida and have been found to effectively reduce body temperature with no apparent adverse effect on udder health (protothecal or coliform mastitis) or other diseases. Ponds are man-made with approximate dimensions of 50 x 80 ft. and 4-6 ft. deep. Well water is continuously pumped into each pond and overflow pipes are positioned at the opposite end to carry effluent into contained settling areas. Ponds are drained and dredged every 1-2 years. Seven of 12 groups of lactating cows in a 1,400 cow Florida herd were located in lots with access to cooling ponds. All groups had permanent shade structures. The incidence of clinical mastitis for cows accessing ponds was half that of cows without ponds. These cows were cleaner and easier to milk, with lower somatic cell and bacteria counts; perhaps resistance was enhanced by lower heat stress. However, in Florida, it rained almost daily and lots were quite muddy. Cows in lots without ponds were quite dirty. The use of man-made ponds is different from simply allowing cows to access natural ponds and streams and the latter is not recommended.

Ration Modification for Hot Weather

Some things that good managers consider when feeding lactating dairy cattle during hot weather are feeding frequency (an extra feeding or two), time of feeding (cooler time of day), adequate feed bunk space (all cows can eat together without crowding), plenty of cool water, and adequate air flow. Keeping cows comfortable is the key to keeping them eating which is critical in keeping them productive.

Ration modification can help minimize the drop in milk production that hot weather causes. Decreasing the forage to concentrate ratio (feeding more concentrate) can result in more digestible rations that may be consumed in greater amounts. However, many herds already feed the maximum amount of concentrate and more would cause problems with acid rumens and cows going off feed. Feed high quality forage but don't go below 18-19% ADF (acid detergent fiber). Sodium bicarbonate or sesquicarbonate can help buffer the rumen to accommodate higher levels of concentrate. Feed at the rate of .25 to .5 lbs./cow/day. Increase buffer to 0.75% of DMI (0.37 lb. bicarb/day) in Total Mixed Rations or complete feeds and offer free choice. Other feed additives that have been somewhat successful in hot weather are yeast (improved fiber digestion), fungal cultures such as Aspergillus oryzae, and niacin (improved energy utilization). However, all of these additives would not usually be used together.

Supplemental fat can be added to rations to increase energy intake. This supplemental fat can come from whole seeds such as cottonseeds or soybeans, tallow, rumen inert sources, or combinations. Most diets will contain about 3% fat (dry basis) without any high fat feeds. The next 2 to 3% fat can come from whole seeds. This results in rations with 5 to 6% fat. Anything above this should be added as rumen inert fat (commercial sources are available). Rations should not exceed 7 to 8% of the overall dry matter as fat. Because fatty acids reduce the intestinal absorption of calcium and magnesium, requirements for these two minerals increase when fats are fed. Supply .9% calcium and .35% magnesium in the ration when fats are fed. Also avoid feeding excess fat especially in hotter weather. Overfeeding can cause problems with rumen function and can reduce dry matter intake.

Overfeeding protein during hot weather should be avoided because it takes energy to excrete excess nitrogen. Rations usually should be 18% protein or less on a dry basis. Only the highest producing cows will need the 18% protein ration. Also, rations having greater than 65% of the total protein as rumen degradable protein should be avoided because the excess nitrogen produced would have to be excreted by the kidney. It is best to feed a ration balanced for ruminal and post ruminal digestion.

Hot weather increases the need for **certain minerals** (Harris, 1992). This is due to increased sweating and urination resulting in more minerals being excreted. **Potassium** should be increased to at least 1.5% of dry matter, **sodium** to .45%, and **magnesium** to .35%. Magnesium may be increased already if fats are being fed. Complete minerals designed to contain the higher levels of potassium and sodium should be fed only to lactating cows since udder edema is more prevalent in dry cows receiving extra salt or potassium.

Some nutritionists have suggested raising levels of supplemented **vitamins** during heat stress. However, if you are supplementing 100,000 international units (IU) of vitamin A per day, 50,000 IU of vitamin D, and 500 IU of vitamin E, it would not appear that more would do any good. Cows can manufacture vitamin D with exposure to sunlight and summer is a time where we might need less supplementation. Also, cows receiving fresh cut plants or pasture will get high levels of vitamin E in the forage. Therefore, supplementing extra vitamins during summer is not usually warranted.

In Table 1, a ration has been formulated that includes some of the ideas for ration modification. For instance, whole cottonseeds and a rumen protected fat are added to increase the energy. Soybean hulls have been used to supply a readily fermentable fiber source that is non-starchy in nature. Hulls replace some corn and keep the non-fiber carbohydrates at acceptable levels. Fish meal was added as a rumen resistant protein source and supplies some limiting amino acids for milk production. Sodium bicarbonate was added to buffer the rumen. Potassium chloride was added to increase the potassium and magnesium oxide to increase magnesium. Limestone was added to supply calcium at a level needed for high fat diets.

Other nutritional tips include:

- Feed total mixed rations, increase number of feedings but offer smaller quantities at cooler times of day, add buffers or yeast culture, pull unpalatable feed from the ration, remove old feed, use higher quality, more palatable feedstuffs;
- Feed high quality forages and more digestible feedstuffs;
- Avoid secondary fermentation in feed bunk: Provide shade over feed bunk, use mold inhibitors such as propionic acid, feed at night, add water to dry rations, and increase corn silage in ration to lower ration pH; and
- Maintain constant feeding times, meet minimum fiber levels (18% ADF), and avoid slug feeding (Hutjens, 1998).

Fly Control

Flies can cause cows to pile up or gather in one closely compacted group and contribute to heat stress. The first and most important step in fly control is sanitation. Eliminate fly breeding areas on a weekly basis, including manure, wet spilled feed and silage, rotting hay, manure drains, and leaking water cups. Commercial preparations can be used to spray on feeders or applied to animals as pour-on or treated ear tags.

Summary

Successful herds emphasize the importance of cow comfort. Glen View Dairy in Mt. Sidney, VA, stresses cow comfort rather than milk production and their herd average is 27,492 lb. milk per cow. In their holding area, there are two fans equipped with misters. The holding area has open sides and an open ridge in the roof. On the northwest side of the freestall barn, there is a large fan in each window and they are controlled by two thermostats. One half of the fans are set at 70° F and run continuously.

Every other fan is controlled by a thermostat set at 80° F and during the hot weather in early July, 1999, these fans ran until 3 AM. Cows are fed smaller quantities 4-5 times a day but they eat it all. Other practices that could be considered include: a fan and sprinkler system at the feed bunk, and sprinklers to wet cows as they leave the parlor.

Table 1. Example of a hot weather ration for lactating dairy cows.

Feeds	lbs./cow/day
Alfalfa silage	10.00
Corn silage	50.00
Shelled corn	10.00
Soybean hulls	3.00
Whole cottonseeds	5.00
Fish meal	1.00
Soybean meal, 48%	7.00
Rumen protected fat	.75
Sodium bicarbonate	.50
Salt	.10
Potassium chloride	.40
Magnesium oxide	.10
Limestone	.45

Nutrient content	% Total Ration Dry Matter
Acid detergent fiber	19.50
Non-fiber carbohydrates	37.00
Net energy, Mcal/lb.	.78
Fat	6.30
Crude protein (CP)	17.10
Rumen degradable protein, % CP	64.00
Calcium	.90
Phosphorus	.42
Magnesium	.35
Potassium	1.53
Sodium	.45
Sulfur	.21

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