Environmental Modification To Reduce Heat Stress

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WESTERN LARGE HERD
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Introduction

Summer depresion in milk production and reproductive performance is a very serious dairy industry problem in hot semi-arid and arid climates of the world. When the temperature exceeds 100°C even with low humidity, the microclimate is above the comfort zone for high milk production according to Bianca (1962) Hahn (1976), and Sainburg (1967). Stress occurs whenever the temperature humidity index (THI)* exceeds 72. A THI of 72°F also occurs at the following temperature (F) and relative humidity (RH) (75°F and 80% RH); (88°F and 5% RH) and (82°F and 20% RH) all common temperature and relative humidity in western United States. Figure 1 by Wiersma (1990) shows the effect of heat stress on dairy cows from THI for a mild stess to a THI that causes dead cows. A high producing dairy cow exposed to long periods above the comfort zone reacts in several ways to retain comfort (1) seek out shade (2) increase water intake (3) reduce feed intake (4) stand rather than lying (unless wet ground is available) (5)increased respiration rate (6) increased body temperature (7) and excessive saliva production.

Shades

Shade for dairy cattle is considered essential to minimize loss in milk production and reproduction efficiency. Trees are the most effective shade as they combine protection from the sun with the radiation sink effect created by the cool leaves evaporating moisture. Wood, asbestos or palm tree branches are effective shading material. Sheet steel and aluminum are the most popular because of cost, length of life and low maintenance cost. Slatted shade is less effective than total shade. Kelly (1958) found that slatted snow fencing with approximately 50% openings was only 59% as effective as new aluminum sheeting for shading ground. Welchert et al. (1965) compared solid shade vs. slatted shade on a dairy farm in Arizona. Milk production for the solid shade cows averaged 3.1 lbs/day higher than for cows under a slatted shade, demonstrating the necessity for solid shade in hot-arid climates.

The location and size of the shade in dairy design is important. A mature dairy cow (lactating or non-lactating) requires from 38-48 sq. ft. of shade. Less than 38 ft can result in udder injury as cows crowd together, and excessive shade over 48 ft has no benefit as cows tend to group together under the shade. Shades should be 11-14 ft high to decrease the amount of reflected solar radiation from the shade roof to the cow. The orientation of the shade should usually be from north to south to allow the area under the shade to be exposed to the morning and afternoon sun to keep the ground dry.

(*: Temperature-humidity index incorporates both temperature and humidity index and is defined by the equation THI=(Dry-Bulb Temp.°C)+ (0.36 dew point Temp.,°C)+41.2.)

Under extremely high temperature conditions, it may be preferable to use an east-west orientation. However, this orientation will require additional ground maintenance to keep the surface dry. In either case, location of the shade in the center of the corral or pen will help in the distribution of manure. Ground maintenance by dragging the wet material out from under the shade and replacing it with dry is necessary to help keep the cows dry and clean.

Holding Pen Cooling

It is common to confine dairy cattle for 15 to 60 minutes in a holding pen adjacent to the milking parlor prior to milking. Most holding pens add to the heat stress in summer months because the pens are crowded and hot. In most hot climates, cows are sprayed from below to clean the udder. With this practice, the holding pen becomes very hot and humid. To improve this environment, overhead sprinklers (not foggers) and large fans that bring in drier outside air were installed and tested by Wiersma and Armstrong (1983). The sprinklers run continuously with low volume (3 gal per hour) sprinklers. Large fans (48 in) are located above the cow, mounted at a 30° angle from vertical so that the air blows downward and around the cow. Air flow per cow was approximately 1000 cfm/per cow. Daily high temperature for the experimental period ranged from 81 to 115°F. Cows were milked three times per day. Body temperature of cows was determined by measuring milk temperature during milking. Body temperature in cows with access to the spray/fan system in the holding pen were about 3.5°F lower. The milk production averaged 1.7 lb higher for the cooled cows for the summer months. This represents a rather modest increase, but the return over investment and operating cost was realized in less than one summer season.

