HEAT STRESS AND DRY PERIOD MANAGEMENT EFFECTS ON SUBSEQUENT REPRODUCTION AND LACTATIONAL PERFORMANCE OF HIGH YIELDING COWS IN ISRAEL

by

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Introduction

Warm climate depresses feed intake, milk production, and reproductive performance of dairy cattle. Maintenance of productivity at high ambient temperatures is determined mostly by the balance between metabolic heat production and heat loss. Metabolic heat generated is relative to the amount of milk produced, plus heat production associated with maintenance. Higher milk yields, therefore, increase the overall thermal load. At air temperatures above 78-80°F, heat dissipation from the cow depends mostly on water evaporation from the skin and upper respiratory tract. Heat loss at maximal sweating rate is only about half of the heat produced by a cow yielding 66 lbs. milk per day. Therefore, increased productivity in warmer climates depends largely on increased heat loss from the animal's body. Failure to increase heat loss causes a rise in body temperature which subsequently induces a decrease in feed intake, alterations in hormonal secretions and in blood flow to inner body organs. These changes subsequently decrease milk production and fertility during summer.

Several cooling methods for dairy cows have been examined over the years. Some of them alter the microclimate around the animals like: shades, which reduce direct solar radiation; evaporative air coolers, which lower the air temperature surrounding the animals. Other methods are also aimed to increase heat losses directly from the body of the cow; such a method is a sprinkling and ventilation cooling system (direct evaporative cooling).

In this report some aspects related to our experiences in Israel with the use of the sprinkling and ventilation cooling system will be discussed. In addition, the effects of cooling and body condition during the dry period, and cooling during lactation on milk production and reproductive performance are presented.

The Sprinkling and Ventilation Cooling System

Cooling Cycles. Sprinkling was supplied by inverted static garden sprinklers spraying about 3.2 gal/min. Forced ventilation, of about 10 feet/sec, was produced by large fans. The system was located in the holding area adjacent to the milking parlor or along the feeding line. In the various experiments, cows were cooled 6 to 8 times during daylight hours at 2-hour intervals. Each cooling period lasted 30 minutes and consisted of repeated cycles of sprinkling (30 sec) and forced ventilation

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4.5 min (5-minute cooling cycle). The common routine on commercial dairy farms is that cows are cooled, in the holding area, three times before milking. In addition, cows are brought to be cooled two more times between milkings.

Body Temperatures. A typical pattern of body temperature of cooled (C) cows or non-cooled (NC) cows is presented in Figure 1. Body temperatures of C cows were lower than those of NC cows for most of the 24-hour period. Temperature of NC cows peaked at 7 pm reaching about 103.5°F on average and declined thereafter. In contrast, body temperature of C cows remained below 101.3°C (body temperature of normothermic cows) during the hours of peak air temperatures, and increased slightly (by 0.7°F) after cessation of cooling at 6 pm in the evening. A difference of about 1.5 to 2.0°F between body temperature of C and NC cows was recorded during the hot afternoon hours.

Night Cooling. As seen in Figure 1, body temperatures tended to be higher during evening and night hours, in both cooled and non-cooled cows. This is probably the result of: 1) cows not being cooled at night (except once before night milking in the holding area) and 2) relative humidity rising to above 90% causing poor evaporative cooling (The latter situation is even worse in Florida where humidity can reach 100% many nights during summer). Body temperature at 6 am in the morning following humid (above 90%) and warm (72-76°F) nights was 103.5°F. These data demonstrate the importance of night cooling. So far there is no solution to keep body temperature of cows near normal at night. Fan and sprinkling may not be effective at night because evaporative heat loss is not very effective at high relative humidities.

Controlled Cooling vs. Voluntary Cooling. A controlled cooling management system means that cows are forced to be cooled at fixed times during the day. It has the advantages of low water usage, and excellent control of cooling of all cows in the herd. This system, however, requires use of labor and it may not be convenient to use it frequently enough.

The voluntary cooling system is based on the willingness of the cows to come voluntarily to the cooling area to be cooled whenever their body temperature rises above a certain level. Such a cooling system usually is located along the feeding lines and operates during all daylight hours. As a result, more water is used and minimal labor is needed. There is, however, no control on individual cow's cooling, and there is a clear decrease in the proportion of cows in a herd willing to be cooled in the afternoon and evening hours, as compared to the morning hours.

Cooling during the Dry Period

The effect of cooling high-producing dairy cows in summer during the dry period was examined in 84 Israeli-Holstein cows. Cows were paired, at the beginning of the dry period according to previous production and age, and then randomly allocated to a control group maintained under natural conditions with shade or to a cooled group which had shade plus cooling throughout the dry period. Sprinkling and ventilation cooling was for a half-hour at 2-hour intervals during daylight hours. No more than a 1.0°F difference in average body temperature was recorded between cooled and non-cooled cows during the dry period. Thus, only a relatively mild hyperthermia (rise in body temperature) was developed in the non-cooled controls. Following calving, in late summer or autumn, control and cooled cows were grouped together and were maintained under similar management conditions. Milking cows were maintained under large open sheds equipped with forced ventilation between 6 am to 6 pm. Fresh cows also were cooled twice daily in the holding area until the end of October.

