SDSU Extension

BEEF

Chapter 7

Heat Stress Impacts on Cattle

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Introduction

Heat stress losses to the cattle industry over the past 10 years are estimated to be in excess of $75 million (The Samuel Roberts Noble Foundation). Cattlemen have no control over the weather systems responsible for the environmental conditions which result in heat stress to cattle. However, cattlemen do have managerial control over production practices which can buffer the effects of those conditions.

Most published research that provides management recommendations for dealing with heat stress is based on the feedlot sector. However, much of that information has application for beef cow managers also, and is consequently included here.

Predicting Periods of Heat Stress in Cattle

Beef cattle function most efficiently when temperatures range from 41°F and 77°F but may be subjected to heat stress when temperatures rise above this upper level. Ambient temperature alone contributes to heat stress although there are several additional factors that, when occurring at the same time, elevate stress levels. They include hide color, relative humidity, ground surface temperature, hair coat, breed and prior respiratory incidences that left lasting effects to the respiratory system of the animal. Solar radiation in systems without shade cover and night time cooler temperatures are also contributors.

The **Heat Index** offers cattlemen one tool for predicting weather conditions which could compromise cattle performance due to heat stress. The index accounts for combinations of temperature, humidity, wind speed and solar radiation levels which can cause environmental stress on livestock.

A factor of vital importance for predicting heat stress that is not included in the Heat Index is night time temperature. Animals that do not cool sufficiently at night, due to temperature and humidity levels remaining elevated or lack of air movement are candidates

Key Points

- Beef cattle function most efficiently when temperatures range from 41°F and 77°F but may be subjected to heat stress when temperatures rise above this upper level.
- In addition to weather factors, numerous other risk factors increase the risk of heat stress in cattle including genetics, hide color, health, production status, and previous exposure.
- Slobbering, high respiratory rates or rapid panting, open-mouth breathing, lack of coordination and trembling are signs an animal is experiencing heat stress.
- Mitigating heat stress is challenging; however, there are modifications that can be made to the landscape, which can provide some relief.
- Embryos are susceptible to heat stress, with the early stage of development being the time point when an embryo is most susceptible to increased temperatures. Temperatures greater than 90°F can impact the reproductive function of bulls.

for increased heat loads the following day. Planning ahead by monitoring predicted weather conditions and utilizing tools such as the Heat Index may help cattle survive these times of extreme heat stress.

The Livestock Weather Hazard Guide provides guidelines based on relative humidity and temperatures. However, there are other weather conditions that impact the heat stress on cattle. Three weather condition occurrences that can put cattle may be in danger of death due to heat stress are:

1. The Heat Index is 75 or greater for a 72-hour period;
2. The Heat Index during a 48-hour period is no lower than 79 during the day and no lower than 75 at night; and
3. The daytime Heat Index reaches 84 or higher for two consecutive days.

	Relative Humidity (%)																			
Dry Bulb Temperature (F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
75									70	70	71	71	72	72	73	73	74	74	75	75
76							70	70	70	71	72	72	72	73	74	74	74	75	76	76
77						70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
78					70	70	71	71	72	72	73	74	74	75	75	76	76	77	78	78
79				70	70	71	72	72	73	73	74	74	75	75	76	77	77	78	78	79
80			70	70	71	72	72	73	73	74	74	75	76	76	77	78	78	79	79	80
81		70	70	71	71	72	73	73	74	75	75	76	77	77	78	78	79	80	80	81
82		70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
84	70	71	72	72	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
86	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
88	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	85	86	87	88
89	73	74	74	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	87	87	88	89	90
91	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	74	75	76	77	78	79	80	81	82	83	84	84	85	86	87	88	89	90		
93	75	76	77	78	79	80	80	81	82	83	84	85	87	87	88	89	90			
94	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90				
95	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90					
96	76	77	78	79	80	81	82	84	84	86	87	88	89	90	91					
97	77	78	79	80	81	82	83	84	85	86	87	88	90	91						
98	77	78	79	80	82	83	84	85	86	87	88	89	90							
99	78	79	80	81	82	83	84	86	87	88	88	90								
100	78	79	80	82	83	84	85	86	87	88	90	91								
105	80	82	83	84	86	87	89	90	91											

Key
Alert
Danger
Emergency

Table 1: Livestock weather hazard guide. The Samuel Roberts Noble Foundation.