Present installation in southwestern United States and northern Mexico follow the majority of the specifications which were used in this experiment. Thirty and thirty-six fans are being used because they are more readily available. In the 1983 trial the direction of the air movement was from the milking stall area out of the parlor. Some dairies have installed the fans to blow from the wash/holding pen area into the parlor. Both methods will cool the cows when both fans and spray lines are on. The only disadvantages are that on the days just before the hot summer (April-May) or after (Sept.-Oct) or at night when the spray lines are not used, even then blowing the air out of the parlor can reduce cow stress in the wash-holding pen area. The majority of dairymen in western United States should consider holding pen cooling.

Exit Lane Cooling

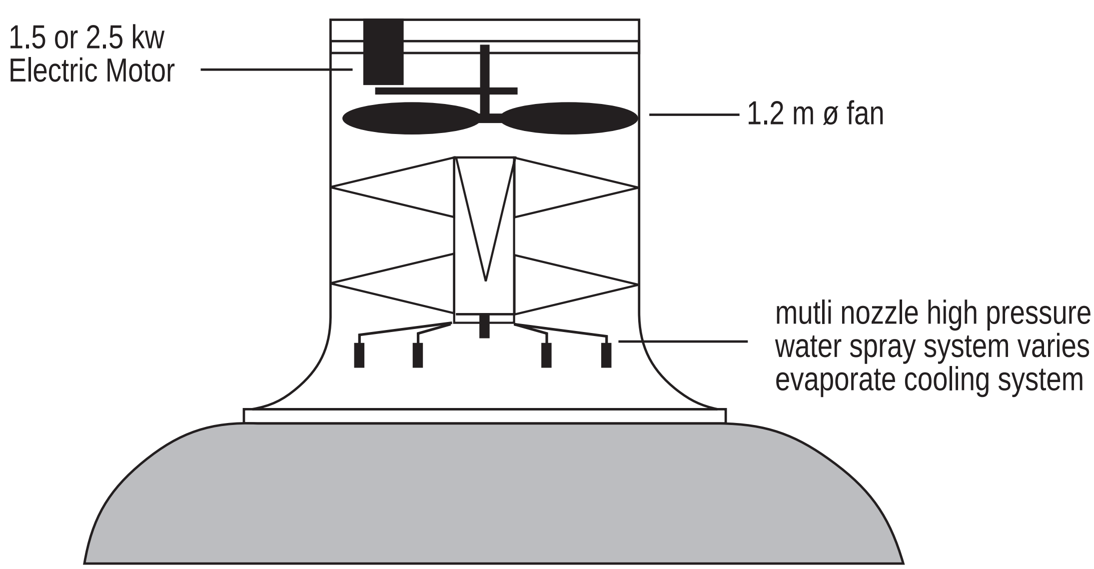
To increase the cooling period past the milking period, parlor exit sprinklers should be installed in the exit lanes. If the cow enters the corral with a wet body surface the moisture will evapoate thus cooling the cow for an additional 15-25 minutes depending upon weather conditions. Although this may seem like a short period of the total time for the cow it can contribute to cow comfort. On the majority of dairy farms that have both holding pen cooling and exit sprinklers, instead of the cow returning immediately to the shade, the cow will go to the feed manger and eat.

The installation of exit lane sprinklers include nozzle (approximately 3-4 nozzles) with a delivery of approximately 8 gallons of water per minute (ordinary shower sprays are excellent) at 35-40 P.S.I. pressure. This will drive the water into the hair coat. Common control switch to control the water spray include electric eyes, wands or leaf gates. The switch activates a normally closed solenoid valve so that the nozzles eject a spray on each cow as she exits. The nozzles are located one foot behind the control switch mechanization so a cow is sprayed just after her head extends past the area of the spray pattern. This avoids spraying water in the ear cavity. The nozzles are arranged to spray from the top and side only. If installed properly the water does not wet the udder or teats, therefore, not interfering with the post-milking teat dip.

Corral Shade Cooling

Improvement in milk production and reproductive efficiency have been demonstrated for dairy cows in open corrals with access to evaporative cooling under shade in southwestern United States and Saudi Arabia. Wiersma and Stott (1962) used a horizontal pad system to increase milk production and Stott et al. (1972) improved the reproductive performance with the same kind of horizontal-pad evaporative cooler. The benefits of evaporative cooling are not limited to semi-arid regions. In Florida with a humid climate Taylor et al. (1986) found that air temperature was reduced using an evaporative pad system. Although the evaporative pad system was effective in reducing the stress on dairy cows, its maintenance was viewed by dairy owners as a time consuming and costly endeavor. Consequently its adoption by the dairy industry was slow.