Cooling increased mean 150-day milk production by more than 7 lbs. per cow per day. Lactation curves of cooled and non-cooled control cows during the first 150 days of lactation are presented in Figure 2. Calf birth weights increased significantly by cooling; the effect was greater for calves of older cows. Mean calf birth weight was 95.0 lbs for calves of cooled cows, as compared with 89.3 lbs for calves of control cows. Likewise, the beneficial effect of cooling on milk production was more pronounced in older cows. The physiological reasons for the age differences are not fully understood. These results indicate benefit of cooling dry cows even under mild heat stress. Similar effects also have been shown in studies done in Florida. However, the cooling system applied in Israel is likely to be more efficient due to better shade structures and a slightly lower relative humidity.

Cooling Cows during Lactation

In this experiment, the effect of intensive cooling in summer during the first 150 days of lactation on milk production and fertility was examined. Body energy stores were altered by nutritional means during the last month of previous lactation and the 2 months of the dry period. Cows were fed to reach, at calving, high body condition (3.8 on a scale of 0 to 5), or low body condition (score of 2.6). High body condition was aimed to compensate for the reduction in feed intake after calving during summer. After calving, half of the cows in each high or low body score group were cooled and the other half of each group served as non-cooled controls. Cows were first inseminated 60 days or more after calving.

Milk Production. Mean maximum air temperature was 87°F, but temperature very often peaked at about 97°F. Mean maximum relative humidity was 71%, but often it reached 94%. On average, cooling increased milk production by about 4.1 lbs. above controls (Table 1). Within the summer season, in the period of time when nighttime temperatures and humidity are high, cooled cows had higher milk yield than non-cooled cows (81.6 vs. 74.4 lbs/day). Body condition at calving did not have an effect on milk production. Milk fat percentage increased significantly with high body condition. Consequently, production of 4% FCM increased by about 3.3 lbs above the low body condition group. Milk protein production was not affected by body condition. However, cooling significantly increased milk protein production from 2.1 to 2.3 lbs/day. Collectively, high body condition at calving apparently was not able to compensate for the reduction in feed intake during summer. Only milk fat production was increased in the high condition group.

Fertility. Body condition at calving had a significant effect on the time interval from calving to the resumption of ovarian cyclicity.

High body condition cows first show ovarian cyclicity (as measured by plasma progesterone) after 26 days as compared with 31 days in the low body condition cows.

Estrous behavior was more pronounced in cooled cows but only among those cows that had low body condition. The length of estrus was 16 hours in cooled cows and only 11.5 hours in non-cooled cows. In a similar experiment conducted with estrous-synchronized cows, higher proportion of cooled cows showed standing estrus than non-cooled cows (70% versus 45%), Improvement of estrous behavior might have an important effect on shortening days open irrespective of the effect of heat stress on maintenance of pregnancy.

Body condition did not have any effect on conception rate (40% and 34% for low and high body condition groups, respectively). In contrast, cooling fresh cows had a significant effect on conception rates. It rose to 57% for cooled cows from 20% for control non-cooled cows (Table 2). The fertility of the cooled cows is at the range of winter level of fertility in Israel (around 50%). It should be mentioned, however, that total elimination of the negative effect of summer heat stress on fertility (winter level of conception rate) was attained under the conditions of an experimental herd. Our experimental conditions allowed full control of the cooling regimen of each individual cow within the cooled group. Such conditions are not met in a commercial dairy herd. These data demonstrate, therefore, the high potential of the cooling system to alleviate thermal stress from the dairy cow and to improve summer fertility.

Conclusions

1. The sprinkling and ventilation cooling system has a high potential to effectively cool dairy cows in summer.

2. Both cooling during the dry period or during lactation increase milk production by 4 to 7 lbs.

3. Intensive and efficient cooling of fresh cows can improve low summer fertility.

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Table 1: Effect of body condition and cooling on milk production (lbs/day)

	Cooled*	Non-cooled	High Condition	Low Condition
Mean	79.6	75.5	78.3	77.0
SE	1.3	1.5	1.5	1.3
N	41	38	36	43

* $P < 0.05$

TABLE 2: Conception rate[1] (%) and pregnancy rate[2] (%) of cooled and non-cooled cows.

Group	Cooled		Non-Cooled	
	%	(n)	%	(n)
<u>Conception rate.</u>				
First insemination	59*	(20/34)	17	(6/35)
All inseminations	57*	(32/56)	20	(14/70)
<u>Pregnancy rate.</u>				
at 90 days	44*	(15/34)	14	(5/35)
at 120 days	59*	(20/34)	31	(11/35)
at 150 days	73*	(25/34)	31	(11/35)

1 - Number of cows diagnosed as pregnant by day 45 post AI, divided by number of inseminations.
2 - Percent of pregnant cows, by days after calving.
* - Cooled and non-cooled groups differ, $P<.01$.