In addition to weather factors, numerous other factors increase the risk of heat stress in cattle. Factors can be grouped in four different categories, including genetics, health, production status, and previous exposure to heat stress. Table 2 lists the risk factors and associated animal traits that will increase the animal's susceptibility to heat stress.

Genetic components may include many different factors, but the most relevant are breed, temperament, and color. Breeds, breed crosses, or composite breeds with historical origins in the tropics or subtropics tend to be more heat tolerant relative to cattle of 100% European origin. Color plays an important role in heat tolerance simply because dark colors absorb more heat than light colors. As a result, a black animal will be more susceptible to heat stress than a white, red or tan animal. It has recently been shown that temperament also plays a role in heat tolerance. Animals that are calmer are more heat tolerant than animals that are more excitable.

The current general health of the animal will influence its ability to withstand additional stresses, including heat stress. Previous health issues, particularly pneumonia, will also impact heat tolerance. The effects of pneumonia are long lasting and an animal that has been treated for pneumonia at any time in its past has a higher risk of exhibiting symptoms of heat stress than those animals that have not had pneumonia. Animals that have had pneumonia and have not been treated could even be at higher risk.

In reference to production status, finished cattle that are ready to go to market, cattle in poor condition, and cattle that have recently arrived at the feedlot are among the most vulnerable.

Previous exposure to high temperatures and/or humidity can "pre-condition" cattle to be better able to tolerate a high heat index. Cattle that have

Table 2: Risk factors and associated traits. *USDA, 2010*

	Risk Factors			
	Genetics	**Health**	**Production Status**	**Previous Exposure**
Traits	European breed	Poor current health	Finished cattle	All cattle in the early spring and early summer
	Black or dark red	Past case of pneumonia	Poor condition	Cattle recently transferred from northern locations
	Excitable or high strung	Many previous health issues	Newly arriving	---

not been preconditioned to hot weather will have a greater stress response (higher breathing rate, higher body temperature). Moving cattle from a cool region of the country to a hot environment can also increase the animal's susceptibility to heat stress.

Indicators Of Heat Stress

Cattle that exhibit any of the following signs can be suffering from the effects of some degree of heat stress: Slobbering, high respiratory rates or rapid panting, open-mouth breathing, lack of coordination and trembling. Bunching or posturing themselves for access to available shade is also an obvious sign that cattle are experiencing some degree of stress. In feedlot situations most or all of the cattle will stand, and as conditions become severe, breathing becomes more labored causing tongues to protrude and animals begin to lower their heads.

Panting or breathing rate is one of the best indictors of the degree of heat stress. A predicted breathing rate can be calculated using the factors of temperature, humidity, wind speed and solar radiation levels in the following formula:

For temperatures higher than 80°F

Breathing Rate = (2.83 x Temperature) + (0.58 x Humidity) - (0.76 x Wind Speed) + (0.039 x Solar Radiation) - 196.4

The categories found in Table 3 are based on the formula above. Producers can use predicted weather conditions to calculate the predicted breathing rate and corresponding heat stress category, which allows them to put additional management and prevention factors in place.

Table 3: Stress categories defined by predicted breathing rate. *Brown-Brandl et al., 2005*

Predicted Breathing Rate	Heat Stress Category
Less than 90 breaths per minute	Normal
From 90 - 110 breaths per minute	Alert
From 110 - 130 breaths per minute	Danger
Above 130 breaths per minutes	Emergency

Heat Stress Management/Prevention

Water Supply

Water consumption is driven by a number of factors including environmental temperature, body weight of the animal, moisture content of the diet and lactation demands for nursing cows. As shown in Table 4, water consumption at 90°F can be almost twice that at 70°F. Even at 80°F, consumption may be 50% more than at 70°F. Because sufficient water intake is critical to reducing body temperature in times of heat stress, providing adequate water space is important in preventing heat stress. A general guideline is that cattle require three inches of linear

Table 4: Approximate total daily water intake of beef cattle. *Winchester and Morris, 1956*