In 1981, a company in Mesa, Arizona, (Korral Kool) developed an evaporative cooling package that could be mounted in a conventional corral shade. (Figure 1) The system featured a fan driven by a 1 HP kw motor which drives the air (425 m3/min through vanes located directly under the fan creating a cyclonic motion in the descending air stream. Water nozzles inject atomized water under high pressure (1400-5000 kPa). The microscopic water droplets are discharged at 55 microns diameter but evaporate as they descend toward the ground. Some of the minute particles collect and stay on the hair of the cow but do not wet the ground. A fiberglass flare is designed to disperse the cooled air under the shaded area. A synthetic canvas curtain is suspended from the edge of the shade on the side of the prevailing wind to semi-confine the cooled air. The entire system is automatically controlled in response to air temperature and wind velocity. Modifications have been made since 1984 to increase the air flow to 800 m3/min and the water injection system has been automated to vary the water spray output as the water holding capacity of the air changes. The increased



water use increases the effective cooling available to the dairy cow. One unit is sufficient for 13-15 mature dairy cows.

What type of cooling will be cost effective is the major factor when considering dairy cattle cooling in the corral area. In areas with a long summer May through September (150 days) one type of corral cooling may be more cost beneficial than another. If the summer period of hot days is shorter, 100 days or less, then other types or no corral cooling would be the correct decision. What stage of the cow's life should the cow be cooled with corral cooling also is an important decision. Is it only early lactation, mid or late lactation or the dry period? Table (1) is based upon the results of research trials in southwestern United States, Mexico and Saudi Arabia. Some of the figures for different temperature responses being estimated. In calculating the total benefit from corral shade cooling, the milk production has usually been one-half of the total benefits which would include improved reproduction performance, less culling percentage and fewer sick cows and dead cows during the summer months.

Summary

Some form of dairy cattle cooling would benefit the majority of dairy farms in western United States. For a dairyman to choose which cooling method he should consider the following order should be of benefit:

1. Solid shade for all milking and dry cows 2. Holding pen cooling 3. Exit lane cooling 4. Corral shade cooling 5. Feed line cooling 6. Covered feed line

Improving the comfort of dairy cattle as milk production increased is necessary if you are to receive the maximum benefits from your nutrition, genetic and management programs.

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Table 1. Estimated milk production response for different types of cooling systems when compared to no cooling, in climates with an average day time humidity less than 30%.*

Different stage of lactation	(3 HP Units) & daily high temperature	Evap. Cooling	Spray & Fan
Early Lactation	> 85lb/day	lbs of milk	lbs of milk
	>105°F	16.5	8.8
	95 - 104	13.2	7.0
	<94°	11.6	6.2
Mid-lactation	65 - 85lb/day		
	>105°F	14.2	7.7
	95 - 104	11.4	6.2
	<94	10.0	5.4
Late lactation	<65lb/day		
	>105°F	12.3	7.1
	95 - 104	10.0	5.7
	<94	8.6	5.0
Dry Cows: milk production first 120 days of lactation (total lbs of milk)			
	>105°F	4.5(540)	3.0(360)
	95 - 104	3.0(360)	2.0(240)
	<94	2.0(240)	1.3(156)

*: Based upon research projects in southwestern United States, Mexico and Saudi Arabia. (See reference Numbers 1, 2, 3, 4, 8, 9, 11 and 14).