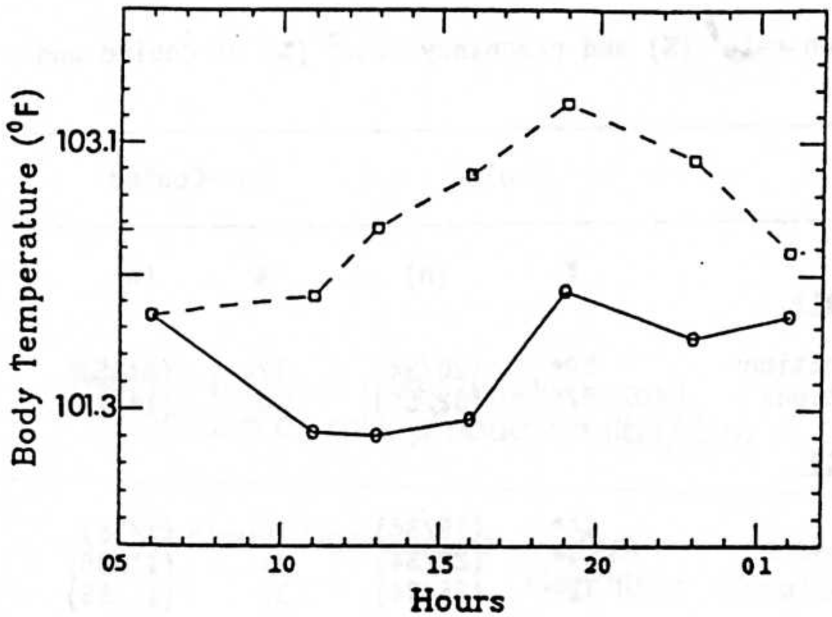

Figure 1: Body temperature of cooled (O) and non-cooled (□) cows.

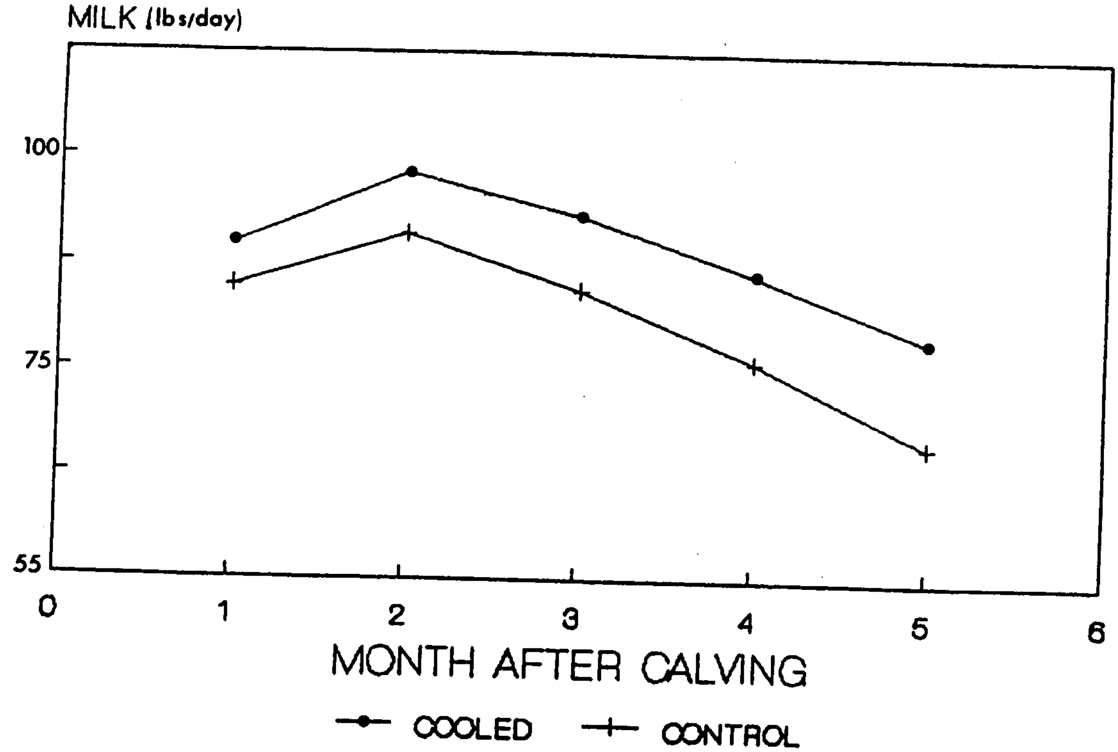

Figure 2: **Effect of cooling during the dry period on subsequent milk production.**