Weight Pounds	Tempurature in °F					
	40 gallons	50 gallons	60 gallons	70 gallons	80 gallons	90 gallons
	Gallons per d					
Growing Heifers, Steers, and Bulls						
400	4.0	4.3	5.0	5.8	6.7	9.5
600	5.3	5.8	6.6	7.8	8.9	12.7
800	6.3	6.8	7.9	9.2	10.6	15.0
Wintering Pregnant Cows						
900	6.7	7.2	8.3	9.7	---	---
1,100	6.0	6.5	7.4	8.7	---	---
Lactating Cows						
>900	11.4	12.6	14.5	16.9	17.9	16.2
1,100	6.0	6.5	7.4	8.7	---	---
Mature Bulls						
1,400	8.0	8.6	9.9	11.7	13.4	19.0
>1,600	8.7	9.4	10.8	12.6	14.5	20.6

water space per head during summer months. Not only is fountain space a priority, volume of water supplied hourly is also crucial. Research conducted by Dewell (2013) indicates that fountains should deliver 1.1% of the body weight of the cattle per hour.

Providing auxiliary water tanks during these periods of extreme heat can also be an effective management tool to ensure cattle have easy access to ample clean water. Furthermore, cattle will sometimes cool themselves by partially submerging their heads in the auxiliary tanks. Finishing cattle consumed between 10 and 12 gallons of water from the auxiliary tanks in addition to what they consumed from the fountains during an SDSU Extension demonstration project (Personal communication, Jim Krantz).

Ration Delivery

Heat generated from rumen digestion occurs several hours after the diet is consumed. Cattle fed in the morning would experience that heat build-up during the hottest portion of the day. Moving the ration delivery to later afternoon or early evening shifts rumen fermentation to occur during cooler night time temperatures. If cattlemen deliver rations twice daily and prefer to maintain that schedule, consideration should be given to delivering a smaller portion in the morning and delivering the remaining amount later in the day. Researcher by Dahlen and Stoltenow (2012), confirms that scaling-back diet delivery during and for several days after an extended period of extreme Heat Indexes improved adaption to heat stress conditions.

Timing of delivery is not the only nutritional management strategy related to heat stress. While high-energy feeds such as corn are typically referred to as making the diet "hotter", they actually produce less heat from digestive processes than forages. Poorer quality forages, in particular, contribute to the heat build-up of the fermentation process. Research by Reynolds et al. (1991) showed that heifers on higher fiber, pelleted diets had greater heat production as compared to heifers fed pelleted diets containing 75% concentrate. Excess protein levels may also result in increased body heat as animals attempt to detoxify the extra protein and excrete it through the urine (Boyles, 2014). Changing fiber content and/or quality and limiting excess protein consumption have been shown to influence heat production. Modifying diet composition is difficult for grazing animals, but these principles should be considered for managing diets of confinement animals, including cows in drylot.

Lot Management

Mitigating heat stress in feedlot cattle is challenging; however, there are modifications that can be made to the lot landscape, which can provide some relief to the cattle.

Shades

Solar radiation is one of the most significant contributors to heat stress in feedlot cattle, especially black-hided cattle. Shades limit the effect of solar radiation and can provide another management tool for producers to reduce the effects of heat stress. Shade structures can be constructed of various materials including galvanized metal, aluminum, steel or wood to make slats for the roof. Recently, light-colored fabric has become more popular. It is effective in providing desirable shaded areas and is relatively easy to handle if the roofs are removed or rolled up in the winter.

Several factors should be included in any checklist when considering construction of a shade:

- Shades are typically constructed toward the center of a pen to allow cattle access to shade for a large portion of the day, as the shaded area moves across the pen during the day.
- Designs that include a north-south orientation consistently provide dryer pen surfaces as the shadow provided by the shade moves over a greater area.
- Constructing shades over or near water sources is not advised.
- It is highly recommended that areas beneath shade structures be regularly cleaned of wet manure to limit odor and ammonia production and maintain a desirable lot surface.
- Increased shade height will allow for greater air movement and cleaning with equipment; however it is also more costly to construct.