Figure 1 **THI for Dairy Cows**
Dr. Frank Wiersma (1900) - Dept. of Ag. Engineering
Th eUniversity of Arizona, Tucson Arizona

DEG	DEG	RELATIVE HUMIDITY																				
F	C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22.2																				72	72
73	22.8																		72	72	73	73
74	23.3																72	72	73	73	74	74
75	23.9														72	72	73	73	74	74	75	75
76	24.4												72	72	73	73	74	74	75	75	76	76
77	25.0											72	72	73	73	74	74	75	75	76	76	77
78	25.6										72	73	73	74	74	75	75	76	76	77	77	78
79	26.1									72	73	73	74	74	75	76	76	77	77	78	78	79
80	26.7							72	72	73	73	74	[illegible]	75	76	76	77	78	78	79	79	80
81	27.2						72	72	73	73	74	[illegible]	75	76	77	77	78	78	79	80	80	81
82	27.8						72	73	73	74	[illegible]	[illegible]	76	77	77	78	79	79	80	81	81	82
83	28.3					72	73	73	74	75	[illegible]	76	77	78	78	79	80	80	81	82	82	83
84	28.9				72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	29.4			72	72	73	74	75	[illegible]	76	77	78	78	79	80	81	81	82	83	84	84	85
86	30.0			72	73	74	74	[illegible]	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	30.6		72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
88	31.1	72	72	73	74	75	[illegible]	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	31.7	72	73	74	75	[illegible]	76	.7	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	32.2	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	32.8	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	33.3	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	33.9	74	75	76	77	78	79	80	80	81	82	83	[illegible]	85	86	87	88	89	90	91	92	93
94	34.4	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	35.0	75	76	77	78	79	80	81	82	83	[illegible]	[illegible]	86	87	88	89	90	91	92	93	94	95
96	35.6	75	76	77	78	79	80	81	82	[illegible]	85	86	87	88	89	90	91	92	93	94	95	96
97	36.1	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	36.7	76	77	78	79	80	82	83	[illegible]	85	86	87	88	89	90	91	93	94	95	96	97	98
99	37.2	76	78	79	80	81	82	83	[illegible]	85	87	88	89	90	91	92	93	94	96	97	98	99
100	37.8	77	78	79	80	82	83	84	[illegible]	86	87	88	90	91	92	93	94	95	97	98	99	
101	38.3	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	97	99		
102	38.9	78	79	80	81	83	84	85	86	87	89	90	91	92	[illegible]	95	96	97	98			
103	39.4	78	79	81	82	83	84	86	87	88	89	91	92	[illegible]	[illegible]	96	97					
104	40.0	79	80	81	82	84	85	86	88	89	90	91	93	[illegible]	95	96						
105	40.6	79	80	82	83	84	86	87	88	89	91	92	[illegible]	[illegible]	96	97						
106	41.1	80	81	82	84	85	86	88	89	90	91	93	[illegible]	95	97	98						
107	41.7	80	81	83	84	85	87	88	89	91	92	[illegible]	95	96	98							
108	42.2	81	82	83	85	86	87	89	90	92	93	[illegible]	96	97								
109	42.8	81	82	84	85	87	88	89	91	92	[illegible]	95	96	98								
110	43.3	81	83	84	86	87	89	90	91	[illegible]	[illegible]	96	97									
111	43.9	82	83	85	86	88	89	91	[illegible]	[illegible]	95	96	98									
112	44.4	82	84	85	87	88	90	91	[illegible]	[illegible]	96	97										
113	45.0	83	84	86	87	89	90	[illegible]	[illegible]	95	96	98										
114	45.6	83	85	86	88	89	91	[illegible]	[illegible]	96	97											
115	46.1	84	85	87	88	90	91	[illegible]	95	96	98											
116	46.7	84	86	87	89	90	92	94	95	97												
117	47.2	85	86	88	89	91	93	94	96	98												
118	47.8	85	87	88	90	92	93	95	97													
119	48.3	85	87	89	90	92	94	96	97													
120	48.9	86	88	89	91	93	94	96	98													
121	49.4	86	88	90	92	93	95	97														
122	50.0	87	89	90	92	94	96	97														
123	50.6	87	89	91	93	94	96	98														
124	51.1	88	90	91	93	95	97															
125	51.7	88	90	92	94	96	97															
126	52.2	89	90	92	94	96	98															
127	52.8	89	91	93	95	97																
128	53.3	90	91	93	95	97																
129	53.9	90	92	94	96	98																
130	54.4	90	92	94	96	98																
131	55.0	91	93	95	97																	
132	55.6	91	93	95	97																	
133	56.1	92																				

NO STRESS

MILD STRESS

WHOOEE!!

SEVERE STRESS

DEAD COWS

NOTES