Shades should be constructed with a height range from eight to 15 feet. Taller heights allow for pen grooming equipment and better air flow. Cattle need about 20 to 40 square feet of ground space per head to prevent bunching. In a demonstration project in Miner County, South Dakota in the summer of 2012, the following temperature readings were recorded using an infrared heat gun:

- Air temperature – 108°F.
- Non-shaded ground temperature – 144.4°F.
- Shaded ground temperature – 110°F.
- Hide temperature, non-shaded reading – 106°F
- Hide temperature, shaded reading – 100°F.

These data indicate the benefits of cattle shades in reducing cattle hide temperatures and ground temperatures, and thus also impacting the ability of the cattle to cool down over night (Krantz and Pohl, 2012, unpublished data.) Costs to construct the shades were estimated to be between $16 and $20 per head.

Researchers at the University of California-Davis Animal Science Department conducted two studies which document performance differences for groups of cattle finished in lots where shades were included and where no shades were accessible for the cattle (Mitloehner et al., 2001, 2002). In one study, cattle that were provided shade went to market three weeks earlier, resulting in $18 additional profit per head. The cattle provided shades also showed improved quality grades and less incidence of dark cutters.

Mounds

Cattle in feedlots where mounds are available benefit from increased air movement, along with a reduction in fly activity. Bedding mounds is a proven means of reducing heat stress, as it results in reduction of ground temperatures by as much as 15°F. Wetting the bedding can result in even greater reductions in temperatures.

Sprinklers

Cooling the ground with sprinklers can be an effective method of cooling cattle during heat stress. Droplet size of water particles is extremely critical as fine mists have the potential to increase the Heat Index by increasing the relative humidity around the animal. Cooling the ground, instead of the cattle, with sprinklers is preferred. This process should begin well before peak heat periods during the day.

Fly control

Feedlot cattle fighting flies tend to bunch together for relief which, in turn, compounds the effects of heat stress. Managing manure by grooming lots regularly greatly reduces fly infestations. Sprays and back rub products can also be effective.

Reproductive Effects of Heat Stress

The early stage of development is the time point when the embryo is most susceptible to increased temperatures. Temperature, humidity, radiant heat, and wind will affect heat stress in cows. The rectal temperature of cattle is normally 102.2°F, and an increase in rectal temperature by as little as 2°F can result in decreased embryonic development. When rectal temperatures reach 105.8°F for as little as nine hours on the day of insemination, embryonic development can be compromised. Heat stress has also been shown to change follicular waves, resulting in reduced oocyte quality. Researchers have shown that heat stress 42 days prior to and up to 40 days after breeding can affect pregnancy rates (Field and Perry, 2007). However, using embryo transfer during times of heat stress can increase pregnancy rates. High quality, fresh embryos have been shown to increase pregnancy rates as compared to AI in heat stressed cows. Embryos at time of embryo transfer can adapt to the elevated temperatures. Therefore, use of embryo transfer during times of heat stress can improve pregnancy success.

Extreme heat also makes estrus detection difficult for. Cows will not move around as much or show signs of estrus during extreme heat, leading to unobserved estrus, and ultimately result in fewer cows inseminated.

Management of Heat Stress in the Bulls

Temperatures greater than 90°F can impact the reproductive function of bulls. Semen quality can be compromised, even though the bulls do not show physical signs of heat stress. Semen quality tends to decrease one to two weeks after an acute heat stress event and will persist for an additional 4 to 8 weeks. This may be a practical concern if the bull is expected to breed a large number of females (i.e. as in a synchronized breeding program) in this time frame.

Handling Of Cattle During Heat Stress

If it is necessary to work cattle during periods of heat stress, the best time is in the early morning. Try to avoid afternoon and evening work when their body temperatures are already high. Body temperatures of cattle exposed to high daytime temperatures tend to peak in the early evening, decline during the night, reach a low point in the hours just after sunrise, and then slowly rise again throughout the day. If possible, avoid working the cattle at all when under prolonged heat stress conditions.

Transportation of cattle during heat stress should also be avoided if possible. However, the best time of day to transport cattle is during the early morning or cooler parts of the evening if delaying transportation isn't possible. Transportation of cattle during heat stress events may contribute to an increased incidence of dark cutters.

Summary

While cattlemen have no control over weather patterns, they do have a number of tools available to help predict when those events will happen. Prediction and application of various management procedures will help mitigate their magnitude of negative effects of heat stress.

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